European Union Water Initiative Plus for the
Eastern Partnership Countries (EUWI+)

Result 2

DRAFT RIVER BASIN MANAGEMENT PLAN FOR SEVAN RIVER BASIN DISTRICT IN ARMENIA

Version 3, October 2020

ENI/2016/372-403

Beneficiaries

Ministry of the Environment of Armenia (MoE)

Responsible EU member state consortium EUWI+ project leader

Mr Alexander Zinke, Umweltbundesamt GmbH (AT)

EUWI+ country representative in ARMENIA

Vahagn TONOYAN

Responsible international thematic lead expert

Florence PINTUS, OIEau

Responsible national thematic lead expert

Edgar Pirumyan, Head of the Department for Licenses, Permits and Compliances, Ministry of Environment

Nazik Jzmachyan, Chief Specialist, Department for Licenses, Permits and Compliances, Ministry of Environment

Andranik Arakelyan, Head of Hrazdan Territorial Water Basin Management Division, Department Ministry of Environment for Licenses, Permits and Compliances, Ministry of Environment

Stepan Stepanyan, Head of Sevan Territorial Water Basin Management Division, Department Ministry of Environment for Licenses, Permits and Compliances, Ministry of Environment

Levon Azizyan, Director, Hydrometeorology and Monitoring Centre, Ministry of Environment

Gayane Shahnazaryan, Deputy Director, Hydrometeorology and Monitoring Centre, Ministry of Environment

Edgar Misakyan, Head of Hydrology Service, Hydrometeorology and Monitoring Centre, Ministry of Environment

Harutyun Yeremyan, Head of Groundwater Monitoring Service, Hydrometeorology and Monitoring Centre, Ministry of Environment

Hovik Aghinyan, Chief Hydrogeologist, Hydrometeorology and Monitoring Centre, Ministry of Environment

Armine Hakobyan, Head of Hydrogeological Research Division, Groundwater Monitoring Service, Hydrometeorology and Monitoring Centre, Ministry of Environment

Karen Daghbashyan, Deputy Chairman, Water Committee, Ministry of Territorial Administration and Infrastructures

Authors

Geocom, Ltd., 24a M. Baghramyan Ave, 0019, Yerevan, Armenia

Aleksandr Arakelyan, Hayk Yeritsian, Liana Margaryan, Gayane Shahnazaryan, Arshavir Avagyan, Armen Martirosyan, Narek Tarasyan, Lilit Sargsyan, Harutyun Uloyan, Araksya Nersisyan

Imprint

Owner and Editor: EU Member State Consortium

Umweltbundesamt GmbH Spittelauer Lände 5 1090 Vienna, Austria	Office International de l'Eau (IOW) 21/23 rue de Madrid 75008 Paris, France

Responsible IOW Communication officer:

Ms Chloé Déchelette c.dechelette@oieau.fr

October 2020

CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS (ATLAS)

ABBREVIATIONS

ADA .... Austrian Development Agency

AEC......................Annual Equivalent Cost

AMD...................... Armenian Dram

ASPIRED .... Advanced Science & Partnerships for Integrated Resource Development

AWB .... Artificial Water Body

AWSC................... Armenian Water Sewerage Company

BMO .... Basin Management Organization

BOD_5..................... Biochemical Oxygen 5-days Demand

CEA.......................Cost effectiveness analysis

CEPA .... Comprehensive and Enhanced Partnership Agreement

CEWP................... Clean Energy and Water Program

CJSC .... Closed Joint-Stock Company

COD...................... Chemical Oxygen Demand

CORINE................ Coordination of Information on the Environment

DG NEAR............. Directorate-General for Neighborhood and Enlargement Negotiations

DO .... Dissolved Oxygen

DoA....................... Description of Action

DRR .... Daily Regulation Reservoir

DSS .... Decision Support System

EaP .... Eastern Partnership

EBRD.....................European Bank for Reconstruction and Development

EC......................... European Commission

EEA .... European Environment Agency

EECCA .... Eastern Europe, the Caucasus and Central Asia

EMBLAS............... Environmental Monitoring in the Black Sea

EMIC..................... Environmental Monitoring and Information Centre

ENI........................ European Neighborhood Instrument

ENP .... European Neighborhood Policy

ENPI………………European Neighbourhood and Partnership Instrument

EPIRB................... Environmental Protection of International River Basins

ESCS.................... Ecological Status Classification Systems

EU......................... European Union

EU-MS.................. EU-Member States

EUR .... Euro

EUWI+.................. European Union Water Initiative plus

FD......................... Floods Directive

GEF .... Global Environment Facility

GIS .... Geographic Information Systems

GPM .... GeoProMining

GWB..................... Groundwater Body

HMWB .... Heavily Modified Water Body

HP…………………. HydroPower Plant

HPP .... Hydropower Plant

ICPDR .... International Commission for the Protection of the Danube River

INBO..................... International Network of Basin Organisations

IOWater/OIEau …. International Office for Water, France

IPCC .... Intergovernmental Panel on Climate Change

ISEP..................... Irrigation Systems Enhancement Project

IU .... Industrial Union

IWRM.................... Integrated Water Resources Management

KfW....................... Kreditanstalt für Wiederaufbau

KW .... Kilowatt

LLC .... Limited Liability Company

LTD .... Limited Company

MAC………………. Maximum Allowable Concentration

ME&A .... Mendez England & Associates

MSFD .... Marine Strategy Framework Directive

MW .... Megawatt

NAS .... National Academy of Sciences

NESB.................... National Executive Steering Board

NFP .... National Focal Point

NGO .... Non-Governmental Organization

NPD .... National Policy Dialogue

NRW………………. Non-Revenue Water

OECD .... Organisation for Economic Cooperation and Development of the European Commission

OJSC .... Open Joint-Stock Company

OMC......................Operational and Maintenance Costs

PoM...................... Program of Measures

PPP………………..Polluter Pays' Principle

RA .... Republic of Armenia

RBC .... River Basin Council

RBD .... River Basin District

RBMP .... River Basin Management Plan

RBO...................... River Basin Organisation

RCP………………..Representative Concentration Pathway.

ROM .... Result Oriented Monitoring

RU .... Regional Union

SAP .... Strategic Action Program

SCADA..................Supervisory Control and Data Acquisition

SCM...................... Steering Committee Meeting (of the EU Action EUWI+)

SEIS .... Shared environmental information system

SHPP.................... Small Hydropower Plant

SNCO .... State Non-Commercial Organization

SRES.................... Special Report on Emissions Scenarios

SS......................... Suspended Solids

SWB .... Surface Water Body

TA .... Technical Assistance

TDA .... Transboundary Diagnostic Analysis

TDS .... Total Dissolved Solids

TIN........................ Total Inorganic Nitrogen

TOC .... Total Organic Carbon

ToR....................... Terms of References

TP .... Total Phosphorous

TS.........................Transfer Station

UBA .... Umweltbundesamt GmbH, Environment Agency Austria

UNDP .... United Nations Development Programme

UNECE .... United Nations Economic Commission for Europe

USAID .... United States Agency for International Development

USSR.................... Union of the Soviet Socialistic Republics

VAT………………..Value Added Tax

WB........................ Water Body

WBPR................... Water Body Possible at Risk

WBR .... Water Body at Risk

WFD .... Water Framework Directive

WISE .... Water Information System for Europe

WRMP .... Water Resources Management and Planning

WUA .... Water Users' Association

WWTP.................Wastewater Treatment Plant

Country Specific Abbreviations Armenia

AMD……………….Armenian Dram

AWSC……………..Armenian Water Sewerage Company

EMIC..................... Environmental Monitoring and Information Centre SNCO (Envronmental Monitoring and Information Center SNCO, Hydromet Service SNCO, and Forest Monitoring Center SNCO have been merged into the Hydrometeorology and Monitoring Center SNCO)

HMC .... Hydrometeorology and Monitoring Centre SNCO

MNP...................... Ministry of Nature Protection (currently, Ministry of Environment, MoE)

MoE .... Ministry of Environment (former Ministry of Nature Protection, MNP)

PSRC……………...Public Services Regulatory Commision

SWCIS.................. State Water Cadastre Information System of Armenia

WC………………...Water Committee

WRMA .... Water Resources Management Agency (Water, Biosource and Waste and Atmospheric Management Agencies of MoE have been merged into the Department for Licenses, Permits and Compliances)

EXECUTIVE SUMMARY

Draft River Basin Management Plan for the Lake Sevan Basin District in Armenia have been developed by Geocom Ltd. in the period of 2018-2020 within the frames of the European Union Water Initiative Plus for Eastern Partnership Countries (EUWI+ East) Project. The EUWI+East Project addresses existing challenges in both development and implementation of efficient management of water resources. It specifically supports the Eastern Partnership countries to move towards the approximation to EU acquis in the field of water management with a focus on transboundary river basin management as identified by the EU Water Framework Directive (WFD).

The ecosystem of Lake Sevan has a strategic significance and economic, social, scientific, historical-cultural, esthetical, recreational, and spiritual value for the Republic of Armenia. Currently, the lake is an important water source for irrigation, hydropower, and recreational uses. In additional to environmental, economic, and strategic importance, the role of the lake is extremely important for mitigation of irrigation water deficit. Particularly, releases from the lake help in supplying additional water to the basins of Aparan and Marmarik Reservoirs, and the agricultural lands areas of Ararat valley and adjacent sub-mountainous zones.

The level of Lake Sevan fell dramatically due to excessive use during the period from 1930 to the 1980s, resulting in serious environmental and ecological problems, including deterioration of water quality, destruction of natural habitats, and loss of biodiversity. Starting in the 1980s, programs to stabilize and raise the lake level were initiated. This includes the construction of the Arpa-Sevan and Vorotan Arpa tunnels, transferring up to 250 and 165 million m^3, respectively, and outflow limits up to 170 million m^3 per year. As a result, the level of Lake Sevan has been steadily rising since 2001.

Economic activities in and around Lake Sevan are the sources of many pollutants, including the flow of excess nutrients into the lake, resulting in significant changes that ultimately induced the lake's eutrophication. Worsening of the water quality will eventually result in a collapse of the ecosystem, leading to grave environmental & economic repercussions for the energy, tourism & fisheries sectors. This would put the livelihood of great many at stake.

In order to save the lake and its ecosystem, urgent measures should be taken, and the first thing to do is establishing the efficient management framework for the lake's basin. Achieving sustainable water management requires a multidisciplinary, holistic approach that addresses technical, environmental, economic, societal and cultural issues.

A River Basin Management Plan is a guiding document that ensures this holistic, global approach to water management: it considers various economic, social and ecological aspects on a specific river basin to guide the development of appropriate sustainable water management measures, strategies and policies. The main objective of the river basin management plan are:

- the protection of inland surface waters, transitional waters, coastal waters and groundwater;
- to improve the status of waterbodies (qualitative and quantitative);
- to prevent further deterioration of waterbodies;
- to promote sustainable water use; etc. (see WFD).

It also aims to support water resources management bodies, including the state authorized water resource management body of Sevan RBD, administrative bodies, policymakers and the public in decision making in the field of water resources.

Draft Basin Management Plan for Lake Sevan have been developed in accordance with the EUWI+ project's technical task and requirements of the River Basin Management Plan's Model Guidance, as defined in Appendix 2, Decision 45-6 of 26 October 26, 2017 of Government of Armenia, taking into account the main characteristics of the Lake Sevan.

The main components of river basin management plan are:

- Basin characterization;
- Characterisation of protected areas in the basin (focusing on the water ecosystems);
- Identification of the significant pressures in the basin and their possible impacts on water resources;
- Assessment of the status of water resources;
- Risk assessment of the water bodies;

- Setting the environmental objectives;
- Economic analysis of water use; and
- Design of the program of measures in order to achieve a “good status” of water bodies in the basin.

Public consultations with local governments, residents of the basin, and other stakeholders are the important part of the basin management plan development. That process helps to collect insights on the issues regarding the water resources management and other related problems in the basin and then adjust and refine the program of measures accordingly.

INTRODUCTION

The EUWI+East project addresses existing challenges in both development and implementation of efficient management of water resources. It specifically supports the Eastern Partnership countries to move towards the approximation to EU acquis in the field of water management with a focus on transboundary river basin management as identified by the EU Water Framework Directive (WFD).

The overall objective of the project is to improve the management of water resources in the EaP countries. The specific objective is to achieve convergence of national policies and strategies with the EU Water Framework Directive, Integrated Water Resource Management (IWRM) and relevant Multilateral Environmental Agreements (MEAs).

The EUWI+East project is divided into three result areas as follows:

- Result 1: Legal and regulatory frameworks improved in line with the WFD, IWRM and MEAs;
- Result 2: River Basins Management Plans (RBMPs) designed and implemented in line with the WFD principles;
- Result 3: Lessons learnt regularly collected, shared and communicated to stakeholders.

River Basin Management Plans are recommended planning tools that give the overall orientations of water management in the basin and the objectives to be reached, the delay and the priorities in the actions to be developed. In Armenia, Sevan and Hrazdan River Basin Districts are selected as pilot areas for the implementation of the activity 2.3.2. “Technical Support in the elaboration and implementation of the pilot RBMPs” under result 2 of the EUWI+ project.

Draft River Basin Management Plan of Sevan RBD has been implemented in accordance with the EUWI+ project's technical task and requirements of the River Basin Management Plan's Model Guidance (EUWI+, 2018a; EUWI+, 2018b), as defined in Appendix 2, Decision 45-6 of 26 October 26, 2017 of Government of Armenia, taking into account the main characteristics of the Lake Sevan.

The main objective of the river basin management plan are:

- the protection of inland surface waters, transitional waters, coastal waters and groundwater;
- to improve the status of waterbodies (qualitative and quantitative);
- to prevent further deterioration of waterbodies;
- to promote sustainable water use; etc. (see WFD).

It also aims to support water resources management bodies, including the state authorized water resource management body of Sevan RBD, administrative bodies, policymakers and the public in decision making in the field of water resources.

1. LEGAL AND INSTITUTIONAL FRAMEWORK ANALYSIS

This chapter includes legislative acts and agreements which regulate and contribute to efficient water resources management and for this must be considered for RBM Planning. The responsibilities and role in river basin management of the competent authorities in the water sector, as well as donor-funded projects related to water resources management in Armenia are reviewed.

1.1 Analysis of Main Documents on Water Resources Management and their Linkage to Other Strategic Documents

The legislative framework currently existing in Armenia is formed since 1999-2000 through the World Bank supported "Integrated Water Resources Management" project. The "Integrated Water Resources Management Program" started in 2001 had been initiated by the Government of the Republic of Armenia as a targeted program for improving water sector performance in the country. Taking into consideration the recommendations of the Program, in 2001 the Government of the Republic of Armenia revised the legal and institutional framework in this field. The results and decisions were incorporated in Resolution No. 92 on "Concept for Water Sector Reforms in the Republic of Armenia", adopted by the Government in February 2001. The resolution clearly presented the strategy of legal and institutional reforms of the Armenian Government in the field of water resources.

Based on the above-mentioned Concept the new Water Code of Armenia was performed and adopted on June 4, 2002, which is considered as one of the most important steps in water sector reforms. The Water Code shows the way forward for efficient water resources management, in line with international best practice. It declares Armenian water resources as state property which use and disposal controlled through economic instruments, also stated that water use permissions to be issued and enforced on the basis of monitoring information, contained in a digital National Water Cadastre. It is important that the Water Code strengthened the basin-oriented principles of water resources management and public awareness and participation. The Water Code established a balanced approach to water resources management in Armenia with provisions for the proper regulatory, management, and operational divisions of responsibilities in the water sector. It also establishes need of a number of new Government agencies to carry out these varying responsibilities.

The Law of Republic of Armenia on "Fundamental Provisions of the National Water Policy" was adopted in 2005. This document defines the concept of long-term development for strategic use and protection of water resources and water systems.

In 2006, "Law on the National Water Program of the Republic of Armenia" was adopted. That document is aimed on development of measures for satisfying the needs of the population and economy, ensuring of ecological sustainability, formation and use of the strategic water reserve, and protection of the national water reserve.

In 2011, Government Resolution “On approving the outline of the model river basin management plan” was adopted. It outlines the model river basin management plan and development of technical characteristics for 6 river basin management plans. The Resolution was updated on October 26, 2017. This document is used as an outline for Draft Sevan RBD management plan development.

On November 24, 2017 the European Union and Armenia signed an agreement aimed at significantly deepening relations between of parties. Signatures to the document entitled the Comprehensive and Enhanced Partnership Agreement (CEPA) were put by High Representative of the European Union for Foreign Affairs and Security Policy Federica Mogherini and Armenia’s Foreign Minister Edward Nalbandian.

With new agreement Armenia had taken obligations to approximate its legislation to the EU acts and international instruments. In the field of water quality and resources management, this approximation will include 5 Directives: Water Framework Directive, Floods Directive, Urban Wastewater Directive, Drinking Water Directive and Nitrates Directive.

In order to ensure the proper application of the new Water Code of Armenia, since 2002 over 120 regulations and by-laws, which relate to the procedures of issuing water use permits, river basin management, transparency and public participation in decision-making process, information accessibility, establishment of the state water cadastre, formation of water resources monitoring, management of transboundary water resources, new surface water quality standards, outline of the model river basin management plan and others were adopted in Armenia.

Lake Sevan is a national treasure and is the subject of special protection: due to that, the number of specific laws and governmental by-laws had been adopted for the regulation of its issues.

This Law of the Republic of Armenia (RA) on Lake Sevan was adopted by RA National Assesmbly on July 4. 2001. The law establishes legal and program framework of the state policy for restoration, reproduction, protection and use of natural resources of Lake Sevan as of an ecosystem that has a strategic significance and economic, social, scientific, historical-cultural, esthetical, recreational, and spiritual value for the Republic of Armenia.

As the river basin management planning is a complex and cross-sectoral task, in this review not only water resources related legal acts are presented, but also regulations of other components of environmental systems discussed, such as climate, fauna, flora and others.

The list of reviewed documents presented in Annexes consists of legislative acts which are different by subject and scale of regulations and for this they grouped in the two classes as follows:

Documents related to the entire territory of Armenia (Annex 1);

Documents related to Lake Sevan (Annex 2).

1.2 Analysis of Institutional Framework

Governmental and non-governmental organizations in WRMP sector, their responsibilities and activities are presented in Annexes 3 and 4.

List of the Governmental organizations reviewed includes:

- Presidential Commission on Lake Sevan Issues;
- Department for Licenses, Permits and Compliances and Water Policy Department of the Ministry of Environment of Armenia;Ministry of Energy Infrastructures and Natural Resources (MEINR)
- Water Committee of the Ministry of Energy Infrastructures and Natural Resources (SCWS);
- Ministry of Economy of RA;
- Ministry of Health of RA;
- Gegharkunik Regional Administration (Marzpetaran);
- Experts Commission on Lake Sevan Conservation (Academy of Sciences of the Republic of Armenia);
- “Sevan” National Park State Non-commercial organization.

According to the Changes and Ammendments to the Law of Armenia on the Govenment Structure and Activities accepted on May 8, 2019, the Ministry of Nature Protection renamed to the Ministry of Environment; Water, Biosource and Waste and Atmospheric Management Agencies of Ministry - to the Department for Licenses, Permits and Compliances.

According to the Government Decision from January 30, 2020, the Envronmental Monitoring and Information Center SNCO, and Hydromet Service SNCO, and Forest Monitoring Center SNCO have been merged into the Hydrometeorology and Monitoring Center SNCO. In this RBMP, the old names of the agencies and centers were used as data sources in case if the data was obtained or produces before the mentioned changes.

1.3 Donor-Funded Projects Related to Water Resources Management

Number of donor-funded projects on water resources management has been implemented in Armenia in last two decades. The most significant of them are presented below.

1. Model Guidelines for River Basin Management Planning in Armenia, 2008

These guidelines has been prepared by the USAID/PA Program for Institutional and Regulatory Strengthening of Water Management in Armenia and its subcontractor consortium of "Geocom Ltd." and "Kapan Communities' Union" NGO in collaboration with water sector stakeholders in Meghriget River basin. The purpose of the prepared Model Guidelines for River Basin Management Planning in Armenia is to provide water management authorities with practical, user-friendly tools for development of river basin management plans in Armenia. Meghriget River Basin was selected as a pilot basin of the project.

The guidelines are based on the concepts of integrated water resources management and adaptive management, and on the approach of the EU WFD. These concepts reflect the intent of Armenia's Water Code adopted in 2002.

The guidelines proceed logically through a ten-step process of river basin planning. The process includes six data collection and analytical steps resulting in a river basin management conceptual plan. The final four steps explain in general terms the administrative process recommended for transforming that conceptual plan into a "projects plan" – a set of targeted projects which are approved, financed and implemented in the river basin.

2. Transboundary River Management for the Kura River – Phase II, 2008-2011[1]

This EU-funded project with budget 5,2 million EUR was aimed to improve the water quality in the Kura River basin through trans-boundary cooperation and implementation of the integrated water resources management approach. The project supported the development of a common monitoring and information management system to improve transboundary cooperation and enhanced the capacities of environmental authorities and monitoring establishments engaged in long-term integrated water resources management in the Kura River basin.

Following activities were implemented in the scope of the project:

- Held training and workshops in monitoring and river basin management.
- Organized study tour to Europe on the implementation of Water Framework Directive.
- Carried out quarterly monitoring missions with laboratories from all three Caucasus countries.
- Prepared a baseline report and river basin management plans for selected sub-basins (for Aghstev and Debed River Basins in Armenia)
- Translated major EU directives and guidelines.
- Prepared communication and public participation tools.

3. Reducing Transboundary Degradation in the Kura-Ara(k)s River Basin, 2011-2014[2]

[1] https://www.euneighbours.eu/en/east/eu-in-action/projects/transboundary-river-management-kura-river-phase-ii

UNDP/GEF-funded Project for Reducing Degradation in the Kura-Ara(k)s River Basin addressed transboundary water resource and environmental issues towards the sustainable management of the basin, as identified in priority sequence through the completion of the Transboundary Diagnostic Analysis (TDA) process, and addressed in an agreed Strategic Action Program (SAP) of policy, legal and institutional reforms, and priority investments. GEF funding was used for finalization of the comprehensive TDA and SAP, and the implementation of targeted water quality demonstrations identified as priorities in the preliminary TDA/SAP. The SAP development was closely linked to national IWRM plans. A phased approach is planned that progressively builds the knowledge base and strengthens technical, managerial and decision-making capabilities at the national and regional scales so as to address environmental concerns and transboundary developments (in all relevant sectors). The Project also supported to build political will to undertake threat abatement activities and leverages finances proportionate to management and governance needs. In scope of the project, draft river basin management plan for Arpa River in Armenia was developed.

4. Clean Energy and Water, 2011-2014[3]

ME&A (Mendez England and Associates) was implemented the USAID funded Clean Energy and Water Program (CEWP) in Armenia. This $5.6 million program provided support to the Government of the Republic of Armenia in its efforts to enhance Armenia's energy and water security and improve climate resilience through improving integrated energy and water resources planning. The CEWP worked at the community-level to improve energy and water management practices through capacity building and the implementation of small-scale pilot demonstration projects to demonstrate to public and private sectors, and to communities the benefits of applying new approaches and innovative technologies.

The CEWP has introduced technical tools and mechanisms for improving integration management of the country's water resources and developed a **Decision Support System (DSS)**, to provide analytical information for river basin management planning and water use permitting. The DSS, a customized **geographic information system (GIS)-based application**, is capable of generating sophisticated hydrological, economic, and climate change models for threatened rivers and water basins throughout Armenia. Pilot **basin management plans** for 3 rivers within Southern RBD of Armenia were developed in scope of this project.

5. Draft Basin Management Plan for Akhuryan River Basin District (Akhuryan and Metsamor River Basins), 2011-2015[4]

This EU-funded project was implemented in the framework of "Environmental Protection of International River Basins" Project (Contract No. 2011/279-666) by the consortium led by Hulla & Co. Human Dynamics KG. The Draft Basin Management Plan for the Akhuryan River Basin District (RBD) was developed according to methodology of the EU WFD. The aim of the draft plan is to improve the common understanding of the authorities responsible for water management, the administration, the politicians of the Akhuryan RBD and the public in general an understanding of the advantages and disadvantages of the WFD methodology, as well as to increase technical capacities by means of development and implementation of RBMPs.

6. Feasibility of the Master Plan for Integrated Water Resources Management in the Six Water Basin Management Districts of Armenia, 2013[5]

Feasibility study for the water resources management in the 6 basin management area conducted by SHER Ingenieurs-Conseils for the WRMA (currently, Department for Licenses, Permits and Compliances).

2 http://kura-aras.iwlearn.org

3 http://sbaic.org/usaidarmenia-funded-clean-energy-and-water-program-implemented-by-mea/

4 http://blacksea-riverbasins.net/en/pilot-basins/akhuryan-basin-akhuryan-and-metsamor

5 http://www.sher.be/en/page/download-the-description-of-master-plan-for-integrated-water-resources-management-in-armenia.html

The general objective of the study is to assist in the development of more effective management and regulatory mechanisms in the field of water sector management.

The specifics objectives are:

- to verify how the Armenian water sector organization complies with the EU WFD;
- to analyze decentralization issues; and
- to propose a sustainable water sector management system.

7. Advanced Science & Partnerships for Integrated Resource Development (ASPIRED), 2015-2020[6]

ME&A (Mendez England & Associates) currently implements the Advanced Science & Partnerships for Integrated Resource Development (ASPIRED) Project for the USAID Mission in Armenia.

The purpose of the ASPIRED Project is to support sustainable water resource management and sustainable practices of water users in the Ararat Valley through the use of science, technology, innovation and partnership initiatives. The ultimate goal is to reduce the rate of groundwater extraction in the Ararat Valley to the sustainable levels.

8. The Shared Environmental Information System (ENPI-SEIS) Project, 2010-2015[7] and Implementation of the Shared Environmental Information System (SEIS) principles and practices in the ENP East region (ENI-SEIS II EAST) Project, 2016-2020[8]

The European Environment Agency (EEA) and Zoï Environment Network are engaged in implementation of a project for improving environmental monitoring and information sharing in the European Neighborhood Policy (ENP) countries and the Russian Federation. The aim is to gradually extend the Shared Environment Information System (SEIS) principles. The main outcomes of the ENPI-SEIS project will address the three SEIS components – cooperation, content and infrastructure – through enhanced networking with the national capacities on environmental information. Furthermore, that should promote open public access to information through compatible and freely available exchange tools.

The pilot project was initiated by the national authorities and supported by the European Environment Agency, aiming at establishing small scale SEIS for the Lake Sevan basin in Armenia. A background paper on Lake Sevan has been prepared to provide baseline information and data flows available for the basin, and to develop and implement small scale SEIS for Lake Sevan in Armenia. It describes existing environmental issues in the basin, as well as ongoing monitoring activities by various organizations and their products and access conditions.

On 1 February 2016, the European Environment Agency (EEA) embarked upon the second phase of the EU-funded European Neighborhood Instrument (ENI) Shared Environmental Information System (SEIS) II EAST project together with the six Eastern Partnership countries; Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine. The ENI SEIS II EAST runs from 2016-2020 and is financed by the European Commission's Directorate-General for Neighborhood and Enlargement Negotiations (DG NEAR) under the European Neighborhood Instrument (ENI).

The main objective of the project is to continue to implement the principles and practices of the Shared Environmental Information System (SEIS). The project builds on previous cooperative activities in the six Eastern Partnership countries, carried out under the ENPI SEIS project.

The expected results of the project are:

- Improved implementation of regional/international commitments related to environmental reporting in line with EU/EEA best practices;

[6] http://www.aspired.wadi-mea.com
[7] http://seis-sevan.am
[8] https://eni-seis.eionet.europa.eu/east/governance

- Improved capacities in the national administrations to manage and use environmental data, statistics and information to support decision-making in line with EU/EEA best practices; and
- Preparation of regular State of the Environment reports and indicator-based assessments in line with EU/EEA best practices.

9. Participatory Utilization and Resource Efficiency of Water in the Ararat Valley (PURE Water), 2017-2020[9]

The project is funded by USAID and implemented by Urban Foundation for Sustainable Development. Project supports the development of a policy and regulatory framework for improved access to water, facilitates participation and oversight of integrated water management practices in target communities, raises public awareness of water related issues, and fosters water-related behavioral change among water stakeholders in Ararat Valley.

10. EUWI Plus EAST Project[10]

The project helps Armenia, Azerbaijan, Belarus, Georgia, Moldova, and Ukraine bring their legislation closer to EU policy in the field of water management, with a main focus on the management of trans-boundary river basins. It supports the development and implementation of pilot river basin management plans, building on the improved policy framework and ensuring a strong participation of local stakeholders.

The main objective of the project is to improve the management of water resources, in particular transboundary rivers, developing tools to improve the quality of water in the long term, and its availability for all.

More specifically, the project aims to support partner countries in bringing their national policies and strategies into line with the EU Water Framework Directive and other multilateral environmental agreements.

Targeted results of the Project are:

Result 1: legal and regulatory framework improved in line with the WFD, Integrated Water Resources Management and Multilateral Environmental Agreements.

Result 2: River Basins Management Plans designed and implemented in line with the WFD principles.

Result 3: Lessons learnt are regularly collected, shared and communicated to stakeholders.

The model outline for river basin management plans was upgdraded with the support of the EUWI Plus EAST Project and adopted by the Resolution №45.6 of the Government of RA.

1.4 Conclusion

The analysis of legal acts, institutional framework and donor-funded projects shows that in last two decades serious efforts have been undertaken toward establishing of efficient water resources management planning framework in Armenia. RA Laws On Water Code, Law On Fundamental Provisions of the National Water Policy, On National Water Program contain the river basin-based principles of water resources management and highlight importance of public awareness and participation.

Government Resolution “On approving the outline of the model river basin management plan” presents the RBMP for RBDs of Armenia. RBMPs for several river basins and RBDs are already developed with support of international donors. Comprehensive and Enhanced Partnership Agreement (CEPA) signed between EU and Armenia in 2017 encouraging that water resources management sector in Armenia should get more support.

[9] http://urbanfoundation.am/archives/2201

[10] http://euwipluseast.eu/en/countries/armenia

Number of specific laws and governmental by-laws are adopted for the regulation of Lake Sevan and its watershed area issues due to strategic importance of this lake for Armenia (the most significant are Law of RA on Lake Sevan, Annual Programs of Measures for Restoration, Protection, Natural Development and Use of Lake Sevan Ecosystem).

All of the legal acts discussed above should be considered during the RBMP development for Lake Sevan RBD. The main issue identified in the process of legal framework analysis is that the legal acts in some cases do not refer to each other. Scope of regulation of various governmental organizations is not fully clear as well. These issues have to be discussed and taken into consideration by the Component 1 of the EUWI+East Project.

Thus, development of river basin management plan should be open, iterative procedure. Public discussions involving governmental, non-governmental organizations, representatives of donor-funded projects should be conducted to determine in time the possible deviations from the legal acts and contradictions between different documents.

2. INITIAL CHARACTERISATION OF THE RIVER BASIN DISTRICT

The characterisation of the river basin is aimed to investigate the current physical, geographical, demographic, hydrological, economic, social, biological and environmental conditions in the Sevan RBD to reveal the major water resource management issues.

For this research mainly existing data sources were used, and also if needed field survey and measurements and interviews with local government representatives (Gegharkunik Regional Administration, Sevan BMO, Rural Municipalities) were conducted for the complete physical, geographic, and socio-economic characteristics of Lake Sevan RBD .

The Basin of Lake Sevan is the area from where surface and groundwater flows to the main Lake. According to the “Law about the Lake Sevan” of RA, Kechut and Spandaryan Reservoirs, as well as the catchment basins of Arpa and Vorotan Rivers are also considered as the part of Lake Sevan watershed area as the water reaches Lake Sevan through the Arpa-Sevan tunnel (Map 1). Though these territories are not considered as a part of Sevan RBD, however water transfers will be considered as inputs or outputs during the calculation of the water balance.

2.1 The Natural Conditions of Sevan RBD

2.1.1 Location and Geographic Overview

Sevan RBD is situated in the Eastern part of Armenia. The basin of the Lake Sevan covers 1/6th of the total territory of Armenia (Map 2). The surface area of Sevan RBD is 4721 sq. km. Sevan RBD surrounded by Geghama Mountains (from West), Vardenis Mountains (from South), Areguni Mountains (North-East) and Sevan and East Sevan (East) mountain ranges with elevations up to 3598 m (Vardenis). Sevan RBD spreads from 39°52' to 40°41' of Northern latitude and from 44°45' to 45°59' of Eastern longitude. The maximum stretch from South to North is 90 km, from East to West – 103 km. One of the peculiarities of Sevan RBD is the small ratio between the catchment area and the surface area of the Lake (3:1) compared to other major lakes (10:1 in average) (Babayan et. al., 2006).

Sevan is a high-mountain lake located on the altitude of 1900.65 m above the sea level. Lake Sevan is in the fifth place among the major high-mountainous lakes in the world in terms of altitude and surface area, (after the lakes Titicaca (Bolivia, Peru), Poopo (Bolivia), Namtso (China) and Qinghai (China)).

Noratus and Artanish capes and Shorzha underwater shaft-threshold are dividing the Lake Sevan into two parts: Major Sevan (910 sq..km) and Minor Sevan (345 sq. km).

2.1.2 Climate Characteristics

The climate in the basin of Lake Sevan is moderately continental. Its formation is influenced by the intensity of solar radiation, atmospheric circulation, the absolute altitude and topography. The high-mountainous location of the Lake Sevan makes the basin cooler than other areas in Armenia.

The basin is distinguished by considerable sunshine. There are only 20-25 cloudy days in a year. The number of sunny hours in Martuni reaches 2779, which makes Martuni the sunniest territory of Armenia. The sunniest months here are July and August.

The total value of solar radiation in the lake basin is 165-170 kcal/cm^2 per year, reaching its maximum in June or July (19-20 kcal/cm^2). Part of the solar radiation is reflected by the surface of water and land, but in general the radiation balance in the basin is positive and amounts to 62 kcal/cm^2 in Sevan) - 60 kcal/cm^2 (Martuni station).

The average annual rainfall in the Lake Basin is about 595 mm, with the largest amount falling on the Eastern slope of the Geghama Massif (over 900 mm), and the smallest - over the mirror of the Lake (less than 400 mm).

The average temperature in January in the lake zone is -10°C, in the watersheds – -12°C, in July, respectively, 16)°C and 8)°C. Annual precipitation is 450 mm on the lake, 850 mm in the highlands. In winter, a stable snow cover is formed. The Lake Sevan is famous with bristle winds (especially in the summertime). The seasonal climate change is quite significant in the basin of the lake.

Winter here is moderately cold and lasts from December to March. The average monthly air temperature ranges from 1°C to -12°C, but it can drop from -27°C to -32°C in cold snaps. Precipitation falls mainly in the form of snow. Before the decrease of the water level in the winter months, no continuous ice cover is formed on the lake. It was partially covered by ice, with the most stable ice cover recorded in the bays.

Spring in the lake basin is cool, with frosts mainly in April and May. The average monthly air temperature at this time is 0°C to 11°C, the maximum temperature is 24°C, the minimum temperature is 15°C to 21°C. Precipitation falls in the form of rain, in the mountains - in the form of snow (for a month there are 8-15 days with precipitation). In May, thunderstorms with hail are frequent.

Summer (June - September) is usually characterized by clear sunny, but cool weather. In the mountains at night there may be frosty. The average monthly air temperature is 10°C to 16°C, the maximum temperature is 30°C to 32°C, the minimum -2°C to -9°C. Precipitation falls in the form of rain (there are 3-10 days with precipitation in month). In the highlands until 17-20 days for a season there are fogs. In summer, thunderstorms are frequent - up to 42 days per season.

Autumn (October - November) is warm, in the highlands it is cold. The average monthly air temperature is 2°C to 8°C, the maximum temperature is 20°C to 24 °C, and the minimum temperature is -21°C to -27° C. Precipitation falls in the form of rain and snow. The snow cover appears at the end of October. In the highlands are frequent fogs (up to 25 days per season). At this time, the winds blow from the western directions and reach a speed of 1 to 5 m/s (sometimes more than 15 m/s) (Baghdasaryan, 1971).

The following types of climate are characteristic of the Lake Sevan basin (Map 3):

1. Moderate climate, with relatively dry warm summers and cold winters - It is typical for volcanic slopes and mountain slopes up to 2200 m altitude. Cold weather is dominant; snow cover (15 to 40 cm) lasts for about 4 months. The average air temperature in January is 6 to 8°C, the minimum goes down to -35 °C. The wind speed reaches (3 to 6) m/sec. Usually there are snowfalls and fogs. In May - June there are thunderstorms (average 10 to 15 days), the number of precipitation fluctuates between 100 to 150 mm and the number of hail days ranges from 4 to 6. In the second half of June, the temperature rises above 15 °C.

2. Moderate, with short cool summers and cold winters - Formed at altitudes of 2000 to 3000 meters. Winter is cold and lasts for 4-5 months; the average January temperature fluctuates from -10 °C to -13 °C. The snow cover reaches 50-70 cm. Spring begins in early April, when the average air temperature rises from 0°. Summer is short, cool in many places. The average daily air temperature does not exceed 15°C, in August, the average air temperature is 13-15 °C. The autumn is cold and short. Annual precipitation is 500 to 600 mm.

3. Cold, high mountain climate - Formed in the area up to 3000 m and is characterized by great intensity of solar energy. The maximum intensity of direct sun radiation reaches 1.67 kcal / cm2 per minute. The duration of the sunshine is also great, especially in the winter when the average and low zones are covered by clouds.

Winter is cold, lasting about 6 months. In some forms of relief at the altitudes of 3800 to 4000 meters, the snow cover remains the whole year. The average snowfall is over 2 meters, and the snow cover lasts for 270 days. The average temperature in winter months does not rise from -10 °C, and, at least, decreases to -41 °C.

Spring is cold and wet. The average monthly temperature in the shortest month does not rise from 10 °C. In August, the average air temperature is below 12 °C and rises at most 20 °C. In summer, the number of monthly precipitation is about 50 mm, and there are plenty of thunderstorms. Autumn is short, cold and wet. The precipitation is mostly in the form of snow. The frost duration is 50 to 60 days. The annual precipitation fluctuates between 800 and 950 mm. The wind speeds are high all year round. The maximum is observed in winter and reaches 5 to 7 m /sec.

Tables with the average monthly and annual values of precipitation, temperature, relative humidity, snow cover formation and loss dates are presented in the Annex 6.

2.1.3 Description of Topography, Geology and Hydrogeology

2.1.3.1 Topography

Lake Sevan is located in the Eastern part of Armenia and is surrounded by mountain structures on all sides: in the North-East - by Areguni and Sevan folded-block ridges, in the East - by the East Sevan Ridge, in the West and South - by Gegham and Vardenis volcanic arrays.

The range of Areguni with a length of 60 km extends southeast from the Sevan Pass to the Drakhtik River Valley consists of three blocks. The maximum height of the ridge is 2673.2 m. Its southwestern slopes are short and steep and dissected by numerous river valleys and there are widely spread steep rocky slopes

The Sevan range (length 55 km) is the highest of the ridges of Northern Armenia. It has an anticlinal structure which extends from the valley of the Drachtik River to the Hinal dome - the highest peak of the ridge (3367m).

In the Eastern part of the Lake Sevan basin is bounded by the Sevan meridional Ridge (length 42 km). The maximum height of the ridge is 3426 m (Tsarasar). There are traces of glaciation in the summit belt of the ridge.

In the West, the Sevan depression is fringed by the Geghama volcanic massif, which is an elongated convex shield extended in the meridian direction. Its highest point is 3597m (Azhdahak), length 68km, width 48km. The slopes facing Sevan, gently sloping with a wavy relief, are dissected by numerous river valleys, and in the sectional part also by ancient glacial valleys.

From the South, the Sevan depression is bounded by the Vardenis volcanic massif, which is an oval-shaped latitudinal strike structure with a cross-shaped transverse profile. The tops of the massif rise to heights of 3000-3500m (Vardenis - 3521m) and bear the traces of ancient glaciation. The northern slopes of the Vardenis massif descend gently to the lake basin, are of considerable length and are dissected by river valleys (Boynagryan, 2006).

The Lake Sevan basin is interpreted as the Neogene-Anthropogenic depression. However, the origin of the lake is also associated with overlapping of an ancient Hrazdan river bed with lavas of Geghama volcanic massifTraces of this old riverbed can also be seen at the bottom of Major Sevan. And so, Sevan belongs to the lakes of mixed origin (Maps 4, 5, 6).

2.1.3.2 Geological structure of the basin

In the geological structure of the Lake Sevan basin, different rocks are involved, ranging from the Upper Cretaceous to modern sediments (Geological map of Lake Sevan Basin, 2003; Geological Map of RA, 2005).

Below is given the characterization of the geological structure of the lake basin according to the maps mentioned above.

The southwestern slope of Areguni Ridge, steeply descending to the lake's surface, is composed mainly of Cretacous -Eocene volcanic-terrigenous flyshe with a total thickness of up to 1500 m and only partially - volcanogenic flyshe of the same age with a thickness of 500 m.

Sevan range differs from Areguni in composition age of rocks. Here, on its southwestern slopes, marine sedimentary rocks of the Upper Cretaceous, interrupted by intrusions of the Upper Cretaceous and Eocene age, occur in places. The sedimentary rocks of the Sevan range are limestones, marls, sandstones, siltstones, conglomerates, andesite-basalt covers, basalts, andesite basalts and their tuffs.

The southern slope of the Sevan range is distinguished by significant outcrops of the volcanogenic stratum, which encloses the gabbro-hyperbasites. In the western part of the ridge, the fine outcrops of stratified rocks of the ophiolite association are known near the Artanish Peninsula. To the east of the basin of Daranak River is exposed to the "main field" of the siliceous-effusive formation on the southern (south-western) slope of the Sevan Ridge reaching 900-1100 m (Satyan, 1984).

The western slopes of the Eastern Sevan Ridge in the northern part are composed of Lower Pliocene andesitic basalts, andesites, andesitic dacites, rhyodacites, as well as rhyolites, obsidians, perlites and their pyroclasts. In the southern part, Middle Eocene volcanogenic-sedimentary rocks (andesite-basalts, trachyandesites, trachydacites, tuff sandstones, interlayers of limestones) appear.

In the west, the lake is bounded by the eastern slopes of the Geghama volcanic massif, composed mainly of Quaternary lavas the northern slopes of the Vardenis volcanic massif, which descend gently to the lake basin, are composed of Lower Pliocene volcanogenic formations, and Lower Quaternary lava of andesitic basalts, andesites, andesic dacites, dacites.

At the foot of the ranges Areguni and especially Sevan, there are large cones carrying out proluvial material. The thickness of the proluvium in these cones reaches 25-85 m, and in individual cases - 216-250 m (Map 7).

2.1.3.3 Hydrogeology

In the South-East, Southern and Western coastal zones and slopes of Sevan RBD water-bearing Quaternary lacustrine-river formations (Q1-4) and water-bearing complex of Pliocene-Quaternary volcanic rocks (N23 – Q) are widely spread. On the Northern and North-East slopes complexes of low water-bearing volcanic sedimental (₽22) and intrusive (K1- ₽2) rocks are common. Here water-bearing complex of Upper Cretaceous sedimentary, mainly carbonate rocks are spread within very small areas.

Main part of groundwater resources is formed in the complex of volcanic rocks, and the accumulation and discharge is in the complex of volcanic rocks and lacustrine-river formations. Therefore, groundwater bodies with great discharge are identified in local water-bearing complex of Pliocene-Quaternary volcanic rocks and in the water-bearing complex Quaternary lacustrine-river formations (Map 18, 19).

2.1.4 Description of Hydrography

2.1.4.1 Lake Sevan

Lake Sevan is the largest lake in the South Caucasus, and at the same time one of the largest mountainous freshwater lakes in the world. The basin of Lake Sevan makes up one sixth of the total territory of Armenia (16%). Surface area of Sevan RBD is 4721 km^2, the area of lake itself is 1279 km^2 (according to the Hydromet data for 2017). The surface area of the lake before its artificial decrease was F=1416 km^2. Length of the lake through larger axis of Dzkanget River mouth (northwest) to Tsovak village (southwest) is 74 km, whereas the average width is 19.2 km and the largest width across the axes is 32 km. The average depth is 46.8 m, the maximum depth is 83 m, the volume of water is 38,3 km^3 (according to the Hydromet data for 2017).

Origin of the lake

There is a number of assumptions concerning to the origin of the lake of Sevan:

- Sevan is a dam lake. Supporters of this hypothesis was P. Rohrbach (1902), E. Markov (1911), K. Paffenholz (1950). According to these authors, earlier on the territory of Sevan was a river valley, the water of which flowed into the river Araks. Then the streams of lavas dammed the valley, the flow of water stopped and started again when the dammed valley was filled with water and the latter began to pour through the reservoir.
- V. Trifonov and A. Karakhanyan (2004) believe that the flooding of the Sevan basin by water is most likely due to the growth of the young tectonic uplift at the source of the river Hrazdan, and not with the lava flow of the volcano Metx Lchasar, as many geologists have supposed.
- Sevan is a relict formation, the remnant of an ancient lagoon of the Upper Tertiary age. Supporters of this hypothesis are E. Dyakonova-Savelyeva and G. Afanasyev (1933), A. Aslanian (1947). According to Aslanyan, after the regression of the Upper Pliocene Sea, relict reservoirs were preserved. The basin of Sevan was formed in connection with the formation of the Gegham anticlinorium. During the uplifts, this basin diminished and became smaller in size than the modern Major Sevan. Minor Sevan at this time was a continent with a river valley, which was then filled with lavas of the volcano Metz Lchasar. Minor Sevan was formed, which later merged with the Major Sevan. Hypothesis of the relict origin of the lake does not meet the support of specialists.
- E. Milanovsky (1953) believes that the Sevan basin was formed at the end of the Miocene and in its development passed two stages: the stage of geosynclinal deflection of the Sevan-Kurdistan zone (finished in the Paleogene) and the stage of embedment of depression existing now (Boynagryan, 2007).

Lake Level Fluctuations in 19th and early 20th Centuries

Fluctuations in the level of the Lake Sevan in historical times and during the 19th and 20th centuries drew attention to its early explorers, who linked the phenomenon with different reasons - from the underground connection of Sevan with the Van and Urmia Lakes to filling of the part of the lake with river sediments and the influence of tectonic processes (Sarkisyan, 1962). However, most researchers are still tend to accept climate change as the main cause of level fluctuations. A. Gabrielyan (1944) gave a great importance to the tectonic movements, although he also recognized the role of climate.
According to B. Bek-Marmarchev (1951), the level of Lake Sevan for the period from 1810 to 1950 repeatedly changed and the maximum value of the changes was approximately 3 m. Seasonal level changes were 20-90cm (Manukyan, 1996; Boynagryan, 2007).

Artificial Changes in Lake Sevan Level in the 20th Century

In the 1920s, as a result of the multilateral expedition surveys of the USSR Academy of Sciences, a technical plan for the use of the lake was developed, known as “Sevan-Hrazdan” water-economic complex. It was planned to implement it in 2 phases. In the first phase (would last 50 years), the artificial reduction of the lake level would have been completed (1200 mln. m^3 per annum). The lake level would decrease by 50 meters, and the surface of the water mirror would be reduced to seven times (Major Sevan would dry completely). In the second phase, the use of long-term water resources would be stopped and the new, stable water balance of the lake would be set to 700 mln. m^3 annually. These were aimed to reduce evaporation through reduction of the surface area of the lake.

“Sevan-Hrazdan” water-economic complex includes the network of 80,000 ha of irrigated lands in Ararat valley, and hydro-energetic complex of a cascade of 6 hydropower plants with overall capacity of 55 MW. In the natural conditions, the annual flow of Hrazdan River was 50 mln. m^3. After the launch of Sevan HPP in 1948, the flow of the river was regulated and the river actually became an artificial canal. Groundwater outflow from Sevan before the level decrease was 85 mln. m^3 (Hydrography of Armenian SSR, 1981).

Decrease of the level of Lake Sevan started in 1933 and continued until 1981. Decrease of Lake Sevan’s water level at the end of 1980 was about 18.5 m.

In parallel with the artificial reduction of the lake's level, the ecological state of the lake getting worse faster than it was supposed to be. The lake has been deprived of more than 40% of the water reserves within the next 10 years; the maximum depth was not exceeding 80 m. The negative effects of the decrease of the water level were evident especially in the Major Sevan. In the 1970s, it was decided to stop the water discharge and gradually raise the level in order to save the lake.

Further decrease of the lake stopped in order to restore the ecological equilibrium of the lake, which was violated largely due to artificial decrease of the level of the lake, as well as to store the strategic water reserve in the lake. The plan was to increase the level of the lake by 6 m. In order to ensure the optimal level of the lake, Arpa-Sevan tunnel (48,3 km, 1963-81) was constructed, which was supposed to annual transfer about 250 mln. m^3 of water from Arpa River (its tributary Yeghegis) to Lake Sevan. The tunnel was put into exploitation in 1981. Also construction of Vorotan-Arpa tunnel (21,6 km) has been completed in 2004, which transfers annually 165 mln. m^3 of water from Vorotan River to Lake Sevan.

From 1981-2001, the level of the lake was increased (after exploitation of Arpa-Sevan tunnel) by 0.9 m (1981-1990), and then again decreased (due to excessive use of waters of the lake) by 1.68 m (1991-2001), reaching its minimum level 1896.32 m. Since then the level of the lake has been increasing (SHER, 2013).

With the exploitation of the Vorotan-Arpa-Sevan tunnel system, not only the stabilization of Lake Sevan level but also gradual increase has been ensured. On March 25, 2010 the tunnel was named "Arpa-Sevan" tunnel named after Yakov Zarobyan.

Lake Sevan also has seasonal fluctuations of level. The highest level of the year is observed in July, the lowest is in March. The seasonal variations are about 20-30 cm and depend on the hydro-meteorological conditions of the lake.

The highest temperature on the lake surface is observed in July-August, with a maximum of 24°C. The temperature is high in the coastal areas, moreover, is higher in the the eastern parts. Usually the temperature is higher in the Major Sevan than in Minor Sevan. The reason is that the warm waters from the northern parts move to the south by the wind.

The water temperature on the lake surface does not have large fluctuations during the day: it is between 1.5°C and 2°C, rarely 3-4°C. It is worth mentioning that the "dome" of cold water in the summer months is formed in the Major Sevan, in the center of which the temperature is lower by 5-6°C.

The water temperature in Sevan varies by depth. Temperature in the bottom layer is 4-5°C during the year, and seasonal changes are not noticeable.

The convection phenomenon is quite obvious at the depth of 20-25 m. Temperature is increasing from the bottom to the surface during summer months. In January, reverse stratification is established, t temperature is increasing by 0,5-1°C from the surface to the bottom.

Under the previous level conditions of the lake, temperatures were lower in the near-bottom parts of the lake. After the level decrease, fluctuations increased. There is a temperature rise on the bottom of the Major Sevan: the sunrays reach the bottom and contribute to the growth of algae. Lake Sevan was oligotrophic lake before the lake level drop. Now the lake is in the process of eutrophication (Hydrography of Armenian SSR, 1981).

An important phenomenon in the hydrological processes of the lake is the glaciation. Prior to level decrease, the surface of the lake only in few years has been covered by ice. In the period from 1890 to 1960 the lake has been frozen for only 9 times, and now, when the lake level dropped about 18 meters, it is getting frozen almost every year.

In past, the frost of Sevan used to start in the middle of January or February, and now it is about 15-17 days earlier. The ice melt begins at the end of March or early April. The ice thickness varies between 20 and 40 cm.

Sevan is one of the most transparent lakes in the world. Prior to the level decrease the maximum transparency reached 21 m, now it has dropped to 11-15 m. The highest transparency is observed in August-September, the lowest is in February-April. Transparency is high in the eastern part of Minor Sevan where the wind is weak and the depth is great.

The Law of RA “On Annual Program of Measures for Restoration, Protection, Natural Development and Use of Lake Sevan Ecosystem” envisages a maximum annual amount of water outlets from Lake Sevan to 170 million cubic meters. In paragraph 6.1 of the program established in the same law outlets exceeding a maximum annual amount of water outlets should be done "according to the relevant decisions of the Government of Armenia on the basis of two-week forecasting proposals submitted by the authorized water management body".

2.1.4.2 Rivers

There are 993 rivers and streams in Lake Sevan RBD with total length of 2687 km. 56 of these rivers have a length of 10-25 km, 6 – 25-50 km and 1 – more than 50 km (Table 1) (Mnatsakanyan, 2006).

Table 1: Overall Statistics of River Network within Sevan RBD

Rivers by Size	<10 km	10 – 25 km	25 – 50 km	50 –100 km	Entire River Network	Watershed Area of Rivers	Density Coefficient of River Network
Quantity	930	56	6	1	993	3500 km2	0.77 km/km2
Length, km	1585	866	185	51	2687		

28 rivers (including the large springs in form of the rivers) flow into the Sevan, and only Hrazdan River originates from the lake. In general, most of the rivers of Lake Sevan Basin are small, their length are less than 10 km, only 6 rivers have a length over 26 km and only Argichi river is more than 50 km in length (Table 2).

Table 2: Main Characteristics of Several Rivers of Sevan RBD (Resources of Surface Waters of USSR, 1973, v. 9; Chilingaryan and others, 2002, GIS Datasets of Geocom Ltd.)

River Name	Length, km	Watershed Area, km^2	Altitude at Source, m	Altitude at Mouth, m	Average incline, ‰
Argichi	56	367,2	2520	1900,6	11,1
Artanish	8	16,7	2612	1900,6	88,9

Bakhtak	31	152,1	3220	1900,6	42,6
Daranak	8	23,3	2850	1900,6	118,7
Areguni	9	11,7	2820	1900,6	102,2
Jil	10	17,5	2780	1900,6	87,9
Artsvanist	20	82,7	3260	1900,6	68,0
Astghadzor	21	48	3220	1900,6	62,8
Vardenis	30	110	3160	1900,6	42,0
Gavaraget	50	480	3130	1900,6	24,6
Dzknaget	22	86,3	2310	1900,6	18,6
Zolakar	14	31,5	2840	1900,6	67,1
Karchaghbyur	24	109,6	2905	1900,6	41,9
Lichk	8	36,9	2006	1900,6	13,2
Martuni	28	96,5	3070	1900,6	41,8
Masrik	51	675	2880	1900,6	19,2
Pambak	10	23,2	2762	1900,6	86,1
Drakhtik	11	39,5	2670	1900,6	69,9
Tsakkar	23	67,2	3180	1900,6	55,6
Geghamasar	12	21,6	3030	1900,6	94,1
Yeranos	4	7,9	1960	1900,6	14,9
Selavagetak	15	19	2650	1900,6	50,0
Pokr Masrik	15	69	2800	1900,6	60,0
Sarinar	11	14,2	3094	1900,6	108,5
Shishkert	9	18,6	2600	1900,6	77,7
Tsapatagh	8	17,3	2670	1900,6	96,2
Dali	5	7,4	2422	1900,6	104,3
Spitakajur	12	23,9	2405	1900,6	42,0

5 rivers originate from Geghama Massif, from which Gavaraget flows into Minor Sevan, and the rest 4 – Yeranos, Bakhtak, Tsakkar and Lichk flow into Major Sevan. Total flow of the rivers of Geghama Massif is the 27,7 % of the total runoff of all rivers flowing into Lake Sevan.

9 rivers originate from Vardenis Massif – Argichi, Martuni, Astghadzor, Zolakar, Selavagetak, Vardenis, Artsvanist, Karchaghbyur and Masrik which flow into Major Sevan. Total flow of the rivers of Vardenis Massif is the 61,9 % of the total runoff of all rivers flowing into Lake Sevan.

12 rivers originate from Sevan Massif – Pokr Masrik, Gehgamasar, Sarinar, Areguni, Daranak, Pambak, Shishkert, Tsapatagh, Jil, Dali, Noruz and Artanish which flow into Major Sevan. Total flow of the rivers of Sevan Massif is the 4,6 % of the total runoff of all rivers flowing into Lake Sevan.

2 small rivers originate from Areguni mountain range – Spitakajur and Drakhtik, and only 1 from Pambak mountain range – Dzknaget. Total flow of the rivers of Areguni-Pambak Massif is the 5,8 % of the total runoff of all rivers flowing into Lake Sevan (Map 8).

Annual average river flow into the lake is 26,8 m^3/s (without Arpa-Sevan tunnel).

In general, coefficient of river network density within the Sevan RBD is less than 1, but the southern high-mountain part is characterized with significant topography dissection (to 1,5-2,0 km/km^2). Feeding of rivers is mixed, mainly from snow and rain, but there are some specifics.

The only **river which originates** from Lake Sevan is Hrazdan River, which flows to transboundary Araks River. Hrazdan is the longest river (141 km) which completely flows within the territory of Armenia. .

2.1.5 Description of Ecosystems (Soils, Landscape Types, Flora and Fauna, Land Cover)

2.1.5.1 Soils

Numerous types, subtypes and varieties of mountain soils with a high-altitude distribution are found on the territory of the Lake Sevan Basin.

The lower degree of the altitude ladder is occupied by the soils of the coastal zone of Lake Sevan. These soils are actually newly formed, associated with the lowering of the lake level. On the bare ground, soil-forming was stimulated. As soil-forming sedimentary (sand, pebbles) and volcanic rocks act.

The soil of Sevan ridges is brown carbonate with 30-50% stoniness. The natural soil of the remainder of the basin is chernozem (black soil) with pH 5.8-6.2. On the southwestern shore of Minor Sevan, stony deposits predominate, on the western and southern shore of Major Sevan stoniness is 10-30%, and less than 10% in other parts of the basin.

The lands of the basin belong to 3 soil zones:

1. Mountainous (2000 - 4000 m): mountain-meadow, meadow-steppe soils,

2. Forest (1900 - 2400 m): forest gray, cellar, forest brown soils,

3. Steppes (1900 - 2450 m): black-earth, meadow-grassy, wind-protective-grassland and Sevan-water-free soil plots (wet meadow sand, incomplete silt, asparagus desert) (Babayan et. al., 2006) (Map 9).

2.1.5.2 Natural zones

Sevan Basin is one of the richest natural regions in Armenia. There are 5 natural zones: such as Mountain steppes, Mountain forests, Mountain meadows, as well as Alpine and Sub-alpine meadows.

1. Mountain steppes are mainly situated in lower regions of the basin (1900-2200 m). Climate is semi-continental with warm summers and cold winters.

2. Mountain forests are not widespread. They are common only on the Pambak and Sevan ranges (2100-2300 m). The main species for this zone is oak.

3. Mountain meadows are spread on altitudes of 2300-2600 m. Climate here is cold mountain. This zone is mainly using for pastures.

4. Alpine and Sub Alpine meadows occupy high-mountain areas in the Sevan Basin above the 2500-2600 m (Baghdasaryan, 1971) (Table 3, Map 10)

Table 3: Natural Zones and Main Soil Types in the Sevan RBD

Altitude (m)	Natural Zones	Soil type
1900-2200	Mountain steppes	Typical and carbonated black soils
2100-2300	Mountain forests	Steppe-forest soils
2300-2600	Mountain meadows	Steppe-meadow soils
Above 2500-2600	Alpine and Sub Alpine meadows	Meadow soils

2.1.5.3 Flora

The flora of the basin is typical to the highlands of the Transcaucasus Region known with great diversity of plants. Along the shoreline of the lake the greatest artificial woodland of the country is situated, which offers various examples of natural and human affected ecological successions. Aquatic associations (plankton, benthos, ichthyofauna) are qualitatively poor with only a few dominant species, which has simplified studies on ecological relationships (food web, etc.).

About 1,600 species of vascular plants (50% of Armenia's flora) are growing in the lake basin. 48 species out of 1600 are in the Red Data Book of Armenia, 6 species are endemic: Acantholimon gabrieljanae, Alyssum hajastanum, Astragalus shushaensis, Isotis arnoldiana, Isotis sevangensis, and Ribes achurjani.

The dominant vegetation communities of the Sevan basin are mountain steppe, sub-alpine and alpine vegetation with different species of Astragalus and Acantholimon. The most characteristic arboreal plants of Sevana Mountains are junipers (Juniperus policarpos, J. oblonga). There are remains of natural oak forests in the central part of the Sevana Mountains. In the Vardenis and Geghama Mountains, sweetbrier (Rosa canina) and other species Rosa sp. are common everywhere.

After the water level decreased, the dried areas of the former lake bottom have been forested by alien species of plants. Artificial forests composed of pine (Pinus caucasica), poplar (Populus canadensis, Populus simoni), acacia (Caragana brevespina, Caragana trutex), and willow (Salix viminalis). In some area the sallow thorn (Hippopae ramnoides) forms almost impassable bush.

On Lake Sevan, emergent vegetation exists only in limited calm areas. Pondweeds (Potamogeton spp.) are abundant to depths of 2-5 m. Stonewort (Chara spp.) thickets cover the littoral zone to depths of 4-8 m. There is luxuriant development of aquatic vegetation in shallow coves, bogs and ponds (Babayan et. al., 2006) (Map 11).

2.1.5.4 Fauna

In the Lake Sevan basin there are six species of fishes (two species are in the Red Data Book of Armenia, another two are endemic). All native fish species, ishkhan (Salmo ischchan), Sevan barbel (Barbus goktschaikus), Sevan koghak (Varicorhinus capoeta sevangi) are in decline. The famous endemic ishkhan (Salmo ischchan) (means "prince" in Armenian) is now at the edge of extinction.

There are also four species of amphibians, luckily none of them considered as endangered. Amphibians are abundant everywhere that there are small ponds, pools and puddles. There are 18 species of reptiles, two of which are in the Red Data Book of Armenia. The herpetofauna is more abundant on the northeastern shore of the lake and only grass snakes (Natrix natrix and N. tesselata) are common everywhere.

Two-hundred ten species of birds (36 are in the Red Data Book of Armenia, one is endemic, and 83 are included in the Agreement on the Conservation of African-Eurasian Migratory Waterbirds of the Convention on the Conservation of Migratory Species of Wild Animals). The artificial water-level decrease influenced on the number of breeding waterfowl. From approximately 60 breeders formerly, only about 25 species are registered as breeding during recent years. The Eurasian coot (Fulica atra), mallard (Anas platyrhynchos) and endemic Armenian gull (Larus armenicus) are abundant currently.

The Lake Sevan serves as an important stop for migratory birds, especially in October-December months, before the lake becomes covered with ice. Such rare birds as great egret (Casmerodius albus), glossy ibis (Plegadis falcinellus), mute swan (Cygnus olor), whooper swan (C. cygnus), demoiselle crane (Grus vigro) fly here regularly during the migrations. Lake Sevan is important both as a resting and a wintering site for migratory waterfowl. Half a century ago, the area was known as a breeding area for waterfowl between the Black and the Caspian Seas. Because of the water-level decrease and draining of most of wetlands, Lake Sevan's role as breeding area is now much reduced.

There are 36 species of mammals, eight of which are in the Red Data Book of Armenia. The most typical mammals are European hare (Lepus europaenus), red fox (Vulpes vulpes), wolf (Canis lupus), weasel (Mates foina) and most of the rodents.

Investigations on invertebrates have so far included only aquatic fauna: 14 plankton and 136 benthic species of different systematic groups. Plankton and benthos associations showed a close dependence on the trophic status of the lake.

Since the 1990s, an export-oriented commercial fishery (including the European Union) has developed with the recently-acclimatized long-hand crayfish (Astacus leptodactylus) abroad (Babayan et. al., 2006).

2.1.5.5 Land Cover Types Distribution within Sevan RBD

Land cover has a crucial role in surface and groundwater flow formation within any river basin.

Land cover of Sevan RBD was analyzed using CORINE classification and spatial data from following sources:

- GlobeLand30 free global land cover datasets of 30m resolution (extracted from Landsat and Chinese HJ-1 satellite images), http://globeland30.org;
- Data obtained from Gegharkunik Regional Administration;
- Spatial datasets available at Geocom Ltd.

Data from above mentioned sources was combined and analyzed. Land cover was classified using the second Level of CORINE system[11] (Table 4, Figure 1, Map 12).

Table 4: Land Cover Types Distribution within Sevan RBD (based on the data of GlobeLand30; Gegharkunik Regional Admimistration, Geocom Ltd., 2010-2018)

Land Cover Type	Area, km^2	Percentage, %
Arable land	401.7	8.54
Pastures and grasslands	2241.9	47.68
Forests	395.9	8.42
Shrub	0.2	0.004
Spaces with little or no vegetation	6.2	0.13
Inland waters	1508.3	32.08
Inland wetlands	0.5	0.01
Urban fabric	141.8	3.02
Industrial, commercial and transport units	0.6	0.01
Mine, dump and construction sites	4.5	0.10

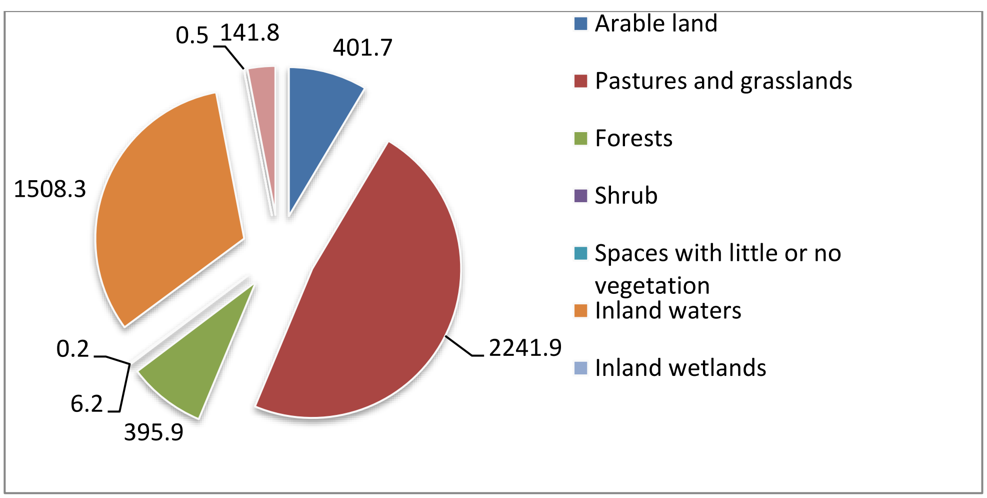


Figure 1: Land Cover Types Distribution within Sevan RBD (based on the data of GlobeLand30; Gegharkunik Regional Admimistration, Geocom Ltd., 2010-2018)

[11] https://land.copernicus.eu/user-corner/technical-library/corine-land-cover-nomenclature-guidelines/html/

2.1.6 Identification of Ecoregions and Typology of Water Bodies

Ecoregion is a recurring pattern of ecosystems associated with characteristic combinations of soil and landform that characterize that region, within which there is spatial coincidence in characteristics of geographical phenomena associated with differences in the quality, health, and integrity of ecosystems.

Southern Caucasus countries including Armenia are situated within 24th ecoregion (Caucasus) (Map 13).

The boundaries of the ecoregions are defined in the shape file (vector data, polygon): **wfd_shp_ecoregions.zip**, available at: http://www.eea.europa.eu/data-and-maps/data/ecoregions-for-rivers-and-lakes. It includes 25 European Ecoregions based on the ideas of Illies (1967) and adapted by the European Union to assess the ecological quality in European water bodies.

The water bodies were differentiated by surface water body types according to the descriptors defined in the system A of the WFD Annex II. Based on that, the typology for the "river" water bodies and "lake" water bodies in the Sevan RBD is presented in Tables 5 and 6 below.

Table 5: Typology Parameters for the "River" Water Bodies in the Sevan RBD

Descriptors	Types		
	I	II	III
Ecoregion	24 (Caucasus)		
Altitude	>800m		
Geology	Siliceous	Calcareous	Siliceous
Catchment size, km^2	<100		100-1000

Table 6: Typology Parameters for the "Lake" Water Bodies in the Sevan RBD

Descriptors	Types		
	I	II	III
Ecoregion	24 (Caucasus)		
Altitude	>800m		
Geology	Siliceous		
Area, km^2	0,5-1		>100
Depth, m	<3	3-15	>15

2.1.7 Definition of type-specific reference sites in the Sevan RBD

In line with the CIS Guidance document No.10 on Reference Conditions (EU WG 2.3 Refcond 2003) and based on the experiences from other countries, reference sites were selected using pre-defined criteria. In the development of reference conditions for rivers in Armenia, the following criteria were defined:

No habitat alteration (metric value = 1)
No impact from impoundment (metric value = 1)
No water abstraction (metric value = 1)
No alteration of riparian vegetation
No toxic impact

In addition, criteria for CORINE land cover were used, which is not possible for Armenia since such data are not available. However, since chemical data turned out to serve as useful indicators of pressure (point / diffuse sources of pollution; see below), these data can be added to the list of criteria:
Concentrations of selected parameters during the survey:

Chloride <10 mg/L
Ammonium NH_4-N <0.150 mg/L
Orthophosphate PO_4 <0.050 mg/L

Based on these criteria, the following **candidate reference sites** were selected in the Sevan RBD:

River	*Site*	*Type*	*Altitude*	*Comments*
Drakhtik	0.5 km above the Drakhtik village	I	2026	NH_4-N 0.100–*0.190* mg/L
Gavaraget	Above Tsaghkashen	I	2185	riparian vegetation: *2*
Masrik	upstream of Verin Shorja	II	2225	riparian vegetation: *2*

In all of Armenia sites at 8 type I rivers and 3 type II rivers were considered as potential reference sites. No reference sites are available from Armenia for river type III, but from a comparable river from Georgia (Khramesi). For Details refer to the EUWI+ document: “Definition of Reference Conditions and Class Boundaries in Rivers of Armenia for the BQE Benthic Invertebrates” (EUWI+, 2020b).

2.1.8 Description of Natural Hazards

The Sevan RBD is affected by various natural hazards – floods, debris flows, earthquakes, landslides, etc.

Floods mainly observed during spring high-water period, but in some years summer they may occur in summer caused by torrential rains. Especially often flash floods are noted on the rivers of the north-eastern shore of the lake but they do not present significant hazard. (Annex 7.1, Map 14).

Debris flows mainly occur on the eastern part of the basin – on rivers Hovsatsakhk, Artsatabek, Norakert, Drakhtik, Satanakhach, Tsapatagh, Pambak, Jil, Artunj, Kaputjur. Debris flows have a negative impact on infrastructure (roads), agriculture and ecology. The description of debris flows in last century is presented in Annex 7.2 and presented on the map (Map 15).

There are 175 landslide areas registered in Sevan RBD (Map 15).

Earthquake events in 20th century presented in the Annex 7.3 and Map 15.

2.2 Population and Demography Description

2.2.1 Data Sources

Demographic analysis are conducted based on the data obtained from the following sources:

- Armstat website: http://www.armstat.am;
- Community and Marz development programmes from Gegharkunik Regional Administration website: http://gegharkunik.mtad.am ;
- Data collected during field visits and requests to Gegharkunik Regional Administration.

2.2.2 Population Distribution within the Territory of Sevan RBD

The total population of the Sevan RBD is approximately 212,238 permanent residents (about 58,045 urban, and 154,193 rural) according to the data provided by Gegharkunik Regional Administration as of January 1, 2018. The urban residents live in 3 towns: administrative center of Gegharkunik Province Gavar (pop.: 29,146), Vardenis (pop.: 15,272) and Martuni (pop. 13,627). The most populous rural settlement is Nerkin Getashen with a population around 8,785, as well as Vardenik (with the population of 8,668), Sarukhan (population: 8,397). The rest of other rural villages have less than 7,000 permanent residents.

There are 3 enlarged communities: Geghamasar (pop. 7,133), which includes 18 small villages, Shoghakat (pop. 3,518), which includes 6 villages and Vardenis (pop. 15,950), which includes Vardenis town and 3 villages, according to the data requested by Gegharkunik Regional Administration. Population density in the Sevan basin is high, with an average of 62 persons/ km². Most densely populated settlement is Vardenis town with 406 person/km² result (Map 16).

Table of population distribution within Sevan RBD by the settlements and enlarged communities presented in the Annex 8.

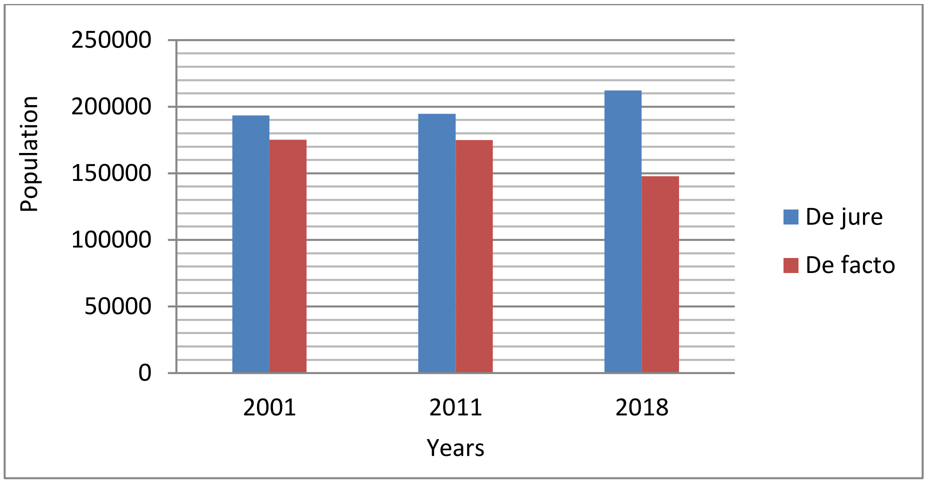


Figure 2: De Facto and De Jure Population of Sevan RBD, for 2001[12], 2011[13] and 2018[14] years

2.2.3 Demographic Analysis (Age, Gender and Social Parameters)

The population of Sevan RBD consists of approximately 51.5 % male and 48.5 % female residents. Age structure in the rural areas is not complete, because there is a lack of data for some communities.

In the age structure in rural areas residents of 18-63 years dominate (around 65%), then comes 7-17 years old group (about 14%), and the smallest percent (9 % and 12%) falls for respectively 0-6 and 63 ages. Many school-age children relocate to town for educational purposes. The age structure in urban areas 18-63 years old group also dominates (61.5 %), population older than 62 years is around 19.4% and a young people (less than 18) – 19.1%.

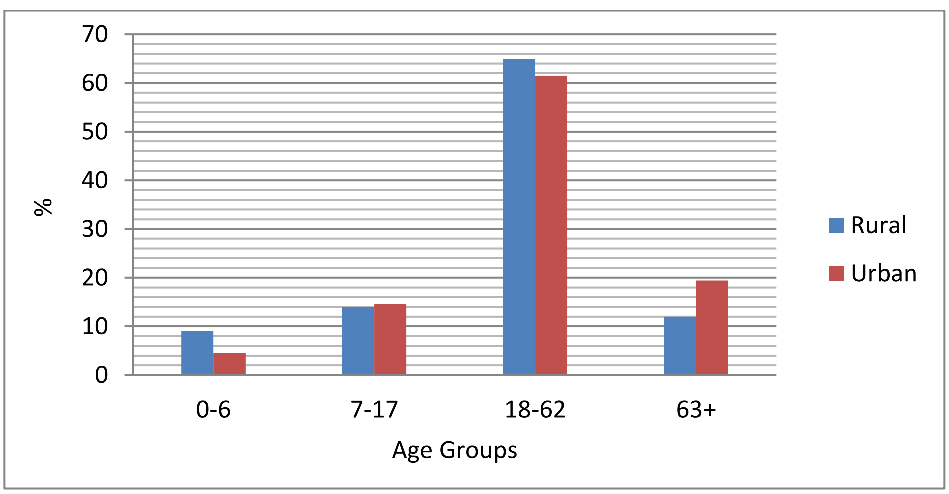


Figure 3: Urban and Rural Population Comparison by Age[15] (Source: Community Development Programs)

[12] http://www.armstat.am/file/doc/146.pdf
[13] http://www.armstat.am/file/doc/99481703.pdf
[14] Gegharkunik Regional Admnistration

2.2.4 Permanent and Seasonal Migration Trend

A large scope of migration exists in Sevan basin area because of unemployment problem. During seasonal migration a large number of residents (mainly man) leave the country for jobs abroad. Thus, the official population numbers might be not absolutely correct. As Armenia has a slightly negative national growth rate and low level of female fertility, population growth predictions are is not expected for this area.

Below permanent migration trend is shown for 2001, 2011 and 2018 years (Figure 4) (Map 17).

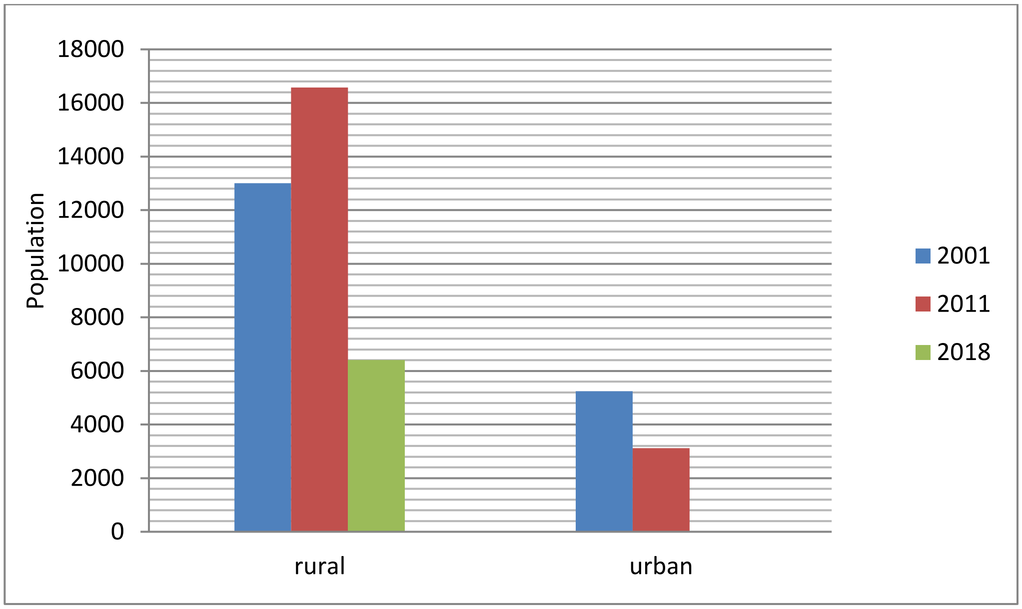


Figure 4: Migration trend for 2001, 2011 and 2018 years

2.3 Description and Analysis of Hydrological Characteristics of the Sevan RBD

2.3.1 Characterization of Surface Water Resources

2.3.1.1 River flow

Surface water resources of Sevan RBD entirely belong to Araks River Basin that is transboundary with Turkey.

As it presented in Hydrography sub-chapter, 28 rivers in total flow into Lake Sevan, and only Hrazdan River originates from it. Below are presented the hydrological characteristics of the main rivers of Sevan RBD (Table 7).

[15] http://gegharkunik.mtad.am/zargacum/

Table 7: Main Hydrological Characteristics of Rivers within Sevan RBD (Source: State Hydromet Service)

River	Monitoring Site	Watershed Characteristics		Annual Flow Characteristics				Critical Discharges	
		Watershed Area, km^2	Average Altitude, m	Average Flow, m^3/sec	Flow Volume, mln. m^3	Average Flow Module, l/sec x km^2	Flow Layer Height, mm	Maximum, m^3/sec	Winter Decade Minimum, m^3/sec
Dzknaget	Tsovagyugh	82.6	2202	1.08	34.06	13.08	412.34	46.40	0.14
Drakhtik	Drakhtik	39.2	2247	0.24	7.57	6.12	193.08	46.70	0.05
Pambak	Pambak	20.4	2536	0.21	6.62	10.29	324.64	2.27	0.07
Masrik	Tsovak	673.0	2319	3.31	104.38	4.92	155.10	20.30	2.32
Karchaghbyur	Karchaghbyur	116.0	2521	1.03	32.48	8.88	280.02	15.40	0.84
Vardenis	Vardenik	117.0	2759	1.53	48.25	13.08	412.39	22.70	0.49
Martuni	Geghhovit	84.5	2761	1.66	52.35	19.64	619.52	26.70	0.60
Argichi	Verin Getashen	366.0	2470	5.39	169.98	14.73	464.42	265.00	1.95
Tsaghkashen	Vaghashen	92.4	2562	1.52	47.93	16.45	518.77	17.90	0.47
Lichk	Lichk	33.0	2497	1.88	59.29	56.97	1796.60	6.26	1.51
Bakhtak	Tsakkar	144.0	2514	0.64	20.18	4.44	140.16	31.50	0.14
Gavaraget	Noratus	467.0	2432	3.49	110.06	7.47	235.68	72.50	2.63
Arpa-Sevan tunnel	Tsovinar	-	-	3.75	118.26				

According to L.A. Chilingaryan and co-authors (Chilingaryan and others, 2002), three types of rivers by their feeding peculiarities are distinguished in the Sevan RBD:

- Rivers flowing from the eastern slopes of Geghama and part of northern slopes of Vardenis mountain range (Gavaraget, Vardadzor, Lichk, Tsakkar, Bakhtak, Karchaghbyur, as well as part of Argichi River in its middle and lower flows) are receiving enough feeding from groundwater although in the upper flows prevails snowmelt and rainfall feeding.
- Masrik River in its middle and lower flows fed from groundwater accumulated in the alluvial-proluvial sediments of Masrik Plain.
- The rest of the rivers have mainly snowmelt-rainfall feeding. These include rivers flowing into the lake from the north-east coast (Dzknaget, Drakhtik, Spitakajur, Artanish, Jil, Shampirt (Tsapatagh), Pambak, Daranak, Areguni and others), as well as upper flows of the rivers of two types described above (V.R. Boynagryan, 2009).

Maximum flows are in April-May, only few rivers have also weakly expressed autumn (October-November) maximum (Figure 5).

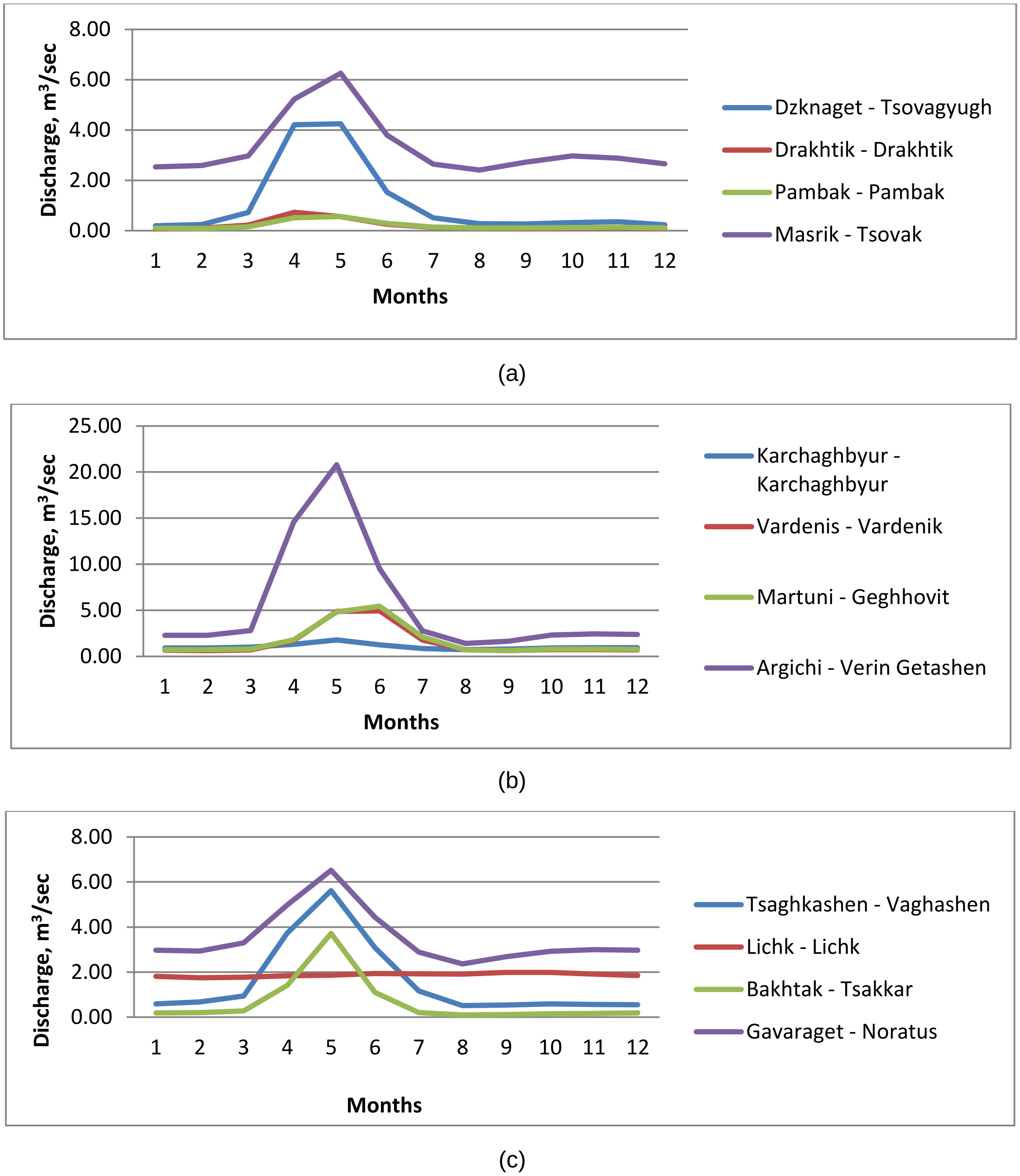


Figure 5: Annual Distribution of River Flow in Sevan RBD

Seasonal distribution of river flow in Sevan RBD is shown in Annex 10.

Maximum Flow

Maximum river flows within Sevan RBD are primarily observed during spring high water period. In general, the maximum flows of almost all rivers are formed due to a rapid snowmelt. Sometimes the waters of spring heavy rainfalls are added to that. The value of maximum discharges formed from snowmelt is depending not only from the accumulated snow reserve, but also from duration and intensity of snowmelt. Studies have shown that the maximum discharges of the rivers with mixed feeding are mainly formed in case of the intense rainfall with daily values of more than 15-20 mm.

It is calculated that in general the module of average value of maximum flow are greater from the module of annual average flow by 4-5 times. However, in case of small rivers the module of average value of maximum flow is 10-15 times greater from the annual average flow module (for example: Drakhtik – 24.3, Geghamasar – 17.0, Tsapatagh – 14.9, Areguni –13.4 times).

Minimum flow

Minimum flows are observed during summer-autumn and winter low water periods. It should be noted that the minimum discharge values of summer-autumn low water period are distorted due to high amount of water abstraction for agricultural purposes. For this reason, small rivers (in particular the rivers sourcing from Sevan and Areguni mountain ranges) sometimes are drying up in their low flows during the summer.

2.3.1.2 Lakes and Reservoirs

Characterization of Sevan Lake, including its origin, geometry, level and temperature fluctuations are given in Hydrography subchapter of this report. Below are presented level, surface area and volume changes in Lake Sevan in the period of 2002-2017.

Table 8: Annual Average Level, Surface Area and Volume Changes in Lake Sevan within the period of 2002-2017 (Source: State Hydromet Service)

Year	Annual Average		
	Level, m	Surface Area, km^2	Volume, km^3
2002	1896.72	1240.50	33.49
2003	1897.18	1245.24	33.98
2004	1897.64	1249.94	34.55
2005	1898.03	1253.79	35.05
2006	1898.34	1256.91	35.44
2007	1898.68	1260.39	35.87
2008	1899.01	1263.50	36.28
2009	1899.17	1265.48	36.49
2010	1899.69	1270.74	37.15
2011	1900.19	1275.58	37.79
2012	1900.26	1276.26	37.87
2013	1900.30	1276.57	37.92
2014	1900.28	1276.40	37.89
2015	1900.29	1276.51	37.91
2016	1900.52	1278.74	38.21
2017	1900.60	1279.46	38.30

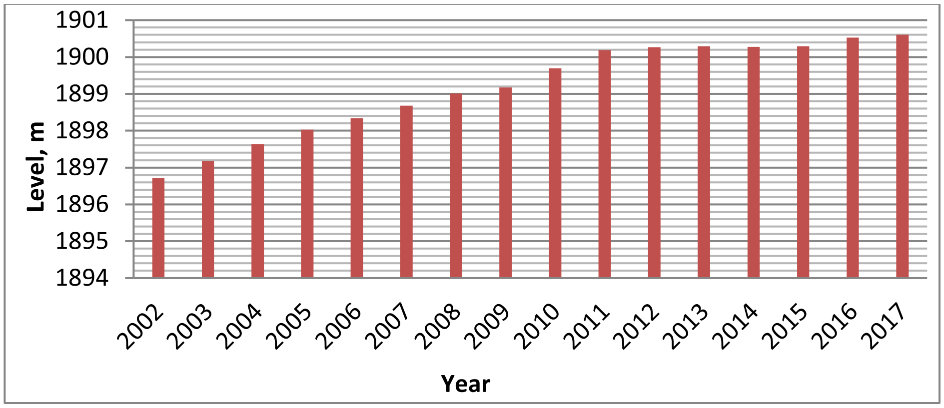


Figure 6: Annual Average Level Changes in Lake Sevan within the period of 2002-2017 (Source: State Hydromet Service)

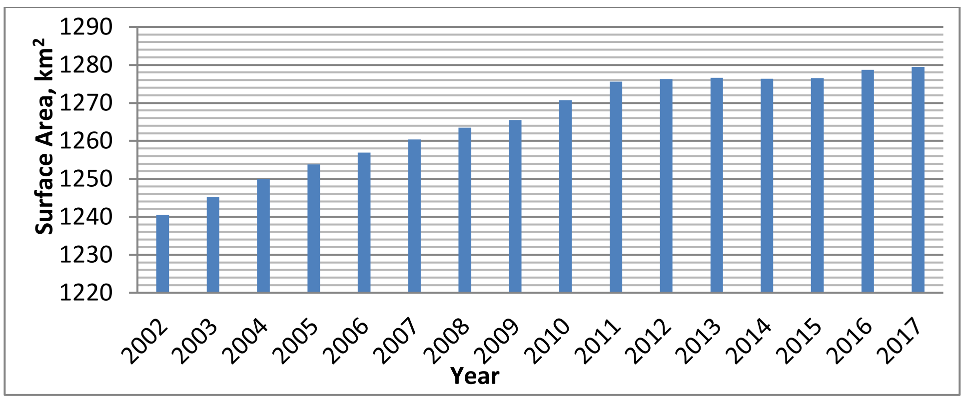


Figure 7: Annual Average Surface Area Changes in Lake Sevan within the period of 2002-2017 (Source: State Hydromet Service)

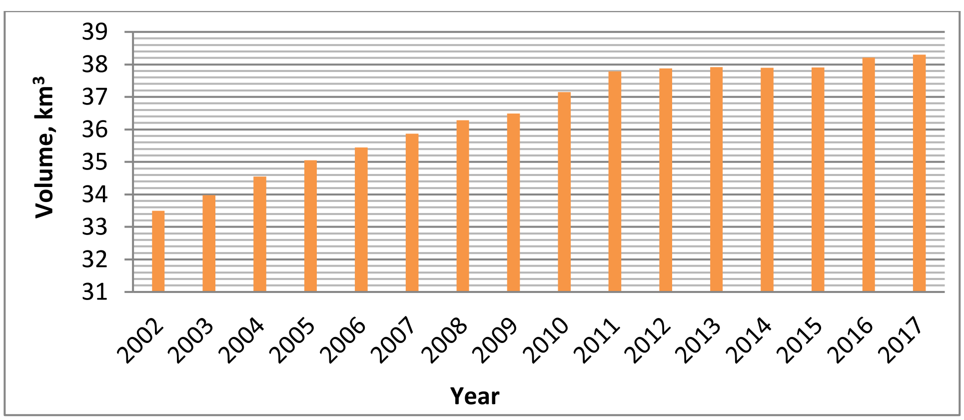


Figure 8: Annual Average Volume Changes in Lake Sevan within the period of 2002-2017 (Source: State Hydromet Service)

From the table and charts above increase of water reserves in Lake Sevan during past 15 years can be noted.

There are also several **small lakes and reservoirs** within Sevan RBD (Table 9 and 10).

Table 9: Several Small Lakes within Sevan RBD (Sources: Chilingaryan et. al, 2002, Mnatsakanyan, 2006)

Name	Watershed Area, km^2	Absolute Altitude, m	Length, m	Width, m	Surface Area, ha	Average Depth, m	Volume, thousand m^3	Lake Type	Feeding Type	Water Use Purpose (s)
Armaghan	-	2780	-	-	1,9	0,78	14	Closed	Snowmelt	Watering
Heragrayin	-	3080	220	152	2,1	0.23	4,82	Open	Mixed	Watering
Ghazi	0.4	3000	340	134	4,6	1,4	71,1	Open	Mixed	Irrigation, watering
Tsovagyugh	0,05	2290	170	68	1.15	1.68	19,4	Open	Mixed	Watering

Table 10: Reservoirs within Sevan RBD(Source: Mnatsakanyan, 2006, GIS data available at Geocom Ltd)

Name	Volume, mln. m^3	Dam Height, m	Surface Area, ha	Year of (Re)Construction	Water Use Purpose
Gegharkunik 1	0,325	14.5	5,8	1982	Irrigation
Gegharkunik 2	0,071	-	2,0	1978	Irrigation
Lanjaghbyur 1	0,212	11,7	3,3	1981	Irrigation
Lanjaghbyur 2	0,352	-	1,3	1978	Irrigation

The canals of Sotk and Masrik are constructed in the Sevan RBD on the rivers of same name.

Detailed description of canal network is produced by another project on inventory of irrigation systems in Sevan and Hrazdan RBDs by Geoinfo Ltd. The key information on iirigation systems will be included in Final Report.

2.3.2 Characterization of Groundwater Bodies

Metamorphic volcanic, volcanic-sedimentary, sedimentary, intrusive rocks of Meso-Cenozoic age, as well as Pliocene-Quaternary and contemporary volcanic rocks, eluvial-deluvial, alluvial-proluvial and lacustrine-river formations are involved in the geological structure of Hrazdan and Sevan RBDs.

Depending on the degree of porosity and fracture, these geological formations have been grouped into the following hydrogeological subdivisions, according to water-bearing and permeability levels:

- Local water-bearing Quaternary – contemporary complex of eluvial-proluvial, alluvial-proluvial and lacustrine-river formations (Q1-4): pebbles, piles, debris, sand, clay, loam, loamy sand and clay.
- Local water-bearing complex of Pliocene-Quaternary volcanic rocks (N23 – Q): dacites, andesites, andesitic dacites, basalts, tuffs and their clastolites.
- Local water-bearing complex of Upper Cretaceous sedimentary, mainly carbonate rocks (K2Sn2): limestone, marls with interlayers of sandstones and volcanic rocks.
- Local low water-bearing, low-permeable-impermeable complex of Meso-Cenozoic volcanic, volcanic-sedimentary, metamorphic intrusive rocks (MzKz): tuff-conglomerates, tuff-sandstones, tuff-breccias, limestone, clay, clay shales, porphyrites, granodiorites.
- Mineral water bodies: clay, sand, tuff-breccias, tuff-sandstones.

Table 11: Groundwater Bodies of Sevan River Basin District (Source: Environmental Monitoring and Information Centre SNCO)

№	GWB Name	GWB Code, Number	GWB Total Discharge, l/sec	Total Mineralization of Groundwater, g/l	Type of Water Abstraction Structure	Count of monitoring sites	
						Operating	Proposed
1	Dzknaget-Areguni	3G-1	35	0.16	springs	-	2
2	Lchashen-Gavar-Shatjrek	3G-2	4771.3	0.44	wells	2	6
3	Shorja-Sotk	3G -3	16.1	0.54	springs	-	2
4	Vardenis or Masrik	3G-4	960	0.32	spring-well	9	5
5	Sevan (Gavar)	3G-5	10.0	3.5	mineral water wells	-	-
6	Lichk	3G-6	74,0	3.9 – 4.2	mineral water wells	-	-
	Total in Sevan RBD		5866.4			11	15

Table 12: Description of GWBs of Sevan RBD (Source: Environmental Monitoring and Information Centre SNCO. See also Map 19)

N	Number of Site	Type of the Monitoring Site	Location	River Basin	Discharge (Q) , l/sec or level (below the Earth surface) (S), m		Total Mineralization, mg/l		Total Hardness, mg-equivalent/l	
					May	Nov.	May	Nov.	May	Nov.
5	31	Spring	Gegharkunik Marz, v. Akunk	Masrik	Q= 547	Q= 407	100	120	1.0	1.1
6	1809	Fountaining well	Gegharkunik Marz, c. Vardenis	Masrik	Q= 23.1	Q= 25.5	190	233	2.0	1.7
7	1810	Fountaining well	Gegharkunik Marz, c. Vardenis	Masrik	Q= 8.9	Q= 8.5	128	150	1.4	1.1
8	2013	Fountaining well	Gegharkunik Marz, v. Gandzak	Gavaraget	Q= 4.13	Q= 4.0	149	187	1.0	1.7
9	2014	“Fadei” Spring	Gegharkunik Marz, c. Gavar	Gavaraget	Q= 1.54	Q= 1.63	344	392	3.8	3.5

2.4 Analysis of Water and Water-Economic Balance

2.4.1 Analysis of Main Components and Calculation of Water Balance for Sevan RBD

The water-economic balance analysis is critical for understanding the relationship between water availability and water use in the basin. In the case of Armenia, monthly water balances are important to understand natural seasonal water shortages. Water-economic balance presents a real picture of water availability, demand and use in the river basin. It provides ground for allocating or reallocating water and issuing water use permits based on reliable information, as well as defining realistic measures for achieving the environmental objectives of a river basin plan.

In this sub-chapter water and water economic balance of Sevan RBD is analyzed using:

- Hydromet data on annual water balance for 2002-2017 years;

- Compilation of works of Armenian Hydromet Centre, Volume 5: “Hydrometeorological Studies in Armenia”, Moscow, Hydrometoizdat, 1990; Water balance for the basins of Armenia calculated by B. Mnatsakanyan (2005);
- Information collected during field survey, interviews with Regional Administrations and Municipalities, co-working with Sevan BMO staff.
- Decision Support System (DSS) developed in scope of the USAID Clean Energy and Water Program in Armenia.

2.4.1.1 Annual Water Balance of Sevan Lake

At the end of each year Armenian State Hydromet Service composes the annual water balance for Lake Sevan. Annual balances for the 2002-2017 were analyzed in this section.

The inflow elements of water balance are:

- River flow (surface runoff into the lake);
- Water transferred from Kechut and Spandaryan Reservoirs by Arpa-Sevan tunnel;
- Precipitation on the lake surface;
- Groundwater inflow.

Outflow elements are:

- Outflow by Hrazdan River;
- Evaporation from the lake surface;
- Groundwater outflow.

Changes in volume (positive or negative) are presented too (Table 13).

Table 13: Annual Water Balance of Lake Sevan (2002-2017, State Hydromet Service data)

Water Balance Elements	Total, mln. m^3															
	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017
Inflow																
River Flow	692,49	760,6	750,5	735,2	703,2	804,1	668, 0	764,3	891,8	855,1	675,2	710,4	626,1	686,3	806,0	677,01
Arpa-Sevan tunnel	243,51	260,64	247,92	240,62	183,76	177,54	192,44	203,78	237,09	5,53	45,43	97,97	95,47	82,7	94,83	80,02
Precipitation on the lake surface	585,62	620,9	567,8	577,4	554	742,9	469,4	625,7	601,5	603,2	441,0	468,8	541,7	560,5	608,1	418,7
Groundwater flow	94,2	94,2	94,2	94,2	94,2	94,2	94,2	94,2	94,2	94,20	94,2	94,2	94,3	94,2	94,2	94,2
Total	1615,82	1736,34	1660,42	1647,42	1535,16	1818,7	1424,04	1687,98	1824,59	1605,66	1255,83	1410,45	1392,33	1452,7	1629,11	1300,38
Outflow																
Hrazdan River	99,456	118,31	149,91	149,55	152,37	154,56	303,69	126,49	157,74	168,33	317,62	169,95	269,63	167,7	167,13	266,76
Evaporation from the lake surface	966,5	1018,4	1015,4	1001,2	1170,3	1092,8	1044,93	1053,7	1154,6	1159,8	1051,5	1138,2	1147,3	1151,9	1153,3	1217,3
Groundwater flow	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4	14,4
Total	1080,36	1151,11	1179,71	1165,15	1337,07	1261,8	1363,02	1194,59	1326,74	1342,53	1383,52	1322,55	1431,33	1334,0	1334,83	1498,46
Accumulation (Reduction)	544,9	600,7	517	510,6	229	677,1	84,7	478,4	590,9	287,2	-31,9	72,8	-44,7	76,5	347,8	-51,0
Absolute Unconnectivity	-9,436	-15,47	-36,29	-28,33	-30,91	-120,12	-23,68	15,0	-93,05	-23,9	-63,6	15,1	5,70	42,2	-53,52	-147,08
Relative Unconnectivity, %	0,58	0,9	2,1	1,7	2	6,2	1,6	0,89	4,9	1,49	4,6	1,1	0,40	2,90	3,2	9,8

Table 13 presents the water-economic balance of the Sevan Lake, the main water body within Sevan RBD. Arpa-Sevan tunnel transfers water from Kechut and Spandaryan Reservoirs which are located in the Ararat and Southern RBDs respectively, and the annual volume of transferred water mainly depends on natural factors. The flow of Hrazdan River that originates from Sevan Lake is completely regulated and depends on water demand in Hrazdan RBD (mainly in Ararat Valley, the main agricultural region in Armenia) in the specific year. As it was mentioned earlier in this report (Sub-chapter 2.1.4.1) The Law of RA “On Annual Program of Measures for Restoration, Protection, Natural Development and Use of Lake Sevan Ecosystem” envisages a maximum annual amount of water outlets from Lake Sevan to 170 mln. m^3, but this value can be exceeded according to the relevant decisions of the Government of Armenia and National Assembly.

As seen in the table above, the years 2012, 2014 and 2017 were dry and the water demand was high, but for the same reason water transfers to the Sevan Lake through Arpa-Sevan tunnel, as well as river inflow and precipitation on the lake surface was low. Thus, the balance of Sevan Lake in these years was negative. The situation may become even worse due to climate change and increase of water demand in future. This is a crucial and very debated problem in Armenia currently and requires the involvement of all stakeholders and experts to identify the optimal solution for efficient management of above-mentioned water resources.

Groundwater flow values are scientifically estimated and are considered as the same for all years due to the lack of appropriate monitoring data.

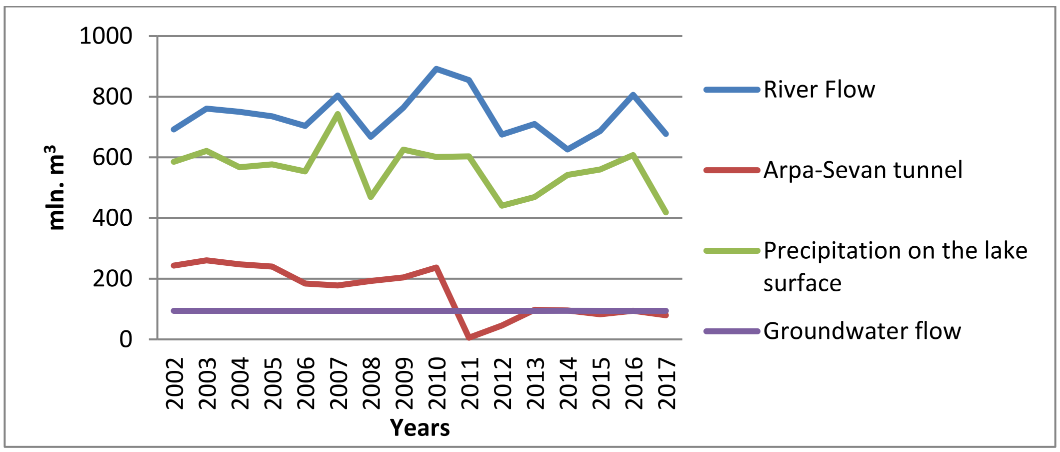


Figure 9: Changes in Inflow Elements of Lake Sevan Water Balance in the Period of 2002-2017

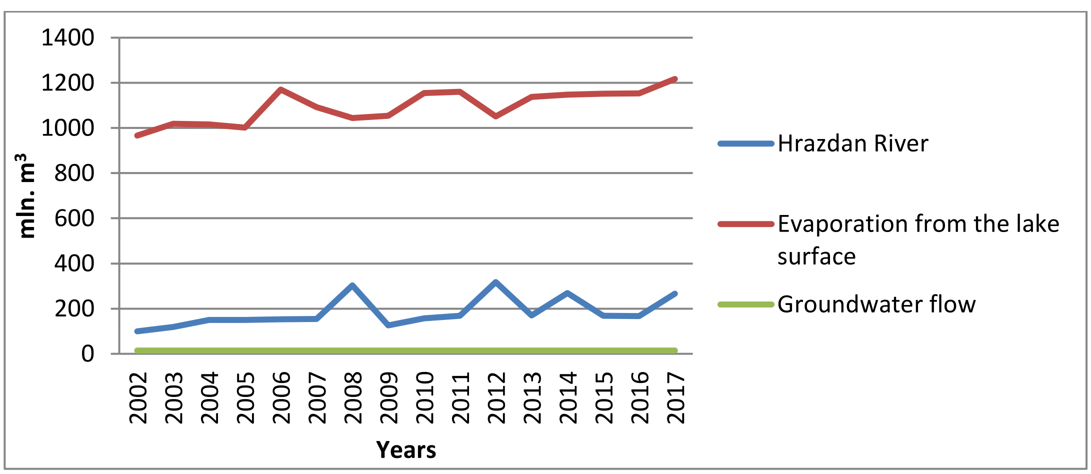


Figure 10: Changes in the Outflow Elements of Lake Sevan Water Balance in the Period of 2002-2017

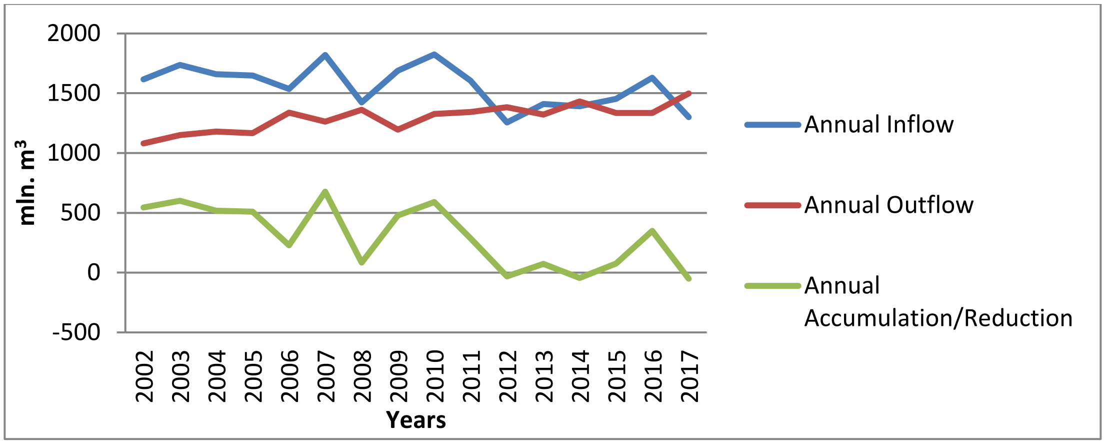


Figure 11: Changes in the Total Annual Inflow to and Outflow from Lake Sevan in the Period of 2002-2017

2.4.1.2 Water Balance by Altitude Zones

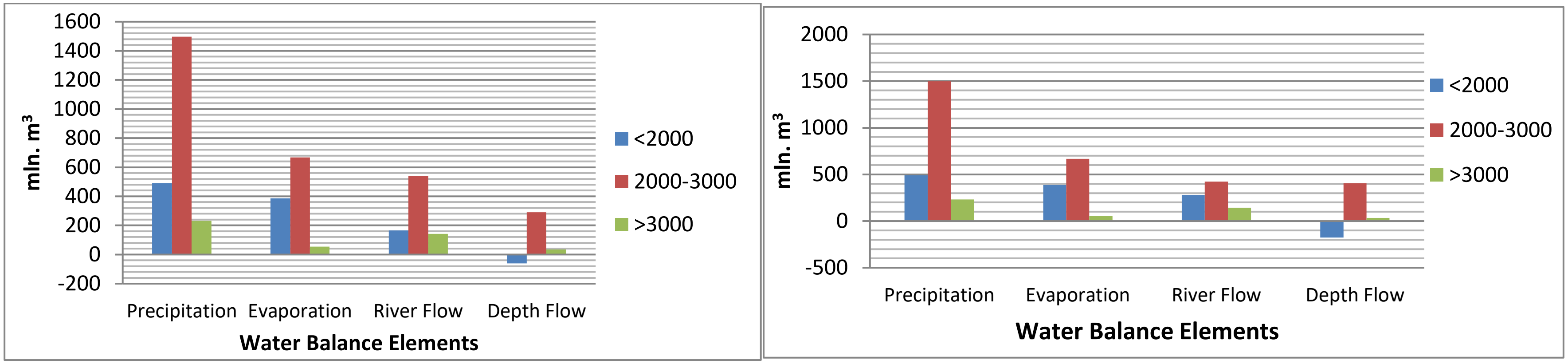
Water balance for altitude zones of the river basins of Armenia are calculated during in scope of several studies. In this section we present the results of works of Armenian Hydromet Centre (1990) and B. Mnatsakanyan (2005).

Table 14: Water Balance of Sevan RBD by Altitude Zones (Armenian Hydromet Centre, 1990)

Altitude Zone, m	Area, km^2	Precipitation (X)		Evaporation (Z)		River flow (Yr)		Depth flow (Ud)		Surface flow (S)		GW flow (G)		Gross Humidification (W)		Coefficient				
		mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln .m^3	mm	mln.m^3	mm	Groundwater flow (Kx)	Groundwater feeding (Ky)	Infiltration, (Kw)	Surface flow, (Kc)	River flow, (H)
<2000	1066	491	461	387	363	165	158	-61	-61	162	152	3	3	329	309	0,01	0,02	0,01	0,33	0,34
2000-3000	2194	1497	682	667	304	539	248	291	130	257	117	282	128	1240	565	0,19	0,53	0,23	0,17	0,36
>3000	240	232	967	54	225	143	596	35	146	68	283	75	313	164	683	0,32	0,53	0,46	0,29	0,61
Total	*3500*	*2220*	*634*	1108	316	847	245	*265*	*73*	*487*	*139*	*360*	*103*	*1733*	*495*	*0,16*	*0,42*	*0,21*	*0,22*	*0,38*

Table 15: Water Balance of Sevan RBD by Altitude Zones (Mnatsakanyan, 2005)

Altitude Zone, m	Area, km^2	Precipitation (X)		Evaporation (Z)		River flow (Yr)		Depth flow (Ud)		Surface flow (S)		Groundwater flow (G)		Gross Humidification (W)		Coefficient		
		mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	Groundwater flow (Kx)	Surface flow, (Kc)	River flow, (H)
<2000	1066	491	461	387	363	279	262	-175	-164	48	45	231	217	443	416	0,47	0,10	0,57
2000-3000	2194	1497	682	667	304	425	194	405	185	237	108	188	86	1240	565	0,12	0,16	0,28
>3000	240	232	967	54	225	143	596	35	146	106	442	37	154	164	683	0,16	0,46	0,66
Total	*3500*	*2220*	*634*	*1108*	*316*	*847*	*242*	*265*	*76*	*391*	*112*	*456*	*130*	*1733*	*495*	*0,20*	*0,18*	*0,38*



(a) (b)

Figure 12: Distribution of Water Balance Elements in Sevan RBD by Altitude Zones

Source: Armenian Hydromet Ceentre, 1990 (a); Mnatsakanyan, 2005 (b))

2.4.1.3 Water Balance of Several Sub-Basins within Sevan RBD

Armenian State Hydromet Centre (1990) and B. Mnatsakanyan (2005) also composed water balances for the separate river basins.

Table 16: Water Balance by Altitude Zones of River Basins within Sevan RBD (Armenian Hydromet Centre, 1990)

River Basin	<2000m					2000-3000m					>3000m				
	F	X	Z	Yr	Ud	F	X	Z	Yr	Ud	F	X	Z	Yr	Ud
	km^2	mln. m^3	mln. m^3	mln. m^3	mln. m^3	km^2	mln. m^3	mln. m^3	mln. m^3	mln. m^3	km^2	mln. m^3	mln. m^3	mln. m^3	mln. m^3
		mm	mm	mm	mm		mm	mm	mm	mm		mm	mm	mm	mm
Dzknaget-mouth	10	6	4	2	0	80	55	23	32	0	-	-	-	-	-
		600	400	200	0		688	288	400	0					
Areguni Coast	80	38	30	17	-9	128	85	38	38	9	-	-	-	-	-
		475	375	212	-112		664	297	297	70					
Masrik-mouth	155	64	56	8	0	520	347	161	114	72	10	10	3	7	0
		413	361	52	0		667	310	219	138		1000	300	700	0
Argitchi-mouth	20	10	7	2	1	340	219	105	154	-40	24	23	5	17	1
		500	350	100	50		644	309	453	-118		958	208	708	42
Bakhtak, Tsakkar, Shoghvak	74	35	27	49	-41	210	140	64	42	34	30	29	7	12	10
		473	365	662	-554	210	667	305	200	162		967	233	400	333
Martuni, Vardenis, Artsvanist	134	64	50	38	-24	416	273	127	84	62	96	92	21	67	4

		478	373	284	-179		656	305	202	149		958	219	698	42
Gavaraget	60	29	18	3	8	340	272	100	75	97	80	78	18	40	20
		483	300	50	133		800	294	220	286		975	225	500	250
Drainless area	80	32	28	0	4	160	106	49	0	57	-	-	-	-	-
		400	350	0	50		662	306	0	356					
Remaining area	453	213	167	46	0	-	-	-	-	-	-	-	-	-	-
		472	368	104	0										
Total	1066	491	387	165	-61	2194	1497	667	539	291	240	232	54	143	35
		523	412	176	-65		686	304	246	136		967	225	596	146

Table 17: Water Balance of River Basins within Sevan RBD (Armenian Hydromet Centre, 1990)

River or Inter-River Basin	Area, km^2	Precipitation (X)		Evaporation (Z)		River Flow (Yr)		Deep Flow (Ud)	
		mln.m^3	mm	mln.m^3	mm	mln.m^3	mm	mln.m^3	mm
Dzknaget	90	61	678	27	300	34	378	0	0
Areguni Coast	208	123	591	68	327	55	264	0	0
Masrik	685	421	614	220	321	129	188	72	105
Vardenis Karchaghbyur, Artsvanist, Martuni	646	429	664	198	306	189	292	42	65
Argichi	384	252	656	117	305	173	450	-38	-99
Bakhtak, Tsakkar, Shoghvak	314	204	650	98	312	103	328	3	10
Gavaraget	480	379	790	136	294	118	246	125	240
Drainless area	240	138	575	77	321	0	0	61	254
Remaining area	453	213	470	167	369	46	102	0	0
Total for RBD	*3500*	*2220*	*634*	*1108*	*316*	*847*	*242*	*265*	*76*

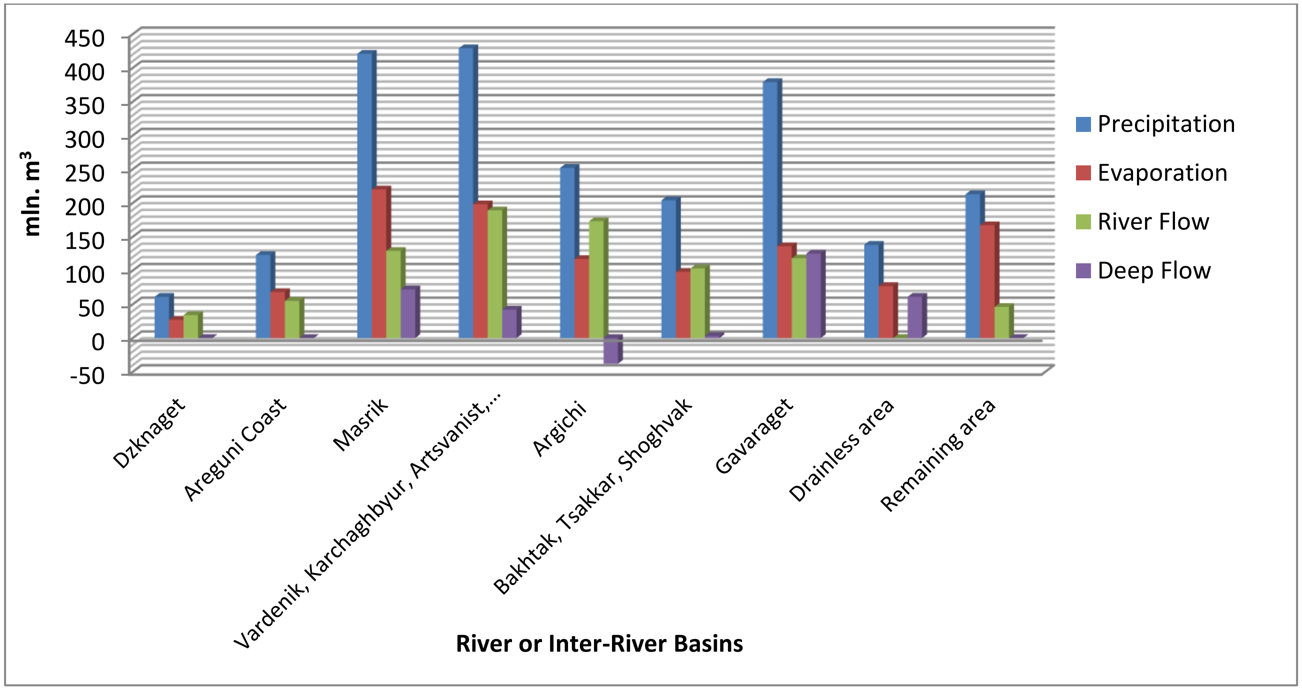


Figure 13: Water Balance of River Basins within Sevan RBD (Armenian Hydromet Centre, 1990)

Table 18: Water Balance of Several River Basins within Sevan RBD (Mnatsakanyan, 2005)

River Basin	Area	Precipitation (X)		Evaporation (Z)		River Flow (Yr)		Depth Flow (Ud)	
	km^2	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm	mln. m^3	mm
Masrik	685	421	614	220	321	129	188	72	105
Argitchi	384	252	656	117	305	173	450	-38	-99
Gavaraget	480	379	790	136	294	118	246	125	260

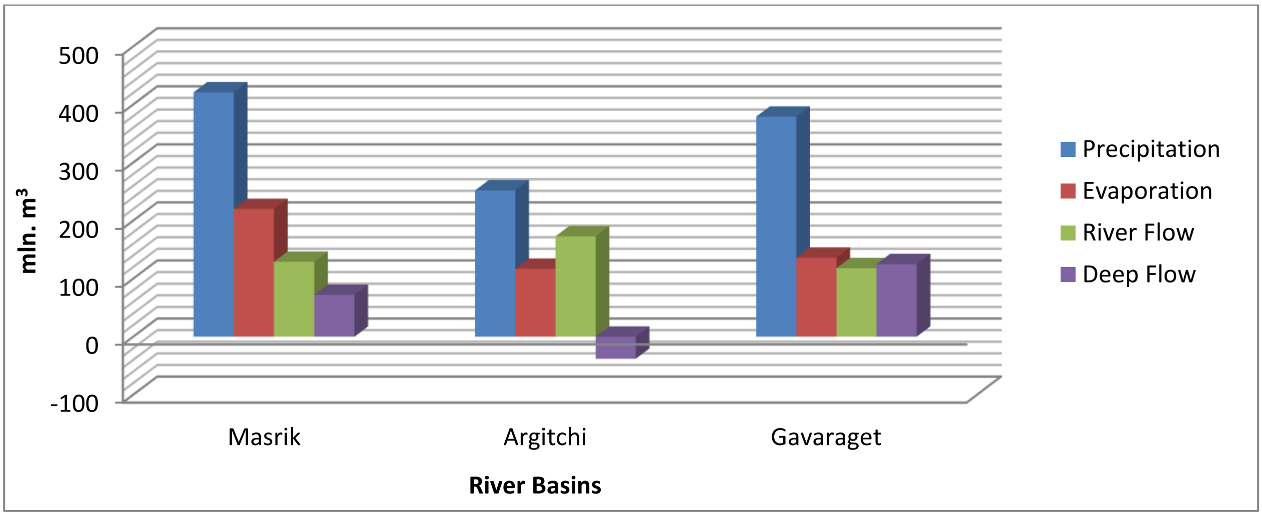


Figure 14: Water Balance of River Basins within Sevan RBD (Mnatsakanyan, 2005)

2.4.1.4 Factual Assessment of Water and Water-Economic Balance

Map of the balanced and unbalanced areas (sub-basins) has been developed based on the information collected during field survey, interviews with Regional Administrations and Municipalities and co-working with Sevan BMO staff (Map 20).

Field study on water quantity conditions in riverbeds within Sevan RBD were conducted on July 28, 2018. In result, online map with (pop-up images of rivers) were developed (available at: https://arcg.is/yma4T).

Map of balanced/unbalanced areas can be a starting point for the water and water-economic balance assessment in sub-basin level.

2.4.1.5 Water Balance Calculation Using DSS

Using GIS models such as Decision Support System (DSS) developed in scope of USAID Clean Energy and Water Program in Armenia can be the solution for more precise assessment of water and water-economic balance of sub-basins.

Below are presented the results of multi-year average and 2017 average water balance for the rivers flowing into Sevan Lake.

Table 19: Water Balance Calculated Using DSS (based on the data of State Hydromet Service)*

Name	Multi-Year Average					2017				
	P	E	NF	SNF	DF	E	P	NF	DF	SNF
Areguni	549.77	305.81	243.96	169.42	74.54	289.48	482.55	193.07	20.95	172.12
Argichi	599.87	296.04	303.83	181.31	122.52	278.82	510.83	232.01	48.62	183.39
Artsataberd	570.78	301.89	268.89	170.35	98.54	284.56	492.51	207.95	34.84	173.12
Artsvanist	554.98	299.16	255.81	204.37	51.44	283.65	472.07	188.43	-14.60	203.02
Artunj	492.82	311.22	181.60	152.01	29.60	292.89	430.73	137.85	-17.79	155.64
Astghadzor	556.58	302.38	254.20	164.47	89.73	283.77	473.22	189.45	21.99	167.45
Drakhtik	640.97	286.64	354.33	221.33	133.00	271.58	531.21	259.63	39.77	219.86
Dzknaget	603.37	294.20	309.17	200.65	108.52	278.53	510.69	232.15	31.28	200.87
Dzoragyugh	584.28	297.91	286.36	179.27	107.10	280.52	493.95	213.43	32.18	181.25
Gavaraget	594.23	295.43	298.81	186.81	112.00	278.55	501.57	223.02	34.58	188.44
Geghamasar	639.23	290.86	348.37	188.42	159.95	273.79	538.10	264.32	74.18	190.14
Hrazdan	683.74	278.42	405.32	252.10	153.22	265.32	562.24	296.92	48.65	248.28
Jil	611.27	295.96	315.32	184.20	131.12	279.42	520.13	240.70	54.53	186.18
Karchaghbyur	598.79	297.84	300.95	174.87	126.08	280.34	512.44	232.09	54.75	177.34
Lichk	594.81	298.46	296.35	181.67	114.68	282.23	510.28	228.05	44.25	183.80

Martuni	605.42	294.67	310.75	193.91	116.84	278.50	512.69	234.19	39.38	194.81
Masrik	626.85	290.57	336.28	205.62	130.67	274.96	527.42	252.47	46.78	205.68
Noruz	570.22	302.57	267.65	168.54	99.11	285.27	492.31	207.04	35.74	171.30
Pambak	676.70	283.58	393.12	215.68	177.44	267.87	561.87	294.00	78.92	215.08
Pokr Masrik	603.59	295.07	308.52	174.99	133.52	276.52	506.78	230.26	52.78	177.48
Sarinar	616.16	293.55	322.61	185.66	136.95	276.01	514.76	238.75	51.45	187.30
Satanakhach	542.32	303.25	239.07	158.54	80.53	283.78	455.06	171.28	9.41	161.87
Selavagetak	794.70	250.04	544.66	434.92	109.74	245.89	611.45	365.56	-44.73	410.29
Shamberd	441.61	322.31	119.31	143.73	-24.42	305.93	408.67	102.74	-45.00	147.74
Tsakkar	433.10	326.24	106.86	142.44	-35.58	310.82	406.99	96.17	-50.34	146.51
Tsapatagh	431.68	327.01	104.66	142.22	-37.56	311.87	406.70	94.84	-51.46	146.30
Vardenis	570.92	299.73	271.18	176.56	94.62	282.42	488.23	205.82	26.93	178.88
Zolakar	521.12	311.06	210.05	168.15	41.91	295.83	464.47	168.64	-2.19	170.83

**P – precipitation, E – evaporation, NF – natural flow. SNF – surface natural flow, DF – deep flow.*

The calculation of water balance for Sevan RBD which is corresponds to watershed of Sevan Lake is complicated task due to the fact that it is consists of the separate basins of the rivers flowing into the lake. Flow formation and distribution peculiarities are not the same for all of these basins due to hydrogeological and climatic differences. As it was mentioned earlier in this report, some of the rivers flowing into the Sevan Lake have groundwater feeding (especially Lichk). Therefore the correlation between water balance parameters and geomorphometrical parameters of the basins (average altitude, area) is weak. Another issue is the lack of hydrometeorological monitoring data for the RBD. Thus, the numbers presented in the table above give a general view of water balance parameters distribution within the separate river basins of Sevan RBD. Adding to this water use data and calculated ecological flow values for the rivers, delineated water bodies by the other component of the Project can be assessed whether they are under the risk or not (in water quantity perspective). The results of this assessment will be presented in our next report.

2.4.2 Estimation of River's Ecological Flow

Ecological flows for the rivers of Sevan RBD were calculated by the methodology accepted by the Government of RA, Annex 1 (25.01.18 N 57-Ն), of the Decision from 30.06.2011: "Setting water demand for drinking-household, agricultural purposes, as well as estimations of ecological flow by the river basin districts of RA". Ecological flow is the indicator of ecosystem stability in RBD and these values also necessary for usable water reserve estimation.

Table 20: Monthly Ecological Flow Values for the Rivers of Sevan RBD (Calculated based on the State Hydromet Service Data)

Flow, m^3/sec	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Dzknaget-Tsovagyugh												
Natural Average	0,20	0,24	0,73	4,21	4,27	1,56	0,55	0,31	0,28	0,33	0,36	0,24
Natural Minimum	0,084	0,070	0,092	0,90	0,76	0,37	0,18	0,10	0,10	0,090	0,12	0,083
Ecological	0,084	0,070	0,092	0,36	0,31	0,18	0,12	0,097	0,097	0,090	0,10	0,083
Drakhtik-Drakhtik												
Natural Average	0,075	0,095	0,22	0,75	0,61	0,30	0,18	0,15	0,11	0,11	0,12	0,090
Natural Minimum	0,021	0,025	0,059	0,091	0,12	0,083	0,070	0,041	0,020	0,023	0,025	0,016
Ecological	0,013	0,014	0,025	0,036	0,044	0,034	0,029	0,020	0,013	0,013	0,014	0,011
Pambak-Pambak												
Natural Average	0,087	0,086	0,150	0,52	0,57	0,31	0,19	0,14	0,13	0,13	0,13	0,11

Natural Minimum	0,031	0,033	0,053	0,12	0,17	0,11	0,078	0,069	0,065	0,049	0,052	0,039
Ecological	0,031	0,033	0,044	0,066	0,082	0,063	0,052	0,049	0,047	0,042	0,043	0,039
Masrik-Tsovak												
Natural Average	2,55	2,61	2,99	5,25	7,25	5,93	4,72	3,72	3,23	3,01	2,90	2,68
Natural Minimum	1,01	1,17	1,49	2,57	2,84	2,99	2,83	2,57	1,65	1,79	1,40	1,25
Ecological	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65	0.65
Karchaghbyur-Karchaghbyur												
Natural Average	0,99	0,98	1,08	1,39	2,17	2,07	1,53	1,12	0,91	0,99	1,04	1,02
Natural Minimum	0,54	0,54	0,61	0,58	0,80	0,81	0,70	0,61	0,58	0,53	0,59	0,55
Ecological	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46	0.46
Vardenis-Vardenik												
Natural Average	0,66	0,63	0,71	1,74	5,11	5,61	2,37	1,10	0,78	0,75	0,75	0,72
Natural Minimum	0,10	0,11	0,12	0,30	1,17	1,42	0,68	0,31	0,18	0,13	0,16	0,11
Ecological	0,10	0,11	0,11	0,17	0,46	0,54	0,29	0,17	0,13	0,11	0,12	0,11
Martuni-Geghhovit												
Natural Average	0,74	0,73	0,82	1,82	4,98	6,04	2,64	1,05	0,73	0,80	0,82	0,76
Natural Minimum	0,22	0,22	0,28	0,44	1,87	2,48	0,71	0,38	0,23	0,24	0,21	0,23
Ecological	0,22	0,22	0,28	0,35	0,82	1,02	0,43	0,33	0,23	0,24	0,21	0,23
Argichi-Verin Getashen												
Natural Average	2.62	2.59	3.44	17.7	21.1	11.5	6.82	4.51	3.38	2.83	2.80	2.71
Natural Minimum	1.63	1.66	1.82	3.56	7.12	4.66	3.45	2.86	2.57	2.43	2.36	1.92
Ecological	1.63	1.66	1.82	2.80	3.98	3.17	2.77	2.57	2.48	2.43	2.41	2.26
Tsaghkashen-Vaghashen												
Natural Average	0.55	0.64	0.89	3.35	4.72	2.66	1.56	1.03	0.77	0.64	0.57	0.55
Natural Minimum	0.41	0.40	0.45	0.90	1.28	1.06	0.84	0.70	0.61	0.53	0.49	0.42
Ecological	0.41	0.40	0.45	0.70	0.82	0.75	0.68	0.63	0.60	0.53	0.49	0.42
Lichk-Lichk												
Natural Average	1,81	1,75	1,79	1,87	1,88	1,95	1,92	1,91	1,99	1,99	1,93	1,86
Natural Minimum	0,92	0,92	0,97	0,96	1,06	1,29	1,16	1,13	1,24	1,12	1,00	1,01
Ecological	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87	0.87
Bakhtak-Tsakkar												
Natural Average	0,19	0,20	0,28	1,39	4,07	1,97	0,88	0,58	0,40	0,16	0,17	0,19
Natural Minimum	0,023	0,033	0,048	0,14	0,57	0,51	0,37	0,16	0,037	0,040	0,038	0,031
Ecological	0,023	0,033	0,040	0,070	0,21	0,19	0,15	0,075	0,036	0,037	0,037	0,031
Gavaraget-Noratus												
Natural Average	2,99	2,96	3,32	5,01	6,81	5,25	3,84	3,18	2,96	2,95	3,03	3,00
Natural Minimum	2,18	2,19	2,20	2,43	3,21	2,63	2,18	1,62	1,66	1,66	1,71	1,77
Ecological	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92	1.92

Chingil-Yangh (Closed, 1946, 1949-64)												
Natural Average	0.17	0.17	0.19	0.53	0.61	0.38	0.27	0.22	0.20	0.19	0.18	0.17
Natural Minimum	0.15	0.15	0.15	0.19	0.38	0.27	0.22	0.20	0.19	0.18	0.17	0.16
Ecological	0.15	0.15	0.15	0.19	0.28	0.24	0.22	0.20	0.19	0.18	0.17	0.16
Karadzi-Karadzi (Closed, 1946-67)												
Natural Average	1.05	1.04	1.22	4.08	4.72	3.07	2.15	1.63	1.34	1.18	1.09	1.07
Natural Minimum	0.87	0.87	0.93	1.24	2.80	2.00	1.55	1.30	1.16	1.08	1.04	0.95
Ecological	0.87	0.87	0.93	1.24	1.79	1.53	1.38	1.30	1.16	1.08	1.04	0.95

Masrik, Karchaghbyur, Lichk and Gavaraget rivers are mainly fed from groundwater, and the monthly environmental flow values are calculated according to the requirements presented in the II point of the Annex 1 (25.01.18 N 57-Ն), of the Decision from 30.06.2011: “As an ecological flow of the rivers with stable flow and mainly with groundwater feeding, the average value of 10 sequental days with the most minimal flow values in a winter period (multi-year) is accepted”.

3. SIGNIFICANT PRESSURES AND POSSIBLE IMPACTS ON WATER STATUS

The Pressure and Impact Analysis according to the EU WFD's Article 5 and the corresponding Annex II is an essential component. According to the initial characterization of the Sevan RBD (Sevan RBMP Phase I), in case of the data gaps and uncertainty were revealed, the expert judgments put in place to provide more quantitative updated assessments of pressures and impacts in both surface water and groundwater. However, the methodologies that have been applied to assess possible impacts of anthropogenic pressures on water bodies show some shortcomings that partly include:

- lacking estimations if water bodies are at possible risk to fail the environmental objectives;
- coherent approaches regarding pressure types and corresponding impact/risk criteria, as well as
- general assessment gaps can be identified.

3.1 Drivers

This chapter includes the analysis of key drivers, related significant pressures and the assessment of possible impacts on water status (Pressure & Impact Analysis according to EU WFD Article 5). The chapter also elaborates on main data gaps regarding the Pressure & Impact Analysis.

3.1.1 Agriculture

Data Gaps

- Data on the organic fertilizers used in the Sevan RBD
- The amount of pesticides used in each river basin
- Monitoring data for pesticides in surface water and groundwater
- Types of pesticides used in each river basin

Agriculture is one of the leading sectors of economy (12,7 %) in the Sevan RBD. The agricultural lands occupy about 56 % (264,360 ha) of the total land of the Sevan RBD, out of which 224,200 ha are grasslands and pastures, 40,170 ha - arable lands.

The agricultural land distribution across the main river basins is presented in the Table 22. As it is seen from that table, the largest areas of agricultural lands are located in Masrik (24.7%), Gavaraget (17.5%), Argichi (12.5%), Pokr Masrik (2.7 %), Bakhtak (5.8 %), Lichk (1.3%) river basins. The other river basins together hold over 35.5 % of total agriculture lands. Masrik holds about 52% of total arable lands, followed by Argichi (17.5%) and Gavaraget (8.6%). The largest grasslands are also located in Masrik (21.1%), Gavaraget (18.6%) and Argichi (11.8%) river basins.

Table 21: Agriculture Land Structure by River Basins

River basin	Land area per river basin, ha	
	Arable lands including small-size household farms	Grasslands and pastures
Masrik	12825.4	39944.7
Argichi	4324.3	22308.8
Gavaraget	2123.7	35175.9
Pokr Masrik	1750.4	4075.9

Bakhtak	977.1	11422.0
Lichk	942.5	1863.7
Others	1699.8	74099.0

Source: GlobeLand30 Gegharkunik Regional Administration.Geocom Ltd, 2010-2018.

The agricultural production in the RBD is focused on the crops and potato (Table 22), followed by livestock production, including cows, sheep and pigs.

In the Sevan RBD the main crops are grains which are cultivated on about 44% of the cultivated land, 14.7 % are fodder crops and potatoes (Table 22).

Table 22: Crop Gross Production in the Sevan RBD, 2013-2017.

Crop	Cultivated land, ha				
	2013	2014	2015	2016	2017
Grain	41 753	40 902	38 625	35 875	*30 913*
Potato	14 109	13 276	10 235	10 239	*9 431*
Vegetables	2 023	2 092	1 607	1 689	*1589*
Fruits	1 488	1 488	1 384	1 403	*1407*
Other	19 675	19 955	21 796	-	-

Source: Statistical Committee of the Republic of Armenia (www.armstat.am).

Detailed description of canal network is produced by the project on inventory of irrigation systems in Sevan and Hrazdan RBDs by Geoinfo Ltd[16].

“Gegharkunik” Water Users Association (WUAs) supplies and serves agricultural lands in the Sevan RBD. The total service area of the WUAs is 3742 ha. The irrigation infrastructure consists of about 19 secondary irrigation canals, which provide water from rivers and springs (Table 23). As of January 2018, the permitted annual water use for irrigation purposes in the RBD comprised 10356,242 thousand m^3, which is almost 3.65% of the total permitted water use. Due to poor condition of the irrigation infrastructure, water losses in the network currently comprise about 50%.

The irrigation data shows that irrigation network is mainly distributed in Masrik, Argichi, Gavaraget, Karchaghbyur and Martuni river basins.

Table 23: Main Characteristics of the Canals in Sevan RBD Operated by “Gegharkunik” WUA

Name of the canal	Canal type	Length, km	Discharge, m^3/sec	Water source	Purpose	Dominant crops	Service area (ha)	Irrigation supply mode
Averakneri	Secondary	6.1	0.5	Lchavan natural springs	Agriculture	Potato	56	Gravity
Sarukhan	Secondary	5.9	0.1	Sarukhan springs	Agriculture	Potato	211	Pumped
Masrik	Secondary	31.5	2.0	Akunk springs	Agriculture	Potato	1846	Gravity
Ayrk pipeline	Secondary	13.9	1.0	Ayrq River	Agriculture, Energy	Potato, wheat	90	Gravity
Dotation	Secondary	5.6	0.5	Argichi River through Getashen Canal	Agriculture	Potato	240	Gravity
Getashen	Secondary	13.4%	2.0	Argichi River	Agriculture	Potato	30	Gravity
HPP Canal	Secondary	6.8%	0.3%	Argichi River	Agriculture, Private water users	Vegetables , Potato	110	Gravity

[16] Detailed Assessment of Modern Flow Measurement Equipment, Needs for Irrigation Water Accounting in Sevan and Hrazdan Pilot Basins of Armenia. (EUWI+, 2018c)

Waterfall Stream	Secondary	2.6	0.4	Argichi River	Agriculture	Potato	348	Gravity
Lchavan	Secondary	7.2	0.4	Makenis River	Agriculture	Potato	87	Gravity
Makenis	Secondary	3.6	0.7	Makenis River	Agriculture, Private water users	Vegetables, Potato	110	Gravity
Tsovak 2) Vanq	Secondary	8.2	0.2	Makenis River	Agriculture	Potato	67	Gravity
Mountain Stream Martuni	Secondary	7.0	0.5	Martuni River	Agriculture	Potato	150	Gravity
Vaghashen (Manas)	Secondary	19.3	0.5	Martuni River	Agriculture	Potato	174	Gravity
Noratus (left)	Secondary	6.7	2.5	Gegharkunik River	Agriculture	Potato	91	Out of operation
Noratus (right)	Secondary	10.8	0.15	Gegharkunik River	Agriculture	Potato	180	Pumped
Tsovinar	Secondary	5.2	0.4	Artsvanist River	Agriculture	Potato	140	Gravity
Zolaqar	Secondary	5.3	0.4	Astghadzor River	Agriculture	Potato	310	Gravity
Gegharkunik no 1 Reservoir Canal	Secondary	2.5	0.1		Agriculture	Potato	15	Gravity

Source: EUWI+, Detailed Assessment of Modern Flow Measurement Equipment Needs for Irrigation Water Accounting in Sevan and Hrazdan Pilot Basins of Armenia. (EUWI+, 2018c)

Cattle breeding have always been a traditional branch of agriculture in the Sevan RBD as widespread pastures (Table 24), geographical position and natural climatic conditions create favorable conditions. This is proven by an annual increase of both livestock capita and livestock yield.

Table 24: Number of Livestock in the Sevan RBD, thousand heads

Livestock	Number of Livestock				
	2013	2014	2015	2016	2017
Cattle	112.3	115.6	120.9	125.0	124.9
from which cow	54.3	56.7	58.6	61.0	59.9
Sheep and goat	101.4	102.6	111.4	113.8	113.4
Pig	11.9	11.5	12.8	15.2	15.9
Horse	1.4	1.6	1.6	1.5	1.5

Source: Statistical Committee of the Republic of Armenia.

The livestock distribution in Sevan basin is presented in the Table 25. As it is seen from the table, the cattle breeding is mainly developed in Major Sevan Basin (83%) especially in Masrik, Gavaraget, Martuni, Argichi, Artsvanist, Vardenis, Tsakkar, Karchaghbyur and Lichk River Basins.

Many settlements in the basin are located on the coastal zone of Lake and the agricultural diffuse pollution is directly flowed into Lake Sevan.

Table 25: Number of Livestock in the Sevan RB, thousand heads

River basins	Number of Livestock				
	Cattle	Pig	Sheep and goat	Horse	Poultry
Major Sevan					
Masrik	23922	1404	33227	145	63688
Gavaraget	20972	2501	14529	193	53420
Martuni	9424	2170	6854	11	29459
Argichi	7520	827	4106	12	23465

Artsvanist	5604	624	6192	21	19029
Vardenis	4637	912	1991	13	12066
Tsakkar	4396	540	1695	6	22437
Karchaghbyur	3738	515	3104	15	6532
Lichk	2450	238	1334	1	17085
Others	20834	2748	20143	95	80131
Minor Sevan					
Dzknaget	4 865	461	2302	41	9459
Other basins	15046	2109	15353	468	37273

Source: Statistical Committee of the Republic of Armenia. Comprehensive Agricultural Census of the Republic of Armenia for Gegharkunik Marz,2014.

The gross agricultural product in the Sevan RBD has amounted to 123.8 billion AMD in 2017 (Figure 15). One of most important priorities of the territorial development strategy for 2017-2025 in the region is agriculture.

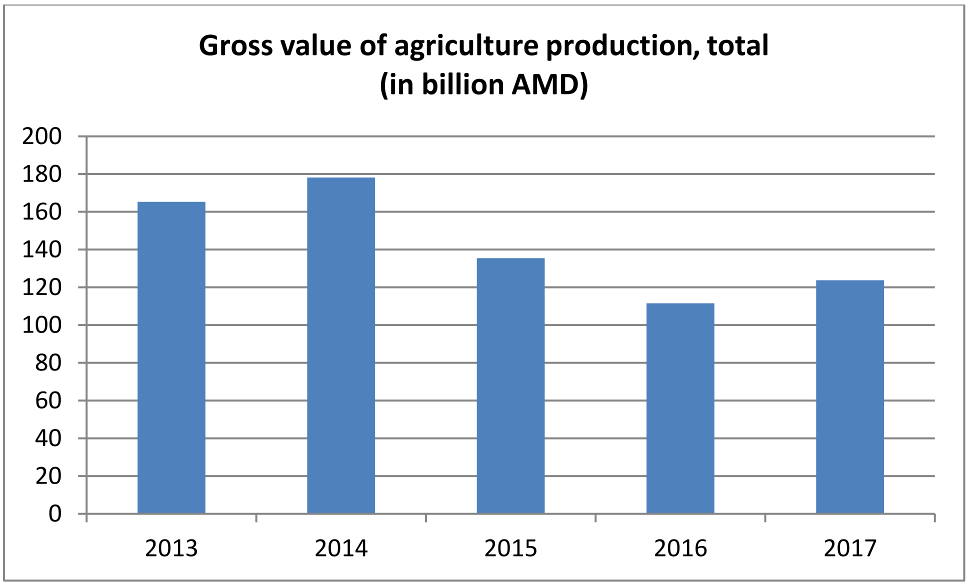


Figure 15: Gross value of Agricultural Production in the Sevan RBD in billion AMD (Data source: Statistical Committee of the Republic of Armenia)

According to the statistical data[17], the total annual input of mineral fertilizers (nitrogen, phosphorus, potassium and etc.) is amounted to 21,000 tons which is 22.6% of the national total (93,019 t). Fertilizers are used only on permanent croplands, with about annual average area of 8000-10000 ha cropland treated by fertilizers. There are no data available on the organic fertilizers in the basin.

The aggregated amounts of pesticides used in the Gegharkunik Province are presented in Table 26. Regarding the use of pesticides, data on amounts used per river basin in the Sevan RBD are not available.

From 2012 through 2017 total annual consumption of pesticides has not changed noticeably on average 400 t (1.4 t/ha). In 2017, the total area treated with pesticides was 272,400 ha which is 57 % of agricultural lands in the Sevan RBD.

To assess pesticides impact on water resources the data on monitoring required. Monitoring data of pesticides are generally poor. Key pesticides are included in the monitoring schedule of Armenia (RA

[17] Statistical Committee of the Republic of Armenia. Comprehensive Agricultural Census of the Republic of Armenia for Gegharkunik Marz. 2014.

government resolution, 75-N, 27.01.2011), however the cost of analysis and the necessity to sample at critical times of the year (linked to periods of pesticide use) often preclude development of an extensive data set. Information on types of used pesticides is also not available.

Table 26: Pesticides Cconsumption in Gegharkunik Province

Assessment Parameters	2012	2013	2014	2015	2016	2017
Agricultural land, 1000 hectares	481,8	481,5	481,5	481,0	481,1	481,1
Total area treated with pesticides, 1000 hectares	290,6	299,0	285,0	282,0	282,0	272,4
Total consumption of pesticides (according to the quantity of active substance), t	431,0	349,4	412,9	508,6	348,7	403,4
Total consumption of pesticides per unit of land, kg/hectare	1,5	1,2	1,4	1,8	1,2	1,5

Source: Statistical Committee of the Republic of Armenia, www.armstat.am.

3.1.2 Fish Farming

Data Gaps

- Uncertainty of data on fish farms
- Real water abstraction of fish farming
- Data on phosphorus release from fish farms
- Fish-farm impact on water quality of Lake Sevan

There are different data sources on the fish-farming which contain completely different information (Water Resources Management Agency, Gegharkunik Regional Administration, Ministry of Agriculture). As of January 2018, there were 10 fish farms in the Sevan RBD. The total annual permitted water use for fish farms composed 12,634 thousand m^3 permitted water use**.** These farms occupy 29,464 m^2 of land and abstract water from 5 natural springs. 13 groundwater wells and two rivers (Argichi).The fish farms mainly located in the Gavaraget, Karchaghbyur, Argichi and Martuni River Basins.

Table 27: Fish-farms in Sevan RBD

N	River Basin	Settlement	Number of fish farms/number of ponds	Area, m^2	Fish type	Productivity, t/y
	Gavaraget	Gavar, Sarukhan	5/26	6700	Rainbow trout	10
	Karchaghbyur	Karchaghbyur	1/20	1000	Sevan Trout	200
	Dzknaget	Tsovagyugh	2/26	20864	Sevan Trout	200
	Lake Sevan	Near Hayrivanq village	1/12	4000	Sevan Trout	60.86
	Lake Sevan	Near Shorja village	¼	800	Sevan Trout	50

In the Minor Sevan, two cage farms are operated. One of them is located near the Shorzha village. From 2012, 4 cages have been installed with the area of 6,400 m^2 and capacity 50t. The second fish cage farm is located near the Hayrivank village and operating since 2017. It occupies 82,425 m^2 and produce about 60.86 t fish.

The cage farms and fish farms located in Lake Sevan can have an influence on the water quality and the bottom quality of the rivers and Lake Sevan. The eutrophic impact of fish farming has not been intensively studied yet and phosphorus balance has not estimated. However, fish farms are source of phosphorus.

Figure 16: Fish farm in Sarukhan Community (2018)

3.1.3 Hydropower Generation

Data Gaps

- Water discharge after SHPPs

There are 9 small hydropower plants operating within Sevan RBD (Table 28) with a total installed capacity of 18678 kW. 9 small hydropower plants in the Gegharkunik province produce about 64 million kilowatts x hour electricity which constitutes 7.47% of the energy generated by Small HPP in Armenia and 0.8% of total generated electricity in Armenia.

Although the HPPs of the Sevan RBD are of small capacities, they cause significant pressures on water resources. Small hydroelectric power plants (HPPs) were built on the rivers without maintanance of environmental norms, which led to the distortion of the river basin ecosystems.

Detailed description of hydromorphological alteration in the streams of Sevan RBD is produced by another project[18] According to the results of above mentioned project the ecological flow has not maintained in Tsakkar river.

According to the Armenian government protocol decision[19] the construction of SHPPs in Lake Sevan Basin is forbidden in order to improve ecological status of rivers flowing to Lake Sevan and restore fish stocks.

[18] "Delineation of surface water bodies in Sevan and Hrazdan River Basin in Armenia, EUWI+ project, 2018.

[19] RA Government Protocol Decision "On Approving Environmental Impact Assessment Standards for Small Hydro Power Plants Construction and Operation", 01.03.2018 N 8 "https://www.e-gov.am/protocols/item/876/

Table 28: Characterization of SHPPs in Sevan RBD

N	Name of SHPP	River Basin	Water source	Capacity, KW	Water abstraction, thousand m^3/day	Ecological flow maintained	Fish ladder exist
1	Dzoragyugh-1	Tsakkar	Irrigation water pipe of Dzoragyugh	530	18.3	No	No
2	Dzoragyugh-3	Tsakkar	Irrigation water pipe of Dzoragyugh	274	18.3	No	No
3	Ayrk-1	Masrik	Ajrk tributary of Masrik river	209	33.1	Yes	-
4	Ayrk-2	Masrik	Ajrk tributary of Masrik river	659	30.9	Yes	-
5	Martuni	Martuni	Martuni river	1 800	49.0	Yes	Yes
6	Tsovak	Karchaghbyur	Lchavan springs on irrigatin water pipe	230	34.6	Yes	
7	Vardenik	Vardenis	Vardenis river	6 170	412	Yes	Yes
8	Argichi	Argichi river	Argichi river	8 400	150	Yes	Yes
9	Daranak	Daranak	Daranak river, left tributari of Daranak river	406	16.5	Yes	Yes

Source: Public Services Regulatory Commission, 2017;

Figure 17: Vardenik SHPP (Water Abstraction Structure) (2018)

3.1.4 Industry

In the Sevan RBD the main branches of industry are mining and manufacturing (Table 29).

The Gegharkunik Province is rich with metallic and non-metallic mines. There are operating 2 metallic and 21 non-metallic mines: gold, chromites, basalt, granite, marble, tuff, perlite sand and magnesium-silicate ore mines.

Table 29: Structure of the industrial product of the Sevan RBD by branches of industry

Branches of industry	Volume of Industrial Production by years, million AMD				
	2013	2014	2015	2016	2017
Mining and open mine exploitation	9170.3	8306.8	12877.4	14877.4	15098.2
Manufacturing	8164.4	9611.4	9823	9336.5	9363.4
manufacture of food products	8103.6	9580.9	9731.4	9093.7	8982.4
manufacture of beverages	4.5	5.1	77.1	195.2	106.2
manufacture of textiles	17.7	9.2	4.3	4.5	4.1
others	6.6	16.3	10.1	0.1	1.1

Data source: Statistical Committee of the Republic of Armenia

The main operating companies in the Gegharkunik province are classified as small and medium-sized enterprises. The GEOPROMINING GOLD LLC, which has a large stake in the mining industry, is specialized in precious metals mining, processing and it is one of the largest enterprises in the country. GPM Gold includes the Zod mine and the Ararat gold extraction plant. Ore from the Zod deposit is transported by rail to the Ararat processing plant, where it is milled and then processed.The mining activities in Sotk are one of source of non-point and point source pollution. Diffuse mine water can impact on water quality of Sotk and then Masrik Rivers and groundwater due to the high concentration of heavy metals.

Table 30: Mining Enterprises in the Sevan River Basin

Settlement	Name of Enterprise	Field of activity
Sotk	‘’Geo Pro Mining Gold’’ Ltd	Gold mining
Shorzha	"Gegamet plus’’ Ltd	Dunite (Chromite) and magnesium –silicate
Gavar	"Yeryuna"Ltd	gypsum
Artanish	Mika Cement Ltd	sand-gum
Geghamasar	"Kapavor" ltd	Sandstones
Geghovit	"Hayk Vardanyan"	Basalt
Lchashen	"Tuf-granit"	Basalt
Lchashen	"Gog-Ars" ltd	Volcanic slag
Tsovak	‘’Vardenisiqarhanq’’	Sandstones
Tsovak	‘’Regional unit of Vardenis’’ OJSC ‘’ of Agrospasarkum’’ IU	Pumice sands
Karmirgyugh	"Gavar CHSHSH " OJSC	Basalt
Dzoragyugh	"Kaloyan" Ltd	Perlite sand
Dzoragyugh	"Syuzi-Hrachya" Ltd	Basalt
Dzoragyugh	"Shoghag" Ltd	Perlite Sand
Masrik	"Vardenisi torf" Ltd	Torf
Noratus	‘’Mary and Hayk’’ Ltd	Sandstones
Geghakar	"Vardenis qarhank" OJSC	Subatan Tuf
Sarukhan	"Perlaro local investments" Ltd	Gabrons
Lanjaghbyur	"M.M.P.e" Ltd	Sand
Gegharkunik (Arevasar)	"Gri Nore" Ltd	Gabrons
Gegharkunik (Koghasar)	"Aratta Mining" Ltd	Gold
Makenis	"Aratta Mining" Ltd	Gold
Verin Shorzha	"Aratta Mining" Ltd	Gold
Shatjrek	"Aratta Lernayin" Ltd	Gold
Masrik	"Aratta Mining" Ltd	Gold
Aghberk	‘’Yerani Me’’ Ltd	Gabrons

Source: Republican geological fund. *www.geo-fund.am/en/Issued-permits*

Figure 18: Sotk Gold Mine (2016)

3.1.5 Tourism

Data gaps
• Sewage impact

Tourism is sufficiently developed in the Sevan RBD. There are 57 hotel facilities, hotel complexes, hotel cottages, stone and wooden cottages, hospitality families and so on. Tourism in the region is characterized with strictly seasonality. The overwhelming majority of incoming tourists, especially those who visit the region for the sake of leisure, come to Lake Sevan in the period from June to September, and the number of tourists in the rest of the year is considerably shorter. Generally, about 1.5 million people visit to the Sevan region.

In the territory of the Sevan National Park (in Recreation Zone) 8 public beach territories have been allocated according to the RA Government Decisions[20]. About 250 to 300 thousand people annually visit public beaches.

Figure 19: Public Beach near Sevan Town (2018)

3.1.6 Solid Waste Landfills

Only 11 communities in the Sevan RBD have the operating landfills, of which 2 are in Sevan, 2 in Gavar, 6 in Martuni, 1 in Vardenis (Table 31). The operating landfills annually accumulate 172 m^3 of waste in total.

In 34 communities of the region where 60% of the population of Marz lives, garbage disposal is carried out by specialized organizations. All 4 towns have specialized garbage disposal trucks which serve 29.8% of the population of the Marz. In communities, the collected garbage is shifted into open landfills. 4 towns of Gegharkunik Marz – Gavar, Martuni, Sevan, Vardenis have been included in the solid waste management program in Kotayk and Gegharkunik Regions, funded by the European Bank for Reconstruction and Development and the Eastern European Energy Efficiency and Environmental Partnership.

[20]Government Decisions N 527-N April 28, 2011, N-752 N of 7 June 2012 and N1122-N of 1 October 2015

Table 31: Operating Solid Waste Landfills within the Sevan River Basin

Settlement/SWDS		Service	Opening year	Status	Area, ha	Accumu lated waste, m³/year	Type of SWDS
Sevan region	Chkalovka	Chkalovka. Sevan. Lchashen. Varser	2008	operating	2.5	36.75	Unmanaged
	Tsovagyugh	Tsovagyugh	2010	opereting	1.0	5.2	Unmanaged
Gavar region	Noratus	Gavar. Noratus	2004	operating	5.0	40.82	Unmanaged
	Karmirgyugh	Karmirgyugh. Saruxan	2008	operating	2.5-3.0	17.03	Unmanaged
Martuni	Martuni	Martuni	1995	operating	4.5	15.73	Unmanaged
	Vardenik	Vardenik	2005	operating	1.5	11.44	Unmanaged
	Tsovinar	Tsovinar	2008	operating	0.2	5.85	Unmanaged
	Yeranos	Yeranos	2002	operating	1.4	6.89	Unmanaged
	Geghhovit	Geghhovit	2007	operating	1.0	7.41	Unmanaged
	Zolaqar	Zolaqar	2007	operating	0.5	8.06	Unmanaged
Vardenis	Vardenis	Vardenis	1992	operating	5.0	16.51	Unmanaged

Source: RA government decision N22. 2011

Issues related to waste management in the Sevan RBD are a priority and urgent, due to lack of sanitary municipal waste landfills, compliant with the requirements of urban development, lack of separate collection of industrial and municipal wastes, as well as lack of actions aimed at waste prevention, collection, transportation, storage, processing, recycling, reclamation, removal, decontamination and disposal.

There are also considerable construction waste and municipal solid waste accumulations in various sections of the cities, communities, gorges, watercourses, irrigation canals, etc., which significantly impact the ecological status of the river basins and lake Sevan. During rainfalls and snowmelts, waste accumulated in the city area is washed with water, and the latter results in infiltration of hazardous chemical compositions into groundwater basins, rivers and Lake Sevan.

According to national norms, one person annually produces 1.3 m^3 garbage. Taking into account only population of Gegharkunik province in the Sevan Basin, about 390,000 m^3 garbage produced annually in the basin (not included the garbage produced by tourists).

Figure 20: Open Dump near Hayravank Community (2018)

3.1.7 Transport

The total length of roads in the Sevan RBD is 1681 km (Table 32).

Table 32: Roads of the Sevan RBD by their Significance

Area	Total roads, km	Inter-state roads, km	National roads, km	Community roads, km
Sevan RBD	1681	286	36	1359

Source: Geocom Ltd.

Cargo and passenger transportation in the Sevan basin is carried out by roads and, partially, by railway. During the last years the community roads in the river basin were renovated. However, many intercommunity roads are still in a poor condition.

Table 33: Passenger and Cargo Transportations in the Sevan RBD in 2017

Area	Cargo transported, thousand tons	Cargo circulation, million t/km	Passenger circulation, million passenger/km
Sevan RBD	17934.7	77.4	39.4

Source: National Statistical Service of the Republic of Armenia, 2017

Figure 21: M10 Inter-State Road near Lchashen Village (2017)

Transportation affects water quality directly in the following ways: 1) road construction and maintenance, including the creation of impervious surfaces can adversely affect water quality due to faster rates of runoff, lower groundwater recharge rates, and increased erosion; 2) pollutants such as vehicle exhaust, oil, and dirt, and deicing chemicals, are deposited to roadways and other impervious surfaces; The pollutants are either directly leaked into the natural water system, or pollutants are air-borne and then deposited. Dealing with pollution from transport is a complex task and special research needs to assess the impact.

3.1.8 Future Infrastructure Development

The main priorities of the territorial development strategy for 2017-2025 in the region are:

- Modernization of agriculture.
- Maintaining the ecosystem of the Lake Sevan and developing tourism with emphasis
- rural tourism.
- Renewable energy production and efficiency enhancement.

3.2 Pressures and Impact

Pressure-Impact Analysis

The need for conducting analysis of pressures and impacts for the river basin planning is formulated in Article 5 of the EU WFD. Following Article 5 and the EC CIS Guidance Document #3 on the Analysis of Pressures and Impacts (Impress Document), the Driver-Pressure-State-Impact-Reponses (DPSIR) approach has been implemented within this RBMP to identify significant pressures and to analyse related impacts in. In addition, the EPIRB Guidance document on “Addressing hydromorphology and physico-chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD” (2014) was used.

Pressures stemming from the drivers discussed in Chapter 3.1, such as change in the flow regime and discharge and/or chemistry of waters, are analysed according to the following types of pressures:

- point source pollution;
- diffuse source pollution; and
- quantitative pressures.

3.2.1 Point Source Pollution

Following the identification of key driving forces and water management issues, the section outlines existing pressures in the Sevan Basin (Map 21).

3.2.1.1 Municipal Wastewater Discharge

Data gap

- Data on wastewater composition

The municipal wastewaters are not treated at all before being discharged into the rivers (direct emission) or public sewer systems (indirect emission) and then to the Lake Sevan. There are three mechanical treatment stations in the Sevan RBD which are located in Gavar, Martuni and Vardenis cities. The wastewater treatment plants only do the following: collect wastewater from towns and then conduct mechanical treatment – screening and sedimentation of suspended and solid particles. As a result, the semi-treated wastewater is deposited directly into the rivers. The sewage sludge penetrates into the underground waters, deteriorating their quality.

In the basin not all communities have sewerage networks. Total length of network is 50.4 km, and total amount of domestic wastewater discharged in the sewer networks is 4.2 million m^3/year. Due to the absence of a sewage network in many residential areas of Gegharkunik province, residents use in their own sewage wells in the yards. According to the statistical data based on the population number total wastewater discharge into the Gavaraget, Martuni and Masrik Rivers is 2672.1 m^3/day. The data on wastewater composition could not be obtained.

Figure 22: Wastewater Treatment Plant in Artsvakar District of Gavar Town (2018)

Untreated wastewater from municipalities is the significant source of organic pollution. Organic pollution can cause significant changes in the oxygen balance of surface waters. As a consequence it can impact upon the composition of aquatic species/populations and therefore water status. Organic emissions and their impact can be measured and expressed with parameters like COD (chemical oxygen demand). BOD_5 (biological oxygen demand) and TOC (total organic carbon).

To analyze pressures from municipal wastewater discharge, the simplified model of point source pollution has been applied which was adapted and used for the other RBM plans (Akhuryan, Debed, Aghstev and Araratyan) in Armenia.

The impact of wastewater was considered as a point source pressure in Sevan RBD, and the assessment of the impact was conducted based on the number of population and wastewater discharge. Domestic wastewater can be characterized by the following parameters:

Table 34: Domestic wastewater characterization

Parameter	Person equivalents. gram/capita*day
BOD_5	60
Suspended solids	90
Phosphorus	3
Nitrogen total	15.5
Ammonium	10.3

The assessment of emissions shows that the total emission contribution from large agglomerations (>10.000 PE) is 1906.8 t/a for COD, 1271.2 t/a for BOD_5, 63.6 t/a for total phosphorus, and 328.4 t/a for total nitrogen (Table 35). Contribution of emission is substantially higher (76 % higher) from rural communities.

Table 35: Nitrogen, phosphorus, SS, COD and BOD_5 emissions from communities entire Sevan Basin

Settlement	Population	P- total, t/a	N-total, t/a	N-ammonia, t/a	BOD_5, t/a	COD, t/a	Suspended solids, t/a
Gavar	29146	31.9	164.9	109.6	638.3	957.4	957.4
Martuni	13627	14.9	77.1	51.2	298.4	447.6	447.6
Vardenis	15272	16.7	86.4	57.4	334.5	501.7	501.7
Total	58045	63.6	328.4	218.2	1271.2	1906.8	1906.8
Rural communities	183381	200.8	1037.5	689.4	4016.0	6024.1	6024.1
Total emission	241426	264.4	1365.9	907.6	5287.2	7930.8	7930.8

As data on wastewater composition could not be obtained, the assessment done based on population and wastewater discharge flow. According to the statistical data (The sewage system of the Republic of Armenia in 2017) annual discharge of wastewater from Gavar, Martuni and Vardenis cities and estimated concentration values of total nitrogen, ammonia-nitrogen, total phosphorus, suspended solids, COD and BOD5 concentrations in wastewater are presentedin the Table 36.

Table 36: Estimated composition of wastewater of cities

Settlement	Wastewater flow, l/sec	P- total, mg/l	N-total, mg/l	N-ammonia, mg/l	BOD_5,mg/l	COD, mg/l	SS, mg/l
Gavar	13,4	33,4	172,7	114,8	668,5	1002,7	1002,7
Martuni	7,1	14,9	76,8	51,0	297,2	445,8	445,8
Vardenis	10,5	7,6	39,2	26,0	151,7	227,6	227,6

As a result of applying the mentioned approach, Martuni, Gavar and Vardenis cities are considered as potential sources of significant pressures in the Sevan Basin. Using the above-mentioned method, the impact of these sources of pressure was assessed.

Subsequently, having the discharge of wastewater, the concentrations (mg/l) of the above mentioned components in wastewater can be calculated. Having the inflow rate of the aforementioned components in wastewater, as well as the value of minimum river flow, it is possible to calculate the expected concentration of each component in the river water, using the simplified model. Pollutant concentration (C) in the location of the point pressure in river water was calculated by using the following formula:

$$C = (Q_0C_0+Q_1C_1)/(Q_0+Q_1).$$

where Q_0 is the river discharge before the source pressure point. C_0 is the pollutant concentration in the same point of the river water. Q_1 is the volume of wastewaters discharged in the location of pressure, C_1 the pollutant concentration in wastewaters. Following the same logic, the concentration of pollutants penetrated into the river flow through water discharge was calculated, which were viewed as a quantity of point pressure:

$$C=Q_1C_1/(Q_0+Q_1).$$

In order to assess the pressure of municipal wastewater discharge, an approach taking into account the number of population was used. Weather is a variable included to calculate the BOD_5 value. According to the Water Quality Guidelines Memorandum #1 of 1978, 1mg/l of BOD_5 is considered as a maximum permissible amount in summer low water conditions and any excess is viewed as a significant pressure. Based on the well-known standard, according to which the BOD_5 load discharged by wastewaters is calculated as N*60g/day, where N is the number of population, the concentration (C) of this pollutant was calculated at the point of discharge in river water by the following formula:

$$C=((60*N*1000)/ (24*60*60)) / Q_0 \text{ mg/l}$$

The results of the assessment are summarized in Table 37 below:

Table 37: Estimating concentration Pressure from Wastewater of the Cities of the Sevan Basin

Communities	River flow, m^3/s*	P- total, mg/l	N-ammonia, mg/l	BOD_5,mg/l	COD, mg/l	Suspended solids, mg/l
Projected increased values						
Gavaraget	3.63	0,10	0,24	2,9	20,9	9,1
Martuni	1.53	0,12	0,24	3,1	16,4	13,7
Masrik	3.5	0,07	0,18	2,4	18,1	26,2
Before influence of wastewater (monitoring data)						
Gavaraget (sampling site №77)		0,08	0,17	2,5	20,4	8,5
Martuni (sampling site №71)		0,08	0,09	2,2	15,2	12,5
Masrik (sampling site №62)		0,06	0,13	2,1	17,7	25,8
After influence of wastewater (monitoring data)						
Gavaraget (sampling site №78)		0,24	0,45	2,7	24,4	14,1
Martuni (sampling site №72)		0,14	1,12	2,5	18,6	10,2
Masrik (sampling site №63)		0,13	0,25	2,7	20,2	24,4

*Annual average flow data were used.

The results show that there are significant differences between water quality monitoring data and model calculated values for total phosphorus and ammonia, indicating existence of other source of pollution after discharge of domestic wastewater.

This difference also could be explained by the fact that recognition of the point nature of pressure of municipal wastewaters and use of the model are most probably incomplete or limited. Firstly, there are great losses in sewage pipelines, which lead to dispersion of wastewaters and reduction of the impact on river water quality. The process of self-purification also needs to be taken into account, which is apparent from relatively low values of actual concentrations of nitrogen and phosphorus. The concentration trends of BOD_5 and ammonia nitrogen are presented in the Figure 23 and 24. The data show that nevertheless the impact of domestic wastewater in the river basins is different the concentration values of BOD_5 are similar indicating the intensity of self-purification of rivers.

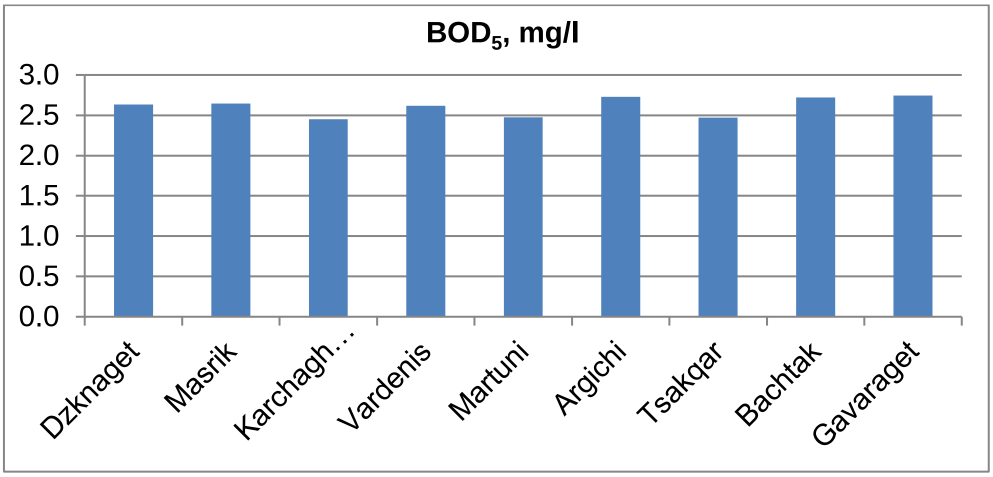


Figure 23: BOD5 concentration in Sevan basin rivers (Source: EMIC, 2017)

The concentration trend pattern of ammonia differs from BOD_5. The high concentrations of ammonia (Figure 24) are observed in Vardenis, Martuni and Gavaraget Rivers.

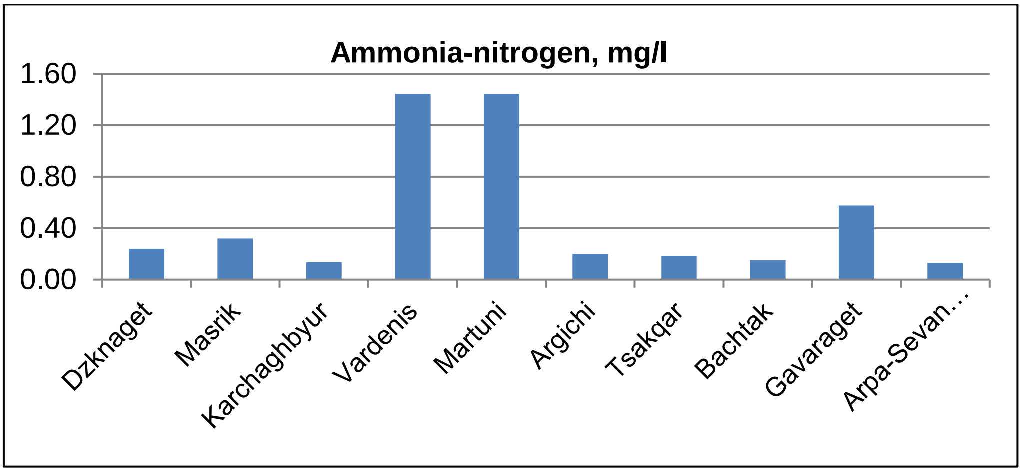


Figure 24: Ammonia concentration in Sevan basin rivers (Source: EMIC, 2017)

Impact: Data shows that point source pollution from municipal wastewater is a significant pressure and impact on water resources chemistry and biology within the Sevan RBD.

3.2.1.2. Wastewater Discharge from Food Industry

Data gap

- Data on wastewater composition and volume in each river basin in Sevan RBD

Manufacturing industry of food and beverage, the volume of which is increasing year by year, currently it constitutes only 10-15 % of the total industry. Food and beverage industry wastewaters are discharged into the sewage network in the Sevan RBD, therefore the impact of these water flows is added to the impact from municipal wastewater.

Impact: Taking into account small volume of food and beverage industry in the basin, the pressure and impact on quality of water resources of the Sevan Basin is not significant.

3.2.1.3 Solid Wastes

Data gap

- The amount of waste generated per stream basin in the Sevan RBD

There are 11 officially operating landfills in in the Sevan RB (Table 31). The operating landfills annually accumulate 172 m^3 waste in total. In 2017, the annual household waste generation per capita was 20.2t. All the mentioned landfills are in a poor condition. Landfills have turned into areas of irregular waste piles. They lack filtrated wastewater collection systems, and, as a result, wastewaters infiltrate into soils, causing pollution of ground and surface waters. In the Sevan basin industrial and construction wastes are transported together with solid wastes to urban and rural landfills. In many places domestic solid waste directly realises into the streams (Figure 25). Infiltration of pollutants from solid waste into groundwater can cause long-term damage. Repairing this damage is both technically difficult and very expensive.

It can be concluded that solid wastes have certain local impact on quality of water resources of the Sevan RBD. Thus, it cannot be considered as significant pressure due to spatial distribution and small footage area. However, the local impact of solid wastes on water quality shall be checked.

Figure 25: Tsakkar (left) and Martuni (right) rivers polluted with household waste (2018)

3.2.2 Diffuse Sources of Pollution

Diffuse source pollution is caused by widespread activities such as agriculture and other sources (see Figure 26). The levels of diffuse pollution are not only dependent on anthropogenic factors such as land use, and land use intensity, but also on natural factors such as climate, flow conditions and soil properties. These factors influence pathways that are significantly different. For N, the major pathway of diffuse pollution is groundwater while for P it is erosion. The emission of substances from diffuse sources cannot be easily measured. The emissions estimation of diffuse source pollution for Sevan Basin is only possible by mathematical modeling.

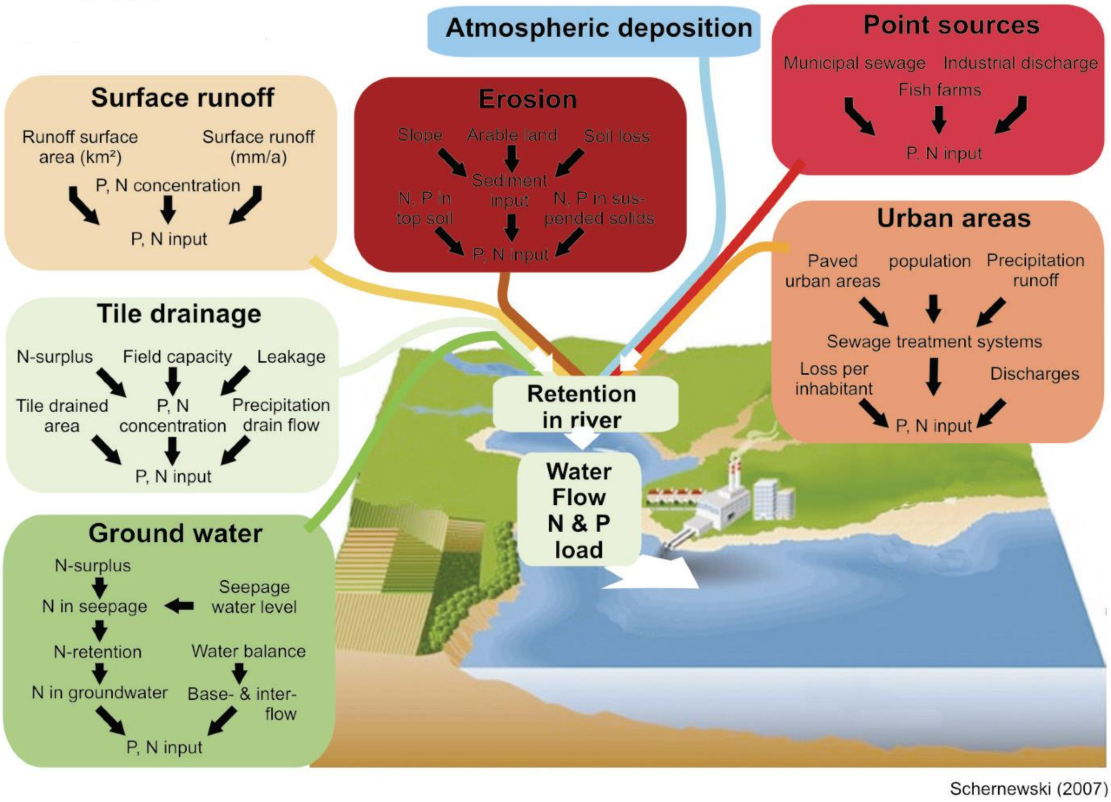


Figure 26: Main processes in relation to sources and pathways of nutrient inputs

The main contributors for both N and P emission are settlements not served by sewerage collection and wastewater treatment. For N pollution, the input from agriculture (fertilizers, manure, fish cages) is the most important. For P, emissions from agriculture (area under cultivation, erosion, detergents, fish cages, livestock manure) are the second largest source aftermunicipal wastewaters.

3.2.2.1 Cultivation of Agricultural Crops and Use of Fertilizers

About 11.6 % of agricultural lands in the Sevan RBD are arable lands. In 2017, 30000 ha of arable lands of the river basin were cultivated. Grains crops accounted for 44% of the agricultural crops in the Sevan Basin. The most cultivated lands are located in the Masrik, Gavaraget and Argichi River Basins. According to the information obtained from the Gegarkunik province 2000 tons of mineral fertilizers were used for agricultural crops in the river basin in 2017. Fertilizers were used only on permanent croplands, with about annual average area of 8000-10000 ha cropland treated by fertilizers. The are no data available on the organic fertilizers in the basin. About 2000 kilograms of mineral fertilizers were applied for 1 ha which is similar to on average 150-200 kg required value for 1 ha with similar agricultural crops.

Based on information that fertilizers are applied evenly on agricultural lands across the RBD, and based on figures available on agricultural lands and total fertilizers applied, it is proposed to conduct more studies aimed on revealing the impacts of nitrogen fertilizers used in the in the Sevan RBD on water quality.

3.2.2.2 Livestock Production

Manure from livestock production is one of the pressures on water resources of the Sevan RBD. Manure is washed into surface waters and infiltrates into groundwater resources, leading to increased concentrations of nitrogen, phosphorous and organic compounds in the waters.

Livestock production is a traditional branch of agriculture in the **Sevan River Basin District**. Natural climatic conditions and extensive pastures are favorable for development of cattle breeding, particularly in Masrik, Argichi, Gavaraget and Martuni River basins. After collapse of the Soviet Union and subsequent economic crisis, the total number of livestock significantly decreased in the Sevan RBD However, during the recent years an increase of the livestock capita has been recorded (Figure 27).

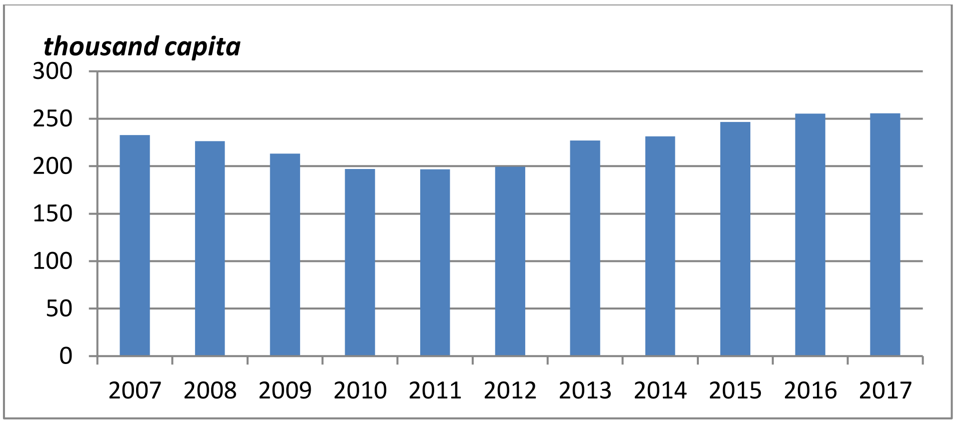


Figure 27: Total livestock in the Sevan River Basin, 2007-2017, thousand capita (Data source: Statistical Committee of the Republic of Armenia)

Data on pollution loads of nitrogen and phosphorous from the livestock production in the Sevan basin as of 2017 is presented in Table 38 below.

Table 38: Annual Pollution Loads from Livestock Production in the Sevan Basin, ton/year

Livestock	Capita	Norm from 1 animal, ton/year per anima			Total, ton/year		
		Manure	Nitrogen	Phosphorus	Manure	Nitrogen	Phosphorus
Cattle	124900	8	0.0055	0.0013	999200	687	162
Pigs	15900	2	0.0059	0.0020	31800	94	32
Sheep and goats	113400	0.4	0.0107	0.0022	45360	1213	249
Poultry	340000	0.04	0.0130	0.0041	13600	4420	1394
Total					1089960	6414,1	1837,7

Basin analysis indicates (Number of livestock production, Table 38) that the number of livestock is correlated to the concentrations of total inorganic nitrogen (Figure 28). The highest concentrations are observed in the Masrik, Gavaraget, Martuniand Vardenisriver sbasin of the Sevan Basin.

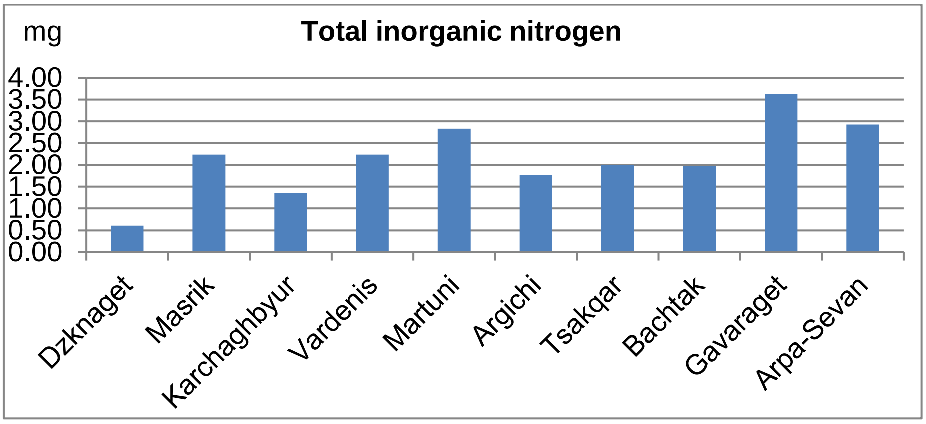


Figure 28: Total Nitrogen in the Sevan River Basin, 2007-2017, thousand capita (Data source: Statistical Committee of the Republic of Armenia)

Summarising the situation regarding nutrient inputs from the agricultural sector, emissions from diffuse sources (such as those from mineral and organic fertilizers and manure) are significant. **Livestock production is having a significant pressure and impact on quality of water resources in the Sevan RBD.**

3.2.2.3 Nutrient Pollution

Nutrient pollution – particularly by Nitrogen (N) and Phosphorus (P) - can cause eutrophication of surface waters and long-term pollution of groundwater, particularly where aquifers are not protected by overlying impermeable layers. Further, their emission and discharge into Lake Sevan can significantly impact upon the status of ecosystem. For the period 2013-2017, the total nutrient load was estimated taking into account the major rivers of Sevan basin discharging into the Lake Sevan. The total load of nutrients was estimated about 85.0 tonnes of P and 18,6 tonnes of inorganic N into the Lake each year by the rivers. The estimation was done based on the monthly monitoring data for 9 rivers. These values do not include the load directly flowing into the lake.Thus, the present level of the total nutrient load into the Sevan Lake is considerable higher than estimated.

Phosphorus load from fish cages has not estimated due to the lack of data.

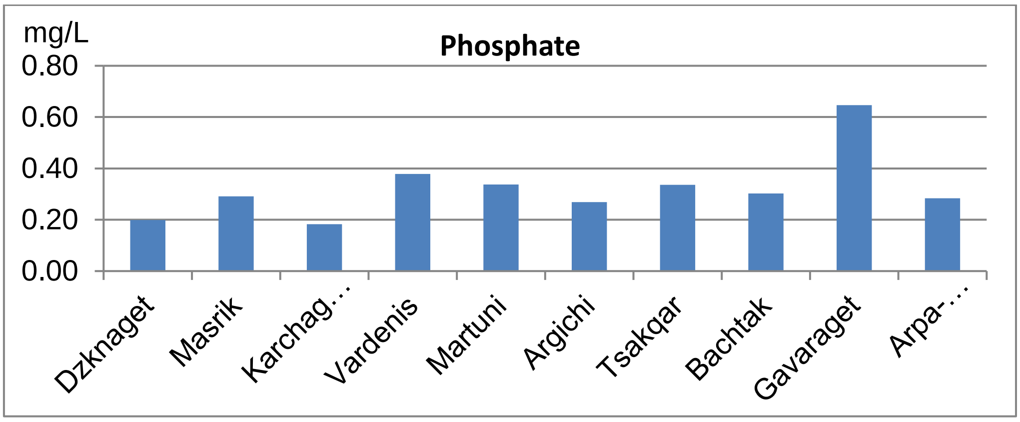


Figure 29: Phosphate concentration in Sevan basin rivers (Source: EMIC, 2017)

3.2.2.4 Vehicle Transport

Based on the analysis and evaluation of the highway traffic density and freights conducted at the stage ofthe basin analysis, as well as taking into account the fact that roads mainly pass by locations far from surface and ground water resources, **it can be concluded the that vehicle transport does not pose a significant pressure and impact on water resources.**

3.2.3 Quantitative Pressures: Water Abstraction and Services

Data gaps

- Amount of water used without permits

Water abstraction and allocation in the Sevan RBD is carried out for drinking-household, irrigation, industrial, hydropower generation, fish-farming and watering purposes. As of January 2018, according to the water use permits, the recorded water abstraction in Sevan RBD was 337,586.7 thousand m^3, from which about 80% abstracted from surface water sources, and 20% - from groundwater sources. Detailed analysis of water use is presented in the Chapter 7.2.1 of this Report (“Status of key water users”) (Map 22).

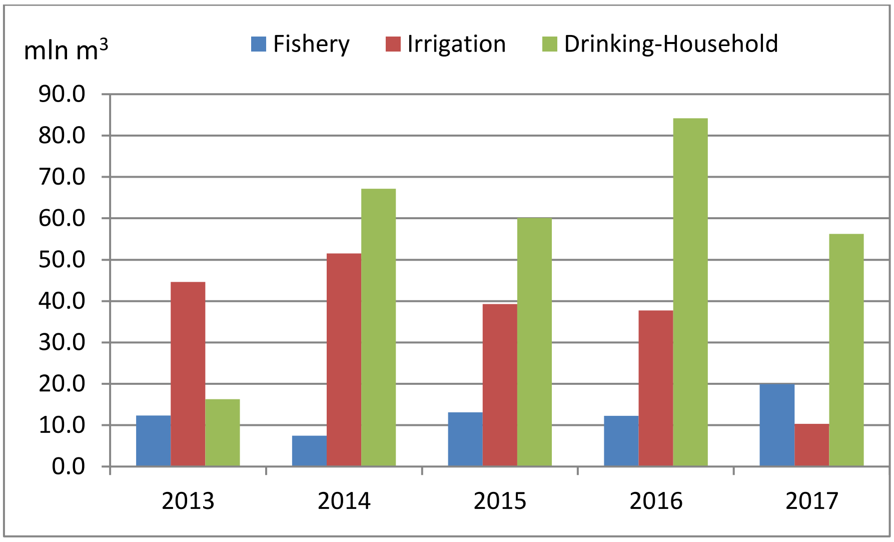


Figure 30: Water use permits by sectors, from 2013-2017, (Data Source WRMA, www.wrma.am)

It should be mentioned that unknown amount of water is used for irrigation. watering and drinking-household purposes by the population of communities of Sevan RBD without water use permits.

Lake Sevan has environmental, economic, and social significance and is an important water source for irrigation, hydropower, and recreational uses. In additional to environmental, economic and strategic importance, the role of the lake is extremely important for mitigation of irrigation water deficit.

Particularly, releases from the lake help in supplying additional water to the basins of Aparan and Marmarik Reservoirs, and the agricultural lands areas of Ararat valley and adjacent sub-mountainous zones.

The level of Lake Sevan fell dramatically due to excessive use during the period from 1930 to the 1980s, resulting in serious environmental and ecological problems, including deterioration of water quality, destruction of natural habitats, and loss of biodiversity. Starting in the 1980s, programs to stabilize and raise the lake level were initiated. This includes the construction of the Arpa-Sevan and Vorotan Arpa tunnels, transferring up to 250 and 165 million m^3, respectively, and outflow limits up to 170 million m^3 per year. As a result, the level of Lake Sevan has been steadily rising since 2001.

In 2017, about 111 million m^3 of water was transferred to the lake through Arpa-Sevan tunnel. As of December 31, 2017 the level of the Lake Sevan was 1900.42 m.

Water abstraction from Lake Sevan for irrigation purposes are made pursuant to the requirements of Article 6.1 of Chapter 6 of the Republic of Armenia law “On Adoption of the Annual and Complex Program of Activities for the Use, Protection, Reconstruction and Reproduction of the Lake Sevan Ecosystem”. According to this, the Government of Armenia each year adopts a corresponding Resolution on the volume of releases from the Lake, within the maximum volume of 170 million m^3.

The indicators from the recent years on the releases from the lake and changes in the water level show that the releases from the lake for irrigation purposes mostly do not have dominant impacts on the water balance of the lake, which cannot be claimed for waterAscarce years. For water scarce years, taking into consideration the requirements of Article 92 of the Water Code of Armenia there is a possibility to declare water scarce year with special restrictions on the water releases and water use permits. For example, on September 18, 2014 Government Resolution No 1111AN was adopted, which defined water scarcity in Ararat, Hrazdan and Akhuryan River Basin Districts. This allowed the Water Resources Management Agency to revise all water use permits issued in these RBDs, and make corresponding adjustments (reductions in abstraction limits), taking into consideration the extent of the water scarcity.

Water released from the lake for irrigation purposes first is transferred through the Sevan Hrazdan derivation system, after which the water is abstracted by 5 primary canals (Kotayk, Arzni Shamiram, Lower Hrazdan, Artashat and Nork) in charge of irrigation water supply to WUAs. The head strictures of these 5 primary canals are already equipped with modern water measuring equipment.

At the same time, it should be noted, that water released for irrigation purposes is also being used by the HPPs of the derivation system. These HPPs have different operational regimes, and also sometimes cause fluctuations in the levels of water in their regulatory reservoirs. As a result of this, the regime of the water intake in the head structures of the above mentioned 5 primary canals is disturbed, which often causes shifts from the original plan schedule of irrigation water supply, based on the applications received. The releases from the Lake Sevan are measures and registered by the Hydrometeorological Service of the Ministry of Emergency Situations of the Republic of Armenia at Geghamavan hydrological post. In order to increase the control over water releases from Lake Sevan, downstream of Geghamavan hydrological post, as well as on Marmarik River at the inflow point to Akhpara reservoir, additional measurements equipment are installed, under the ownership of “Jrar” CJSC.

4. PROTECTED AREAS

In this Chapter the areas which have been designated as requiring special protection under Armenian legislation for the protection of their surface water and groundwater or for the conservation of habitats and species directly depending on water are described.

Protected areas are linked to several European Directives which the Republic of Armenia is committed to align with after the CEPA agreement signature with the EU. This register of protected areas shall be kept under review and up to date regularly.

4.1 Drinking Water Catchments

The prevailing part of Gegharkunik Marz (Gavar, Martuni and Vardenis regions) is rich with drinking water springs. Total proven resources of the Marz are 8000 l/sec, of which the springs are 4835 l/sec, wells - 3165 l/sec.

Table 39: Water Supply Sources in the Sevan RBD (Government Decree of RA N 746-N from 18.07.2013)

Regions	Water Supply Sources
Gavar	“Hacarat”, “Sarukhan”, “Khacher” springs; “Gandzak” wells
Sevan	“Hacarat”, “Makravan”, “Dzknaget” springs; wells; lake
Martuni	“Tsakkar”, “Bor-bor”, “Sarnaghbyur”, “Hopoyi var” and local springs
Vardenis	“Akner”, “Akunk”, “Masrik”, “Shatjrek” springs and springs above the settlements with local systems

According to information provided by the Gegharkunik regional center of the State Hygienic and Epidemiological Inspectorate of the Ministry of Health of the RA, as a result of microbiological, laboratory researches of drinking water of the population of the Marz, it is revealed that the water supply systems of the region are in poor sanitation condition.

48 of 98 catchments of 98 water supply providers in the Marz, (11 in Martuni region, 8 in Sevan region, 11 in Chambarak region, 3 in Gavar region, 15 in Vardenis region) are open, half-devastated and do not have determined sanitary protection zones. There is no guard service. There are no detecting disinfection equipments in the catchments (except for Gavar, Hatsarat, Khacher catchments).

Currently, 37 of the 72 daily regulation reservoirs (DRRs) are in ruins and non-hermetic conditions. 41 reservoirs haven’t sanitary protection zones. There is no guard service. Drinking water disinfection is not performed in the DRRs of the RBD. Therefore, no proper protection is undertaken for drinking water catchments and relevant structures district wide.

Sanitary protection zones of drinking water sources should be regulated according to the Resolution of the Government of Armenia No 64 of 2005 “On Criteria for Defining Territories for Sanitary Protection of Water Ecosystems, Flow Formation, Protection of Groundwater Resources, Water Protection, Ecotone and Inalienable Zones”. According to that Resolution it is necessary to designate water protection zones. Sanitary protection zones of water resources are necessary for protection of ecological, biological, hydrological and recreational values of water resources. They should include all territories envisaged for the protection of water resources. This includes all vulnerable locations of water resources, which can cause ecological disturbances of water resources and cause damage to human health and well-being (EUWI+, 2019g).

The internal water supply networks of the communities are in very poor conditions, which were built 20-40 years ago, often have accidents, and water losses are high (50-55%). The operation of the 11 water providers of the Marz is carried out by the Armenian Water and Sewerage CJSC's territorial branches, the rest are carried out by the communities that do not have a proper service and do not perform frequent quality control.

It should be noted that laboratory supervision is carried out only in Gavar AWSC, Geghama CJSC and “Sevan” Laboratory of Water Supply and Sewerage CJSC in the Town of Sevan. There is no permanent laboratory supervision in the remaining community water providers. Out of the 2915 bacteriological studies in the province, 274 have deviated from the norm (Project on Regional Planning of Lake Sevan Watershed Basin, 2013). The level of exploitation of water supply and drainage systems has fallen sharply. The condition of the water supply is poor.

On the other hand, "Veolia Jur" CJSC reports that in a result of bacteriological studies in Sevan RBD during 2018 deviations from sanitary norms and rules were not detected. "Veolia Jur" CJSC conducts monitoring on drinking water quality according to provisions on sanitaory norms and rules fixed in the Order N876 of the Minister of Health from December 25, 2002: “Drinking water: hygienic requirements to the water quality of centralized water supply systems. Quality control”.

The town of Sevan receives drinking water from Gavar’s “Hatsarat” springs through pump station with 250-270 l/sec capacity, from which the city of Sevan gets 30-50 l/sec (Map 24).

4.2 Specially Protected Nature Areas

4.2.1 Sevan National Park

4.2.1.1 Description of Sevan National Park

“Sevan National Park” was established in 1978, the area of which with a Lake Sevan is 147.343 ha, without the lake - 22.585 ha. Thus, the lake itself is a part of the protected area.

According to the Law on Sevan Lake adopted on May 15, 2001, the ecotone of the Lake Sevan is an interconnected transitional zone between water and land ecosystems, which includes coastal water and terrestrial areas. The boundaries of ecotone can vary within the range of 150 m depending on topography specifics. Lake Sevan and its ecotone area are state property and are not subject to alienation. The activities of Lake Sevan and its ecotone area are carried out in accordance with the procedure established by the Government.

The reserve zone of the Sevan National Park occupies 342.920 ha. It was established based on the extremely important task to conserve ecosystem and fresh-water resources of Lake Sevan, endemic fish (Sevan trout, Sevan barble, Khrami carp-Varicorhinus capoeta sevangi), vegetation, animal species involving Armenian seagulls and birds.

Sevan National Park is also rich with historical-cultural monuments: Sevanavank (X century), Hayravank (XII century), Vanevank (X century), a number of khachkars of Noratus and etc.

After the establishment of the Soviet Union in Armenia, Lake Sevan appeared on the nodal point of economic development and the creation of an energy base. It was decided to use the water resources and drain the Major Sevan in 50 years. The program started operating in 1933.

As a result of this project, lake regressed. The former Island Sevan turned into a peninsula, Lake Gilli in the Masrik plain dried up leaving only a small peat area. Fast aging of Lake Sevan started. The increase of organic matter in the lake, namely fixed nitrogen and phosphorus compounds as results of economic activity contributed to the aging of the lake. In 1963 the eutrophication or swamping of the lake began. Water “blooming” appeared due to drastic increase of blue-green algae and bacteria leading to the change of water color and transparence. In 1975-1978 the lake was under intensive eutrophication. The risk of swamping became alarming. The Lake Sevan problem emerged as the anthropogenic disturbance of the natural balance of the lake ecosystem.

Temperature of the surroundings is several degrees higher in the winter than in the highlands and less in the summer due to the lake. This means that the lake significantly soften the climate of its surroundings.

As a result of inefficient management of the forest (deforestation and cattle grazing) quercus macranthera (Caucasian oak), sorbus armeniaca, pyrus, high-mountainous maple and broad-leaved forests, as well as juniper forests almost disappeared. About 200 years ago large part of the Sevan basin were covered with this plants. Currently, some of them are preseved only on the northern slopes of the Areguni Ridge. Destruction of the Sevan basin forests contributed to the climate change (climate becoming drier).

Subsequently, lake level decrease has also contributed to the destruction of the rest, even the small forest masses, as the level of groundwater decreased along with it.

The lake flora includes algae (Chara, Spirogyra, Zygnemia, Euglena, Volvox, Oscillaria, Diatomeae etc.) as well as other aquatic flowering plants which occupy their own niche - the littoral zone of the lake down to several meters in depth. 19 out of 36 species of aquatic flowering plants common for Armenia occur in the lake. The genus Potamogeton L. (pondweed) is especially well represented with seven species occurring in the lake (narrow leaved Potamogeton pectinatus L., broad-leaved P. natans L., semi-transparent P. perfoliatus L. and others). They all grow either in water or on its surface. They bloom in small greenish flowers emerging from the water and then settle green or gray fruits.(Khanjyan, 2004)

The fauna of the lake is represented by invertebrates (water fleas - Daphnia, cyclops - Cyclopidae etc.) and vertebrates including mainly fish species. Poor species composition, prevalence of endemics and presence of species adapted to the lake environment again prove that the lake is unique. Endemic species Sevan trout (ishkhan) - Salmo ischchan is the gem of the lake fauna. It has silvery scale and delicious reddish meat. In the lake it is represented by four ecological races - winter ishkhan, gegharkuni, summer ishkhan and bojak. The races differ from each other externally, by the shape ofthe head and body, color of scale and reproduction peculiarities – spawningseasons and grounds. Bojak and winter ishkhan multiply in the littoral area ofthe lake, summer ishkhan - in the lake and in cold rivers flowing into the lake,while gegharkuni rises upstream to lay spawns. Unfortunately, artificial decrease in water level and pollution of river mouths affected ischchan. Ischchan having economic significance due to its nutritional value and great demand appeared in danger of extinction and was registered in the Red Data Book of Armenia (Harutyunyan, 2005).

Sevan beghlou (barbus) is also registered in the Red DataBook of Armenia. Among fish species it is worth mentioning as well Sevan koghak (Varicorhinus capoeta sevangi), Sevan white fish (the hybrid introducedto Lake Sevan from Lakes Ladoga and Chud in the 1920s) and goldfish (silvertsatsan) which was brought to the lake accidentally in 1983. The latter reproduces itself very well in the lake due to its adaptability. The same is true for crayfish. The commercial significance of Sevan white fish became particularly evident during the economic crisis of Armenia. During economic hardship white fish was an essential food product due to its affordable price.

List of rare species of mammals is presented in the table below:

Table 40: Rare Species of Mammals within Sevan RBD

Name	Spread
Porcupine	Artanish and surrounding forest areas
Edible dormouse	
Eurasian otter	Along the Artanish, Gilli, Lichk, Karchaghbyur rivers and streams
Brown bear	Artanish: forest areas
Marbled polecat	Artanish, Karchaghbyur: conservation zone
Wildcat	Artanish: conservation zone
Wild goat	Artanish, Sevan Range: conservation zone
Brown long-eared bat	The northern coast of Lake Sevan
Lynx	met in the northern part of the park

In the National Park and its conservation zone, the main factors affecting the condition of mammals are poaching, logging, insufficient feeding, and adverse conditions of seasonal and feeding migration routes.

The birds make another important and rich group of the lake's fauna. Pelicans (Pelecanus onocrotalus, P. crispus), common flamingo (Phoenicopterus ruber), scoter (Melanita fusca), mute and whooping swans (Cygnus olor, C.cygnus) and various species of ducks at the national park territory are registered in the Red Data Book of Armenia and the Red Data Book of the USSR (Khanjyan, 2004).

From 267 bird species In the National Park and its conservation zone 20 species are rare but not included to the Red Book. They are:

Table 41: Rare Species of Birds within Sevan RBD not included to the Red Book

Red–necked grebe	Lesser spotted eagle	Common sandpiper
Great crested grebe	Ruddy shelduck	Common tern
Little egret	Oriolidae	Long-eared owl
Grey heron	Thrush nightingale	European nightjar
Black kite	Little Ringed Plover	Western marsh harrier
Long-legged buzzard	Green sandpiper	Northern lapwing
Great spotted woodpecker	Eurasian crag martin	

Status of following bird species included to the Red Book is particularly disturbing due to scarcity and vulnerability of nurseries:

Table 42: Rare Species of within Sevan RBD included to the Red Book

Common raven	Whooper swan	Levant sparrowhawk
Great white pelican	Gadwall	Tawny eagle
almatian pelican	Marbled duck	Cinereous vulture
Great cormorant	White-headed duck	Lanner falcon
Northern shoveler	Montagu's harrier	Peregrine falcon
Common crane	Common rock thrush	

The main negative factors impacting the birds are the lowering of the lake level and the adjustment the drying of adjusted marshes in the National Park and its conservation zone.

Among other groups of fauna numerous species of reptiles (lizards – Darevskia unisexualis, D. nairensis, grass-snakes - Natrix natrix, N. tesselata, various species of snakes etc.), amphibians (green toad - Bufo viridis, frogs – Rana ridibunda, R. macrocnemus ect.) occur in the national park.

The total number of reptiles in the National Park and its conservation zone is decreasing as compared with 1972, which is caused by anthropogenic factors, in particular, by lowering the level of the lake and drying of reproduction sites.

Sevan Peninsula is one of the largest terrestrial areas of the national park, which was impacted by anthropogenic pressures during years and lost its original natural vegetation. It is edged with small artificial forests; patches of mountainsteppe vegetation have survived only on the hill top of the former island (Khanjyan, 2004). List of plants included in Red Book is presented below:

Table 43: Plants listed in Red Book, which Need a Special Attention

Genus, species	National Park	Conservation Zone	Comments
Peucedanum zedelmeyeranum	-	Lake Gilli	Probably disappeared species. Last registered in 1945.There are no materials in Herbarium of NAS Botany Institute.
Draba rigida	-	Near the village Shishkaya	Probably disappeared species. Last registered in 1923.

Isatis arnoldiana	-	Precise location is unknown	Probably disappeared species. There are no materials in Herbarium of NAS Botany Institute. Last registered in 1930.
Isatis sevangensis	-	Near the Artanish, Tsapatagh, Daranak villages	Probably disappeared species. Last refgistered in 1970.
Eleocharis uniglumis	Near the Tsovak village	Near the villages Noratus, Hayrivank, Sotk and towns Sevan and Gavar	Probably disappeared species. Last registered in 1966.
Puccinellia grossheimiana	Precise location is unknown	-	Probably disappeared species. There are no materials in Herbarium of NAS Botany Institute.
Falcaria falcarioides	-	Lake Gilli	Probably disappeared species. Last registered in 1966.
Prangos arcis-romanae	-	Near the villages Gomadzor, Tsamakaberd, Areguni and town Sevan	Status is poor. There is a negative impact from grazing. Part of population could be saved in case of appropriate protection regime.
Convolvulus calvertii	-	Near the Daranak village	Only one population is known. There is no danger of disappearance, however monitoring of status is needed.
Acantholimon gabrielianae	-	Near the Jil and Tsapatagh villages	Population status is good.
Menyanthes trifoliata	-	Lake Gilli	Status of studied population is good.
Botrychium lunaria	-	Near the Daranak village, Vardenis and Geghama mountain ranges	Populations status is good.
Polemonium caeruleum	-	Near the Semyonovka village	Populations status is good.
Lactucella undulata)	Near the Noratus village		Registered once in the past.

There are also a number of rare mushroom types within Sevan RBD.

Table 44: Distribution and Population Status of Rare Mushrooms

Name	Population Status	National Park	Conservation Zone	Impact Factors on Status
Tabular mushroom	Moderate	-	Near the Semyonovka village	Loss of settlements, picking of fruitbodies
Yellow–staining mushroom, Yellow stainer	Moderate	-	Near the Gavar town	Loss of settlements
Parasol mushroom	Poor/ threatened	Artanis Peninsula	–	Picking of fruitbodies
Desert Inky Cap	Poor/insufficient, threatened	Sevan Peninsula	-	Negative anthropogenic impact, Ecosystem degradation
og Stinkorn	Moderate	Martuni	-	Intensive forest exploitation, deforestation
Pepper pot	Poor/ threatened	Artanis Peninsula	-	Negative anthropogenic impact
Wrinkled Peach, Rosy Vein Cap	Moderate	Martuni-Lichk	-	Intensive forest exploitation, deforestation
Sarcosoma globose	Poor/ threatened	Sevan Peninsula	-	Negative anthropogenic impact, ecosystem degradation

Lake Sevan has significant spiritual and material value for Armenian nation. Lake Sevan is a national symbol and its water resources are of vital importance for the Armenian people. The ultimate goal of Sevan National Park is to protect this national wealth which is possible only by joint efforts through the reduction of water withdrawal via the River Hrazdan, raise of the lake water level and protection from wastewaters.

Management Plan of the “Sevan” National Park (2007-2011) assumes the creation of 4 reserve zones with a total area of 7464 hectares (the surface area is 4289 hectares, water - 3175 hectares) and 2 sanctuary zones with a total area of 2652 hectares (the surface area is 2359 hectares, water-293 hectares).

“Norashen” reserve: In the past, this did not exist, but the territory preserved as a reserve by the “Sevan” National Park. It covers an area of 839 hectares, of which the terrestrial area is 341 ha and the aquatic area is 498 ha. The objective of the reserve is to ensure natural livelihood and regeneration of birds (particularly Armenian seagulls).

“Lichk-Argichi” reserve: Covers an area of 1175 ha (of which the terrestrial part covers 482, the aquatic part is 693 ha). It includes the existing “Lichk” reserve (the total area is 600 ha, of which 350 ha of land, 250 ha of water), as well as the river mouth areas of the “Tsakkar”, “Lichk” and “Argichi” sanctuaries. The objective of the reserve is to ensure conservation of Lichk mineral water; aquatic and wetland biodiversity of residual lakelets near the estuaries of the Lichk and Argichi rivers, nesting areas of birds, and spawning and development of valuable and unique fish species Lake Sevan trout, Khrami carp-Varicorhinus capoeta sevangi and Sevan barbel – Barbus goktschaicus.

“Gilli” reserve: Covers an area of 1810 ha (of which the terrestrial part covers 1325 ha and the aquatic part - 485 ha). It includes the area of existing “Gilli” reserve (1000 ha land only).The objective of the reserve is to ensure conservation of riverheads of the Masrik and Geghamasar rivers for spawning and development of valuable and unique fish species and conservation of adjacent wetlands as a nesting area for birds.

“Artanish” reserve: Covers an area of 3640 ha, of which 2142 ha is terrestrial and 1498 ha is aquatic. The objective of the reserve is to ensure conservation of diverse relict plant species of before-glacial period, rare juniper forests and steppes of Artanish peninsula and conservation of migration routes for unique animal species (brown bear, roe deer, goat, boar, red deer (Capra aegagrus, Cervus elaphus, etc).

The existing “Karchaghbyur” (total area is 3750, of which 200 ha is terrestrial and 3550 ha is aquatic) and “Noratus” (total area is 3600 ha, of which 150 ha is terrestrial and 3450 ha is aquatic) reserve zones are included in economic zone of “Sevan” national park, taking into account the fact that in previous years they did not act as reserve zones (Project on Regional Planning of Lake Sevan Watershed Basin, 2013).

“Gavaraget” sanctuary (planned): Covers an area of 845 ha (552 ha is terrestrial and 293 is aquatic), includes part of river mouth area of Gavaraget and part of “Noratus” reserve (total area is 3600, of which 150 ha is terrestrial and 3450 ha is aquatic). The objective of the sanctuary is to ensure conservation of residual lakes near the mouth of the Gavaraget River, bird nests in the coastal area of Noratus peninsula, the development and spawning of the valuable and unique fish species.

“Juniper-Oak” Sanctuary - The sanctuary covers 1807 ha square and situated the southwestern slopes of the Sevan mountain range (Daranak, Pambak, Shapir, Tsapatagh and Jill river basins-1950m-2500m). The objective of the sanctuary is to ensure conservation of natural rare relict woodlands of oak and juniper.

4.2.1.2 Main Problems Identified in “Sevan” National Park

The main indicators of natural and anthropogenic changes in the Sevan basin are the activation of erosion, landslide and mudflow processes.

Problems in the National Park are divided into three groups:

Natural: degradation of forest landscapes on the eastern coast of Lake Sevan, active geodynamic processes (mudflows, weather and gravity substances and salinization processes), the impact of climate change on water resources (decrease of surface water resources), air pollution in the eastern coastal part of Lake Sevan (strong eroded fold mountains with poor vegetation).

Anthropogenic: Planning increase of lake level up to 1903 m, destruction of valuable biotopes under impact of tourism and socio-economic development, pollution of water objects and air, activation of erosion processes as a result of anthropogenic and agricultural load, unsustainable development of tourism and recreation within “Sevan” National Park.

Legal: National Park and indirect impact zones are influenced by local government bodies and the population for different purposes: hunting for fish and crayfish, forests protection, grazing of animals in vegetation areas which are registered in the Red Book of Armenia, violation of pasture and grassland regimes.

Particularly, consideration of the following issues is very important:

Emissions of hazardous substances into the lake: Due to the intensive development of the economy and inadequate disposal of polluted water, lake pollutants containing heavy metals, biogenic elements, fertilizers and pesticides have increased sharply.
The average annual substances released to the lake are 7,000 t of nitrogen, 400 t of phosphorus, about 13 t of pesticides and 135 t of heavy metals. The oil content in the lake has increased, which is associated with a sharp increase of water transport.

Loss of land: In addition to lowering of the lake level, artificial forests were planted in the grounds (13,000 ha), although erosion processes exist and contribute to the entrance of mineral compounds inthe lake.

Drying of natural reservoirs: About 10,000 hectares of wetlands have been dried in the basin of Lake Sevan. In the process of biodiversity loss, drying of Lake Gilli has particular importance.

Biodiversity loss: As a result of the drying of the stony bed, the spawning areas of the Sevan trout disappeared, which was the main cause of the irreversible loss of this type (generative). In recent years, the population of coregonus has declined. So as trophic chain, changes have additional influence on the quality of water in the lake, which contribute to eutrophication.

Unexpected breeding of crayfish and cyprinus has also took place in recent decades. Due to drying of Lake Gilli and other wetlands, only 18 out of 167 species of endemic and flight birds currently present. The number of mammals has also decreased.

Conflicts and discussions on the rise of the level of Lake Sevan: on the one hand, the infrastructures developed on the lake shores for decades are not ready for this, and on the other hand, some of the ecologists are for immediate rise of the level. There are also conflicts which are related to removal of artificial forests biomass from wetlands as well.

The conflict between preserving current land use composition in “Sevan” National Park and Lake Sevan Basin and sustainable development of recreation potential: that is to say, on the one hand, preservation of the lake water purity and ecological balance, on the other hand possibility of developing various types of tourism and sport (Sayadyan,2009).

One of the relatively large sections of the terrestrial area of the National Park is the Sevan peninsula, which was impacted by anthropogenic factors for many years and loses its natural vegetation. It is banded with artificial forests and only on the peak of the former island scraps of Mountain-steppe vegetation are preserved (Khanjyan, 2004).

Studies show that in the basin of Lake Sevan 159 species of birds are spread, especially ducks, anser, pelicans, ciconias, gruss, predatory birds: falcon, eagle, aegypiinae. 30 bird species are rare or endangered. Amphibians (lake frog, green toad) are also common in water areas. Before drying, the shallows, Gilli reservoirs and river mouths were nest for aquatic and marsh birds, which have fed with many insects, fish and amphibians. Some of them no longer exist. That is why currently, many birds reach the Sevan basin and do not find the Gilli swamps, fly away and move to the north. As a result, the birds of the Sevan basin are severely damaged (Harutyunyan, 1981).

4.2.2 Sanctuary Zones

“Juniper Sparse Forests” state sanctuary was established in 1958 and covers an area of 3312 ha. It is situated at the southern slopes of the Sevan mountain range (1900m-2200m) near Tsapatagh village. The objective of the sanctuary is to ensure conservation of natural rare relict woodlands of various species of juniper.

4.2.3 Nature Monuments

Sevan basin is also rich with natural monuments such as:

- Volcanic and cinder cone of the Vardenis mountin range (Azhdahak, Karmrasar, Spitakasar peaks)
- Mountain outcrops of surrounding Lanjaghbyur, Karmir gyugh, Gegharkunik villages
- Outcrops of ophiolitic rock on the slopes of Sevan mountain range (surrounding Shorzha village)
- Limestone outcrop of Artanish peninsula
- Obsidian outcrop in the eastern part of Spitakasar mountain,
- Eluvial scatterings (chingils) near the Lchashen village and Gavar town
- Gorges of Gridzor and Argichi rivers
- Cupuliform valley of upper streams of Martuni, Gridzor, Gegharkunik, Astghadzor and Vardenis rivers;
- Lichk, Karchaghbyur, Gridzor, Hatsarat, Yeranos, Gavar mineral and drinking water springs;
- Oak and juniper slender forests of the Areguni mountain range
- Various relictic forms of the Areguni, Sevan, Pambak mountain ranges
- Marshy meadows and cane fields of Masrik and Vardenis rivers valleys
- Scatterings: "lunar landscape" of the eastern slopes of the Geghama Ridge
- The Argichi River meanders and the marshland valley, gorges of rivers in the northern slopes of the Vardenis Ridge with relict forests.

The list of natural monuments approved by the Government of the Republic of Armenia is presented in Table 45.

It should be mentioned that some parts of the coast of Sevan are rich in tomb fields of archeological value that need to be studied (Project on Regional Planning of Lake Sevan Watershed Basin, 2013).

Table 45: Natural Monuments in Sevan RBD (Source: Ministry of Nature Protection of RA, 2014)

Geological monuments

1.	“Sevkatar” volcano	Gegharkunik Marz, 20 km east of Gavar Town
2.	“Azhdahak” volcano	Gegharkunik Marz, 25 km south-west of Gavar Town
3.	“Ananun/unknown” folding	Gegharkunik Marz, norheastern shore of the Lake Sevan, on the railway poster, about 45 km away from Sevan
4.	“Kare Tsov” scatterings (chingils)	Gegharkunik Marz, 1 km away from Lchashen village to the cinderal quarry
5.	“Ananun/unknown” expressed volcanic stratum	Gegharkunik Marz, 1 km south from Lchashen village to the operating quarry of volcanic cinder
6.	“Armaghan” volcano	Gegharkunik Marz, 3.5 km west from Madina village
7.	“Hayravank” fossil of fauna	Gegharkunik Marz, 2-3 km north-east from Hayravank village

Hydrogeological monuments

1.	“Sarants” spring	Gegharkunik Marz, In the Hatsarat district of Gavar, at 1937 m above sea level
2.	“Khacheri” spring	Gegharkunik Marz, western outskirts of Gavar
3.	“Artsunk kar” spring	Gegharkunik Marz, within Akunk village, at 1980 m above sea level from outskirts
4.	“Ananun” spring	Gegharkunik Marz, within Lchavan village, at 2045 m above sea level from outskirts
5.	“Ananun/unknown” spring	Gegharkunik Marz, south-eastern part of Karchaghbyur village, at 1930 m above sea level from outskirts
6.	“Vanki aghbyur” group of springs	Gegharkunik Marz, southern part of Sarukhan village, at 1977 m above sea level from outskirts

Hydrographical monuments

1.	“Akna” Lake	Gegharkunik Marz, 10 km west from Tsaghkashen village, on the slopes of Aknasar mountain

Biological monuments

1.	“Subalpian meadow”	Gegharkunik Marz, near Drakhtik village

4.3 Fish Species

From ancient times the Lake Sevan basin was famous due to its valuable fish species. In this region fishing was developing as the first sector of economy because of being favorite work of population. As a consequence of changes in the Lake water levels launched in the 20th century, severe socio-economic crisis and drying of lake spawnings and and contaminating rivers spawnings and uncontrolled hunting of the Lake fish, all together caused a drastically reduction of its amount.

The Lake is well-known for its endemic fish species: Sevan ischchan (Salmo ischchan); Sevan khramulya (Capoeta capoeta sevagni or Varicorhinus capoeta sevangi); Sevan barbel (Barbus goktschaicus)

The Sevan ischchan is divided into 4 ecological subspecies: winter bakhtak (Salmo ischchan ischchan), summer bakhtak (Salmo ischchan aestivalis), gegharkuni (Salmo ischchan gegarkuni), bojak (Salmo ischchan danilewskii).

However, nowadays winter bakhtak and bojak have disappeared irreversibly. Summer bakhtak and gegharkuni are artificially cultivated in the Ararat valley fish farms. Summer bakhtak and gegharkuni, as well as Sevan barbel (Barbus goktschaicus) are listed in the Red Book of Armenia.

The biological and ecological subtypes representing the Sevan trout (Salmo ischchan Kessler) differed in morphological features: Winter ischchan or bakhtak (Salmo ischchan ischchan Kessler) – lacustrine subspecies with autumn-winter spawning period. Gegharkuni (Salmo ischchan gegarkuni Kessler) is reproducing in the rivers in fall and winter seasons; Summer ischchan or bakhtak (Salmo ischchan aestivalis Fortunatov) spawning in spring in the rivers. Bojak (Salmo ischchan danilewskii Iakowlev) is lacustrine dwarf typewith reproduction period in winter-early spring.

Sevan khramulya (Capoeta capoeta sevagni De Filippi, 1865 or Varicorhinus capoeta sevangi) is represented by lacustrine, lacustrine-fluvial forms, as well as by exclusively fluvial form (Levin and Rubenyan, 2010). According to some authors (Gabrielian, 2010) Sevan khramulya was observed solely in the Lake Sevan basin. During the last decade Sevan khramulya stock has dramatically reduced. Overfishing is counted as one of major reasons, as well as competition with fish species introduced into the Lake ecosystem influenced in certain way.

Sevan barbel (Barbus goktschaicus Kessler, 1877) endemic specie, has three biological forms, and lacustrine-fluvial, thatdiffer in their living and spawning territories. This fish specie is also listed in the Red Book of Armenia.

In the past times the river trout (Salmo trutta Linnaeus, 1758) was very popular and lived mainly in rivers and streams: the alabalakhe could have been observed in the Lake Sevan tributary (river Makenis) that was later detached into separate specie, which differs from the Lake trout and never enters the Lake itself. Besides it was also found in Argichi and Masrik rivers. Karmrakhayt was registered in Armenian reservoirs (name is due tored spotson the body and back fin) such as Arpa River near Jermuk and Tsav River (r. Araks basin, left tributary).

Rainbow trout (Parasalmo mykiss Walbaum, 1972) is cultivated in the Ararat Valley, it can be found in Hrazdan, Metsamor, Vorotan (r. Araks basin) and Aghstev rivers (r. Kur Basin).

Whitefish or sig (Coregonus lavaretus Linnaeus, 1758) is an introduced species into the Lake ecosystem. In 1986 Dadikyan revealed structural differences, which became basis to separate it in to a new subspecie – Coregonus lavaretus sevanicus.

In 2016, whitefish industrial reserves were 450 t, in 2017 – 554 t. As for Sevan trout, in 2016 the reserves were 1-1.5 t, and 1.7 t in 201721. The crayfish reserves in 2016 were 4582 t, and 2600 t in 2017.From endemic species of Lake Sevan, labeobarbus and Sevan barbel populations are in very poor condition.

4.4 Recreational Zones (Public Beaches)

In the Sevan National Park and its conservation zone activities related to tourism and recreation are mainly carried out by organizations with a status of the legal entity acting on a contractual basis with Sevan National Park SNCO.

Since 2011, the National Park also has 11 free public beaches, 8 of which are territories allocated by relevant government decisions, and 3 have been allocated by the Sevan National Park[22]. 3 of the 11 public beaches are furnished with all the necessary things for a beach. Annual average amount of people resting at public beaches is 250 to 300 thousand.

The sanitary-hygienic state of a number of sites in the National Park is conditioned by solid waste accumulated in the tourist season or presence of technogene waste[23].

4.5 Ecological Zoning

Taking into account the fact that Lake Sevan is a strategic ecosystem and has ecological, economic, social, scientific, historical-cultural, aesthetic, climatic, recreational and spiritual value for the Republic of Armenia, there are a number of legal regulations on the lake and its basin developed (presented in Chapter I. Legal and Institutional Framework Analysis). According the Law on Lake Sevan, for the purposes of restoration, conservation, reproduction and use of Ecosystem Lake Sevan, and regulating the economic or other activities, 3 ecological zones are defined (May 15, 2001): central zone, direct impact zone and indirect impact zone (Map 24).

- The central zone includes the entire territory of "Sevan" National Park. The delineation of this zone is aimed to restore and maintain the natural state (the quality of water, the natural and artificial landscapes and biodiversity of the lake and coastal land areas) of Lake Sevan ecosystem. The territory of the central zone is an object of special regulation of limited economic and urban development activities maintained by the appropriate regime.

[22] http://mnp.am/en/post/2132
[23] https://www.arlis.am/DocumentView.aspx?DocID=31830

- Direct impact zone, natural watershed basin outside the central zone (territory of Sevan RBD without central zone), where any activity directly or indirectly affects on hydrophysical, hydrochemical, hydrobiological, sanitary, hygienic, other qualitative and quantitative indicators of Lake Sevan. In addition, the Lake Sevan Law prohibits the development of mineral processing facilities in the immediate impact zone. The border of direct impact zone were modified several times and difined by the decissions of Government of RA.
- Indirect impact zone is the territory of the Republic of Armenia, which has a potential impact on the lake outside the watershed basin of Lake Sevan. The objective of the separation of the indirect impact zone is to prevent possible adverse effects on Lake Sevan.

According to article 11 of the Law on Lake Sevan, one of the principles of the state policy on restoration, protection, regeneration, natural development and exploitation is the considering the Lake Sevan and its watershed territory as single-unit system by the operational nature of territory (Project on Regional Planning of Lake Sevan Watershed Basin, 2013).

4.6 Vulnerable Zones to Nitrates

Vulnerable zones were identified based on nitrate concentrations in surface water and groundwater. According Armenian normatives (RA government decision 75N, 27.01.2011) target values for nitrate concentration in surface waters is 11.0 mg/l. This value is exceeded in Gavaraget river near the mouth. The limit value of EU Nitrate Directive (50 mg/l) is never exceeded in the surface water of Sevan BMD.

The nitrate concentrations in growndwaters is exceeded the limit value of EU Nitrate Directive (50 mg/l) in borehole of Martuni City. The existing groundwater quality monitoring network is not sufficient for identifying nitrate sensitive zones. In the next field survey, new monitoring data will contribute to improved understanding of groundwater systems and their vulnerability to pressures.

As the diffuse pollution by nitrates originates from agricultural activities mainly, nitrate fluxes are mainly the result of diffuse discharges linked to the supply of mineral and organic fertilizers in crops, and to the discharge of livestock effluents.

In Sevan RBD, the agriculture is mainly located in Gavaraget, Masrik, Martuni and Argichi River basins. The middle and lower parts of rivers basin are mostly impacted by diffuse pollution of agriculture and this parts of rivers basins can be identified as vulnerable zones. Action programmes for vulnerable zones should be further established and implemented in order to reduce water pollution from nitrogen compounds.

4.7 Territories for Sanitary Protection of Water Ecosystems, Flow Formation, Protection of Groundwater Resources, Water Protection, Ecotone and Inalienable Zones

4.7.1 Ecotone Areas

According to the RA Water Code, the Ecotone is defined as an interconnected transition zone of water and land ecosystems, which includes coastal territories. According to the RA Government Decision N 64-N of January 20, the ecotone territories cover vulnerable areas of rivers, lakes, ponds, and natural formations within a radius of 150 meters (Map 25).

Taking these standards as a basis, 20 river ecotone areas have been identified in the lake Sevan basin, which mainly cover river mouth sections.

Table 46: Ecotone areas identified in the Sevan RBD

№	River name and ecotone area	Length (km)	Area (km²)	Coordinates	
				Latitude	Longitude
1	r. Dzknaget, south of Tsovagyugh village	2,1	0,7	40.61634	44.96156
2	R Drakhtik, south-west of Drakhtik village	3	0,9	40.55035	45.22014
3	r. Artunj, south-east of Artanish village	2,1	0,7	40.49032	45.37074
4	r. Jil, east of Jil village	2,6	0,8	40.45383	45.4344
5	r. Babajan, south-west of Tsapatagh village	0,9	0,3	40.4101	45.46853
6	r. Pambak, south of Pambak village	2,3	0,7	40.3766	45.52757
7	r. Satanakhach, south-west of Daranak village	1,6	0,5	40.36023	45.56422
8	r. Hovsatsakhk, south-west of Areguni village	1,8	0,6	40.33037	45.59952
9	r. Sarinar, south of the middle flow	6,1	1,9	40.29923	45.65129
10	r. Pokr Masrik, south of the Arpunk village	9,2	2,8	40.25339	45.68765
11	r. Mets Masrik, west of the Sotk mine	36	9,9	40.20895	45.79809
12	r. Karchaghbyur, north of the Karchaghbyur village	0,9	0,3	40.17789	45.58008
13	r. Artsvanist, north of the Artsvanist village	0,8	0,3	40.16067	45.50785
14	r. Vardenis, south of Vardenik village	4,7	1,4	40.15239	45.43494
15	r. Hrbeker, north of Zolakar village	2,5	0,8	40.14378	45.38341
16	r. Astghadzor, north of Astghadzor village	3	1	40.14281	45.35599
17	r. Martuni, north of Geghhovit village	9,8	2,9	40.12465	45.2898
18	r. Argichi, north of Verin Getashen river	11,4	3,3	40.14678	45.26778
19	r. Tsakkar, north-east of Tazagyugh and Dzoragyugh villages	19,4	5,6	40.16852	45.21316
20	r. Gavaraget,north-east of Gavar town and the river bed of Geloidzor	55	16,1	40.37604	45.16057

4.7.2 Flow Formation Areas

According to the RA Water Code, the flow formation zone is defined as the territory where a river is formed. According to the RA Government Decision N 64-N of January 20, the flow formation territories cover the river sources within a radius of 4000 meters. Based on these criteria, 38 reference zones for river flow formation were identified in the Lake Sevan Basin using the Digital Elevation Model.

Table 47: Flow formation areas identified in the Sevan RBD

№	River name	Area (km²)	Coordinates	
			Latitude	Longitude
1	r. Dzknaget	36,7	40.65226	44.81982
2	r. Drakhtik	13,3	40.44535	45.5008
3	r. Artsataberk	17,1	40.56501	45.28205
4	r. Jil	11,2	40.47093	45.4768
5	r. Babajan	11,4	40.39219	45.61098
6	r. Shamberd	11,1	40.42438	45.53195
7	r. Pambak	16,1	40.41143	45.57438
8	r. Satanakhach	11,7	40.33384	45.73259
9	r. Hovsatsakhk	8,8	40.36015	45.63897
10	r. Sarinar	8,5	40.3553	45.68174
11	Left tributary of r. Sarinar	5,8	40.34369	45.71058
12	r. Kaputjur (right tributary of r. Pokr Masrik)	12,1	40.59838	45.21502
13	r. Aghsu (Mets Masrik basin)	19,7	40.29345	45.7968
14	r. Karasi (Mets Masrik basin)	22,7	40.2856	45.83195

15	r. Vozmunk (Mets Masrik basin)	40,9	40.26919	45.90277
16	r. Sotk (Mets Masrik basin)	55,6	40.2117	45.92951
17	Left tributary of r. Sotk (Mets Masrik basin)	19,8	40.16121	45.94314
18	r. Aziz	31,7	40.13024	45.90399
19	r. Mets Masrik	105,4	40.05846	45.84037
20	r. Karchaghbyur	47,3	40.05078	45.64488
21	Left tributary of r. Karchaghbyur	14	40.30358	44.96317
22	r. Artsvanist	34,6	40.06101	45.54163
23	Left tributary of r. Artsvanist	11,2	40.03933	45.51658
24	r. Vardenis	72,2	40.00384	45.4654
25	r. Astghadzor	25,6	40.03705	45.39295
26	r. Martuni	79,5	40.01823	45.34426
27	r. Gayladzor (Argichi basin)	88,6	39.96847	45.2491
28	r. Argichi	81,1	39.94367	45.13728
29	r. Karadzi (Argichi basin)	46,4	40.06731	45.06078
30	Right tributary of r. Karadzi (Argichi basin)	19,4	40.02565	45.10018
31	r. Tsakkar	20,7	40.08405	45.08411
32	Left tributary of r. Tsakkar	34,3	40.11978	45.0676
33	r. Dzoragyugh	20,1	40.17877	45.06132
34	r. Gegharkunikjur (Gavaraget basin)	18,1	40.20356	45.04323
35	r. Gridzor (Gavaraget basin)	22,8	40.22668	45.00048
36	r. Geloidzor (Gavaraget basin)	48,9	40.2615	44.99053
37	r. Gumeri (Gavaraget basin)	10,1	40.28592	44.97209
38	Left tributary of r.Gumeri (Gavaraget basin)	14	40.02166	45.58268

4.7.3 Water Protection Areas

According to the RA Water code, water protection zones are defined as territories established for the purpose of preventing pollution and depletion of water resources, as well as ensuring a favorable water regime, which are not subject to privatization and withdrawal. According to the RA Government Decision N 64-N of January 20, the territories of water protection zones cover all territories intended for the protection of water resources in the form of a layer up to 32 meters long. In order to define the water protection areas, the river systems of Sevan RBD have been ranked. The main river of the river network was identified as a category 1 river with a water protection area of 32m, a tributary flowing directly into it – category 2 river with 24m protection area, its tributary – category 3 river with 16m protection area, then the 4 category river with 8m protection area.

Table 48: Water protection areas defined in the Sevan RBD

Category	Water protection area length (m)	Area (km^2)
1	32	27,5
2	24	24,9
3	16	8,9
4	8	2

4.7.4 Unalienable Areas

According to the Water Code of the Republic of Armenia, an inalienable zone is defined as a delineated territory that has a certain regime for the use, restoration, and protection of water supply, sanitation, and hydrotechnical systems, which is not subject to privatization or withdrawal. According to the RA Government Decision N 64-N of January 20, inalienable zones include territories directly adjacent to water supply, wastewater discharge, and hydraulic structures in the form of an up to 10 meters-long layer. Inalienable areas (10m) are delineated along 27 canals and around the 4 reservoirs of Sevan RBD.

Table 49: Inalienable areas of the canals

№	Name	Area, km^2	Coordinates	
			Latitude	Longitude
1	Noratus Right Branch Canal	0,215	40.36048	45.17443
2	Dotation Canal	0,128	40.07544	45.26187
3	Manasi Aru Canal	0,386	40.06231	45.34618
4	Zuskar inner Canal	0,087	40.09912	45.37162
5	Tsovinar Mets Aru Canal	0,107	40.10316	45.50089
6	HPP Canal	0,156	40.16548	45.70066
7	Ruins Canal	0,124	40.16161	45.57084
8	Noratus Left Branch Canal	0,136	40.36255	45.1602
9	Sarukhan Water Station Tail-race Left Branch	0,096	40.28745	45.12119
10	Geghamabak Canal	0,051	40.17746	45.8035
11	Yeranos Canal	0,141	40.18032	45.20383
12	Verin Getashen Canal	0,172	40.10587	45.23849
13	Sarukhan Water Station Tail-race Right Branch	0,049	40.30388	45.12006
14	Sarukhan Self-flowing Canal	0,119	40.31217	45.12672
15	Getashen Canal	0,098	40.06894	45.25257
16	Masrik Canal	0,525	40.22715	45.74002
17	Hord Aru Canal	0,043	40.16592	45.1979
18	Parz Aghbyur Canal	0,104	40.19178	45.11405
19	Makenis Canal	0,178	40.14197	45.63452
20	Tsovinar N2 Canal	0,159	40.14474	45.62777
21	Tsovak N1 Canal	0,152	40.16636	45.61788
22	Karchaghbyur Canal	0,057	40.15746	45.59963
23	Sotk Canal	0,193	40.21137	45.85508
24	Avazan Canal	0,123	40.28776	45.70531
25	Sari Aru – Lichk Canal	0,107	40.14542	45.20217
26	Arpa-Sevan tunnel Canal	0,014	40.15752	45.49463
27	Arpa-Sevan Tunnel	0,522	40.04919	45.4633

Table 50: Inalienable areas of the reservoirs

№	Name	Area, km^2	Coordinates	
			Latitude	Longitude
1	Lanjaghbyur 1	0,065	40.2501	45.13225
2	Lanjaghbyur 2	0,017	40.25832	45.15317
3	Gegharkunik 1	0,067	40.25386	45.15605
4	Gegharkunik 2	0,044	40.23663	45.14015

4.7.5 Groundwater Protection Areas

According to the Water Code of the Republic of Armenia, groundwater protection area is defined as a zones what are vulnerable for groundwater resources. According to the RA Government Decision N 64-N of January 20, groundwater protection areas are delineated with the radius of up to 150m. For 38 wells and springs of the Sevan RBD, territories for the groundwater protection with a total area of 2,684 km^2 have been delineated.

Table 51: Groundwater protection areas

ID	Name	Coordinates	
		Latitude	Longitude
1	Water well	40.12611	45.35611
2	Springs Hatsarat	40.04719	45.11169
3	Springs Hatsarat	40.04722	45.11206
4	Springs Hatsarat	40.04947	45.10408
5	Springs Hatsarat	40.04967	45.09778
6	Springs Hatsarat	40.05147	45.09842
7	Water well	40.47578	45.32194
8	Spring Aghbyurakner	40.18472	45.19139
9	Water well	40.30492	45.12881
10	Water well	40.12278	45.36167
11	Water well	40.12306	45.35333
12	Water well	40.11472	45.35889
13	Springs Satananots	40.156	45.49592
14	Spring Borbor-bulaghi	40.16602	45.49088
15	Water well	40.41169	45.47108
16	Water well	40.41172	45.47108
17	Springs Hatsarat & Khacher, well Kaler	40.34694	45.10861
18	Springs Hatsarat & Khacher, well Kaler	40.34694	45.10861
19	Springs Hatsarat & Khacher, well Kaler	40.3475	45.10806
20	Springs Hatsarat & Khacher, well Kaler	40.3475	45.10806
21	Springs Hatsarat & Khacher, well Kaler	40.34778	45.09389
22	Springs Hatsarat & Khacher, well Kaler	40.34778	45.10806
23	Springs Hatsarat & Khacher, well Kaler	40.34778	45.10806
24	Springs Hatsarat & Khacher, well Kaler	40.34778	45.10833
25	Springs Hatsarat & Khacher, well Kaler	40.34778	45.10833
26	Springs Hatsarat & Khacher, well Kaler	40.34833	45.10889
27	Springs Hatsarat & Khacher, well Kaler	40.34833	45.10889
28	Springs Hatsarat & Khacher, well	40.34833	45.10917

	Kaler		
29	Springs Hatsarat & Khacher, well Kaler	40.34833	45.10917
30	Springs Hatsarat & Khacher, well Kaler	40.34833	45.10917
31	Springs Hatsarat & Khacher, well Kaler	40.34833	45.10917
32	Springs Hatsarat & Khacher, well Kaler	40.50278	45.28361
33	Water well	40.50556	44.91861
34	Water well	40.50833	44.91833
35	Water well	40.50917	44.91664
36	Water well	40.54917	44.96583
37	Water well	40.55389	44.95778
38	Water well	40.55556	44.95644

4.7.6 Territories of Sanitary Protection of Water Ecosystems

According to the Water Code of the Republic of Armenia, territories of sanitary protecton of water ecosystems are defined as territories of water resources protection that are used to meet the needs of the population in drinking water, health care, communal-household services, recreational and wellness needs. According to the RA Government Decision N 64-N of January 20, territories of sanitary protecton of water ecosystems are delineated with the radius of up to 90m. For 38 wells and springs of the Sevan RBD, territories of sanitary protecton of water ecosystems with a total area of 0,966 km^2 have been delineated.

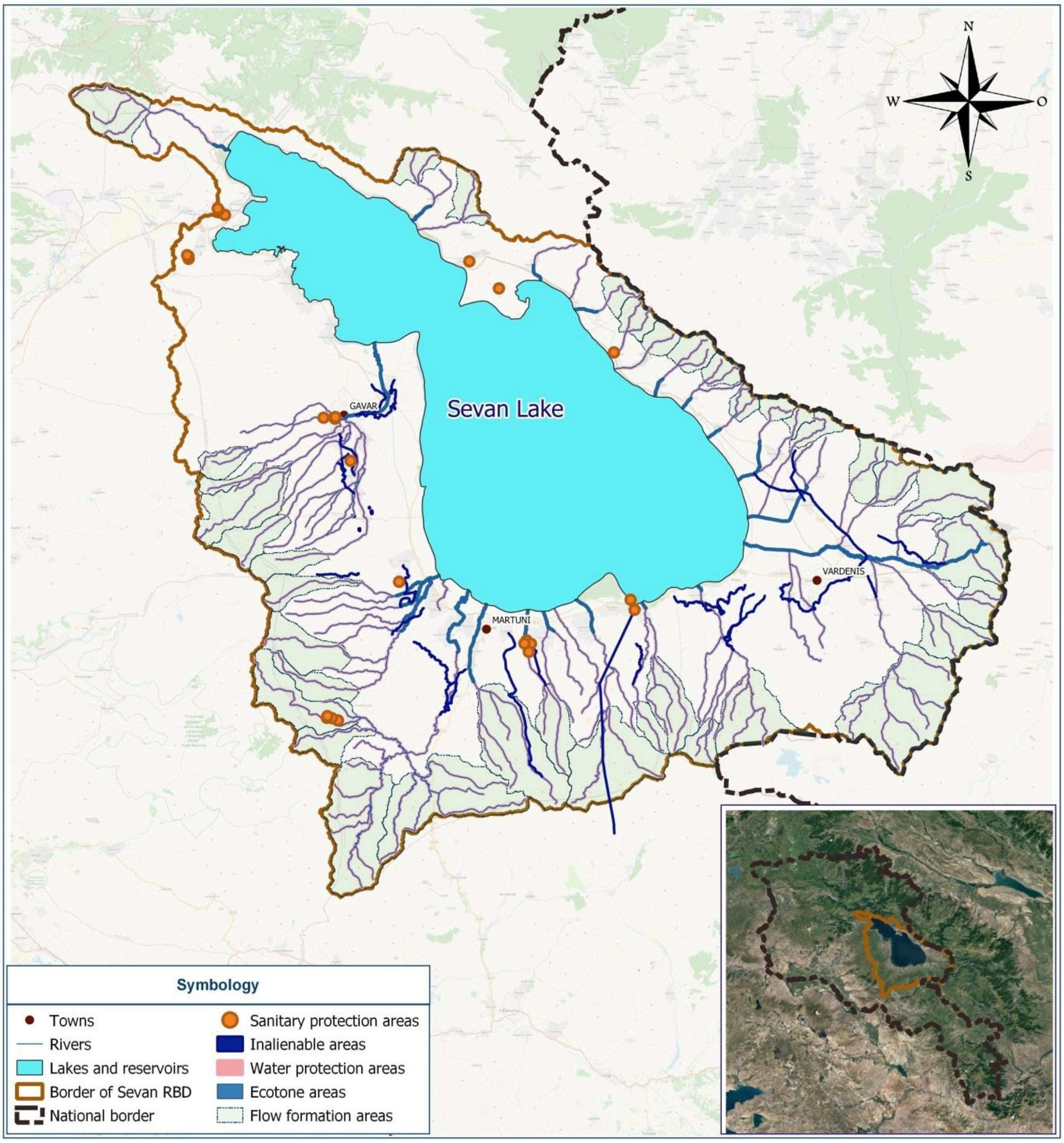


Figure 31: Territories for Sanitary Protection of Water Ecosystems, Flow Formation, Protection of Groundwater Resources, Water Protection, Ecotone and Inalienable Zones

5. ASSESSMENT OF THE STATUS OF WATER BODIES

5.1 Water bodies delineated within Sevan RBD

5.1.1 The Principles of Water Body Delineation

A water body is a homogeneous natural hydrological basic unit or volume of groundwater within an aquifer.

Methodology on delineation and characterisation of surface water bodies

The delineation of surface water bodies in the Sevan RBD is based on the provisions laid down in the WFD and the methodologies given in the following guidance documents of the EU Common Implementation Strategy (CIS) for the WFD:

- CIS Guidance Document No. 2 on “Identification of Water Bodies”;
- CIS Guidance Document No. 3 on “Analysis of Pressures and Impacts”;
- CIS Guidance Document No. 4 on “Identification and Designation of Heavily Modified and Artificial Water Bodies”;
- CIS Guidance Document No 5 on “Transitional and Coastal Waters. Typology, Reference Conditions and Classification Systems”;
- CIS Guidance Document No. 9 on “Implementing the Geographical Information Systems (GIS)”.

Sevan and RBD belongs to the 24th ecoregion (Caucasus). Surface water bodies have been delineated according to the descriptors defined in the System A (WFD Annex II) (EUWI+, 2020a).

Revealing artificial and heavily modified water bodies

According to EU WFD, the term **Artificial Water Body** (AWB) describes a body of surface water created by human activity, where no water has existed before (Article 2). A water body can be designated as artificial water body only if it meets the following criteria:

- Changes in the hydromorphological properties of the water body, which would be required to achieve a good ecological potential, would have a significant negative impact on (a) the environment in general; (b) activities for which the water is abstracted, such as fisheries or irrigation; and (c) water regulation, protection against floods, or drainage.

- Due to limited technical resources or excessive costs, the benefits resulting from the artificial nature of the water body would not be achievable through alternative methods, which would be more favorable for the environment.

The category of artificial bodies of surface water includes: means reservoirs, artificial canals built for hydropower, irrigation, drainage ect., uses, lakes formed in pits, ponds, impounded reservoirs and artificial storage basins fed by transferred water.

According to WFD, **Heavily Modified Water Body (HMWB)** is defined as ‘a body of surface water which as a result of physical alterations by human activity is substantially changed in character’ (Article 2).

The identification of artificial and heavily modified water bodies of the Sevan and Hrazdan River basin areas has been carried out based on the *WFD Guidance Document No. 4 "Identification and Designation of Heavily Modified and Artificial Water Bodies".*

Methodology of Delineation of Groundwater Bodies

Approaches presented in EU WFD CIS Guidance Document N2 were used for the delineation of GWBs, according to which the GWB is a certain volume of groundwater in the water-bearing horizon or horizons. Article 7 of WFD requires the identification of all groundwater bodies used, or intended to be used, for the abstraction of more than 10 m^3 of drinking water a day as an average. Following parameters have been taken into account for GWBs delineation: groundwater feed, water movement, accumulation and discharge conditions, specifics of water-bearing horizons according to the filtering properties (water-solubility, water-abundance level), the amount of water used and the purpose of use. The delineation of water bodies is considered to be an iterative-long term process that is improved over time (Guidance Document N2, page 36). Details on the delineated groundwater bodies can be found in Annex 17 and in the final report on the delineation and characterization of groundwater bodies and the design of a groundwater monitoring network in the Hrazdan and Lake Sevan river basin districts in Armenia carried out in the EUWI+ project (EUWI+, 2018d).

5.1.2 Summary on Water Bodies Delineated in Sevan

Totall 103 surface water bodies and **6** groundwater bodies have been delineated in Sevan Basin District, out of which:

- **87** are natural surface water bodies; (Annex 12).
- **14** are artificial water bodies, including **1 tunnel and 14 canals;** (Annex 13).
- **2** are heavily modified water bodies;
- **6** are groundwater bodies, including two mineral groundwater bodies (Table 52)

4 SWBs have been delineated in coastline areas of the lake, as well as 2 HMWBs are Major and Minor Lake Sevan (EUWI+, 2020a):

- WB 4-084, Lake Sevan coastline, from Lchashen to Tsovazard settlement, about 16.95 km^2
- WB 4-085, Lake Sevan coastline, surroundings of Gavaraget River, from Gavaraget estuary to Noratus, about 16.3km^2
- WB 4-086, Lake Sevancoastline, from the Noratus Peninsula to the end of the community border Noratus, about 7.31km^2
- WB 4-087, Lake Sevancoastline, from Yeranos settlement to Small Masrik settlement, about 66.9km^2
- WB 4-088, Major Lake Sevan occupies an area of 866.35 km^2, and its average depth is approximately 32 meters. It is located at an altitude of about 1,900 meters above sea level. The nutrient content is high, intensive growth of algae and eutrophication were observed.
- WB 4-089, Minor Lake Sevan is separated by the HMWB occupying 304,78 km^2 and the average depth is approximately 75 m. It is located at an altitude of about 1,900 meters above sea level. The nutrient content is high, intensive growth of algae and eutrophication were observed (EUWI+, 2020a).

The definition of 6 WBs for the Sevan lake, however, is not in line with WFD, and, based on the regulations, it should be only 2 WBs for the lake. Question on delineating the 4 coastlines water bodies, as well as Major and Minor Sevan as two HMWBs have been intensively discussed during and after the training session on economic analysis conducted in the frames of EUWI+ project in Georgia (2019). Finally, all the parties agreed on considering Major and Minor Sevan as HMWBs and definded 4 separate coastline areas as SWBs taking into account the changes in lake caused by anthropogenic factor (Map 26).

The delineation of WB of Sevan Lake will have to be reviewed during the next planning cycle to take account of additional data and information being produced meanwhile.

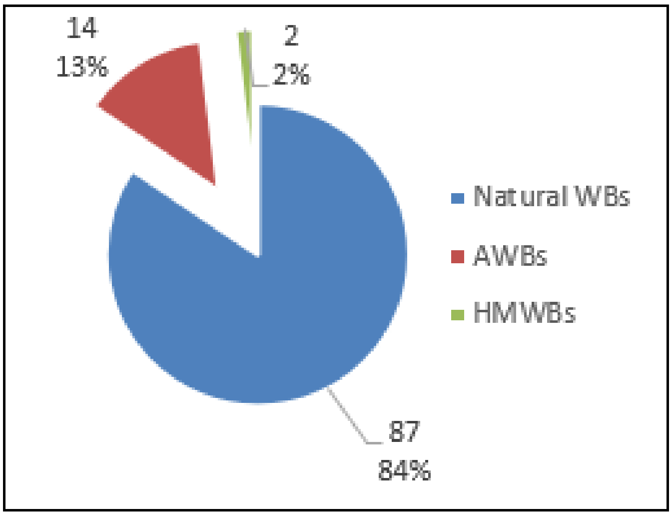


Figure 32: Distribution of Surface Water Bodies by Types in Sevan RBD

Source: EUWI+ Reports: Development of Draft RBMP for Sevan RBD in Armenia: Part 1-characterisation phase" Geocom LTD, 2018; Technical Report on Delineation of surface water bodies in Sevan and Hrazdan River Basins in Armenia, Institute of Chemical Physics NAS RA(2020); Delineation and Characterisation of Groundwater Bodies and the Design of a Groundwater Monitoring Network in the Hrazdan and Lake Sevan River Basin Districts in Armenia, Geocom LTD, 2018; EUWI+ East, 2018, and report on "Definition of reference conditions and class boundaries in rivers of Armenia for the BQE benthic invertebrates", EU member state consortium, 2020.

Table 52: Groundwater bodies delineated within Sevan RBD

№	GWB Name	GWB Code, Number	Type of Water Abstraction Structure	Surface Area, km^2
1	Dzknaget-Areguni	3G-1	springs	172
2	Lchashen-Gavar-Shatjrek	3G-2	wells	2156
3	Shorja-Sotk	3G -3	springs	157
4	Vardenis or Masrik	3G-4	spring-well	140
5	Sevan (Gavar)	3G-5	mineral water wells	0.32 (in the discharge area)
6	Lichk	3G-6	mineral water wells	0.48 (according to wells location)

5.2 Surface Water Monitoring in the Sevan River Basin District

5.2.1 Surface Water Quality Monitoring

According to the Decree N121-L of the Ministry of the Environment from April 21, 2020, in the Sevan Basin, surface water quality monitoring is performed in the Arpa-Sevan tunnel outlet and in 9 main rivers flowing into Lake Sevan: Dzknaget, Masrik (with its tributary Sotk), Karchaghbyur, Vardenis, Martuni, Argichi, Tsakkar, Shoghvak, and Gavaraget. There are 19 sampling sites in total.

Lake Sevan is the only lake with the area of more than 50 hectares. There are 33 sampling sites for Lake Sevan (in the coastal and central parts) from where water samples are taken from different depths.

The comprehensive list of water quality parameters was defined in accordance with the corresponding decision of the Government of RA (Decision #75-N, dated 27 January 2011, “On Approving the Norms of Water Quality Assurance in each River Basin District, Depending on Local Characteristics”). That list contains 103 hydrochemical and 2 hydrobiological parameters (these two hydrobiological parameters have not been monitored yet). The list of hydrochemical parameters includes the 33 priority pollutants described in the WFD (the organic micro contaminants), as well as 8 specific polluting substances and 62 other chemical and physico-chemical indicators. Currently 45-60 out of total 105 hydrochemical parameters are traceable for surface waters. The capacity for laboratory tests of the remaining parameters is in the phase of installation and shall come into application in the near term future.

Currently there is no regular **biological monitoring in Armenia**. The first biological survey for Sevan RBD has been carried out in 2018-2019 (EUWI+, 2019a; EUWI+, 2020e) in frame of the study Definition of Reference Conditions and Class Boundaries in Rivers of Armenia for the BQE Benthic Invertebrates” by the EUWI+ project (EUWI+, 2020b). A preliminary Ecological Classification System (ESCS) was developed. However, it is necessary to further refine this system as more data will be available by future surveys, and also to include the remaining biological quality elements (BQE). The process of developing a method for the BQE phytobenthos was also started during EUWi+.

List of Surface Water Monitoring Sites in the Sevan RBD is given in Table 54 (Chapter 5.3), location is shown in Figure 33 (also, see Annex 9.3 and 9.4).

5.2.2 Surface Water Quantity Monitoring

Quantitative and regime monitoring and studies on surface water resources in Armenia are conducted by “State Hydromet Service” SNCO of Ministry of Emergency Situations of RA. Operation of hydrological monitoring posts is regulated by hydrological stations of 7 river basins. Operation of the hydrological monitoring posts in Sevan RBD is regulated by the hydrological station of Sevan-Hrazdan Basin.

Following observations are performed in the hydrological monitoring posts of Hydromet Service:

Rivers:

- Water discharge measurements are performed 25-30 times per year (i.e. up to 3-4 times monthly during the high water period from March to June and 1-2 times monthly during the rest of the year). The calculation of the daily discharge is performed graphically based on the analysis of the stage-discharge relation[24].
- Water level, water and air temperature measurements are performed daily, once every 12 hours (at 800 and 2000).
- Reservoirs:
- Water level, fullness, water and air temperature measurements are performed daily, once every 12 hours.
- Ice and other hydrological phenomena measurements are performed upon occurrence.

The current hydro-meteorological monitoring network within the Sevan RBD comprises 17 water quantity monitoring sites (12 from which are on rivers, 4 – on Sevan Lake, 1 – on the outlet of Arpa-Sevan tunnel near Tsovinar village) (Map 27, Annex 9.1 and 9.2).

[24] https://water.usgs.gov/edu/streamflow3.html

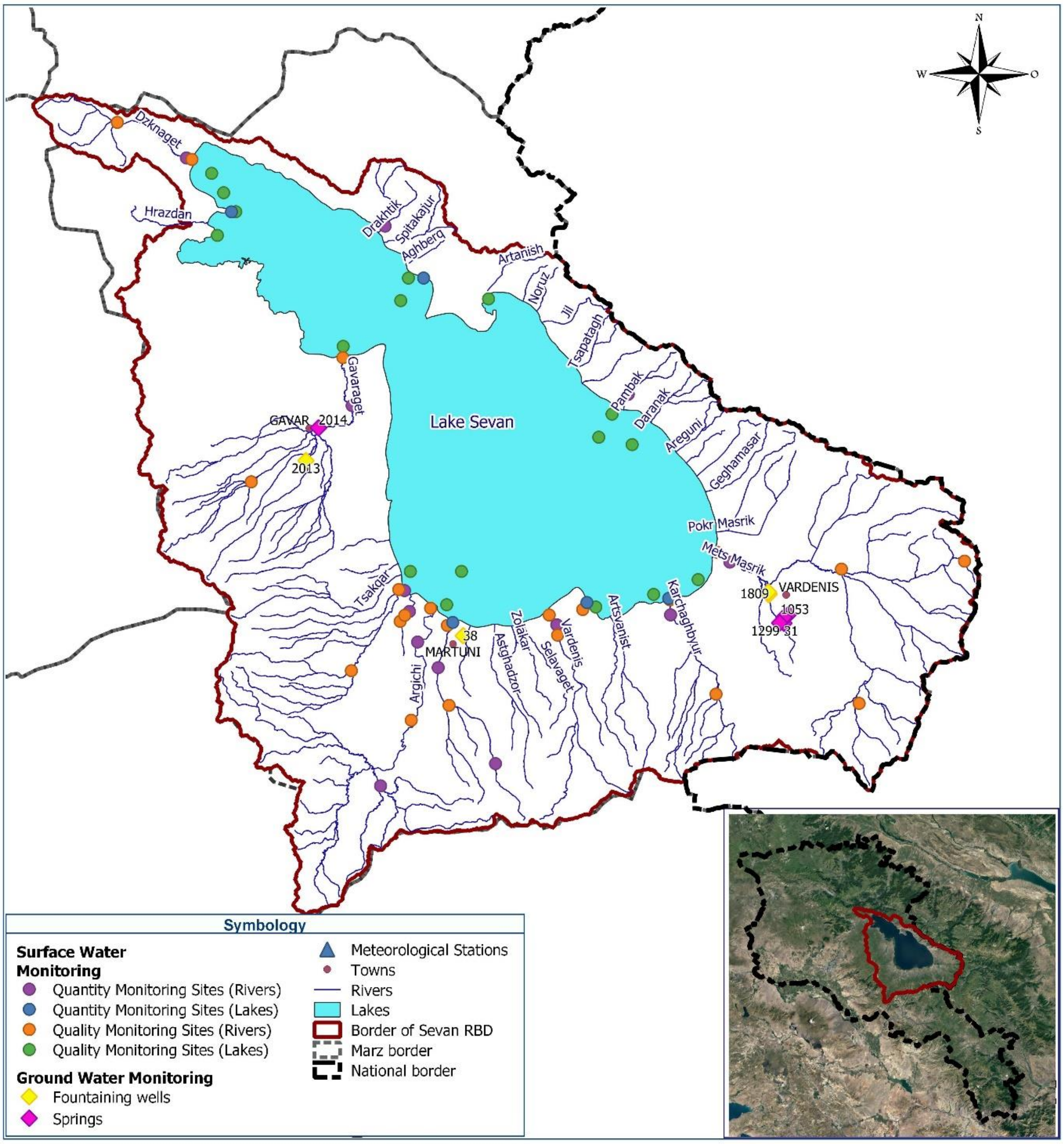


Figure 33: The locations of Water Quality and Quantity Monitoring sites in the Sevan BMA (Source: Environmental Monitoring and Information Centre, 2018)

Table 53: Operating Hydrological Monitoring Posts in Sevan River Basin

Code	Water Body	Monitoring Post	Coordinates		F, km^2	H, m	Discharge, m^3/s		
			Latitude	Longitude			Avg	Max	Min
85352	r. Dzknaget	Tsovagyugh	40^{0}37'03,45''	44^{0}57'42,71''	82.6	1909.14	1.08	46.40	0.14
85353	r. Drakhtik	Drakhtik	40^{0}32'46,27''	45^{0}12'44,00''	39.2	1920.92	0.24	46.70	0.05
85339	r. Pambak	Pambak	40^{0}23'05,79''	45^{0}32'02,74''	20.4	1994.52	0.21	2.27	0.07
85363	r. Masrik	Tsovak	40^{0}13'08,03''	45^{0}39'08,33''	673	1908.16	3.31	20.30	2.32
85366	r. Karchaghbyur	Karchaghbyur	40^{0}10'45,05''	45^{0}34'55,85''	116	1904.69	1.03	15.4	0.84
85370	Arpa-Sevan tunnel	Tsovinar	40^{0}09'22,56''	45^{0}29'40,81''	-	1899.42			
85371	r. Vardenis	Vardenik	40^{0}07'57,93''	45^{0}26'34,16''	117	1961.71	1.53	22.70	0.49
85376	r. Martuni	Geghhovit	40^{0}05'49,56''	45^{0}16'59,05''	84.5	2049.29	1.66	26.70	0.60

85378	r. Argitchi	Verin Getashen	$40^0$07’52,34’’	45^0 15’17,76’’	366	1947.87	5.39	265.00	1.95
85379	r. Tsaghkashen	Vaghashen	$39^0$59’52.92’’	$45^0$12’39.30’’	92.4	2262.00	1.52	17.90	0.47
85380	r. Lichk	Lichk	$40^0$10’00,66’’	$45^0$14’35,66’’	33	1912.60	1.88	6.26	1.51
85381	r. Bakhtak	Tsakkar	$40^0$10’05,83’’	$45^0$13’14,65’’	144	1934.85	0.64	31.50	0.14
85384	r. Gavaraget	Noratus	$40^0$22’38,95’’	$45^0$10’15,91’’	467	1912.70	3.49	72.50	2.63

Source: State Hydromet Service of MES, 2018

Hydrological observations in the most of monitoring posts in Sevan RBD are mainly conducted manually, using worn-out tools and equipment – staff level gauges, flow probes.

5.3 Assessment of Chemical Status of Surface Water Bodies

Ecological status is an assessment of the quality of the structure and functioning of surface water ecosystems. It shows the influence of pressures (e.g. pollution and habitat degradation) on the identified quality elements. Ecological status is determined for each of the surface water bodies of rivers, lakes, transitional waters and coastal waters, based on biological quality elements and supported by physico-chemical and hydromorphological quality elements. The overall ecological status classification for a water body is determined, according to the ‘one out, all out’ principle, by the element with the worst status out of all the biological and supporting quality elements.

All potential pressures, from point and diffuse sources were analyzed and assessed in previous sections, as well as water quality measurements were generalized, in order to assess impacts on water bodies of the Sevan RBD. The classification of water quality was made according to the provisions of RA Government Decree №75-N “On establishing the norms for assuring water quality of each Water Basin Management District, depending upon local peculiarities” enacted 27 January 2011. The classification was based on average annual concentration values of indicators for the period of 2013-2017. EU WFD ‘one-out all-out’ principle have been also used. This key principle reflects the integrated approach for the protection of water resources and associated aquatic ecosystems. The overall status would only be ‘good’ if all the elements comprised are at least considered ‘good’. This ensures that all pressures capable of degrading the water status are addressed and is a guarantee of the environmental integrity of the objectives of the directive.

The classification was conducted for 21 WBs and was based on average annual concentration values of hydrochemical parameters of oxygen and mineralization regimes, nutrients, metals for the period of 2015-2018 obtained from the RA MoE EMIC (Annex 15). The results of the SWB chemical status assessment was shown in Figure 34.

The Resolution does not separate general physico-chemical parameters and specific pollutants relevant for the ecological status and priority pollutants relevant for the chemical status according to EU WFD (cf Annex V of the WFD). The status classification of the SWB is based on the existing classification system as defined in Resolution №75-N and will be adapted according to the requirements of EU WFD in future. Thus, no chemical status classification of surface water bodies according to WFD exists by now.

In terms of the hydro-chemical water quality (which includes mostly parameters relevant for the ecological status), only Gavaraget river SWB in the Sevan RBD is identified as “bad” chemical status. The most common source of pollution of rivers in the RBD is mainly point and non-point discharges of untreated domestic wastewater and diffuse pollution from agriculture.

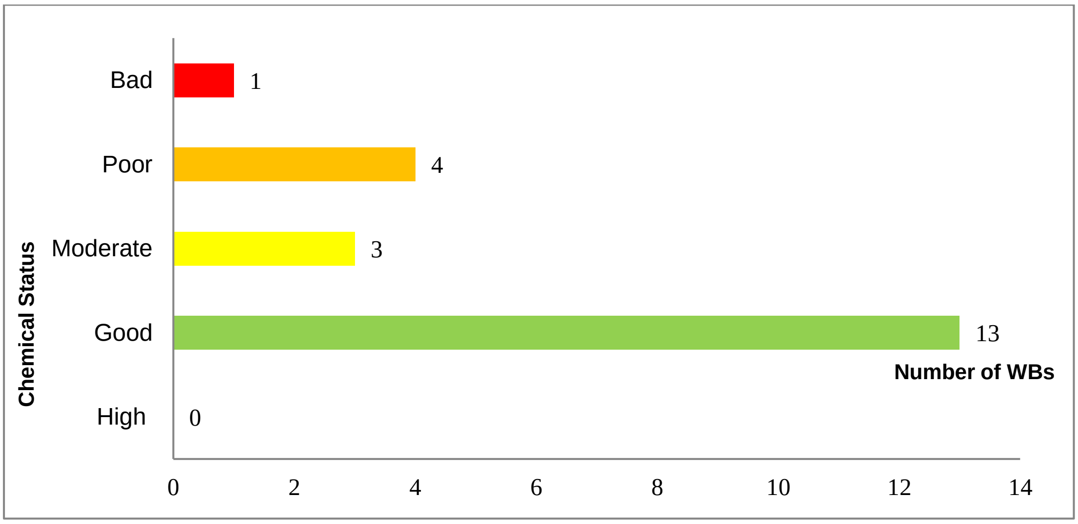


Figure 34: Chemical status assessment of Surface Water Bodies in Sevan RBD

Source: Technical Report on Delineation of surface water bodies in Sevan and Hrazdan River Basins in Armenia, Institute of Chemical Physics NAS RA, EUWI+ East, 2018

The list of monitoring sites and the results of assessment of Chemical Status in the Sevan RBD are given in Tables 54 and 55.

Table 54: The Chemical Status of waters in Monitoring sites in the Sevan RBD

River	Location of sampling sites (Number of sampling sites),	Number of water body	Water quality class	Main indicators (Water quality parameter class)	Cause of main pressure
Dzknaget	0.5 km upstream of the village Semyonovka (#60)	WB 4-001	Good (II)	-	**No significant pressure**
	River mouth (#61)	WB 4-003	Good (II)	-	**No significant pressure**
Masrik	0.5 km upstream of the village Verin Shorja (#62)	WB 4-036	Good (II)	-	**No significant pressure**
	River mouth (#63)	WB 4-041	Moderate (III)	Phosphate (III) Antimony (III), Vanadium (III)	Domestic wastewater and diffuse pollution from agriculture, diffuse pollution from mining industry
Sotq	1.5km upstream of the viliage Sotq (#64)	WB 4-032	Good (II)	-	**No significant pressure**
	River mouth (#65)	WB-031	Moderate (III)	Nitrate (III), SS (III), Antimony (III)	Domestic wastewater, diffuse pollution from mining industry
Karchagh byur	0.5 km upstream of the village Akhpradzor (#66)	WB 4-043	Good (II)	-	**No significant pressure**
	River mouth (#67)	WB 4-047	Good (II)	-	**No significant pressure**
Arpa-Sevan tunnel	0.7 km upstream of the village Tsovinar (#68)	WB 4-100	Moderate (III)	Nitrate (III), Arsenic (III)	Influence of underground water

Vardenis	0.5 km upstream of the village Vardenik (#69)	WB 4-051	Good (II)	-	**No significant pressure**
	River mouth (#70)	WB 4-052	Poor (IV)	Nitrite (III), Phosphate (III), Ammonia (IV)	Diffuse pollution from domestic wastewater and agriculture
Martuni	0.5 km upstream of the village Geghhovit (#71)	WB 4-056	Good (II)	-	No significant pressure
	River mouth (#72)	WB 4-058	Poor (IV)	Phosphate (III), Ammonia (IV)	Domestic wastewater and diffuse pollution from agriculture
Argichi	0.5 km upstream of the village Lernahovit (#73)	WB 4-061	Good (II)	-	**No significant pressure**
	River mouth (#74)	WB 4-065	Good (II)	-	**No significant pressure**
Shoghvak	River mouth (#75)	WB 4-073	Moderate (III)	Phosphate (III)	Domestic wastewater and diffuse pollution from agriculture
Bakhtak	River mouth (#76)	WB 4-069	Moderate (III)	Phosphate (III)	Domestic wastewater and diffuse pollution from agriculture
Gavaraget	0.5 km upstream of the village Tsaghkashen (#77)	WB 4-074	Good (II)	-	**No significant pressure**
	River mouth (#78)	WB 4-082	Poor (IV)	Phosphate (IV), Ammonia (III), TP (III), Nitrate (III)	Domestic wastewater and diffuse pollution from agriculture,
Lichq	0.5 km upstream of the village Lichq	WB 4-066	Good (II)	-	**No significant pressure**
	River mouth	WB 4-066	Good (II)	-	**No significant pressure**

Source: Environmental Monitoring and Information Centre, SNCO of the Ministry of Nature Protection of Armenia, 2017

According to the monitoring results, in the upper section of the rivers the water quality corresponds to the “good” (II) class. In the lower sections of the rivers near the mouths, the water quality is characterized by “moderate” (III) and “poor” (IV) status. The rivers are being polluted with the point and non-point discharge of untreated domestic wastewater and diffuse pollution from agriculture. Most polluted rivers are Gavaraget, Masrik, Vardenis and Martuni.

Some rivers being negligible impacted by domestic wastewater and diffuse pollution from agriculture and also due to the self-purification thus lowering the impacts of the anthropogenic pressures. Karchaghbyur, Lichk, Argichi and Dzknaget rivers belong to the rivers remaining in good quality from source to mouth.

The Sotk and Masrik rivers are impacted by mining activities. The water quality of Sotk and Masrik rivers after the influence of gold mining corresponds to "moderate" (III) class.

Due to the point and non-point influence of domestic wastewater and diffuse sources from agriculture the content of nutrients in rivers as well as in the RBD are increased and finally is discharged to the Lake Sevan, together with direct discharges from coastal settlement.

The list of Surface water bodies not having good chemical status based on chemical quality of the monitoring data of Sevan BMA are presented in Table 54.

1) Masrik River from the confluence of the Sotk River to river mouth: This stretch of the river faces significant pressures by diffuse pollution of mining industry, agriculture, non-point and point pollution from domestic wastewater. As an impact of diffuse pollution of mining industry the contents of heavy metals such as antimony (III class) and vanadium (III class), have been increased comparing to the water quality objectives specific for Masrik River Basin. The water quality has been assessed to be at risk to fail the RA environmental objectives due to “moderate” chemical status at the EMIC’s Sampling point #63 Masrik River. (**WB 4-041)**

2) Sotk River downstream Sotk gold mine to river mouth: This stretch of the river faces significant pressures by diffuse pollution of mining industry. As an impact of diffuse pollution of mining industry the contents of antimony (III class), aluminum (III class), iron (III class), vanadium (III class) and suspended solids (III class), have been increased. The water quality has been assessed to be at risk to fail the RA environmental objectives due to “moderate” chemical status at the EMIC’s Sampling point #65 Masrik River (**WB 4-031)**.

3) Vardenis River from Vardenik village to the river mouth: This stretch of the river faces significant pressures by diffuse pollution of domestic wastewater and agriculture. As a result, the contents of nitrogen and phosphorus have been increasing. The concentrations of nitrite and phosphate were assessed in moderate class (III class), and ammonia - poor class (IV class). The water quality has been assessed to be at risk to fail the RA environmental objectives due to “poor” chemical status at the EMIC’s Sampling point #70 Vardenis River. (**WB 4-052)**.

4) Martuni River from the village of Geghovit to river mouth: This stretch of the river faces significant pressures by diffuse pollution of domestic wastewater and agriculture. As a result, the contents of nitrogen and phosphorus have been increasing. The concentration of phosphate was assessed in in moderate class (III class), and ammonia - poor class (IV class). The water quality has been assessed to be at risk to fail the RA environmental objectives due to “poor” chemical status at the EMIC’s Sampling point #72 Martuni River (**WB 4-057, WB 4-058)**.

5) Bakhtak river from the village of Tsakkar to river mouth: This stretch of the river faces significant pressures by diffuse pollution of domestic wastewater and agriculture. The concentrations of phosphate were assessed in moderate class. The water quality has been assessed to be at risk to fail the RA environmental objectives due to “moderate” chemical status at the EMIC’s Sampling point #76 Bakhtak River (**WB 4-069)**.

6) Shoghvak river from the Dzoragyugh village to river mouth: This stretch of the river faces significant pressures by diffuse pollution of domestic wastewater and agriculture. The concentrations of phosphate were assessed in moderate class. The water quality has been assessed to be at risk to fail the RA environmental objectives due to “moderate” chemical status at the EMIC’s Sampling point #75 Shoghvak River (**WB 4-073)**.

7) Gavaraget river from the Gavar town to river mouth: This stretch of the river faces significant pressures by diffuse pollution of domestic wastewater and agriculture. The concentrations of nitrate, ammonia and total phosphorus were assessed in moderate class (III class). The concentration of phosphate was assessed to the poor class (IV class). The water quality has been assessed to be at risk to fail the RA environmental objectives due to “poor” chemical status at the EMIC’s Sampling point #78 Gavaraget River. (**WB 4-082)**.

The content of nutrient in the water of the Lake Sevan during the year varies considerably. The data for three seasons (spring-May, summer-July, autumn-October) of Lake Sevan's water quality monitoring in 2017 are summarized in the Table 55.

Table 55: Nutrients in Lake Sevan, 2017

Number of Water Body	Characterization of WBR	Surface, m^2	Sampling date	Phosphate ion, mg/L	Nitrate ion, mg/L	Ammonia ion, mg/L
HMWB 4-088 (provisional)	Major Sevan	861.02	May July October	0.128 0.056 0.056	0.037 0.041 0.043	0.238 0.293 0.361
HMWB 4-089 (provisional)	Minor Sevan	302.22	May July October	0.097 0.066 0.107	0.038 0.020 0.020	0.103 0.253 0.323
WB 4-084	Lake Sevan, from Lchashen to Tsovazard	16.30	May July October	0.098 0.048 0.010	0.037 0.015 0.034	0.061 0.205 0.309
WB 4-085	Lake Sevan, From Gavaraget estuary to Noratus	7.31	May July October	0.106 0.033 0.029	0.050 0.041 0.088	0.134 0.239 0.230
WB 4-086	Lake Sevan, from the Noratus Peninsula to the end of the community border Noratus	7.90	May July October	0.123 0.068 0.133	0.022 0.037 0.020	0.285 0.307 0.391
WB 4-087	Lake Sevan, from Yeranos to Poqr Masrik	66.90	May July October	0.120 0.062 0.071	0.054 0.039 0.014	0.218 0.326 0.337

Source: Environmental Monitoring and Information Centre, SNCO of the Ministry of Nature Protection of Armenia, 2017

As shown in the table, the nutrient content in the Lake Sevan is high, which contributes to the intensification of biogen processes, the development of eutrophication and to the decrease of water quality in the lake. Monitoring data show that there are additional pressure on water quality of the water bodies of Lake Sevan, identified based on hydromorphological characteristics, and water quality is pure.

8) Major Lake Sevan. The isolated section of the Major Sevan, which has been separated as a HMWB, occupies an area of 866.35 km^2, and its average depth is approximately 32 meters. It is located at an altitude of about 1,900 meters above sea level. The nutrient content is high, see Table 55. In 2018, intensive growth of algae and eutrophication were observed.**(HMWB 4-088).**

9) Minor Lake Sevan. The Minor Sevan part is separated by the HMWB occupying 304,78 km^2 and the average depth is approximately 75 m. It is located at an altitude of about 1,900 meters above sea level. The nutrient content is high, see Table 55. In 2018, intensive growth of algae and eutrophication were observed.**(HMWB 4-089).**

5.4 Assessment of Ecological Status of Surface Water Bodies

According to the WFD, the ecological status is assessed by an Ecological Status Classification System (ESCS) based on data of Biological Quality Elements (BQE) consisting of fish, macroinvertebrates, phytobenthos, phyto-plankton, and macrophytes, while physico-chemistry and hydromorphology act as supporting elements.

As outlined above, there is no official WFD compliant ecological status classification system (ESCS) available up to now. However, a preliminary ecological status of a selected number of SWB was done based on a new proposal for a WFD compliant ESCS for benthic invertebrates in rivers during the EUWI+ project (EUWI+, 2020b). For the HMWB reservoirs, no classification of the ecological potential is available yet.

The ecological status of surface water bodies was based on the results of the study “Definition of Reference Conditions and Class Boundaries in Rivers of Armenia for the BQE Benthic Invertebrates” (EUWI+, 2020b) . Totally, 83 WBs were assessed, 77.1% of which has High or Good ecological status, 7.3% of WBs has Moderate ecological status, 12% of WBs has Moderate to Bad, 2.4% of WBs has Poor ecological status and only1.2% of WBs has Bad ecological status. The assessment results are shown in the Figure 35 and 36 (Map 28).

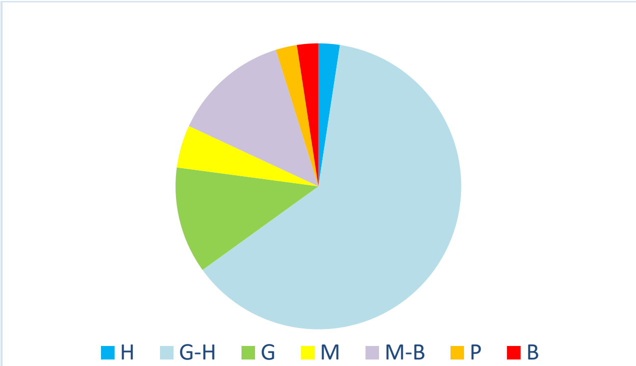


Figure 35: Ecological status assessment of rivers in Sevan RBD

Source: Report on "Definition of reference conditions and class boundaries in rivers of Armenia for the BQE benthic invertebrates", EU member state consortium, 2020.

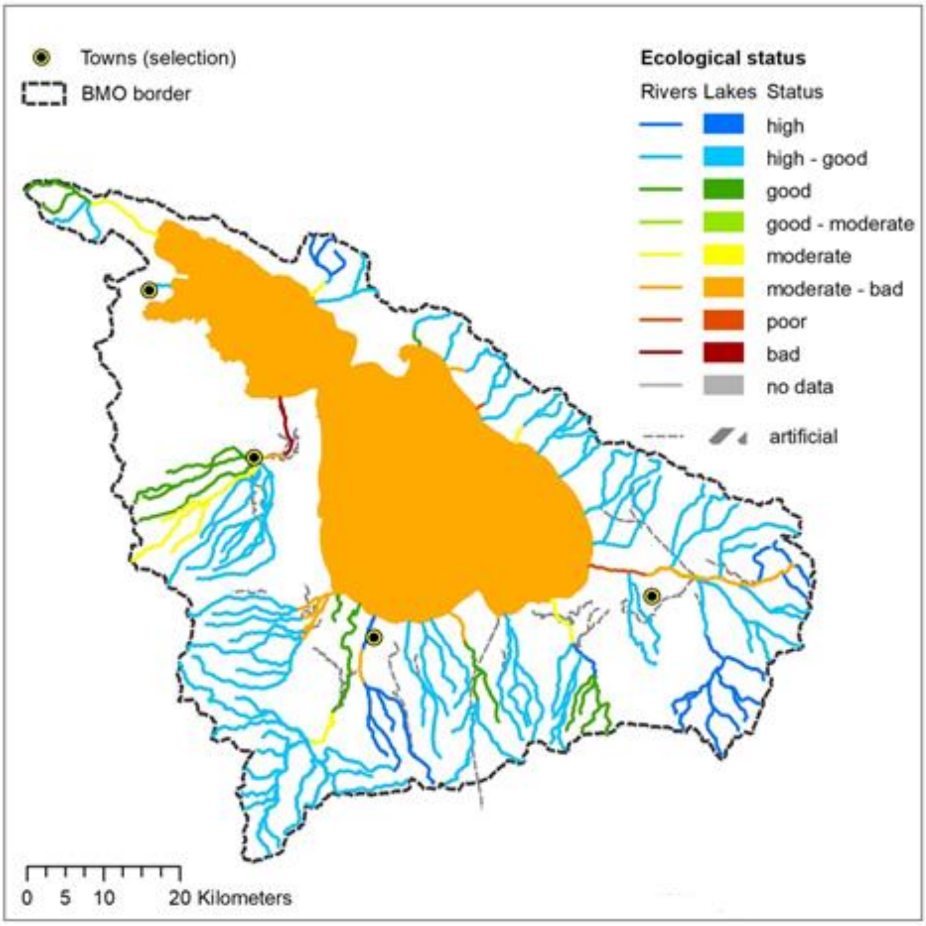


Figure 36: Ecological Status based on preliminary Ecological Classification Of Surface Water Bodies In Sevan RBD

5.5 Assessment of Surface Water Bodies based on Hydromorphology

The ecological flows of the water bodies in RBD have been determined in accordance with the requirements of the Decision No. 57-N on 25 January 2018 of the Government of Armenia. The ecological flow values has been determined for 12 hydrological monitoring posts and also assessed for the rest of delineated water bodies. Monthly ecological flow values for hydrological monitoring posts are given in First Technical Report (Chapter 2.4.3). In order to assess the ecological flow in the hydrological monitoring posts, the multi-year average and minimum natural flows have been restored.

In the Annex 16, monthly ecological flow values for delineated surface water bodies are presented.

Below the assessment of the status of ecological flow in hydrological monitoring post are presented:

(WB 4-003) Dzknaget-Tsovagyugh*.* The ecological flow is violated at gauging site relative to long-term minimum average monthly discharges. But when we compare it with minimum monthly discharges in 2017, then it's fully maintained (Water body).

(WB 4-006) Drakhtik-Drakhtik*.* The ecological flow is violated at gauging site relative to long-term minimum average monthly discharges. The ecological flow is maintained relative to long-term, 2007-2017 period average monthly, and 2017 average monthly discharges (Water body at risk).

(WB 4-019) Pambak-Pambak*.* There isn't violation of ecological flow at gauging site(Water body).

(WBR 4-041) Masrik-Tsovak*.* There isn't violation of ecological flow at gauging site (Water body).

(WB 4-047) Karchaghbyur-Karchaghbyur. The ecological flow at gauging site have been determined in accordance with the requirements of the Annex 2 of Decision No. 57-N on 25 January 2018 of the Government of Armenia and it's for all months equal to 0.46 m^3/s. The ecological flow violation is viewed at gauging site only in case, when it is compared with long-term minimum average monthly discharges. But the ecological flow is fully maintained at gauging site relative to long-term, 2007-2017 period and in 2017 average monthly and minimum monthly discharges (Water body).

(WB 4-051) Vardenis-Vardenik*.* There isn't violation of ecological flow at gauging site (Water body).

(WB 4-057) Martuni-Geghhovit*.* The ecological flow is violated at gauging site. The comparison of ecological flow with minimum monthly discharges in 2017 is show that the ecological flow isn't maintained in June-September period. It is caused by water intake for irrigation (Water Body at Risk).

(WB 4-065) Argichi-Verin Getashen. The ecological flow is violated at gauging site. It isn't maintained compare with 2007-2017 period average monthly discharges, the ecological flow isn't maintained also compare with average monthly discharges in 2017. The ecological flow isn't maintained in June-November months, and it's caused by water intake for irrigation and economic purposes(Water Body at Risk).

(WB 4-060) Tsakhkashen-Vaghashen*.* The ecological flows light violation is seen at gauging site relative to minimum average monthly discharges in 2017, and the ecological flow also isn't maintained compared with long-term minimum average monthly discharges (Water body).

(WB 4-066) Lichk-Lichk. The ecological flow at gauging site have been determined in accordance with the requirements of the Annex 2 of Decision No. 57-N on 25 January 2018 of the Government of Armenia and it's for all months equal to 0.87 m^3/s. There isn't violation of ecological flow at gauging site.(Water body).

(WB 4-069) Bakhtak-Tsakkar*.* The ecological flow is violated at gauging site. The ecological flow is violated when we compare it with long-term and 2007-2017 period minimum average monthly discharges. The ecological flow is violated also relative to minimum monthly discharges in 2017. The violation is viewed in summer months (Water Body at Risk).

(WB 4-082) Gavaraget-Noratus. The ecological flow at gauging site have been determined in accordance with the requirements of the Annex 2 of Decision No. 57-N on 25 January 2018 of the Government of Armenia and it's for all months equal to 1.92 m^3/s. The ecological flow violation is seen at gauging site relative to long-term minimum average monthly discharges and minimum monthly discharges in 2017. The ecological flow is violated in July-September period (Water Body at Risk).

In some water bodies violations of ecological flow have been identified in a result of field studies. Ecological flow in these water bodies does not maintaned due to the water abstraction by communities.

Thus, based on the monitoring data and expert judgments, ecological flow does not maintained in the following 12 water bodies: Drakhtik River from the Drakhtik settlement to mouth, 2640.7m (WB 4-006), Artanish River from village Artanish to mouth, 2108.8m (WB 4-010), River Jil from Dzorashen village to mouth, 2284.6m (WB 4-013), Tsapatagh River from Tsapatagh village to mouth, 869.8m (WB 4-016), Pambak River from Pambak settlement to mouth, 2321.2km (WB 4-020), Masrik River from the confluence of the Sotk River to river mouth, 10606.5m (WB 4-038), Masrik River from Vardenis town to the mouth, 7675.1m (WB 4-041), Martuni River from the village of Geghovit to Martuni town, 4446.8m (WB 4-057), Bakhtak River - from Tsovasar village to Tsakkar village, 5422.8m (WB 4-068), Bakhtak river from the village of Tsakkar to river mouth, 4715.6m (WB 4-069), Tsakkar River - from Dzoragyugh village to mouth, 5566.4m (WB 4-071), Gavaraget river from the Gavar town to river mouth, 4102.2 m (WB 4-082).

Also, nearly 1000 buildings, tens of kilometers of roads and 4000 ha of forests have been waterlogged as a result of the lake level increase since 2002, which cause the hydromorphological changes in the coastal zone of lake and the source of organic pollution of the lake.

Within the "Hydro-Morphological Assessment 2019" (EUWI+, 2019b), the hydro-morphological status have been assessed for the 18 sutvey units in Sevan RBD (Table 56).

Table 56: Hydro-morphological assessment of the survey units

River Basin	Date	Survey unit No	River name	Hydrological status	Morphological status	Hy-Mo Status
Sevan	19.09.2019	7	Argichi	1.0	1.5	1.25
Sevan	23.09.2019	8	Argichi	2.0	1.4	1.7
Sevan	24.09.2019	9	Gavaraget	1.0	1.5	1.25
Sevan	24.09.2019	10	Gavaraget	2.5	3.5	3.0
Sevan	21.09.2019	11	Masrik	1.0	1.4	1.2
Sevan	19.09.2019	12	Masrik	1.0	1.5	1.25
Sevan	22.09.2019	13	Masrik	2.0	3.6	2.8
Sevan	25.09.2019	14	Drakhtik	1.0	1.6	1.3
Sevan	18.09.2019	15	Drakhtik	3.5	2.6	3.05
Sevan	18.09.2019	23	Dzknaget	2.0	2.2	2.1
Sevan	24.09.2019	24	Dzknaget	1.0	1.9	1.45
Sevan	23.09.2019	25	Martuni	2.5	2.0	2.25
Sevan	23.09.2019	26	Martuni	2.0	1.9	1.95
Sevan	22.09.2019	27	Karchaghbyur	2.5	2.1	2.3
Sevan	22.09.2019	28	Karchaghbyur	1.0	1.6	1.3
Sevan	25.09.2019	29	Artanish	2.0	2.6	2.3
Sevan	25.09.2019	30*	Pambak	-	-	-
Sevan	25.09.2019	31*	Tsapatagh	-	-	-

Source: "Hydro-Morphological Assessment 2019" (EUWI+, 2019b)

According to the results of the assessment, the 18 sampling sites were classified of the following classes: 8 - high status, 5 - good status, 3 - moderate status, 2 - no status* (no flow in the river beds).

5.6 Future Surface Water Monitoring

During this period of the development of the RBMP, the first plannuíng cycle, the planning and implementation of a monitoring network based on the requirements of the WFD was started. An overview on new proposed monitoring, which shall include surveillance, operational and investigative monitoring sites and programmes is given in the Programme of Measures in Chapter 8.3.2.2 , and in the EUWI+ documents “Surface Water Monitoring in the Sevan River Basin District, Armenia” (EUWI+, 2020c) and “Surface Water Monitoring Development Plan – Armenia” (EUWI+, 2020d).

5.7 Assessment of Groundwater Bodies Status

5.7.1 Groundwater Monitoring Network

Groundwater monitoring in Armenia was established in accordance with the Resolution N1616 of 08.09.2005 of the RA Government, but regular monitoring started in 2010.

There are 11 hydrogeological monitoring sites in the Sevan RBD (Table 57). These sites are concentrated in the groundwater bodies 3G-2 and 3G-4. Two groundwater bodies (3G-5 and 3G-6) are mineral groundwater bodies and are monitoring by the Ministry of Energy Infrastructures and Natural Resources Following parameters are measured in the sites: groundwater level (in fountaining and non-fountaining wells), discharge (in springs and fountaining wells) and temperature.

Measurements of parameters in all points are performed 6 times a month. Field data are filled by observers in templates and mailed at the beginning of next month (EUWI+, 2019e).

After the necessary processing, the data for the given month is entered to MS Excel spreadsheet before 15th of the following month. Each month the average monthly values are sent to the Department of Cadastre Management of the Division of State Cadastres, Maintenance of Registers and Monitoring of the Department for Licenses, Permits, and Compliances og the Ministry of Environment.

Twice a year (in May and November) water sampling is carried out to perform full chemical analyzes. The analyzes are performed in the laboratory of Hydrometeorology and Monitoring Center SNCO. The following chemical elements and compounds are identified during laboratory tests: HCO_3^-, SO_4^{2-}, Cl^-, NO_3^-, NO_2^-, NH_4^+, Ca^{2+}, Mg^{2+}, Na^++ K^+, Fe^{2+}, F, J, Br, F, total hardness, pH, H_2SiO_3 (EUWI+, 2019f).

In scope of the Draft RBMP development for Sevan and Hrazdan RBDs and in order to improve the monitoring system groundwater survey were conducted and additional sites have been monitored in fall 2018 and in fall 2019.

Total mineralization and dry residue are determined by a computational method. From the physical indicators of water, color and smell are identified.

In each quarter, a summary report is produced, and a final report on the chemical and quantitative changes of groundwater of the RBDs submitted to the authorized body (Ministry of Environment) at the end of the year.

Table 57: Operating Groundwater Monitoring Sites in Sevan River Basin District

№	Site Number	GWB Code	Site Type	Location	Coordinates	Measured Parameters	Measurement Unit
1	31	3G-4	Spring	Gegharkunik Marz, Akunk Village	X=40º 09’ 21.78”, Y=45º 43’ 44.41” H=1974	discharge	l/sec
						temperature	^{0}C
2	38	3G-4	Spring	Gegharkunik Marz, Martuni	X=40º 08’ 44.2”, Y=45º 19’ 02.7”	discharge	l/sec

				City	H=1924	pressure	m
						temperature	^{0}C
3	902	3G-4	Spring	Gegharkunik Marz, Akunk Village	X=40º 09’ 53.22”, Y=45º 44’ 06.39” H=1967	discharge	l/sec
						temperature	^{0}C
4	1053	3G-4	Spring	Gegharkunik Marz, Akunk Village	X=40º 09’ 43.3”, Y=45º43’ 45.0” H=1968	discharge	l/sec
						temperature	^{0}C
5	1299	3G-4	Spring	Gegharkunik Marz, Akunk Village	X=40º 09’ 22.8”, Y=45º 43’ 24.4” H=1965	discharge	l/sec
						temperature	^{0}C
6	1809	3G-4	Fountaining well	Gegharkunik Marz, Vardenis City	X=40º 11’ 07.2”, Y=45º 42’ 36.5” H=1926	discharge	l/sec
						pressure	m
						temperature	^{0}C
7	1810	3G-4	Fountaining well	Gegharkunik Marz, Vardenis City	X=40º 11’ 03.6”, Y=45º 42’ 35.4” H=1927	discharge	l/sec
						pressure	m
						temperature	^{0}C
8	1811	3G-4	Fountaining well	Gegharkunik Marz, Vardenis City	X=40º 11’ 11.8”, Y=45º 42’ 34.3” H=1925	discharge	l/sec
						pressure	m
						temperature	^{0}C
9	1812	3G-4	Fountaining well	Gegharkunik Marz, Vardenis City	X=40º 11’ 13.0”, Y=45º 42’ 33.8” H=1926	discharge	l/sec
						pressure	m
						temperature	^{0}C
10	2013	3G-2	Fountaining well	Gegharkunik Marz, Gandzak Village	X=40º 19’ 06.3”, Y=45º06’ 57.3” H=1984	discharge	l/sec
						pressure	m
						temperature	^{0}C
11	2014	3G-2	Spring “Fadei”	Gegharkunik Marz, Gavar City	X=40º 21’ 02.5”, Y=45º07’ 55.8” H=1952	discharge	l/sec

Source: Environmental Monitoring and Information Centre SNCO, 2018

5.7.2 Chemical and Quantitative Status of Groundwater Bodies

On the chemical and quantitative changes in groundwater agricultural, water-economic, mining, industrial, urban and transport factors in the studied area may have an impact. Agricultural and water economic factors have relatively high spread. In the potential impact zone of these pressures the hydrogeological sites of chemical status monitoring are located.

Assessment of the status of the groundwater bodies in Sevan RBD is based on the quantitative characteristics (groundwater level (in fountaining and non-fountaining wells), discharge (in springs and fountaining wells) and temperature) of 11 hydrogeological monitoring sites, at 6 of which the chemical characteristics (oxygen regimes, nutrients, metals) of water quality are also taken into account. Structured methods to aggregate chemical and quantitative monitoring data into reliable assessments of chemical and quantitative status still need to be developed. A first step in this direction was taken when EMIC, with support by a consultant, developed a national methodology to assess the available groundwater resources in mountain regions and implemented the methodology in the Sevan RBD. This was seen as a step to bring Armenian legal obligations and requirements of the WFD together, and prepare the assessment of quantitative status of groundwater bodies.

In addition, the results of report “Groundwater Surveys 2018 and 2019” (EUWi+) was taken into consideration in order to identify the status of the groundwater bodies in Sevan RBD. Accoring to the report, 10 wells and springs which are not part of the official groundwater monitoring network were sampled in 2018 and 2019. Some of them were sampled in both years. Each sampled was analyzed for a comprehensive number of chemical substances and indicators.

According to the groundwater monitoring results for 2015-2018 and field survey for 2018-2019, the quantitative fluctuations are close to natural, and at present the impacts of anthropogenic pressures on groundwater quantity are not significant. The high discharges and high levels of water in monitoring sites within in the Sevan RBD correspond to relatively low mineralization and vice versa.

Exception here is the results of the analysis of water of N1809 and N2014 monitoring sites, where the opposite phenomena are observed, the high discharges correspond to high mineralization and vice versa. Here unknown anthropogenic factor impacts or omissions in laboratory research are possible that should be clarified during next years. In all cases, the fluctuations are close to natural, and at present the impacts of mentioned pressures are not significant. Based on the report on “Groundwater surveys 2018 and 2019”, "Aghbulakh" or "Spitak" spring (Aghberk village) is periodically used for drinking water supply in case of seasonal water scarcity. Thus, the quantitative status of GWBs can be evaluated as a "good” status.

Based on the hydrochemical monitoring data, the groundwater bodies were distinguished with low mineralization and low total hardness. The nitrate concentration in water samples is exceeded 50 mg/l limit value of the Nitrates Directive and 45 mg/l limit value of the Drinking water norms set up in Armenia only at the spring N 38, in Martuni town (see Chapter 4.6). The relatively high concentration of nitrates also was observed at the spring N 2014, in Gavar town.

According to the report on “Groundwater Surveys 2018 and 2019”, elevated nitrate (NO_3) concentrations (including in some cases exceedances of the 45 mg/l drink water norm approved by the Ministry of Health of the Republic of Armenia) were recorded at following observed sites:

- at the well in Shoghakat village (Shorzha) in Gegharkunik Province, which is located on groundwater body 3G-1, with concentrations of 100.8 mg/l NO_3 (N7 sample of 2018) and 110.135 mg/l NO_3 (N3 sample of 2019);
- at the "Aghbulakh" or "Spitak" spring in Aghberk village in Gegharkunik Province, which is located on groundwater body 3G-1, with concentrations of 53.4 mg/l NO_3 (N8 sample of 2018) and 52.25 mg/l NO_3 (N2 sample of 2019); and
- at the well in Norakert village in Gegharkunik Province, which is located on the groundwater body 3G-4, with a concentration of 111.014 mg/l NO_3 (N8 sample of 2019) (Map 29).

However, the existing data on water quality and frequency of monitoring are not sufficient for providing the chemical status assessment of the GWB in the Sevan RBD. Additional data from a representative groundwater monitoring network and covering a larger set of parameters, including heavy metals, pesticides and other synthetic chemicals, is required.

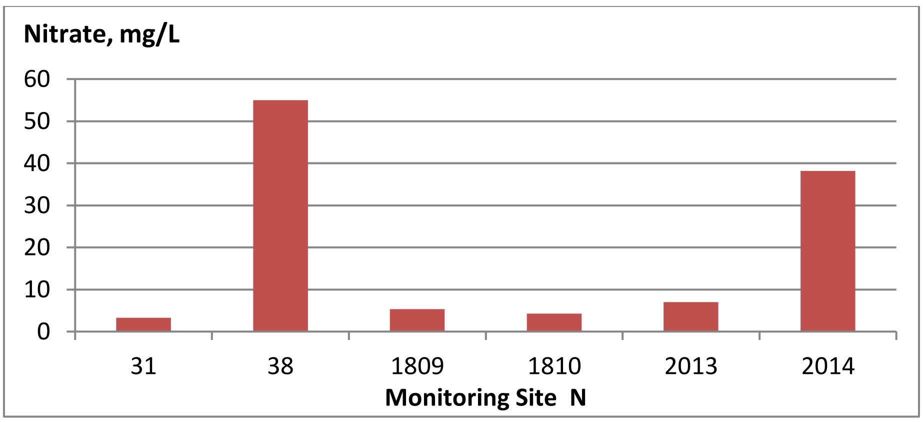


Figure 37: Nitrate Values in Groundwater Monitoring Sites (Source: Environmental Monitoring and Information Centre, 2018)

Characterization of GWBs delineated within Sevan RBD is presented in Annex 17.

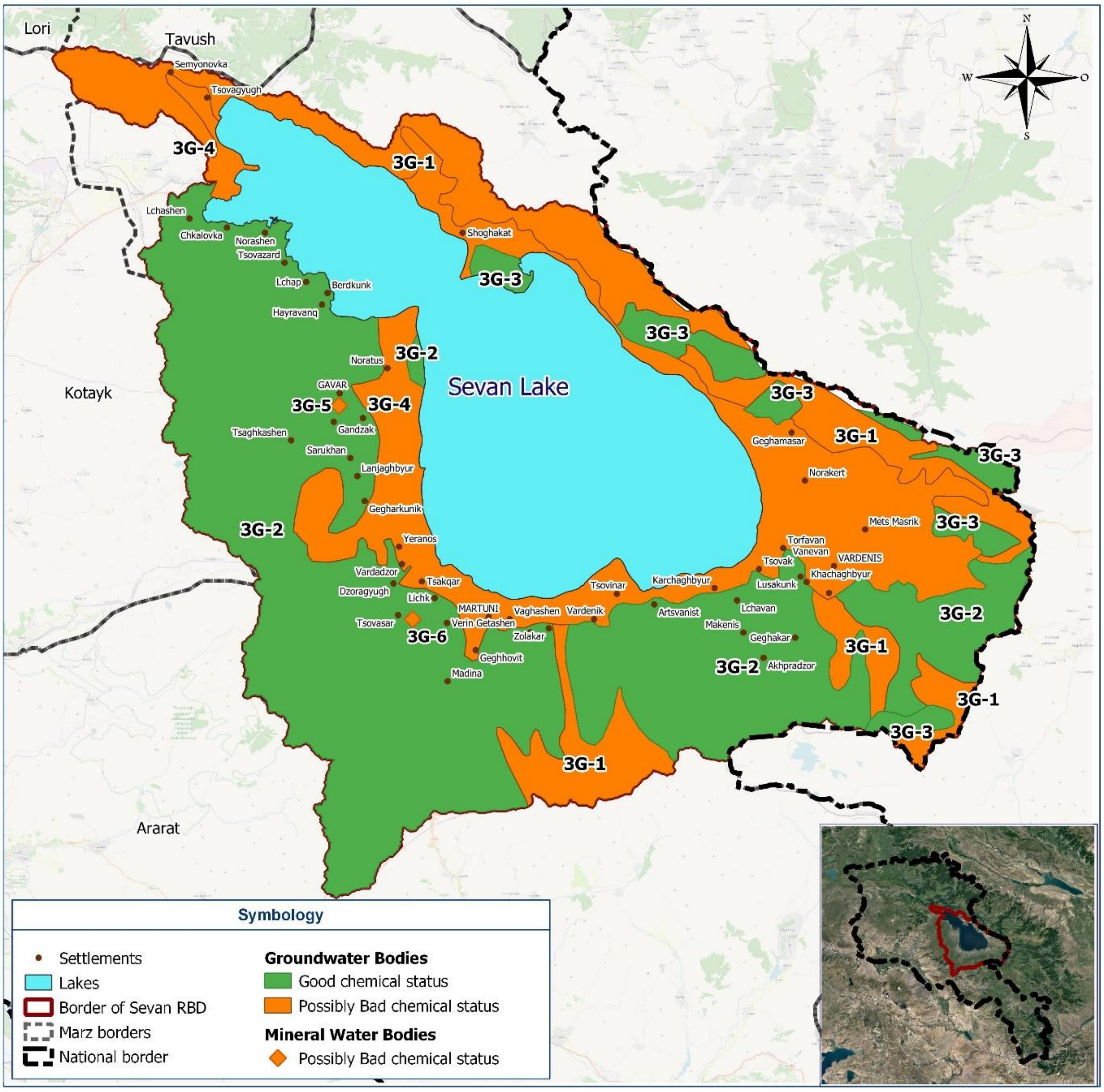


Figure 38: Map of Groundwater Bodies Status within Sevan RBD

5.7.3 Future Groundwater Monitoring

As a main output of the delineation and characterization of groundwater bodies and the design of a groundwater monitoring network in the Hrazdan and Lake Sevan river basin districts in Armenia carried out in the EUWI+ project it is indisputable that 11 groundwater monitoring sites within Sevan RBD with area of around 3500 km^2 are insufficient for the assessment of quantitative and chemical for changes in groundwater resources.

Since the current operating monitoring sites are mainly characterizing GWBs formed in permeable water-bearing hydrogeological complexes and no monitroring data are available in areas where settlements use the water of from the GWBs formed in the mentioned hydrogeological complexes for potable water supply, the future monitoring network should cover the GWBs used for drinking water supply in those areas.

5.8 Assessment of Climate Change Impacts on Water Resources

5.8.1 Climate Change Trends in Sevan RBD

Annual average temperature and total precipitation data of the 4 operational meteorological stations were used for the assessment of the climate change trends in Sevan RBD. Observation data for the period of 1961-2017 were examined.

As seen from the charts below, increase trends in annual air temperature are observed in all 4 meteorological stations (Figures 39 and 40).

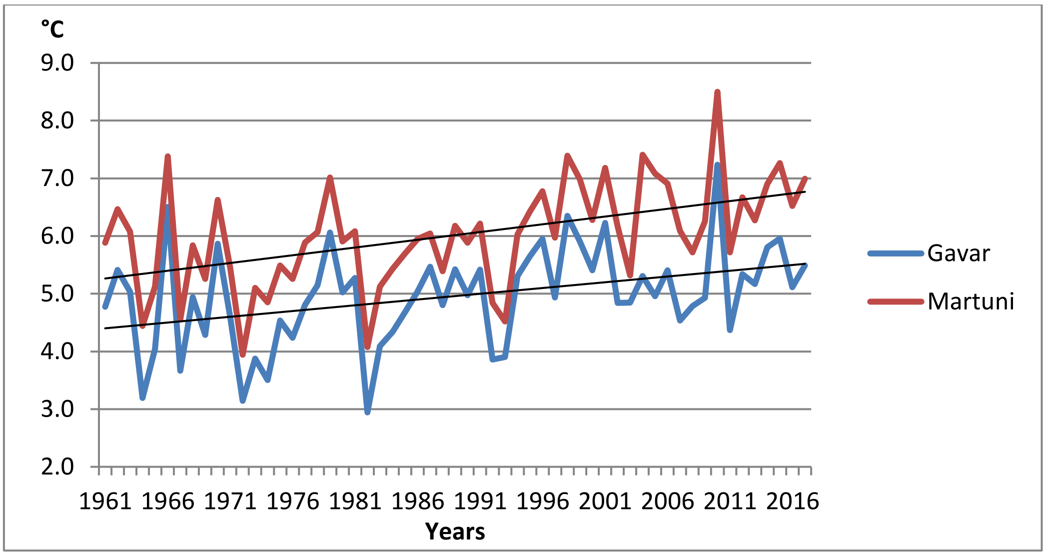


Figure 39: Annual Average Air Temperature in Gavar and Martuni Meteorological Stations, 1961-2017, °C (Source: State Hydromet Service of MES, 2018)

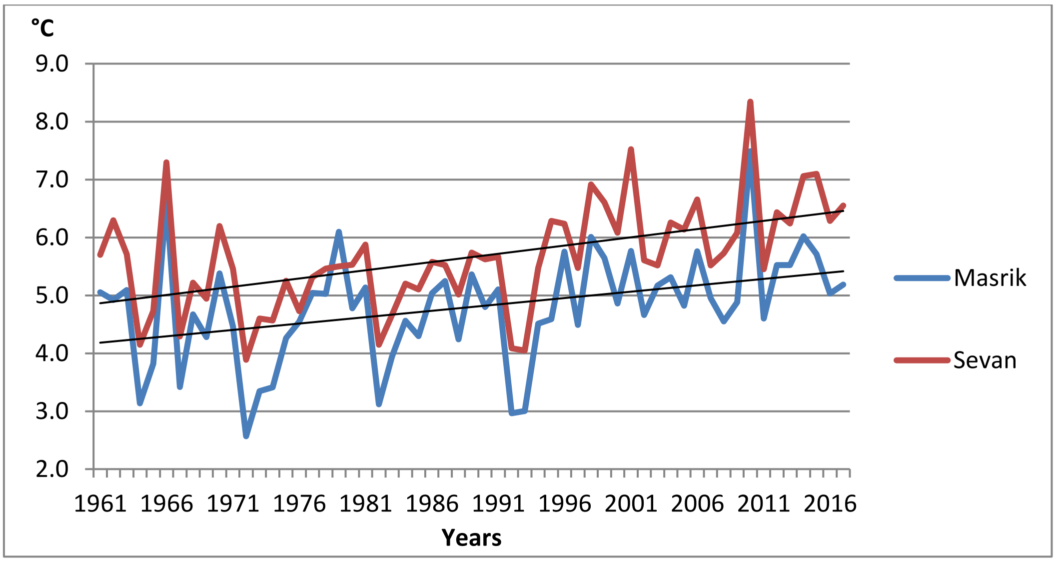


Figure 40: Annual Average Air Temperature in Masrik and Sevan Meteorological Stations, 1961-2017, °C (Source: State Hydromet Service of MES, 2018)

Increase trends in annual precipitation are observed in Martuni and Sevan (Figures 41 and 42).

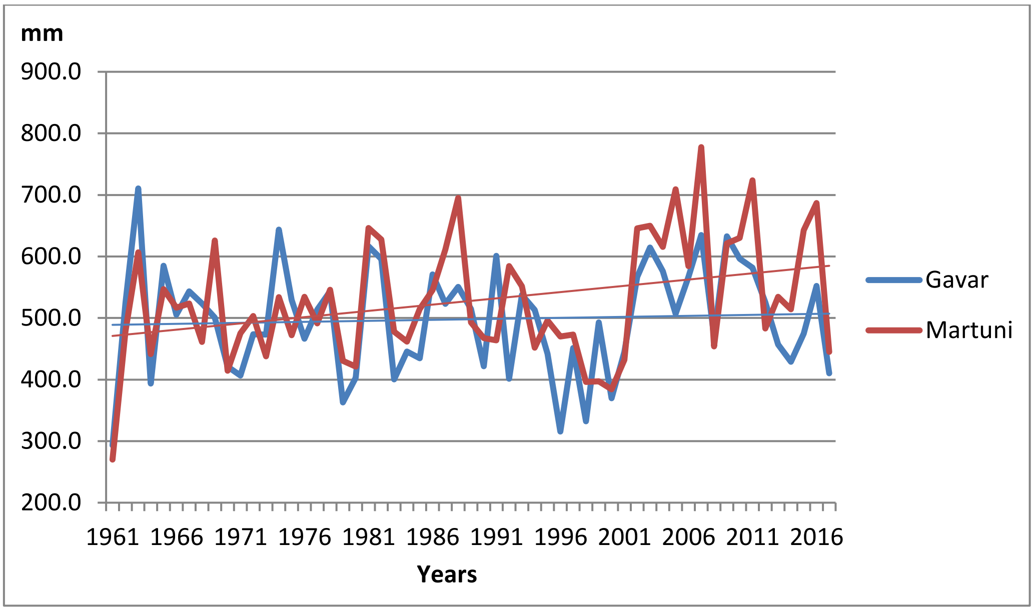


Figure 41: Annual Precipitation in Gavar and Martuni Meteorological Stations, 1961-2017, mm (Source: State Hydromet Service of MES, 2018)

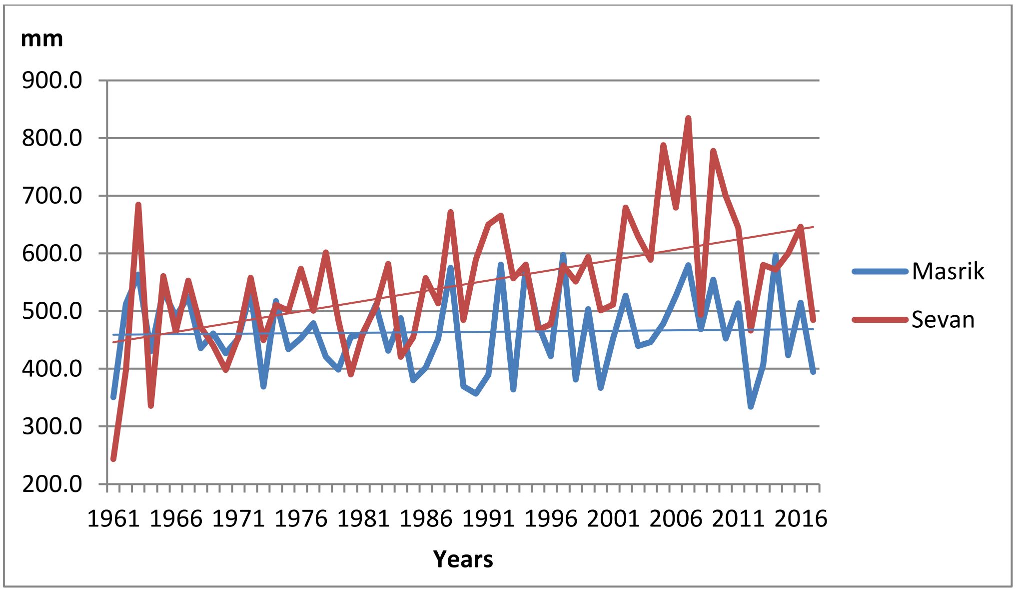


Figure 42: Annual Precipitation Masrik and Sevan Meteorological Stations, 1961-2017, mm (Source: State Hydromet Service of MES, 2018)

5.8.2 Assessment of the Impact of Climate Change on Surface Flow in Sevan River Basin District

Climate change in Armenia is assessed using the CCSM4 and METRAS models in accordance with the IPCC recommended RCP8.5 and RCP6.0 scenarios for CO_2 emissions. Therefore, as per the RCP6.0 scenario (equivalent to the SRES B2 scenario) CO_2 concentration will be 670ppm by 2100 and it will be 936ppm according to the RCP8.5 scenario (equivalent to the SRES A2 scenario). Future change forecasts for ambient air temperature and rainfall have been developed up until 2100.

The results of CCSM4 model application indicate that the temperature will continue to increase in all seasons of the year. However, according to the RCP8.5 scenario, starting from the mid-21th century (2041-2100) the temperature will rise at a more rapid rate. According to the RCP8.5 scenario, it is very likely that, by 2100, the average annual temperature in Armenia will be 10.2°C, which exceeds the baseline (1961- 1990) by 4.7°C. Evaluation results for precipitation change show that, according to the RCP8.5 scenario, there might be 5.2% increase in annual precipitation to 2070, then by the 2100 the precipitation will rapidly decrease and will be around the baseline (+0.7%) (Table 58).

Table 58: Projected Changes in Temperature and Precipitation according to IPCC RCP6.0 and RCP8.5 Scenarios (CCSM4 model)

Parameter	1961-1990	2011-2040		2041-2070		2071-2100	
		RCP6.0	RCP8.5	RCP6.0	RCP8.5	RCP6.0	RCP8.5
Temperature, °C	5.5	+1.7	+1.8	+2.3	+3.2	+3.1	+4.7
Precipitation, mm / %	592/100	+18.9/+3.2	+6.9/+1.2	+13.0/+2.2	+30.7/+5.2	+22.0/+3.7	+4.0/+0.7

METRAS regional model with 12 km resolution is also accepted. The results ACCES, CNRM, MPIM, GFDL global models are in the basis of the METRAS which allowed to downscale the rough results of low-res global models for the territory of Armenia taking into account the complex mountainous topographic conditions of the country.

METRAS model is applied for temperature and precipitation changes projection according to pessimistic RCP8.5 scenario. Projected temperature changes are close to the values obtained from the CCSM4 model, but the precipitation values differ considerably: according to the METRAS model, the precipitation might decrease by 8.3% to 2100 (Table 59).

Table 59: Projected Changes in Temperature and Precipitation according to IPCC RCP8.5 Scenarios (METRAS model)

Parameter	1961-1990	2011-2040	2041-2070	2071-2100
Temperature, °C	5.5	+1.4	+3.1	+4.5
Precipitation, mm / %	592/100	-16/-2.7	-32/-5.4	-49/-8.3

The possible changes in surface natural flow due to the climate change impact were calculated using Climate Change Projections module of DSS developed by USAID Clean Energy and Water Programme using the projected values of changes in meteorological parameters presented above and multi-year observation data on temperature and precipitation in Sevan RBD (Table 60 and 61).

Table 60: Projected Changes in Annual Surface Natural Flow, % (CCSM4)

Hydropost Code	River-Post	RCP6.0			RCP8.5		
		2040	2070	2100	2040	2070	2100
85339	Pambak-Pambak	1	1.3	1.7	1	1.8	2.6
85352	Dzknaget-Tsovagyugh	-12.8	-21	-27	-17.3	-25.5	-49.4
85353	Drakhtik-Drakhtik	-18.4	-26.9	-35.6	-21.6	-35.4	-58.7
85363	Masrik-Tsovak	8.3	9.8	13.7	7.3	15	17.6
85366	Karchaghbyur-Karchaghbyur	-14.7	-20	-26.9	-15.6	-27.7	-41
85371	Vardenis-Vardenik	9.8	11.4	16	8.5	17.7	20.2
85376	Martuni-Geghhovit	6.2	6.5	9.4	4.6	11	9.7
85378	Argichi-Verin Getashen	-17.7	-25.1	-33.5	-19.9	-33.8	-53.4
85379	Tsaghkashen-Vaghashen	-9.2	-14.8	-19.1	-12.1	-18.3	-34.3
85380	Lichk-Lichk	13.8	18.3	24.8	14.2	25.9	36.6
85381	Bakhtak-Tsakkar	-2	-3	-3.9	-2.4	-3.9	-6.5
85384	Gavaraget-Noratus	0.5	0.8	1	0.7	1	1.8

Table 61: Projected Changes in Annual Surface Natural Flow, % (METRAS)

Hydropost Code	River-Post	RCP8.5		
		2040	2070	2100
85339	Pambak-Pambak	0.8	1.7	2.5
85352	Dzknaget-Tsovagyugh	-19.7	-42.7	-62.8
85353	Drakhtik-Drakhtik	-20.3	-44.4	-64.8
85363	Masrik-Tsovak	3.4	7.9	11.1
85366	Karchaghbyur-Karchaghbyur	-12.3	-27.3	-39.6
85371	Vardenis-Vardenik	3.5	8.3	11.7
85376	Martuni-Geghhovit	0.2	1	1.1
85378	Argichi-Verin Getashen	-17.5	-38.4	-56
85379	Tsaghkashen-Vaghashen	-13.3	-28.9	-42.5
85380	Lichk-Lichk	10.3	22.9	33.1
85381	Bakhtak-Tsakkar	-2.2	-4.9	-7.2
85384	Gavaraget-Noratus	0.7	1.5	2.3

As can be seen from Tables 60 and 61, changes in surface flow in different river basins are of a different nature. The most dramatic decrease in surface natural flow compared to the baseline period (1961-1990) is predicted in Drakhtik (up to -64.8%), Dzknaget (up to -62.8%), Argichi (up to -56%), Karchaghbyur (up to -41%) and Tsaghkashen (up to -42.5%), and the biggest increase is predicted in Lichk (up to +36.6%), Vardenis (up to +20.2%) and Masrik (up to +17.6%) river basins. Thus, climate change impacts should be considered in the planning and assessment of water demand and supply in future.

Changes in surface natural flow were interpolated for entire territory of Sevan RBD through spatial analysis in GIS environment using the surface natural flow height raster calculated through DSS Water Balance module and surface flow projections (Annex 18).

6. RISK ASSESSMENT AND ENVIRONMENTAL OBJECTIVES

6.1 Risk Assessment Indicators and Criteria

This chapter is undertaking the final risk assessment that is improving the preliminary risk assessment for surface and groundwater bodies considering the result of all pressure-impact issues and using the following data available:

- Hydrological and hydro-morphological monitoring data provided by the RA MES Armhydromet service;
- Surface water physico-chemical and chemical monitoring data: Results of physico-chemical monitoring conducted by the RA MNP Environmental Monitoring and Information Centre at 21 sampling sites in the rivers and at 17 sampling sites in the Lake Sevan.
- Groundwater physico-chemical and chemical monitoring data: Results of chemical-physical monitoring conducted by the RA MNP Environmental Monitoring and Information Centre from at 6 observation points.
- Groundwater quality monitoring data: Results of qualitative monitoring conducted by the RA MNP Environmental Monitoring and Information Centre.
- Identification of the drivers in the Sevan RBD.
- Statistical data on social and economic setting.

Due to the absence of data of the biological monitoring of surface water in Armenia, it made impossible to identify the risk assessment indicators and criteria for biological elements. There are a partial (minor) biological monitoring observation data for Sevan lake and some of the rivers at RBD, conducted by Institute of Hydroecology and Ichthyology of Scientific Center of Zoology and Hydroecology of the RA National academy of Science. In addition, there are data on biological monitoring and ecological status assessment of Sevan RBDfor 2018-2019 within the framework of the study “Definition of reference conditions and class boundaries in rivers of Armenia for the BQE benthic invertebrates” conducted by the EU member state consortium. However, these observations are not systematic and data set is statistically insignificant, as well as there is no methodology and criteria adopted by the government for ecological status assessment.

In this chapter of Sevan RBD, the surface water risk assessment, as well as pressure-impact analyses were focused on physico-chemical, hydro-morphological and a single assessment of hydro-biological parameters. Risk assessment for groundwater was based on quantitative and physico-chemical characteristics, as well.

Further, on the Chapter on Program of Measures of the Sevan RBMP, biomonitoring observations will be proposed in the water monitoring system for surface water ecological status assessment.

According to the definition of the EU WFD, a **Water Body at Risk** is a water body that is identified as being at risk of failing the WFD environmental objectives (Article 2). This is based on the results of basin characterization (Article 5) and pressure-impact analysis and/or operational monitoring (Article 8). Water bodies possibly at risk to fail the EU WFD environmental objective is a water body for which datasets are insufficient to apply risk criteria.

6.1.1 Surface water risk assessment

The identification of Surface Water Bodies at risk was conducted using the results of pressure-impact analysis and risk indicators and criteria recommended in the “Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD" (prepared by EPIRB Project, 2014), which have been adapted to taking into consideration data availability in Armenia.

Due to the unavailability of biological monitoring data, the risk indicators and criteria were proposed only for physico-chemical and hydro-morphological parameters.

The surface water bodies should be assigned to the three categories based in their risk status: 1. water body at risk; 2. water body possibly at risk; 3. water body not at risk.

6.1.1.1 Risk Assessment for hydromorphological elements

Hydromorphological alterations are changes to the natural flow regime and structure of surface waters such as modification of bank structures, sediment/habitat composition, discharge regime, gradient and slope. The consequences of these pressures can impact on aquatic ecological fauna and flora and can henceforth significantly impact the water status. Hydromorphological pressures comprise all physical alterations of water bodies modifying their shores, riparian and littoral zones, water level and flow (Hydromorphological Alterations and Pressures in European rivers, lakes transitional and coastal waters, 2012).

The ecological classification system required under the WFD (Annex V) describes hydromorphological elements as 'supporting the biological elements' (Figure 43). This means assessing pressures and impacts on:

- hydrological regime (quantity and dynamics of flow, connection to groundwater);
- continuity (ability of sediment and migratory species to pass freely up and down rivers and laterally with the floodplain);
- morphology (i.e. physical habitat – compositions of substrate, width/depth variation, structure of bed, banks and riparian zone).

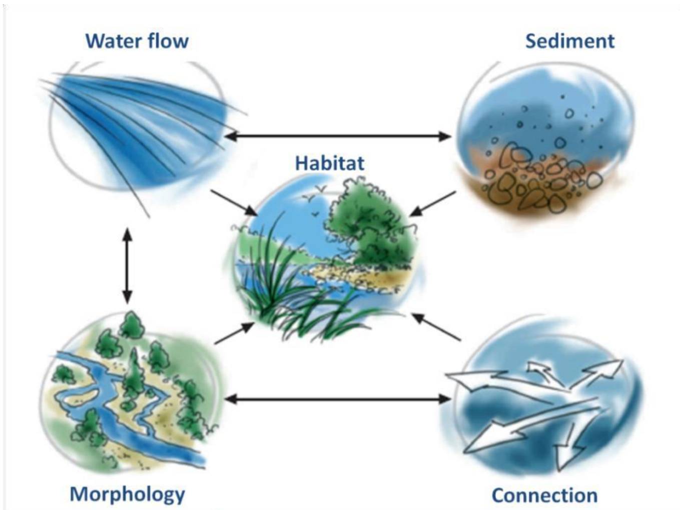


Figure 43: Hydromorphological Elements. Source: Bourdin et al. (2011)

Table 62 clearly shows that hydromorphological pressures are only assessed indirectly for good and moderate status.

Table 62: Definitions for high, good and moderate ecological status in rivers taking into account hydromorphological parameters (EU WFD Annex V)

HYMO Element	High Status	Good Status	Moderate Status
Hydrological regime	The quantity and dynamics of flow, and the resultant connection to groundwaters, reflect totally, or nearly totally,	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

	undisturbed conditions.		
River Continuity	The continuity of the river is not disturbed by anthropogenic activities and allows undisturbed migration of aquatic organisms and sediment transport.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.
Morphological condition	Channel patterns, width and depth variations, flow velocities, substrate conditions and both the structure and condition of the riparian zone correspond totally or nearly totally to undisturbed conditions.	Conditions consistent with the achievement of the values specified above for the biological quality elements.	Conditions consistent with the achievement of the values specified above for the biological quality elements.

Sources: EU WFD, Annex V; Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD, prepared by EPIRB Project, 2014

When it comes to hydromorphology related anthropogenic pressures,their impact depends on the size of the river or its catchment area. When implementing a risk assessment this fact has to be taken into account, specifically when setting and applying risk criteria. Different methodologies are in use regarding this challenge, e.g. taking into account stream order rankings, catchment area size categories or river typologies. To ease implementation, this approach will make use of river size categories that are based on typology (Table 63):

Table 63: Three groups of river sizes for which risk criteria shall be applied

River Size Category	Description of River Type	Proposed Catchment Area Sizes
Small	Mountain ‘gravel’ river type	10 km^2 – 100 km^2
Medium	Semi-Mountain ‘gravel’ river type	100 km^2 – 1000 km^2
Large	Lowland/Plain river type	> 1000 km^2

Sources: Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD, prepared by EPIRB Project, 2014

In the Guidance Document on Pressure/Impact Analysis (Risk Assessment) in the EPIRB Project Pilot Basins, hydromorphological pressure types have been identified:

Table 64: Pressure types for which criteria are identified to determine if water bodies are at risk not to achieve good status or at risk of deterioration of their good status

Pressure Group	Pressure Type *including the indication of drivers*
Longitudinal river and habitat continuity interruption	**1. Interruption of river continuity and fish migration routes** Drivers: Irrigation; hydropower; drinking water reservoirs; other barriers;
Hydrological alteration	**2. Water abstraction** – River stretches impacted by in-sufficient ecological flow. Drivers: Irrigation; hydropower; drinking water reservoirs; other barriers;
	3. Impoundments / Reservoir Effects / Back water: River stretches impacted by altered flow conditions upstream of (i) artificial barriers (change of river like to lake like character) and (ii) due to dredged river bed materials.

	Drivers: Irrigation dams; hydropower; drinking water reservoirs; other barriers;
	4. Hydropeaking: River stretches impacted by altered flow conditions downstream of artificial barriers/hydropower schemes and that are effected by regular artificial flood pulses Drivers: hydropower; drinking water reservoirs; other barriers;
Morphological alterations *(only feasible if survey information in 5 classes for entire river reaches are available)*	**5. Changes in overall nature-like morphological condition of rivers.** Drivers: broad set of human water uses including agriculture flood protection, urban settlements, industry, hydropower, navigation, etc.

Sources: Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD, prepared by EPIRB Project, 2014

To assess a hydrological alterations pressure, the monthly ecological flows of the water bodies in RBD have been determined in accordance with the requirements of the Decision No. 57-N on 25 January 2018 of the Government of Armenia.

Three risk categories to indicate the possible failure of the EU WFD environmental objectives due to hydropmorphological pressures are presented in the table below.

Table 65: Three risk categories to indicate the possible failure of the EU WFD environmental objectives

Risk Category	Risk Category Name
1	**Water body at risk** to fail the EU WFD environmental objective One or more significant (see risk criteria) hydromorphological alterations are assessed (barriers, impoundments, water abstraction, hydropeaking) River morphology (if available) is "extensively modified or severely modified'. Water bodies of this group should be considered as heavily modified (HMWB).
2	**Water body possibly at risk** to fail the EU WFD environmental objective Data sets are insufficient to apply criteria and gaps need to be filled. OR No significant (see risk criteria) hydromorphological alterations (barriers, impoundments, water abstraction, hydropeaking) are assessed. However, river morphology (if available) is "moderately modified". This group is temporary, because decision whether these water bodies should belong to category "provisional HMWB" cannot be done and needs additional data and investigation.
3	**Water body not at risk** to fail the EU WFD environmental objective No significant (see risk criteria) hydromorphological alterations (barriers, impoundments, water abstraction, hydropeaking) are assessed. River morphology is "near-natural" or "slightly modified". Water bodies of this group should be considered as natural river water bodies regarding hydromorphology. However, other pressures may be assessed.

Sources: Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD, prepared by EPIRB Project, 2014

6.1.1.2 Risk Assessment based on the Physico-Chemistry

For surface water chemical status assessment, the WFD compliant One-Out-All-Out Principle should be applied. This key principle reflects the integrated approach for the protection of water resources and associated aquatic ecosystems. The overall status would only be ‘good’ if all the elements comprised are at least considered ‘good’. This ensures that all pressures capable of degrading the water status are addressed and is a guarantee of the environmental integrity of the objectives of the directive. This means, even if only one of the criteria is rated ‘at risk’ but the others not, this puts the water body at risk.

The following risk assessment indicators are proposed to identify the surface water bodies risk category within the Seven RBD.

- pressure indicators and related criteria, and
- water quality indicators and related risk criteria for physico-chemical elements

Pressure indicators

Pressure indicators address the following main pollutions sources:

- Two pressure indicators for pollution from municipal wastewater sources (including industrial (also mining) wastewater sources as far as possible) and
- Two pressure indicators for diffuse agricultural and mining pollution sources.

Pressure Indicator 1: Untreated wastewater (Driver: domestic and industrial, including mining)
This pressure indicator describes the untreated wastewater load in relation to the annual minimum flow. D_{ww} expresses the dilution of wastewater in a river water body. The pressure indicator helps to categorize the (raw) wastewater loads and rank them according to the magnitude of the expected impact on water status. Priority ranking and the classification of hot spots may be based on this indicator combined with information on the size of the impacted river stretch and magnitude of the pressure (Table 66).

The indicator can be calculated to analyse pressures according to the following equation:

$$\mathbf{D_{ww} = L / Q_{min,r}}$$

Description of used variables:

- Dww: Specific wastewater discharge into the respective river water body
- L: Total (dimensionless) load equivalent originating from wastewater discharge into the river in terms of (1) organic matter as BOD; and (2) number of inhabitants connected to the sewerage system. This load equivalent (L) is discharged at a distinct location (point source) to the river. The total load equivalent is expressed as calculated dimensionless number L, using either the number of connected inhabitants or – in case loads are given - population equivalents, based on 1 population equivalent (PE) BOD = 60g/d, 1PE = 1 person connected to the sewerage system.

Table 66: Values for the treatment efficiency of different wastewater treatment schemes

Parameter	Treatment Efficiency η [-]			
	Setting Tank	Primary	Secondary	Advanced (nutrient removal)
Organic matter BOD	20	85	90	95
Organic matter COD		70	75	80
TSS	50	>90	>90	>90

NH_4		<25	>90	
Total N				75
Total P				80

Source: Short guid to improve small WWTP efficiency, 2006

Pressure Indicator 2: Likelihood for diffuse pollution (Driver: Agriculture)

This indicator describes the likelihood of diffuse pollution including typical agricultural contaminants, such as nutrients from fertilizers, pesticides and other plant protection products. The indicator uses a general variable for the quantification of agricultural activities. Therefore not only general physic-chemical influences are covered but also other impacts that may go along with agriculture, such as pollution with agriculture related priority substances.

The indicator is calculated to analyse pressures according to the following equation:

$$\mathbf{S_{agri} = A_{agri} / A_{WB}}$$

Description of equation:

S_{agri} : Share of agricultural area in Sevan river basin catchment
A_{WB} : Catchment area of the Sevan BMD [km^2]

Pressure Indicator 3: Likelihood for diffuse pollution (Driver: Animal livestock)

This indicator describes the likelihood of diffuse pollution with typical pollutants stemming from animal live stocking, such as nutrients (with potentially toxic (e.g. NH_4) or chronic effects (e.g. PO_4) that can impact on biological quality elements and organic matter with potentially negative effects on river oxygen regime).

This indicator is calculated to analyse pressures according to the following equation:

$$\mathbf{I_{hus} = U_e / A_{WB}}$$

Description of equation:

I_{hus} : Indicator for animal livestock [LU/ha]
U_e : Animal livestock unit
A_{WB} : Catchment area [ha]

Pressure Indicator 4: Total share of wastewater (agriculture, mining, household) in the river

This indicator describes the total share of wastewater, including wastewater from mining, that has been discharged to river from its source. It does not specifically show the expected impact on general physico-chemical parameters but before all it indicates the likelihood of contamination with conservative substances and substances that tend to accumulate in sediment and biota, such as heavy metals. This pressure indicator gives an overall estimate for the potential contamination with micro pollutants (such as priority substances and specific pollutants).

This indicator is calculated to analyse pressures according to the following equation:

$$\mathbf{S_{ww} = \Sigma Q_{ww} / MQ_r}$$

Description of equation:

S_{ww} : Total share of wastewater in a river at a given cross section along the river
Q_{ww} : Total of all (current/future) upstream wastewater discharges into the river [m^3/s]
MQ_r : Mean annual flow of the river [m^3/s]

Water quality indicators

The EU WFD lists under the term general physico-chemical parameters the following indicators which are relevant for the Sevan BMD. The list of physico-chemical parameters was defined based on the „Pressure-impact analysis“ described in the Sevan RBMP –part 1 (Characterization) report.

“Thermal conditions” may be measures with the following parameters

- Temperature – T [°C]
- Delta T (abrupt Temperature change/increase due to anthropogenic influence (cooling water, wastewater inlet, stagnation due to abstraction etc.)

“Oxygenation conditions” may be measures with the following parameters

- O_2 [mg/l]
- BOD-ATH, TOC, (COD) as indicators for organic matter, degradability and oxygen demand

“Nutrient conditions” may be measures with the following parameters

- NH_4, NO_3
- PO_4

“Heavy metals conditions” may be measures with the following parameters

- Vanadium
- Cobalt
- Antimony

The thresholds of listed parameters are specified for each river in the Sevan RBD by water quality norms set up by the RA Gov 75-N, 2011 (Annex 14).

Criteria to assess the risk of failing the environmental objectives

The Risk criteria used for <u>pressure indicators</u> are as follows:

1. **Criteria to assess the risk regarding an identified pressure *Untreated Wastewater* ($D_{ww} = (L*(1-\eta))/ Q_{min,r}$)**

Risk Category	Risk Criteria
At Risk	$D_{ww}>1.5$
Possibly at Risk	$1<D_{ww}<1.5$
Not at Risk	$D_{ww}<1$

2. Criteria to assess the risk regarding an identified pressure Likelihood Diffuse Pollution *(Agriculture* - $S_{agri} = A_{agri} / A_{WB}$)

Risk Category	**Risk Criteria**
At Risk	S_{agri}>0.3
Possibly at Risk	0.1<S_{agri}<0.3
Not at Risk	S_{agri}<0.1

3. Criteria to assess the risk regarding an identified pressure *Likelihood Diffuse Pollution (Animal live stocking* - $I_{hus} = U_e / A_{WB}$)

Risk Category	**Risk Criteria**
At Risk	I_{hus}> 1
Possibly at Risk	0.3<I_{hus}< 1
Not at Risk	0<I_{hus}< 0.3

4. Criteria to assess the risk regarding an identified pressure Total Share of Wastewater in River ($S_{ww} = \Sigma Q_{ww}/MQ_r$)

Risk Category	**Risk Criteria**
At Risk	S_{ww}> 0.1
Possibly at Risk	0.05<S_{ww}< 0.1
Not at Risk	S_{ww}< 0.05

Table 67: The Risk criteria used for water quality indicators are as follows:

River Size	Oxygen [% sat]*	BOD**	NH_4**	NH_4***	PO_4***	pH
Small	75	5	0.4	0.15	0.2	6.5-8.5
Medium	70	6	0.6	0.2	0.3	
Large	60	7	0.8	0.3	0.4	

* 10% percentile (all seasons, comparable measurement conditions, at least 12 measurements)
** 90% percentile (all seasons, representative flow conditions, at least 12 measurements)
*** annual mean

Source: "Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD", EPIRB Project, 2014

6.1.2 Groundwater risk assessment

The Article 5 (Pressures and Impacts) groundwater assessment uses a simple pressure, pathway, receptor model to identify where the impacts on groundwaters are likely to occur.

Risk Categories for groundwater bodies defined the same logic as for surface water:

- Water bodies for which it is already clear without the need for further characterization or additional monitoring data, that the objectives will be failed **(at risk);**
- Water bodies for which it is possible that the objectives of the Directive will be failed but, because of inadequate data, further characterization and operational monitoring are considered necessary to be sufficiently confident that this is the case **(possibly at risk);**
- Water bodies for which it is already clear, without the need for further characterization or additional monitoring data, that the achievement of the objectives are not at risk **(not at risk).**

For water bodies, which identified at significant risk, consideration of appropriate measures to improve status can start as soon as practical.

The groundwater bodies for which further information will be needed to confirm that they are not at significant risk or for which confidence in the available information not being comprehensive and reliable are identified "probably at risk". For those groundwater bodies more detailed risk assessments (including, where necessary, further characterization) should aim at determining whether or not the water bodies in this category are at risk.

The following risk assessment indicators are proposed to identify the ground water bodies risk category within the Seven BMD:

1 pressure indicators and related criteria (groundwater abstraction, diffuse source pollutants and point source pollutants);
2 water quality indicators and related risk criteria (available representative monitoring data show an environmentally significant upward trend in groundwater nitrate concentrations).

The Risk criteria used for water quality indicators are as follows:

Risk Category	Risk Criteria
At Risk	NO_3> 45mg/l*
Possibly at Risk	• If the groundwater body located in the nitrate vulnerable zone defined by surface water • If random monitoring observation recorded values close to the 45mg/l limit of the NO_3 concentration.
Not at Risk	NO_3< 45mg/l

**Drinking water norm of nitrate set up by Republic of Armenia*

Based on the requirements of the Nitrates Directive the groundwaters contain more than 50 mg/l nitrates or could contain more than 50 mg/l nitrates if environmental action is not taken. However, according to the Drinking water norms set by RA Government (N 2-III-A2-1 sanitary rules and regulations on "Drinking water: Hygienic requirements for water quality at the centralized water supply systems: Quality control" No 876, 25.12.2002 Order of the Minister of Health), the limit for nitrates concentration in the drinking water is 45 mg/L.

Taking into account, that groundwater in the Sevan RBD is considered as a freshwater source and mostly used for drinking purpose, it will be logical consideration to apply more strict limits for nitrate contain in groundwaters.

6.2 Identification and mapping of water bodies at risks

This chapter was prepared based on the initial characterization and the results on water monitoring data and chemical status assessment given in the final report on the Sevan RBMP Part I. The data used on the ecological status assessment of the Sevan BMD is also presented in the study “Definition of reference conditions and class boundaries in rivers of Armenia for the BQE benthic invertebrates” study report. The water monitoring data and risk assessment criteria were used for the identification and mapping of the water bodies at risks in the Sevan BMD.

Surface and groundwater bodies delineation in the Sevan RBMP Part I was based on the RBD's characterization result, particularly, the “drivers-pressure-impact” analyses were used. The pressures to which the water bodies are liable to be subject were identified including point sources of pollution, diffuse sources of pollution and changes in water levels and flow caused by abstraction or recharge, etc.

Following this initial characterization, further characterization was carried out for those surface and groundwater bodies which have been identified as being at risk in order to establish a more precise assessment of the significance of such risk and identify any measures to be required under Article 11 of the WFD.

6.2.1 Risk Assessment of Surface Water Bodies based on Hydromorphology

The ecological flows of the water bodies in RBD have been determined in accordance with the requirements of the Decision No. 57-N on 25 January 2018 of the Government of Armenia. Monthly ecological flow values has been determined for 12 hydrological monitoring posts and also assessed for the rest of delineated water bodies.

Below the identification of surface water bodies at risk based on hydromorphology is presented:

(WB 4-003) Dzknaget-Tsovagyugh*.* The ecological flow is violated at gauging site relative to long-term minimum average monthly discharges. But when we compare it with minimum monthly discharges in 2017, then it’s fully maintained (Water body).

(WB 4-006) Drakhtik-Drakhtik*.* The ecological flow is violated at gauging site relative to long-term minimum average monthly discharges. The ecological flow is maintained relative to long-term, 2007-2017 period average monthly, and 2017 average monthly discharges (Water body at risk).

(WB 4-019) Pambak-Pambak*.* There isn’t violation of ecological flow at gauging site (Water body).

(WB 4-041) Masrik-Tsovak*.* There isn’t violation of ecological flow at gauging site (Water body).

(WB 4-047) Karchaghbyur-Karchaghbyur. The ecological flow at gauging site have been determined in accordance with the requirements of the Annex 2 of Decision No. 57-N on 25 January 2018 of the Government of Armenia and it’s for all months equal to 0.46 m^3/s. The ecological flow violation is viewed at gauging site only in case, when it is compared with long-term minimum average monthly discharges. But the ecological flow is fully maintained at gauging site relative to long-term, 2007-2017 period and in 2017 average monthly and minimum monthly discharges (Water body).

(WB 4-051) Vardenis-Vardenik. There isn’t violation of ecological flow at gauging site (Water body).

(WB 4-057) Martuni-Geghhovit*.* The ecological flow is violated at gauging site. The comparison of ecological flow with minimum monthly discharges in 2017 is show that the ecological flow isn’t maintained in June-September period. It is caused by water intake for irrigation (Water Body at Risk).

(WB 4-060) Tsakhkashen-Vaghashen*.* The ecological flows light violation is seen at gauging site relative to minimum average monthly discharges in 2017, and the ecological flow also isn’t maintained compared with long-term minimum average monthly discharges (Water body).

(WB 4-066) Lichk-Lichk. The ecological flow at gauging site have been determined in accordance with the requirements of the Annex 2 of Decision No. 57-N on 25 January 2018 of the Government of

Armenia and it's for all months equal to 0.87 m³/s. There isn't violation of ecological flow at gauging site.(Water body).

(WB 4-069) Bakhtak-Tsakkar. The ecological flow is violated at gauging site. The ecological flow is violated when we compare it with long-term and 2007-2017 period minimum average monthly discharges. The ecological flow is violated also relative to minimum monthly discharges in 2017. The violation is viewed in summer months (Water Body at Risk).

(WB 4-082) Gavaraget-Noratus. The ecological flow at gauging site have been determined in accordance with the requirements of the Annex 2 of Decision No. 57-N on 25 January 2018 of the Government of Armenia and it's for all months equal to 1.92 m³/s. The ecological flow violation is seen at gauging site relative to long-term minimum average monthly discharges and minimum monthly discharges in 2017. The ecological flow is violated in July-September period (Water Body at Risk).

In some water bodies violations of ecological flow have been identified in a result of field studies. Ecological flow in these water bodies does not maintaned due to the water abstraction by communities.

Thus, based on the monitoring data and expert judgments, ecological flow does not maintained in the following 12 water bodies: Drakhtik River from the Drakhtik settlement to mouth, 2640.7m (WB 4-006), Artanish River from village Artanish to mouth, 2108.8m (WB 4-010), River Jil from Dzorashen village to mouth, 2284.6m (WB 4-013), Tsapatagh River from Tsapatagh village to mouth, 869.8m (WB 4-016), Pambak River from Pambak settlement to mouth, 2321.2km (WB 4-020), Masrik River from the confluence of the Sotk River to river mouth, 10606.5m (WB 4-038), Masrik River from Vardenis town to the mouth, 7675.1m (WB 4-041), Martuni River from the village of Geghovit to Martuni town, 4446.8m (WB 4-057), Bakhtak River - from Tsovasar village to Tsakkar village, 5422.8m (WB 4-068), Bakhtak river from the village of Tsakkar to river mouth, 4715.6m (WB 4-069), Tsakkar River - from Dzoragyugh village to mouth, 5566.4m (WB 4-071), Gavaraget river from the Gavar town to river mouth, 4102.2 m (WB 4-082).

Based on the biological and chemical status assessment results for 2019 and following the EU WFD regulation, the ecological status of the Argichi River from Verin Getashen village to mouth (WB 4-065) as identified as a Good. However, based on the expert judgments and hydrological data, the ecological flow isn't maintained in June-November from 2007-2017, and it's caused by water intake for irrigation and economic purposes. During the risk assessment, it was proposed to categories this water body as a ***possibly at risk*** and further investigate the ecological status of it.

6.2.2 Risk Assessment of Surface water based on biology and chemistry

Based on the chemical status assessment for the period of 2015-2018, ***9 surface water bodies in Sevan RBD*** are identified at risk (Table 68): Sotk River downstream Sotk gold mine to river mouth (WB 4-031); Masrik River from the confluence of the Sotk River to river mouth (WB 4-041); Vardenis River from Vardenik village to the river mouth (WB 4-052); Martuni River from the village of Geghovit to river mouth (WB 4-057, 4-058); Bakhtak from the village of Tsakkar to river mouth (WB 4-069); Shoghvak river from the Dzoragyugh village to river mouth (WB 4-073); Gavaraget river from the Gavar town to river mouth (WB 4-082) and Geloidzor river from source to estuary with its tributaries (WB 4-079).

The identified water bodies at risk distinguished by "moderate" (III) and "poor" (IV) chemical status, as well as "poor" (IV) to "bad" (V) status for Gavaraget River accordance with the ecological norms and requirements set by RA Gov. #75-N decision. The water bodies are being polluted by untreated domestic wastewater discharge from, both, point and non-point sources, as well as polluted by the return flows from agriculture. In case of Sotk and Masrik rivers the water bodies are being polluted by return flows from mining sites, as well.

Based on the both biological and chemical surveys during 2019, also ***17 surface water bodies in Sevan RBD*** are identified at risk: Drakhtik River from village Drakhtik to mouth (WB 4-006); Jil River from village Dzorashen to mouth (WB 4-013); Tsapatagh River from village Tsapatagh to mouth (WB 4-016); Pambak River from village Pambak to mouth (WB 4-020); Sotk River from mine of Sotq to mixing with Masrik river (WB 4-031); Masrik River from the the confluence of River Sotq to the confluence of waste water of city Vardenis (WB 4-038); River Masrik-from the confluence of waste water of Vardenis city to estuary (WB 4-041),Vardenis River from village Vardenik to estuary (4-052), Martuni River from Geghovhit to Martuni town (4-057), Martuni River from the village of Geghovit to river mouth (WB 4-057, 4-058); Bakhtak River from village Tsovasar to village Tsakkar (WB 4-068); Bakhtak River -from village Tsakqar to estuary (WB 4-069); Tsakkar River from village Dzoragyugh to estuary (WB 4-071); Shoghvak River from village Dzoragyugh to estuary (WB 4-073), Geloidzor River left tributary of the river Gavaraget, from source to estuary with its tributaries (WB 4-079); Gavaraget River in the area of Gavar town (WB 4-081); and Gavaraget River from city Gavar to estuary (WB 4-082).

Table 68: Risk assessment for surface water bodies of Sevan BMD based on biological, physico-chemical, and hydrological monitoring data

River	Code of water body	*Risk Category by physico-chemical parameters	Risk Category by biological status	Risk Category by hydrological status	Risk Category by ecological status	Cause of main pressure	Physico-chemical parameters causing “moderate”, “poor” or “bad” water quality class for a water body.
Dzknaget	WB 4-001	Not at risk (Good (II))	Not at risk (Good (II))	na	Not at risk (Good (II))	No significant pressure	-
	WB 4-003	Not at risk (Good (II))	At risk (Moderate (III))	Not at risk (Good (II))	At risk (Moderate (III))	No significant pressure	-
Masrik	WB 4-036	Not at risk (Good (II))	Not at risk (High (I))	na	Not at risk (High (I))	No significant pressure	-
	WB 4-041	At risk (Moderate (III))	At risk (Poor (IV))	At risk (Moderate (III))	At risk (Poor (IV))	Domestic wastewater and return flows from agriculture, *may also diffuse pollution from mining industry*	Phosphate (III), Vanadium (III)
Sotq	WB 4-032	Not at risk (Good (II))	Not at risk (High (I))	Not at risk (High (I))	Not at risk (High (I))	No significant pressure	-
	WB-031	At risk (Moderate (III))	At risk (Moderate (III) to Bad (V))	na	At risk (Moderate (III) to Bad (V))	Domestic wastewater, *may also diffuse pollution from mining industry*	Nitrate (III), SS (III), Vanadium (III)
Karchaghbyur	WB 4-043	Not at risk (Good (II))	Not at risk (Good (II))	na	Not at risk (Good (II))	No significant pressure	-
	WB 4-047	Not at risk (Good (II))	At risk (Moderate (III))	Not at risk (Good (II))	At risk (Moderate (III))	No significant pressure	-
Arpa-Sevan tunnel	AWB 4-097	At risk (Moderate (III))	**na	**na	**na	Diffuse pollution from domestic wastewater	Nitrate (III)

Vardenis	WB 4-051	Not at risk (Good (II))	Not at risk (Good (II))	Not at risk (Good (II))	Not at risk (Good (II))	No significant pressure	-
	WB 4-052	At risk (Poor (IV))	At risk (Moderate (III) to Bad (V))	na	At risk (Moderate (III) to Bad (V))	Diffuse pollution from domestic wastewater and return flows from agriculture	Nitrite (IV), Phosphate (IV), Ammonia (IV)
Martuni	WB 4-056	Not at risk (Good (II))	Not at risk (High (I) to Good (II))	Not at risk (Good (II))	Not at risk (High (I) to Good (II))	No significant pressure	-
	WB 4-058	At risk (Poor (IV))	Not at risk (High (I))	Not at risk (Good (II))	At risk (Poor (IV))	Domestic wastewater and diffuse sources from agriculture	Phosphate (IV), Ammonia (III)
Argichi	WB 4-061	Not at risk (Good (II))	Not at risk (High (I) to Good (II))	na	Not at risk (High (I) to Good (II))	No significant pressure	-
	WB 4-065	Not at risk (Good (II))	Not at risk (Good (II))	Not at risk (High (I))	Not at risk (Good (II))	No significant pressure	-
Bakhtak	WB 4-073	At risk (Poor (IV))	At risk (Moderate (III) to Poor (IV))	na	At risk (Moderate (III) to Poor (IV))	Domestic wastewater and diffuse sources from agriculture	Phosphate (IV)
Shoghvak	WB 4-069	At risk (Poor (IV))	At risk (Moderate (III) to Poor (IV))	na	At risk (Moderate (III) to Poor (IV))	Domestic wastewater and diffuse sources from agriculture	Phosphate (III)
Gavaraget	WB 4-074	Not at risk (Good (II))	Not at risk (High (I) to Good (II))	Not at risk (High (I) to Good (II))	Not at risk (High (I) to Good (II))	No significant pressure	-
	WB 4-082	At risk (Poor (IV))	At risk (Bad (V))	At risk (Moderate (III))	At risk (Bad (V))	Domestic wastewater and diffuse sources from agriculture	Phosphate (V), Ammonia (III), TP (III), Nitrate (III)
Lichq	WB 4-066	Not at risk (Good (II))	Not at risk (Good (II))	na	Not at risk (Good (II))	No significant pressure	-

** Risk Category by Physico-chemical parameters was defined based on the data for 2015-2018 provided by RA ME Environmental Monitoring and Information Centre SNCO.*
***na- no data*

Source: Report on "Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase" EUWI plus project, Geocom LTD, 2018, Report on "Definition of reference conditions and class boundaries in rivers of Armenia for the BQE benthic invertebrates", EU member state consortium, 2020 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

Based on the trend analyses of physico-chemical parameters changes in 2015-2018, there aren't "not at risk" water bodies potentially may reach "at risk" category by 2026 due to the water quality change and degradation.

Two water bodies at risk in Masrik and Sotq rivers were identified as potentialy under the risk from Sotk gold mining sites. **These water bodies are WB 4-031**: Masrik River from the confluence of the Sotk River to river mouth and **WB 4-041:** Sotk River downstream Sotk gold mine to river mouth. In separate months the pollution by the heavy metals, such as vanadium, cobalt and antimony, were observed in the water bodies. The increase in the concentrations of these metals may cause by the natural factors or being the diffuse impact of Sotk mine site. However, additional observation is required to investigate the mining impact on those water bodies.

The water body WB 4-058 (Martuni River from Martuni Town to estuary) was identified as a potential under the risk, despite “High” biological status. For this water body the ecological status was provided based on the chemical status assessment as the level of confidence for biological assessment was defined as low. However, additional observation is required to investigate the pressures and assess the ecological status of the water body.

Based on WB risk assessment results, the WB 4-003: Dzknaget River from right tributary to the estuary, WB 4-010: Artanish River from village Artanish to estuary, WB 4-047: Karchaghbyur River from village Maqenis to estuary, WB 4-063: Argichi River (from confluence tributary of the Pokr Masrik to farms of the village Madina, WB 4-065: Argichi River from village Verin Getashen to estuary, WB 4-079: Geloidzor river-left tributary of the river Gavaraget, from source to estuary with its tributaries, water bodies was identified **possibly at risk**. Water status for the WB defined as a moderate chemical and biological in accordance with a single assessment conducted during 2019. In addition, no visible anthropogenic pressures identified for this WB. **Thus, the additional biological and chemical investigation and pressure-impact analysis is needed to clarify the status of this water body.**

For Lake Sevan the identification of water bodies at risk was based on the "pressure-impact" assessment the method using the available data on the chemical and biological quality of the water, the intensity of life-sustaining processes, the presence of waterlogged forests in the coastal zone and the hydromorphological changes of the coast. **4 water bodies at risk were identified for Lake Sevan** based on their ecological status: Lake Sevan coastline, from Lchashen to Tsovazard settlement, 9506.0 km (WB 4-084), Lake Sevan coastline, surroundings of Gavaraget River, from Gavaraget estuary to Noratus, about 16.3 km^2 (WB 4-085), Lake Sevan coastline, from the Noratus Peninsula to the end of the community border Noratus, about 7.31 km^2 (WB 4-086), Lake Sevan coastline, from Yeranos settlement to Small Masrik settlement, about 66.9 km^2 (WB 4-087).

Lake Sevan was delineated into two highly modified water bodies (WB 4-088 and WB 4-089). According to the preliminary ecological classification of SWB, their status is moderate to bad. Consequently **lake Sevan water bodies must be considered as possibly at risk**, until the data gaps are completed and the level of uncertainty is reduced (Map 30).

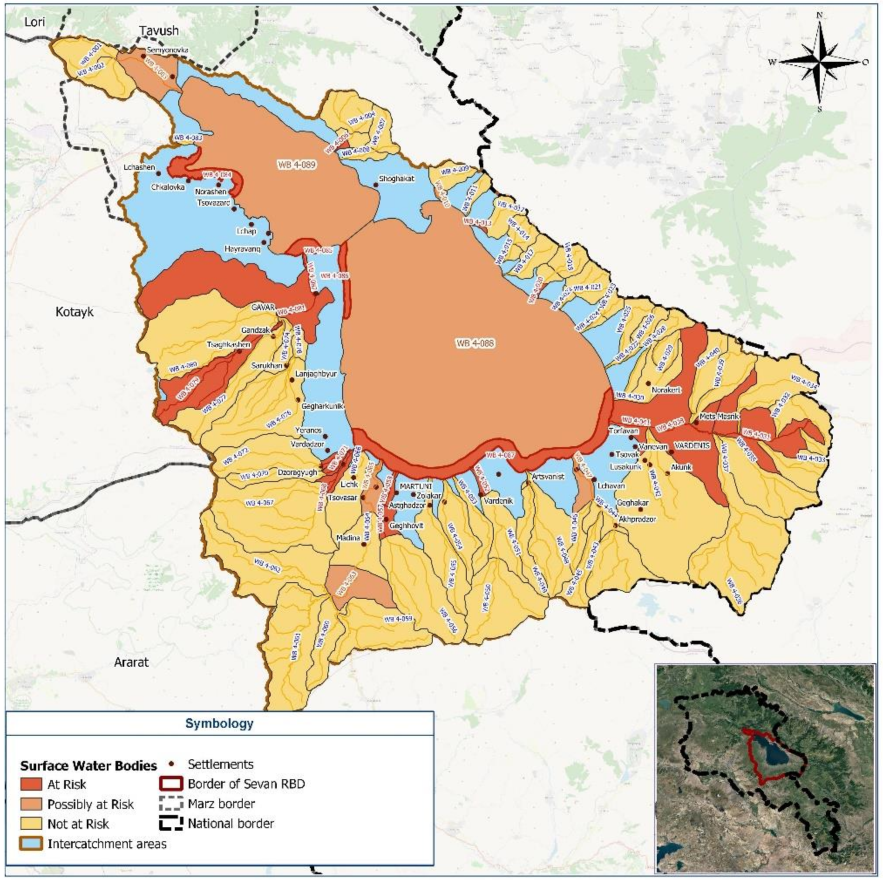
6.2.3 Risk Assessment of Groundwater Bodies based on quantitative status

6 ground water bodies in the Sevan RBD are identified as not at risk based on quantitative status. The quantitative status of GWB was defined based on the hydrological characteristics (groundwater level (in fountaining and non-fountaining wells), discharge (in springs and fountaining wells) and temperature) of 11 official groundwater monitoring sites and 10 field survey sites in the Sevan RBD. Data of the hydrological characteristics refere to the water quantity monitoring (6 times a month) for 2015-2018 of the RA MNP Environmental monitoring and Information Center. According to the groundwater monitoring results, the hydrological data fluctuations are close to natural, and at present the impacts of anthropogenic pressures on groundwater quantity are not significant.

6.2.4 Risk Assessment of Groundwater Bodies based on the chemistry

Assessment of the chemical status of the groundwater bodies was carried out for 6 observation sites based on water quality monitoring data for 2015-2017 of the RA MNP Environmental monitoring and Information Center. According to the groundwater monitoring results, the water monitoring data the groundwater bodies were distinguished with low mineralization and low total hardness. The nitrate concentration in water samples is exceeded 50 mg/l limit value of the Nitrates Directive and 45 mg/l limit value of the Drinking water norms set up in Armenia only at the spring N38 (GWB 3G-4), in Martuni city, "Aghbulakh" or "Spitak" spring in Aghberk village (GWB 3G-1), at the well in Shoghakat village (Shorzha, GWB 3G-1), and at the well in Norakert village (GWB 3G-4). The relatively high concentration of nitrates also was observed at the spring N2014 in Gavar city (GWB 3G-2).

The existing groundwater quality monitoring network and water sampling frequency (twice during the year) is not sufficient for chemical classification of GWB in the Sevan RBD and for identification a reason for the high level of nitrate concentrations in 4 GWBs, whatever it is a single case or periodically observed. Consequently, **Dzknaget-Areguni, 3G-1, (172 km^2), Vardenis or Masrik, 3G-4, (140km^2), Sevan-Gavar 3G-5, (0.32km^2**) and **Lichk, 3G-6, N_1** (**0.48km^2**) **groundwater bodies** (both of these are mineral groundwater bodies) **in Sevan RBD** are identified possibly at risk, until more information of water quality monitoring will be obtained during next cycle of the RBMP.
Thus, none of 6 groundwater bodies delineated within Sevan RBD are identified as being at risk, but further monitoring is necessary to validate the possibility of risk (Map 31).



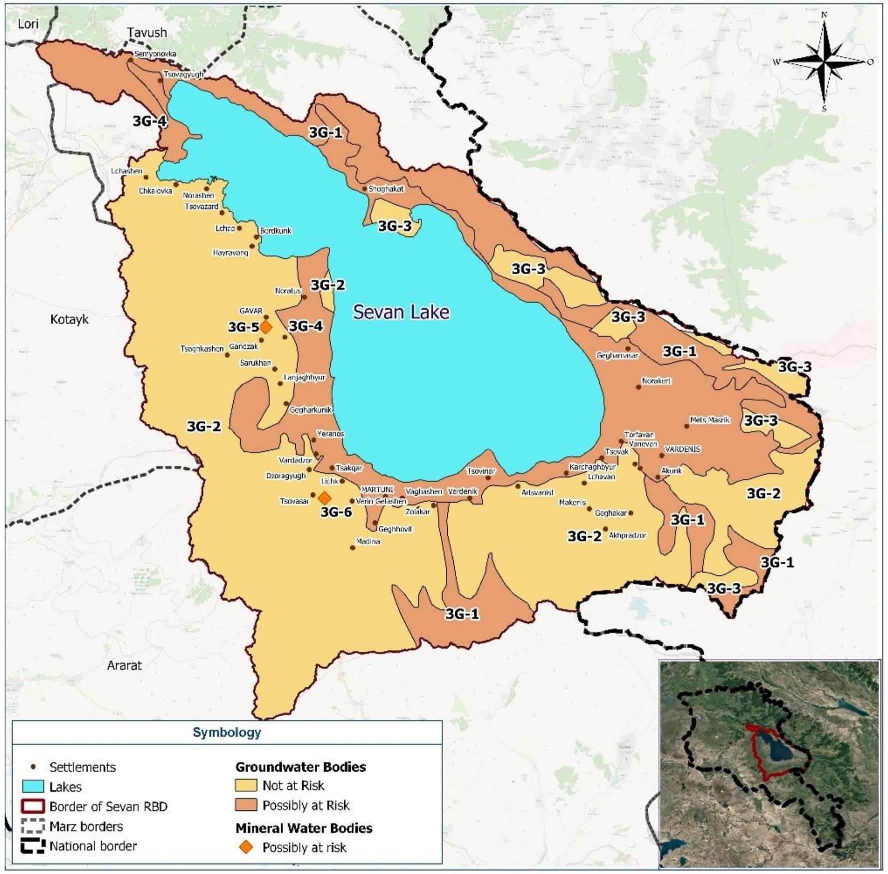


Figure 44: Risk Assessment of Water Bodies within Sevan RBD a: Surface water bodies b: Groundwater bodies

Source: Report on "Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase" EUWI plus project, Geocom LTD, 2018.

6.3 Environmental objectives

According to the WFD Article 4, through implementation of the RBMP the following environmental objectives should be achieved:

- Good ecological/chemical status of surface water bodies;
- Good ecological potential and chemical status of HMWBs and AWBs;
- Good chemical/quantitative status of groundwater bodies.

Setting environmental objectives for surface waters and groundwater in Sevan Basin District were aim at achieving good status for all water bodies, prevent deterioration of water status, ensure sustainable water management and meet specific requirements for protected areas.

Environmental Objectives set up for surface water bodies **at risk** in the Sevan RBD are listed in Table 69 (Map 32).

Table 69: Environmental Objectives for surface water bodies at risk

N/N	Surface water body at Risk and its length	Reason for being Water Body at Risk	Water status in 2018	Environmental Objectives	Deadline
1	**WB 4-006: Drakhtik River from the Drakhtik settlement to mouth, 2640.7m**	Non-maintenance of ecological flow.	Bad ecological status by river hydromorphology and moderate ecological status by hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve “good status” by 2027 and maintain it by 2033
2	**WB 4-013: River Jil from Dzorashen village to mouth, 2284.6m**	Non-maintenance of ecological flow.	Bad ecological status by river hydromorphology and Moderate to Poor ecological status by hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve “good status” by 2027 and maintain it by 2033
3	**WB 4-016: Tsapatagh River from Tsapatagh village to mouth, 869.8m**	Non-maintenance of ecological flow.	Bad ecological status by hydromorphology and moderate to poor ecological status by hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve “good status” by 2027 and maintain it by 2033
4	**WB 4-020: Pambak River from Pambak settlement to mouth, 2321.2km**	Non-maintenance of ecological flow.	Bad ecological status by hydromorphology and moderate to poor ecological status by hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve “good status” by 2027 and maintain it by 2033
5	**WB 4-031: Sotk River downstream Sotk gold mine to river mouth, 17712.8m**	Diffuse pollution of the river water from the Sotk gold mining site.	Moderate chemical and biological status.	To improve the water chemical status of the river, particularly reducing	To have the EU WFD compliant assessment system in place by 2027

				concentrations of vanadium and suspended solids in the river's water, due to preventing the flows of surface runoff from mining sites.	and achieve and maintain "good status" by 2033
6	**WB 4-038: River Masrik from the the confluence of River Sotq to the confluence of waste water of city Vardenis, 10606.5m**	Non-maintenance of ecological flow. Diffuse pollution of the river water from the Sotk gold mining site.	Bad ecological status by hydromorphology and hydrobiology. Moderate chemical status.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation and industrial purpose. To improve the water chemical status of the river, particularly reducing vanadium concentration in the river's water, due to preventing the flows of surface runoff from mining sites.	To have the EU WFD compliant assessment system in place by 2027 and achieve and maintain "good status" by 2033
7	**WB 4-041: Masrik River from the confluence of waste water of Vardenis city to the mouth, 7675.1m**	Non-maintenance of ecological flow.	Bad ecological status by hydromorphology and hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve "good status" by 2027 and maintain it by 2033
8	**WB 4-052: Vardenis River from Vardenik village to the river mouth, 4673.2m**	Diffuse pollution of domestic wastewater and return flow from agriculture.	Moderate and poor chemical status.	To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	To achieve "good status" by 2027 and maintain it by 2033
9	**WB 4-057: Martuni River from the village of Geghovit to**	Non-maintenance of ecological flow.	Bad ecological status by hydromorphology and Poor	To improve the ecological status of the river,	To achieve "good status" by 2027 and maintain it

	Martuni town, 4446.8m	Diffuse pollution of domestic wastewater and return flow from agriculture.	ecological status by hydrobiology. Moderate and poor chemical status.	particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose. To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	by 2033
10	**WB 4-058: Martuni River from Martuni town to the river mouth, 5382.4m**	Diffuse pollution of domestic wastewater and return flow from agriculture.	Moderate ecological status by hydrobiology. Moderate and poor chemical status.	To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	To achieve "good status" by 2027 and maintain it by 2033
11	**WB 4-068: Bakhtak River - from Tsovasar village to Tsakkar village, 5422.8m**	Non-maintenance of ecological flow.	Bad ecological status by hydromorphology and moderate to poor ecological status by hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve "good status" by 2027 and maintain it by 2033

12	**WB 4-069: Bakhtak river from the village of Tsakkar to river mouth, 4715.6m**	Non-maintenance of ecological flow. Diffuse pollution of domestic wastewater and return flow from agriculture.	Bad ecological status by hydromorphology and Moderate to Poor ecological status by hydrobiology. Moderate chemical status.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose. To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	To achieve "good status" by 2027 and maintain it by 2033
13	**WB 4-071: Tsakkar River - from Dzoragyugh village to mouth, 5566.4m**	Non-maintenance of ecological flow.	Bad ecological status by hydromorphology and moderate to poor ecological status by hydrobiology.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose.	To achieve "good status" by 2027 and maintain it by 2033
14	**WB 4-073: Shoghvak river from the Dzoragyugh village to river mouth, 3716.4m**	Diffuse pollution of domestic wastewater and return flow from agriculture.	moderate to poor ecological status by hydrobiology. Moderate chemical status.	To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	To achieve "good status" by 2027 and maintain it by 2033
15	**WB 4-079: Geloidzor river from source to estuary with**	Diffuse pollution of domestic wastewater and	Poor ecological status by hydrobiology.	To improve the water biological status of the	To achieve "good status" by 2027 and maintain it

	its tributaries, 39913.2m	return flow from agriculture.		river,	by 2033
16	**WB 4-081: Gavaraget river in the area of city Gavar, 4102.2m**	Diffuse pollution of domestic wastewater and return flow from agriculture.	Moderate to Bad ecological status by hydrobiology and hydrochemitsry	To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	To achieve “good status” by 2027 and maintain it by 2033
17	**WB 4-082: Gavaraget river from the Gavar town to river mouth, 9506m**	Non-maintenance of ecological flow. Diffuse pollution of domestic wastewater and return flow from agriculture.	Bad ecological status by hydromorphology and hydrobiology. Bad chemical status.	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation purpose. To improve the water chemical status of the river, particularly to prevent river's water pollution by nutrients (N and P) from households and agriculture wastewater.	To achieve “good status” by 2027 and maintain it by 2033
18	**WB 4-084: Lake Sevan coastline, from Lchashen to Tsovazard settlement, 16.95 km^2**	Hydromorphological alterations. High content of nutrients.	Bad ecological status by hydromorphology. Poor chemical status.	To improve the hydromorphological status of the lake, as well as to improve the water chemical status of the river, particularly to reduce nutrients content in the water.	To achieve “good potential” and maintain it by 2030* in compilnace with EU WFD and Sevan Law

19	**WB 4-085: Lake Sevan coastline, surroundings of Gavaraget River, from Gavaraget estuary to Noratus, about 7.3km^2**	Hydromorphological alterations. High content of nutrients and diffuse pollution of domestic wastewater and return flow from agriculture.	Bad ecological status by hydromorphology. Poor chemical status.	To improve the hydromorphological status of the lake, as well as to improve the water chemical status of the river, particularly to reduce nutrients content in the water.	To achieve “good potential” and maintain it by 2030* in compilnace with EU WFD and Sevan Law
20	**WB 4-086: Lake Sevancoastline, from the Noratus Peninsula to the end of the community border Noratus, about 8.21km^2**	Hydromorphological alterations. High content of nutrients.	Bad ecological status by hydromorphology. Poor chemical status.	To improve the hydromorphological status of the lake, as well as to improve the water chemical status of the river, particularly to reduce nutrients content in the water.	To achieve “good potential” and maintain it by 2030* in compilnace with EU WFD and Sevan Law
21	**WB 4-087: Lake Sevancoastline, from Yeranos settlement to Small Masrik settlement, about 66.9km^2**	Hydromorphological alterations. High content of nutrients.	Bad ecological status by hydromorphology. Poor chemical status.	To improve the hydromorphological status of the lake, as well as to improve the water chemical status of the river, particularly to reduce nutrients content in the water.	To achieve “good potential” and maintain it by 2030* in compilnace with EU WFD and Sevan Law

**The „Good potential“ status and date was given based on the environmental measures and timetable established on Sevan Law of the RA.*

Source: Report on “Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase” EUWI plus project, Geocom LTD, 2018 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

Environmental Objectives set up for surface and groundwater bodies ***possibly at risk*** in the Sevan RBD were listed in Table 70 (Map 32).

Table 70: Environmental Objectives for surface and groundwater bodies possibly at risk.

N/N	Water body Possibly at Risk	Reason for being Water Body Possibly at Risk*	Water status in 2018	Environmental Objectives	Deadline
	Surface water bodies				
1	WB 4-003: River Dzknaget from right tributary to the estuary, 11441.9m	Water status for the WB defined as a “Moderate” biological, however, ecological status by hydrochemistry and hydrology was “Good” in accordance with a single assessment conducted during 2019. In addition, no anthropogenic pressures identified for this WB.	“Moderate” biological or “good” chemical and hydrological status. (additional studies required)	To define the source of pressure and improve the water biological status of water body.	To have the EU WFD compliant monitoring and assessment system in place by 2027 and achieve and maintain “good status” by 2033.
2	WB 4-010: Artanish River from village Artanish to mouth, 2108.8m	Water status for the WB defined as a “High” biological and “Moderate to Bad” chemical in accordance with a single assessment conducted during 2019. However, based on the expert judgments and hydrological data the ecological flow isn’t maintained from 2007-2017, and it’s caused by water intake for irrigation and economic purposes.	“Bad” hydrological or “High” biological or “Moderate to poor” chemical status. (additional studies required)	To define the source of pressure and improve the water morphology and chemical status of water body.	To have the EU WFD compliant monitoring and assessment system in place by 2027 and achieve and maintain “good status” by 2033.
3	WB 4-047: Karchaghbyur River from village Maqenis to estuary, 7597.4m	Water status for the WB defined as a “Moderate” biological, however, ecological status by hydrochemistry and hydrology was “Good” in accordance with a single assessment conducted during 2019. In addition, no anthropogenic pressures identified for this WB.	“Moderate” biological or “good” chemical and hydrological status. (additional studies required)	To define the source of pressure and improve the water biological status of water body.	To have the EU WFD compliant monitoring and assessment system in place by 2027 and achieve and maintain “good status” by 2033.
4	WB 4-063: Argichi River - from confluence tributary of the Poqr	Water status for the WB defined as a moderate chemical and biological in accordance with a single	“Moderate” or “good” biological and chemical	To define the source of pressure and improve the water biological and chemical status of water	To have the EU WFD compliant monitoring and assessment system in place by 2027 and

	Masrik to farms of the village Madina, 7801,2m	assessment conducted during 2019. However, based on the hydrochemical assessment data for 2015-2018, the water status was defined as a good. In addition, no anthropogenic pressures identified for this WB.	status. (additional studies required)	body.	achieve and maintain “good status” by 2033.
5	WB 4-065: Argichi River - from Verin Getashen Village to mouth, 11435.5m	Water status for the WB defined as a good chemical and biological in accordance with a single assessment conducted during 2019. However, based on the expert judgments and hydrological data the ecological flow isn’t maintained in June-November from 2007-2017, and it’s caused by water intake for irrigation and economic purposes.	“Good” or “bad” ecological status (additional studies required)	To improve the ecological status of the river, particularly maintaining the ecological flow on monthly bases and control water abstraction for irrigation and economic purposes.	
6	WB 4-088: Major (Big) Lake Sevan	Status fort wo WBs of Lake Sevan defined as moderate to bad chemical and biological based on the "pressure-impact" assessment the method using the available data on the chemical and biological quality of the water, the intensity of life-sustaining processes, the presence of waterlogged forests in the coastal zone and the hydromorphological changes of the coast.	“moderate” to “bad” ecological status (additional studies required)	To improve the water biological, chemical and hydromorphological potential of water bodies.	To have the EU WFD compliant monitoring and assessment system (water quality norms for lake) in place by 2027 and achieve and maintain “good potential” by 2033.
7	WB 4-089: Minor (Small) Lake Sevan				
	Groundwater bodies				
1	Dzknaget-Areguni, 3G-1, 172 km^2	High content of nitrate in one –two water samples which may be a result of the diffuse pollution from agricultural and municipal wastewater discharge.	Possibly “Bad” chemical status. (additional studies required)	To improve the water chemical status of water body, particularly to reduce nitrates content by preventing municipal and agricultural wastewater infiltration to groundwater body.	To have the EU WFD compliant monitoring and assessment system in place by 2027 and achieve and maintain “good status” by 2033.
2	Vardenis or Masrik, 3G-4, 140km^2	High content of nitrate in one-two water sample which may be a result of the diffuse pollution from	Possibly “Bad” chemical status. (additional studies		

		agricultural and municipal wastewater discharge.	required)		
3	Sevan-Gavar 3G-5, N1, 0.32km^2	High content of nitrate in one water sample which may be a result of the diffuse pollution from agricultural and municipal wastewater discharge.	Possibly “Bad” chemical status. (additional studies required)		
4	Lichk, 3G-6, N1, 0.48km^2	High content of nitrate in one water sample which may be a result of the diffuse pollution from agricultural and municipal wastewater discharge.	Possibly “Bad” chemical status. (additional studies required)		

**Farther water quality monitoring is required to identified whatever the high content of nitrate in groundwater is a result of a single case of pollution or water test/sampling error or periodicaly observed water pollution.*

Source: Report on “Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase” EUWI plus project, Geocom LTD, 2018 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

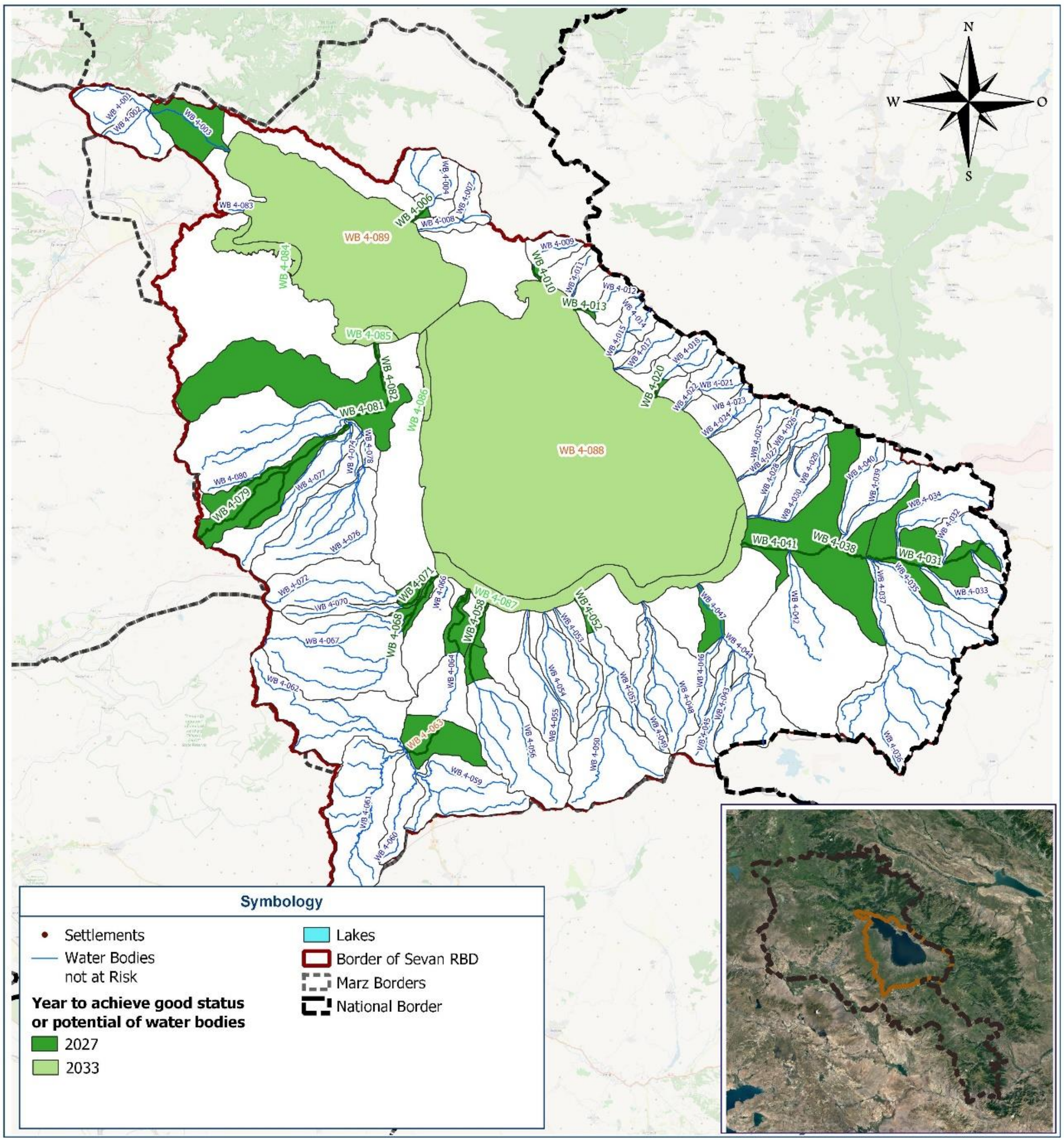


Figure 45: Environmental Objectives within Sevan RBD

Table 71: Environmental Objectives for Artificial Water Bodies

N/N	Artificial water body and its length	Reason for being Artifical Water Body	Water Status in 2018	Environmental Objectives
1	**AWB 4-090:Masrik Canal, 26232.6m**	Hydromorphologocal alterations of the surface water body resulting from the artificial characteristics of the water body and non-mainatining the best approximation to the ecological continuum, in particular with respect to migration of fauna and	Bad ecological potential*	To have the EU WFD compliant monitoring and assessment system in place by 2027 and achieve and maintain “Maximum
2	**AWB 4-091: Avazan Canal, 6150.2m**			
3	**AWB 4-092: Sotk Canal, 9655.6m**			
4	**AWB 4-093: HPP Canal, 7788.5m**			
5	**AWB 4-094: Makenis and Tsovinar #2 Canals, 16825.8m**			
6	**AWB 4-095: Tsovak #1 and Karchaghbyur Canals, 10426.1m**			
7	**AWB 4-096: Ruins Canal,**			

	6163.3m	approximate spawning and breeding grounds.		Ecological potential"** by 2033.
8	**AWB 4-097: Arpa-Sevan Tunnel, 26768.3m**			
9	**AWB 4-098: Manas Ditch Canal, 19310.1m**			
10	**AWB 4-099: Getashen, Verin Getashen and Dotation Canals, 19886.7m**			
11	**AWB 4-100:Hord Aru and Yeranos Canals, 9212.8m**			
12	**AWB 4-101:Sarukhan Water Station Tail-race Right and Left Branches, 7217.8m**			
13	**AWB 4-102:Sarukhan Gravity Canal, 5957.6**			
14	**AWB 4-103:Noratus Right and Left Branch Canals, 17527.4m**			

** Due to the absence of the relevant data, the ecological status of the AWB was carried out based on the hydromorphological expert judgement.*

***The Maximum Ecological Potential for Artifical Water Body is defined as the state where "the values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions, which result from the artificial or heavily modified characteristics of the body" (WFD Annex V 1.2.5).*

Source: Report on "Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase" EUWI plus project, Geocom LTD, 2018 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

6.4 Protected areas objectives

Environmental Objectives set up for the following categories of protected areas identified in the Sevan BD (Table 72):

1. Drinking water catchment areas
2. Zones for water ecosystem sanitary protection, flow formation, groundwater resources protection, water protection, ecotone and inalienable zones
3. Natural monuments: hydrogeological and hydrological monuments and reserves
4. Special areas of conservation of natural habitats and biodiversity (Sevan Juniper)
5. Economically significant species (fish species)
6. Areas potentially vulnerable to Nitrates
7. Natural disaster zones

Table 72: Environmental Objectives and specific requirements for Protected areas in Sevan RBD

N/N	Protected area	Environmental Objectives	Deadline
1	**"Sevan National Park" National park, 22.585 ha**	To have the EU WFD and the RA Law on Natural Specially Protected Areas, 2006, compliant register of the protected area, "Sevan National Park" management plan in place.	By 2027 and maintain requirements set in the management plan by 2033.
2	**"Juniper Sparse Forests" state sanctuary, 3312 ha**	To have the EU WFD and the RA Law on Natural Specially Protected Areas, 2006, compliant register of the protected area, "Juniper Sparse	By 2027 and maintain requirements set in the management plan by 2033.

		Forests" state sanctuary management plan in place.	
3	**Natural monuments (7 geological, 6 hydrogeological, 1 hydrographical and 1 biological)**	To have the EU WFD and the RA Law on Natural Specially Protected Areas, 2006, compliant register of the protected area in place.	By 2027 and maintain it by 2033.
4	**Drinking water 98 catchment areas**	To have the EU WFD and the RA No 803, 29.11.2002 Order of the Minister of Health compliant register of the protected area and to designate sanitary protection zones in place.	By 2027 and maintain "good status" by 2033.
5	**Zones for water ecosystem sanitary protection, flow formation, groundwater resources protection, water protection, ecotone and inalienable zones**	To have the EU WFD and the RA Gov. resolution no 64-N, 20.01.2005 compliant register of the protected area, monitoring and assessment system in place.	By 2027 and achieve and maintain "good status" by 2033.
6	**Special areas of conservation of natural habitats and biodiversity (Sevan Juniper)**	To have the EU WFD, Seval Law, 2001 (last modification in 2014) and Law on Establishment of annual and complex programs on restoration, maintenance, restructure and use of lake Sevan Ecological system, 2001 (last modification in 2018) compliant register of the protected area, monitoring and assessment system in place.	By 2027 and achieve and maintain "good status" by 2033.
7	**Economically significant species (fish species)**	To have the EU WFD, Seval Law, 2001 (last modification in 2014) and Law on Establishment of annual and complex programs on restoration, maintenance, restructure and use of lake Sevan Ecological system, 2001 (last modification in 2018) compliant register of the protected area, monitoring and assessment system in place.	By 2027 and achieve and maintain "good status" by 2033.
8	**Areas potentially vulnerable to Nitrates**	To have the EU WFD and Nitrates Directive compliant register of the protected area, monitoring and assessment system in place.	By 2027 and maintain "good status" by 2033.
9	**Natural disaster zones**	To have the EU WFD and Floods Directive compliant register of the protected area in place.	By 2027 and maintain it by 2033.

Source: Report on "Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase" EUWI plus project, Geocom LTD, 2018 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

6.5 Exemptions to Environmental Objectives

Exemptions to Environmental objectives were defined in accordance with the requirements of Article 4(5) of the EU WFD and use of the EPIRB Guidance Document on the Development of Program of Measures and the Achievement of Environmental Objectives According to the EU WFD.

Exemptions were set in a way to take into account factors which can lead to exceptional or unexpected circumstances, such as possible hydromorphological changes in Lake, the extremal hydrometeorological events, regional economic changes that will hinder to achieve the environmental objectives, as well as feasibility of implementation of the technical measures, etc.

As it was mentioned in the hydromorphological pressures analysis part (Phase 1), nearly 1000 buildings, tens of kilometers of roads and 4000 ha of forests have been waterlogged as a result of the lake level increase since 2002, which cause the hydromorphological changes in the coastal zone of lake and the source of organic pollution of the lake.

Exemptions to environmental objectives set up for 4 surface water bodies at risk and 2 heavily modified water bodies delineated in the Sevan RBD, which are listed in Table 73 and 74.

Table 73: Exemptions to Environmental Objectives in Sevan RBD

N/N	Surface water body at Risk and its length	Type of Exemption	Reason to apply exemption
1	**WB 4-084: Lake Sevan coastline, from Lchashen to Tsovazard settlement, 9506.0km**	Less stringent environmental objective for the first planning cycle	Technical infeasibility in terms of complexity of the source of impacts on coastline part of Sevan lake, as well as difficult to separate the water body (affected zone) from other part of the lake.
2	**WB 4-085: Lake Sevan coastline, surroundings of Gavaraget River, from Gavaraget estuary to Noratus, about 16.3km^2**	Less stringent environmental objective for the first planning cycle	Technical infeasibility in terms of complexity of the source of impacts on coastline part of Sevan lake, as well as difficult to separate the water body (affected zone) from other part of the lake.
3	**WB 4-086: Lake Sevan coastline, from the Noratus Peninsula to the end of the community border Noratus, about 7.31km^2**	Less stringent environmental objective for the first planning cycle	Technical infeasibility in terms of complexity of the source of impacts on coastline part of Sevan lake, as well as difficult to separate the water body (affected zone) from other part of the lake.
4	**WB 4-087: Lake Sevan coastline, from Yeranos settlement to Small Masrik settlement, about 66.9km^2**	Less stringent environmental objective for the first planning cycle	Technical infeasibility in terms of complexity of the source of impacts on coastline part of Sevan lake, as well as difficult to separate the water body (affected zone) from other part of the lake.

Source: Report on “Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase” EUWI plus project, Geocom LTD, 2018 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

Table 74: Exemptions to Environmental Objectives for Heavily Modified Water Bodies

N/N	Heavily Modified water body and its area	Reason for being heavily Modified Water Body	Water Status in 2018	Type of Exemption	Reason to apply exemption	Potential Environmental Objectives
1	**HMWB 4-088:** isolated section of the Major Sevan with 866.35km^2 area.	Ecological alterations of the surface water body resulting from the heavily modified characteristics of the water body, particularly increase euthrophication proceses, alterated geographical characteristics, water seasonal outflow, domestic wastewater discharge, climatic parameters change, etc, as well as non-mainatining the best approximation to the ecological continuum. The alterations variate in different levels depends on the water depth of the Minor and Major Sevan.	Bad ecological potential*	Less stringent environmental objective for the first planning cycle	Technical infeasibility, including the hydromorp-hologiocal, geological, biological and chemical data gapes, in terms of complexity of the source of anthropogenic and natural pressures on Minor and Major Sevan lake's parts.	To have the EU WFD compliant monitoring and assessment system in place by 2027 to achieve "maximum ecological potential" for the Lake Sevan.
2	**HMWB 4-089:** isolated section of the Minor Sevan with 304.78km^2 area.					

** Due to the complexity of the ecological issues (hydromorphological, chemical, geological and biological) of the Sevan lake, the ecological status of the HMWB was carried out based on the experts judgement.*

***The Maximum Ecological Potential for Heavily Modified Water Body is defined as the state where "the values of the relevant biological quality elements reflect, as far as possible, those associated with the closest comparable surface water body type, given the physical conditions, which result from the artificial or heavily modified characteristics of the body" (WFD Annex V 1.2.5).*

Source: Report on "Development of Draft RBMP for Sevan RBD in Armenia: Part 1- characterisation phase" EUWI plus project, Geocom LTD, 2018 and the RA ME Environmental Monitoring and Information Centre SNCO, 2015-2018.

7. ECONOMIC ANALYSIS OF WATER USE

7.1 Economic Analysis of Water Use for Different Sectors

Prices constitute the most efficient information system; they largely determine decisions taken by producers and consumers. When prices do not reflect the full costs and benefits of production and consumption, the facts about resource scarcity and environmental values aren't made known — and nor are the actual costs of producing or consuming goods and services. Since they have nothing else to hand, however, people must base their decisions on such erroneous information: this results in the overuse of some resources (with a related degradation of the environment), and the underuse of others. So there is a direct causal connection between mispricing and unsustainable development.

If governments want to promote sustainable development, they have to make sure the prices and incentives are right. This means identifying them, measuring them and assessing their impact.

Taxes, charges, tariffs, etc. are water pricing instruments (or economic instruments) that are commonly applied to correct for market failures, and to ensure that the polluter pays. The revenue from water pricing instruments should help realize environmental and economic policy objectives in a cost-effective way.

Water pricing refers to the processes involved in assigning a price to water, including elements such as utility tariffs. In this report, water pricing means 'monetising the abstraction, use, or pollution of water'.

Prices can be charged in many ways.

- Taxes are compulsory, unrequited payments to general government. Taxes are unrequited in the sense that benefits provided by government to taxpayers are not usually in proportion to their payments. For instance, a tax can be raised to compensate for the use of the water system and for cleaning polluted water.
- Water tariffs are prices assigned to water supplied by a public or private utility through a piped network to its customers.
- Water charges are usually made for the (compulsory) payment related to a specific service, e.g. wastewater collection and treatment, but they are also applied to levies on emissions/discharges (air and water pollution charges) and for water supplies. While taxes are usually not earmarked (revenues go to the general budget), charges usually are (with revenues spent on purposes related to the object of the charge).

More specific provisions regarding water pricing are listed in Article 9 of the European Union's Water Framework Directive or WFD (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy): this introduces the concepts of cost recovery, the 'polluter pays' principle (PPP) and incentive pricing.

Republic of Armenia water sector legislation also refers to economic and financial mechanisms in water management. Thus, Article 5 of the Water Code of Armenia, which outlines the main principles of management, use and protection of water resources and water systems, states that water has environmental and economic value when it is used and even when it is not used. According to that article, the economic value of the water is mainly formed from the sum of the drinking, environmental, energy and agricultural values of water. It also mentions that in the processes of water resources use, distribution and protection it is necessary to take into consideration the economic value of water. Article 76 of the Water Code of Armenia refers to the principles of economic regulation of use, restoration and protection of water resources, water supply and sanitation systems. This article stresses the requirement for efficient water allocation and proper water pricing. Article 79 of the Water Code of Armenia relates to water use tariffs, including the principles of forming regulatory tariffs. It highlights that tariffs can be different according to river basins, according to different water use groups and according to qualitative indicators, contingent upon the classification of water resources.

Currently the above-mentioned principles are not fully applied due to lack of data on environmental and economic valuation of water in Armenia, as well as taking into consideration several socio-economic circumstances. Among the main economic mechanism applied in the water management field of Armenia nowadays is the water abstraction fee and environmental (pollution) tax, which aim at ensuring rational use and fair distribution of water resources, as well as maintaining minimum environmental flow. Water abstraction fee is applied for drinking-household, irrigation, fish-farming sectors, and the environmental fee is applied for discharges of wastewater into open water basins (EUWI+, 2019h).

7.1.1 Water Abstraction Fee

The main management objective for application of water abstraction fees in Armenia is to ensure rational use and efficient allocation of water resources, and to maintain minimum environmental flow. The fee is applied to drinking-household, industrial, irrigation, and fisheries sectors. It is one of the key economic instruments applied in water management of Armenia.

Rates for water abstraction fees are currently defined according to Tax Code of Republic of Armenia adopted on October 4, 2016 (Chapter 40 – “Fees, Payers and Authorized Bodies for Natural Resource Use” and Chapter 41 – “Object, Base and Rates for Natural Resource Use”).

According to Article 204 of above – mentioned Tax Law, the rates of water abstraction fees are defined as follows:

Table 75: **Water Use Fees (AMD/m^3)**

Sector	Surface water, excluding Lake Sevan	Surface water, Lake Sevan	Groundwater, suitable from drinking	Groundwater, not suitable for drinking
Fish farming	1.2	1.8	1.2	1.2
Industry	0.6	1.8	1.2	1.2
Drinking-household (excl. local authorities and water supply companies)	0.6	1.8	1.2	1.2
Drinking-household (local authorities and water supply companies)	0.03	1.8	0.06	1.2
Irrigation	0	0.24	1.2	0
HPP	N/A	N/A	N/A	N/A

Source: Tax Code of Republic of Armenia

Mentioned-above water use fees should be multiplied by 1.1 starting January 1, 2020.

Major weaknesses of current water abstraction system are as follows:

- Several water use sectors are completely or partially exempted from water abstraction fees. For example, hydropower sector does not pay any water abstraction fee. Despite the fact that hydropower sector is considered as non-consumptive water user, the sector generates economic benefit using water, whereas is received the main resource – water, free of charge.
- The existing system does not take into consideration the relative abundance or scarcity of water resources (supply and demand, seasonal variations), which is required by the Water Code of Armenia. Moreover, it only takes a partial consideration of the economic value of water (according to water use sector and according to the quality of water used).
- According to new lease contract signed by Veolia and Government of Armenia, a special lower rate (0.025 AMD/m3) was introduced for Veolia for the whole lease term of 15 years.

7.1.2 Environmental taxes

The payments associated with discharging wastewater into the open water basin (environmental taxes/pollution taxes) are regulated according to Article 169 of Chapter 41 of Tax Code of Republic of Armenia adopted on October 4, 2016.

Table 76: Environmental tax rates per discharged tone

Discharged Pollutants	Tax per discharged tone
Suspended Particles	5 300
Ammonium Nitrogen	5 100
Biological Oxygen Demand	18 400
Oil Products	204 600
Copper	1 023 900
Zinc	1 023 900
Potassium	100
Chloride	30
Nitrites	511 500
Nitrates	1100
Total Phosphorous	40 000
Detergents	102 300
Heavy Metal Salts	511 500
Cyan and Cyanide Compound	511 500
Other chemical and organic pollutants	Amount = AMD 10000 /MAC_{fish} where MAC_{fish} is Maximum Allowable Concentration of pollutant for fish farming

Mentioned-above taxes are ***doubled*** for entities (except water supply and sanitation companies) discharging pollutants in water resources of Sevan lake basin. According to RA LAW N 131-N (adopted on June 29, 2016) there is an exemption for Veolia Jur for the whole lease period and the environmental tax should be calculated by multiplying the norms of polluted materials, wastewater actual quantities and the rates mentioned in the points of 1 and 2 of the article N 169 of Tax Code.

In general, the table above shows that low level of environmental taxes for pollution is not consistent with "Polluter pays" principle, which is the cornerstone of EU WFD.

7.1.3 Water Tariffs and Subsidies

Starting from January 1, 2017 a single tariff for water and wastewater services was applied for retail customers of Veolia Jur. According to new memorandum signed between Veolia Jur and State Water Committee, the retail price in 2019 of water and wastewater services was set up at AMD 202.172 per m^3 of water, out of which AMD 10.858 was deferred to 2025 and 11.414 is subsidized by the Government of Armenia. So in reality, the retail customer of Veolia Jur pays AMD 180 per m^3 (with VAT) for water and wastewater services provided by Veolia Jur.

Water supply and wastewater services constitute AMD 153 and AMD 27 of AMD 180 price accordingly. The wholesale price of water supplied by Veolia Jur to several off-grid communities is fixed at AMD 38.282 per m^3. Wholesale price of wastewater services is fixed at AMD 19.141.

Water tariffs for irrigation are regulated by Decision 61-A of PSRC Chairman adopted on 01.03.2007. The price of water for irrigation supplied by gravity system is AMD 1.01 per m^3, and price of water for irrigation supplied by pumping is 11.52 m^3.

Water for irrigation in Armenia is heavily subsidized by State. In 2019, Gegharquniq WUA has received AMD 378.8 mln for supplying 8.6 mln m^3 water to farmers in Sevan RBD, while total income from sold water to farmers is expected at AMD 80.1 mln.

Water tariffs for water supply and sanitation services in off – grid communities of Sevan RBD vary and they are set up by local administration council. Water supply in those communities is non-metered and varies from AMD 200 per person or AMD 1000 per household/month.

7.1.4 Fines and Penalties

The rates of fines and penalties for water pollution are stipulated in paragraph 169 of Armania's Tax Code. Particularly, it states that when the amount of pollutants exceeds the allowable quantities, the entities have to triple the taxable amount. In case there was no water permit for water discharge, the entity should pay 10 times more in Ararat and Armavir marzes and 10 times more in the rest of Armenia.

The rates of fines and penalties for exceeding the allowable water abstraction quanitities are stipulated in paragraph 204 of Armania's Tax Code. Same as above, for exceeding the abstraction of allowable quantities, the entities have to triple the water abstraction fees. In case there was no water permit for water discharge, the entity should pay 10 times more in Ararat and Armavir marzes and 10 times more in the rest of Armenia.

Penalties for administrative violoations are stipulated in Paragraph 61, 62 and 63 of Law on Administrative Violoations. Paragraph 61 states that violoation of water protection rules, which has caused water pollution, water erosion of soils or other harmful effects, may result in a fine of 50 times the amount of minimum wage and 100 times of minimum wage for officials. Paragraph 62 states that violation of water use supply and use rules, as well as conducting unauthorized construction of hydrotechnical structures may result in a fine of 100 times the amount of minimum wage and 300 times of minimum wage for officials. Paragraph 63 states that unauthorized conducting of works on water systems may result in a fine of 30-50 times the amount of minimum wage and 150 times of minimum wage for officials and elimination of hydrotechnical structures.

7.1.5 Water Systems and Assets of Special State Significance

The table below outlines the assets of special state significance as identified during the interviews with officials from marzpetarans, local governments and SCWE.

Table 77: Main Water Infrastructure Assets in Sevan RBD

Asset Name	Asset Description
Arpa-Sevan Tunnel	A major tunnel spanning 48.4 kms and diverting water from Arpa river to Sevan lake. It is expected that around 150 to 180 mln m^3 water will be diverted to Sevan from Arpa river in 2019.
Gavar Water and Wastewater Treatment Plant	Gavar WWTP provides mechanical treatment to Gavar town. Water treatment capacity is 10,500 m^3/day
Martuni Water and Wastewater Treatment Plant	Martuni WWTP provides mechanical treatment to Martuni town. Water treatment capacity is 4,600 m^3/day
Vardenis Water and Wastewater Treatment Plant	Vardenis WWTP provides mechanical treatment to Vardenis town. Water treatment capacity is 5,000 m^3/day
Tsak-qar and Hopoyi Var water intake structures	Main water supply source for 3500 subscribers living in Martuni city.
Shatjreq, Akunq, Sourb Vardan and Akner water intake structures	Main water supply source for 4600 subscribers living in Vardenis city.
Hatsarat, Saroukhan and Gandzak water intakes and Hatsarat pump station	Main water supply source for 6500 subscribers in Gavar city, 750 subscribers in Lchashen community, 1040 subscribers in Saroukhan community and 850 subscribers in Gandzak community
Lchashen wells and pump station system	Main water supply source for 7000 subscribers in Sevan city
Masrik canal	With a length of 31.5 kms, it provides irrigation water to 1846 ha of land
Waterfall canal	Sourcing water from Argichi river, it provides irrigation water to 348 ha of land
Dotation canal	Sourcing water from Argichi river through Getashen canal, it provides irrigation water to 211 ha of land
Sarukhan canal	Sourcing water from Sarukhan springs, it provides irrigation water to 211 ha of land
Zolaqar canal	Sourcing water from Astghadzor river, it provides irrigation water to 310 ha of land

7.2 Analysis of Application of the Principle of Recovery of the Costs of Water Services in the RBD

Annex III of the WFD Directive stipulates that the economic analysis of water uses should contain enough information in sufficient detail (taking account the costs associated with collection of relevant data) in order to:

- Make the relevant calculations necessary for taking into account the principle of recovery of the costs of water services under Article 9, taking into account long term forecasts of supply and demand for water in the river basin district and where necessary:
  - estimates of the volume, prices and costs associated with water services; and
  - estimates of the relevant investment including forecasts of such investments.
- Make judgements about the most cost-effective combination of measures with respect to water uses to be included in the programme of measures under Article 11 based on estimates of the potential costs of such measures.

The assessment of the current levels of cost-recovery of water services is the basis for ensuring transparency on costs, prices, subsidies, cross-subsidies, etc.

Key elements to be investigated include:

- Status of key water services (e.g. number of persons connected/using the service);
- Costs of water services (financial costs, environmental and resource costs);
- Institutional set-up for cost-recovery (prices and tariff structure, subsidies, cross-subsidy);
- Resulting extent of cost-recovery levels (for financial costs, for environmental and resource costs);
- Extent of contribution of key water uses to the costs of water services (link with pollution and use information collected for the analysis of pressures and impacts); and
- Complementary information whenever relevant (e.g. affordability for key water users).

7.2.1 Status of Key Water Services

Water Services are services of general (economic) interest. Water services are defined in Article 2 (38) of the WFD as: “all services which provide for households, public institutions or any economic activity: (a) abstraction, impoundment, storage, treatment and distribution of surface water or groundwater, (b) waste-water collection and treatment facilities which subsequently discharge into surface water.”

In Armenian legislation there are no clear definitions of “water services” and “wastewater services”. There is a definition of “water supplier”, which is a physical or legal entity carrying out water “abstraction, storage, and provision to water users”. The main difference between those definitions is that WFD also includes waste water collection, treatment and discharge in this term.

As it was mentioned in “Part 1, Characterization Phase of the Report on Development of River Basin Management Plan for Sevan River Basin District in Armenia”, the water services are used for the following activities in Sevan RBD:

- Water supply and sanitation,
- Irrigation,
- Watering of livestock,
- Fish farming,
- Industry,
- Hydro-power generation.

The graph below shows distribution of water abstraction by main sectors of economy in Sevan RBD. Total abstracted volume of water for 2017 was 337,586.7 thousand m³.

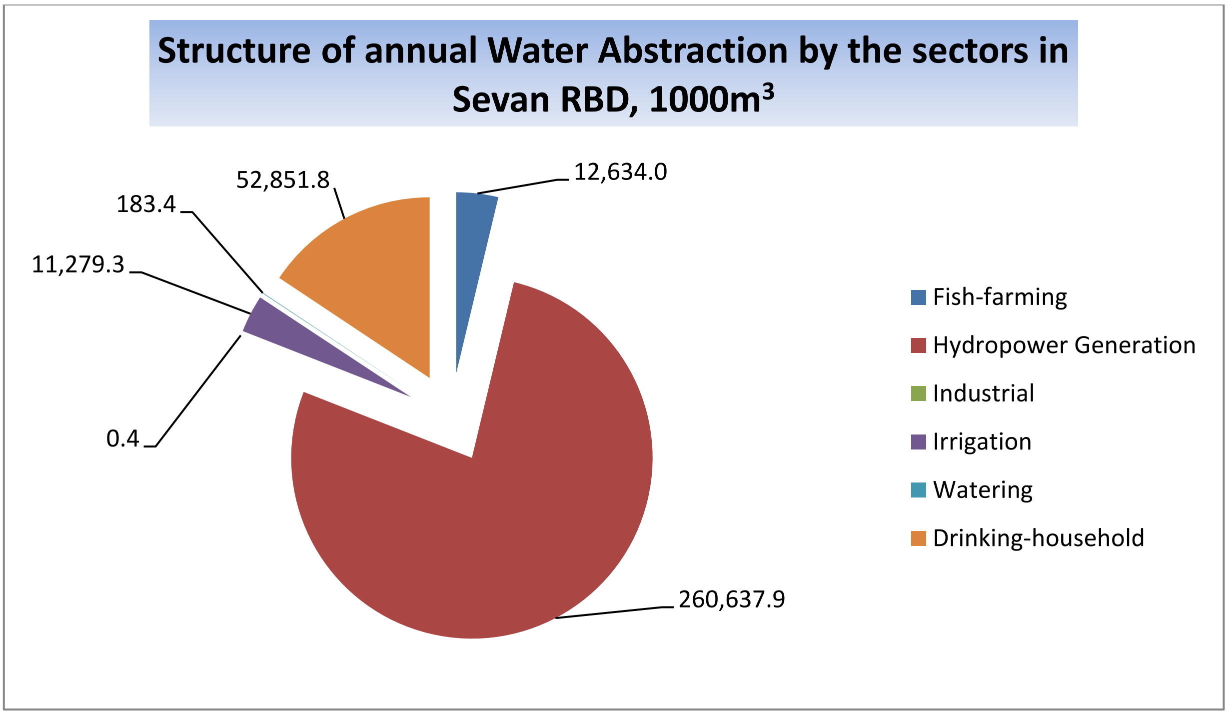


Figure 46: Structure of annual water abstraction by Sectors in Sevan basin, in 1000m³
Source: (http:// http://wrma.am/4_1.php), 2017

The table below shows key variables of activities that water services are used for, which will be used for the analysis and assessment of cost recovery principle:

Table 78: Description of key water services in Sevan RBD

Water Service	Variable description	Units
Drinking Water Supply (Veolia jur)	No of people connected to network	46,414
Drinking Water Supply (Self-serviced)	No of people connected to network	
Sewerage (Veolia jur)	No of people connected to sewerage network	43,458
Sewerage (Self-serviced)	No of people connected to sewerage network	
Irrigation		
Grain	Irrigated land (in ha)	30
Potato	Irrigated land (in ha)	4205
Vegetables	Irrigated land (in ha)	20
Fruits	Irrigated land (in ha)	12
Other	Irrigated land (in ha)	
Watering of Livestock		
Cattle	No of animals	118543
Pig	No of animals	15049
Sheep and Goat	No of animals	110830
Horse	No of animals	1021
Poultry	No of animals	374044
Fish-farming	Total area of fish-farms (sqm)	33364
Industry		

Mining and Quarrying		N/A
Manufacturing of food Products		N/A
Manufacturing of Beverages		N/A
Manufacturing of Textiles		N/A
Other		N/A
Hydro-Power Generation	Capacity, KW	18678
Recreation and Tourism	Number of visitors	1500000

7.2.2 Costs of water services

The WFD lays down the principle of cost recovery for water services in Article 9 by defining costs as *economic costs*, which are the costs to society as a whole. In the Directive (*Article 9*), economic costs are made up of three components: financial costs, resource costs and environmental costs.

Financial costs are the costs of the water services incurred by particular economic agents. *Environmental costs*, broadly speaking, include the costs borne by others through environmental media (i.e. through environmental externalities), and *resource costs* can include resource use beyond sustainable boundaries as well as inefficient resource allocation.

The EU WFD introduced the concept of environmental and resource costs in connection with both the PPP as well as cost recovery for water services. Additionally, water prices should provide incentives for the efficient use of the resource, while taking the other aspects of comprehensive water pricing into consideration.

Although many countries in EU have tried to incorporate environmental and resource costs for assessing the cost recovery, those options have not been fully utilized and are not used for practical applications. In Armenia this concept has not been adopted, yet, and hence, we will use only financial costs in this research for assessing the cost recovery in Sevan RBD.

Table 79: Cost Recovery: Annual Revenues and Subsidies in Centralized Water Supply and Wastewater Removal Systems in Sevan RBD (Veolia Jur service area)

N/N	FINANCIAL ISSUES	GAVAR			MARTUNI			VARDENIS			TOTAL		
		2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
I	Total Operational and maintenance cost*	299,872	363,877	363,145	42,269	84,850	92,573	31,020	45,283	49,167	373,161	494,010	504,885
II	Total Operational and maintenance cost without depreciation	177,462	188,887	208,151	19,744	20,041	27,680	20,446	18,666	20,892	217,652	227,594	256,723
III	Total revenue from water supply and wastewater services	130,207	149,248	154,454	36,582	41,192	54,097	53,744	113,324	87,064	220,533	303,764	295,615
IV	Balance between Cost and Revenue (III-I)	-169,665	-214,629	-208,691	-5,687	-43,658	-38,476	22,724	68,041	37,897	-152,628	-190,246	-209,270

V	Subsidy from the State Budget*	8,205	9,405	9,733	2,305	2,596	3,409	3,387	7,141	5,486	13,897	19,142	18,628
VI	Final Balance, Financial Gap (IV+V)	-161,460	-205,224	-198,958	-3,382	-41,062	-35,067	26,111	75,182	43,383	-138,731	-171,104	-190,642
VII	Cost recovery ratio (V+III)/I	46%	44%	45%	92%	52%	62%	184%	266%	188%	63%	65%	62%
VIII	Population in service areas, persons	29,002	29,351	24,856	8,438	9,299	9,504	9,173	9,321	9,219	46,613	47,971	43,579

Source: Armwater CJSC 2015 actual figures

** Expense details are outlined in Table 80*

The annual amount of subsidy in 2019 is 1,074,818 (without VAT) and the portion of subsidy for Sevan RBD was calculated taking into consideration the ratio of RBD's revenue to the total revenue

Table 80: Cost Recovery: Annual Revenues and Financial Gap in Water Supply and Wastewater Removal Systems in Sevan RBD (Off-grid communities)

N/N	Expenses	TOTAL in Sevan RBD		
		2013	2014	2015
I	Total Operational and maintenance cost water supply and wastewater service***	953,454	1,059,393	1,324,305
II	Total revenue from water supply and wastewater services	137,872	146,489	172,340
III	Cost recovery ratio (II/I)	14%	14%	13%
IV	Population in service areas, persons	194,734	194,734	194,734

Source: "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia" developed by the CES and "Jrtuq" LLC, 2015

** The annual revenue was calculated multiplying the quantities of abstracted water and the average tariff AMD 35 which uses in off-grid communities*

***Population number is based on 2011 census data*

**** Expense details are outlined in Table 81*

According to statement of “Gegharquniq” WUA submitted to SCWE, total expenses and encomes are not balanced and are introduced in the below table.

Table 81: Cost Recovery: Expenses, Revenue, Subsidy and Expected Financial Gap (Irrigation*)

N/N	Financial issues	Total ('000 amd)
I	**Total Operational and maintenance cost, from which:**	**538,310**
	Electricity	312,600
	Salary	81,500
	Operational and maintenance costs	66,100
	Fees and liabilities to budget	30,510
	Other costs	47,600
II	Total revenue from irrigation services	**94,200**
III	Collected revenue	**80,100**
IV	Balance between Cost and Collected Revenue (III-I)	-458,210
V	Subsidy from the State Budget*	**378,830**
VI	Final Balance, Financial Gap (IV+V)	-79,380
VII	Cost recovery ratio (V+III)/I	**85%**

Cost of recovery for hydropower generation, fish farming, livestock watering and industrial sectors was not possible to calculate, because financial data for these sectors were not available. In order to calculate the cost recovery for mentioned-above sectors, a special mechanism should be elaborated.

7.2.2.1 Cost of Drinking-household Water Supply and Sanitation Services

Water abstraction for drinking-household purposes was 52,851.8 thousand m^3 or 15.7% of total intake in 2017. Water supply and sanitation is provided by "Veolia Jur" CJSC and "off-grid" communities. "Veolia Jur" CJSC started its activities in this region from January 1, 2017. This company provides centralized water supply and sanitation in several communities of this region and is not covering the whole territory of the region. The figure below outlines water abstraction for drinking – household by Veolia Jur and off-grid communities in Sevan RBD.

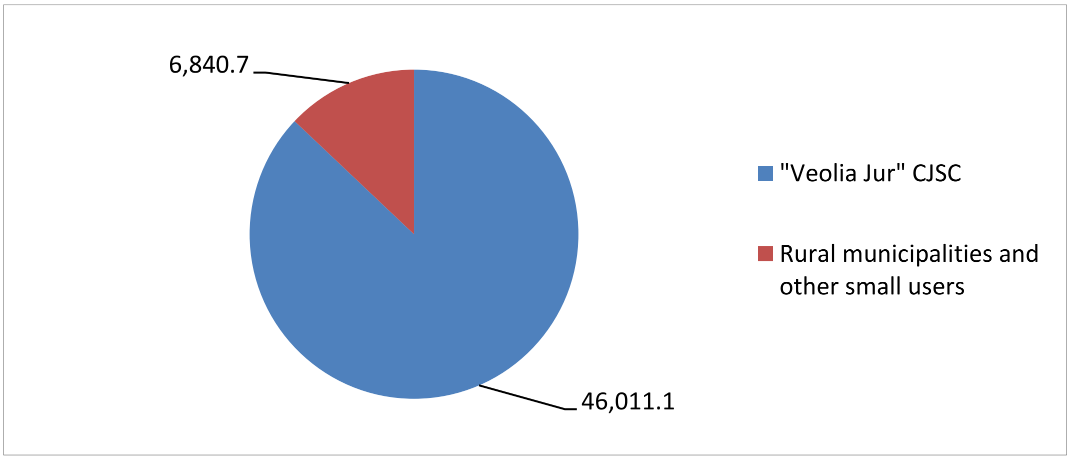


Figure 47: Structure of annual Water Abstraction for Drinking-Household, in 1000m³,

Source: (http:// http://wrma.am/4_1.php), 2017

Costs of water supply and sanitation services for in-grid communities were calculated using financial data of AWSC from 2015.

Table 82: Annual Operational and Maintenance Costs in Centralized Water Supply and Wastewater Systems in Sevan RBD (Veolia jur service area)

N/N	Expenses	Gavar			Martuni			Vardenis			Total in sevan rbd		
		2013	2014	2015	2013	2014	2015	2013	2014	2015	2013	2014	2015
I	**For water supply, total from which:**	**260,557**	**300,057**	**304,777**	**18,946**	**53,831**	**59,454**	**19,218**	**16,603**	**20,118**	**298,721**	**370,491**	**384,349**
1	Energy	110,317	123,480	147,035	23	15	122	31	29	32	110,371	123,524	147,189
2	Salary	22,351	23,458	26,977	8,160	8,505	12,334	7,328	7,429	8,669	37,839	39,392	47,980
3	Material expenses	12,609	8,364	8,677	3,316	3,338	4,196	3,894	3,323	2,073	19,819	15,025	14,946
4	Repair and maintenance	12,549	18,340	13,417	527	1,782	2,223	722	1,306	3,231	13,798	21,428	18,871
5	Depreciation, amortization	95,614	122,968	106,334	4,995	39,256	39,123	5,476	4,409	5,799	106,085	166,633	151,256
6	Other costs	7,117	3,447	2,337	1,925	935	1,456	1,767	107	314	10,809	4,489	4,107
II	**For wastewater, total from which:**	**39,315**	**63,820**	**58,368**	**23,323**	**31,019**	**33,119**	**11,802**	**28,680**	**29,049**	**74,440**	**123,519**	**120,536**
1	Salary	5,770	6,139	5,276	3,811	4,368	5,557	4,500	4,970	4,915	14,081	15,477	15,748
2	Material expenses	3,191	2,429	1,798	1,067	635	820	1,131	1,030	512	5,389	4,094	3,130
3	Repair and maintenance	967	914	1,257	274	309	547	198	455	1,006	1,439	1,678	2,810
4	Depreciation, amortization	26,796	52,022	48,660	17,530	25,553	25,770	5,098	22,208	22,476	49,424	99,783	96,906
5	Other costs	2,591	2,316	1,377	641	154	425	875	17	140	4,107	2,487	1,942
III	**Total Operational and maintenance cost water supply and wastewater service**	**299,872**	**363,877**	**363,145**	**42,269**	**84,850**	**92,573**	**31,020**	**45,283**	**49,167**	**373,161**	**494,010**	**504,885**
IV	**Total Operational and maintenance cost without depreciation**	**177,462**	**188,887**	**208,151**	**19,744**	**20,041**	**27,680**	**20,446**	**18,666**	**20,892**	**217,652**	**227,594**	**256,723**

Source: Armwater CJSC 2015 actual figures

O & M expenses for off – grid communities were extracted from an extensive analysis carried out by CES and "Jrtuq" LLC in 2014 and 2015.

Table 83: Annual Operational and Maintenance Costs of Water Supply and Wastewater Services in Sevan RBD (Off-grid communities)

N/N	Expenses*	Total in sevan rbd		
		2013	2014	2015
I	**For water supply, total from which:**	**408,771**	**454,190**	**575,727**
1	Energy	5,626	6,251	6,945
2	Salary	171,072	190,080	237,600
3	Material expenses	136,414	151,571	189,464
4	Repair and maintenance	72,180	80,200	106,933
5	Other costs	23,480	26,089	34,785
II	**For wastewater, total from which:**	**544,682**	**605,203**	**748,578**
1	Energy	67,439	74,933	83,259
2	Salary	215,957	239,952	299,940
3	Material expenses	3,063	3,403	4,538
4	Repair and maintenance	234,483	260,536	325,670
5	Other costs	23,741	26,379	35,172
III	**Total Operational and maintenance cost water supply and wastewater service**	**953,454**	**1,059,393**	**1,324,305**

Source: "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia" developed by the CES and "Jrtuq" LLC, 2015

* Detailed description of expenses is outlined in Annex 19 and 20.

7.2.2.2 Importance of Water for Irrigation

Irrigation services in the Sevan RBD is provided by "Gegharkunik" Water Users Association (WUA). The total service area of the WUA is 3742 ha. The irrigation infrastructure consists of about 19 secondary irrigation canals, which provide water from rivers and springs. The water used for irrigation purposes was 11,279.3 thousand m^3 or 3.3 % of total water use permit volume in RBD. There are 26 major water users of irrigation water in this region, out of which 13 are rural communities and the remaining part are different users. The figure below shows the allocation of water abstraction among different users.

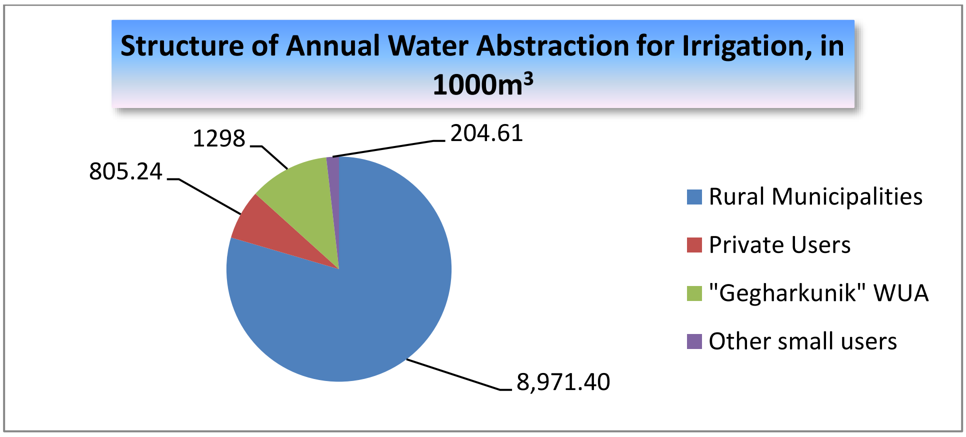


Figure 48: Structure of annual water abstraction for irrigation in Sevan basin, in 1000m³

Source: (http:// http://wrma.am/4_1.php), 2017

Water use for irrigation from surface and ground water resources is outlined below.

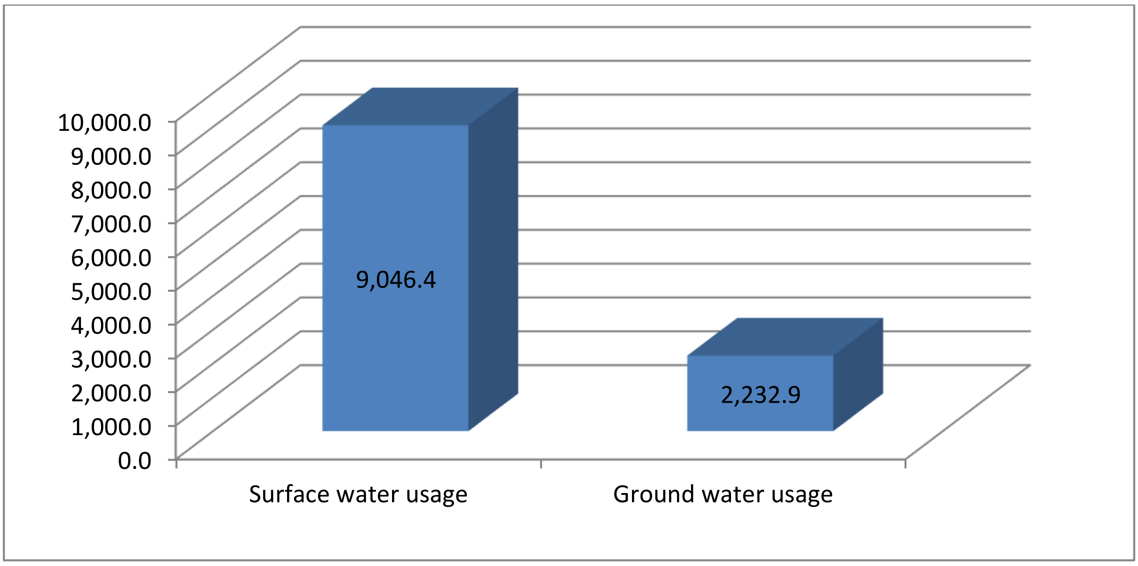


Figure 49: Surface and Ground water abstraction for Irrigation in Sevan RBD, in 1000m^3

Source: (http:// http://wrma.am/4_1.php), 2017

In general, water use for irrigation and livestock watering purposes is very important for this region because the agriculture is one of the leading sectors of economy (12.7 %) in Sevan RBD. The agricultural lands occupy about 56 % (264,360 ha) of the total land of the Sevan RBD, out of which 224,200 ha are grasslands and pastures and 40,170 ha - arable lands.

Distribution of agricultural lands across the main river basins is presented in Table 84. It shows that the largest areas of agricultural lands are located in Masrik (24.7%), Gavaraget (17.5%), Argichi (12.5%), Pokr Masrik (2.7 %), Bakhtak (5.8 %) and Lichk (1.3%) river basins. The other river basins together include over 35.5 % of total agricultural lands. Masrik holds about 52% of total arable lands, followed by Argichi (17.5%) and Gavaraget (8.6%). The largest grasslands are also located in Masrik (21.1%), Gavaraget (18.6%) and Argichi (11.8%) river basins.

Table 84: Distribution of Agriculture Land by River Sub-basins, 2010-2018

Sub-river basin in Sevan basin	Land area per river basin, ha	
	Arable lands including small-size household farms	Grasslands and pastures
Masrik	12825.4	39944.7
Argichi	4324.3	22308.8
Gavaraget	2123.7	35175.9
Pokr Masrik	1750.4	4075.9
Bakhtak	977.1	11422.0
Lichk	942.5	1863.7
Others	1699.8	74099.0
Total	24643.2	188890

Source: GlobeLand30, Gegharkunik Regional Administration, Geocom Ltd, 2010-2018.

The agricultural production in the RBD is focused on crops and potato, followed by livestock production, including cows, sheep and pigs.

In Sevan RBD the main crops are grains which are cultivated on about 44% of the cultivated land, 14.7 % are fodder crops and potatoes (Table 85).

Table 85: Gross Production of Crops in Sevan RBD, 2013-2017

Crop	Cultivated land, ha				
	2013	2014	2015	2016	2017
Grain	41 753	40 902	38 625	35 875	*30 913*
Potato	14 109	13 276	10 235	10 239	*9 431*
Vegetables	2 023	2 092	1 607	1 689	*1589*
Fruits	1 488	1 488	1 384	1 403	*1407*
Other	19 675	19 955	21 796	-	-
Total	79048	77713	73647	49206	43340

Source: Statistical Committee of the Republic of Armenia (www.armstat.am).

Detailed description of canal network is produced by the project on inventory of irrigation systems in Sevan and Hrazdan RBDs by Geoinfo Ltd[25].

Most part of the irrigation network is maintained by ”Gegharkunik“ Water Users Associations (WUA), which supply water to most part of agricultural lands in Sevan RBD. The total service area of the WUA is 3742 ha.

The irrigation data shows that irrigation network is mainly distributed in Masrik, Argichi, Gavaraget, Karchaghbyur and Martuni river basins.

Table 86: Main Characteristics of the Canals in Sevan RBD Operated by ”Gegharkunik” WUA

Name of the canal	Canal type	Length, km	Discharge, m^3/sec	Water source	Purpose	Dominant crops	Service area (ha)	Irrigation supply mode
Averakneri	Secondary	6.1	0.5	Lchavan natural springs	Agriculture	Potato	56	Gravity
Sarukhan	Secondary	5.9	0.1	Sarukhan springs	Agriculture	Potato	211	Pumped
Masrik	Secondary	31.5	2.0	Akunk springs	Agriculture	Potato	1846	Gravity
Ayrk pipeline	Secondary	13.9	1.0	Ayrq River	Agriculture, Energy	Potato, wheat	90	Gravity
Dotation	Secondary	5.6	0.5	Argichi River through Getashen Canal	Agriculture	Potato	240	Gravity
Getashen	Secondary	13.4	2.0	Argichi River	Agriculture	Potato	30	Gravity
HPP Canal	Secondary	6.8	0.3	Argichi River	Agriculture, Private water users	Vegetable Potato	110	Gravity
Waterfall Stream	Secondary	2.6	0.4	Argichi River	Agriculture	Potato	348	Gravity
Lchavan	Secondary	7.2	0.4	Makenis River	Agriculture	Potato	87	Gravity
Makenis	Secondary	3.6	0.7	Makenis River	Agriculture, Private water users	Vegetables Potato	110	Gravity
Tsovak 2) Vanq	Secondary	8.2	0.2	Makenis River	Agriculture	Potato	67	Gravity
Mountain Stream Martuni	Secondary	7.0	0.5	Martuni River	Agriculture	Potato	150	Gravity
Vaghashe n (Manas)	Secondary	19.3	0.5	Martuni River	Agriculture	Potato	174	Gravity
Noratus	Secondary	6.7	2.5	Gegharkun	Agriculture	Potato	91	Out of

[25] Detailed Assessment of Modern Flow Measurement Equipment, Needs for Irrigation Water Accounting in Sevan and Hrazdan Pilot Basins of Armenia. (EUWI+, 2018c)

(left)				ik River				operation
Noratus (right)	Secondary	10.8	0.15	Gegharkunik River	Agriculture	Potato	180	Pumped
Tsovinar	Secondary	5.2	0.4	Artsvanist River	Agriculture	Potato	140	Gravity
Zolaqar	Secondary	5.3	0.4	Astghadzor River	Agriculture	Potato	310	Gravity
Gegharkunik no 1 Reservoir Canal	Secondary	2.5	0.1		Agriculture	Potato	15	Gravity

Source: EUWI+, Detailed Assessment of Modern Flow Measurement Equipment Needs for Irrigation Water Accounting in Sevan and Hrazdan Pilot Basins of Armenia (EUWI+, 2018c)

7.2.2.3 Importance of Water for Watering of Livestock

The water abstraction used for livestock watering was 183.43 thousand m^3 or 0.1% of total intake. This type of activity is organized in 5 rural communities - Semyonovka, Tsaghkashen, Sarukhan, Ayrk and Vaghashen. Watering of livestock is very important for this region because there are many pastures where water is scarce. The figure below shows allocation of watering abstraction between the rural communities.

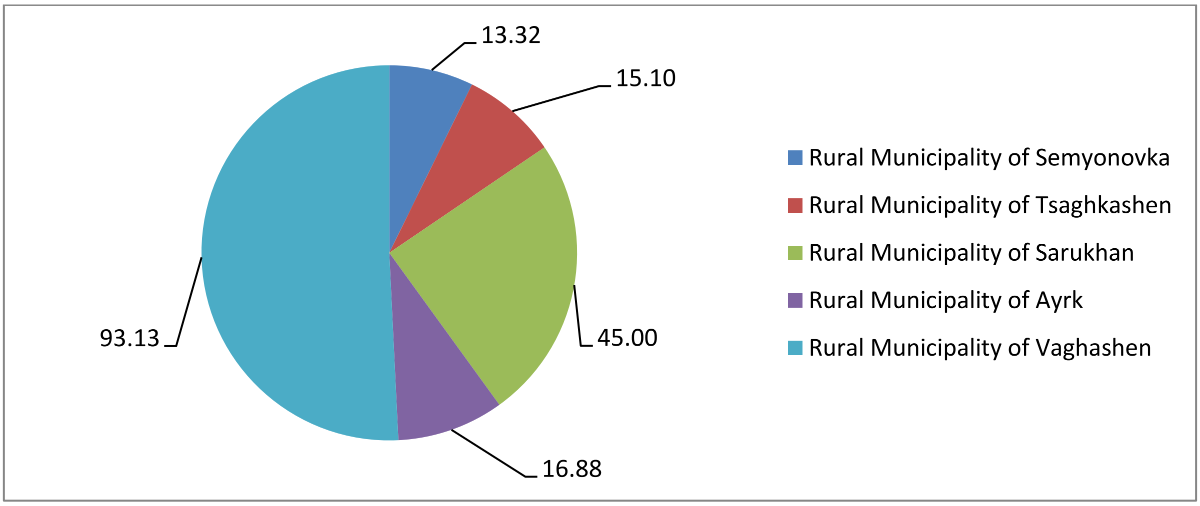


Figure 50: Structure of annual water abstraction for the Livestock Watering in Sevan RBD, in 1000m^3

Source: (http:// http://wrma.am/4_1.php), 2017

Cattle breeding has always been a traditional branch of agriculture in the Sevan RBD as widespread pastures (Table 87), geographical position and natural climatic conditions create favorable conditions. This is proven by an annual increase of both livestock capita and livestock yield.

Table 87: Number of Livestock in the Sevan RBD, thousand heads, 2013-2017

Livestock	Number of Livestock				
	2013	2014	2015	2016	2017
Cattle	112.3	115.6	120.9	125.0	124.9
from which cow	54.3	56.7	58.6	61.0	59.9
Sheep and goat	101.4	102.6	111.4	113.8	113.4
Pig	11.9	11.5	12.8	15.2	15.9
Horse	1.4	1.6	1.6	1.5	1.5

Source: Statistical Committee of the Republic of Armenia.

The livestock distribution in Sevan basin is presented in Table 88. As it is seen from the table, the cattle breeding is mainly developed in Major Sevan Basin (83%) especially in Masrik, Gavaraget, Martuni, Argichi, Artsvanist, Vardenis, Tsakkar, Karchaghbyur and Lichk River Basins.

Table 88: Number of Livestock in the Sevan RBD, thousand heads, 2014

River basins	Number of Livestock				
	Cattle	Pig	Sheep and goat	Horse	Poultry
Major Sevan					
Masrik	23922	1404	33227	145	63688
Gavaraget	20972	2501	14529	193	53420
Martuni	9424	2170	6854	11	29459
Argichi	7520	827	4106	12	23465
Artsvanist	5604	624	6192	21	19029
Vardenis	4637	912	1991	13	12066
Tsakkar	4396	540	1695	6	22437
Karchaghbyur	3738	515	3104	15	6532
Lichk	2450	238	1334	1	17085
Others	20834	2748	20143	95	80131
Minor Sevan					
Dzknaget	4 865	461	2302	41	9459
Other basins	15046	2109	15353	468	37273

Source: Statistical Committee of the Republic of Armenia. Comprehensive Agricultural Census of the Republic of Armenia for Gegharkunik Marz, 2014.

7.2.2.4 Importance of Water for Fish Farming

Data on fish farms comes from different sources (Water Resources Management Agency, Gegharkunik Regional Administration, Ministry of Agriculture) and statistical numbers vary on numbers of fish farms and water used is different. Within this study we have used data provided by WRMA.

As of January 1, 2018, there were 10 fish farms in the Sevan RBD. The total annual permitted water use for fish farms was 12,634 thousand m^3 (or 3.7% of total water use permits)**.** These farms occupy 29,464 m^2 of land and abstract water from 5 natural springs, 13 groundwater wells and Argichi river. The fish farms are mainly located in Gavaraget, Karchaghbyur, Argichi and Martuni River Basins. The picture below shows the amount of water abstracted annually in each of the 10 fish farms.

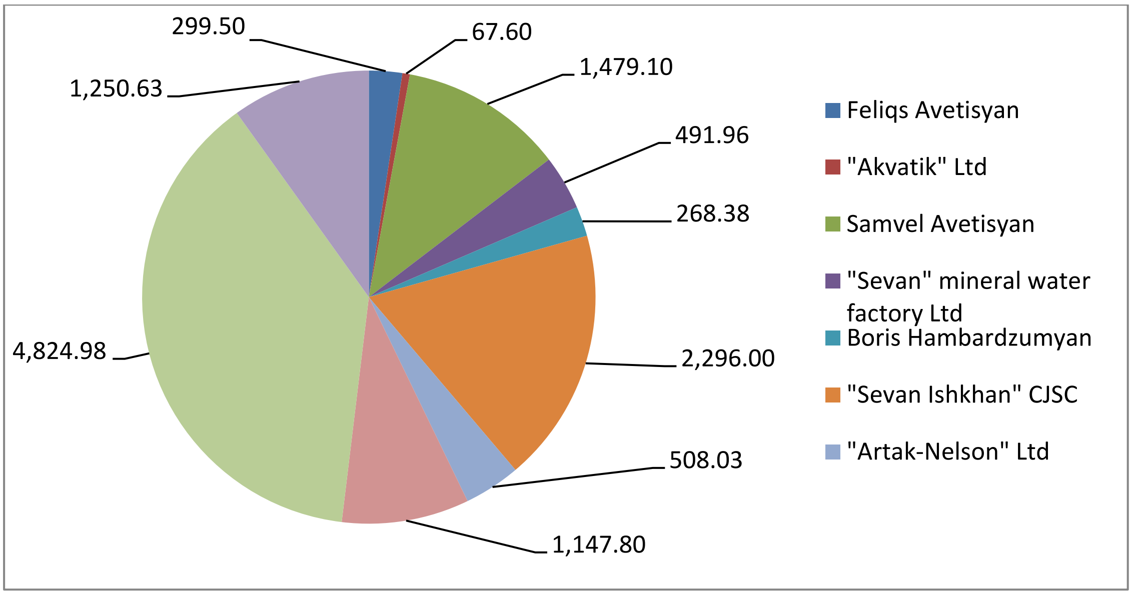


Figure 51: Structure of annual water abstraction for Fish Farming in Sevan RBD, in 1000m^3

Source: (http:// http://wrma.am/4_1.php), 2017

At the same time it should be noted that only two fish farms use surface water resources and the other eight are using groundwater resources. The figure below shows the data on the water type resources allocation.

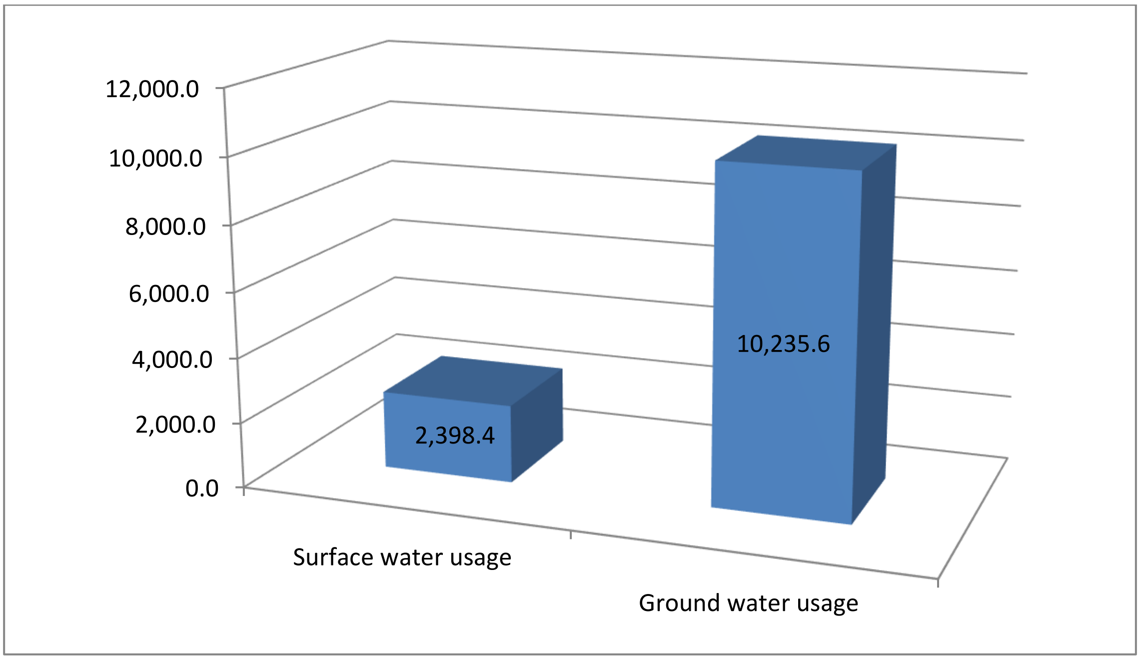


Figure 52: Surface and Ground water abstraction by the Fish Farming in Sevan RBD, in 1000m^3
Source: (http:// http://wrma.am/4_1.php), 2017

Table 89: Fish-farms in Sevan RBD

N	River Basin	Settlement	Number of fish farms/number of ponds	Area, m^2	Fish type	Productivity, t/y
1.	Gavaraget	Gavar, Sarukhan	5/26	6700	Rainbow trout	10
2.	Karchaghbyur	Karchaghbyur	1/20	1000	Sevan Trout	200
3.	Dzknaget	Tsovagyugh	2/26	20864	Sevan Trout	200
4.	Lake Sevan	Near Hayrivanq village	1/12	4000	Sevan Trout	60.86
5.	Lake Sevan	Near Shorja village	¼	800	Sevan Trout	50

Two cage fish farms are operated in Minor Sevan. One of them is located near Shorzha village. Since 2012, 4 cages have been installed with an area of 6400 m^2 and capacity of 50t. The second fish cage farm is located near Hayrivank village and started its operation in 2017. It occupies 82,425 m^2 and produces around 60.86 t of fish.

Fish farms may have a negative influence on the water quality of the rivers and Lake Sevan. The eutrophic impact of fish farming has not been intensively studied yet and phosphorus balance has not been estimated. However, fish farms are source of phosphorus which may cause eutrophication of Lake Sevan.

7.2.2.5 Importance of Water for Hydro-Electricity Production

Analysis of water use permits shows that the overwhelming part of allocated water is used for hydropower generation. The total annual permitted water use for hydropower generation was 260,637.9 thousand m^3 (or 77.2 % of total water use permits)*.* There are 9 small hydropower plants operating within Sevan RBD (Table 90) with a total installed capacity of 18,678 kW. 9 small hydropower plants in Gegharkunik province produce about 64 million kilowatts per hour electricity, which constitutes 7.47% of the energy generated by Small HPP in Armenia and 0.8% of total generated electricity in Armenia.

The figure below outlines water amount used by 9 hydro power plants in Sevan RBD (Dzoragyugh 3 and Dzoragyugh 1 HPPS use the same quantity of water abstracting at first by the Dzoragyugh 3 and flowing to the Dzoragyugh 1 HPP).

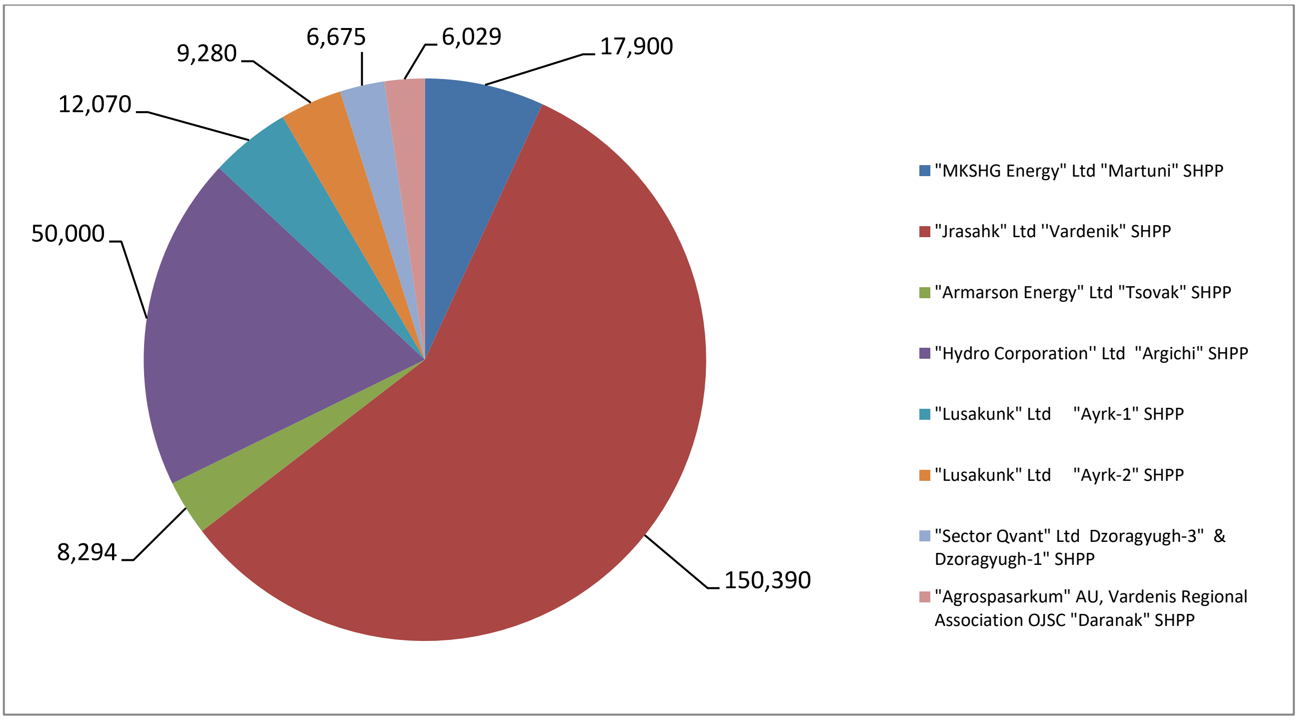


Figure 53: Structure of Annual Water abstraction by 9 SHPP's, in 1000m^3

Source: (http:// http://wrma.am/4_1.php), 2017

All the HPPs use surface water and three of them (Tsovak, Dzoragyugh 3 and Dzoragyugh 1) use water from irrigation channels.

Although the HPPs of the Sevan RBD are of small capacities, they cause significant pressures on water resources. Small hydroelectric power plants (HPPs) were built on the rivers without maintaining environmental norms, which led to the distortion of the river basin ecosystems.

According to the Armenian government protocol decision[26], the construction of SHPPs in Lake Sevan Basin is forbidden in order to improve ecological status of rivers flowing to Lake Sevan and restoration of fish stocks.

[26] RA Government Protocol Decision "On Approving Environmental Impact Assessment Standards for Small Hydro Power Plants Construction and Operation", 01.03.2018 N 8

Table 90: Characterization of SHPPs in Sevan RBD

N	Name of SHPP	River Basin	Water source	Capacity, KW	Water abstraction, thousand m^3/day	Ecological flow maintained	Fish ladder exist
1	Dzoragyugh-1	Tsakkar	Irrigation water pipe of Dzoragyugh	530	18.3	No	No
2	Dzoragyugh-3	Tsakkar	Irrigation water pipe of Dzoragyugh	274	18.3	No	No
3	Ayrk-1	Masrik	Ajrk tributary of Masrik river	209	33.1	Yes	-
4	Ayrk-2	Masrik	Ajrk tributary of Masrik river	659	30.9	Yes	-
5	Martuni	Martuni	Martuni river	1 800	49.0	Yes	Yes
6	Tsovak	Karchaghbyur	Lchavan springs on irrigatin water pipe	230	34.6	Yes	
7	Vardenik	Vardenis	Vardenis river	6 170	412	Yes	Yes
8	Argichi	Argichi river	Argichi river	8 400	150	Yes	Yes
9	Daranak	Daranak	Daranak river, left tributari of Daranak river	406	16.5	Yes	Yes

Source: Public Services Regulatory Commission, 2017

7.2.2.6 Importance of Water in Industrial Production

The water abstracted directly from ground water for the industry was 0.41 thousand m^3 or 0.0001% of total intake. The remaining water for industry is provided through the services of Veolia Jur CJSC.

In Sevan RBD the main branches of industry are mining and manufacturing (Table 91).

Gegharkunik Province is rich with metallic and non-metallic deposits. There are 2 metallic and 21 non-metallic mines in operation: gold, chromites, basalt, granite, marble, tuff, perlite sand and magnesium-silicate ore mines.

Table 91: Structure of industrial production in Sevan RBD by branches of industry

Branches of industry	Volume of Industrial Production by years, million AMD				
	2013	2014	2015	2016	2017
Mining and open mine exploitation	9170.3	8306.8	12877.4	14877.4	15098.2
Manufacturing	8164.4	9611.4	9823	9336.5	9363.4
manufacture of food products	8103.6	9580.9	9731.4	9093.7	8982.4
manufacture of beverages	4.5	5.1	77.1	195.2	106.2
manufacture of textiles	17.7	9.2	4.3	4.5	4.1
others	6.6	16.3	10.1	0.1	1.1

Data source: Statistical Committee of the Republic of Armenia

The main operating companies in the Gegharkunik province are classified as small and medium-sized enterprises. The GEOPROMINING GOLD LLC, which has a large stake in the mining industry, is specialized in precious metals mining, processing and it is one of the largest enterprises in the country. GPM Gold operates Sotk mine and the Ararat gold extraction plant. Ore from the Sotk deposit is transported by rail to the Ararat processing plant, where it is milled and then processed. The mining activities in Sotk are sources of non-point and point source pollution. Diffused mine water can impact the water quality of Sotk and then Masrik Rivers and groundwater due to the high concentration of heavy metals.

Table 92: Mining Enterprises in Sevan River Basin

Settlement	Name of Enterprise	Field of activity
Sotk	‘’Geo Pro Mining Gold’’ Ltd	Gold mining
Shorzha	"Gegamet plus’’ Ltd	Dunite (Chromite) and magnesium –silicate
Gavar	"Yeryuna"Ltd	gypsum
Artanish	Mika Cement Ltd	sand-gum
Geghamasar	"Kapavor" ltd	Sandstones
Geghovit	"Hayk Vardanyan"	Basalt
Lchashen	"Tuf-granit"	Basalt
Lchashen	"Gog-Ars" ltd	Volcanic slag
Tsovak	‘’Vardenisiqarhanq’’	Sandstones
Tsovak	‘’Regional unit of Vardenis’’ OJSC ‘’ of Agrospasarkum’’ IU	Pumice sands
Karmirgyugh	"Gavar CHSHSH " OJSC	Basalt
Dzoragyugh	"Kaloyan" Ltd	Perlite sand
Dzoragyugh	"Syuzi-Hrachya" Ltd	Basalt
Dzoragyugh	"Shoghag" Ltd	Perlite Sand
Masrik	"Vardenisi torf" Ltd	Torf
Noratus	‘’Mary and Hayk’’ Ltd	Sandstones
Geghakar	"Vardenis qarhank" OJSC	Subatan Tuf
Sarukhan	"Perlaro local investments" Ltd	Gabrons
Lanjaghbyur	"M.M.P.e" Ltd	Sand
Gegharkunik (Arevasar)	"Gri Nore" Ltd	Gabrons
Gegharkunik (Koghasar)	"Aratta Mining" Ltd	Gold
Makenis	"Aratta Mining" Ltd	Gold
Verin Shorzha	"Aratta Mining" Ltd	Gold
Shatjrek	"Aratta Lernayin" Ltd	Gold
Masrik	"Aratta Mining" Ltd	Gold
Aghberk	‘’Yerani Me’’ Ltd	Gabrons

Source: Republican geological fund. www.geo-fund.am/en/Issued-permits

Figure 54. Sotk Gold Mine (2016)

7.2.3 Analysis of Water Use Impact on Generated Income in Key Sectors

For each economic sector mentioned above, water is a key resource for generating income. Hence, an attempt has been made to calculate how much revenue is generated for each sector when 1 m^3 of water is abstracted. Tables below show water abstraction, generated produce, revenue from generated produce and income generated by 1m^3 of water.

Table 93: Income generated by 1m^3 of water by SHPPs

1	Water abstraction for SHPP, '000m3	260,638
2	Generated Electricity, 000'kvt/hours	74,700
3	Income from Generated Electricity, '000 AMD	1,120,500
4	Income per 1m^3, AMD	4.30

Source: http://www.minenergy.am/page/448, https://www.oecd.org/environment/outreach/Armenia_Energy%20subsidies_Armenian%20version.pdf

Table 94: Income generated by 1m^3 of water by fish farm sector

1	Water abstraction for Fish Farming , '000m^3	12,634
2	Fish Production, '000 ton	521
3	Income from Fish Sale, '000 AMD	989,634
4	Income per 1m^3, AMD	78.33

Source: http://agroshuka.am/products/fish_breeding/step-2

Table 95: Income generated by 1m^3 of water by irrigation and animal watering sectors

1	Water abstraction for Irrigation and watering , '000m3	11,463
2	Agricultural product, '000 AMD	123,800
3	Income per 1m^3, AMD	10.80

Source: Final Geocom Report, page 59, 04.03.19

Table 96: Income generated by 1m^3 of water by water supply and sanitation sector

1	Water abstraction for Drinking, '000m^3	52,852
2	Income from Drinking Water services, '000 AMD	467,955
3	Income per 1m^3, AMD	8.85

The analysis shows that the highest amount of income is generated by fish farms, followed by agriculture, water supply and sanitation and hydro-power generation.

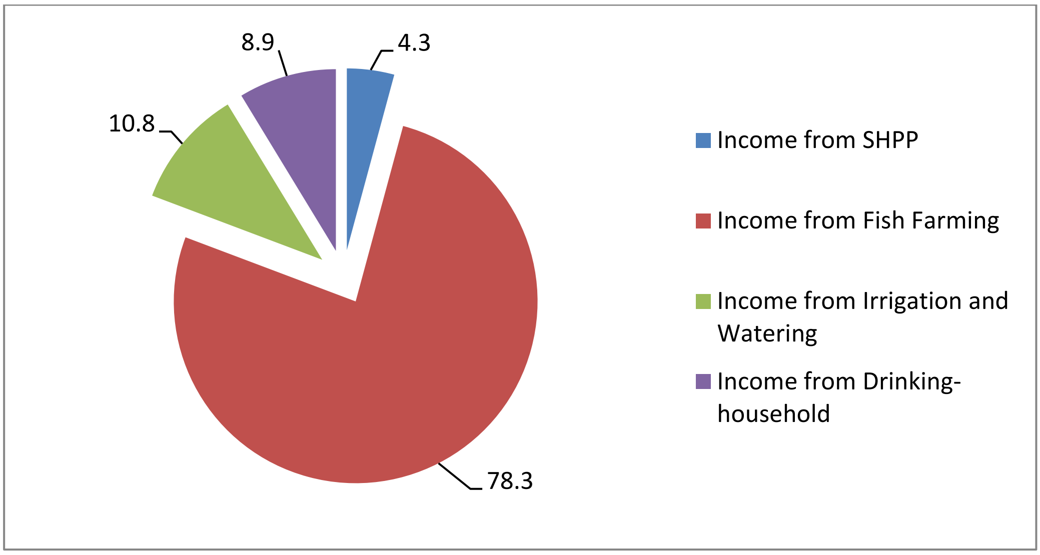


Figure 55: Income generated by 1m^3 of abstracted water in each sector

Data gaps:

- Extent of contribution of key water uses to the costs of water services
- Affordability Analysis
- Uncertainty of data on fish farms, livestocks
- Real water abstraction of each sector
- Real impact of each sector on water quality of Lake Sevan

7.3 Water Supply and Demand Assessment in Sevan RBD

7.3.1 Usable, Strategic and National Water Reserves

National Water Program establishes the fundamental principles for national, strategic and usable water reserves estimation, water supply and demand assessment, main issues and perspectives of protection and development of water sector, as well as the program of measures due to the limited availability of water, its importance for human life and health and conservation of flora and fauna. Thus, according to the National Water Program of the Republic of Armenia, water supply is primarily significant to evaluate water resources in relation to demand in order to maintain the ecological balance of both the water ecosystem and the given ecosystem.

In the National Water Program the estimated values of usable, strategic and national water reserves are presented for all 6 RBDs.

Usable Water Resources: The portion of water resources that may be allocated for consumptive use without reducing the National Water Reserve.

Usable water resources include the river flow formed within the territory of Armenia, part of the transboundary Araks and Akhuryan rivers flow, and renewable groundwater resources, excluding ecological flow. Water use permits can’t exceed the usable resources of the given water object established by basin management plan.

Strategic Water Reserve: the quality and quantity of water that required to meet basic human needs and preserve water ecosystems in the emergency situations (draught, ecological disasters, energetic crysis, etc.)

Strategic reserve can be increased by accumulating part of usable water resources in Sevan Lake and in the constructing reservoirs. Strategic water reserve includes the increase of Sevan Lake volume after January 1, 2005, possible usable portion of the dead volume of reservoirs, usable portion of the volume of lakes (excluding Sevan Lake), groundwater flow. Strategic groundwater reserves are formed through all-day use of the flow from existing and additionally drilled wells. Strategic groundwater reserves are the subject of periodical adjustment by the Government of Armenia. Strategic reserve is used by the decision of Government of Armenia.

National Water Reserve: The quality and quantity of water that required to satisfy present and future basic human needs, as well as to protect aquatic ecosystems and to secure sustainable development and use of that water resource. National water reserve is formed as a difference between overall water resources of Armenia and usable + strategic water reserves.

The use of the National water reserve is prohibited, except for the case of strategic water reserve depletion – based on the decision of the Government of the Republic of Armenia, on the conclusion of the National Water Council of the Republic of Armenia. National water reserve includes the volume of the lakes (including the volume of Lake Sevan as of January 1, 2005 - 34,583.6 million m^3), deep groundwater resources and glaciers before their melting. Lake Sevan contains 96.5% of the National water reserves of Armenia.

In the table below the values for Sevan RBD are presented.

Table 97: Usable, Strategic and National Water Reserves in Sevan RBD (based on the National Water Program Main Water Infrastructure Assets in Sevan RBD)

Water Resources	mln.m3
Usable water resources	
River flow (without environmental flow)	443.8
Usable groundwater reserves set byA+B category, including the annual average flow of the springs	259.5
Total	*703.3*
Strategic water reserve	
Increase of the volume of Lake Sevan after 2005	3700
1/3 of the volume of natural lakes	0.04
2/3 of the volume of reservoirs	0.5
Groundwater reserves set by C1 category	1.64
Total	*3702.18*
National water reserves	
River environmental flow	233.2
Lake Sevan volume (as per Jan. 1, 2005)	34586.6
2/3 of the volume of natural lakes	0.07
1/3 of the volume of reservoirs	0.25
Glaciers and firn fields	2
Groundwater reserves set by C2 category or deep flow	0.8
Total	*34822.92*

Source: Mnatsakanyan, V.H. Sargsyan, 2015; Law on National Water Program, 2006

7.3.2 Current and Future Water Supply in Sevan RBD

In this chapter, surface water supply is calculated for the basins of the main rivers flowing into the Sevan Lake, as well as for the groundwater bodies identified and characterized in scope of the Draft Sevan RBD Management Plan Development activities.

Water supply of the surface water bodies (rivers) is the difference of the surface natural flow and ecological flow. Surface water bodies are grouped by the main rivers flowing into Sevan Lake. In the table below, SWB code refers to the water bodies with outlet to the Lake.

Table 98: Surface Water Supply in Sevan RBD

N	River	SWB Code	SW Supply, m^3/s (multi-year average)	SW Supply, m^3/s (2016)	SW Supply, m3/s (2017)	SW Supply, mln. m^3 (Multi-year average)	Usable Resource, mln. m^3 (2016)	Usable Resource, mln. m^3 (2017)
1	Dzknaget	SWB 4-003	0.84	1.1	0.74	26.6	36.1	23.3
2	Drakhtik	SWB 4-006	0.27	0.3	0.24	8.5	9.1	7.6
3	Artsatabeghk	SWB 4-008	0.16	0.1	0.13	4.9	4.3	4.2
4	Artanish	SWB 4-010	0.12	0.1	0.10	3.8	2.9	3.2
5	Gizhget	SWB 4-011	0.07	0.0	0.05	2.2	0.9	1.7
6	Jil	SWB 4-012	0.12	0.1	0.10	3.9	3.0	3.2
7	Tsapatagh	SWB 4-015	0.17	0.2	0.15	5.5	4.9	4.7
8	Shampur	SWB 4-017	0.16	0.1	0.13	4.9	4.2	4.1
9	Pambak	SWB 4-019	0.22	0.2	0.18	6.9	5.4	5.7
10	Daranak	SWB 4-022	0.23	0.2	0.20	7.3	7.1	6.2
11	Areguni	SWB 4-024	0.11	0.1	0.09	3.5	2.5	2.9
12	Geghamasar	SWB 4-027	0.50	0.6	0.44	15.7	17.4	13.7
13	Pokr Masrik	SWB 4-030	0.53	0.6	0.46	16.7	18.6	14.6
14	Masrik	SWB 4-041	3.25	4.1	3.69	102.5	127.7	116.4
15	Karchaghbyur	SWB 4-047	0.81	1.1	0.93	25.5	34.1	29.3
16	Artsvanist	SWB 4-048	1.18	1.4	1.16	37.3	43.7	36.6
17	Vardenis	SWB 4-052	1.54	1.7	1.40	48.6	52.6	44.1
18	Aknakhar	SWB 4-053	0.18	0.2	0.10	5.6	5.1	3.2
19	Zolakar	SWB 4-054	0.28	0.3	0.21	8.9	9.1	6.6
20	Astghadzor	SWB 4-055	0.58	0.7	0.53	18.4	20.6	16.6
21	Martuni	SWB 4-058	1.45	1.3	0.95	45.7	42.5	30.1
22	Argichi	SWB 4-065	3.06	3.5	2.16	96.5	109.8	68.1
23	Lichk	SWB 4-066	1.02	1.0	0.89	32.2	32.5	28.1
24	Bakhtak	SWB 4-069	2.75	2.5	1.85	86.7	78.8	58.4
25	Gavaraget	SWB 4-082	1.86	2.6	1.99	58.7	83.3	62.8
Total			21.47	23.98	18.87	677.0	756.2	595.2

Source: Armenian State Hydromet Service

Table 99: Groundwater Supply in Sevan RBD

№	River	Groundwater renewable resources, m^3/s	Groundwater usable resources, m^3/s	Groundwater usable resources, million m^3
1.	Dzknaget	0.23	0.11	3.5
2.	Dzknaget-Drakhtik interfluve	0.07	0.04	1.3
3.	Drakhtik	0.19	0.09	2.8
4.	Drakhtik-Artanish interfluve	0.11	0.06	1.9
5.	Artanish	0.07	0.03	0.9

6.	Artanish-Pambak interfluve	0.54	0.27	8.5
7.	Pambak	0.48	0.24	7.6
8.	Geghamasar	0.23	0.11	3.5
9.	Masrik	3.26	1.63	51.4
10.	Karchaghbur (Makenis)	1.59	0.79	24.9
11.	Artsvanist	0.64	0.32	10.1
12.	Vardenis	0.68	0.34	10.7
13.	Vardenis-Argichi interfluve	0.88	0.44	13.9
14.	Argichi-Lower Getashen	1.82	0.91	28.7
15.	Argichi- Gavaraget interfluve	1.28	0.64	20.2
16.	Gavaraget-Noratus	3.48	1.74	54.9
17.	Noratus-Lchashen	0.94	0.47	14.8
Total		**16.49**	**8.23**	**259.5**

Source: Environmental Monitoring and Information Center SNCO, Ministry of Environment

Water supply was analyzed for the multi-year period (average), 2016 (high-water year), 2017 (low-water year), as well as projected for the period of First Sevan RBMP Implementation period (2020-2025) and 2040. Two climate change scenarios were used for water supply projection: optimistic (IPCC RCP6.0) and pessimistic (IPCC RCP8.5).

Table 100: Current. Average and Future Surface Water Supply in Sevan RBD (by main river basins)

N	River	SWB Code	Surface Water Supply, mln. m^3																			
			Multi-year average	2016	2017	First RBMP Implementation Period (optimistic scenario)								2033*	First RBMP Implementation Period (pessimistic scenario)								2033
						2020	2021	2022	2023	2024	2025	2026	2027		2020	2021	2022	2023	2024	2025	2026	2027	
1	Dzknaget	SWB 4-003	26.6	36.1	23.3	26.5	26.3	26.2	26.1	25.9	25.8	25.7	25.5	24.7	26.4	26.2	26.1	25.9	25.7	25.5	25.4	25.2	24.2
2	Drakhtik	SWB 4-006	8.5	9.1	7.6	8.4	8.4	8.3	8.3	8.3	8.2	8.2	8.1	7.9	8.4	8.4	8.3	8.3	8.2	8.1	8.1	8.0	7.7
3	Artsatabeghk	SWB 4-008	4.9	4.3	4.2	4.9	4.9	4.9	4.8	4.8	4.8	4.8	4.7	4.6	4.9	4.9	4.8	4.8	4.8	4.7	4.7	4.7	4.5
4	Artanish	SWB 4-010	3.8	2.9	3.2	3.8	3.8	3.8	3.7	3.7	3.7	3.7	3.7	3.6	3.8	3.8	3.7	3.7	3.7	3.7	3.6	3.6	3.5
5	Gizhget	SWB 4-011	2.2	0.9	1.7	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0	2.2	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.0
6	Jil	SWB 4-012	3.9	3.0	3.2	3.9	3.8	3.8	3.8	3.8	3.8	3.7	3.7	3.6	3.9	3.8	3.8	3.8	3.8	3.7	3.7	3.7	3.5
7	Tsapatagh	SWB 4-015	5.5	4.9	4.7	5.5	5.4	5.4	5.4	5.4	5.3	5.3	5.3	5.1	5.5	5.4	5.4	5.4	5.3	5.3	5.2	5.2	5.0
8	Shampur	SWB 4-017	4.9	4.2	4.1	4.9	4.9	4.8	4.8	4.8	4.8	4.7	4.7	4.6	4.9	4.8	4.8	4.8	4.8	4.7	4.7	4.7	4.5
9	Pambak	SWB 4-019	6.9	5.4	5.7	6.9	6.9	6.8	6.8	6.8	6.7	6.7	6.7	6.4	6.9	6.8	6.8	6.8	6.7	6.7	6.6	6.6	6.3
10	Daranak	SWB 4-022	7.3	7.1	6.2	7.2	7.2	7.1	7.1	7.1	7.0	7.0	7.0	6.7	7.2	7.2	7.1	7.1	7.0	7.0	6.9	6.9	6.6
11	Areguni	SWB 4-024	3.5	2.5	2.9	3.5	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.2	3.4	3.4	3.4	3.4	3.4	3.3	3.3	3.3	3.2
12	Geghamasar	SWB 4-027	15.7	17.4	13.7	15.7	15.6	15.5	15.4	15.3	15.3	15.2	15.1	14.6	15.6	15.5	15.4	15.3	15.2	15.1	15.0	14.9	14.3
13	Pokr Masrik	SWB 4-030	16.7	18.6	14.6	16.6	16.6	16.5	16.4	16.3	16.2	16.1	16.0	15.5	16.6	16.5	16.4	16.3	16.2	16.1	16.0	15.8	15.2
14	Masrik	SWB 4-041	102.5	127.7	116.4	102.3	102.2	102.0	101.9	101.8	101.6	101.5	101.3	100.4	102.2	101.9	101.6	101.3	101.0	100.6	100.3	100.0	98.2
15	Karchaghbyur	SWB 4-047	25.5	34.1	29.3	25.5	25.5	25.4	25.4	25.4	25.3	25.3	25.2	25.0	25.5	25.4	25.3	25.2	25.2	25.1	25.0	24.9	24.5
16	Artsvanist	SWB 4-048	37.3	43.7	36.6	37.2	37.2	37.1	37.1	37.0	37.0	36.9	36.8	36.5	37.2	37.1	36.9	36.8	36.7	36.6	36.5	36.4	35.7
17	Vardenis	SWB 4-052	48.6	52.6	44.1	48.5	48.4	48.4	48.3	48.2	48.1	48.1	48.0	47.6	48.4	48.3	48.1	48.0	47.8	47.7	47.5	47.4	46.5
18	Aknakhar	SWB 4-053	5.6	5.1	3.2	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.6	5.5	5.6	5.6	5.6	5.6	5.6	5.5	5.5	5.5	5.4
19	Zolakar	SWB 4-054	8.9	9.1	6.6	8.9	8.9	8.9	8.9	8.9	8.8	8.8	8.8	8.7	8.9	8.9	8.8	8.8	8.8	8.8	8.7	8.7	8.5
20	Astghadzor	SWB 4-055	18.4	20.6	16.6	18.3	18.3	18.3	18.3	18.2	18.2	18.2	18.2	18.0	18.3	18.3	18.2	18.1	18.1	18.0	18.0	17.9	17.6
21	Martuni	SWB 4-058	45.7	42.5	30.1	45.7	45.6	45.5	45.5	45.4	45.3	45.3	45.2	44.8	45.6	45.5	45.3	45.2	45.0	44.9	44.8	44.6	43.8
22	Argichi	SWB 4-065	96.5	109.8	68.1	96.4	96.2	96.1	95.9	95.8	95.7	95.5	95.4	94.6	96.2	95.9	95.6	95.3	95.1	94.8	94.5	94.2	92.4
23	Lichk	SWB 4-066	32.2	32.5	28.1	32.2	32.3	32.4	32.4	32.5	32.6	32.6	32.7	33.1	32.2	32.3	32.3	32.4	32.4	32.4	32.5	32.5	32.8
24	Bakhtak	SWB 4-069	86.7	78.8	58.4	86.9	87.1	87.3	87.4	87.6	87.8	88.0	88.1	89.2	86.9	87.0	87.1	87.2	87.4	87.5	87.6	87.7	88.5
25	Gavaraget	SWB 4-082	58.7	83.3	62.8	58.8	58.9	59.0	59.1	59.3	59.4	59.5	59.6	60.3	58.7	58.8	58.9	59.0	59.1	59.2	59.3	59.3	59.9
Total			**677.0**	**756.2**	**595.2**	**676.2**	**675.5**	**674.7**	**674.0**	**673.2**	**672.5**	**671.7**	**671.0**	**666.5**	**675.4**	**673.7**	**672.1**	**670.5**	**668.8**	**667.2**	**665.6**	**664.0**	**654.2**

**Second RBMP Implementation Deadline*

Table 101: Average and Future Groundwater Supply in Sevan RBD

N	River	Groundwater Supply, mln. m^3																		
		Optimistic Scenario										Pessimistic Scenario								
		Multi-Year Usable Groundwater Resources, million m^3	First RBMP Implementation Period								2033	First RBMP Implementation Period								2033
			2020	2021	2022	2023	2024	2025	2026	2027		2020	2021	2022	2023	2024	2025	2026	2027	
1	Dzknaget	3.5	3.48	3.46	3.45	3.43	3.41	3.39	3.38	3.36	3.34	3.48	3.45	3.43	3.41	3.39	3.36	3.34	3.32	3.29
2	Dzknaget-Drakhtik interfluve	1.3	1.29	1.29	1.28	1.27	1.27	1.26	1.25	1.25	1.24	1.29	1.28	1.27	1.27	1.26	1.25	1.24	1.23	1.22
3	Drakhtik	2.8	2.79	2.77	2.76	2.74	2.73	2.72	2.70	2.69	2.67	2.78	2.76	2.75	2.73	2.71	2.69	2.67	2.65	2.64
4	Drakhtik-Artanish interfluve	1.9	1.89	1.88	1.87	1.86	1.85	1.84	1.83	1.82	1.81	1.89	1.88	1.86	1.85	1.84	1.83	1.81	1.80	1.79
5	Artanish	0.9	0.90	0.89	0.89	0.88	0.88	0.87	0.87	0.86	0.86	0.89	0.89	0.88	0.88	0.87	0.86	0.86	0.85	0.85
6	Artanish-Pambak interfluve	8.5	8.46	8.41	8.37	8.33	8.29	8.24	8.20	8.16	8.11	8.44	8.39	8.33	8.28	8.22	8.17	8.11	8.06	8.00
7	Pambak	7.6	7.56	7.52	7.49	7.45	7.41	7.37	7.33	7.29	7.26	7.55	7.50	7.45	7.40	7.35	7.30	7.25	7.20	7.15
8	Geghamasar	3.5	3.48	3.46	3.45	3.43	3.41	3.39	3.38	3.36	3.34	3.48	3.45	3.43	3.41	3.39	3.36	3.34	3.32	3.29
9	Masrik	51.4	51.33	51.25	51.18	51.10	51.03	50.96	50.88	50.81	50.73	51.25	51.09	50.94	50.78	50.63	50.47	50.32	50.17	50.01
10	Karchaghbur (Makenis)	24.9	24.86	24.83	24.79	24.76	24.72	24.68	24.65	24.61	24.58	24.83	24.75	24.68	24.60	24.53	24.45	24.38	24.30	24.23
11	Artsvanist	10.1	10.09	10.07	10.06	10.04	10.03	10.01	10.00	9.98	9.97	10.07	10.04	10.01	9.98	9.95	9.92	9.89	9.86	9.83
12	Vardenis	10.7	10.68	10.67	10.65	10.64	10.62	10.61	10.59	10.58	10.56	10.67	10.64	10.60	10.57	10.54	10.51	10.48	10.44	10.41
13	Vardenis-Argichi interfluve	13.9	13.88	13.86	13.84	13.82	13.80	13.78	13.76	13.74	13.72	13.86	13.82	13.77	13.73	13.69	13.65	13.61	13.57	13.52
14	Argichi-Lower Getashen	28.7	28.66	28.62	28.58	28.53	28.49	28.45	28.41	28.37	28.33	28.61	28.53	28.44	28.36	28.27	28.18	28.10	28.01	27.93
15	Argichi- Gavaraget interfluve	20.2	20.24	20.28	20.32	20.37	20.41	20.45	20.49	20.53	20.57	20.23	20.26	20.29	20.32	20.35	20.38	20.41	20.44	20.47
16	Gavaraget-Noratus	54.9	55.0	55.1	55.2	55.4	55.5	55.6	55.7	55.8	55.9	55.0	55.1	55.1	55.2	55.3	55.4	55.5	55.5	55.6
17	Noratus-Lchashen	14.80	14.83	14.86	14.89	14.92	14.95	14.98	15.01	15.04	15.07	14.82	14.84	14.87	14.89	14.91	14.93	14.95	14.97	15.00
Total		**259.5**	**259.4**	**259.3**	**259.1**	**258.9**	**258.8**	**258.6**	**258.4**	**258.3**	**258.1**	**259.1**	**258.6**	**258.2**	**257.7**	**257.2**	**256.7**	**256.2**	**255.7**	**255.3**

Source: Environmental Monitoring and Information Center

In the table below, the surface and groundwater supply is combined for multi-year average and projection periods.

Table 102. Future Water Supply in Sevan RBD (mln m^3)

Sources	Optimistic Scenario										Pessimistic Scenario								
	Multi-year average	First RBMP Implementation Period								2033	First RBMP Implementation Period								2033
		2020	2021	2022	2023	2024	2025	2026	2027		2020	2021	2022	2023	2024	2025	2026	2027	
Surface Water	677.0	676.2	675.5	674.7	674.0	673.2	672.5	671.7	671.0	666.5	675.4	673.7	672.1	670.5	668.8	667.2	665.6	664.0	654.2
Groundwater	259.5	259.4	259.3	259.1	258.9	258.8	258.6	258.4	258.3	258.1	259.1	258.6	258.2	257.7	257.2	256.7	256.2	255.7	255.3
Total	**936.5**	**935.7**	**934.8**	**933.8**	**932.9**	**932.0**	**931.1**	**930.1**	**929.2**	**924.5**	**934.5**	**932.4**	**930.3**	**928.1**	**926.0**	**923.9**	**921.8**	**919.7**	**909.4**

7.3.3 Current and Future Water Demand in Sevan RBD

Water demand in Sevan RBD for different sectors was calculated using different norms and regulations, as well as population growth forecast developed by UN. The analysis of water demand showed that it should be differentiated into two types: (1) the actual water demand and (2) actual water demand plus NRW that should be abstracted from water source to satisfy the actual water demand. Within this analysis “actual water demand plus NRW” is considered as “water demand”.

Demand of water for drinking and household use was calculated by taking into account the forecast of AWSC (“Total Management Plan” document developed in 2014). The water demand forecast is derived from a statistical analysis of AWSC data for the managed rural areas and is based on the assumption that each person consumes currently 250 l/cap/d. On the long run, it is expected that the average water demand will drop down to 150 l/cap/d for the planning horizon of 2040, with a linear reduction for years in-between. At the same time the margin of non-revenue water will be reduced, too.

For the present analysis, we assume that the average daily consumption of water will remain constant at 250l/cap/day both for urban and rural areas (although in urban areas it is at 150 l/cap/day level). The reason for taking into account average water consumption is that up to now many consumers use drinking water for small scale irrigation and prefer not to be metered. However, as soon as water becomes a commodity people will emphasize on cost saving measures.

Water demand forecast is presented below for the years 2016, 2017, 2020-2025 (short-term) and 2033 (long-term). Population growth rate was derived from UN World Population Forecast website. As a basis, figures from population census of 2011 were taken into account and multiplied by growth rates as defined by UN:

Table 103: Population Growth in Communities of Sevan RBD

Community name	Population by years										
	2011	2016	2017	2018	2019	2020	2021	2022	2023	2024	2027	2033
Aghberk	278	284	285	285	286	286	287	287	287	288	288	285
Akhpradzor	355	362	363	364	365	366	366	367	367	367	367	364
Akunk	4443	4534	4548	4559	4568	4576	4584	4590	4594	4597	4596	4559
Areguni	344	351	352	353	354	354	355	355	356	356	356	353
Arpunk	568	580	581	583	584	585	586	587	587	588	588	583
Artanish	756	772	774	776	777	779	780	781	782	782	782	776
Artsvanist	2825	2883	2892	2899	2905	2909	2914	2918	2921	2923	2922	2899
Astghadzor	4215	4301	4315	4325	4334	4341	4348	4354	4359	4362	4360	4325
Avazan	252	257	258	259	259	260	260	260	261	261	261	259
Ayrq	317	324	324	325	326	326	327	327	328	328	328	325
Azat	101	103	103	104	104	104	104	104	104	105	104	104
Berdkunk	296	302	303	304	304	305	305	306	306	306	306	304
Chkalovka	516	527	528	529	531	531	532	533	534	534	534	529
Daranak	168	171	172	172	173	173	173	174	174	174	174	172
Drakhtik	909	928	930	933	935	936	938	939	940	941	940	933
Dzoragyugh	4737	4834	4849	4860	4870	4879	4887	4893	4898	4902	4900	4860
Gandzak	3815	3893	3905	3914	3922	3929	3936	3941	3945	3948	3946	3914
GAVAR	20765	21191	21256	21306	21350	21386	21422	21451	21472	21487	21480	21306
Geghakar	136	139	139	140	140	140	140	140	141	141	141	140
Geghamabak	135	138	138	139	139	139	139	139	140	140	140	139
Geghamasar	1132	1155	1159	1162	1164	1166	1168	1169	1171	1171	1171	1162
Gegharkunik	1654	1688	1693	1697	1701	1703	1706	1709	1710	1711	1711	1697
Geghhovit	5753	5871	5889	5903	5915	5925	5935	5943	5949	5953	5951	5903
Hayravank	680	694	696	698	699	700	702	702	703	704	703	698
Jaghatsadzor	100	102	102	103	103	103	103	103	103	103	103	103
Jjl	615	628	630	631	632	633	634	635	636	636	636	631
Kakhakn	375	383	384	385	386	386	387	387	388	388	388	385
Karchaghbyur	2337	2385	2392	2398	2403	2407	2411	2414	2417	2418	2417	2398

Karmirgyugh	4964	5066	5081	5093	5104	5112	5121	5128	5133	5137	5135	5093
Khachagbyur	1064	1086	1089	1092	1094	1096	1098	1099	1100	1101	1101	1092
Kut	193	197	198	198	198	199	199	199	200	200	200	198
Kutakan	288	294	295	296	296	297	297	298	298	298	298	296
Lanjaghbyur	2115	2158	2165	2170	2175	2178	2182	2185	2187	2189	2188	2170
Lchap	982	1002	1005	1008	1010	1011	1013	1014	1015	1016	1016	1008
Lchashen	4969	5071	5086	5099	5109	5118	5126	5133	5138	5142	5140	5099
Lchavan	548	559	561	562	563	564	565	566	567	567	567	562
Lernahovit	323	330	331	331	332	333	333	334	334	334	334	331
Lichk	5417	5528	5545	5558	5570	5579	5588	5596	5602	5605	5603	5558
Lusakunk	1440	1470	1474	1478	1481	1483	1486	1488	1489	1490	1490	1478
Madina	1111	1134	1137	1140	1142	1144	1146	1148	1149	1150	1149	1140
Makenis	405	413	415	416	416	417	418	418	419	419	419	416
MARTUNI	12894	13158	13199	13230	13257	13279	13302	13320	13333	13342	13338	13230
Mets Masrik	3132	3196	3206	3214	3220	3226	3231	3235	3239	3241	3240	3214
Nerkin Getashen	8553	8728	8755	8776	8794	8809	8824	8835	8844	8850	8847	8776
Nerkin Shorja	12	12	12	12	12	12	12	12	12	12	12	12
Norabak	246	251	252	252	253	253	254	254	254	255	254	252
Norakert	1015	1036	1039	1041	1044	1045	1047	1049	1050	1050	1050	1041
Norashen	475	485	486	487	488	489	490	491	491	492	491	487
Noratus	6732	6870	6891	6907	6922	6933	6945	6954	6961	6966	6964	6907
Nshkhark	0	0	0	0	0	0	0	0	0	0	0	0
Pambak	548	559	561	562	563	564	565	566	567	567	567	562
Pokr Masrik	626	639	641	642	644	645	646	647	647	648	648	642
Sarukhan	8309	8479	8505	8526	8543	8557	8572	8583	8592	8598	8595	8526
Semyonovka	253	258	259	260	260	261	261	261	262	262	262	260
Shatjrek	466	476	477	478	479	480	481	481	482	482	482	478
Shatvan	612	625	626	628	629	630	631	632	633	633	633	628
Shorja	509	519	521	522	523	524	525	526	526	527	527	522
Sotk	824	841	843	845	847	849	850	851	852	853	852	845
Torfavan	490	500	502	503	504	505	505	506	507	507	507	503
Tretuk	174	178	178	179	179	179	180	180	180	180	180	179
Tsaghkashen	470	480	481	482	483	484	485	486	486	486	486	482
Tsakqar	2692	2747	2756	2762	2768	2772	2777	2781	2784	2786	2785	2762
Tsapatagh	360	367	369	369	370	371	371	372	372	373	372	369
Tsovagyugh	3943	4024	4036	4046	4054	4061	4068	4073	4077	4080	4079	4046
Tsovak	2319	2367	2374	2379	2384	2388	2392	2396	2398	2400	2399	2379
Tsovasar	2708	2764	2772	2779	2784	2789	2794	2797	2800	2802	2801	2779
Tsovazard	1905	1944	1950	1955	1959	1962	1965	1968	1970	1971	1971	1955
Tsovinar	5115	5220	5236	5248	5259	5268	5277	5284	5289	5293	5291	5248
Vaghashen	4267	4355	4368	4378	4387	4395	4402	4408	4412	4415	4414	4378
Vanevan	367	375	376	377	377	378	379	379	380	380	380	377
Vardadzor	2864	2923	2932	2939	2945	2950	2955	2959	2962	2964	2963	2939
Vardenik	9880	10083	10114	10138	10158	10175	10193	10206	10217	10223	10220	10138
VARDENIS	12685	12945	12985	13016	13042	13064	13086	13104	13117	13126	13122	13016
Verin Getashen	5010	5113	5128	5141	5151	5160	5168	5175	5181	5184	5182	5141
Verin Shorja	23	23	24	24	24	24	24	24	24	24	24	24
Yeranos	5479	5591	5609	5622	5633	5643	5652	5660	5666	5669	5668	5622
Zolakar	6381	6512	6532	6547	6561	6572	6583	6592	6598	6603	6601	6547
Total	**194734**	**198728**	**199337**	**199810**	**200217**	**200555**	**200893**	**201164**	**201367**	**201503**	201435	199810

Source: Census 2011, http://esa.un.org/wpp/unpp/panel_population.htm

According to technical proposal of Veolia (Code No: SCWE of RA MoA – CDSA – N15/1, June 2016), which was accepted by Government of Armenia, it is expected to reduce the non-revenue water (NRW) by 2% each year during 15 years of lease contract. It means that water abstraction should be substantially reduced if the condition in the technical proposal are met. Hence, in order to reflect the improvements in water supply network an assumption is made that 2% of NRW reduction is expected each year up to 2025.

Table 104: Drinking-household Water Demand in Sevan RBD

	2016	2017	2018	2019	2020	2021	2022	2023	2024	2027	2033
Population	198728	199337	199810	200217	200555	200893	201164	201367	201503	201435	199810
Actual water demand (mln m^3)	18.1	18.2	18.2	18.3	18.3	18.3	18.4	18.4	18.4	18.4	18.2
NRW%	78.5	76.5	74.5	72.5	70.5	68.5	66.5	64.5	62.5	56.5	44.5
NRW (mln m^3)	66.2	59.2	53.3	48.2	43.7	39.9	36.4	33.4	30.6	23.9	14.6
Water Use Permit (mln m^3)	52.9	-	-	-	-	-	-	-	-	-	-
Adjusted Water Demand (mln m^3)	84.3	77.4	71.5	66.4	62	58.2	54.8	51.8	49	42.3	32.9
Difference (mln m^3)	-31.5	-25.6	-20.7	-16.7	-13.3	-10.4	-8	-5.9	-4.1	0.1	4.6

By taking into account the assumptions loaded in the model (population growth, daily water consumption at 250 l/cap/d, NRW at 78.5% in 2016, it becomes evident that much more water should be abstracted for supplying water to the consumers. However, the analysis of water use permits to rural communities showed, that only 30 out of 60 communities supplying water to its residents have obtained water use permits. As a basis for NRW rate, the rate submitted by Veolia to Public Services Regulatory Commission was taken into account, which may be different in Gavar, Martuni and Vardenis regions, because a lot of work in this region was implemented by Armenian Water and Sewerage company to rehabilitate the water supply network. The project has officially applied to Veolia to receive such information, but no answer was received from them.

Demand of water for irrigation was calculated by taking into account the irrigation norms for different crops as defined by ministry of agriculture for different regions of Armenia ("Norms and regimes for irrigation of agricultural crops in RA", Manual, Yerevan, 2007, 203 p.). It should be noted that irrigation norms depend on several variables, such as soil type, clay content in soils and elevation. Since such detailed data is not available, an assumption has been made that following amounts of water are required for irrigation of the following types of crops:

- Potato – 2400 m^3/ha,
- Vegetables – 2400 m^3/ha,
- Wheat – 800 m^3/ha,
- Fruits and berries – 1800 m^3/ha

Non-Revenue water for irrigation was calculated by taking into account governmental decree No 188-N adopted on February 8, 2007, which defines acceptable NRW rates for all WUAs. The acceptable rate for Martuni, Gavar and Vardenis WUA is 47.5%, 31.2% և 43.9 % respectively.

Table 105: Water Requirements for Irrigation in Sevan RBD

Crops	Irrigated land	Water required per ha (m^3)	Required water (mln m^3)
Potato	4090	2400	9.816
Vegetable	120	2400	0.288
Wheat	45	800	0.036
Total water demand for Irrigation	4255		10.14
NRW%			40%
Adjusted water demand for irrigation			14.196

Statistical data regarding the agricultural lands is contradictory and shows that total area of agricultural lands has decreased from 2013 to 2017. However, the harvest has increased, which means that productivity per ha has increased. Personal interviews in villages showed that new irrigation and cultivation technologies are introduced in several farms, which are less water intensive. Hence, it is expected that water use for irrigation in the long run will decrease by 1% per year.

Since there was no data available on construction of new ***hydro power plants or fish farms***, the water requirements for those two sectors were left unchanged.

According to water use permits, water demand for ***industrial use*** was negligible. It is assumed that most of the water used for industry is supplied by Veolia Jur and cannot be differentiated from drinking and household type. Industrial growth rate is based on average World Bank GDP growth rate defined for Armenia – 3%.

Demand of livestock watering was calculated using ВНТП-Н-97 norms (http://docs.cntd.ru/document/1200030871).

Table 106: Water Requirements for Livestock Watering in Sevan RBD (2017)

Livestock	Number of Livestock (thousands)	Daily Water Demand per animal (m^3)	Water Demand (mln m^3)
Cow	59.9	0.075	0.0044925
Sheep and goat	113.4	0.006	0.0006804
Pig	15.9	0.008	0.0001272
Horse	1.5	0.037	0.0000555
Total			**0.0053556**

Livestock production has increased steadily in Sevan RBD at an average rate of 2.5% per year and hence the demand of water for watering of livestock was calculated accordingly.

7.3.4 Projected Ratio between Water Supply and Demand in Sevan RBD

Difference between water supply and demand (by sectors) is presented in the table below.

Table 107: Current and Future Water Supply and Demand in Sevan RBD (source)

Water Supply& Demand	**Supply Source / Demand Purpose**	**Optimistic Scenario**										**Pessimistic Scenario**						
		Multi-year average	**2016**	**2017**	**2020**	**2021**	**2022**	**2023**	**2024**	**2027**	**2033**	**2020**	**2021**	**2022**	**2023**	**2024**	**2027**	**2033**
Water Supply	Surface	677	756.2	595.2	676.2	675.5	674.7	674	673.2	671	666.5	675.4	673.7	672.1	670.5	668.8	664	654.2
	Groundwater	259.5	259.5	259.5	259.4	259.3	259.1	258.9	258.8	258.3	258.1	259.1	258.6	258.2	257.7	257.2	255.7	255.3
	Total	**936.5**	**1015.7**	**854.7**	**935.7**	**934.8**	**933.8**	**932.9**	**932**	**929.2**	**924.5**	**934.5**	**932.4**	**930.3**	**928.1**	**926**	**919.7**	**909.4**
Water Demand	Drinking-household	57.0	84.3	77.4	62	58.2	54.8	51.8	49	42.3	32.9	71.8	69.2	66.7	64.5	62.3	56.6	47.4
	Irrigation	13.6	14.2	14.1	13.9	13.8	13.6	13.5	13.4	13.2	12.6	13.6	13.5	13.4	13.2	13.1	13	12.3
	Hydropower Generation	270.9	260.6	262.6	265.8	268.4	271	273.6	276.2	278.8	281.4	260.5	263	265.6	268.2	270.7	273.3	275.8
	Industrial	0.0	0.0004	0.0004	0.0004	0.0004	0.0005	0.0005	0.0005	0.0005	0.0007	0.0003	0.0004	0.0005	0.0005	0.0005	0.0005	0.0006
	Fish-farming	13.9	12.6	12.6	13.1	13.4	13.6	13.9	14.2	15	17.1	13.2	13.4	13.7	14	14.3	14.5	15.6
	Watering	2.2	1.98	1.95	1.99	2.03	2.07	2.12	2.16	2.2	3.02	1.97	2.01	2.05	2.09	2.14	2.18	2.99
	Total	0	373.7	368.7	356.8	355.8	355.1	354.9	355.0	351.5	347.0	361.1	361.1	361.5	362.0	362.5	359.6	354.1
Proficit/Deficit			**642.0**	**486.0**	**578.9**	**579.0**	**578.7**	**578.0**	**577.0**	**577.7**	**577.5**	**573.4**	**571.3**	**568.8**	**566.1**	**563.5**	**560.1**	**555.3**
Water demand / supply ratio			**37%**	**43%**	**38%**	**38%**	**38%**	**38%**	**38%**	**38%**	**38%**	**39%**	**39%**	**39%**	**39%**	**39%**	**39%**	**39%**

Pessimistic Scenario for water demand is based on the assumption that only 1% of NRW savings are reached each year. Water demand against water supply in the **Optimistic Scenario** is stable and between 2020 to 2033 equals to 38%, while in **Pessimistic Scenario** the ratio is 39% for the same period.

Current and future water supply and demand is also calculated for the highest water demand season, that is also the driest season (July-September).

Table 108: Current and Future Water Supply and Demand in Sevan RBD for Highest Water Demand Season

Water Supply& Demand	Supply Source / Demand Purpose	Optimistic Scenario										Pessimistic Scenario						
		Multi-year average	2016	2017	2020	2021	2022	2023	2024	2027	2033	2020	2021	2022	2023	2024	2027	2033
Water Supply	Surface	115.3	128.6	101.2	115.2	115	114.9	114.8	114.7	114.3	113.5	115	114.7	114.4	114.2	113.9	113	111.4
	Groundwater	64.9	64.9	64.9	64.9	64.8	64.8	64.7	64.7	64.6	64.5	64.8	64.7	64.5	64.4	64.3	63.9	63.8
	Total	**180.2**	**193.5**	**166.1**	**180.1**	**179.8**	**179.7**	**179.5**	**179.4**	**178.9**	**178**	**179.8**	**179.4**	**178.9**	**178.6**	**178.2**	**176.9**	**175.2**
Water Demand	Drinking-household	17.1	25.3	23.2	18.6	17.5	16.4	15.5	14.7	12.7	9.9	21.5	20.8	20.0	19.4	18.7	17.0	14.2
	Irrigation	6.8	7.1	7.1	7.0	6.9	6.8	6.8	6.7	6.6	6.3	6.8	6.8	6.7	6.6	6.6	6.5	6.2
	Hydropower Generation	81.3	78.2	78.8	79.7	80.5	81.3	82.1	82.9	83.6	84.4	78.2	78.9	79.7	80.5	81.2	82.0	82.7
	Industrial	0.0002	0.0002	0.0002	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0004	0.0002	0.0002	0.0003	0.0003	0.0003	0.0003	0.0003
	Fish-farming	4.9	4.4	4.4	4.6	4.7	4.8	4.9	5.0	5.3	6.0	4.6	4.7	4.8	4.9	5.0	5.1	5.5
	Watering	1.1	1.0	1.0	1.0	1.0	1.0	1.1	1.1	1.1	1.5	1.0	1.0	1.0	1.0	1.1	1.1	1.5
	Total		**90.7**	**91.2**	**92.3**	**93.1**	**93.9**	**94.8**	**95.6**	**96.6**	**98.2**	**90.6**	**91.3**	**92.2**	**93.0**	**93.8**	**94.7**	**95.8**
Proficit/Deficit			102.8	74.9	87.8	86.7	85.8	84.7	83.8	82.3	79.8	89.2	88.1	86.7	85.6	84.4	82.2	79.4
Water supply/demand ratio			**47%**	**55%**	**51%**	**52%**	**52%**	**53%**	**53%**	**54%**	**55%**	**50%**	**51%**	**52%**	**52%**	**53%**	**54%**	**55%**

According to table above during the highest water demand season the water demand against water supply in the **Optimistic Scenario** is between 2020 to 2033 varies from 51% to 55% and roughly the same ratio is observed in **Pessimistic Scenario**.

The water supply is not equally distributed throughout the RBD. In particular, during the risk analysis there were identified water bodies with disturbances of environmental flow. In the table below, water supply and demand are presented for the highest water demand season in the river basins with such disturbances.

Table 109: Current and Future Water Supply and Demand in Sevan RBD for Highest Water Demand Season in the Rivers with Disturbed Environmental Flow

River Basin	Supply / Demand	Optimistic Scenario										Pessimistic Scenario						
		Multi-year average	2016	2017	First RBMP Implementation Period						2033	First RBMP Implementation Period						2033
					2020	2021	2022	2023	2024	2027		2020	2021	2022	2023	2024	2027	
Drakhtik	Surface supply	1.00	1.07	0.89	1.00	0.99	0.99	0.98	0.98	0.96	0.93	1.00	0.99	0.98	0.98	0.97	0.95	0.91
	Groundwater supply	0.70	0.70	0.70	0.70	0.69	0.69	0.69	0.68	0.67	0.67	0.70	0.69	0.69	0.68	0.68	0.66	0.66
	Total Water Supply	1.70	1.77	1.59	1.69	1.68	1.68	1.67	1.66	1.63	1.60	1.69	1.68	1.67	1.66	1.65	1.61	1.57
Argichi	Surface supply	18.26	20.77	12.89	18.23	18.20	18.18	18.15	18.12	18.05	17.89	18.20	18.15	18.09	18.04	17.98	17.82	17.49
	Groundwater supply	7.18	7.18	7.18	7.16	7.15	7.14	7.13	7.12	7.09	7.08	7.15	7.13	7.11	7.09	7.07	7.00	6.98
	Total Water Supply	25.43	27.95	20.06	25.39	25.36	25.32	25.28	25.25	25.14	24.97	25.35	25.28	25.20	25.13	25.05	24.82	24.47
Bakhtak	Surface supply	4.24	3.85	2.85	4.25	4.25	4.26	4.27	4.28	4.31	4.36	4.24	4.25	4.26	4.26	4.27	4.29	4.32
	Groundwater supply	5.05	5.05	5.05	5.06	5.07	5.08	5.09	5.10	5.13	5.14	5.06	5.06	5.07	5.08	5.09	5.11	5.12
	Total Water Supply	9.29	8.90	7.90	9.31	9.32	9.34	9.36	9.38	9.44	9.50	9.30	9.31	9.33	9.34	9.35	9.40	9.44
Gavaraget	Surface supply	11.18	15.87	11.96	11.20	11.23	11.25	11.27	11.30	11.36	11.50	11.20	11.21	11.23	11.25	11.26	11.31	11.41
	Groundwater supply	13.73	13.73	13.73	13.75	13.78	13.81	13.84	13.87	13.95	13.98	13.75	13.77	13.79	13.81	13.83	13.89	13.91
	Total Water Supply	24.91	29.60	25.69	24.96	25.01	25.06	25.11	25.16	25.31	25.48	24.94	24.98	25.02	25.05	25.09	25.20	25.32

8. PROGRAMME OF MEASURES AND RELATED COSTS

8.1 Methodology for programme of measures and cost-effectiveness analysis

8.1.1 Introduction

This chapter was prepared based on the risk assessment and environmental objectives identification results provided for the Sevan RBD. Chapter of Program of Measures (PoM) was developed in accordance with environmental objectives set for each groundwater and surface water body in order to achieve “good water status” in the Sevan RBD.

The PoM is an element of the multi-level governance of water in the European Union, situated between the directive and the national legislations implementing the directive, and the individual administrative decisions within water management. Therefore, the PoM was set up based on the requirements of several EU directives, such as WFD, Urban Wastewater treatment Directive, Nitrates Directive, etc.

In addition, the following main RA Laws were considered to develop the PoM for Sevan RBD:

- the RA Water Code (2002);
- the RA Law on National Water Program (2006);
- the RA Law on Lake Sevan (2001);
- the RA Law on Adoption of the Annual and Complex Programs of Activities for the Use, Protection, Reconstruction and Reproduction of the Lake Sevan Ecosystem (2001);
- the RA Law on Provisions of Environmental Payments, (2006, revised in 2016 and included in the RA Law on Tax Code, Chapter 8);
- the RA Law on Natural Specially Protected Areas (2006), etc.

The list of measures is defined by the relevant Government Decisions of Armenia for Lake Sevan and its watershed area, such as Measures in the Annual and Complex Programs of Activities for the Use, Protection, Reconstruction, and production of the Lake Sevan Ecosystem, Measures in the Lake Sevan Action Plan for restoration, protection, reproduction, and use of the Lake Sevan ecosystem.

The EPIRB Project Guidance Document on the Development of Program of Measures and the Achievement of Environmental Objectives According to the EU WFD was also used.

The PoM ensures the achievement of the environmental objectives in the Sevan RBD through the basic and supplementary measures. Basic Measures are aimed at preventing the degradation of water status in all water bodies, ensuring stepwise improvement of water status in water bodies and enhancing national water management in relation to water uses (permits; licenses). These shall be implemented during the first two planning cycles, following the requirements of the Armenian legislation. Supplementary Measures are based on gaps that have been identified during preparation of the first and second phase of the development of the Sevan RBMP, and are aimed at improving monitoring, national legislation and technical/personnel capacities to ensure WFD compliant implementation in future.

Following the above-mentioned statements the provided program of measures is divided into the following categories: measures improving the water governance (legal and institutional measures), quality and health, water quantity, ecosystem and other categories.

8.1.2 Cost Effectiveness Analysis Methodology

Cost effectiveness analysis (CEA) is an assessment technique that provides a ranking of alternative measures on the basis of their relative costs and effects towards achieving a political objective. The aim is to reach this fixed objective at the lowest cost. The search for the most cost efficient mix of measures might seem easy at a glance, but it is a complex challenge with many interactions between multiple aims, measures and related costs. Cost effectiveness analysis can be used both to rank individual measures and programmes of measures. As discussed by Jacobsen (2007), the standard calculation of the cost-effectiveness ratio (R) is defined as:

R = AEC/Effectiveness

where AEC is the Annual Equivalent Cost (euros/year). ‘Effectiveness’ is defined here as the quantitative change in either the impact on the river flow or in the pressure on the resource. The AEC in turn is defined as:

$$\boldsymbol{AEC = \frac{r \cdot (1+r)^{n}}{(1+r)^{n}-1} \cdot I + OMC}$$

where I represents the investment costs; OMC are the operational and maintenance costs; r is the discount rate; and n is the useful life of the project or measure. In this study a discount rate of 5.5% is used, which is the current rate in Armenia (December, 2019).

Effectiveness analysis for further determination and selection of the measures and/or their combination is conducted in terms of the ecological effectiveness of the measures proposed, based on the indicators of the WFD, Annex V on good ecological status for surface water and groundwater bodies, respectively. It is conducted by using simple “Cause/Effect Matrix with Classification of Priority” and “Classification Key” as presented in Table 110.

Table 110: Classification key for Determining Level of Ecological Effectiveness of the Proposed Measures

Sum Total of Individual Evaluations	Description of Effectiveness	Classification
12-9	High level of ecological effectiveness	3
8-5	Medium ecological effectiveness	2
4-1	Low level of ecological effectiveness	1
0	No ecological effectiveness	0

8.2 Basic Measures

8.2.1 Governance

8.2.1.1 Legislation strengthening measures to achieve environmental objectives and, if necessary, their preliminary cost estimates

- Improve the legal and institutional framework for Lake Sevan ecosystem conservation, particularly, provision of the protection regime for Lake Sevan as a National Park in compliance with the requirements of the RA Water Code, Law on Specially Protected Natural Areas and EU WFD.
- Regulate and provide a scientific basis for water outflow from Lake Sevan, following the policy of raising the lake water level.
- Identification of the zones that are prohibited for construction and operation of SHPPs, including landslide zones, hydrological vulnerable areas, lake coastal zone etc;
- Development of a concept for the introduction of innovative technologies for sustainable farming and water saving;
- Introduction of insurance systems and subsidization mechanisms aimed at protection of population of villages that are vulnerable and at risk (e.g. those with less income, settlements that are sensitive/vulnerable to natural disasters, including the lake's water level estimated raise) from climate risks and to compensate for damages and losses resulting from natural disasters;
- Planning of effective land use and introduction of construction standards to protect vulnerable population from the impacts of natural disasters, as well as the water level rise of the Lake Sevan.
- Development and adoption of legal, economic and administrative incentives to reduce water losses and promote use of water saving technologies;
- Strengthening supervision mechanisms for enforcement of water use permit conditions, including determination of mechanisms for water allocation between water users during the low-flow seasons and water use optimization;
- Improvement of the water users' accountability and reporting with a purpose of obtaining data actual on water use, wastewater removal and levels of pollution of water resources;
- Establishment of management plans for Sevan National Park and Juniper Sparse Forests state sanctuary;
- Inclusion of climate risks in development programs of water use sectors;
- Establish water quality and quantity norms and standards for groundwater protection/use in different sectors;
- Establish water quality norms and standards for irrigation use.
- Incorporation of climate change adaptation measures for Lake Sevan;
- Incorporation of climate change risks in key legal documents related to water resources management (the RA Water Code, RA Laws on National Water Program and Fundamental Provisions of the National Water Policy).
- Strengthening the control over fisheries and fishing in the Lake Sevan.
- Strengthening the control over the maintenance of ecological norms in the mining sites in the Sevan RBD.
- Establishing mechanisms to promoting innovative technologies and solutions for water resource conservation, use, management and monitoring.
- Review water use tariffs in various sectors, as well as establish fees for water abstraction for hydropower generation.

8.2.1.2 Institutional measures to achieve environmental objectives and, if necessary, their preliminary cost estimates

- Strengthening institutional capacity of “Sevan National Park” SNCO, including equipping with state-of-the-art equipment and staff training to manage and protect the Sevan National Park and Juniper Sparse Forests state sanctuary;
- Strengthening institutional and technical capacity of state water bodies to control the water abstraction and use of the SHPPs in accordance with environmental impact assessment standards for the construction and operation of Small HPPs (Protocol Decision No. 8 dated 01.03.2018);
- Building capacities of the RA ME Environmental Monitoring and Information Center SNCO to conduct hydrobiological and hydromorphological monitoring of water resources (rivers and Sevan Lake) and assess ecological status of water resources, including equipping with state-of-the-art equipment and staff training;
- Establish two-way communication between academia and water management authorities on joint scientific-research programs to insure scientific base and effectiveness of the activities aiming to improve ecological potential of the Lake Sevan and watershed area;
- Create scientific-based model of the Lake Sevan for comprehensive monitoring and understanding of the ecological situation.
- Training the staff of local self-government bodies, farms and ArmForest SNCO of the RA MA to prevent diffuse/non-point pollution of water resources through correct use of fertilizers and forest restoration;
- Introducing/improving early warning and rapid response system for hazardous hydrometeorological occurrences in the Sevan BMD, particularly aimed at warning communities on oncoming landslide, mudflow and flood hazards;
- Increase public awareness and public participation in conservation of the Lake Sevan and its watershed area.
- Training the staff of state water management bodies to report the financial data for water use by sectors and provide an assessment of cost recovery for water resources.

8.2.2 Technical measures to achieve environmental objectives and their preliminary cost estimates

8.2.2.1 Quality and Health

8.2.2.1.1 Wastewater Treatment Plants Rehabilitation & Development, Including Improvement or Rebuilding the Sewage and Wastewater Discharge Systems

Taking into consideration the local climatic and topographic conditions, available land surfaces for plant location and required skills for personnel needed for operation and maintenance of the facilities, as well as the effluent quality to be achieved through the wastewater treatment processes, the most appropriate technologies to be used are:

- Innovative wastewater systems with separation of blackwater, urine and greywater for agglomerations having less than 2,000 p.e.[27] and more than 500p.e.
  - Pour Flush System with Twin Pits and Urine Diversion- for blackwater and urine;
  - Greywater Gardens for greywater;
- Extended Aeration activated sludge, including advanced treatment with N and P removal - for communities in the project area included in agglomerations having more than 10,000 p.e.

[27] Households wastewater treatment plant capacity was determined by calculating “population equivalent” value of the agglomeration (PE).

Elaboration of current technical measure was based on the preliminary assessment data provided in the Sevan RBMP Part 1 (3.2.1.1 Municipal Wastewater Discharge, Chapter 3. Significant pressures and possible impacts on water status). The agglomerations have been defined according to the EU Urban Waste Water Treatment Directive Guideline[28].

In addition, the feasibility study results for improving and developing water supply and sanitation systems in rural communities of Armenia developed by the CES and "Jrtuq" LLC (2015) were taken into consideration.

According to the requirements of EU Urban Waste Water Treatment Directive (91/271/EEC), in small communities (500 p.e.) the construction of domestic waste water treatment plant is not required. Thus, the communities having less than 500 population were not included in the agglomerations to identify implementation expediency of domestic wastewater treatment alternative measures (construction of septic chambers, biological ponds, small local systems of primary (chemical/ mechanical) treatment, etc.).

1) Implementation of Pilot Innovative Wastewater Treatment Project in Settlements with Population less than 2000 p.e.

Consultant recommends that the pilot project for implementation of wastewater treatment be implemented in the following communities of Sevan river basin: Akhpradzor, Makenis and Lchavan. The reason for selecting these communities is stipulated by the fact that they are located on Karchaghbyur river and implementation of the pilot project may reveal how these measures will impact the water quality at the mouth of the river.

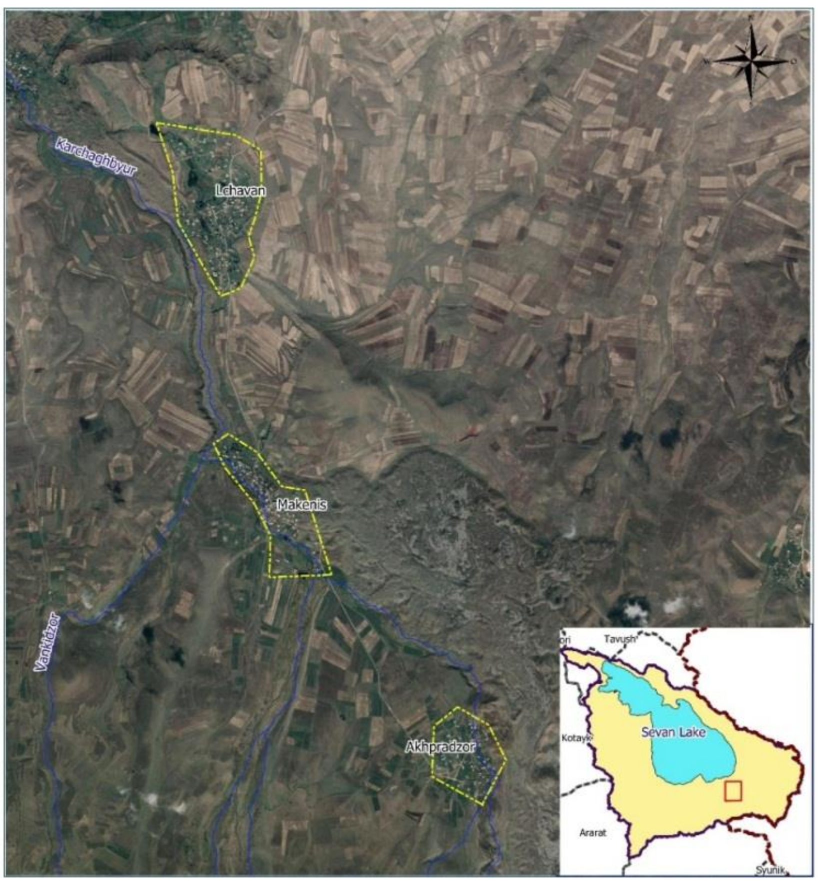


Figure 56: Location of Akhpradzor, Makenis and Lchavan villages

[28]EU Urban Wastewater Treatment Directive (91/271/EEC), 1991: URL. http://ec.europa.eu/environment/water/water-urbanwaste/legislation/directive_en.htm

The table below shows demographic data for those three villages:

Table 111: Number of Population and Households in Akhpradzor, Lchavan and Makenis villages

Community name	Number of permanent population	Number of households
Akhpradzor	395	112
Lchavan	572	121
Makenis	486	152

Source: http://gegharkunik.mtad.am/about-communities/

Construction of septic tanks in mentioned – above 3 villages is recommended to carry out in 2 phases:

Phase 1:

- New pour flush system with twin pits and urine separation for all inhabitants in the settlement, except for the ones living in blocks of flats;

Phase 2:

- New greywater gardens for all households in the settlements.

Detailed cost breakdown for this activity is presented in Table 122.

As soon as the construction of septic tanks and greywater gardens is completed and in use, it is recommended to carry out monitoring of the water quality on Karchaghbyur and see if the measures have been effective.

2) Implementation of Pilot Innovative Wastewater Treatment Project in Settlements with Population more than 2000 p.e.

According to Article 2(4) of the EU Urban Wastewater Directive 91/271/EEC, “Agglomeration” is an area where the population and/or economic activities are sufficiently concentrated for urban waste water to be collected and conducted to an urban waste water treatment plant or to a final discharge point”.

The existence of an agglomeration is independent from the existence of the collecting system. Nor is the presence of an agglomeration related to the existence of a treatment plant. The existence of an agglomeration relates to a de facto situation of “population and/or economic activities, which are sufficiently concentrated for urban waste water to be collected and conducted to an urban wastewater treatment plant or a final discharge point”. The concept of agglomeration therefore also includes those areas which are sufficiently concentrated but where a collecting system is not yet in place.

For identification of agglomerations in Sevan river basin, “Guidance on How to Define Agglomerations under the Urban Wastewater Treatment Directive 91/271” outlines several criteria, such as:

– Population density - minimum 30 people/ha (in locations with higher level of groundwater the density is less),

– Time to reach the wastewater treatment facility - less than 6 hours (taking into consideration the changes of the daily flow),

– For 1 km of sewage collector the minimum number of customers - 45 households (120 people equivalent).

Using the above-mentioned criteria, within the framework of “Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia” project, an assessment was made to delineate agglomerations in all territory of Armenia not serviced by Veolia company. The table below lists the agglomerations outlined for Sevan river basin:

Table 112: Agglomerations above 2000 p.e. in Sevan river basin area

Names of villages	Forecasted Population	Agglomeration Name	Agglomeration Size	WWTP capacity
	inhabitants		p.e.	p.e.
Akunk	4,641	Akunk	4,400	5,000
Lusakunk	1,695	Lusakunk	3,100	4,000
Khachaghbyur	1,543			
Artsvanist	3,440	Vardenik	18,500	20,000
Tsovinar	5,486			
Vardenik	10,598			
Vaghashen	4,575	Vaghashen	4,400	5,000
Astghadzor	4,895	Zolakar	11,600	11,600
Zolakar	7,328			
Gegharkunik	2,235	Lanjaghbyur	4,600	5,000
Lanjaghbyur	2,607			
Geghhovit	6,639	Geghhovit	6,300	7,000
Karchaghbyur	2,713	Karchaghbyur	2,600	3,000
Mets Masrik	3,750	Mets Masrik	3,600	4,000
Tsovak	2,979	Tsovak	2,900	3,000
Tsovasar	3,384	Tsovasar	3,200	3,500
Verin Getashen	5,427	Verin Getashen	5,200	6,000
Dzoragyugh	5,256	Dzoragyugh	5,000	5,000
Yeranos	6,322	Yeranos	9,100	10,000
Vardadzor	3,225			

Source: "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia" developed by the CES and "Jrtuq" LLC, 2015

In order to calculate the increase of BOD_5 in wastewaters of agglomerations, BOD_5 concentration is calculated considering the population number and the norm set for BOD_5 (60g/day*N, where N values is the number of the population). In the result BOD5 concentration for each of the agglomerations was calculated according to the following equation C = ((60g/day*N*1000)/ 24*60*60)/Q0 mg/l, where Q0 value is the water discharge at the given section (Table 113).

Table 113: Agglomerations above 2000 p.e. in Sevan river basin area

Agglomeration Name	Total forecasted population of the agglomeration	River flow before the pressure point, l/s	Estimated increase of BOD_5
Akunk	4641	300	10.74
Lusakunk	3238	500	4.50
Vardenik	19524	1680	8.07
Zolakar	12223	500	16.98
Lanjaghbyur	4842	25	134.50
Geghhovit	6639	1400	3.29
Karchaghbyur	2713	1600	1.18
Mets Masrik	3750	4200	0.62
Tsovasar	3384	1500	1.57
Verin Getashen	5427	4080	0.92
Dzoragyugh	5256	820	4.45

Out of mentioned – above localities, there are clearly outstanding 3 agglomerations that are worth mentioning and inclusion in the list of measures: Vardenik, Zolaqar and Yeranos with p.e. of 18500, 11600 and 9100 respectively. These agglomerations are located on the shore of Lake Sevan and hence construction of the waste water treatment plants will highly contribute to improvement of water quality in the lake.

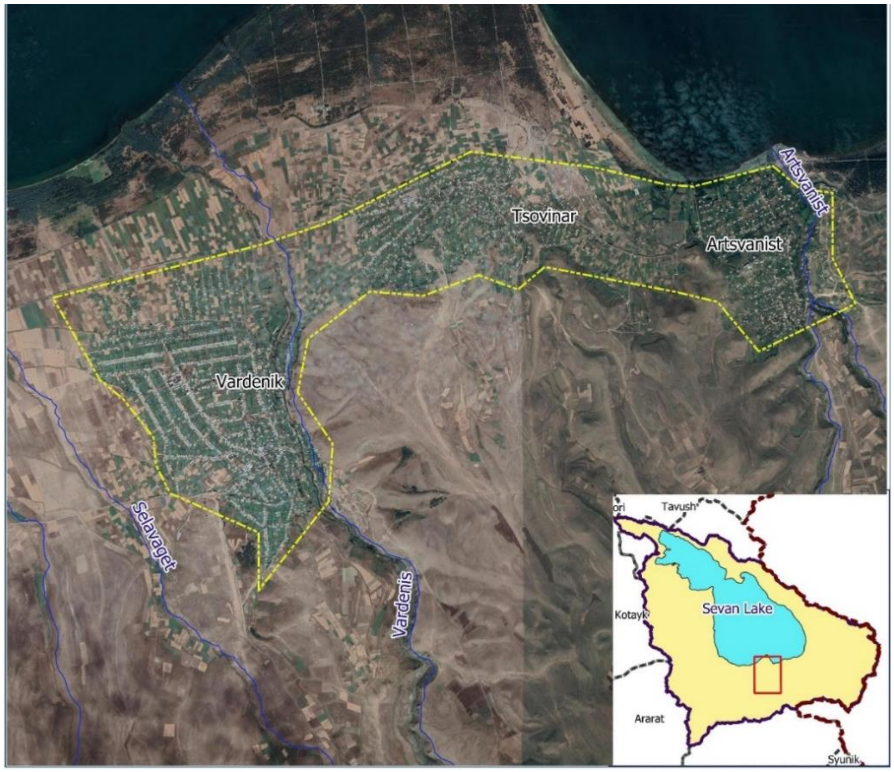


Figure 57: Vardenik Agglomeration

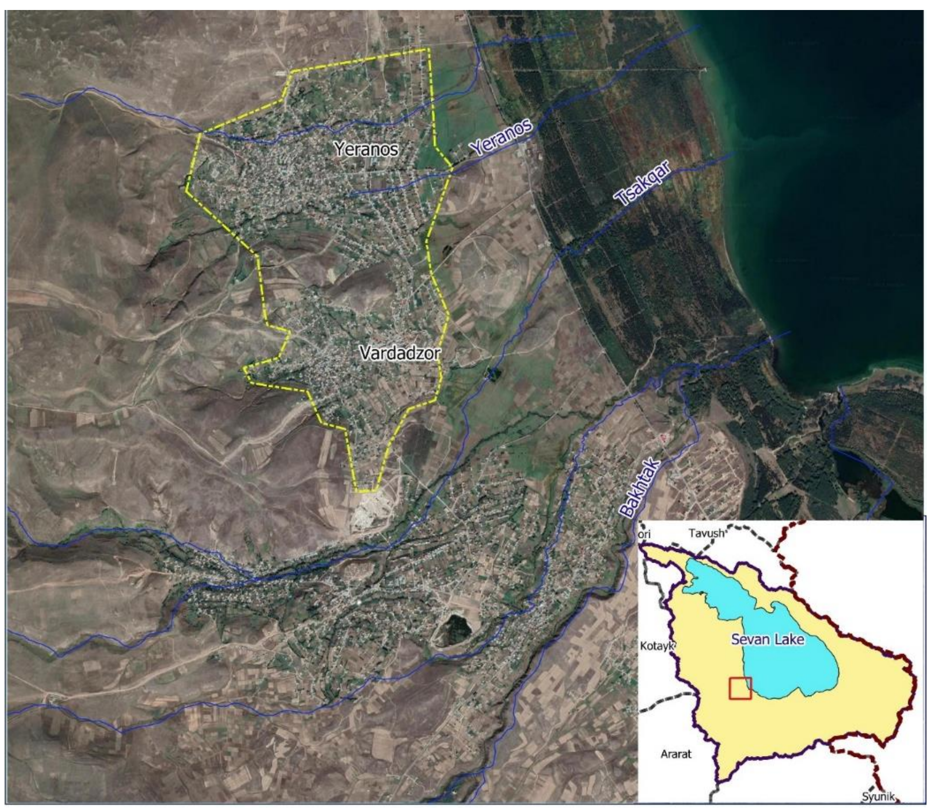


Figure 58: Yeranos Agglomeration

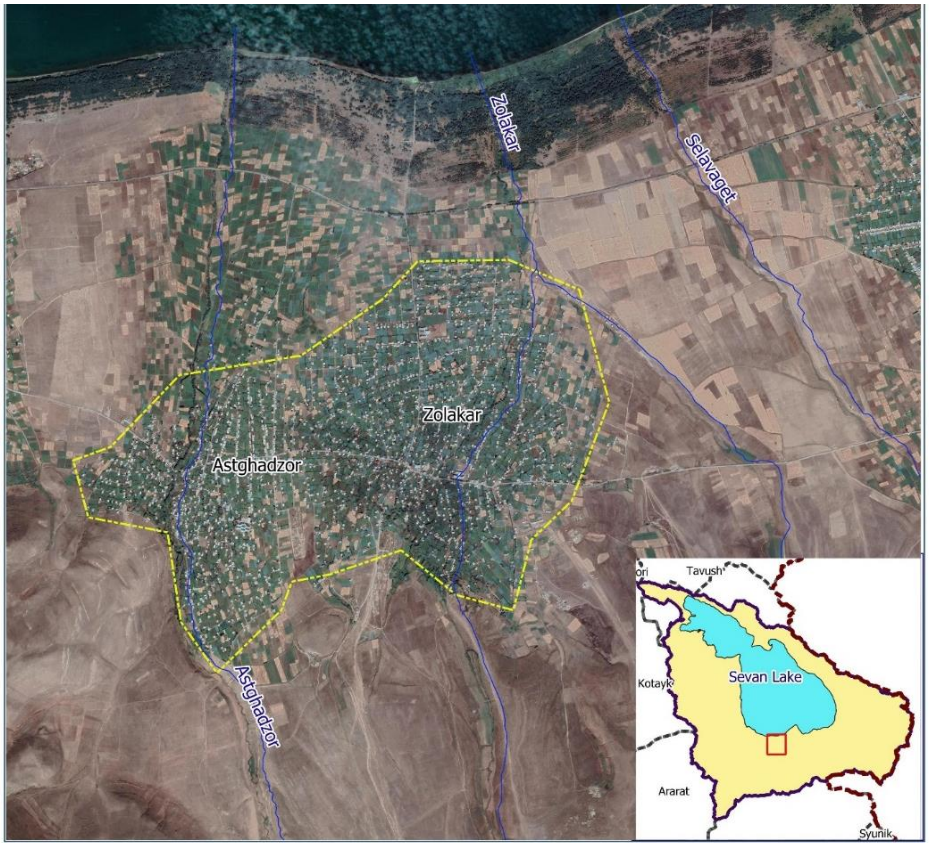


Figure 59: Zolakar Agglomeration

Table 114: Type of WWTP based on the agglomeration size and requirement of the EU Wastewater treatment directive.

#	Agglomeration Name	Agglomeration Size	Agglomeration per p.e in accordance with EU wastewater treatment directive	WWTP type
1	Vardenik	18500	>10000 p.e., vulnerable river section	Primary and secondary treatment
2	Zolakar	11 600	>10000 p.e., vulnerable river section	Primary and secondary treatment
3	Yeranos	9000	2000 – 10000 p.e., less vulnerable river section	Primary treatment

The population equivalent of the total discharged quantity of BOD_5 in Vardenik and Zolakar town sewage water amounts to 18500 and 11600, respectively. Thus, for these two towns WWTP with population equivalent exceeding 10000 both preliminary and secondary treatments needs to be applied. Preliminary treatment includes physical and/or chemical treatment of urban sewage ensuring sedimentation of suspended particles or other processes resulting in reduction of BOD_5 value at least by 20%, while that of suspended particles by 50% as compared to untreated sewage. Secondary treatment includes biological treatment of sewage in combination with secondary sedimentation (or other process) ensuring compliance of household sewage with accepted norms.

Thus, for Yeranos agglomeration WWTP with population equivalent not exceeding 10000 only preliminary (physical and/or chemical treatment) treatment needs to be applied, which will ensure reduction of BOD_5 value in the sewage water to acceptable norm.

Detailed cost for construction of waste water plants for these agglomerations is outlined in Table 123.

For the other communities with 2000-7000 p.e. it is proposed to conduct feasibility studies and to select pilot communities for construction of wetland for wastewater treatment. The advantages of the wetland will be lower construction and operational costs, more effectiveness, as well as the treated wastewater can be an alternative source of irrigation water in the area.

Based on the Parakar case of the wastewater treatment (a basin for mechanical treatment and a biological pond), the cost for constructing the wetland WWTP with a 1600m^3 /daily capacity for 7200p.e. is about 100,000 Euro, which does not include the cost for constructing or renovating the sewage system.

3) Technological upgrade of Gavar, Martuni, and Vardenis WWTPs

WWTPs of Gavar, Martuni and Vardenis cities are equipped with the same model equipment and perform incomplete mechanical treatment of wastewater. Mechanical treatment removes from the wastewater solid waste, grits, oils, and fat. The final stage of mechanical treatment is not performed, since there are no settling ponds in WWTP. Adding biological treatment to wastewater would make the water discharged into lake Sevan safe and may be used for irrigation and other technical purposes.

It should be noted that initially it was planned to build the WWTP with three-stage treatment process: initial, mechanical and biological treatments. The area allocated for WWTPs was intended to include mentioned – above stages. Below we outline the upgrade works in Gavar, Martuni and Vardenis WWTPs. The water use norms of the above-mentioned cities are 80 l/person per day for 50% of the population, and 100 l/person per day for the other 50%.

Modernization of Gavar WWTP

When upgrading the Gavar WWTP, it should be taken into account that the capacity of the WWTP should allow the treatment of wastewater from Gandzak, Noratus and Karmirgyugh settlements, which will be included with city of Gavar in one agglomeration (Table 115).

Table 115: Settlements included in Gavar agglomeration

Settlements	Projected Population (2033)	Name of Agglomeration	Agglomeration P.E.	WWTP Capacity (P.E.)
Gavar	21306	Gavar	37220	40000
Gandzak	3914			
Noradus	6907			
Karmirgyugh	5093			

Source: Census 2011, http://esa.un.org/wpp/unpp/panel_population.htm

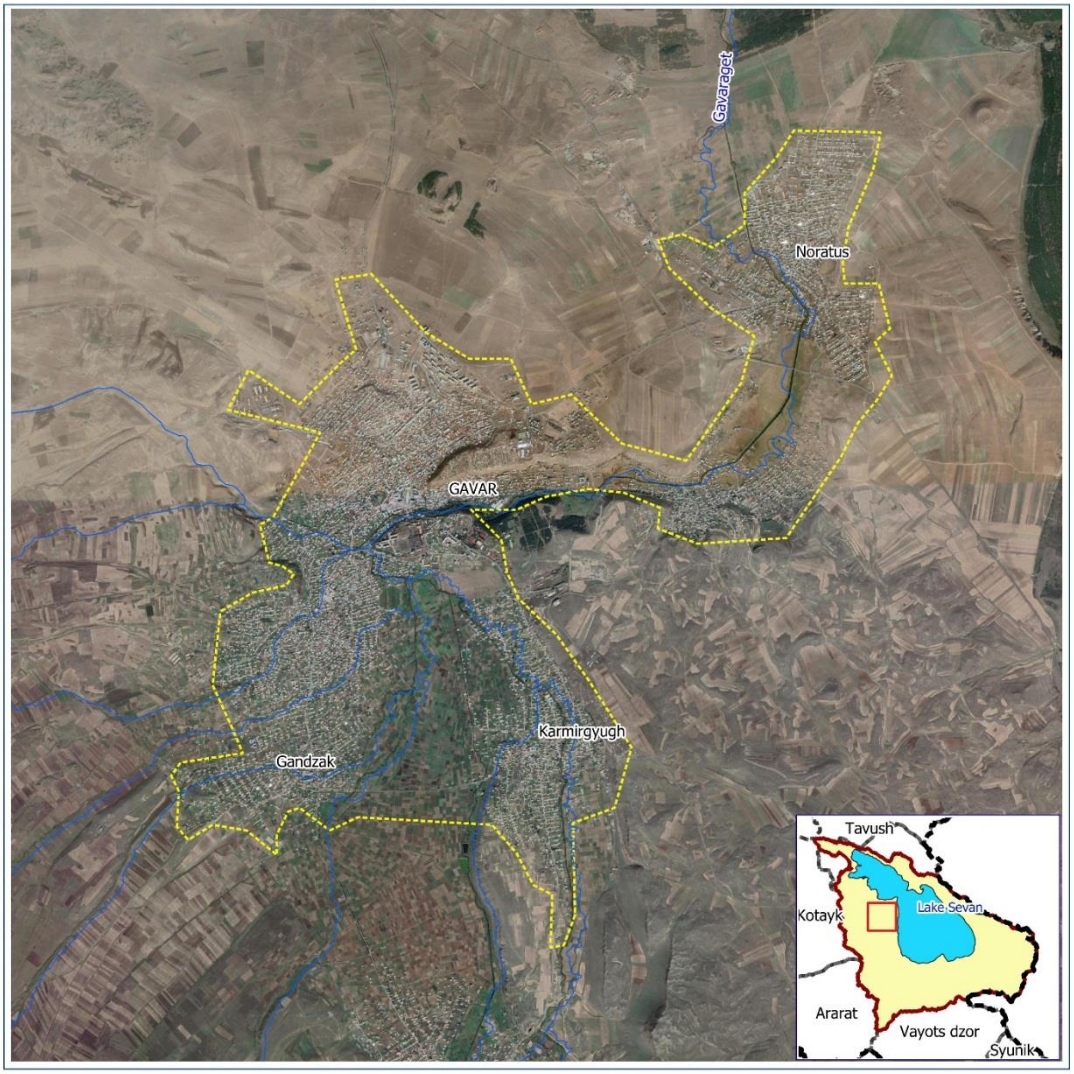


Figure 60: **Gavar Agglomeration**

The scheme below depicts the technological modernization of Gavar WWTP and outlines that the wastewater treatment should be implemented by the following stages:

1. Mechanical Treatment,
2. Biological Treatment,
3. Nitrification,
4. Denitrification.

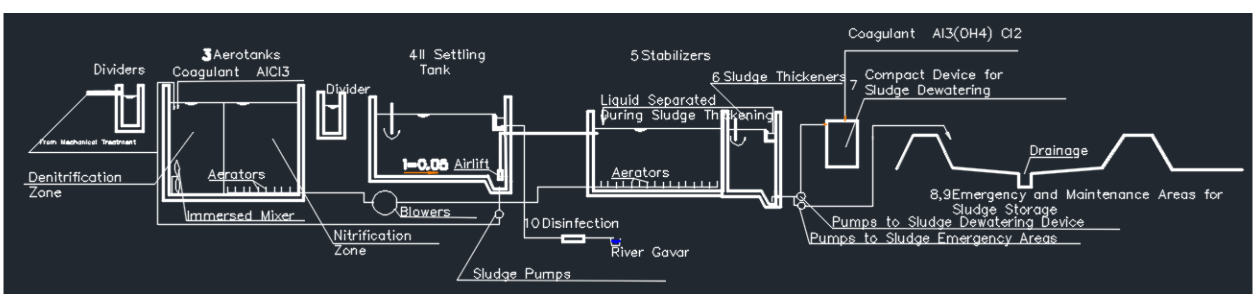


Figure 61: **Technological upgrade scheme of Gavar WWTP**

Modernization of Martuni WWTP

When upgrading the Martuni WWTP, it should be taken into account that the capacity of the WWTP should allow the treatment of wastewater from Vaghashen and Geghhovit settlements, which will be included with city of Martuni in one agglomeration (Table 116).

Table 116. Settlements included in Martuni agglomeration

Settlements	Projected Population (2033)	Name of Agglomeration	Agglomeration P.E.	WWTP Capacity (P.E.)
Martuni	13230	Martuni	23511	25000
Geghhovit	5903			
Vaghashen	4378			

Source: Census 2011, http://esa.un.org/wpp/unpp/panel_population.htm

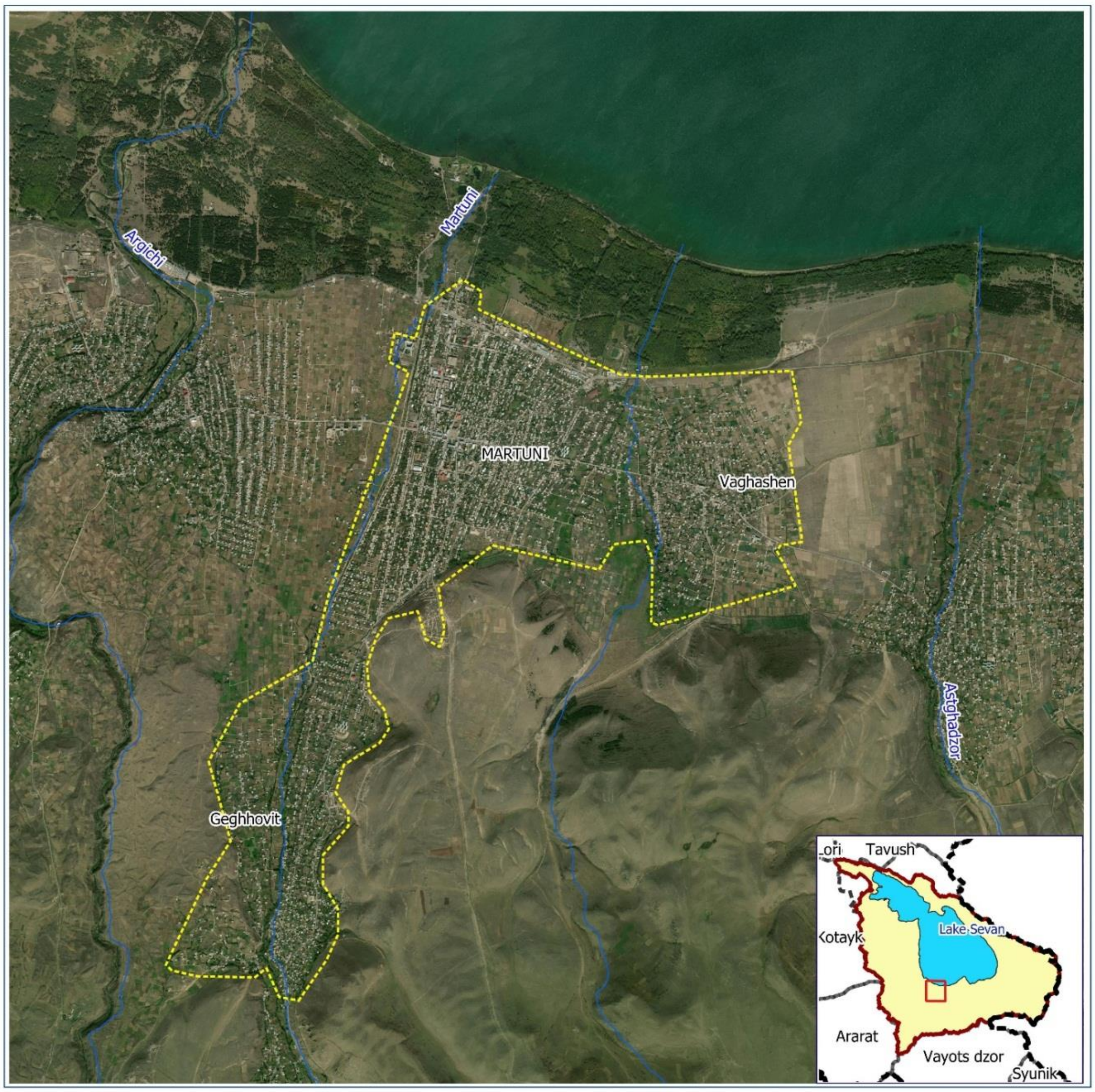


Figure 62: Martuni agglomeration

The scheme below depicts the technological modernization of Martuni WWTP and outlines that the wastewater treatment should be implemented by the following stages:

1. Mechanical Treatment,
2. Biological Treatment,
3. Nitrification,
4. Denitrification.

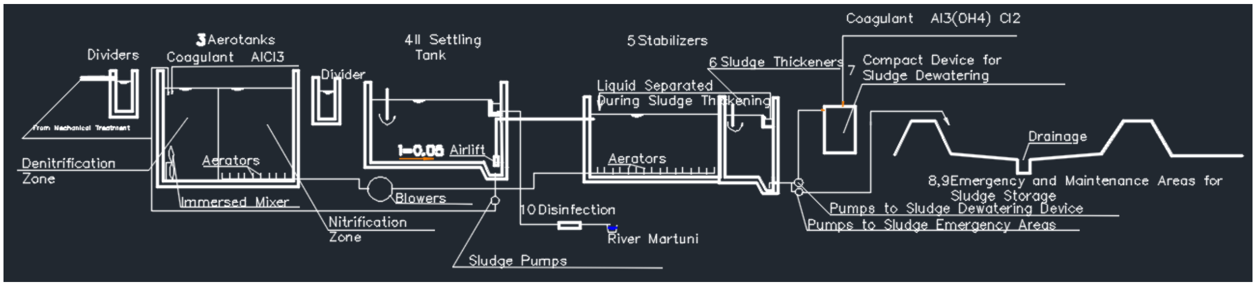


Figure 63: Technological upgrade scheme of Martuni WWTP

Modernization of Vardenis WWTP

When upgrading the Martuni WWTP, it should be taken into account that the capacity of the WWTP should allow the treatment of wastewater from Akunk settlement, which will be included with city of Vardenis in one agglomeration (Table 117).

Table 117. Settlements included in Vardenis agglomeration

Settlements	Projected Population (2033)	Name of Agglomeration	Agglomeration P.E.	WWTP Capacity (P.E.)
Vardenis	13016	Vardenis	17575	20000
Akunk	4559			

Source: Census 2011, http://esa.un.org/wpp/unpp/panel_population.htm

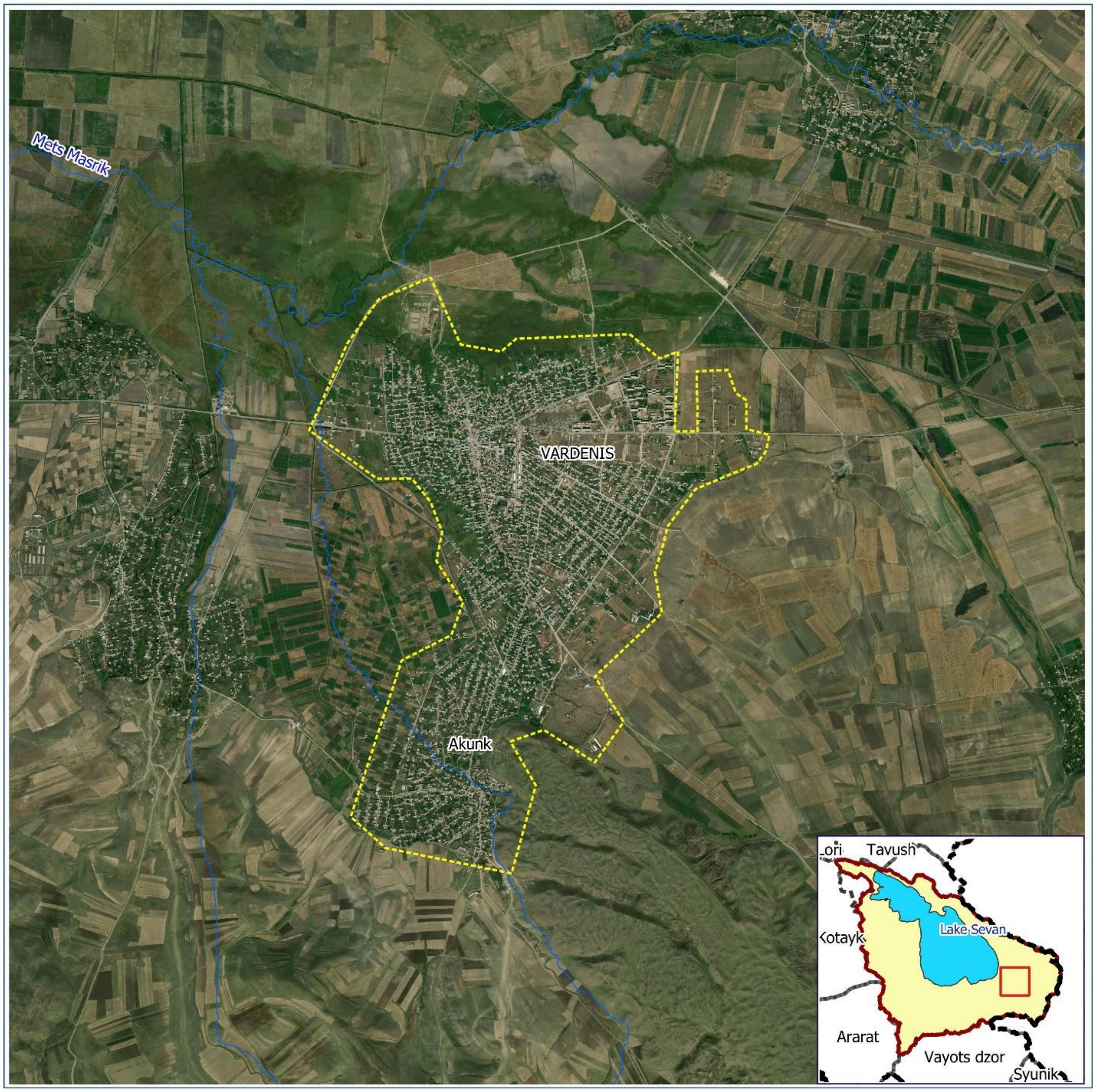


Figure 64: Vardenis agglomeration

The scheme below depicts the technological modernization of Vardenis WWTP and outlines that the wastewater treatment should be implemented by the following stages:

1. Mechanical Treatment,
2. Biological Treatment,
3. Nitrification,
4. Denitrification.

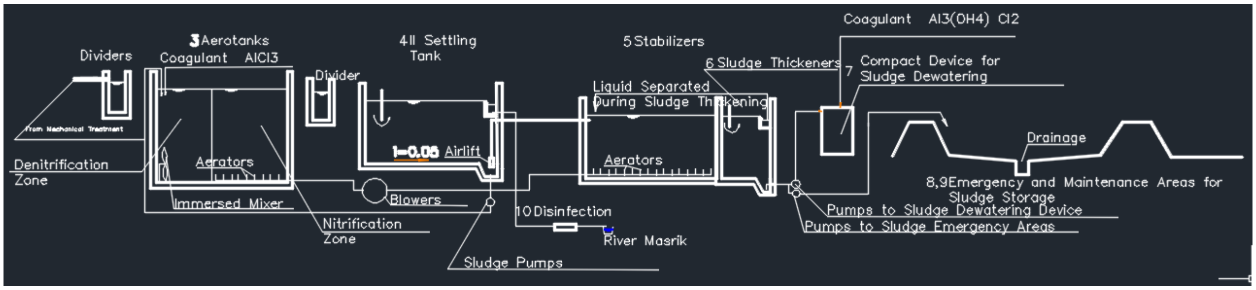


Figure 65: Technological upgrade scheme of Vardenis WWTP

8.2.2.1.2 Strategic Groundwater Quality Protection

Based on the risk assessment results, four ground water bodies were identified at possible risk in the Sevan RBD due to high concentration of nitrate in water. In order to protect the groundwater in the Sevan RBD it is supposed to prevent groundwater pollution by nitrate from the untreated domestic wastewater discharge and from return flows of agriculture.In this regard, introduction of sustainable farming technologies to Martuni and Gavar communities in order to minimize the overuse of nitrate-based fertilizers in agriculture should be implemented, considering the following measures:

1. Identification of agricultural activities causing pressure on groundwater resources;
2. Identification of best agricultural practice to improve farming and minimize agriculture impacts on water bodies;
3. Conduct awareness raising campaigns and training for farmers on topics of sustainable farming technologies, introducing the experience of the pilot projects for the communities located on the groundwater bodies at risk.

8.2.2.1.3 Mining

Based on the Sevan RBMP part 1 report, the Sotk mine is operated in the Sevan RBD. The mining activities in Sotk are one of sources for non-point and point source pollution. Diffuse mine water can impact on water quality of Sotk and then Masrik Rivers and groundwater due to the high concentration of heavy metals.

The mining industry generates wastes (waste dumps) near Masrik and Sotk rivers, belonging to one of the largest mining companies, ‘’Geo Pro Mining Gold’’ Ltd, and has a direct impact on the water resources. To prevent water resources pollution from mining activities, it is required to carry out the following type of measures:

- Rehabilitate mining area dump slopes, strengthening these by soil and providing vegetation cover. According to the license, total area of Sotk mine operated by ‘’Geo Pro Mining Gold’’ Ltd is 766ha.

8.2.2.2 Quantity

8.2.2.2.1 Monitoring of Water Abstractions per Sector and per Type of Resource:

Installation of SCADA for Key Water Users in the Industry and Development of Software for Receiving and Processing of Actual Water Use Data

Water is a very important resource to many industries, and as a result, there are many opportunities to reduce water use. By measuring water use and flows, it becomes much easier to identify water efficiency opportunities..

There are two types of water meters: Source meters measure the amount of water being supplied, while submeters measure usage for specific activities such as cooling towers, process use, or agricultural water use.

Accurately measuring water use can help identifying areas for targeted reductions and track progress from water-efficiency upgrades. Submeters can also help identify leaks and indicate when equipment is malfunctioning. In some cases, it may also be useful to measure water pressure; a drop in pressure can indicate the presence of a leak.

According to water abstraction figures, the biggest users of water are in Sevan river basin are SHPPs, which account for 77% use of all abstracted water. At present, water use in all SHPPs is metered, but there is no SCADA equipment installed. In order to get a real time picture of water use from all SHPPs, it is recommended to install SCADA on all SHPPs.

SCADA systems are widely used in Armenia at present and up to December, 2019 around 80 units of radar and ultrasonic measuring stations have been installed on primary irrigation canals within the framework of WB – funded ISEP Project. Veolia company is also using SCADA system for monitoring and control of its water assets located in distant areas.

Data received from SCADA should be incorporated into existing GIS of State Water Cadastre of WRMA, which already includes an interface and a reporting form for actual use. It is vital that data collected through SCADA systems from different sectors (irrigation, drinking water, industry, fish farms) be stored in WRMA for further analysis.

8.2.2.2.2 Safety and Development (update) of Hydrotechnical Structures, Including Measures to Reduce Water Losses: Improvement or Rehabilitation of the Drinking Water Supply and Irrigation Water Supply Networks;

Currently a draft government decision on Establishment of the concept for development and introduction of the legal, economic and administrative promotions for reducing the water losses in the water supply systems and considering the appropriate programs of measures is under development. The draft concept includes legal, economic and technical measures and regulations for improving the hydro technical structures in order to reduce water losses in the Sevan RBD, as well, particularly:

1. Development and establishment of norms and standards for water losses in the water supply and discharge systems, provision of clear definition for water losses.
2. Conducting water monitoring at the sources (surface and groundwater) for assessment of water losses.
3. Development of methodology for detection and calculation of unrecognized water losses and costs.
4. Introduction and implementation of measures to detect and reduce the water losses in the drinking and irrigation water supply systems using state-of-the-art equipment.
5. Strengthening the administrative control and adopting financial responsibility mechanisms (penalties) for water losses, etc.

8.2.2.2.3 Increase of water storage and strategic water reserve;

Construction of reservoir on Argichi river with 9 mln.m^3 volume capacity

Construction of reservoir on Argichi river would allow to reserve water for irrigation of 2206 ha of agricultural land in Martuni region of Armenia. At present, 1206 ha of agricultural land is irrigated through pump stations that abstract water from Sevan lake and consume around 3 mln m^3 annually. The selected location is suitable for dam construction and Reservoir characteristics are detailed below:

- Type of reservoir: Bank-side Reservoir
- Mirror surface: 128 ha

- Dam type: Stone – filled with clay and silt core
- Structural height: 15.7 m
- Dam crest length: 79 m
- Top of Dam Elevation: 2261.8 m
- Volume: 5.5 mln m^3

Construction of reservoir on Astghadzor river with 1-1.5 mln.m^3 volume capacity

At present a large amount of water is extracted from Sevan lake for irrigation of agricultural lands in Astghadzor, Zolakar and Vaghashen communities. In 2014 around 2.85 million kW electricity was consumed to pump water from Sevan lake through Vaghashen, Astghadzor and Martuni pump stations for irrigation of 450 ha of land. Construction of reservoir on Astghadzor river would allow eliminating the use of pump stations and increase the area of irrigated agricultural land to 1440 ha. Reservoir characteristics are detailed below:

- Type of reservoir: Bank-side Reservoir
- Mirror surface: 8.5 ha
- Dam type: Stone – filled with clay and silt core
- Structural height: 32 m
- Dam crest length: 227 m
- Top of dam Elevation: 2150 m
- Volume: 1.25 mln m^3

8.2.2.3 Ecosystems

8.2.2.3.1 Farmers practices adaptation to climate change

Armenia is considered as a country with high baseline water stress by the World Resource Institute, and is ranked as the 34th most water stressed country among the 164 UN member countries. According to the Organisation for Economic Co-operation and Development (OECD), Armenia is a country with low water availability, and subject to water stress with 45% water exploitation. Whereas the main water user in Sevan RBD is agriculture; therefore, water adaptation measures for farmers need to be introduced.

In this regard, the irrigation systems through introduction of modern water-saving technologies (drip irrigation, micro-sprinkler, less energy-spending systems) and leakage reduction should be implemented.

In addition, identification and implementation of effective agro-technical measures for maintenance of soil humidity and reduction of evaporation volumes in the context of forecasted climate change is needed. This includes:

- Substitution of crops with high water demand with drought tolerant and resistant species;
- Conducting crops rotation;
- Using organic mulch and bio humus;
- Developing agroforestry;
- Restoration of forested areas.

In addition, it is recommended that trainings should be conducted for farmers to introduce water adaptation measures to climate change with regards to the above-mentioned topics.

8.2.2.3.2 Solid waste management: Construction of Sanitary Landfill and Preliminary Cost Estimates

The pressure of solid waste on the water resources in Sevan basin is rather high and is visible everywhere – in Sevan lake and at the banks of the rivers. Although there are officially 11 landfill sites operating in the basin, there are more than 100 unofficial sites used by communities as dumpsites (Figure 66) which are often located on the river banks.

Figure 66: 8 dumpsites registered in Vaghashen community

In order to eliminate the solid waste dumps in Kotayk and Gegharkunik marzes, EBRD is funding construction of a landfill near Hrazdan, that would serve Kotayk and Gegharkunik marzes of Armenia.

Construction and operation of the landfill will be carried out through the establishment of an inter-municipal organization (company owned by shareholders representing the largest 7 urban communities of Kotayk Region and 5 urban communities of Gegharkunik Region) with the following key responsibilities:

- operation of regional sanitary landfill near Hrazdan city with an area of 27000 m^2
- operation of waste collection trucks for servicing the rural communities in the Kotayk Region
- operation of 1 transfer station ("TS") in near Martuni (Gegharkunik Region) and 1 transfer station near Abovyan (Kotayk region)
- operation of waste transfer trucks for delivery of waste from Martuni TS and Abovyan TS to the Hrazdan Landfill.

Total costs for construction of landfill are presented in Table 127. Estimates are based on construction costs sourced from KfW-funded study "Feasibility Study for an Integrated Solid Waste Management for Vanadzor, Republic of Armenia" in 2014.

8.2.3 Measures preventing emergency situations to happen and their preliminary cost estimates

8.2.3.1 Flood and Mudflow Risk Prevention Measures

Latest flood event in Sevan basin was registered in 2011 and the data received from MES and presented in the first report shows that floods are not so frequent in Sevan basin. Most floods were recorded in 2007, when Gavaraget, Martuni, Tsakkar, Astghadzor, Vardenis and Artsvanist rivers damaged both houses and croplands. After 2007 a number of measures have been undertaken by respective communities for flood prevention measures. For example, in 2013 World Bank has allocated AMD 162 million for cleaning of riverbed and reinforcement of river banks in Gegharkunik and Lanjaghbyur communities. The table below outlines flood prevention measures that have been identified during interviews with community mayors:

Table 118*: Flood and Mudflow Prevention Measures in Sevan RBD*

No	Community Name	River name	Description of Measures
1	**City Gavar,** Edik Tonoyan st., Petrosyan st., Nalbandlan St., Demirchyan St., Hatsarat district., H. Abrahamyan St. Azatamartikneri St., Burnazyan 2nd St. 1st Lane. Petrov st. 2nd Lane, Artsvakar district, Azatutyan St., Gedeon Mikayelyan St.	Gavaraget river and associated Mudflow drains	Cleaning of riverbed (4200m), Cleaning of Mudflow drains (3300m)
2	**Village Noratus,** Sevan St., Intersection of G. Lusavoritch and D. Demirchyan Streets	Gavaraget river and associated Mudflow drains	Cleaning of riverbed (650m), Reinforcement of river banks (150m)
3	**Martoy hazaz area,** A. Isahakyan St., V. Sargsyan St., P. Sevak St.,	Gegharkunik river	Cleaning of riverbed (1200m), Reinforcement of river banks (1200m)
5	**Village Sarukhan,** H. Abrahamyan St. 9 deadlock, Section of Badey Creek.	Kukudzor river and associated Mudflow drains	Cleaning of riverbed (1500m), Reinforcement of river banks (350m)
6	**Village Gandzak,** H. Abrahamian St., M. Baghramayan St.	Gri Dzor river and Geloyi Dzor Mudflow drains	Cleaning of mudflow drains Reinforcement of river banks (480m)
7	**Village Karmirgyugh**, Section of Karmirgyugh – Gandzak road	Gegharkunik river	Cleaning of riverbed (300m), Reinforcement of river banks (100m)
8	**Village Tsaghkashen**, 1st St., 5th St.	Geloyi Dzor river	Cleaning of riverbed (1200m), Reinforcement of river banks (1000m)
9	**City Martuni**, Getapnya St.	Martuni river	Cleaning of riverbed (300m), Reinforcement of river banks (350m)
10	**Village Artsvanist**, Atoy district, Gorge district	Mudflow drain	Cleaning of mudflow drain (400m), Reinforcement of river banks (200m)
11	**Village Vardadzor**, Chayirner main creek	Mudflow drain	Cleaning of mudflow drain (150m), Reinforcement of river banks (150m)
12	**Village Geghhovit**, Ghrachneri district, Chayirneri district, Chimankend district.	Martuni river	Cleaning of riverbed (3500m), Reinforcement of river banks (2000m)
13	**Village Nor Getashen**, Riverside district.	Argichi river	Cleaning of riverbed (600m), Reinforcement of river banks (1000m), Construction of retaining wall (50m)
14	**Village Vardenik**, 25th St.	Vardenik river	Cleaning of riverbed (2200m), Reinforcement of river banks (2500m)
15	**Village Lichk**, A 6 district. 1 money, A5 block. 1 St.	Lichk river	Cleaning of riverbed (300m), Construction of drain system (120m)
16	**Village Dzoragyugh**, Chayirner district, Jam district., Ayginer district., Khorunt Dzor district.	Dzoraget river	Cleaning of riverbed (900m), Reinforcement of river banks (500m)
17	**Village Karchaghbyur**,	Karchaghbyur river	Cleaning of riverbed (350m),

	3rd street		Reinforcement of river banks (300m)
18	**Village Kutakan**, 6th Street, 8th Street	Mudflow drain	Cleaning of mudflow drain (1500m)
19	**Village M. Masrik,** Masrik river, 6th St 4th lane	Masrik river and Mudflow drain	Cleaning of riverbed (1600m), Reinforcement of river banks (3200m)
20	**Village Dzoravank**, Entrance to the village and nearby areas	Getik river	Cleaning of riverbed (600m),

8.3 Supplementary Measures

8.3.1 Measures for improving data, knowledge and awareness and their preliminary cost estimates

With the support from the European Environment Agency (EEA) and Zoï Environment Network, the ENPI-SEIS project (2016-2020) for improving environmental monitoring and information sharing in the European Neighborhood Policy (ENP) countries and the Russian Federation are conducted. The main outcomes of project address the three SEIS components – cooperation, content and infrastructure – through enhanced networking with the national capacities on environmental information. Furthermore, that should promote open public access to information through compatible and freely available exchange tools. Under this project, the Sevan SEIS open-source portal was developed, which combines all existed information related to the Lake Sevan.

In addition, with UNDP financial support it is planned to develop a new water data portal based on new Procedure for State Water Cadastre Management adopted by the RA Government in 2017. The development of the water data sharing portal is under the process.

However, it should be noted, that the created data portal should be mate the following requirement:

- Comprehensive water information system relying on automatic data exports;
- Consist of complementary mechanisms for collecting and processing data at different territorial levels;
- Possibility for water data transfer to the GIS for the production of the Sevan RBMP specific atlas;
- Possibility to include the Earth observation (satellite imagery) data for filling in the water data gaps for the Sevan RBD.

For the operation and maintaining the upcoming water data portal the following activities should be carried out:

- Training of relevant staff to operate the data sharing portal, as well as to use Earth observation (satellite imagery) data for filling in the data gaps and conduct comprehensive assessment, prediction of ecological potential of the Lake Sevan;
- Strengthening the technical capacity of water state relevant authorities, including equipping with state-of-the-art equipment in order to maintain the water data portal (Map 33, 34).

8.3.2 Measure to improve the surface water and groundwater monitoring network and the monitoring programmes

8.3.2.1 Improvement of groundwater monitoring

Groundwater monitoring in Armenia was established in accordance with the Resolution N1616 of 08.09.2005 of the RA Government, but regular monitoring only started in 2010.

There are 11 hydrogeological monitoring sites in the Sevan RBD.

The coverage of the groundwater monitoring network needs to be extended so that it adequately covers all groundwater bodies in the Sevan RBD. The existing monitoring sites need to be maintained, and 7 of them (6 wells and 1 spring) need to be refurbished. This refurbishment will be supported by EUWI+.

A long-term proposal to add 15 monitoring sites (13 springs and 2 wells) has been developed. 2 sites will be located in groundwater body 3G-1, 6 additional sites in 3G-2, 2 sites in 3G-3, and 5 sites in 3G-4. In the mineral groundwater bodies 3G-5 and 3G-6 no monitoring sites will be added, as they are already monitored by the Ministry of Energy Infrastructures and Natural Resources. The planning documents for all 15 additional sites are being developed. EUWI+ will support the construction of some of these sites with the highest priority. Some of the monitoring sites could be fitted with automated logging equipment to record quantitative data and some physico-chemical parameters at short intervals. For wells, such equipment costs around 7,000 EUR per piece. The national groundwater database could be improved, including in order to allow integration of data from such automated logging equipment and to facilitate integration with other databases.

The chemical monitoring, which is done twice per year, could be adapted. Currently, all monitoring sites are analysed for the same parameters (physico-chemical parameters, major ions, NH4, NO2, some heavy metals) and at equal intervals. The Water Framework follows a risk-based approach. In this approach, a large set of parameters is analysed at a large number of monitoring sites at least once every six years (i.e. once per RBMP cycle) in what is called surveillance monitoring. Based on the results, a reduced number of parameters is analysed at a reduced number of sites, focusing efforts where needed the most and reducing the costs of monitoring.

8.3.2.2 Improvement of surface water monitoring

- Adaptation of the current monitoring network and the current monitoring programmes
- Further development of the Ecological Status Classification System (ESCS) and establishing methods for the remaining Biologcal Quality Elements (BQE), starting with phytobenthos and phytoplankton.
- Performance of intercalibration exercise for biological, chemical and hydro-morphological parameters and application of existing ESCS for macroinvertebrates by performing a joint survey at transboundary rivers (e.g. Debed: Armenia and Georgia). The transboundary survey 2020 provides important foundation for future collaboration.

For further information on the Armenian surface water monitoring see the EUWI+ report “Surface Water Monitoring in the Sevan River Basin District, Armenia” (EUWI+, 2020c) and for guidance on the development of the Armenian surface water monitoring refer to EUWI+ report “Surface Water Monitoring Development Plan – Armenia” (EUWI+, 2020d).

To improve the current surface water monitoring system and fill in data gaps a realignment of the existing monitoring in accordance with the requirements of the WFD should be done in near future. A recommendation identifying 5 surveillance and 10 operational sites was already given (Figure 67, Table 119Table 119, Annex 21). Investigative monitoring shall be facilitated according to the arising need respectively. The scope of the recommended monitoring network can be complemented, as they are by no means exhaustive.This is especially the case for operational sites, as these should gradually improve the information about all water bodies at risk.

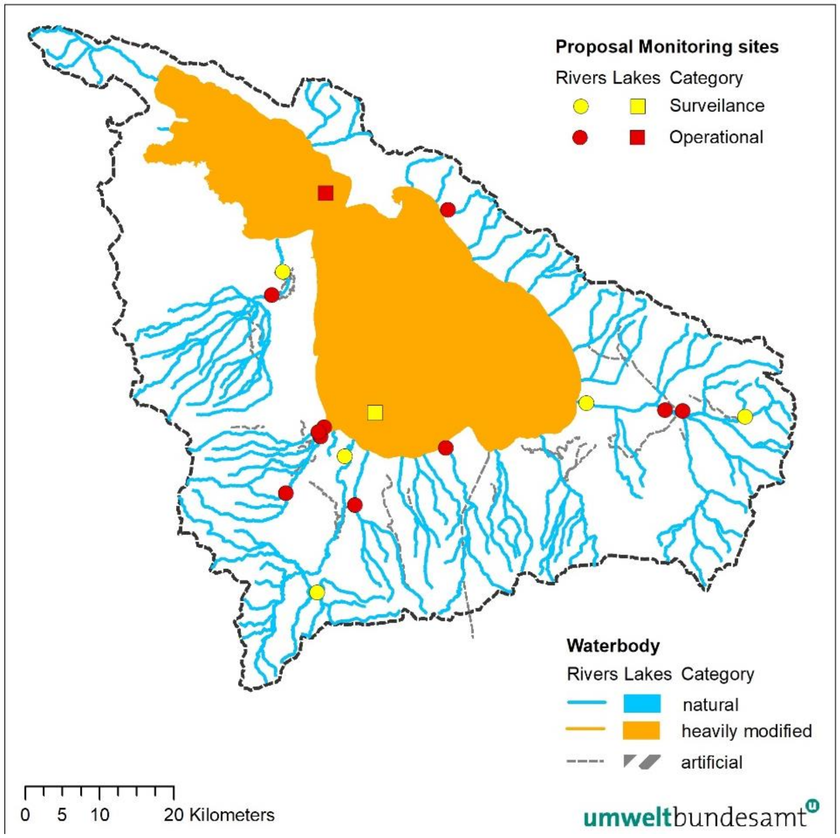


Figure 67: Map of recommended surface water surveillance and operational monitoring sites in the Sevan RBD.

Table 119: No. of recommended surface water surveillance and operational monitoring sites in the Sevan RBD.

RBD	SW Type	Surveillance Sites	Operational Sites
Sevan	Rivers	5	10
	Lakes	1	1

8.3.2.2.1 Chemical Monitoring

Surveillance and operational monitoring sites are listed in Figure 67, Table 119, Annex 21, According to measured parameters, Armenia will further converge towards the EU Water Framework Directive and start to monitor required parameters for both specific pollutants and priorities substances in line with laboratory and personnell capacities.

The measured parameters will depend on the existing pressures and risk assessment in the river basin. This will include, among others, substances emerging from domestic and industrial (especially food industry) wastewater and abandoned mines and tailing dams. Bearing in mind the importance of the agricultural sector in the country, it is recommended to develop monitoring of pesticides in surface water. Sampling of chemical parameters at **surveillance sites** is recommended at a frequency of:12 times over the course of one year, once within the 6-year RBMP cycle. At **operational sites**, general physico-chemical parameters and River

Basin-Specific Pollutants (RBSP) should be sampled 12 times over the course of one year, once within the 6-year RBMP cycle (Table 120, Table 121).

Since Lake Sevan is the only lake in the Sevan RBD and by far the most important water body in Armenia, it will be part of the national surveillance monitoring (Major Sevan). One site (Minor Sevan) shall be considered in the operational monitoring with annual campaigns (only general chemical parameters and phytoplankton). Measurements should be taken at least at six different depths in the lake. An investigative monitoring can be established for specific questions in the littoral zone of the lake.

8.3.2.2.2 Biological Monitoring

Surveillance and operational monitoring sites shall be the same as for the chemical monitoring and are listed in Figure 67, Table 119, and Annex 21.

Current biological monitoring focuses on the Biological Quality Element (BQE) macroinvertebrates. This BQE shall be investigated at all of the surveillance and operational monitoring sites. In addition phytobenthos will be included at surveillance and operational monitoring sites as a second BQE. Concerning frequency, benthic invertebrates and phytobenthos should be sampled once per RBMP cycle in rivers. In lakes, phytoplankton is recommended to be sampled 6 times over the course of one year, but once within the RBMP cycle at surveillance sites and twice within the RBMP cycle at operational sites (Table 120, Table 121). The monitoring of the other biological quality elements (fish, macrophytes) for both rivers and lakes will be postponed until the next RBMP cycle. According to the WFD, bacteria are not a BQE used for biological monitoring. Since the observation of these groups is of national importance, they have been added to Table 120 and Table 121.

A WFD compliant ESCS was established during EUWI+ project, which shall become the basis for the ecological classification in future monitoring (EUWI+, 2020b).

Table 120: Recommended monitoring frequency at surveillance sites in theSevan RBD.

Monitoring	SWB	Biological Quality Elements/ parameter groups	Frequency:	
Chemical	Rivers & Lakes	General physico-chemical parameters	12x within the selected year of the RBMP cycle	To be executed within any of the 6 years RMBP cycle
		Priority pollutants		
		River basin-specific pollutants		
Biological	Rivers	Benthic invertebrates	1x within the selected year of the RBMP cycle	
		Phytobenthos (diatoms)		
		Bacteriological elements* (growing in 20° and 37°saprophytic bacteria, common and thermotolerant coliform bacteria)		
	Lakes	Phytoplankton	6x / within the selected year of the RBMP cycle	
		Cyanobacteria*		

** not a BQE according to WFD.*

Table 121: Recommended monitoring frequency at operational sites in theSevan RBD.

Monitoring	SWB	Biological Quality Elements/ parameter groups	Frequency:	
Chemical	Rivers & Lakes	General physico-chemical parameters	12x within the selected year of the RBMP cycle	To be executed within any 2 years of the 6 years RMBP cycle
		Priority pollutants	-	
		River basin-specific pollutants	12x within the selected year of the RBMP cycle	
Biological	Rivers	Benthic invertebrates	1x within the selected year of the RBMP cycle	
		Phytobenthos (diatoms)		
		Bacteriological elements* (growing in 20° and 37°saprophytic bacteria, common and thermotolerant coliform bacteria)		
	Lakes	Phytoplankton	6x within the selected year of the RBMP cycle	
		Cyanobacteria*		

** not a BQE according to WFD.*

8.3.2.2.3 Hydromorphological Monitoring

Hydromorpholgy is a supporting element according to the WFD, that comes into effect when differentiating between good or high ecological status. While previous hydro-morphological description was carried out at single sites during biological monitoring for contextualizing biological data, future hydromorphological assessments shall cover larger sections of rivers. A first hydromorphological campaign in 2019 was the starting point of hydro-morphological mapping in the whole Sevan river basin. During the next RBMP cycle, the dataset needs to be increased through additional surveys.

Hydrological monitoring shall be continued such as in the current hydrological system. In rivers, water levels will be measured 2x a day and water discharge about 30x per year at a total of 12 sites. In lakes, water levels will be measured 2x a day at 5 sites.

8.4 Preliminary cost estimates

The section below presents preliminary financial assessment of the measures for technical measures in Sevan RBD, including those for construction of treatment plants and sewerage network, septic tanks, reservoirs and measures intended for prevention of emergency situations and mitigation of potential consequences from floods. The main of sources of funding is subject to discussion. The preliminary assessment of the costs of the measures is approximate. It also provides an opportunity for defining the priority measures on a medium-term and annual basis, with a purpose of including the priority measures on the mid-term expenditures program of the RA Government and other relevant programs and plans, as well as phased implementation of the Program of Measures.

Table 122: Investments for Construction of Septic Tanks and Waste Water Removal Systems in Akhpradzor, Lchavan, and Makenis Communities in Sevan RBD (in '000 AMD)

N/N	Community name	Septic tanks capacity, ton	Installation of Septic tanks,	Construction of waste water removal system	Design and Supervision costs	Total investment
1	Akhpradzor	30	17,000	13,600	1,530	32,130
2	Lchavan	45	25,500	20,400	2,295	48,195
3	Makenis	40	21,250	17,000	1,913	40,163
	Total	**115**	**63,750**	**51,000**	**5,738**	**120,488**

Source: Discussions with local enterprise Vilashin LLC which is involved in septic tank construction works in Armenia.

Table 123*:* Total Investments in Water Supply and Waste Water Systems of Vardenik, Yeranos and Zolakar Agglomerations in Sevan RBD (in '000 AMD)

Item	Name			Capex in Drinking Water Systems	Capex in Waste Water Systems	Total Investments in both Systems
	Agglomera-tion name	Region name	Community or village name			
1	Vardenik	Martuni	Vardenik	1,562,864	4,016,901	5,579,766
2		Martuni	Artsvanist	779,076	3,044,645	3,823,721
3		Martuni	Tsovinar	917,745	1,467,914	2,385,658
			Total	**3,259,685**	**8,529,460**	**11,789,145**
4	Zolakar	Martuni	Zolakar	1,348,439	4,415,627	5,764,066
5		Martuni	Astghadzor	1,781,047	2,077,785	3,858,832
			Total	**3,129,486**	**6,493,412**	**9,622,898**
6	Yeranos	Martuni	Yeranos	1,003,201	3,905,009	4,908,210
7		Martuni	Vardadzor	646,213	1,596,200	2,242,412
			Total	**1,649,413**	**5,501,209**	**7,150,622**
TOTAL INVESTMENTS				**8,038,584**	**20,524,081**	**28,562,665**

Source: "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia" developed by the CES and "Jrtuq" LLC, 2015

Table 124*:* Initial Costs for Modernization of Gavar, Martuni and Vardenis WWTPs

No	Measures	WWTP capacity, P.E.	Implementation period (years)	Required funding, thousand drams
1.1	*Modernization of Gavar WWTP*	*40,000*	*2.5*	***803,416***
1.1.1	Construction of biological treatment systems			510,400
1.1.2	Construction of sludge treatment systems			293,016
1.2	*Modernization of Martuni WWTP*	*25,000*	*2.5*	***712,866.4***
1.2.1	Construction of biological treatment systems			447,992
1.2.2	Construction of sludge treatment systems			265,292

1.3	*Modernization of Vardenis WWTP*[29]	*20,000*	*2.5*	***643,713***
1.3.1	Construction of biological treatment systems			411,481
1.3.2	Construction of sludge treatment systems			232,232

Table 125: Cost of Installation of SCADA system and Development of Software for Registration of Actual Water Use (in '000 AMD)

Preparatory works	Monitoring equipment cost	Total cost for installation of monitoring systems	SCADA software	Installation of ultrasonic flow meters	TOTAL COSTS
2,673	16,524	19,197	12,000	6,413	37,610

Table 126: Total Investments for Construction of Argichi and Astghadzor Reservoirs in Sevan RBD (in '000 AMD)

Reservoir name	Reservoir volume, thous. m^3	Investment cost, including: design, tehcnical supervision and construction works, thous. AMD
Argichi	5,500	7,128,000
Astghadzor	1,250	1,620,000
Total cost		**8,748,000**

Table 127*:* Construction Costs of Sanitary Landfill (in '000 AMD)

1	Investment costs, including	5,198,067
1.1	Landfill construction	2,705,000
1.2	Landfill equipment	768,333
1.3	Urban waste collection equipment	963,333
1.4	Rural waste collection equipment	120,000
1.6	Separate waste collection equipment	301,667
1.7	Transfer station construction costs	151,400
1.8	Street cleaning equipment	188,333
2	Contingencies on investment costs	418,349

[29]*For the normal operation of the Vardenis CMC, it is necessary to prevent the penetration of groundwater into the sewer. Otherwise, the biological treatment process will not take place due to the dilution of the active sludge.*

3	Investment and contingency costs	5,616,416
4	Consultancy costs	561,642
5	Taxes and duties	1,497,162
6	Total Costs	7,675,219
7	Dumpsite closure costs	736,228

Source: KfW-funded “Feasibility Study for an Integrated Solid Waste Management for Vanadzor, Republic of Armenia”, 2014

Table 128: Flood and Mudflow Prevention measures in Sevan RBD (in ‘000 AMD)

No	Community Name	River name	Description of activities	Cost	Source of Funding
1	**City Gavar,** Edik Tonoyan st., Petrosyan st., Nalbandlan St., Demirchyan St., Hatsarat district., H. Abrahamyan St. Azatamartikneri St., Burnazyan 2nd St. 1st Lane. Petrov st. 2nd Lane, Artsvakar district, Azatutyan St., Gedeon Mikayelyan St.	Gavaraget river and associated Mudflow drains	Cleaning of riverbed (4200m), Cleaning of Mudflow drains (3300m)	11,250	Other
2	**Village Noratus,** Sevan St., Intersection of G. Lusavoritch and D. Demirchyan Streets	Gavaraget river and associated Mudflow drains	Cleaning of riverbed (650m), Reinforcement of river banks (150m)	2,325	Other
3	**Martoy hazaz area,** A. Isahakyan St., V. Sargsyan St., P. Sevak St.,	Gegharkunik river	Cleaning of riverbed (1200m), Reinforcement of river banks (1200m)	12,600	Other
5	**Village Sarukhan,** H. Abrahamyan St. 9 deadlock, Section of Badey Creek.	Kukudzor river and associated Mudflow drains	Cleaning of riverbed (1500m), Reinforcement of river banks (350m)	5,400	Other, Community budget (1,000)
6	**Village Gandzak,** H. Abrahamian St., M. Baghramayan St.	Gri Dzor river and Geloyi Dzor Mudflow drains	Cleaning of mudflow drains Reinforcement of river banks (480m)	4,320	Other, Community budget (2,000)
7	**Village Karmirgyugh**, Section of Karmirgyugh – Gandzak road	Gegharkunik river	Cleaning of riverbed (300m), Reinforcement of river banks (100m)	1,350	Other
8	**Village Tsaghkashen**, 1st St., 5th St.	Geloyi Dzor river	Cleaning of riverbed (1200m), Reinforcement of river banks (1000m)	10,800	Other
9	**City Martuni**, Getapnya St.	Martuni river	Cleaning of riverbed (300m), Reinforcement of river banks (350m)	3,600	Other
10	**Village Artsvanist**, Atoy district, Gorge district	Mudflow drain	Cleaning of mudflow drain (400m), Reinforcement of river banks (200m)	2,400	Other
11	**Village Vardadzor**,	Mudflow	Cleaning of mudflow	1,575	Other,

	Chayirner main creek	drain	drain (150m), Reinforcement of river banks (150m)		Community budget (900)
12	**Village Geghhovit**, Ghrachneri district, Chayirneri district, Chimankend district.	Martuni river	Cleaning of riverbed (3500m), Reinforcement of river banks (2000m)	23,250	Other
13	**Village Nor Getashen**, Riverside district.	Argichi river	Cleaning of riverbed (600m), Reinforcement of river banks (1000m), Construction of retaining wall (50m)	2,500	
14	**Village Vardenik**, 25th St.	Vardenik river	Cleaning of riverbed (2200m), Reinforcement of river banks (2500m)	25,800	Other
15	**Village Lichk**, A 6 district. 1 money, A5 block. 1 St.	Lichk river	Cleaning of riverbed (300m), Construction of drain system (120m)	1,530	Other
16	**Village Dzoragyugh**, Chayirner district, Jam district., Ayginer district., Khorunt Dzor district.	Dzoraget river	Cleaning of riverbed (900m), Reinforcement of river banks (500m)	5,850	Other
17	**Village Karchaghbyur**, 3rd street	Karchaghbyu r river	Cleaning of riverbed (350m), Reinforcement of river banks (300m)	3,225	Other, Community budget (100)
18	**Village Kutakan**, 6th Street, 8th Street	Mudflow drain	Cleaning of mudflow drain (1500m)	2,250	Other
19	**Village M. Masrik,** Masrik river, 6th St 4th lane	Masrik river and Mudflow drain	Cleaning of riverbed (1600m), Reinforcement of river banks (3200m)	31,200	Other, Community budget (300)
20	**Village Dzoravank**, Entrance to the village and nearby areas	Getik river	Cleaning of riverbed (600m)	900	Other, Community budget (80)
Total				**152,125**	

8.4.1 Monitoring Costs

During recent years within the EUWI+ project, a significant improvement could be achieved through training and procurement of equipment, which is required for chemical, biological, and hydro-morphological monitoring. However, it is absolutely necessary to continue improving technical know-how and data by future surveys, additional parameters, and including further BQE in the national monitoring.

Following estimations represent the costs of the whole six years of an RBMP cycle. As mentioned in in the monitoring chapter of this report, surveillance sites will be investigated once per cycle (chemical monitoring 12x / year; biological monitoring in rivers 1x / year, and lakes 6x / year), and the 11 operational monitoring sites will be sampled twice over the six-year period (same annual frequency).

Taking into account the survey costs of 2018 and 2019 in the EUWI+ project an approximate cost estimation of the surface water monitoring in the Sevan RBD can be calculated. Considering sampling and analyses of general physico-chemical parameters and all BQE (benthic invertebrates, phytobenthos, phytoplankton) for the proposed surveillance and operational monitoring sites will cost around 47,000 € in this RBMP cycle.

The estimation for the monitoring of priority pollutants has lower confidence, as the costs were calculated based on a fraction of costs per parameter in Austrian surface water monitoring. Another assumption was that the number of analyzed parameters is 15. Nevertheless, the rough cost estimate is for priority pollutants is around 35,000 € to 50,000 €. The true costs will vary, depending on the number and kind of analyzed parameters.

Within the framework of EUWI+ a study entitled “Preparation of Detailed Assessment of Priority Needs for Improvement of Hydrological Monitoring in Sevan and Hrazdan Pilot Basins of Armenia” was initiated in 2018 in order to improve the hydrological monitoring in Sevan and Hrazdan RBDs and assess the capacity needs for renovation and upgrade of these monitoring stations. As a result, 4 monitoring stations have been recommended in Sevan RBD that need immediate renovation and upgrade.

Table 129: Renovation and Upgrade Costs of Operating Hydrological Monitoring Posts in Sevan RBD

Water Object	Monitoring Station	Construction Costs (x1000 EUR)	Equipment Cost (x1000 EUR)
r. Argichi	Getashen	11.50	3.27
r. Dzknaget	Tsovagyugh	11.52	3.27
r. Gavaraget	Noratus	1.35	3.27
r. Masrik	Tsovak	11.47	3.27
Total Cost		**35.84**	**13.08**

Source: “Preparation of Detailed Assessment of Priority Needs for Improvement of Hydrological Monitoring in Sevan and Hrazdan Pilot Basins of Armenia”, EUWI+, 2018

The required capital expenditure to add 2 wells and 13 springs in the Sevan RBD in order to adequately cover all groundwater bodies is estimated at 36,000 EUR. Part of the construction costs will be supported by EUWI+, including the full design costs. This amount consists of the following elements. The research and design per site is estimated at 200 EUR. The construction cost per well is estimated at 10,000 EUR, but varies considerably depending on the depth of the wells. The estimated construction cost per new spring capture is 1,000 EUR. These investments can be made step by step, starting from those groundwater monitoring sites that are most urgently needed to improve the understanding of the groundwater bodies, particularly where they are exposed to human pressures.

The cost to refurbish those existing 6 wells and 1 spring in the Sevan RBD which need repairs is estimated at 4,600 EUR. This cost will be covered by EUWI+.

The cost of quantitative and chemical (at the current set of parameters) monitoring per site, including basic maintenance, is estimated at 1,000 EUR per year, for a total of 11,000 EUR for the 11 existing sites in the Sevan RBD. Assuming that set of parameters will be adapted in a risk-based approach, it will, in some cases, include pesticides and other pollutants where needed and in some years. Therefore, the estimated cost per year is increased to 1,100 EUR, as it is more expensive to analyse such additional parameters. Taking into account the slight increase in estimated annual cost per sites and the increase in the number of sites from 11 to 26, the total monitoring cost per year is estimated at 28,600 EUR.

The figures below outline the distribution of proposed measures in Sevan RBD by description and by type.

8.5 Assessment of the financial deficit in the Sevan RBD according to sectors

Financial deficit for Sevan RBD was calculated by the analysis and assessment of the following reports:

- Strategy for Development of Gegharkunik marz for 2017 – 2025 approved by Protocol No 29 of Government of Armenia on July 6, 2017;
- Report on Programme of Measures Planned by Government of Armenia in 2018

- Reports of National Statistical Service on production volumes in different economic sectors of Gegharkunik marz,
- OECD/EUWI Report "FACILITATING THE REFORM OF ECONOMIC INSTRUMENTS FOR WATER MANAGEMENT IN ARMENIA", 2013
- Decree of Government of Armenia No 57-N adopted on January 31, 2019 entitled "Activities for Minimizing the Effects of Tariffs on Water Supply and Sanitation Services of Veolia Jur CJSC"
- KfW – funded Report "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia", 2015

8.5.1 Differentiation of Operating and Capital Costs in Financial Deficit

For the calculation of financial deficit in Sevan RBD, Capital and Operating Expenses as well as the Cash inflows for water abstraction, water supply, irrigation and sanitation were assessed. Operational costs consist of costs for provision of water and wastewater services (Veolia Jur and of Off-Grid communities) and provision of irrigation services. Operational income consist of payments from customers for above – mentioned services, as well as environmental fees paid by water users for water abstraction.

Capital expenses consist of costs for rehabilitation and construction of water and waste water systems, construction of septic tanks, construction of wastewater systems in Vardenik, Zolakar and Yeranos agglomerations, installation of SCADA in SHPPs, construction of Sanitary Landfill, construction of reservoirs in Argichi and Astghadzor rivers, flood and mudflow prevention measures. Funding for these activities is confirmed only for 1,634,110.2 thousand drams. This amount is included in the budgetary expenses of Republic of Armenia for 2020.

Table 130: Calculation of Financial Deficit in Sevan RBD

N/N	Description of Costs	Cost ('000, AMD)	Cost recovery (%) and source
Operational Costs			
1	Centralized water and wastewater services	504,885	about 70 % covered by customer payments
2	Water and wastewater services in off-grid communities	1,324,305	about 13 % covered by customer payments
3	Centralized irrigation services	538,310	about 85 % covered by customer payments
4	**Total operational costs**	**2,367,500**	
5	**Income from operational activities**	**983,143**	
6	**Environmental fees paid by water users for water abstraction**	**25,549**	
7	**Financial deficit from operational activities (4-5-6)**	**1,358,808**	
Capital Expenditures			
8	Rehabilitation and construction of water and waste water systems	1,634,110	KFW loan and Grant, State budget
9	Construction of septic tanks and waste water systems	120,488	Donor Organizations, Local Communities, State Budget

10	Construction of wastewater systems in Vardenik, Zolakar and Yeranos agglomerations	20,524,081	Donor Organizations, Local Communities, State Budget
11	Installation of SCADA in SHPPs	37,610	Donor Organizations, Local Communities, State Budget
12	Construction of Sanitary Landfill	7,675,219	Donor Organizations, Local Communities, State Budget
13	Construction of reservoirs in Argichi and Astghadzor rivers	8,748,000	Donor Organizations, Local Communities, State Budget
14	Flood and Mudflow Prevention measures	152,125	Donor Organizations, Local Communities, State Budget
15	**Total need for Capital Expenditures**	**38,891,633.2**	
16	**Total Annual Capital Expenditures**	**7,920,474.5**	
17	**Source of Expenses already confirmed**	**1,634,110.2**	KFW loan and Grant, State budget
18	**Financial Deficit for Annual Capital Expenditures**	**6,286,364.3**	
19	**Total Annual Financial Deficit in Sevan RBD**	**7,645,172.7**	

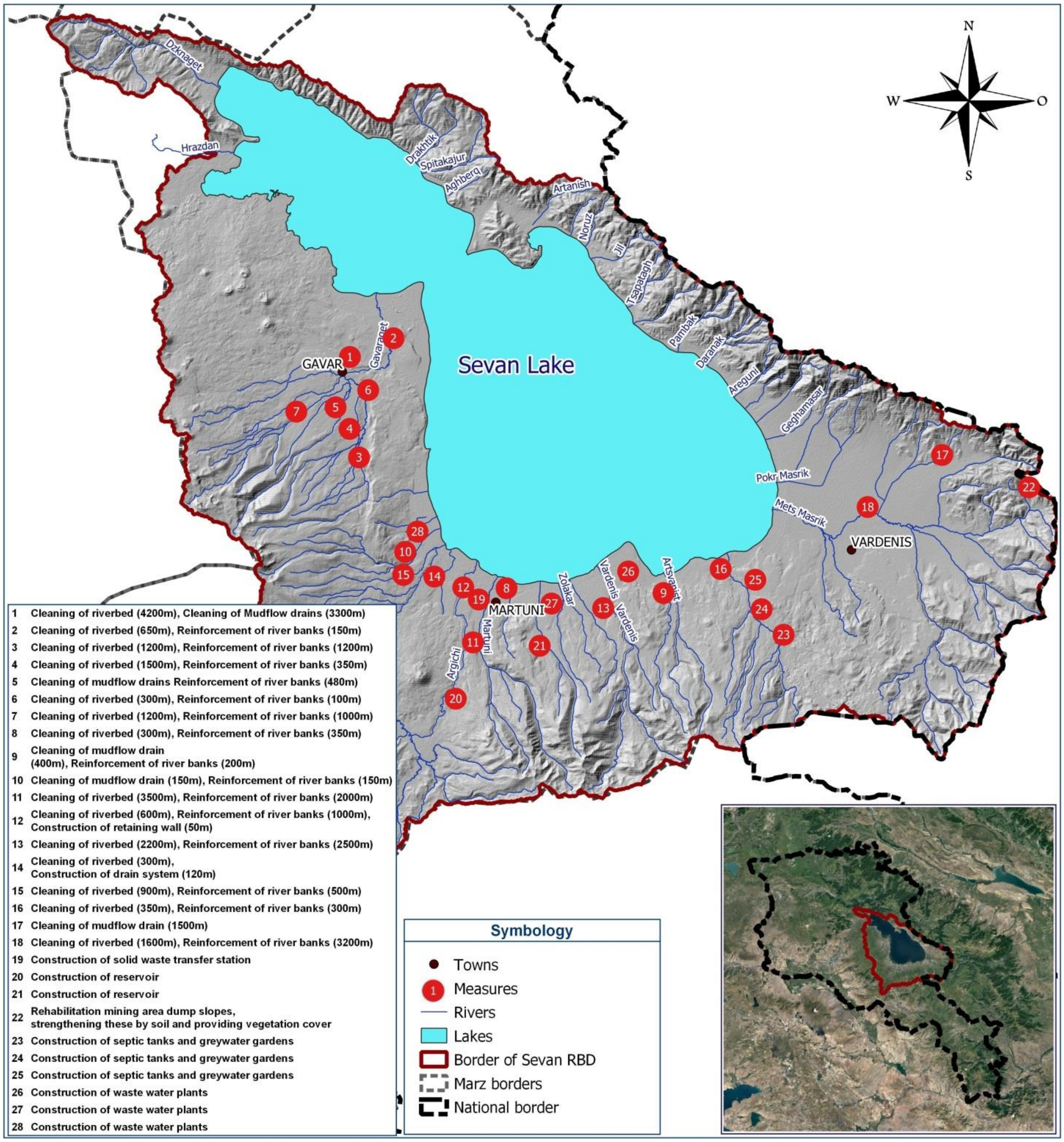


Figure 68: Description of Proposed Measures in Sevan RBD

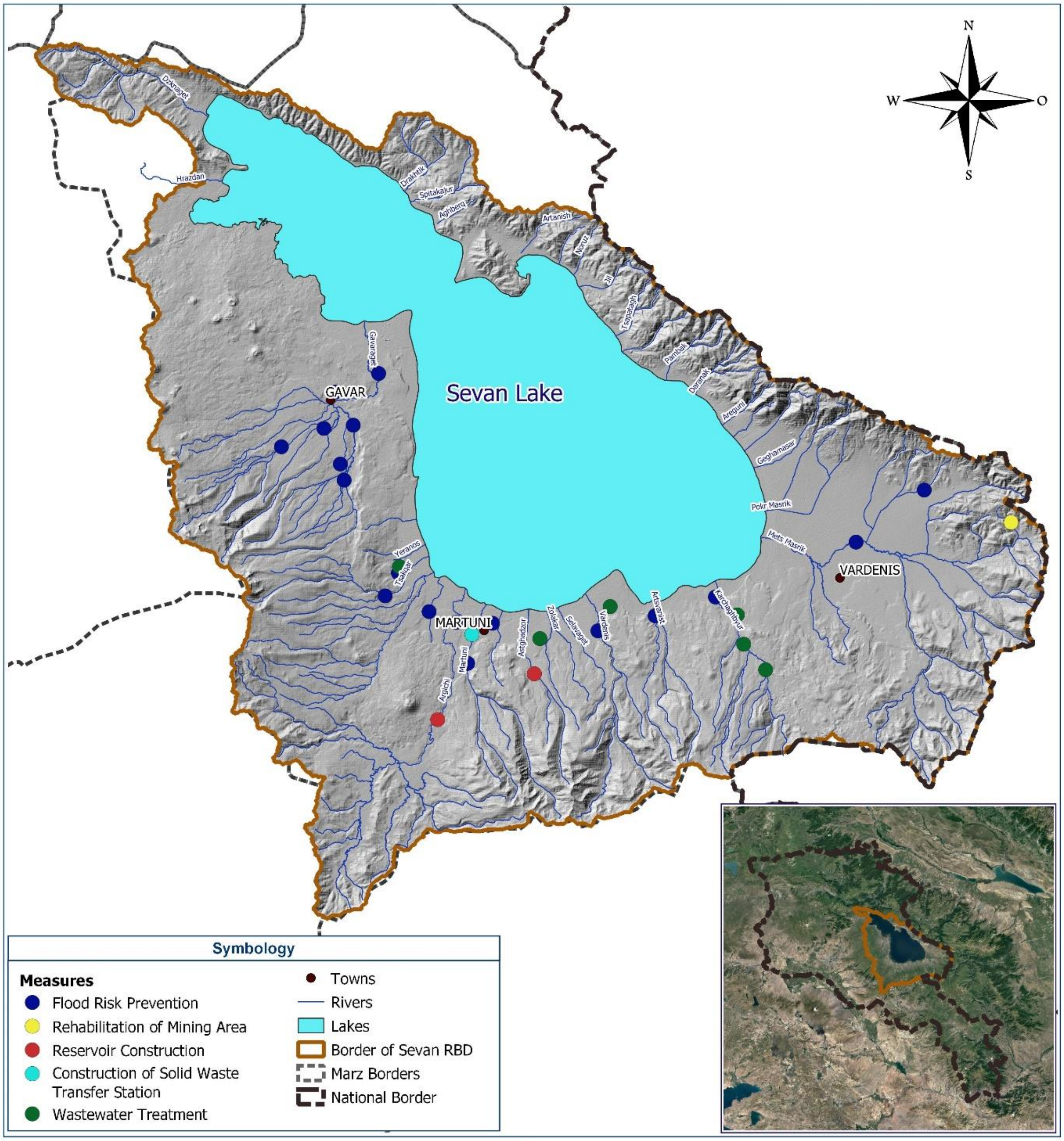


Figure 69: Proposed Measures by Type in Sevan RBD

9. SUMMARY OF THE PUBLIC CONSULTATIONS

Communication and stakeholders' involvement is an important part of the RBM planning process. EUWI+ project activities related to that aspect include i) development and regular update of a communication and visibility strategy and action plan for the whole project, and ii) implementation of the strategy, including communication and awareness raising actions targeting stakeholder information, consultation, and involvement related to RBM Planning.

Developing River Basin Management Plans (RBMP) according to EU WFD implies using a participative approach, which involves bringing together multiple stakeholders with various viewpoints to determine how thr water should be managed in most efficient way. This is done through stakeholder meetings and wider public consultations, as well as information campaigns aimed to raise awareness on water issues.

Public and stakeholder consultations are organised throughout the RBMP development process, particularly at two main stage oft he RBMP development process. At the first stage, the consultations have been aimed to discuss and agree on the main issues in Sevan RBD (EUWI+, 2019c), and at the second stage - the programme of measures (EUWI+, 2019d; EUWI+, 2020f) as determind by Article 14 of WFD.

All documents for consultation are available on the websites of EUWI+ Project[30] and the Ministry of Environment of Armenia[31].

9.1 First Public Consultation

The first public consultations have been conducted from March 12, 2019 to April 12, 2019. The process have been coordinated by Country Water Partnership (CWP) Armenia NGO. As an important tool for public discussion and consultation process, consultation checklists/questionnaires have been applied through which expert opinions and information were collected for the purpose of making amendments in the river basin plans and developing the Project events schedule. These checklists were filled both during the stakeholder consultation meeting held on March 21, 2019 in Gavar town, and the consultation visits conducted by Project Public Outreach Specialists (Team members who are responsible for increasing publicity of the Project. They provide a communication with stakeholders throughout the Project). The questionnaires were also disseminated online, through RA MNP (currently, MoE) official web-page, EUWI+ official web-page, social networks of CWP-Armenia, as well as different Civil Society Organization networks.

The public consultation questionnaire on Sevan RBD has been filled in by 129 stakeholders (63 printed and 66 electronic). Some of the printed questionnaires were filled out during Public Consultation meeting (20 questionnaires), and the other part (43 questionnaires) was filled in a result of community visits. Communities were selected based on 2 main criteria - the population and the community's recreational or economic significance.

In the questionnaire, the stakeholders expressed their opinion on the measures to be taken in the future towards main issues in the basin. Those issues are classified in the into the following groups: health, quality, quantity, ecosystems, and governance. As the questions included in this section are open-ended, the received answers have been grouped in accordance with the logical similarity and being listed as per the order of priority.

[30] https://euwipluseast.eu/en/partner-countries/separator-armenia/public-consultation
[31] http://env.am/en/post/4746

Table 131: Responses of the Stakeholders on Measures to be taken in the Future

Main Group of the Issues	Number of Respondents	Answers on Measures to be taken in the Future	Number of Answers
Health	37 stakeholders	Water quality insurance (monitoring, mobile laboratories)	14
		Construction of wastewater treatment plants (chemical and biological)	11
		Drinking water pipeline repair, adjustment	8
		Implementation of measures on healthcare awareness raising	4
Quality	44 stakeholders	Wastewater treatment, preventing wastewater leakage	17
		Regular water quality testing (acquisition of new testing equipment, public dissemination of the acquired results)	12
		Cleaning of Lake Sevan coastal areas	9
		Construction of new chlorine stations	6
Quantity	41 stakeholders	Insurance of Lake Sevan level sustainability, water extraction regulation, minimizing losses	11
		24-hour water supply with the required pressure	9
		Minimization of water losses	8
		Insurance of irrigation water through irrigation networks	6
		Establishment of the new water quantity observation points	4
		Construction of reservoirs	3
Ecosystems	33 stakeholders	Regulation of fish-farming in Sevan Lake (insurance of endemic fish fertility, banning of fish farming with artificial food)	14
		Cleaning of Lake Sevan coastal areas	8
		Minimization of human influence on the ecosystem	5
		Removal of sewage water from the environment	4
		Increase of eco-education level among the residents	2
Governance	45 stakeholders	Supervision of water use permit issuance	18
		Appropriate application of laws and legislative acts	14
		Imposition of penalties for pollution	6
		Installation of water measurement equipment	5
		Fair water distribution	2

9.2 Second Public Consultation

The process of second public discussion and consultation of the Sevan Basin Management Plan took place during the period of 11 June to 17 July 2020. The process have been coordinated by CWP Armenia..

Consulting questionnaires were used as a key tool in the public discussion and consulting process, through which expert opinions and information was collected to make additions to the basin management plan. The questionnaires were disseminated through Gegharkunik Marzpetaran, the official website of the Ministry of Environment of the RA, the official website of EUWI+, the social networks of the CWP, as well as various CSO networks.

The questionnaire was filled up by local self-government bodies (LSGB) - 27 communities (27 questionnaires) and by other beneficiaries (residents) in the basin - 102 questionnaires.

A total of 129 questionnaires were filled up.

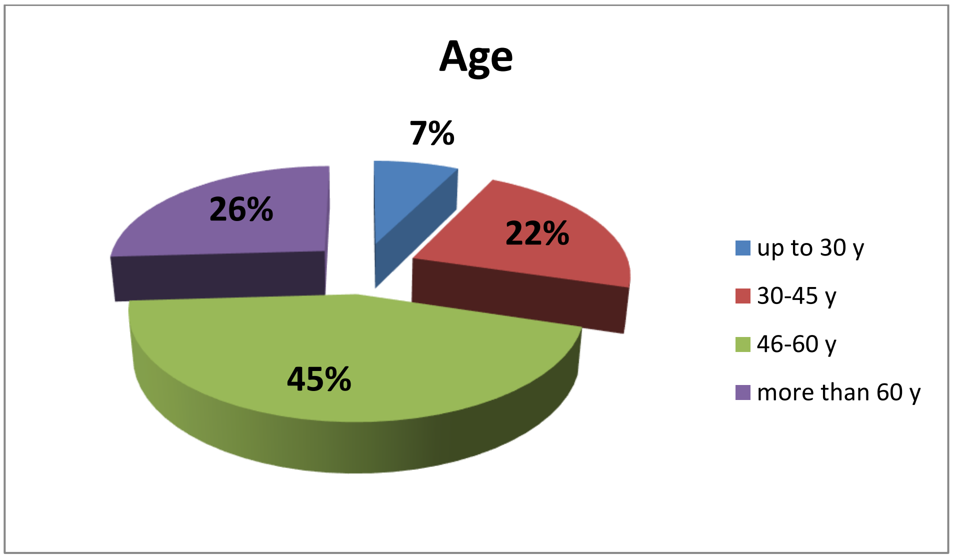
Due to the situation related to COVID-19, a particular attention was given to online consultation (virtual meetings, online questionnaire and mailing campaign). Only one physical meeting with regional authorities were organized, respecting the sanitary conditions.

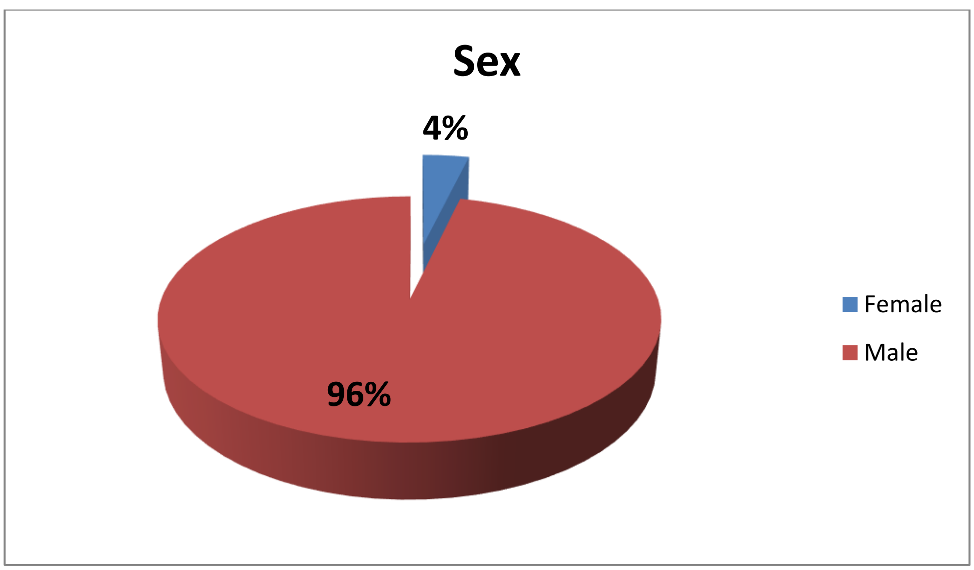
.

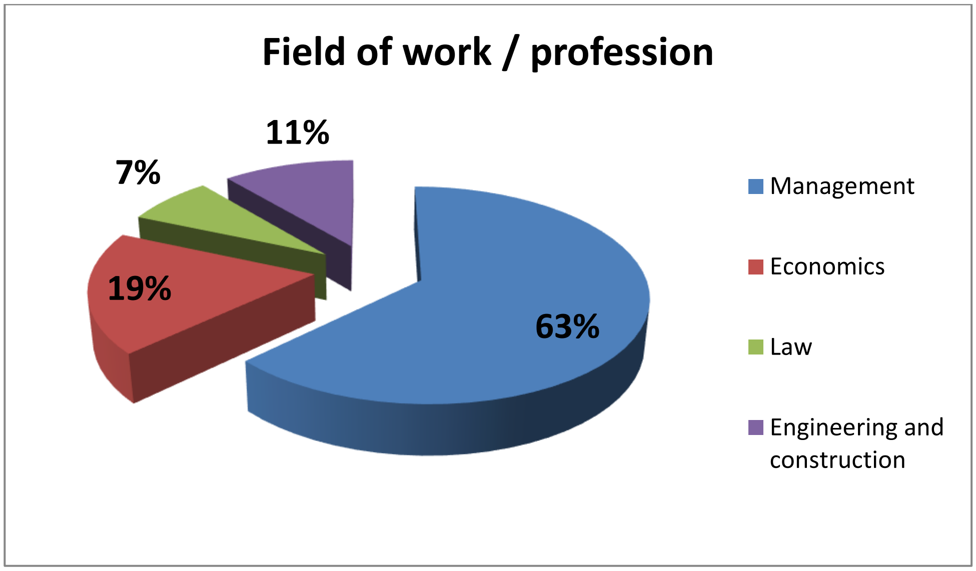
9.2.1 Analysis of the questionnaires filled up by the local self-government bodies

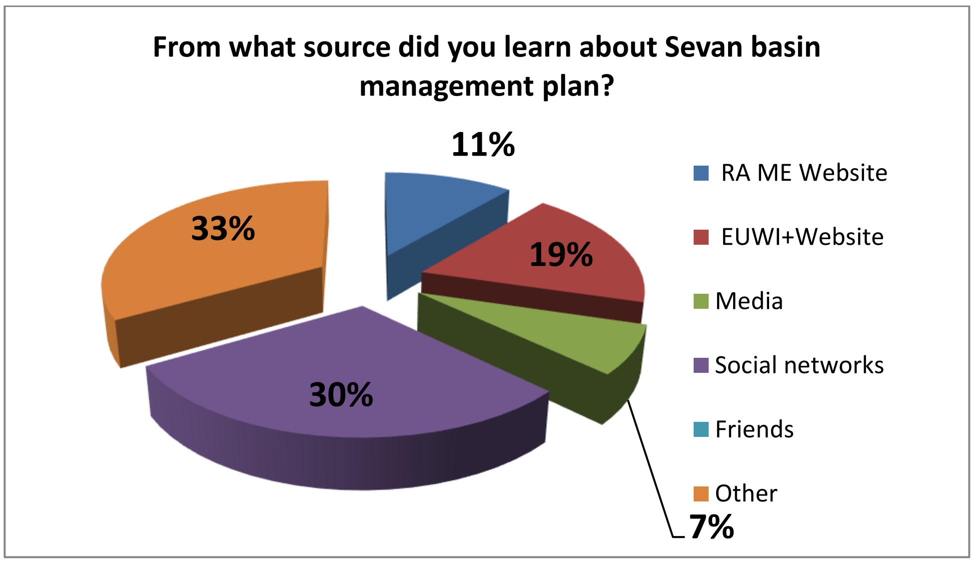
The questionnaire was filled up by the LSGB representatives of Lchavan, Karchaghbyur, Noratus, Akunk, Artsvanist, Berdunk, Gavar, Geghakar, Geghhovit, Yeranos, Lanjaghbyur, Lchap, Tsakqar, Tsovak, Chambarak, Makenis, Shoghakat, Sevan, Torfavan, Khachaghbyur, Tsovazard, Dzoragyugh, Martuni, Norakert, Vaghashen, Vardadzor, and Vardenis communities.

Respondent information



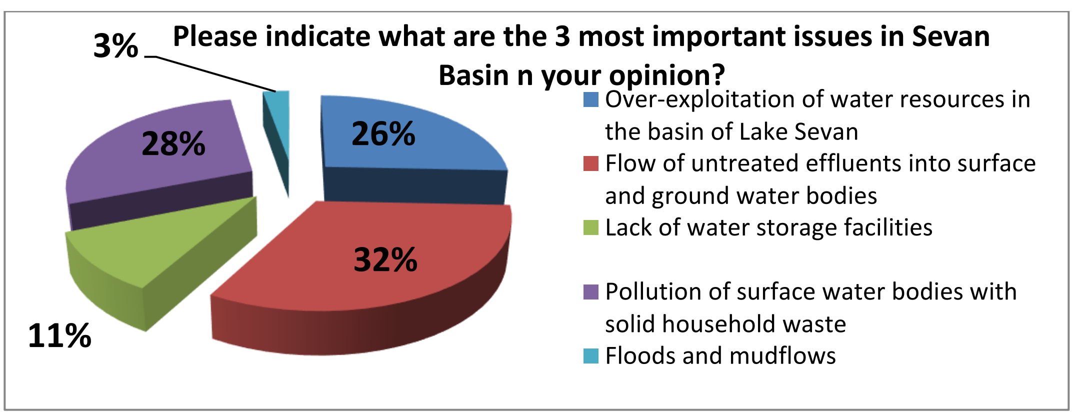






Main questions

QUESTION 1



As seen from the diagram, especially important problems for the residents of the beneficiary communities are the flow of untreated wastewater to surface and groundwater bodies (24 communities answered this way), pollution of surface water bodies with solid household waste (21 communities) and overexploitation of water resources in Sevan basin (this is the answer of 19 communities).

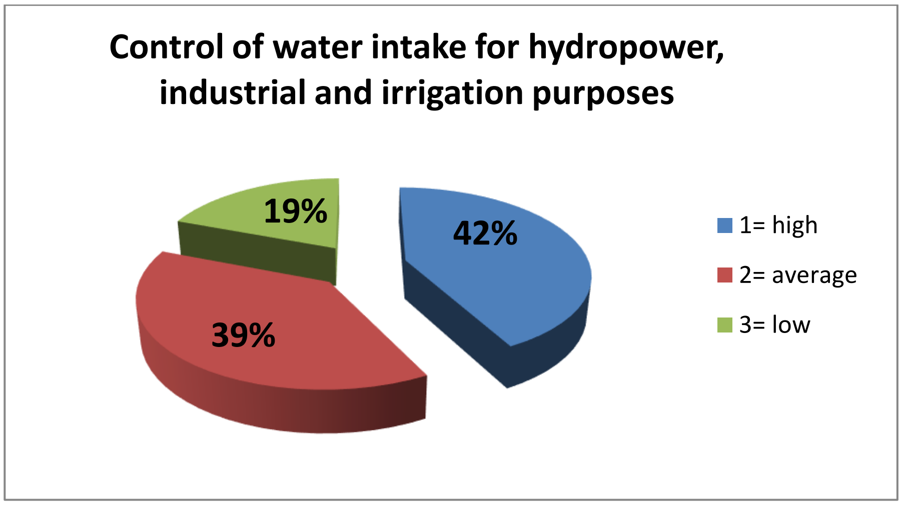
According to the communities, the lack of water storage facilities (8 communities) and the problems of floods and mudflows (2 communities) are less important.

QUESTION 2. PLEASE ASSESS THE ACTIONS IN THE BASIN MANAGEMENT PLAN BY THEIR IMPORTANCE (1= HIGH, 2= AVERAGE, 3= LOW)

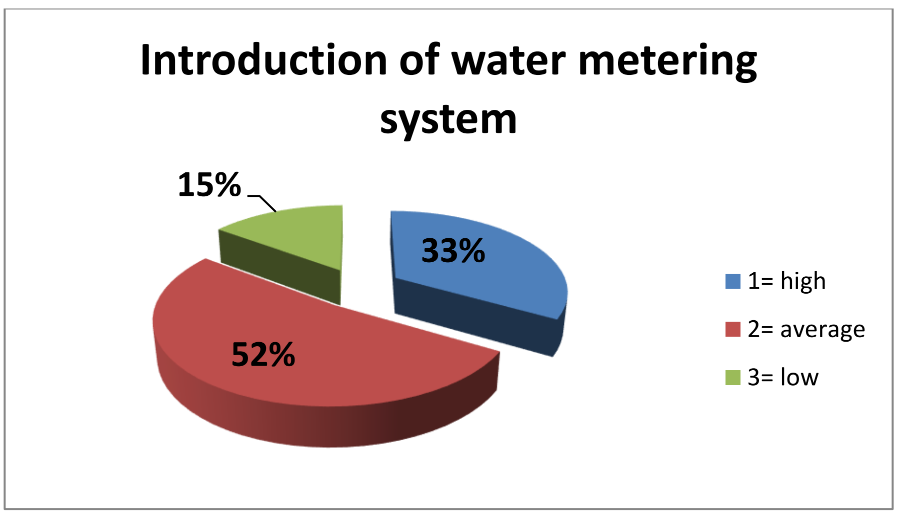
This section of the questions presents the importance of measures for communities to address the key problems included in the basin management plan.

1. **The first problem is the overexploitation of water resources**, for the solution of which 5 measures have been presented.

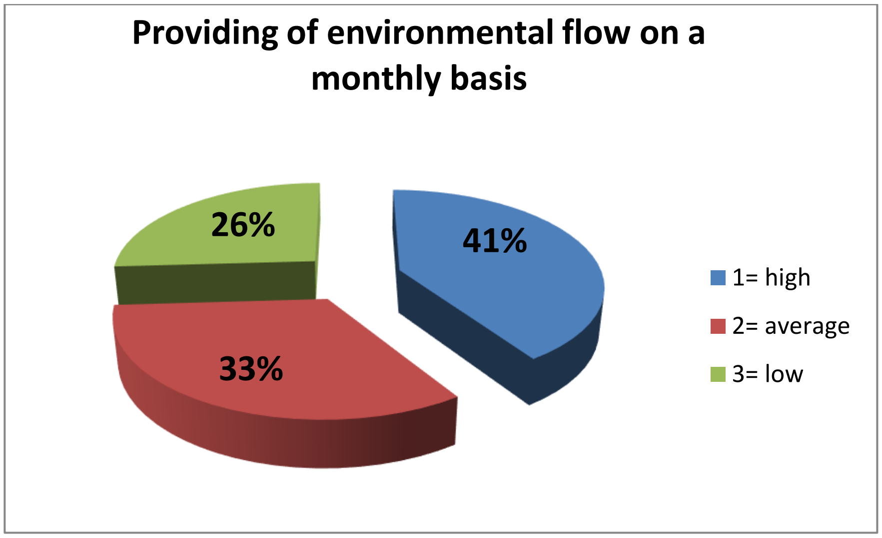
Measure 1.1



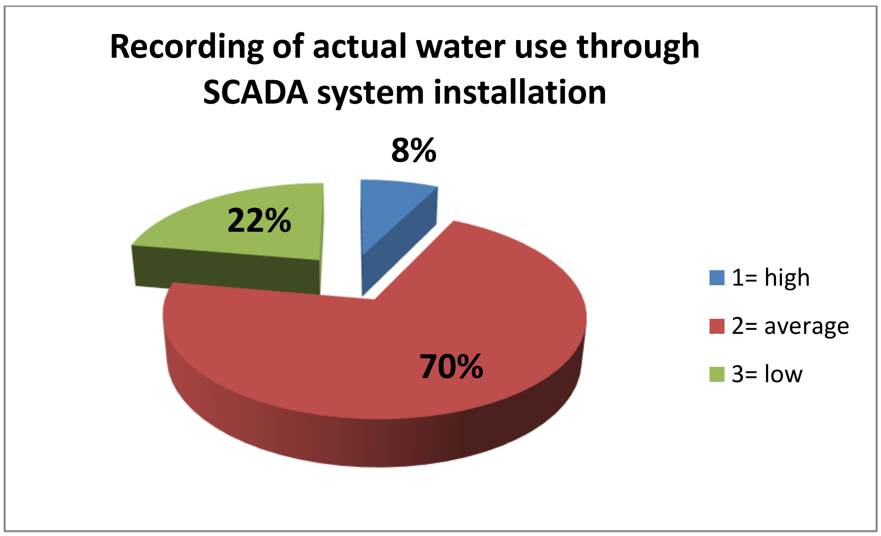
Measure 1.2



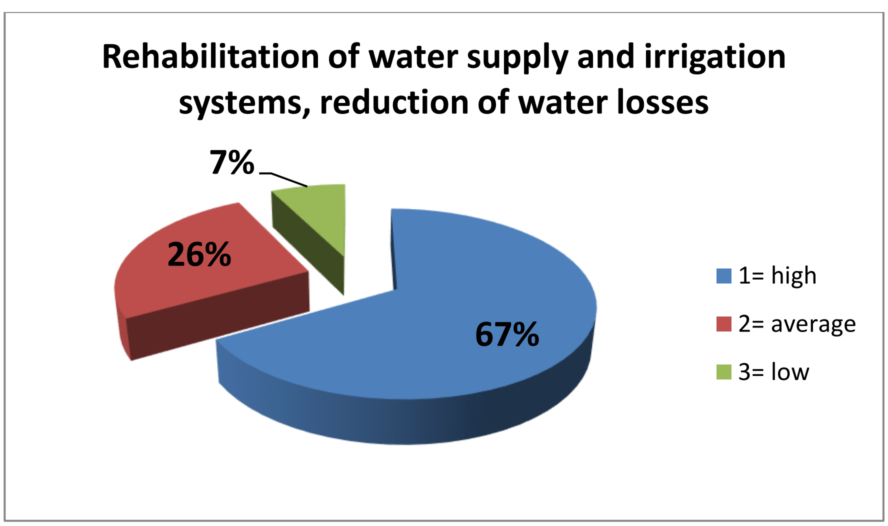
Measure 1.3



Measure 1.4



Measure 1.5



As can be seen from the analysis, the following measures are especially important for 29 communities among the measures aimed at the problem of overexploitation of water resources:

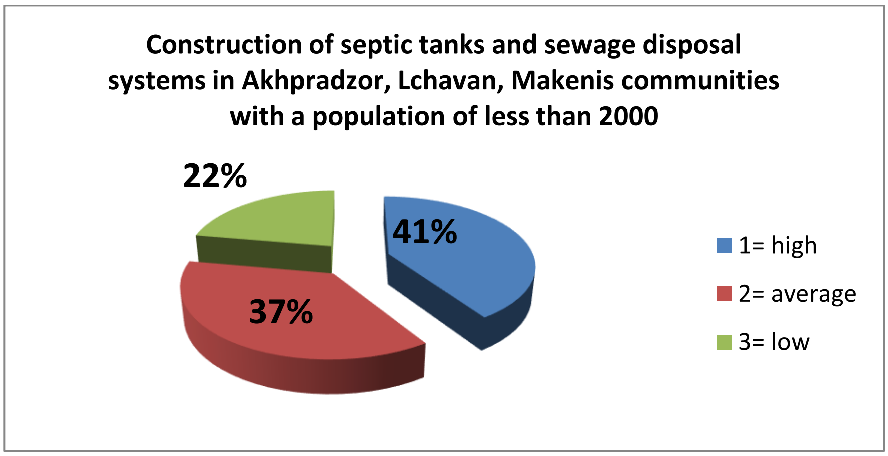
- Rehabilitation of water supply and irrigation systems, reduction of water losses (is of high importance for 18 communities)
- Control of water intake for hydropower, industrial and irrigation purposes (is of high importance for 11 communities)
- Providing of monthly environmental flow (is of high importance for 11 inhabitants)

The following measures are of average importance:

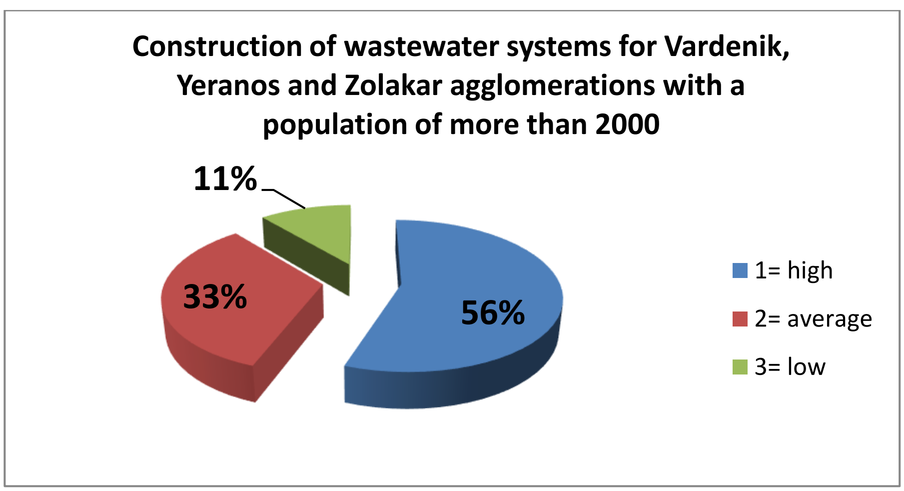
- Introduction of water metering system (is of high importance for 19 communities)
- Introduction of water metering system (is of average importance for 14 communities)

2. **The second problem is the flow of untreated wastewater to water bodies**. Measures refer to household wastewater (measures 2.1, 2.2), industrial wastewater (measures 2.3).

Measure 2.1

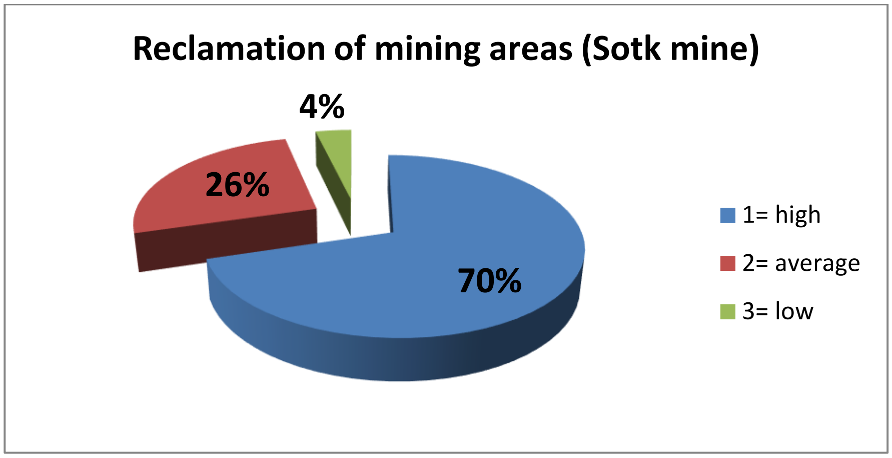


Measure 2.2



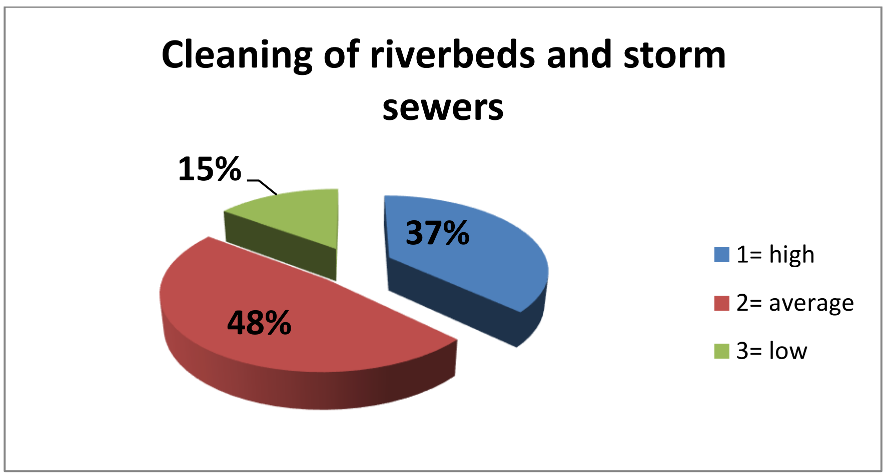
As can be seen from the diagrams, the household wastewater treatment measures are of a high importance for the communities.

Measure 2.3

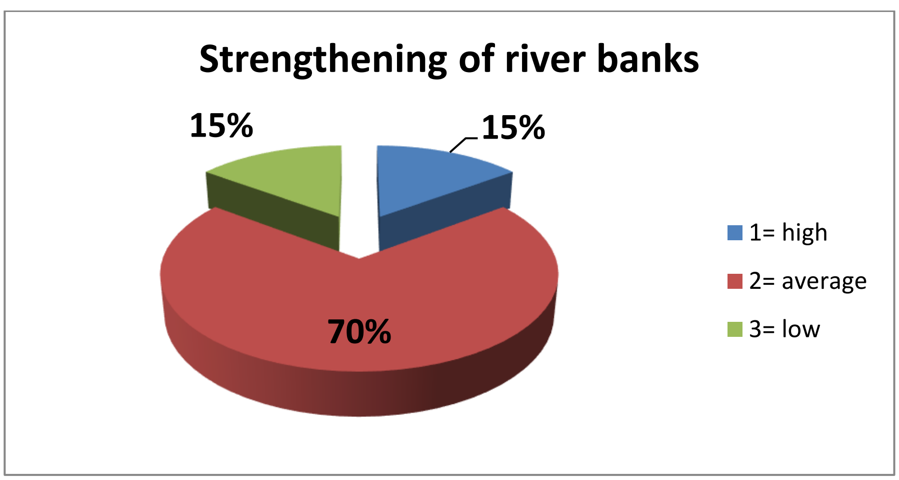


The measure related to industrial wastewater, the reclamation of mining areas (Sotk mine), is also of a high importance for 19 communities.

Measure 2.4



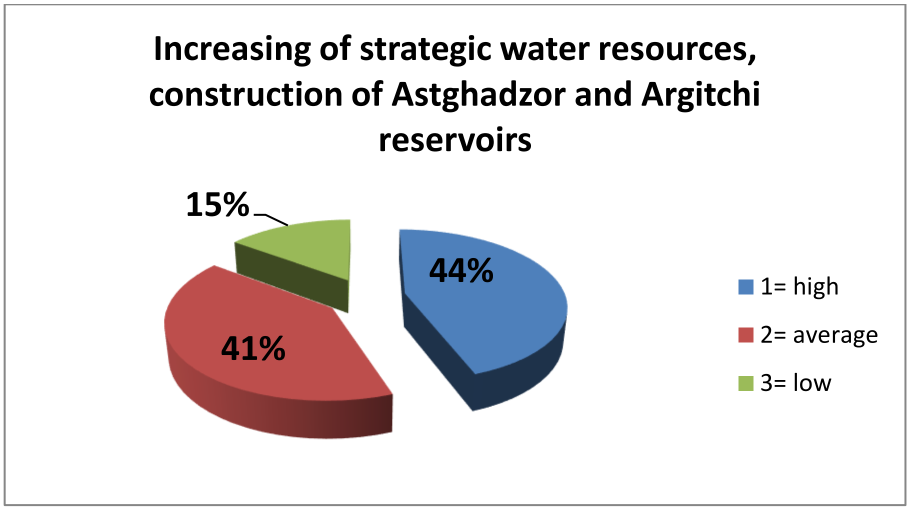
Measure 2.5



3. The third problem is the lack of water storage facilities.

To solve this problem, the following measure is proposed: increasing of strategic water resources, construction of Astghadzor and Argitchi reservoirs (measure 3.1).

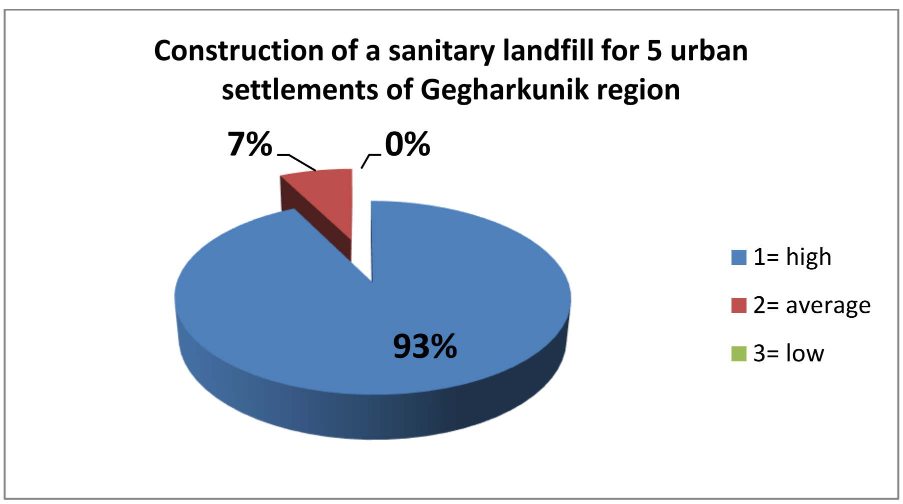
Measure 3.1



The measure aimed at the problem of lack of water storage facilities - increasing of strategic water resources, construction of Astghadzor and Argitchi reservoirs, is of almost equally high (12 communities) and average (11 communities) importance for the communities.

4. The fourth problem is pollution with solid household waste, for the solution of which the following measure is proposed: construction of a sanitary landfill for 5 urban settlements of Gegharkunik region (measure 4.1).

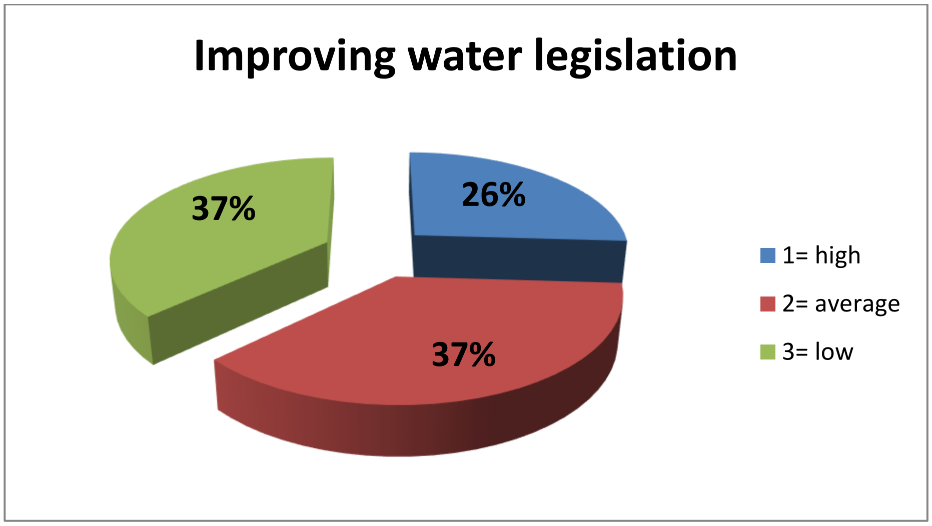
Measure 4.1



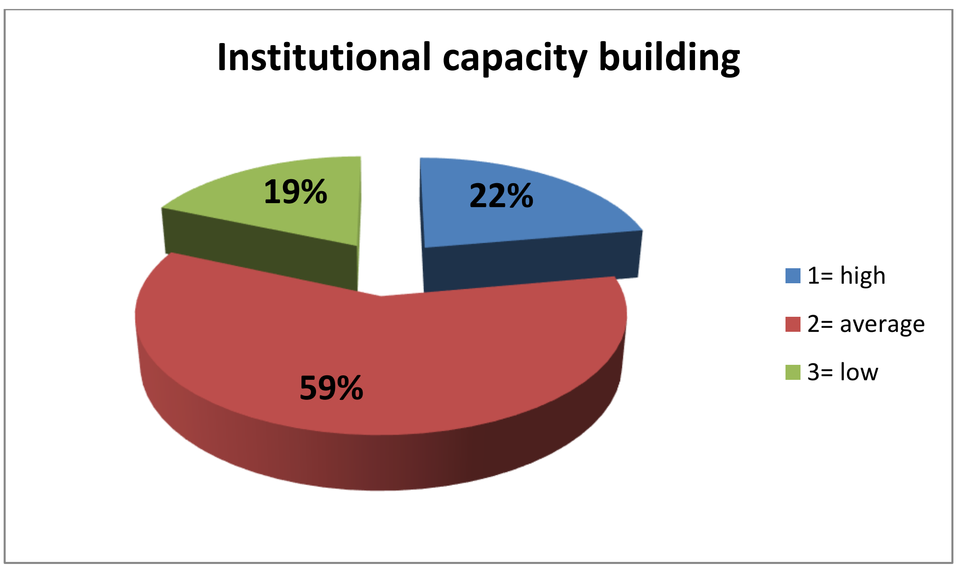
The measure aimed at the problem of pollution with solid household waste - the construction of a sanitary landfill for 5 urban settlements of Gegharkunik region, is of an especially high importance for the communities (25 communities).

5. **The fifth problem is water management**. Two solutions are proposed for this problem: improving water legislation (5.1), strengthening institutional capacity (5.2).

Measure 5.1

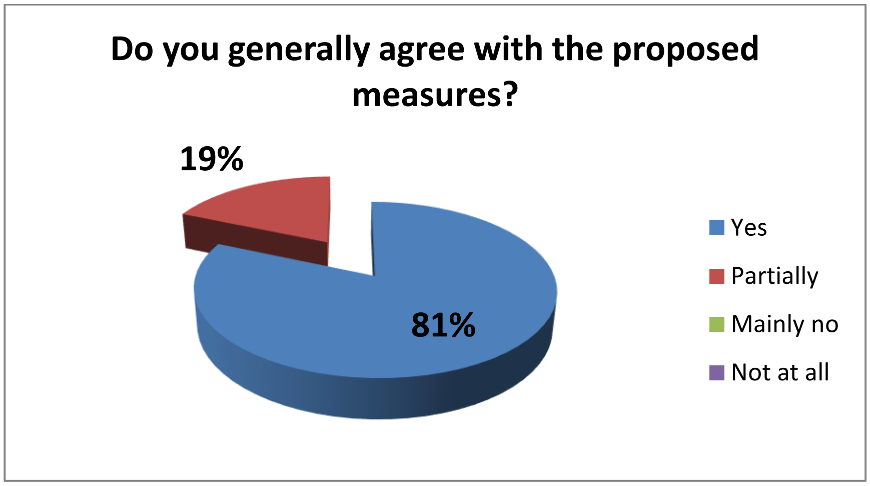


Measure 5.2



Measures to address water management issues are of average importance for the most communities.

QUESTION 3



81% of the beneficiary communities – 22 communities - agree with the measures proposed in the basin management plan, and 19% - 5 communities - partially agree, and there are no communities that mostly disagree or does not agree at all with the measures proposed.

QUESTION 4. In your opinion, in addition to the measures listed in the questionnaire at the basin level, are there other additional issues that need to be addressed?

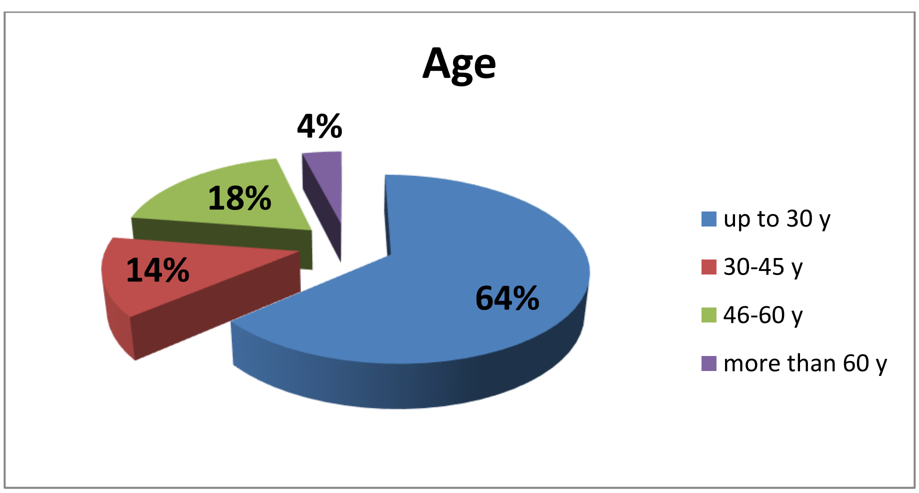
Only 2 communities mentioned additional problems, they highlighted the following problems:

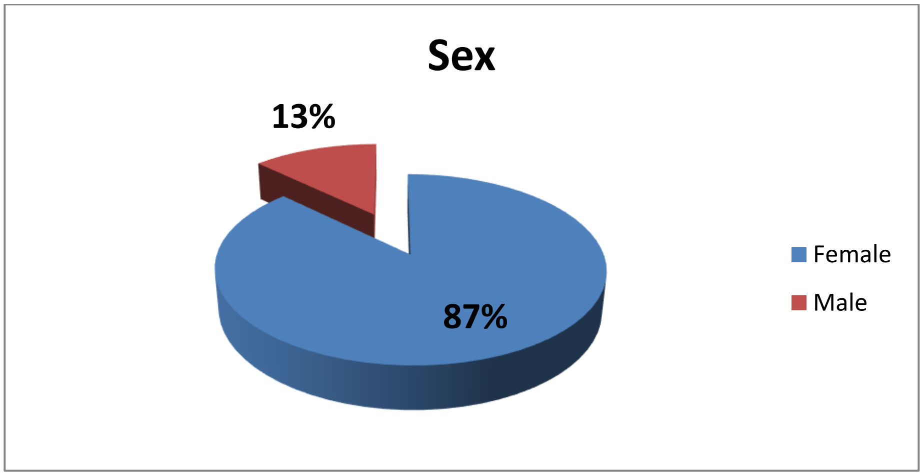
- Cleaning Lake Sevan from polyethylene bottles, fishing net waste, tree roots.
- Fishing regulation and restrictions.

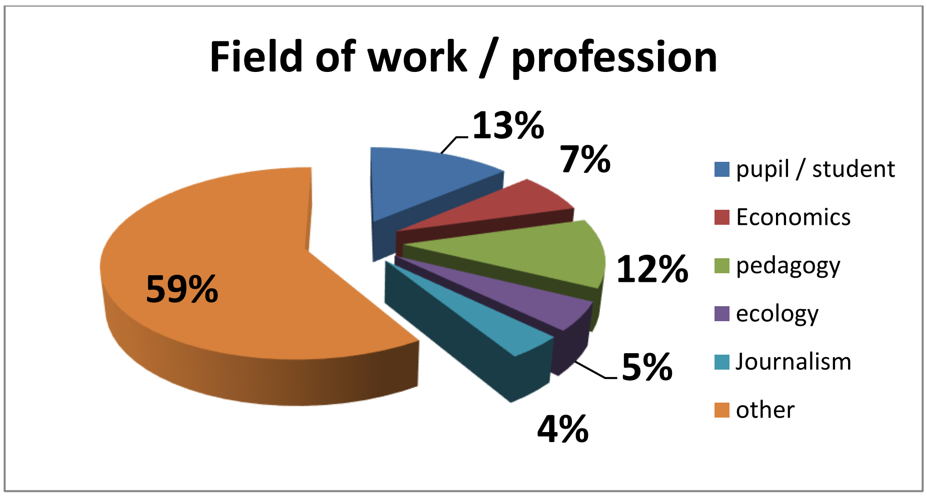
9.2.2 Analysis of the questionnaires filled up by the residents

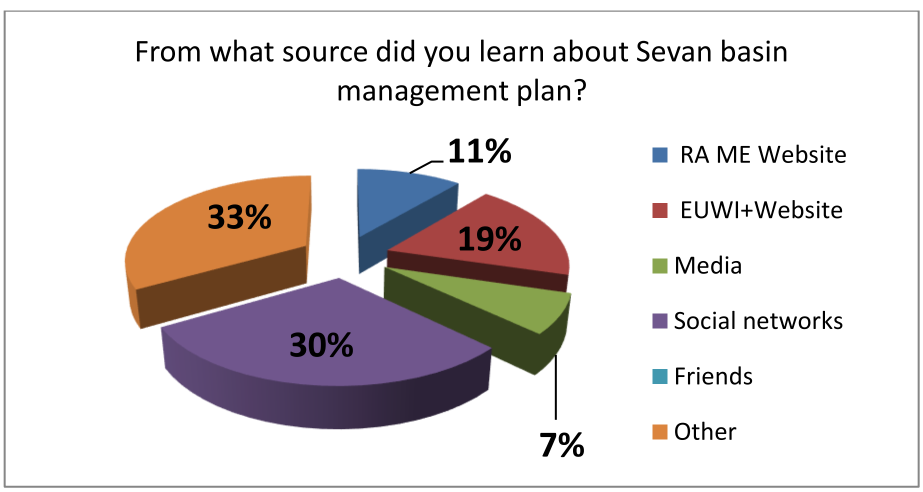
The questionnaire was filled up by the residents of 16 communities of Sevan basin: Gavar, Sevan, Tsovazard, Tsovagyugh, Martuni, Gegharkunik, Vardenis, Gandzak, Tsaghkazard, Lchap, Verin Getashen, Akunk, Chkalovka, Chambarak, Lchashen, Shatvan.

Respondent information

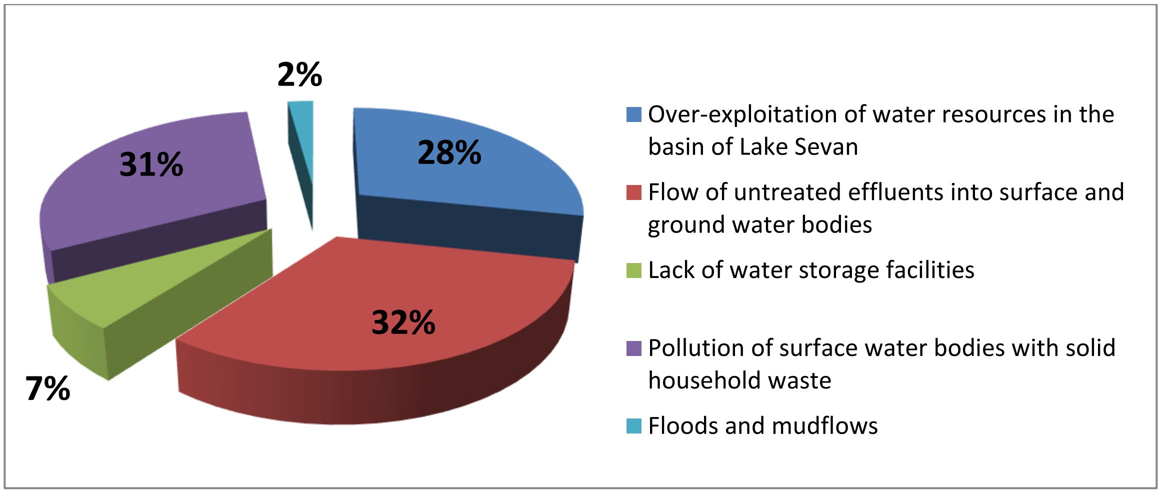



Sex
13%
87%
Female
Male


Field of work / profession
13%
7%
12%
5%
4%
59%
pupil / student
Economics
pedagogy
ecology
Journalism
other


From what source did you learn about Sevan basin management plan?
11%
19%
33%
30%
7%
RA ME Website
EUWI+Website
Media
Social networks
Friends
Other

QUESTION 1 Please indicate what are the 3 most important issues in Sevan Basin n your opinion?



As seen from the diagram, especially important problems for the residents of the beneficiary communities are the flow of untreated wastewater to surface and groundwater bodies (91 residents answered this way), pollution of surface water bodies with solid household waste (87 residents) and overexploitation of water resources in Sevan basin (this is the answer of 80 residents).

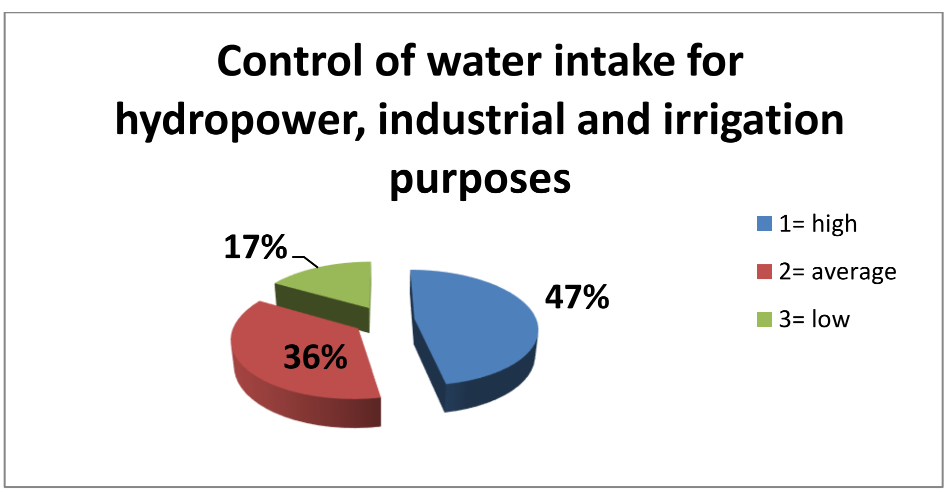
According to the communities, the lack of water storage facilities (19 residents) and the problems of floods and mudflows (6 residents) are less important.

QUESTION 2. PLEASE ASSESS THE ACTIONS IN THE BASIN MANAGEMENT PLAN BY THEIR IMPORTANCE (1= HIGH, 2= AVERAGE, 3= LOW)

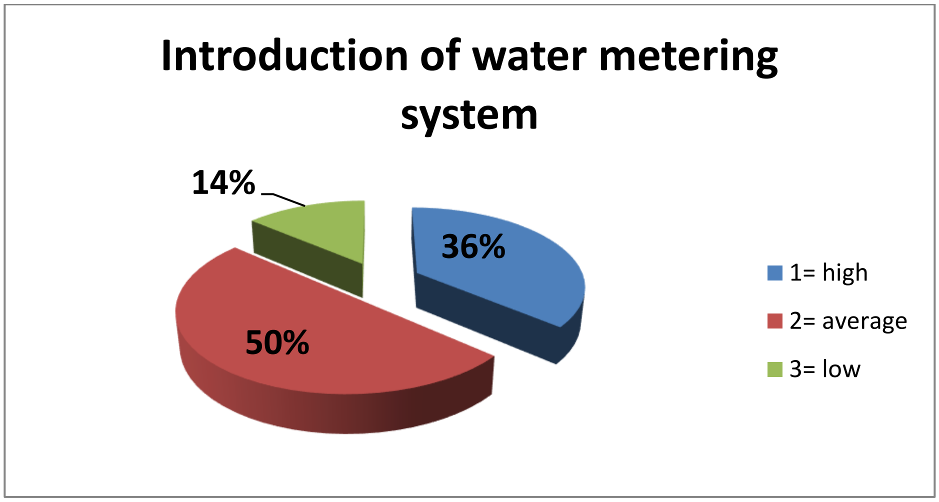
This section of the questions presents the importance of measures for communities to address the key problems included in the basin management plan.

1. The first problem is the overexploitation of water resources, for the solution of which 5 measures have been presented.

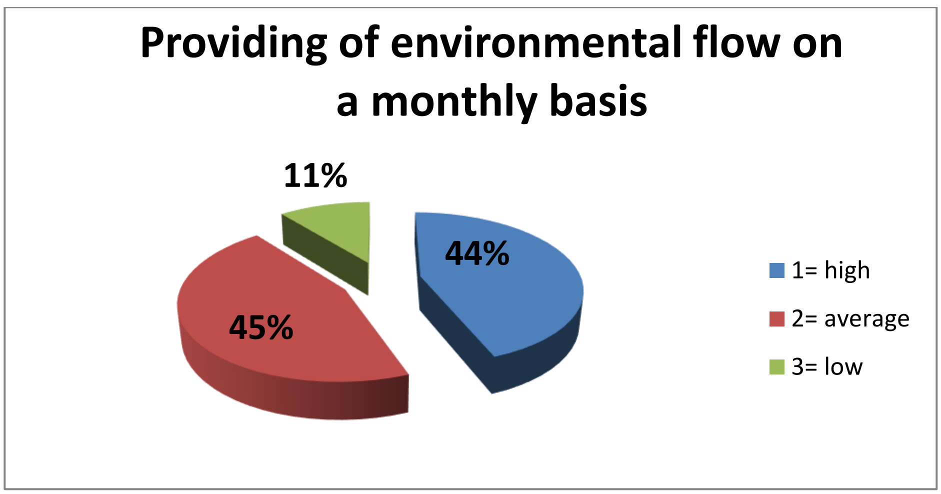
Measure 1.1



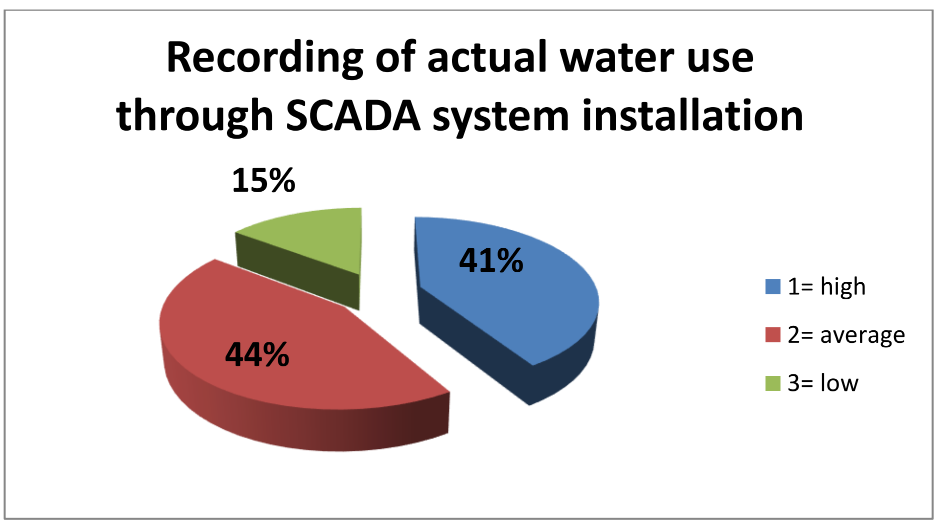
Measure 1.2



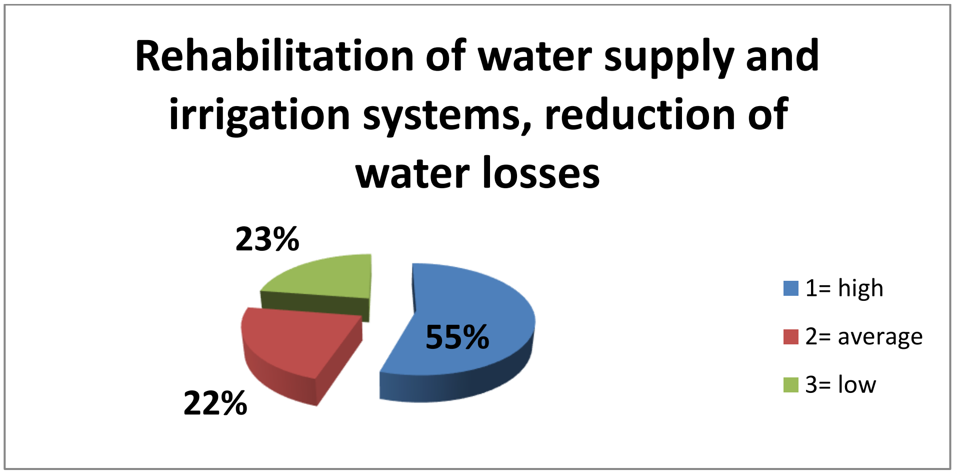
Measure 1.3



Measure 1.4



Measure 1.5



As can be seen from the analysis, the following measures are especially important for the residents among the measures aimed at the problem of overexploitation of water resources:

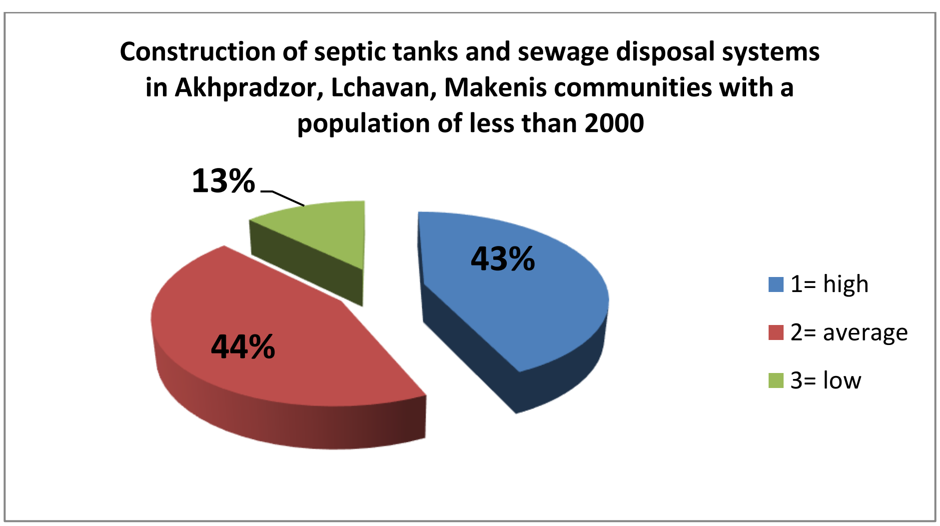
- Rehabilitation of water supply and irrigation systems, reduction of water losses (is of high importance for 56 residents)
- Control of water intake for hydropower, industrial and irrigation purposes (is of high importance for 48 residents)

The following events are of average importance:

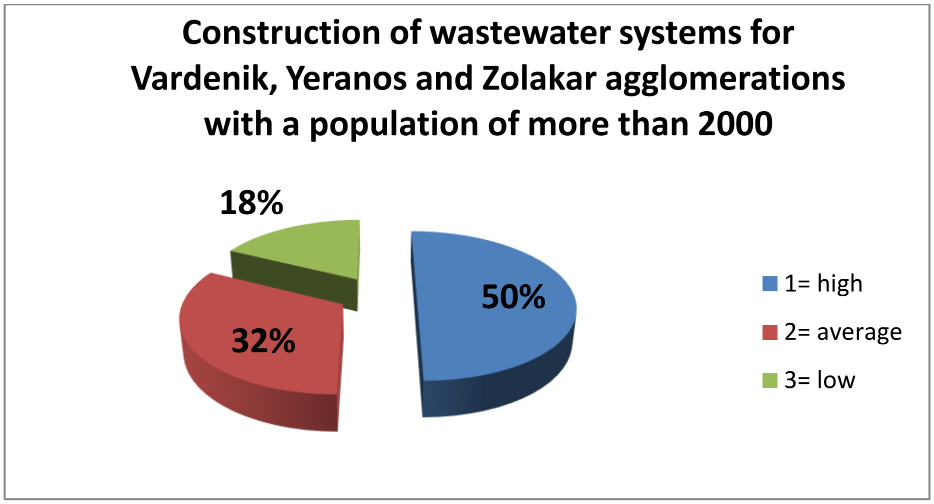
- Introduction of water metering system (is of average importance for 45 inhabitants)
- Providing of monthly environmental flow (is of average importance for 46 inhabitants)
- Recording of actual water use through the installation of SCADA system (is of average importance for 45 inhabitants)

2. **The second problem is the flow of untreated wastewater to water bodies**. Measures refer to household wastewater (measures 2.1, 2.2), industrial wastewater (measures 2.3), floods and mudflows (measures 2.4, 2.5), lack of water storage capacity (measures 2.6, 2.7), pollution with solid waste (measures 2.8), water management (measures 2.9, 2.10)

Measure 2.1



Measure 2.2

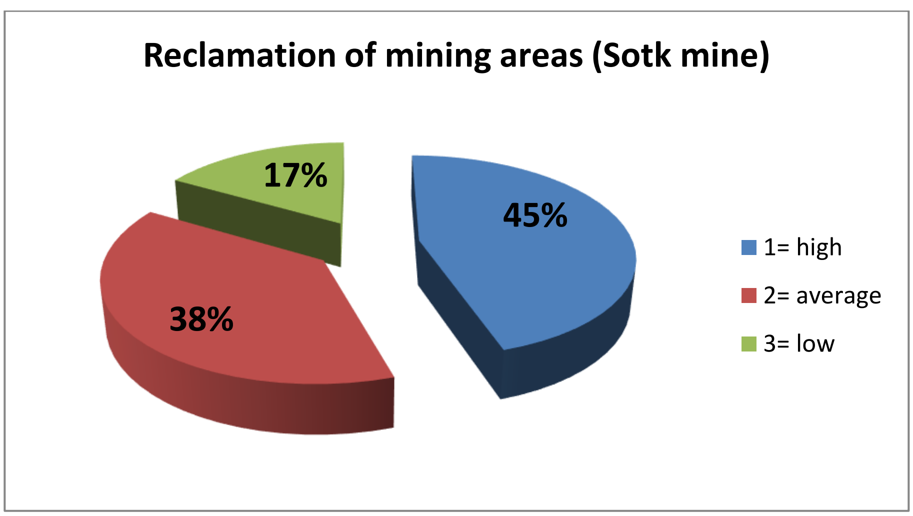


As can be seen from the diagrams, both household wastewater treatment measures are of a high importance:

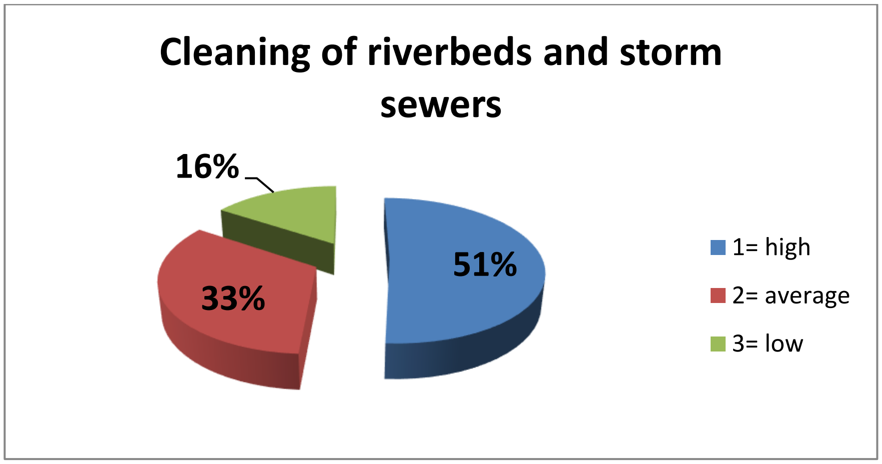
- .Construction of septic tanks and sewage disposal systems in Akhpradzor, Lchavan, Makenis communities with a population of less than 2000 (44 residents)
- Construction of wastewater systems for Vardenik, Yeranos and Zolakar agglomerations with a population of more than 2000 (51 residents)

The measure related to industrial wastewater, the reclamation of mining areas (Sotk mine), is also of a high importance for 46 residents and of average importance for 39 residents.

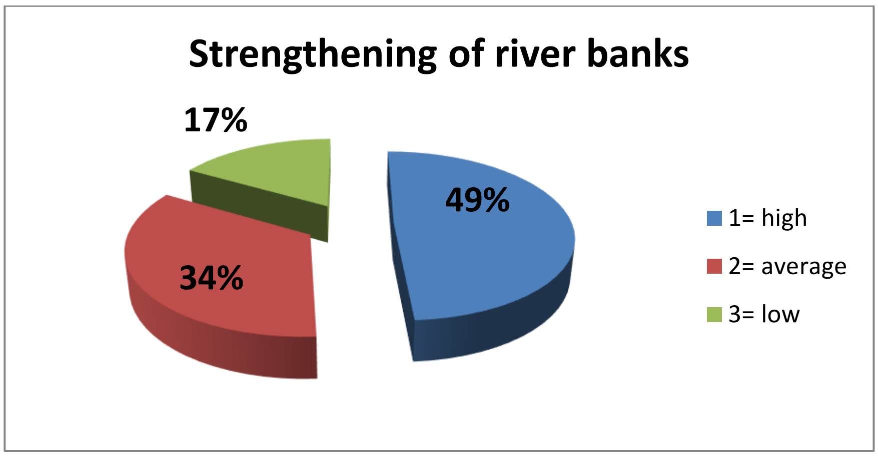
Measure 2.3



Measure 2.4



Measure 2.5

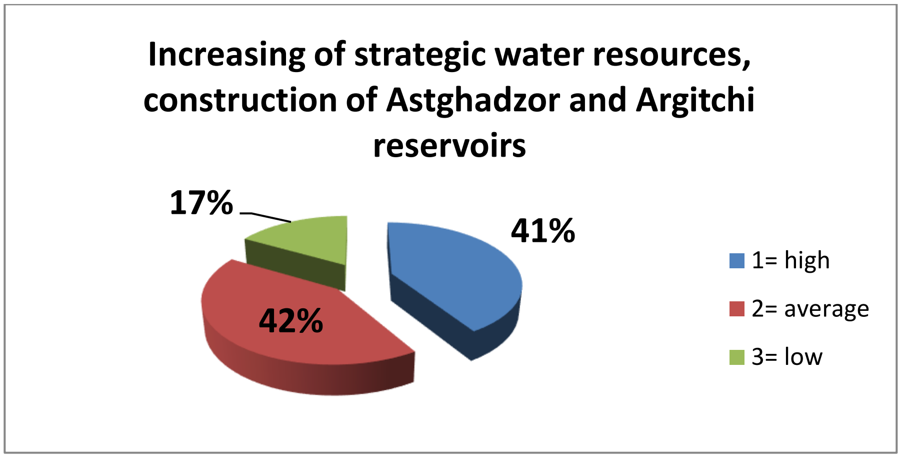


All flood and mudflow measures are of high importance for most residents, and of average or low importance for a smaller percentage.

3. The third problem is the lack of water storage facilities.

To solve this problem, the following measure is proposed: increasing of strategic water resources, construction of Astghadzor and Argitchi reservoirs (measure 3.1).

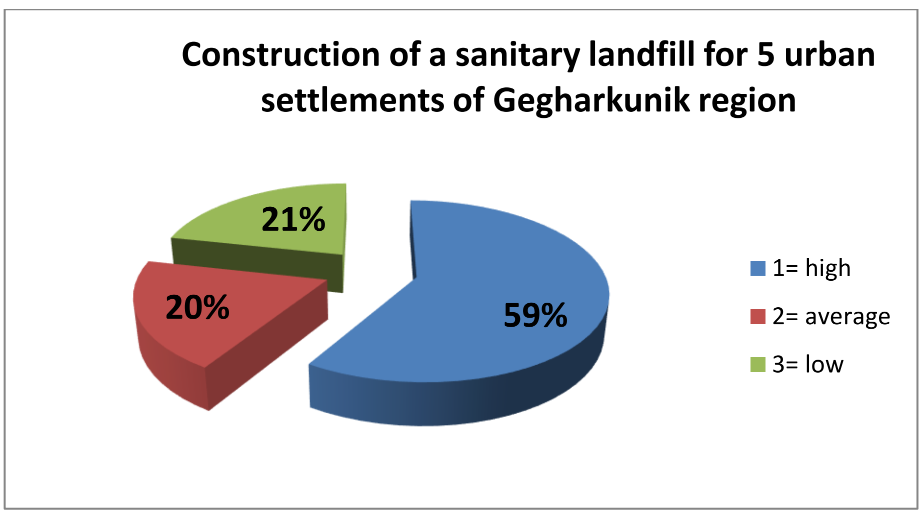
Measure 3.1



The measure aimed at the problem of lack of water storage facilities - increasing of strategic water resources, construction of Astghadzor and Argitchi reservoirs, is of almost equally high (42 residents) and average (43 residents) importance for the residents.

4. The fourth problem is pollution with solid household waste, for the solution of which the following measure is proposed: construction of a sanitary landfill for 5 urban settlements of Gegharkunik region (measure 4.1).

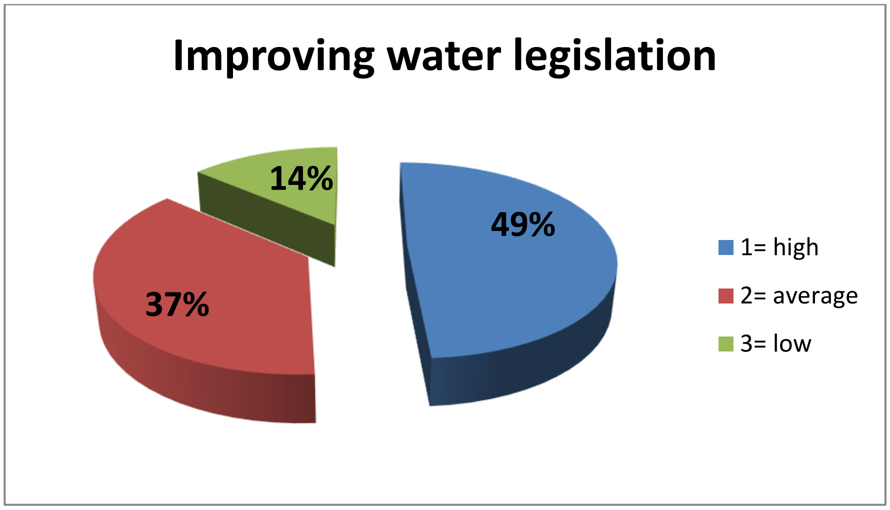
Measure 4.1



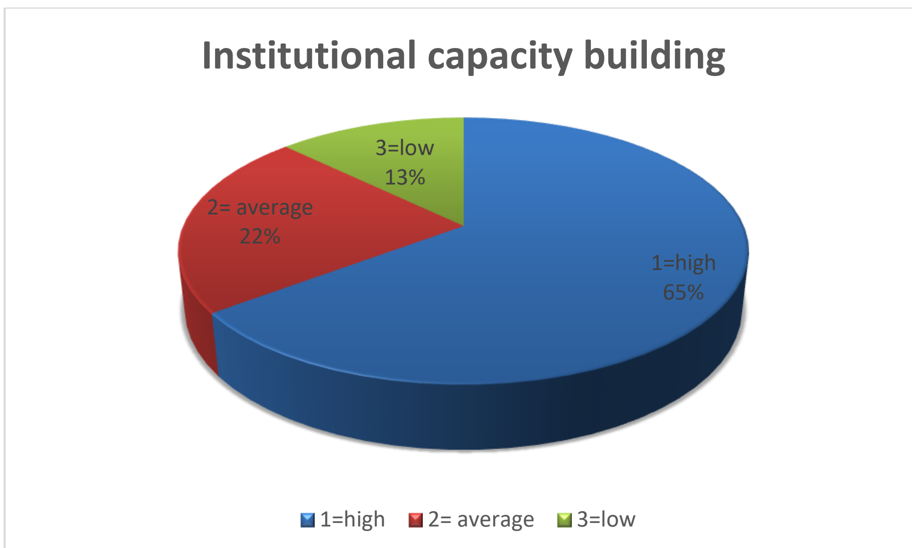
The measure aimed at the problem of pollution with solid household waste - the construction of a sanitary landfill for 5 urban settlements of Gegharkunik region, is of a high importance for 59% of the population (60 residents).

5. **The fifth problem is water management**. Two solutions are proposed for this problem: improving water legislation (5.1), strengthening institutional capacity (5.2).

Measure 5.1



Measure 5.2

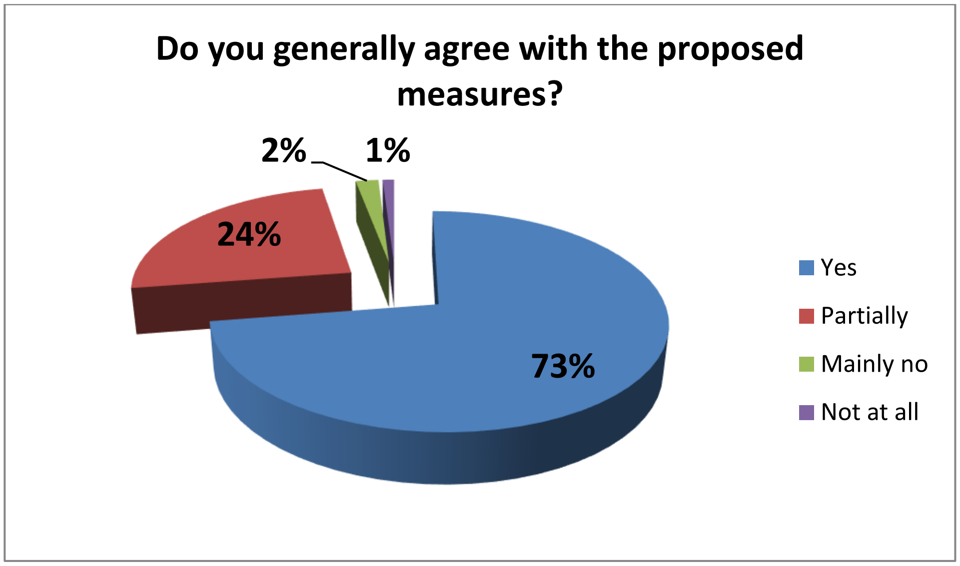


Measures to address water management issues are of high importance:

- Improving water legislation (60 residents)
- Institutional capacity building (66 residents).

QUESTION 3

73% of the population - 74 people - agree with the measures proposed in the basin management plan, 24% - 25 communities - partially agree, 2% - 2 people mostly disagree and 1% - 1 person does not agree at all.



QUESTION 4. In your opinion, in addition to the measures listed in the questionnaire at the basin level, are there other additional issues that need to be addressed?

Only 20 residents mentioned additional problems, they highlighted the following problems:

- Creation of a protective forest strip
- Remove animals from the basin, build a suitable place for the animals to drink water
- Regulate fish farming: this is to checked, if the matter is about the network fish farming
- Remove trees and fishing nets from the lake basin
- Raising public awareness and information on increasing water use efficiency
- Construction of sewerage systems in the communities and rest houses on the coastal slopes of Areguni mountain range: Tsovagyugh, Drakhtik, Aghberk, Shorzha, Artanish, Jil, Tsapatagh and Vardenis settlements. Include mining risk management (gypsum and chrome) in Artanish and Shorzha communities in the management plan;
- Cottages should be located at the maximum distance from the shore of the lake.

9.3 Conclusion on Two Public Conslutations

Within both public consultations, 129 questionnaires have been filled, thus, we the results of the public survey can be considered as representative for Sevan RBD. As it was already mentioned, the first public consultation was aimed to discuss the main issues in the RBD and the second one – the program of measures targeted to achieve the environmental objectives for water bodies.

The situation with COVID-19 complicated the implementation of the second public consultation: it was conducted through video meetings, the application of online questionnaire and mailing campaign. Unfortunately, it was impossible to organize the face-to-face discussion of the program of measures with local governments and community population.

It was identified by CWP that one month is not enough for public consultations and project team has spent more time for information, but not consultation feedback,

During the public consultations, some additional questions raised. 3 communities mentioned the following additional issues and respective measures:

- Cleaning Lake Sevan from polyethylene bottles, fishing net waste, tree roots; and
- Fishing regulation and restrictions.

20 residents mentioned the following additional issues and respective measures:

- Creating of a protective forest strip;
- Removing the animals from the basin, building a suitable place for the animals to drink water;
- Regulating the fish farming;
- Removing the trees and fishing nets from the lake's basin;
- Raising public awareness and information on increasing water use efficiency;
- Constructing sewerage systems in the communities and rest houses on the coastal slopes of Areguni mountain range: Tsovagyugh, Drakhtik, Aghberk, Shorzha, Artanish, Jil, Tsapatagh and Vardenis settlements;
- Including the questions relate to the mining risk management (gypsum and chrome) in Artanish and Shorzha communities in the next management plan; and
- Moving the cottages to the maximum distance from the shore of the lake.

Overall, it may be said that the process and results of public consultations conducted respecting th Article 14 of WFD proved that it is very important and efficient procedure in the basin management planning, as well as for involvement of the public in the implementation phase.

REFERENCES

Reports on Studies and Surveys related to the RBMP Development Conducted under EUWI+ Project

These reports have been developed within EUWI+ Project and available on: https://www.euwipluseast.eu/en/outputs

1. EUWI+ (2018a): Haener, P.,Villeneuve, P.-H., Pintus, F., Videnina, Y.: Assessment of the Needs and Identification of Priorities in Implementation of the RBMPs – Armenia. EUWI+ Project.
2. EUWI+ (2018b): Guidance for Developing River Basin Management Plans in Armenia. Complementary Document to the RBMP outlines. EUWI+ Project.
3. EUWI+ (2018c): Geoinfo Ltd.: Detailed Assessment of Modern Flow Measurement Equipment Needs for Irrigation Water Accounting in Sevan and Hrazdan Pilot Basins of Armenia. EUWI+ Project.
4. EUWI+ (2018d): Geocom Ltd.: “Delineation and Characterisation of Groundwater Bodies and the Design of a Groundwater Monitoring Network in the Hrazdan and Lake Sevan River Basin Districts in Armenia”. EUWI+ Project.
5. EUWI+ (2019a): Shahnazaryan, G., Zatikyan, A, Wolfram, G., Sigmund, E., Schaufler, K.: Surface Water Survey 2018 – Armenia. EUWI+ Project.
6. EUWI+ (2019b): Azizyan, L., Misakyan, E., Frunzikyan, H., Zornig, H. Schaufler, K.: Hydro-Morphological Assessment 2019 – Armenia. EUWI+ Project.
7. EUWI+ (2019c): Geocom Ltd.: Thematic Summary 1 – Development of Draft River Basin Management Plan for Sevan River Basin. EUWI+ Project.
8. EUWI+ (2019d): CWP: Report on Public Consultation on the Main Issues of Sevan Basin. EUWI+ Project.
9. EUWI+ (2019e): Konecny, R., Schaufler, K., Leitner, C., Scheidleder, A., Aghinyan, H., Shahnazaryan, G.: Water Monitoring Assessment Report – Armenia. EUWI+ Project.
10. EUWI+ (2019f): Hohenblum, P., Zeitz, F., Shahnazaryan, G.: Laboratory Assessment Report in Armenia.
11. EUWI+ (2019g): Anakhasyan, E., Arushanyan, A., Bakunts, N., Oganezov, T., Shahnazaryan, G.: Revision of National Targets in the context of the Protocol on Water and Health in Armenia. EUWI+ Project.
12. EUWI+ (2019h): Guidance on the WFD Compliant Use of Economic Analysis in the Development of Pilot RBMPs in the 6 EUWI + Countries. EUWI+ Project.
13. EUWI+ (2020a): Minasyan, S., Sargsyan , V., Misakyan, E., Shahnazaryan, G., Zakaryan; D., Zinke, A.: Delineation of Surface Water Bodies in Sevan and Hrazdan River Basins in Armenia. EUWI+ Project.
14. EUWI+ (2020b): Wolfram, G., Sigmund, E., Schaufler, S., Shahnazaryan, G., Karyan, V., Misakyan, E., Tonoyan, V.: Definition of Reference Conditions and Class Boundaries in Rivers of Armenia for the BQE Benthic Invertebrates. EUWI+ Project.
15. EUWI+ (2020c): Wolfram, G., Schaufler, S., Trauner, D., Vincze, G., Csar, D., Pichler-Scheder, C., Sigmund, E., Macaigne, P.: Surface Water Monitoring in the Sevan River Basin District, Armenia. EUWI+ Project.
16. EUWI+ (2020d): Schaufler, K., Wolfram, G., Trauner, D., Sigmund, E.: Surface Water Monitoring Development Plan – Armenia. EUWI+ Project.
17. EUWI+ (2020e) März: Shahnazaryan, G., Zatikyan, A, , Wolfram, G., Sigmund, E., Schaufler, K.: Surface Water Survey 2019 – Armenia. EUWI+ Project.
18. EUWI+ (2020f): Geocom Ltd.: Thematic Summary 1 – Development of Draft River Basin Management Plan for Sevan River Basin. EUWI+ Project.

Bibliography

1. Afanasyev G.D. “Bottom Sediments of Lake Sevan”. Basin of Lake Sevan. 1933, v. III, 2, p. 53-154.
2. Armenia's Third National Communication to the UNFCCC. Yerevan, 2015, 165 p.
3. Aslanian A.T. “About the Origin of Lake Sevan”. Proceedengs of Academy of Sciences of Armenian SSR, 1947, N8.
4. Atayan J. “Hydrological Conditions”. Geographical Issues. V. 1-2. Erosion and Mudflow Processes of Sevan Basin. Yerevan, YSU, 1984, p. 55-66.
5. Babayan A., Hakobyan S., Jenderedjian K., Muradyan S., Voskanov M. “Lake Sevan, Experience and lessons learned brief”, 2006.
6. Baghdasaryan A.B. “Physical geography of Armenian SSR”. 1971.
7. Bek-Marmarchev B.I. “Multi-year Curve of Level Fluctuations of the Lake Sevan”. Proceedings of Academy of Sciences of Armenian SSR, Physical-mathematical, Natural and Technical Sciences, 1951, v. IV, N1.
8. Bourdin L., S. Stroffek, C. Bouni, J.B. Narcy and M. Dufour (eds.) (2011): Restauration Hydromorphologique et Territoires.
9. Boynagryan V.R. “Lakes of Armenian Highlands”. Yerevan, YSU, 2007.
10. Boynagryan V.R. “Rivers and River Valleys of Armenian Highlands”. Yerevan, YSU, 2009.
11. Chilingaryan L., Mnatzakanyan B., Aghababyan K., Tockmajyan H., “Hydrography of Rivers and Lakes of Armenia”. Yerevan, 2002.
12. Common Implementation Strategy for the Water Framework Directive (2000/60/EC): Guidance document No. 1. Economics and the environment The implementation challenge of the Water Framework Directive. Luxembourg: Office for Publications of the Europe, 2003.
13. Common Implementation Strategy for the Water Framework Directive (2000/60/EC): Guidance document No. 11. Planning Processes. Produced by Working Group 2.9 – Planning Processes . Luxembourg: Office for Publications of the Europe, 2003.
14. Common Implementation Strategy for the Water Framework Directive (2000/60/EC): Guidance document No. 21. Guidance for reporting under the Water Framework Directive. Luxembourg: Office for Publications of the Europe, 2009.
15. Common Implementation Strategy for the Water Framework Directive (2000/60/EC): Guidance document No. 24. River Basin Management in Changing Climate. Luxembourg: Office for Publications of the Europe, 2009.
16. Comprehensive Agricultural Census of the Republic of Armenia for Gegharkunik Marz. Developed by Statistical Committee of the Republic of Armenia. 2014.
17. EC, 2000. Directive 2000/60/EC of the European Parliament and of the Council establishing a frame-work for community action in the field of water policy. European Community, Brussels.
18. Environmental Program Implementation Unit State Institution of the Ministry of Nature Protection of the Republic of Armenia. “Rationalization of Protected Areas System, Formation of Institutional Links of for the Management of Sanctuaries of Armenia”, 2013, 22 p.
19. EPTISA Servicios de Ingenieria S.L. (Spain) & Grontmij Carl Bro A.S. (Denmark), “Aghstev Pilot River Basin Management Plan – Armenia”. Prepared within the “Trans-Boundary River Management Phase II for the Kura River”project. 2011.
20. EU Nitrates Directive, (91/676/EEC), European Communities, 1991
21. EU Water Framework Directive, (2000/60/EC), European Communities, 2000 http://ec.europa.eu/environment/water/water-framework/index_en.html

22. EU Water Framework Directive, (2000/60/EC), European Communities, 2000 http://ec.europa.eu/environment/water/water-framework/index_en.html
23. European Environment Agency, “Towards a Shared Environmental Information System in the European Neighborhood. Building a SEIS for Lake Sevan, Armenia: Final Report on the Implementation of the Pilot Project and Recommendations for Follow-up”. 2014-2015.
24. European Parliament and Council 2000 Directive 2006/11/EC of the European Parliament and of the Council of 15 February 2006 on pollution caused by certain dangerous substances discharged into the aquatic environment of the Community.
25. Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia. Developed by the CES and "Jrtuq" LLC, 2015.
26. Gabrielyan H. “Sevan National Park”. Yerevan, 1983, 26 p.
27. Geocom Ltd./ "Kapan Communities' Union" NGO, “Model Guidelines for River Basin Management Planning in Armenia: Final Report”. Prepared within the USAID/PA Program for Institutional and Regulatory Strengthening of Water Management in Armenia. 2008.
28. Geoinfo LLC, “Inception Report on Preparation of Arpa River Basin Management Plan”. Prepared within the UNDP/GEF “Reducing Transboundary Degradation in the Kura-Ara(k)s River Basin”Project. 2013.
29. Guidance Document on Addressing Hydromorphology and Physico-Chemistry for a Pressure-Impact Analysis/Risk Assessment according to the EU WFD”, prepared by EPIRB Project, 2014, 61p.
30. Guidance document on the application of water balances for supporting the implementation of the WFD. Final – Version 6.1 – 18/05/2015. European Union, 2015
31. Harutyunyan L. “For More Beautiful Sevan”. Yerevan, 1981, 71 p.
32. Harutyunyan L. “Nature of Armenia, Ways of its Preservation and Enrichment”. Yerevan. 2005, 512 p.
33. Hydrography of Armenian SSR. Edited by A.B. Baghdasaryan. Yerevan, Academy of Sciences of Armenian SSR, 1981.
34. Hydromorphological alterations and pressures in European rivers, lakes transitional and coastal waters. Thematic assessment for EEA Water 2012 Report. ETC/ICM, Prague, 2012.
35. Illes J. [ED.] «Limnofauna Europea». Fischer, Stuttgart. 1967.
36. Kampa E., Hansen W. Definition of Maximum Ecological Potential. In: Heavily Modified Water Bodies. International and European Environmental Policy Series. Springer, Berlin, Heidelberg, 2004, 137-152pp.
37. Khanjyan N. “Specially Protected Nature Areas of Armenia”. Yerevan, 2004, 64 p.
38. Khoyetsyan A., Mkrtchyan R. “Causative Relations of Deforestation and Spatial-Temporal Assessment Principles in the Republic of Armenia”. Yerevan, 2006, 250 p.
39. List of the Nature Monuments of RA. Ministry of Nature Protection of RA, 2014.
40. Management Plan of “Sevan” National Park, 2007-2011.
41. Manukyan R. “Use and Integrated Management of the Water Resources of Lake Sevan”. Lake Sevan (Problems and Action Strategy). Yerevan, 1996.
42. Markov E.S. “Geographical Description of Lake Gokcha (Sevan)”. 1911, v. 1.
43. Melkonyan H., Gevorgyan A. “Evaluation of the Changes in Main Climatic Characteristics and Development of Scenarios”. Yerevan, 2017.
44. Milanovsky E.E. “Geological Structure and History of Sevan Depression Formation”. 1953.
45. Mnatsakanyan B.P. “Lake Sevan Basin (Nature, Climate and Water)”. Yerevan, Asoghik, 2007.
46. MNP: Vulnerability of water resources in the Republic of Armenia under climate change. Yerevan, 2009.

47. Model Guidelines for River Basin Management Planning in Armenia. PA Government Services Inc. (Subcontractors: "Geocom Ltd." and "Kapan Communities' Union"). Yerevan, October, 2008.
48. N 2-III-A2-1 sanitary rules and regulations on "Drinking water: Hygienic requirements for water quality at the centralized water supply systems: Quality control" No 876, 25.12.2002 Order of the Minister of Health
49. NABU, "Business for Biodiversity". Berlin/Yerevan, 2013, 36 p.
50. Paffenholz K.N. "About the Origin of Lakes Sevan, Van and Urmia". Proceedings of Academy of Sciences of Armenian SSR, Geological Series, 1950, N1, p. 125-138.
51. Project on Regional Planning of Lake Sevan Watershed Basin. Yerevan, 2013.
52. Public consultation on The River Basin Management Plan for Ireland (2018-2021).
53. RA Government Protocol Decision "On Approving Environmental Impact Assessment Standards for Small Hydro Power Plants Construction and Operation", 01.03.2018 N 8.
54. Resources of Surface Waters of USSR, 1973, v. 9 (by J. Atayan, 1984)
55. Rohrbach P. "Lakes Urmia, Van and Gokcha (Sevan)" (translation from German). Proceedings of Caucasus Branch of Russian Geographic Union, 1902, XV, N2.
56. S. Priestley: Water Framework Directive: Achieving Good Status of Water Bodies. Briefing Paper Number CBP 7246, 27 November 2015.
57. Sarkisyan S.G. "Petrographic-Mineralogical Studies of the Basin of Lake Sevan". Yerevan, 1962.
58. Sayadyan Ho., Sayadyan Ha. "Landscape Planning Methodological Guidelines with Examples from the Southern Caucasus Countries". Yerevan, 2009SHER Ingenieurs-Conseils, "Feasibility of the Master Plan for Integrated Water Resources Management in the Six Water Basin Management Areas of Armenia: Final Report". Prepared for the Ministry of Nature Protection of Armenia. 2013.
59. Short guide to improve small WWTP efficiency. Life Environment DG Demonstration Project LIFE04 ENV/PT/000687, 2006, 61p.
60. Tax Code of Republic of the Republic of Armenia. Adopted on October 4, 2016.
61. Ten Years of Experience in Reforming Water Management Sector in Armenia: Towards the EU Water Framework Directive, prepared within the "Transboundary River Management for the Kura River Basin Phase III – Armenia, Azerbaijan and Georgia" project. 2012.
62. The Official Bulletin of the Republic of Armenia, "National Water Program of the Republic of Armenia". 2006.
63. The Official Bulletin of the Republic of Armenia, "Republic of Armenia Law on Fundamental Provisions of the National Water Policy". Yerevan, 2005.
64. The Official Bulletin of the Republic of Armenia, "Water Code of the Republic of Armenia". 2002.
65. Trifonov V.G., Karakhanyan A.S. "The Origin and Holocene History of Lake Sevan". Geodynamics and History of Civilizations. Moscow, "Nauka, 2004, pp. 407-415.
66. Völker J., Richter S., Borchardt D., Mohaupt V. "Risk and monitoring based indicators of receiving water status: alternative or complementary elements in IWRM?", Water Science & Technology, 2013, v. 67.1, 33-39pp. Water Code of the Republic of Armenia. Adopted on June 4, 2002.WWF-Armenia. "Specially Protected Areas and Forests of Armenia", 2012, 52 p.

ANNEX 1. LAWS, GOVERNMENT RESOLUTIONS AND OTHER DOCUMENTS RELATED TO THE ENTIRE TERRITORY OF ARMENIA

№	Name of the Legal Act	Adopted by, Decision Number and Date of Adoption	Subject of Regulation
	Documents on Water Resources Management		
1	Resolution “On reformation of management of the water economy system”	The Government of the RA, 92-N, 9 February, 2001	Financial rehabilitation of companies of water economy system; improvement of quality of service of these companies, improvement of tariff policy, and implementation of economic reforms in the water sector.
2	Resolution “On approving the classification of exploitable underground water deposits and forecasted resources”	The Government of the RA, 94, 2 February, 2002	Classification of exploitable deposits of underground fresh water and forecasted resources.
3	Resolution “On approving the regulations and structure of the Water Resources Management Agency of the Ministry of Nature Protection of Armenia”	The Government of the RA, 649-N, 14 May, 2004	Definition and regulations of objectives, tasks, functions, organization of works of the Water Resources Management Agency of the Ministry of Nature Protection of Armenia”.
4	Water Code of the RA	RA National Assembly, HO-373-N, 4 June, 2002	Integrated river basin management; Distribution of water resources based on supply, and not demand Provision of water use permits based on monitoring information; Use of economic instruments in management and cost-recovery of water resources.
5	Law “On Water Users Companies and Water Users Companies Associations”	RA National Assembly, HO-374-N, 4 June, 2002	The objective of the Law is to define the scope of activity of the Water Users Companies and their Associations, the order for their establishment and termination, as well as the principles of their relationship with public and other bodies. The activity of these Institutions aimed at increasing the effectiveness of the

			irrigation system in the Republic of Armenia. Three previously operating WUAs within Sevan RBD (“Vardenis”, “Martuni” and “Gavar” are united to one – “Gegharkunik” WUA.
6	Resolution “On approving the water use permit exemplary sheets and water use permit forms”	The Government of the RA, 218-N, 7 March, 2003	Exemplary water use permit form sheet, and water use permit forms.
7	Resolution “On determination of the order of water resources abstraction rates and regime provided to water users”	The Government of the RA, 354-N, 13 March, 2003	Defines principles and rationale of water abstractions quantity and regimes from water resources use, according to water use purpose.
8	Resolution ”On approving the order for alternative re-inventory of water resources”.	The Government of the RA, 499-N, 3 April, 2003	Regulates the methodology of water abstraction quantity calculation in the territory of Armenia in case of hydrological monitoring absence post.
9	Resolution “On approving the order of using drainage waters”.	The Government of the RA, 461-N, 17 April, 2003	Regulates the order of drainage water use taking into consideration the relationship between the state management, self-governance bodies and legal and physical entities.
10	Resolution ”On the order of providing information on transboundary water resources”.	The Government of the RA, 612-N, 8 May, 2003	The document regulates the public disclosure of information on qualitative and quantitative indicators of transboundary water resources of the Republic of Armenia, as well as on conditions of their use, measures of prevention, limitation and reduction of transboundary effects and on the use and protection of water systems.
11	Resolution “On defining the specifics of status, composition, and use and protection of water objects-natural monuments”.	The Government of the RA, 620-N, 22 May, 2003	Assigning the status of natural monuments to lakes, rivers, ponds, geysers, thermal and mineral water springs and glaciers, their composition protection and use specifics.
12	On approving the order of water resources monitoring	The Government of the RA, 639-N, 22 May, 2003	Rules of water resources monitoring operative data collection, registration, processing summarization and reporting.

	implementation and registration of their reports		
13	Resolution “On approving the order transferring water use permit to the other entities and providing the right through subcontract”.	The Government of the RA, 702-N, 22 May, 2003	Transfer, including selling of water use permit or part of the permit right from holder of this permit to another entity.
14	Resolution “On approving the order of use of water resources for the needs of fish farms”.	The Government of the RA, 703-N, 22 May, 2003	The document regulates the order of water resources use for the fish-farming needs.
15	Resolution “On approving the order of using natural medicinal water resources”.	The Government of the RA, 812-N, 22 May, 2003	Rules of use of natural medicinal waters.
16	Resolution “On approving the order of free water use”.	The Government of the RA, 816-N, 5 June, 2003	Legal relationships related to free water use
17	Resolution “On approving the order for use and outflow permit of wells absorbing drainage water, consumed mines and open mines”.	The Government of the RA, 982-N, 10 July, 2003	Rules for providing water use and discharge permit for wells absorbing drainage wastewater from mining.
18	Resolution “On approving the order for document registration in the State Water Cadastre and provision of information”	The Government of the RA, 1060-N, 22 July, 2003	Rules for document flow in the State Water Cadastre, collection and provision of information, and related competence of the authorized body
19	RA Law “On Fundamental Provisions of the National Water Policy”.	RA National Assembly, HO-96, 3 May, 2005	Perspective development of strategic use and protection of water resources and water systems, Assessment of water resources accessibility, characterization of national water reserve, formation of water resources supply and demand, Water resources use priorities, Principles of River basin management and planning,

20	RA Law “On National Water Program”.	RA National Assembly, HO-232, 27 November, 2006	Establishing of concepts of National water reserve, Strategic water reserve, Usable water resources, Water supply and demand, protection and development of water sector, Implementation of national water program measures.
21	Resolution “On water quality maintenance depending on the river basin management district’s peculiarities”.	The Government of the RA, 75-N, 27 January, 2011	Defines quality classes for surface waters according to water use purpose considering the following quality indexes: temperature, Ph, concentration of the more than 30 chemical elements and compounds, biological and other pollutions. Also water quality norms defined in differentiated way, i.e. depending on the river basin management district`s peculiarities.
22	Resolution “On approving the outline of the model river basin management plan”.	The Government of the RA, 4, 3 February, 2011updated: 45-6, 26 October, 2017	The Law outlines the model of river basin management plan and development of technical characteristics for 6 water basin management plans.
23	Resolution”On definition of demand of drinking-domestic, agricultural waters demand and ecological leave in the each of river basin management districts of the Republic of Armenia”.	The Government of the RA, 927-N 30 June, 2011	Regulates provision of ecological equilibrium of water resources, protection of national water reserve and efficient organization of the water resources management.
24	Comprehensive and Enhanced Partnership Agreement (CEPA)	EU/Armenia, 24 November, 2017	European Union and Armenia signed an agreement aimed at significantly deepening their relations at a ceremony in Brussels on Friday held on the sidelines of the Eastern Partnership Summit. Signatures to the document entitled the Comprehensive and Enhanced Partnership Agreement (CEPA) were put by High Representative of the European Union for

			Foreign Affairs and Security Policy Federica Mogherini and Armenia's Foreign Minister Edward Nalbandian. With new agreement, among other things, Armenia will take obligations to approximate its legislation to the EU acts and international instruments. In the field of water quality and resources management, this approximation will include 5 Directives: Water Framework Directive, Floods Directive, Urban Wastewater Directive, Drinking Water Directive and Nitrates Directive.
	Other Strategic Documents		
1	Law of RA on Atmospheric Air Protection	RA National Assembly, HO-121, 1 November, 1994	The tasks are maintenance of purity of atmospheric air and improvement of its quality, reduction and prevention of chemical, physical, biological and other harmful impacts on a condition of atmospheric air, regulation of public relations, and also strengthening of legality in this sphere.
2	Flora Code of the RA	RA National Assembly, HO-22, 27 December, 1999	The law on Flora defines the State policy of the Republic of Armenia on scientifically motivated protection, maintenance, reproduction and use of natural flora.
3	Fauna Code of the RA	RA National Assembly, HO-52, 12 May, 2000	The law on fauna defines the State policy on protection, maintenance, reproduction and use of the wild species in the Republic of Armenia.
4	Land Code of the RA	RA National Assembly, HO-185, 2 May, 2001	Defines and regulates the basic directions of State regulatory system improvement concerning land relations, development of various organizational and legal forms of land economy, fertility of land, land use efficiency raise, protection and improvement of an environment – favorable for human vitality and health and the legal framework concerning the protection of the rights on land.
5	Law of RA on Freedom of Information	RA National Assembly, HO-11-N, 23 September, 2003	Regulates the relations connected with freedom of information, defines the powers of persons holding (possessing) information, as well as the procedures, ways and conditions to get information.
6	Forest Code of the RA	RA National Assembly, HO-211-N, 24 October, 2005	Regulates relations connected with sustainable forest management – guarding, protection rehabilitation, afforestation and rational use of forests and forest lands of the Republic of Armenia as well as with forest stock-taking, monitoring, control and forest lands.
7	Law of RA on Specially Protected Areas	RA National Assembly, HO-211-N, 27 November, 2006	Regulates the State policy of the development, restoration, protection, reproduction and use of ecological systems, natural complexes and separate objects representing special

			protected natural areas of the Republic of Armenia as ecological, economic, social, scientific, educational, historical-cultural, aesthetic, health, recreational value legal bases.
8	Mining Code of the RA	RA National Assembly, HO-280-N, 28 December, 2012	Defines principles and order of mining throughout the territory of the Republic of Armenia, governs relations associated with protection of nature and environment from deleterious effects, ensures security of works during mining, as well as protection of rights and legitimate interests of state and individuals during mining.
9	Law of RA on Environmental Impact Assessment and Expertise	RA National Assembly, HO-110-N, 21 June, 2014	Regulates public relations pertaining to environmental impact assessment in the Republic of Armenia, including state expert examination of transboundary and environmental impact assessment.
10	2014-2025 Strategic Program of Prospective Development of the Republic of Armenia	The Government of the RA, N 442 – N, 27 March, 2014	Three groups of aims are separated in the Strategic Program of Prospective Development: 1. During the period of 2008-2021, reducing material poverty to the level that it stops being the key problem to the economic development of the country, and extreme poverty is generally eliminated as a socially significant phenomenon. 2. Human poverty eradication and human progressive development, as a result of which the country had to move from a group of countries with moderate human development to a group of countries with high human development. 3. Restraint of economic development disparities and ensuring progressive growth of the lagging territories through the development and implementation of appropriate regional policy.
11	Second National Environmental Action Plan	The Government of the RA, 2008	NEAP–2 was developed in order to make environmental protection more efficient. It's provides a systematized package of environmental policy instruments to minimize the pressure on the natural environment. NEAP–2 should make the current and forthcoming sectorial strategies and action plans in the environmental sphere more coordinated; it must refer to the solution of both known and newly identified environmental problems, as well as consider RA international

			commitments in the environmental sector.
12	National Energy Efficiency Action Plan	The Government of the RA. 21 July, 2010	The main objective of the action plan is to contribute to the formulation of the future energy policy of Armenia and to define concrete steps for its implementation. One of the main aims of the national policy in the energy sector is defined to improve energy efficiency and to further develop the use of renewable energy sources.
13	Third National Communication on Climate Change	The Government of the RA, 2015	The Third National Communication (TNC) on Climate Change of the Republic of Armenia (Armenia) was developed according to Articles 4.1 and 12.1 of the United Nations Framework Convention on Climate Change (UNFCCC) and the Guidelines for national communications of Non-Annex I Parties to the Convention (UNFCCC 2003).

ANNEX 2. DOCUMENTS RELATED TO THE LAKE SEVAN

№	Name of the Legal Act	Adopted by, Decision No and Date of Adoption	Subject of Regulation
1	Resolution “On priority measures for regulation of conservation and use of natural resources of Lake Sevan”	The Government of the RA, 261, 22 April, 1999	This Decree establishes norms and tasks for improving the condition of the Lake Sevan caused by irrigation and water intake for energetics purposes and the abrupt decline of the lake level caused by the uncontrolled use of water in the lake basin and its ecological condition.
2	Law of RA on Lake Sevan	RA National Assembly, HO-190, 04 July, 2001	This Law establishes legal and program framework of the state policy for restoration, reproduction, protection and use of natural resources of Lake Sevan as of an ecosystem that has a strategic significance and economic, social, scientific, historical-cultural, esthetical, recreational and spiritual value for the Republic of Armenia.
3	Resolution “On authorizing the Ministry of Nature Protection of the Republic of Armenia as the state management body in the field of nature protection for Lake Sevan ecosystem restoration, conservation, reproduction, natural development and use”	The Government of the RA, 809, 05 September, 2001	The decision defines the empowerment of the Ministry of Nature Protection of RAauthorized in the field of environmental protection, restoration, reproduction, natural development and use of the Lake Sevan ecosystem.
4	Law of RA on “Adoption of the Annual and Complex Programs of Activities for the Use, Protection, Reconstruction and Reproduction of the Lake Sevan Ecosystem”	RA National Assembly, HO-276, 14 December, 2001	The main objective of the Program is to preserve Lake Sevan as a national and regional freshwater reserve, to restore the ecological balance and to ensure the harmonious development and sustainable use of the Lake Sevan basin ecosystem.

5	Resolution “On approving the list of substances, biogenic elements, heavy metals or their compounds having negative impact on Lake Sevan ecosystem”	The Government of the RA, 57, 24 January, 2002	This decision defines the list of substances (such as heavy metals or their compounds and other) which have a negative impact on Lake Sevan ecosystems, vital elements .
6	Resolution “On Reorganization of "Sevan" National Park State Institution, Approval of Charter of "Sevan" National Park and "Sevan National Park" State Non-Commercial Organization”	The Government of the RA, 927-N, 30 May, 2002	This resolution defines the reorganization of Sevan National Park State Non-Commercial Organization.
7	Resolution “On approving the project on regional planning of Lake Sevan catchment basin”	The Government of the RA,1787-N, 11 December, 2003	The decision defines the area of the Lake Sevan basin as an object of special regulation of urban development activities. This draft is approved by the territorial plan of Lake Sevan basin development.
8	Resolution “On establishing a foundation for restoration, conservation and development of Lake Sevan”	The Government of the RA, 517-N, 28 April, 2011	Established foundation for Lake Sevan restoration, protection and development, approved foundation statute.
9	Resolution “On approving of the program of measures on implementation of ecosystem and hydrological monitoring of Lake Sevan developed by the Committee on Lake Sevan Problems under the President of Armenia”	The Government of the RA, 987-N, 14 July, 2011	The resolution establishes the program of measures on the Lake Sevan ecosystem and hydrological monitoring developed by Presidental Commission on Lake Sevan issues.
10	Resolution “On Approving the Procedures for	The Government of the RA, 947-N,	This decision establishes the procedure for development of a unified and centralized electronic database of information on Lake

	Establishment of a Shared Electronic Database, Information Collection, Registration, Processing and Provision based on the Monitoring Data in Lake Sevan and its Watershed”	04 September, 2014	Sevan and its basin and order of data collection, registration, summarizing and information sharing to public.
11	Resolution “On 2018 Annual Program of Measures for Restoration, Protection, Natural Development and Use of Lake Sevan Ecosystem”	The Government of the RA, 1187-N, 28 September, 2017	This decision defines the annual (for 2018) program for restoration, protection, reproduction, natural development and utilization of Lake Sevan ecosystems.

ANNEX 3. GOVERNMENTAL ORGANIZATIONS IN WATER RESOURCES MANAGEMENT AND PLANNING SECTOR

№	Name of Institution	Legislative act and data of establishment	Subject of Regulation
1	Presidential Commission on Lake Sevan Issues	K-234-N 25.12.2008	‘’The Lake Sevan Issues Commission’’ was established to take responsible decisions aimed to preserve, restore and use water resources of Lake Sevan and its catchment basin, to submit proposals on the natural development of fauna, flora and ecological sub-systems.
2	Water Resources Management Agency of Ministry of Nature Protection of RA	N 82 30.01.2002	The Water Resources Management Agency under the Ministry of Nature Protection is responsibie for implementing the government’s water resources management and protection functionalities (for both surface water and groundwater) under the Water Code of RA (2002). This includes providing water availability and use estimates, water use regulation and allocation, issuing water use permits, monitoring, developing river basin management plans, ensuring that environmental needs for water are being met, and classifying water bodies.
3	Sevan Basin Management Office of the WRMA of Ministry of Nature Protection RA	2010	Sevan Basin management office (BMO) established for implementation decentralized Integrated river basin management. BMO authorized for Water Resources Management in Sevan Basin including provision of water use permits, water resources protection based on integrated river basin management principles, defines water resources management authorities.
4	Bioresources Management Agency of Ministry of Nature Protection RA	1236-N 8.08.2002	The Bioresources Management Agency of the Ministry of Nature Protection is the state authorized body to run the Flora and Fauna Cadastres as well as the Cadastre on Protected Areas. However, those cadastres are established on the paper only, no technical tools/information systems exist due to lack of allocations from the State budget.
5	State Committee on Water Systems (SCWS)	N 92 09.02.2001	The State Committee of Water Economy was created in the year of 2001 (by the The Government of the RA decree N 92 as of February 9, 2001 “About Reforms on water

			economy management system" N 92 decree point 2). By the Government decree N 1653 as of October 17, 2002, the Committee was recognized as an authorized body for water system management foreseen by the Water Code of the RA. Since the year of 2005 (Government decree N633, as of May 19, 2005) the State Committee of Water Economy is operating under RA Ministry of Territorial Administration as a state body of management sector of the ministry. The objectives and issues of the Committee are: a) provision of the management and safe use for the state-owned water and non-competitive water supply systems; b) provision of the National Water Program within the frameworks of its eligibility; c) development and implementation of investment policy on water systems, as well as the organization of investment project assessment.
6	Ministry of Agriculture		The Ministry of Agriculture of the Republic of Armenia is a republican body which develops and implements projects relating to the spheres of agriculture, intergovernmental cooperation in the field of agriculture, forestry, plant-growing, cattle-raising, irrigation and projects increasing the productivity of the soil usage.
7	Ministry of Health		The Ministry of Health of the Republic of Armenia is a state body, which develops and implements the policy of the Government of the Republic of Armenia in the field of healthcare, including problems of ensuring the quality of drinking water and other natural resources.
8	Gegharkunik Regional Administration (Marzpetaran)		The Marzpetaran implements the government's territorial policy and coordinates the activities of the territorial bodies of the republican executive bodies.
9	Experts Commission on Lake Sevan Conservation (Academy of Sciences of the Republic of Armenia)	HO-190 04.07.2001	The Expert Committee for the protection of Lake Sevan was established for independent and professional expertise of the documents developed by the State Authorized Bodies and Annual Programs (Reports), as well as the Authorized Bodies responsible for their

			implementation. The Expert Committee is in the structure of the National Academy of Sciences of the Republic of Armenia.
10	“Sevan” National Park State Non-commercial organization	Decree N 125 of Central Committee of the Communist Party of Armenian SSR and Board of Ministers in March 14, 1978.	“Sevan” National Park SNCO implements the conservation of natural ecosystems, landscape varieties and biodiversity, scientific researches of natural heritage, protection, regeneration, recovery, inventory, observation and the utilization of natural resources. It is a non-profit ecological scientific-research and cognitive organization and has a status of Legal Person who operates according to the constitution of RA , the law on “Special Protected Areas’’ and the law on ‘’State Non-Commercial Organizations’’ and to the charter of SNCO “Sevan” National Park and other legal acts. According to the law of RA on “Lake Sevan” the territory of national park was entirely included in the Central Zone of Sevan ecosystem and is defined as a special object for regulation of town building activities.

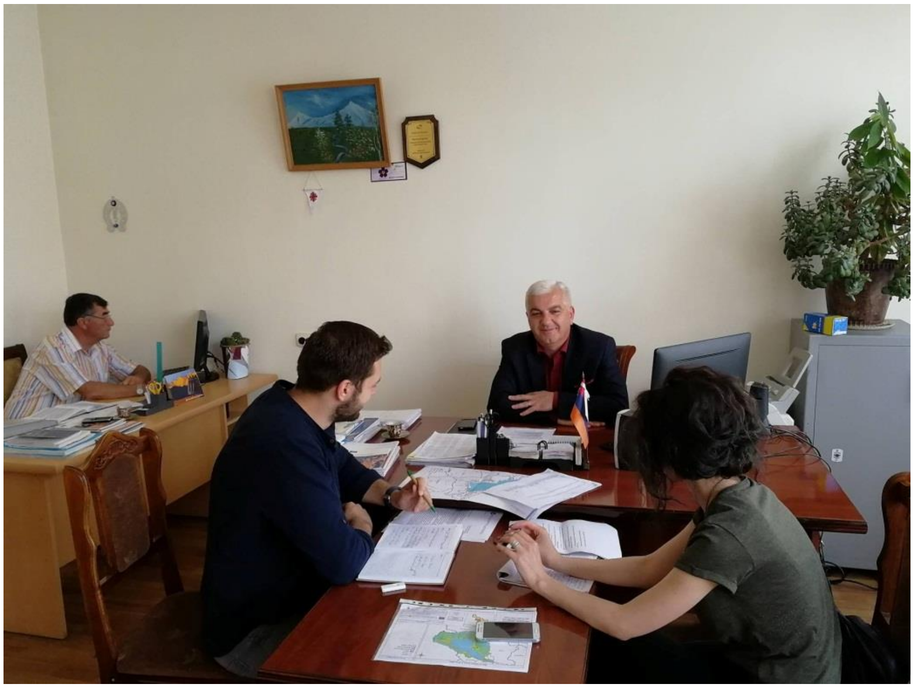
ANNEX 4. NON-GOVERNMENTAL ORGANIZATIONS (NGOS) DESCRIPTION

№	Name of NGO	Mission, Area of Expertise
1	“Country Water Partnership” NGO	The NGO is Armenian division of the Global Water Partnership (GWP) which goal is to support in introduction and development of integrated water resources management in countries, involving the public in the process, providing equity, efficiency and sustainability in water resources management process.
2	“Ecolur” Informational NGO	NGO aimed to provide expert assessments on environmental problems to: - organize media campaigns for nature and environment protection; - guarantee the right of everybody to the access to ecological information; - guarantee the right to healthy life and healthy environment; - involve youth in the processes concerning the rights to healthy life and healthy environment.
3	“Acopian Center for the Environment” NGO	Acopian Center for the Environment promotes the protection and restoration of the natural environment through research, education, and community outreach.
4	“Environmental Research and GIS Centre” NGO	ER&GIS Centre NGO are specialized in natural hazards and risk assessment and mapping, analysis of water resources, environmental research using geospatial technologies, provision of GIS trainings.
5	“Gavar Aarhus Ecological Information Center” NGO	NGO supports public access to environmental information in Gegharkunik marz and promotes public participation in the decision-making process in that area. The Center also contributes to the creation of a transparency for the public in environmental issues as well as to the country's overall democratization and transparent governance process.
6	“Biosophia” NGO	Mission of the NGO is to contribute to the development of healthy, environment-friendly public through the nature protection and the introduction of sustainable agriculture principles, as well as introduction of ecosystem approach principles, promoting civic activity, capacity building and environmental education and culture.
7	“Blejan environmental, social and business”s NGO	The main areas of NGO’s activities are: nature protection, agriculture, social and health issues and business support.
8	“Young Biologists Association” NGO	NGO’s mission is to consolidate young professionals from different fields of biology, to realize their ideas, and to implement biology and nature conservation oriented projects. NGO’s activities are also directed to expand youth participation towards society development.
9	“Bird Protection Union” NGO	Mission of the NGO is protection of birds and their natural environment, as well as disseminate nature protection principles to communities.
10	“Armenian Greens Union” NGO	The NGO aimed to promote the conservation of the biosphere, the efficient use of natural resources, implementation of measures to reduce the number of chemical fertilizers and pesticides in the agriculture and the hazardous emissions of GHGs.
11	“Environmental Public Advocacy Center” NGO	Activities of NGO include: - Preparation and discussion of draft legal acts on environmental

		protection, and their expert assessment; - Consultation on environmental legislation and related issues for public authority, NGOs and business; - Cooperation with competent and other concerned public authorities, NGOs, Aarhus centers, scientists, representatives of the business sector, local organizations, government and media concerning realization of environmental legislation of Armenia; - Creating and maintaining a database of environmental legislation of Armenia and the international legal instruments in this sphere, in particular the International Conventions of RA.
12	“Foundation for the Preservation of Wildlife and Cultural Assets” NGO	The Foundation is focused on nature conservation and environmental issues. FPWC has implemented projects nationwide and has an extensive experience in working with rural communities. FPWC’s mission is to protect Armenia’s unique biodiversity and to raise public awareness for nature conservation and environmental issues.
13	“Armenian Environmental Front” NGO	NGO aimed to nature protection and to supporting of social justice in natural resources utilization.
14	Ajhdahak Eco-center	Ajhdahak eco-center investigates environmental issues and publicizes problems.

ANNEX 5. PHOTOS FROM FIELD STUDIES

Meetings in Gegharkunik Regional Administration and Sevan BMO office, presentation of project objectives, data collection, discussions.



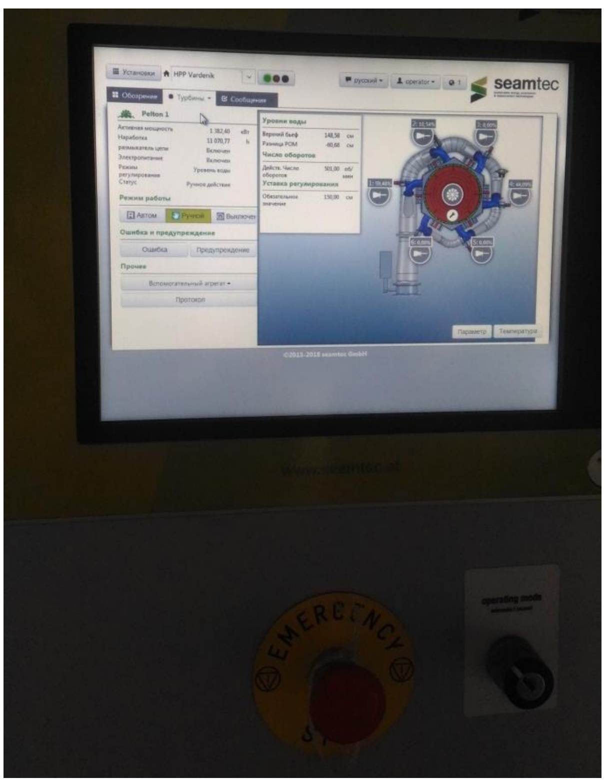
Gegharkunik Regional Administration

Sevan BMO office

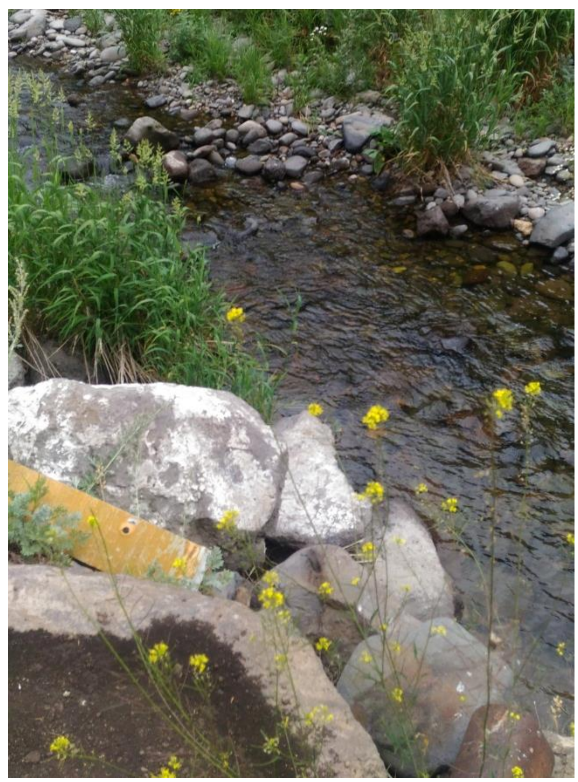
Open dump near Hayravank Community

Fish farm in Sarukhan Community

Vardenik SHPP on Vardenis River



Monitoring Software



Environmental Flow

Water Abstraction Structure

Fishways

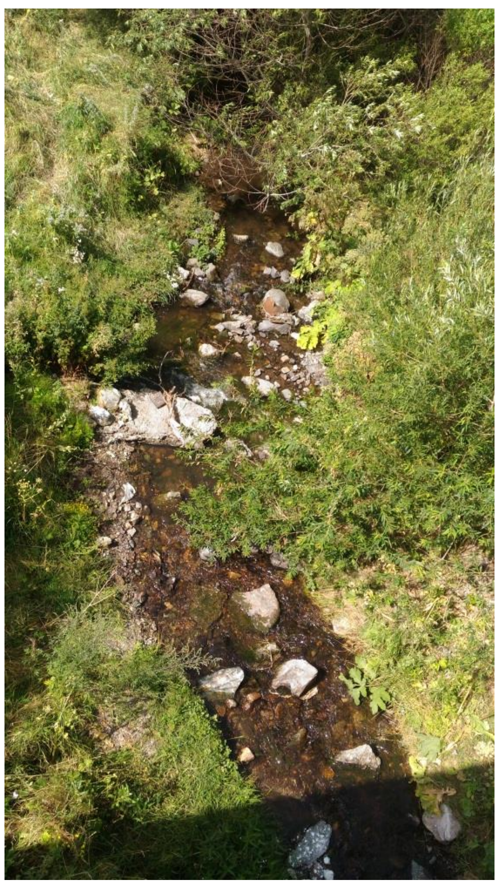
Fish Farm in Lichk Community

Wastewater Treatment Plant in Artsvakar District of Gavar Town

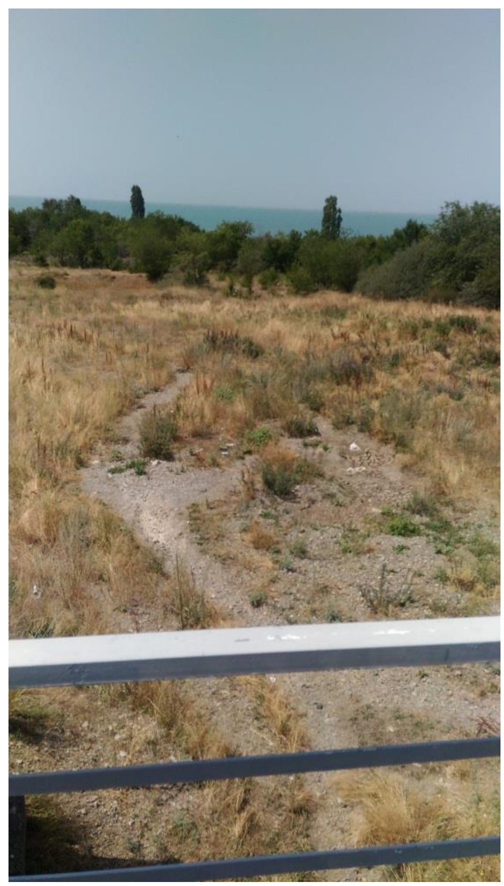
Field study on water quantity conditions in riverbeds within Sevan RBD, July 28, 2018

(online map with pop-up images of rivers is available at: https://arcg.is/yma4T).

Dzknaget



Drakhtik

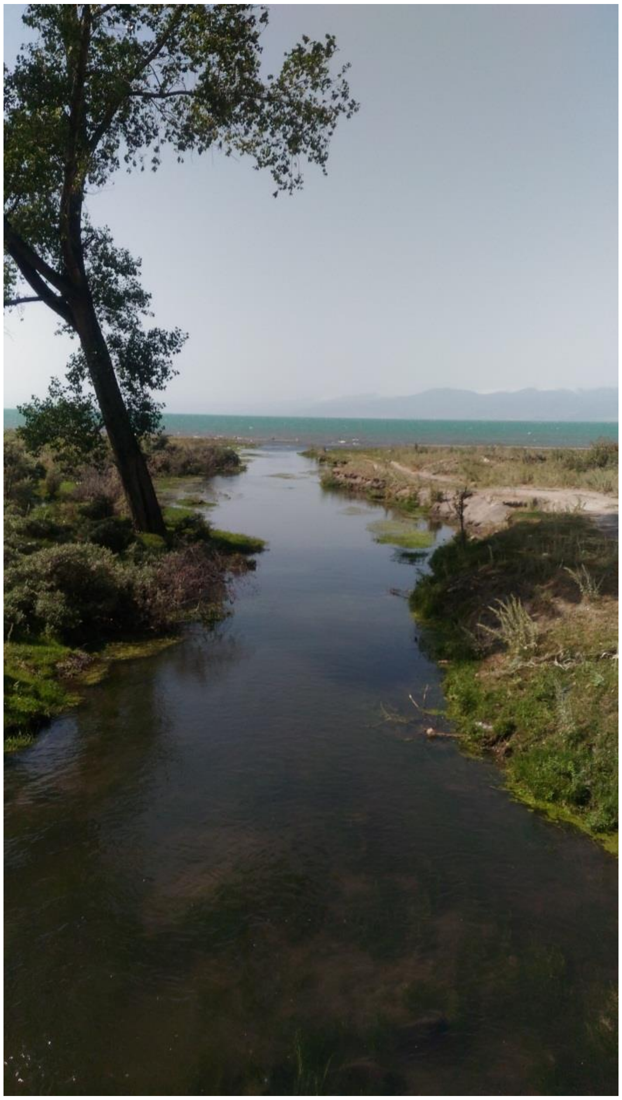


Tsapatagh

Jil

Pokr Masrik

Mets Masrik



Karchaghbyur

Arpa-Sevan Tunnel

Vardenis

Argichi

Lichk

Bakhtak

Gavaraget

ANNEX 6. CLIMATIC CHARACTERISTICS OF THE SEVAN RBD

Annex 6.1 Average Monthly and Annual Precipitation in Lake Sevan RBD, mm

Meteo Station	Elevation, m	Months												Annual Total
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Gavar	1961	17	19	33	44	72	72	61	46	40	38	30	17	489
Martuni	1945	23	28	41	54	71	69	42	29	33	39	39	24	492
Masrik	1940	19	19	27	37	62	65	43	35	29	43	31	22	432
Sevan, HMS	1936	25	30	40	65	103	79	50	40	37	51	38	25	583
Sevan, lake	1913	14	19	28	53	87	76	49	37	33	43	29	16	484
Semyonovka	2104	32	41	60	81	116	97	63	49	49	61	50	33	732
Shorja	1922	12	15	23	42	69	65	49	37	33	40	26	15	426
Yangh	2334	24	25	38	64	79	61	39	27	27	43	41	24	492
Areguni	2027	17	17	23	37	56	64	41	37	45	48	31	18	434
Artsvanist	1925	19	25	32	40	55	64	40	29	28	46	29	27	434
Chkalovka	1915	19	23	32	58	91	76	48	38	34	46	32	20	512
Daranak	1915	17	24	28	43	60	68	49	33	31	42	30	24	449
Drakhtik	2010	25	25	27	45	77	63	46	53	33	46	32	17	489
Dzoragyugh	1991	21	26	41	48	59	62	45	35	25	35	31	22	450
Geghamasar	2028	19	29	34	51	71	84	58	44	41	56	37	26	550
Gegharkunik	2028	34	40	54	53	84	84	53	47	38	41	38	30	596
Getashen	1975	27	37	46	55	65	71	45	29	30	38	41	29	513
Jil	2000	17	25	30	45	61	73	51	38	36	48	33	23	480
Karchaghbyur	1975	23	25	34	41	57	68	45	30	32	41	30	31	457
Lichk	1950	25	32	50	49	61	64	46	36	26	37	37	27	490
Madina	2247	34	41	57	77	99	99	59	43	46	59	52	34	700
Noraduz	1927	16	22	31	45	64	67	50	45	37	38	29	19	463
Pambak	2004	16	24	28	42	58	69	48	36	34	46	31	22	454
Sarukhan	1980	19	21	37	49	81	81	68	52	46	43	34	19	550
Nerkin Shorja	2366	26	33	43	53	68	91	67	46	34	49	34	39	583
Sotk	2009	26	27	33	42	69	80	51	49	36	45	31	26	515
Takakhach	1930	20	30	41	58	84	75	45	38	31	46	30	21	519
Tsaghkashen	2170	56	57	69	69	91	98	66	54	37	49	43	44	733
Tsakkar	1975	22	29	41	50	63	66	47	33	29	37	33	22	472
Tsapatagh	2050	16	25	29	44	60	72	50	37	35	47	32	23	470
Tsovagyugh	2000	31	41	52	71	98	86	50	40	38	56	43	30	636
Tsovak	1936	19	14	22	35	54	61	41	33	34	45	35	21	414
Vardenik	1984	23	24	35	43	61	66	38	26	34	43	33	24	450
Yeranos	1940	20	26	41	47	58	61	45	34	25	35	31	22	445

Annex 6.2 Average Monthly and Annual Temperature in Lake Sevan RBD, °C

Meteo Sation	Elevation, m	Months												Annual Average
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Gavar	1961	-7.5	-6.3	-2.5	3.9	8.9	12.5	15.7	15.8	12	6.7	0.6	-4.8	4.6
Martuni	1945	-5.7	-5.8	-1.7	4.8	9	12.9	16	15.8	12.8	7.5	2.4	-2.9	5.4
Masrik	1940	-8.5	-7.9	-3.1	4.2	9.4	12.9	16.2	16	12.5	6.7	0.6	-5.9	4.4
Noratus	1927	-5.5	-5.6	-2.2	3.9	8.9	12.6	16.1	16.2	12.9	7.6	1.9	-3.3	5.3
Semyonovka	2104	-7.4	-7.1	-4	2.4	7.3	10.4	13.3	13.3	10	5.6	0.3	-4.8	3.3
Sevan, HMS	1936	-8.2	-7.4	-3.3	3.5	8.8	12.1	15.7	15.7	12.2	6.4	0.6	-5.5	4.2
Sevan, lake	1913	-5.5	-5.3	-1.9	3.5	8.4	12.4	15.7	15.9	12.8	8	2.5	-2.8	5.3
Shorja	1922	-4.6	-4.6	-1.7	4.4	9.4	13.2	16.6	16.9	13.7	8.5	3.1	-1.9	6.1
Tsapatagh	2050	-4.4	-4.7	-1.5	4.4	9.5	13.2	16.4	16.5	13	8.2	3	-1.4	6
Vardenis	1930	-8.3	-6.8	-2.7	4.1	9.5	12.9	16.3	16.1	12.2	6.7	0.9	-5.1	4.7
Yangh	2334	-8.5	-7.8	-4.7	1.5	6.9	10.5	14	14.3	10.8	5.2	-0.6	-6.1	3

Annex 6.3 Average Monthly and Annual Relative Humidity of Air (%) in Lake Sevan RBD

Meteo Sation	Elevation, m	Months												Annual Average
		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	
Gavar	1961	71	71	69	66	69	70	70	71	68	69	70	71	70
Martuni	1945	68	71	69	66	68	70	72	72	65	65	66	68	68
Masrik	1940	76	77	75	69	68	69	67	68	66	70	74	76	71
Sevan, HMS	1936	81	80	77	72	73	72	70	68	65	69	76	82	74
Sevan, lake	1913	74	75	74	71	74	73	73	73	69	68	71	74	72
Semyonovka	2104	82	85	83	80	81	82	84	85	79	77	78	81	81
Shorja	1922	68	69	67	63	65	64	63	63	60	62	66	68	65
Yangh	2334	67	69	69	66	65	63	64	63	56	61	65	68	65

Annex 6.4 Snow Cover Formation and Loss Dates in Lake Sevan RBD

Meteo Station	Elevation, m	Number of Days with Snowcover			Snowcover Formation			Snowcover Loss		
		Average	Max.	Min.	Average	Earliest	Latest	Average	Earliest	Latest
Semyonovka	2104	145	191	99	29 X	23 IX	27 XII	27 IV	15 III	31 V
Sevan, lake	1917	121	170	52	11 XI	1 X	12 XII	18 IV	19 III	5 VI
Sevan, city	1937	136	178	66	9 XI	28 IX	26 I	19 IV	26 III	5 VI
Shorja	1917	77	140	15	12 XI	2 X	5 I	12 IV	5 III	29 V
Gavar	1961	96	155	48	9 XI	2 X	2 I	19 IV	6 III	21 VI
Masrik	1940	107	163	39	12 XI	2 X	21 XII	15 IV	4 III	29 V
Martuni	1943	103	163	40	10 XI	2 X	15 XII	22 IV	13 III	5 VI

Yangh	2334	165	192	133	25 X	19 IX	2 XII	7 V	9 IV	22 VI

ANNEX 7. NATURAL HAZARD EVENTS REGISTERED WITHIN SEVAN RBD

Annex 7.1 Flood events in Sevan RBD (Source: Ministry of Emergency Situations)

River	Flooding Date	Description
Norakert	23.07.2008	Heavy rains and hail damaged cropland. Several residential houses were flooded.
Gavaraget	15.04.1998	Gavaraget river flooded basement and first floors of houses in the village.
Gavaraget	11.05.2007	Around 200 households have incurred losses from the rise or Gavaraget river.
Gavaraget	09.05.2007	First floor and cellars of houses in Lord district of the city are flooded from Gavaraget river.
Gavaraget	03.05.2007	Gavaraget river flooded residential houses and barns in Artsvakar district of Town.
Masrik	14.03.2008	150 ha of cropland and 15 residential houses were flooded.
Masrik	25.04.2005	Masrik river flooded community cropland.
Sevan Basin	02.09.1994	Flooding in Yeranos village. 160ha of cropland, 18ha of potatoes, 90 tons of hay, 36 beehives, 600 tons of flour, 39 sacks of sugar and 4 bakeries have been damaged.
Tsakkar	11.05.2007	On May 10 water level increased and flooded 36 ha of wheat fields and 0.9 ha of potato field
Argichi	20.04.2005	Argichi river level has raised and flooded homesteas in the village.
Argichi	16.03.2010	Argichi river flooded 8-10 ha of arable land.
Martuni	31.05.2011	Around 30m of segments of embankments on Martuni river have been destroyed from floods.
Martuni	28.05.2007	2 Residential houses and 0.5 ha of homesteads were flooded.
Astghadzor	10.05.2007	River flooded pump station and power station feeding Astghadzor and Vaghashen villages near lake Sevan
Astghadzor	03.05.2007	Astghadzor river flooded about 5 ha of cropland.
Vardenis	28.05.2007	10 houses and 3 ha of cropland were flooded.
Artsvanist	28.05.2007	8 houses and 3.5 ha of cropland were flooded.

Annex 7.2 Debris flow Events in Sevan RBD (Source: Ministry of Emergency Situations)

River	Length, km	Area of basin, km^2	Dates
Hovsatsakhk	12	25,3	1953
Artsataberk	12	24,5	1942, 1958
Norakert	13	22,5	1957
Drakhtik	11	40	1927, 1936, 1939, 1942, 1946, 1953, 1954, 1955, 1958
Satanakhach	8	12,3	1958, 1959, 1960, 1963, 1964
Tsapatagh	10	19,7	1953, 1956, 1960
Pambak	10	25,4	1932, 1954
Jil	10	21,8	1958, 1960, 1963, 1964
Artunj	8	19	1930, 1939, 1964
Kaputjur	16	22,7	1950

Annex 7.3 Earthquake Events in 20th Century within Sevan RBD

Date	**Coordinates**		**Depth, km**	**Magnitude**	**Intensity**
	Latitude	**Longitude**			
14-10-1933	40.6	45.2	8	4.3	6-7
11-8-1945	40.5	45	9	4.3	6-7
5-9-1945	40.7	45	6	4.4	7
2-5-1947	40.5	45.27	15	4	-
28-12-1951	40.7	45	25	5.4	-
28-9-1953	40.4	45.8	14	4	5
31-10-1954	40.4	45.8	13	4.3	5-6
2-12-1992	40.18	45.33	33	4	-
20-1-1996	40.45	45.5	12	4.4	-

ANNEX 8. POPULATION DISTRIBUTION WITHIN SEVAN RBD (BY SUB-BASINS)

Community Name	Sub-Basin	Area (km^2)	Urban Population	Rural Population	Population Density (persons/km^2)
Lchashen	Inter-catchment	59.5	0	4,863	82
Tsovagyugh	Dzknaget	73.1	0	4,408	60
Norashen	Inter-catchment	13.03	0	434	33
Chkalovka	Inter-catchment	25.8	0	524	20
Semyonovka	Dzknaget	29.4	0	248	8
Gavar	Gavaraget	250.1	29,146	0	116
Berdkunk	Inter-catchment	8.6	0	291	33
Gandzak	Gavaraget	38.2	0	4,306	112
Gegharkunik	Gavaraget	38.04	0	1,874	49
Lanjaghbyur	Gavaraget	36.01	0	2,574	71
Lchap	Inter-catchment	25.3	0	1,159	46
Tsaghkashen	Gavaraget	23.05	0	537	23
Tsovazard	Inter-catchment	39.1	0	2,209	56
Karmirgyugh	Gavaraget	35.3	0	6,319	179
Hayravank	Inter-catchment	25.1	0	894	35
Noratus	Gavaraget	66.3	0	6,138	92
Sarukhan	Gavaraget	67.8	0	8,397	124
Martuni	Martuni	45.1	13,627	0	302
Astghadzor	Astghadzor	29.4	0	4,679	159
Geghhovit	Martuni	151.4	0	6,417	42
Yeranos	Yeranos	53.3	0	5,643	106
Zolakar	Zolakar	62.06	0	6,797	109
Tsovasar	Tsakkar	74.6	0	3,027	40
Litchk	Inter-catchment	91.6	0	5,269	57
Tsakkar	Bakhtak	38.4	0	2,911	76
Dzoragyugh	Tsakkar	58.8	0	4,704	80
Madina	Argichi	73.2	0	1,441	20
Nerkin Getashen	Argichi	25.7	0	8,785	341
Vaghashen	Inter-catchment	61.8	0	4,145	67
Vardadzor	Dzoragyugh	33.2	0	2,769	83
Vardenik	Vardenis	136.7	0	8,668	63
Verin Getashen	Argichi	104.5	0	4,789	46
Tsovinar	Inter-catchment	63.4	0	5,160	81
Artsvanist	Artsvanist	76.5	0	3,301	43
Akhpradzor	Karchaghbyur	46.4	0	395	8
Akunk	Masrik	98.6	0	4,199	42
Geghaar	Masrik	17.08	0	167	10
Lchavan	Karchaghbyur	19.3	0	578	30
Lusakunk	Masrik	12.4	0	1,632	131
Khachaghbyur	Masrik	47.1	0	1,334	28
Tsovak	Inter-catchment	26.3	0	2,749	104
Karchaghbyur	Karchaghbyur	56.6	0	2,550	45
Makenis	Karchagbyur	40.04	0	540	13
Mets Masrik	Masrik	35.3	0	3,414	96
Norakert	Pokr Masrik	27.3	0	1,017	37
Vanevan	Inter-catchment	7.9	0	334	42

Torfavan	Masrik	7.1	0	513	72
Vardenis enlarged community:		129.6	15,950		123.0
Vardenis	Masrik	37.6	15,272		406
Ayrk	Masrik	33.6	0	491	14
Nerkin Shorzha	Masrik	36.6	0	77	2
Verin Shorzha	Masrik	21.7	0	110	5
Geghamasar enlarged community:		544.7	7,133		13.0
Sotk	Masrik	75.8	0	950	12
Azat	Masrik	14.4	0	136	9
Avazan	Pokr Masrik	17.7	0	201	11
Areguni	Areguni	40.2	0	319	8
Arpunk	Pokr Masrik	31.07	0	562	18
Geghamabak	Masrik	4.9	0	130	26
Geghamasar	Sarinar	48.6	0	1,081	22
Daranak	Satanakhach	31.5	0	207	6
Kakhakn	Masrik	39.4	0	385	10
Kut	Masrik	32.3	0	176	5
Kutakan	Masrik	53.6	0	247	5
Norabak	Masrik	41.7	0	269	6
Shatjrek	Masrik	6.9	0	437	63
Shatvan	Masrik	12.5	0	448	36
Jaghatsadzor	Masrik	11.6	0	156	13
Tretuk	Masrik	27.02	0	207	8
Pambak	Pambak	36.5	0	481	13
Pokr Masrik	Pokr Masrik	18.3	0	741	40
Shoghakat enlarged community:		319.5	3,518		11.0
Shoghakat	Inter-catchment	39.2	0	568	14
Artanish	Artunj	56.2	0	612	11
Aghberk	Inter-catchment	39.6	0	316	8
Drakhtik	Drakhtik	96.3	0	1,009	10
Tsapatagh	Babagdan	33.7	0	341	10
Jil	Jil	54.3	0	672	12

ANNEX 9. CURRENT HYDRO-METEOROLOGICAL NETWORK WITHIN THE SEVAN RBD

Annex 9.1 Water Quantity Monitoring Sites on Rivers within Sevan RBD (Source: Armenian State Hydromet)

Code	Water Object Name	Name of Site	Coordinates		"0" graph mark (m)	Observation Period
			Latitude	Longitude		
85352	r. Dzknaget	Tsovagyugh	40^{0}37’03,45’’	44^{0}57’42,71’’	1909.14	1926 - 34,1936 - present
85353	r. Drakhtik	Drakhtik	40^{0}32’46,27’’	45^{0}12’44,00’’	1920.92	1968 - 95,1998 - present
85339	r. Pambak	Pambak	40^{0}23’05,79’’	45^{0}32’02,74’’	1994.52	1968 - 94,1997 - present
85363	r. Masrik	Tsovak	40^{0}13’08,03’’	45^{0}39’08,33’’	1908.16	1967 - present
85366	r. Karchaghbyur	Karchaghbyur	40^{0}10’45,05’’	45^{0}34’55,85’’	1904.69	1926 - 30,1950,1952 - 95,1997 - present
85370	Arpa-Sevan tunnel	Tsovinar	40^{0}09’22,56’’	45^{0}29’40,81’’	1899.42	1968 - present
85371	r. Vardenis	Vardenik	40^{0}07’57,93’’	45^{0}26’34,16’’	1961.71	1957 - 95,1997 - present
85376	r. Martuni	Geghhovit	40^{0}05’49,56’’	45^{0}16’59,05’’	2049.29	1954 - present
85378	r. Argitchi	Verin Getashen	40^{0}07’52,34’’	45^{0} 15’17,76’’	1947.87	1926 - present
85379	r. Tsaghkashen	Vaghashen	39^{0}59’52.92’’	45^{0}12’39.30’’	2262.00	1970 - 2001,2004 - present
85380	r. Lichk	Lichk	40^{0}10’00,66’’	45^{0}14’35,66’’	1912.60	1976 - present
85381	r. Bakhtak	Tsakkar	40^{0}10’05,83’’	45^{0}13’14,65’’	1934.85	1951 - present
85384	r. Gavaraget	Noratus	40^{0}22’38,95’’	45^{0}10’15,91’’	1912.70	1926 - 44,1946,1948 - 50,1952 - 92,1997 - present

Annex 9.2 Water Quantity Monitoring Sites on Lake Sevan (Source: Armenian State Hydromet)

Code	Water Object Name	Name of Site	Coordinates	
			Latitude	Longitude
85531	Lake Sevan	Sevan	40⁰33’46,05’’	45⁰00’30,31’’
85532	Lake Sevan	Shorja	40⁰29’50,00’’	45⁰16’12,00’’
85534	Lake Sevan	Karchaghbyur	40⁰10’42,00’’	45⁰33’52,00’’
85535	Lake Sevan	Martuni	40⁰09’44,30’’	45⁰18’27,42’’

Annex 9.3 Water Quality Monitoring Sites within Sevan RBD (Source: Environmental Monitoring and Information Center SNCO)

Number	River	Location of Sampling Site	Coordinates	
			Latitude	Longitude
60	Dzknaget	0.5 km upstream of the village Semyonovka	40° 39' 11" N	44° 53' 31.9" E
61	Dzknaget	River mouth	40° 37' 1.52" N	44° 57' 45.8" E
62	Masrik	0.5 km upstream of the village Verin Shorja	40° 06' 39.99" N	45° 50' 14.23" E
63	Masrik	River mouth	40° 13' 16.83" N	45° 38' 40.56" E
64	Sotk	1.5 km upstream of the mine	40° 13' 55.90" N	45° 56' 21.20" E
65	Sotk	River mouth	40° 12' 02.6" N	45° 51' 06.7" E
66	Karchaghbyur	0.5 km upstream of the village Akhpradzor	40° 05' 41.9" N	45° 38' 36.3" E
67	Karchaghbyur	River mouth	40° 10' 45.3" N	45° 34' 56.8" E
68	Arpa-Sevan tunnel	0.7 km upstream of the village Tsovinar	40° 09' 22.58" N	45° 29' 40.84" E
69	Vardenis	0.5 km upstream of the village Vardenik	40° 07' 53.89" N	45° 26' 34.54" E
70	Vardenis	River mouth	40° 09' 16.10" N	45° 26' 17.54" E
71	Martuni	0.5 km upstream of the village Geghhovit	40° 04' 40.78" N	45° 17' 40.60" E
72	Martuni	River mouth	40° 09' 02.1" N	45° 18' 00.7" E
73	Argichi	0.5 km upstream of the village Lernahovit	40° 01' 56.4" N	45° 14' 13.0" E
74	Argichi	River mouth	40° 09' 20.5" N	45° 16' 04.4" E
75	Tsakkar	River mouth	40° 11' 09.9" N	45° 13' 35.3" E
76	Shoghvak	River mouth	40° 10' 51.4" N	45° 13' 49.7" E
77	Gavaraget	0.5 km upstream of the village Tsaghkashen	40° 17' 32.93" N	45° 02' 37.17" E
78	Gavaraget	River mouth	40° 21' 49.7" N	45° 10' 38.3" E

Annex 9.4 Water Quality Monitoring Sites on Lake Sevan (Source: Hydrometeorology and Monitoring Center SNCO)

Number	Location of Sampling Site	Coordinates	
		Latitude	Longitude
115-Maj.S	Tsapatagh-coastal	45.46089	40.40914
115’-Maj.	Tsapatagh-central	45.44769	40.40508
116-Maj.S	Pambak-coastal	45.53225	40.36483
116’-Maj.	Pambak-central	45.51911	40.36056
117-Maj.S	Areguni-coastal	45.59022	40.32406
117’-Maj.	Areguni-central	45.584	40.3225
118-Maj.S	Gili-coastal	45.63047	40.25264
118’-Maj.	Gili-central	45.59589	40.27633
119-Maj.S	Arpa-coastal	45.49514	40.16525
119’-Maj.	Arpa-central	45.52719	40.22492
120-Maj.S	Tsovinar-coastal	45.45042	40.18842
120’-Maj.	Tsovinar-central	45.45658	40.20692
121-Maj.S	Martuni-coastal	45.30122	40.16869
121’-Maj.	Martuni-central	45.30433	40.18178
122'-Maj.S	24th station-central	45.24199	40.23124
123-Maj.S	Karmirgyugh-coastal	45.22214	40.286
123’-Maj.	Karmirgyugh-central	45.27681	40.28728
124-Maj.S	Noratus-coastal	45.23767	40.39383
124’-Maj.	Noratus-central	45.33211	40.38058
125-Min.S	Gavaraget-coastal	45.19636	40.42908
125’-Min.	Gavaraget-central	45.18486	40.44906
126-Min.S	Ayrivank-coastal	45.11172	40.43736
126’-Min.	Ayrivank-central	45.12369	40.45083
127-Min.S	Model-coastal	45.00763	40.51261
127’-Min.	Model-central	45.0273	40.51967
128-Min.S	Lcashen-coastal	44.96053	40.52589
128’-Min.	Lcashen-central	44.98335	40.52035
129-Min.S	Tsovagyugh-coastal	44.98456	40.61978
129’-Min.	Tsovagyugh-central	44.98268	40.61211
130-Min.S	Gyunei-coastal	45.04525	40.60908
130’-Min.	Gyunei-central	45.04631	40.609
131-Min.S	Shorja-coastal	45.25161	40.48975
131’-Min.	Shorja-central	45.26961	40.49689

Annex 9.5 Meteorological Stations within Sevan RBD (Source: Armenian State Hydromet)

Stations	Latitude	Longitude	Altitude, m	Observation Period
Semyonovka	40° 39'	44° 54'	2104	1894-present
Lake Sevan	40° 34'	45° 00'	1919	1926-present
Shorzha	40° 30'	45° 16'	1917	1913-present
Gavar	40° 21'	45° 08'	1950	1890-1917; 1920-present
Masrik	40° 14'	45° 45'	1940	1937—present
Martuni	40° 08'	45° 19'	1943	1926-present

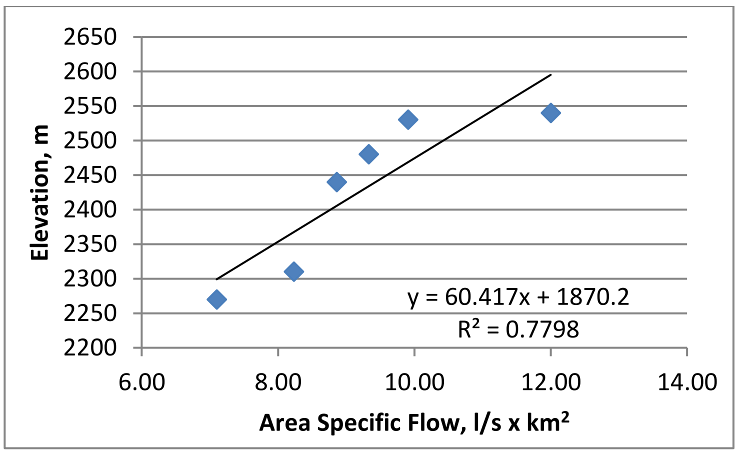
ANNEX 10. SEASONAL DISTRIBUTION OF RIVER FLOW IN SEVAN RBD

River	Monitoring Site	Unit	Months		
			XI - II	III - VI	VII - X
Dzknaget	Tsovagyugh	mln. m^3	2.65	28.22	3.68
		%	7.67	81.69	10.64
Drakhtik	Drakhtik	mln. m^3	0.94	4.63	1.15
		%	13.98	68.93	17.09
Pambak	Pambak	mln. m^3	1.07	3.98	1.27
		%	16.95	62.94	20.11
Masrik	Tsovak	mln. m^3	27.64	48.11	28.58
		%	26.50	46.11	27.39
Karchaghbyur	Karchaghbyur	mln. m^3	9.73	14.09	8.82
		%	29.82	43.16	27.03
Vardenis	Vardenik	mln. m^3	7.11	32.20	10.43
		%	14.29	64.74	20.96
Martuni	Geghhovit	mln. m^3	7.84	33.81	11.28
		%	14.82	63.88	21.30
Argichi	Verin Getashen	mln. m^3	24.41	125.68	21.76
		%	14.20	73.13	12.66
Tsaghkashen	Vaghashen	mln. m^3	6.12	35.20	7.45
		%	12.54	72.18	15.27
Lichk	Lichk	mln. m^3	18.98	19.50	20.71
		%	32.06	32.95	34.99
Bakhtak	Tsakkar	mln. m^3	1.94	17.19	1.49
		%	9.42	83.38	7.21
Gavaraget	Noratus	mln. m^3	30.76	50.72	28.86
		%	27.88	45.96	26.16
Arpa - Sevan tunnel	Tsovinar	mln. m^3	22.26	71.97	24.10
		%	18.81	60.82	20.37

ANNEX 11. REGIONAL CURVES FOR AREA SPECIFIC FLOW WITHIN SEVAN RBD

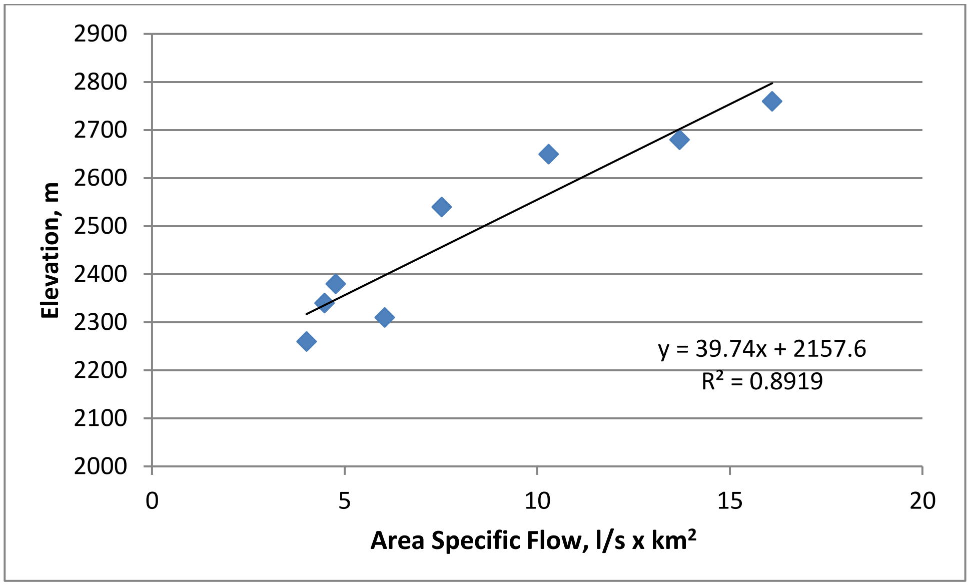
Curve 1.

River-Post	M, l/s x km²	H, m
Tokhluja-Tokhluja	7.10	2270
Artanish-Artanish	8.23	2310
Jil-Jil	9.33	2480
Shampirt-Babajan	8.86	2440
Pambak-Pambak	12.0	2540
Dara-Dara	9.91	2530



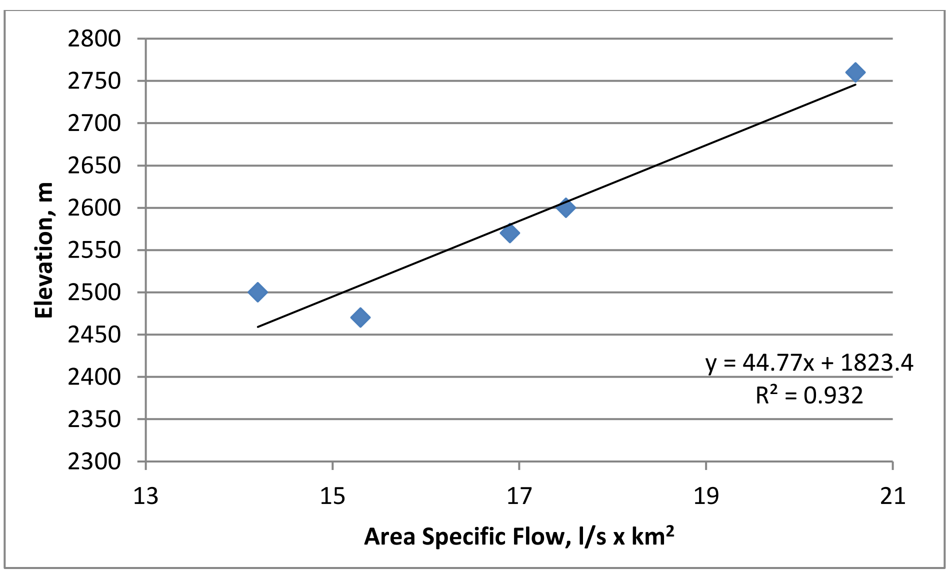
Curve 2.

River-Post	M, l/s x km²	H, m
Masrik-Mets Mazra	4.77	2380
Masrik-Bazargechar	4.48	2340
Masrik-Tsovak	6.04	2310
Karchaghbyur-Karchaghbyur	10.3	2650
Artsvanist=Artsvanist	7.52	2540
Vardenis-Vardenik	16.1	2760
Vardenis-Vardenik	13.7	2680
Zolakar-Zolakar	4.01	2260



Curve 3.

River-Post	M, l/s x km^2	H, m
Martuni-Geghhovit	20.6	2760
Argichi-Verin Getashen	15.3	2470
Argichi-Getashen	14.2	2500
Karadzi-Karadzi	17.5	2600
Tsaghkashen-Vaghashen	16.9	2570



ANNEX 12. WATER BODIES DELINEATED WITHIN SEVAN RBD IN ACCORDANCE WITH HYDROMORPHOLOGICAL AND HYDROLOGICAL PARAMETERS AND CRITERIA

WB number	River name	Name of delineated WB	Risk analysis
4-001	Dzknaget	The river Dzknaget from the source to the merge of right tributeris	WB not at risk
4-002	Dzknaget river	Right tributary of the river Dzknaget	WB not at risk
4-003	Dzknaget	River Dzknaget from right tributary to the estuary	WB possible at risk
4-004	Drakhtik	Drakhtik River together with its tributaries Tandzut and Yerkaynadzor to the village Drakhtik	WB not at risk
4-005	Drakhtik	Drakhtik river from Drakhtik settlement to the estuary	WB not at risk
4-006	Drakhtik	River Drakhtik from village Drakhtik to estuary	WB at risk
4-007	Artsataghberq	The Artsataghberq River from the source to the Sakavjar tributary, along with the Sakavajur tributary	WB not at risk
4-008	Artsataghberq	Artsataghberk river from mix up Sakavjur tributary to the estuary	WB not at risk
4-009	Artanish	Artanish river from the source to the estuary	WB not at risk
4-010	Artunish	River Artanish from village Artanish to estuary	WB possible at risk
4-011	Gijget	The river Gizhget from source to estuary	WB not at risk
4-012	Jil	The river Jil from source to estuary	WB not at risk
4-013	Jil	River Jil from village Dzorashen to estuary	WB at risk
4-014	Tsapatagh	The river Tsapatagh from source to confluence its tributary Yeghegnadzor-with tributary Yeghegnadzor	WB not at risk
4-015	Tsapatagh	The river Tsapatagh-from confluence tributary Yghdzadzor to estuary	WB not at risk
4-016	Tsapatagh	River Tsapatagh from village Tsapatagh to estuary	WB at risk
4-017	Shampur	The river Shampur from source to estuary	WB not at risk
4-018	Pambak	The river Pambak from source to confluence left tributary- with left tributary	WB not at risk
4-019	Pambak	The river Pambak from confluence its left tributary to estuary	WB not at risk
4-020	Pambak	River Pambak from village Pambak to estuary	WB at risk
4-021	Daranak	The river Daranak from source to confluence its left tributary Satanakhach-with left tributary Satanakhach	WB not at risk
4-022	Daranak	The river Daranak from confluence its left tributary Satanakhach to estuary	WB not at risk
4-023	Areguni	The river Areguni from source to confluence its left tributary Hovsatagh-with tributary Hovsatagh	WB not at risk

WB number	River name	Name of delineated WB	Risk analysis
4-024	Areguni	The river Areguni from confluence its tributary Hovsatagh to estuary	WB not at risk
4-025	Sarinar	The river Sarinar-Right tributary of the river Geghamasar	WB not at risk
4-026	Geghamasar	The river Geghamasar from source to village Geghamasar	WB not at risk
4-027	Geghamasar	The river Geghamasar from village Geghamasar to estuary	WB not at risk
4-028	Kapuytjur	The river Kaputjur-right tributary of the river Poqr Masrik	WB not at risk
4-029	Small Masrik	The river Poqr Masrik from source to confluence tributary Norakert-with tributary Norakert	WB not at risk
4-030	Small Masrik river	The river Poqr Masrik from confluence tributary Norakert to estuary	WB not at risk
4-031	Sotq	River Sotq from mine of Sotq to mixing with Masrik river	WB at risk
4-032	Sotq	The river Sotq in sources, and its tributaries till village Sotq	WB not at risk
4-033	Kut	The river Kut-right tributary of the river Sotq	WB not at risk
4-034	Daranak	The river Daranak-right tributary of the river Sotq	WB not at risk
4-035	Azat	The river Azat-right tributary of the river Sotq	WB not at risk
4-036	Masrik	The river Masrik from source to village Jaghacdzor	WB not at risk
4-037	Masrik	The river Masrik from village Jaghacdzor to confluence tributary Sotq	WB not at risk
4-038	Masrik	River Masrik-from the the confluence of River Sotq to the confluence of waste water of city Vardenis	WB at risk
4-039	Sevajur	The river Sevajur-right tributary of the river Masrik	WB not at risk
4-040	Zangik	The river Zangik-right tributary of the river Sevajur	WB not at risk
4-041	Masrik	River Masrik-from the confluence of waste water of Vardenis city to estuary	WB at risk
4-042	Akunq	The river Akunq-left tributary of the river Masrik	WB not at risk
4-043	Karchaghbyur	The river Karchaghbyur from source to village Akhpradzor	WB not at risk
4-044	Karchaghbyur	The river Karchaghbyur from village Akhpradzor till village Maqenis	WB not at risk
4-045	Yerpnapor	The river Erpnapor-tributary of the river Karchaghbyur	WB not at risk
4-046	Aghotadzor	The river Aghotadzor-left tributary of the river Karchaghbyur	WB not at risk
4-047	Karchaghbyur	The river Karchaghbyur from village Maqenis to estuary	WB possible at risk
4-048	Artsvanist	The river Artsvanist from source to estuary	WB not at risk
4-049	Eghnatcujur	The river Eghancujur-tributary of the river Artsvanist	WB not at risk
4-050	Vardenik	The river Vardenik from source to confluence tributary Azizner with tributary Azizner	WB not at risk
4-051	Vardenik	The river Vardenik from confluence tributary Azizner to village Vardenik	WB not at risk

WB number	River name	Name of delineated WB	Risk analysis
4-052	Vardenik	River Vardenis-from village Vardenik to estuary	WB at risk
4-053	Aknakhar	The river Aknakhar from source to estuary	WB not at risk
4-054	Zolaqar	The river Zolaqar from source to estuary	WB not at risk
4-055	Astghadzor	The river Astghadzor from source to estuary	WB not at risk
4-056	Martuni	The river Martuni with its tributary Dashtaget till village Geghhovit	WB not at risk
4-057	Martuni	Martuni River from Geghovhit to Martuni town.	WB at risk
4-058	Martuni	Martuni River from Martuni Town to estuary.	WB at risk
4-059	Gayladzor	The river Gayladzor right tributary of the river Poqr Argichi, with its tributaries Tsaghkashen, Arvak and Arhanch	WB not at risk
4-060	Poqr Argichi	The river Poqr Argichi from source to confluence of the river Argichi	WB not at risk
4-061	Argichi	The river Argichi from source to confluence tributary Poqr Argichi	WB not at risk
4-062	Nazarget	The river Nazarget-left tributary of the river Argichi	WB not at risk
4-063	Argichi	The river Argichi from confluence tributary of the Poqr Masrik to farms of the village Madina	WB possible at risk
4-064	Argichi	The river Argichi from farms of the village Madina till village Verin Getashen	WB not at risk
4-065	Argichi	River Argichi-from village Verin Getashen to estuary	WB possible at risk
4-066	Lichq	The river Lichq from village Lichq to estuary	WB not at risk
4-067	Bakhtak	The river Bakhtak from source to village Tazagyugh	WB not at risk
4-068	Bakhtak	River Bakhtak-from village Tsovasar to village Tsakqar	WB at risk
4-069	Bakhtak	River Bakhtak-from village Tsakqar to estuary	WB at risk
4-070	Tsakqar	The river Tsakqar from source to village Dzoragyugh	WB not at risk
4-071	Tsakqar	River Tsakqar-from village Dzoragyugh to estuary	WB at risk
4-072	Shoghvak	The river Shoghvak from source to village Dzoragyugh	WB not at risk
4-073	Shoghvak	River Shoghvak-from village Dzoragyugh to estuary	WB at risk
4-074	Gegharkunijur	The river Gegharqunikjur with its tributaries from source to village Sarukhan	WB not at risk
4-075	Gegharkunijur	The river Gegharqunikjur from village Sarukhan to confluence of the river Gavaraget	WB not at risk
4-076	Gavaraget	The river Gavaraget from source to confluence tributary Gegharqunikjur	WB not at risk
4-077	Gavaraget	The river Gavaraget from confluence tributary Gegharqunijur till city Gavar	WB not at risk
4-078	Gridzor	The river Gridzor from source to estuary with its tributary Gayladzor	WB not at risk
4-079	Geloidzor	The river Geloidzor-left tributary of the river Gavaraget, from source to estuary with its tributaries	WB at risk
4-080	Gumeri	The river Gumeriget with tributaries	WB not at risk
4-081	Gavaraget	River Gavaraget-in the area of city Gavar	WB at risk

WB number	River name	Name of delineated WB	Risk analysis
4-082	Gavaraget	River Gavaraget-from city Gavar to estuary	WB at risk
4-083	Hrazdan	The source of the river Hrazdan	WB not at risk
4-084	Lake Sevan	Lake Sevan coastline, from Lchashen to Tsovazard settlement, about 16.95 km^2	WB at risk
4-085	Lake Sevan	Lake Sevancoastline, surroundings of Gavaraget River, from Gavaraget estuary to Noratus, about 16.3km^2	WB at risk
4-086	Lake Sevan	Lake Sevancoastline, from the Noratus Peninsula to the end of the community border Noratus, about 7.31km^2	WB at risk
4-087	Lake Sevan	Lake Sevancoastline, from Yeranos settlement to Small Masrik settlement, about 66.9km^2	WB at risk
4-088	Lake Sevan	Big Lake Sevan	WB possible at risk
4-089	Lake Sevan	Small Lake Sevan	WB possible at risk

ANNEX 13. ARTIFICIAL WATER BODIES WITHIN SEVAN RBD

N/N	Artificial water body and its length
1	AWB 4-090:Masrik Canal, 26232.6m
2	AWB 4-091: Avazan Canal, 6150.2m
3	AWB 4-092: Sotk Canal, 9655.6m
4	AWB 4-093: HPP Canal, 7788.5m
5	AWB 4-094: Makenis and Tsovinar #2 Canals, 16825.8m
6	AWB 4-095: Tsovak #1 and Karchaghbyur Canals, 10426.1m
7	AWB 4-096: Ruins Canal, 6163.3m
8	AWB 4-097: Arpa-Sevan Tunnel, 26768.3m
9	AWB 4-098: Manas Ditch Canal, 19310.1m
10	AWB 4-099: Getashen, Verin Getashen and Dotation Canals, 19886.7m
11	AWB 4-100:Hord Aru and Yeranos Canals, 9212.8m
12	AWB 4-101:Sarukhan Water Station Tail-race Right and Left Branches, 7217.8m
13	AWB 4-102:Sarukhan Gravity Canal, 5957.6
14	AWB 4-103:Noratus Right and Left Branch Canals, 17527.4m

ANNEX 14. WATER QUALITY NORMS FOR THE IN RIVERS OF SEVAN RBD

(RA Government Decision #75-N, dated January 27, 2011)
Dzknaget River Basin

Water quality parameter	Unit	Water quality class				
		Excellent	Good	Moderate	Poor	Bad
Dissolved oxygen	mgO_2/L	>7	>6	>5	>4	<4
pH	-	6.5-9		<6.5 and >9		
BOD_5	mgO_2/L	3	5	9	18	>18
COD-Cr	mgO/L	10	25	40	80	>80
Nitrate nitrogen	mg/L	0.060	2.5	5.6	11.3	>11.3
Nitrite nitrogen	mg/L	0.008	0.06	0.12	0.3	>0.3
Ammonia nitrogen	mg/L	0.092	0.4	1.2	2.4	>2.4
Phosphate phosphorus	mg/L	0.02	0.1	0.2	0.4	>0.4
Total phosphorus	mg/L	0.03	0.2	0.4	1.0	>1.0
Copper	µg/L	1.3	21.3	50	100	>100
Zinc	µg/L	1.4	100	200	500	>500
Chromium	µg/L	0.4	10.4	100	250	>250
Arsenic	µg/L	0.8	20	50	100	>100
Cadmium	µg/L	0.01	1.01	2.01	4.01	>4.01
Lead	µg/L	0.1	10.1	25	50	>50
Nickel	µg/L	1.0	11.0	50	100	>100
Molybdenum	µg/L	0.6	1.2	2.4	4.8	>4.8
Manganese	µg/L	22	44	88	176	>176
Vanadium	µg/L	2	4	8	16	>16
Cobalt	µg/L	0.14	0.28	0.56	1.04	>1.04
Antimony	µg/L	0.21	0.42	0.84	1.68	>1.68
Selenium	µg/L	0.25	20	40	80	>80
Tin	µg/L	0.04	0.08	0.16	0.32	>0,32
Iron	mg/L	0.21	0.42	0.5	1.0	>1.0
Aluminum	mg/L	0.14	0.28	0.56	5.0	>5.0
Boron	mg/L	0.009	0.45	0.7	1.0	>1.0
Barium	mg/L	0.01	0.02	0.04	1.0	>1.0

Calcium	mg/L	14.6	100	200	300	>300
Magnesium	mg/L	2.6	50	100	200	>200
Potassium	mg/L	1.2	2.4	4.8	9.6	>9.6
Sodium	mg/L	7.34	14.68	29.36	58.72	>58.72
Sulphate ion	mg/L	6.57	13.14	150	250	> 250
Chloride ion	mg/L	3.0	6.0	150	200	> 200
Silicate ion	mg Si/L	8.8	17.6	35.2	70.4	>70.4
Total Dissolved Solids	mg/L	64.0	128.0	1000	1500	>1500
Suspended Solids	mg/L	7.3	8.8	14.6	30.0	>30.0

Masrik River Basin

Water quality parameter	Unit	Water quality class				
		Excellent	Good	Moderate	Poor	Bad
Dissolved oxygen	mgO_2/L	>7	>6	>5	>4	<4
pH	-	6.5-9		<6.5 and >9		
BOD_5	mgO_2/L	3	5	9	18	>18
COD-Cr	mgO/L	10	25	40	80	>80
Nitrate nitrogen	mg/L	0.38	2.5	5.6	11.3	>11.3
Nitrite nitrogen	mg/L	0.007	0.06	0.12	0.3	>0.3
Ammonia nitrogen	mg/L	0.07	0.4	1.2	2.4	>2.4
Phosphate phosphorus	mg/L	0.016	0.1	0.2	0.4	>0.4
Total phosphorus	mg/L	0.033	0.2	0.4	1.0	>1.0
Copper	µg/L	1.5	21.5	50	100	>100
Zinc	µg/L	2.0	100	200	500	>500
Chromium	µg/L	0.4	10.4	100	250	>250
Arsenic	µg/L	0.4	20	50	100	>100
Cadmium	µg/L	0.01	1.01	2.01	4.01	>4.01
Lead	µg/L	0.17	10.17	25	50	>50
Nickel	µg/L	0.96	10.96	50	100	>100
Molybdenum	µg/L	1.1	2.2	4.4	8.8	>8.8
Manganese	µg/L	6.9	13.8	27.6	55.2	>55.2
Vanadium	µg/L	1.2	2.4	4.8	9.6	>9.6
Cobalt	µg/L	0.14	0.28	0.56	1.12	>1.12
Antimony	µg/L	0.22	0.44	0.88	1.76	>1.76
Selenium	µg/L	0.3	20	40	80	>80

Tin	µg/L	0.05	0.10	0.2	0.4	>0.4
Iron	mg/L	0.11	0.22	0.5	1.0	>1.0
Aluminum	mg/L	0.123	0.25	0.5	5.0	>5.0
Boron	mg/L	0.009	0.45	0.7	1.0	>1.0
Barium	mg/L	0.02	0.04	0.08	1.0	>1.0
Calcium	mg/L	23.6	100	200	300	>300
Magnesium	mg/L	4.0	50	100	200	>200
Potassium	mg/L	1.37	2.74	5.5	11.0	>11.0
Sodium	mg/L	6.7	13.4	26.8	53.6	>53.6
Sulphate ion	mg/L	5.41	10.82	150	250	> 250
Chloride ion	mg/L	3.66	7.32	150	200	> 200
Silicate ion	mg Si/L	8.5	17.0	34	68	>68
Total Dissolved Solids	mg/L	111	222	1000	1500	>1500
Suspended Solids	mg/L	5.0	6.1	10.2	30.0	>30.0

Sotk River Basin

Water quality parameter	Unit	Water quality class				
		Excellent	Good	Moderate	Poor	Bad
Dissolved oxygen	mgO_2/L	>7	>6	>5	>4	<4
pH	-	6.5-9		<6.5 and >9		
BOD_5	mgO_2/L	3	5	9	18	>18
COD-Cr	mgO/L	10	25	40	80	>80
Nitrate nitrogen	mg/L	0.38	2.5	5.6	11.3	>11.3
Nitrite nitrogen	mg/L	0.007	0.06	0.12	0.3	>0.3
Ammonia nitrogen	mg/L	0.07	0.4	1.2	2.4	>2.4
Phosphate phosphorus	mg/L	0.016	0.1	0.2	0.4	>0.4
Total phosphorus	mg/L	0.033	0.2	0.4	1.0	>1.0
Copper	µg/L	1.1	21.1	50	100	>100
Zinc	µg/L	1.5	100	200	500	>500
Chromium	µg/L	4.0	14.0	100	250	>250
Arsenic	µg/L	1.6	20.6	50	100	>100
Cadmium	µg/L	0.01	1.01	2.01	4.01	>4.01
Lead	µg/L	0.18	10.18	25	50	>50
Nickel	µg/L	38.0	48.0	50	100	>100
Molybdenum	µg/L	0.5	1	2	4	>4

Manganese	µg/L	10	20	40	80	>80
Vanadium	µg/L	1.8	3.6	7.2	14.4	>14.4
Cobalt	µg/L	1.6	3.4	6.8	13.6	>13.6
Antimony	µg/L	6.7	13.4	26.8	53.6	>53.6
Selenium	µg/L	0.38	20	40	80	>80
Tin	µg/L	0.02	0.04	0.08	0.16	>0.16
Iron	mg/L	0.12	0.24	0.5	1	>1
Aluminum	mg/L	0.06	0.12	0.24	5.0	>5.0
Boron	mg/L	0.038	0.45	0.70	1.0	>1.0
Barium	mg/L	0.012	0.024	0.048	1.0	>1.0
Calcium	mg/L	34.7	100	200	300	>300
Magnesium	mg/L	34.3	50	100	200	>200
Potassium	mg/L	1.27	2.5	5.0	10.0	>10.0
Sodium	mg/L	4.54	9.8	18.2	36.3	>36.3
Sulphate ion	mg/L	25.0	50.0	150	250	> 250
Chloride ion	mg/L	5.77	11.54	150	200	> 200
Silicate ion	mg Si/L	10.35	18.6	37.4	74.8	>74.8
Total Dissolved Solids	mg/L	266	532	1000	1500	>1500
Suspended Solids	mg/L	4.38	10	20	40	>40

Karchaghbyur River Basin

Water quality parameter	Unit	Water quality class				
		Excellent	Good	Moderate	Poor	Bad
Dissolved oxygen	mgO_2/L	>7	>6	>5	>4	<4
pH	-	6.5-9		<6.5 and >9		
BOD_5	mgO_2/L	3	5	9	18	>18
COD-Cr	mgO/L	10	25	40	80	>80
Nitrate nitrogen	mg/L	0.38	2.5	5.6	11.3	>11.3
Nitrite nitrogen	mg/L	0.007	0.06	0.12	0.3	>0.3
Ammonia nitrogen	mg/L	0.07	0.4	1.2	2.4	>2.4
Phosphate phosphorus	mg/L	0.016	0.1	0.2	0.4	>0.4
Total phosphorus	mg/L	0.033	0.2	0.4	1.0	>1.0
Copper	µg/L	0.6	20.6	50	100	>100
Zinc	µg/L	1.4	100	200	500	>500

Chromium	µg/L	0.5	10.5	100	250	>250
Arsenic	µg/L	0.9	20	50	100	>100
Cadmium	µg/L	0.01	1.01	2.01	4.01	>4.01
Lead	µg/L	0.15	10.15	25	50	>50
Nickel	µg/L	0.6	10.6	50	100	>100
Molybdenum	µg/L	0.46	0.92	1.84	3.68	>3.68
Manganese	µg/L	4.0	8.0	16.0	32.0	>32.0
Vanadium	µg/L	5.0	10.0	20.0	40.0	>40.0
Cobalt	µg/L	0.13	0.26	0.52	1.04	>1.04
Antimony	µg/L	0.2	0.4	0.8	1.6	>1.6
Selenium	µg/L	0.45	20	40	80	>80
Tin	µg/L	0.05	0.1	0.2	0.4	>0.4
Iron	mg/L	0.12	0.24	0.5	1	>1
Aluminum	mg/L	0.05	0.1	0.2	5.0	>5.0
Boron	mg/L	0.009	0.45	0.70	1.0	>1.0
Barium	mg/L	0.008	0.016	0.032	1.0	>1.0
Calcium	mg/L	8.3	100	200	300	>300
Magnesium	mg/L	3.0	50	100	200	>200
Potassium	mg/L	1.9	3.8	7.6	15.2	>15.2
Sodium	mg/L	5.2	10.4	20.8	41.6	>41.6
Sulphate ion	mg/L	4.5	9.0	150	250	> 250
Chloride ion	mg/L	3.2	6.4	150	200	> 200
Silicate ion	mg Si/L	10.2	20.4	40.8	81.6	>81.6
Total Dissolved Solids	mg/L	41.2	82.4	1000	1500	>1500
Suspended Solids	mg/L	8.5	10.2	17.0	34.1	>34.1

Argichi River Basin

Water quality parameter	Unit	Water quality class				
		Excellent	Good	Moderate	Poor	Bad
Dissolved oxygen	mgO_2/L	>7	>6	>5	>4	<4
pH	-	6.5-9		<6.5 and >9		
BOD_5	mgO_2/L	3	5	9	18	>18
COD-Cr	mgO/L	10	25	40	80	>80
Nitrate nitrogen	mg/L	0.38	2.5	5.6	11.3	>11.3

Nitrite nitrogen	mg/L	0.007	0.06	0.12	0.3	>0.3
Ammonia nitrogen	mg/L	0.07	0.4	1.2	2.4	>2.4
Phosphate phosphorus	mg/L	0.016	0.1	0.2	0.4	>0.4
Total phosphorus	mg/L	0.033	0.2	0.4	1.0	>1.0
Copper	µg/L	1.1	21.1	50	100	>100
Zinc	µg/L	1.6	100	200	500	>500
Chromium	µg/L	0.5	10.5	100	250	>250
Arsenic	µg/L	1.0	20	50	100	>100
Cadmium	µg/L	0.014	1.014	2.014	4.014	>4.014
Lead	µg/L	0.12	10.12	25	50	>50
Nickel	µg/L	1.0	11.0	50	100	>100
Molybdenum	µg/L	0.6	1.2	2.4	4.8	>4.8
Manganese	µg/L	14.0	28.0	56.0	112.0	>112.0
Vanadium	µg/L	3.4	6.8	13.6	27.2	>27.2
Cobalt	µg/L	0.23	0.46	0.92	1.84	>1.84
Antimony	µg/L	0.29	0.58	1.16	2.32	>2.32
Selenium	µg/L	0.2	20	40	80	>80
Tin	µg/L	0.09	0.18	0.36	0.72	>0.72
Iron	mg/L	0.014	0.028	0.5	1.0	>1.0
Aluminum	mg/L	0.113	0.226	0.452	5.0	>5.0
Boron	mg/L	0.01	0.45	0.7	1.0	>1.0
Barium	mg/L	0.018	0.036	0.072	1.0	>1.0
Calcium	mg/L	11.0	100	200	300	>300
Magnesium	mg/L	3.4	50	100	200	>200
Potassium	mg/L	2.4	5.8	11.6	22.7	>22.7
Sodium	mg/L	5.5	11.0	22.0	44.0	>44.0
Sulphate ion	mg/L	5.5	11	150	250	> 250
Chloride ion	mg/L	5	10	150	200	> 200
Silicate ion	mg Si/L	9.4	18.8	37.6	75.2	>75.2
Total Dissolved Solids	mg/L	66.3	132.6	1000	1500	>1500
Suspended Solids	mg/L	9.4	11.3	18.8	37.6	>37.6

ANNEX 15. ASSESSMENT OF THE CHEMICAL STATUS OF SURFACE WATER RESOURCES IN THE SEVAN RBD ACCORDING TO MONITORING RESULTS OF EIMC

SWQ monitoring site #60: Dzknaget River, 0.5 km upstream of the village Semyonovka

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.11	8.91	8.37	8.22	7.46
pH	-	7.62	8.38	8.30	7.72	7.89
BOD_5	mgO_2/L	2.18	2.69	2.01	2.87	2.7
COD-Cr	mgO/L	18.00	18.33	22.67	20.33	17
Nitrate nitrogen	mgN/L	0.068	0.068	0.055	0.139	0.113
Nitrite nitrogen	mgN/L	0.004	0.005	0.004	0.003	0.003
Ammonia nitrogen	mgN/L	0.135	0.106	0.105	0.096	0.106
Copper	mg/L	0.0014	0.0013	0.0023	0.0015	0.0013
Zinc	mg/L	0.0010	0.0012	0.0049	0.0021	0.0036
Chromium	mg/L	0.0009	0.0004	0.0003		0.0009
Arsenic	mg/L	0.0005	0.0006	0.0007	0.0005	0.0006
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0003	0.0001	0.0004	0.0001	0.0002
Nickel	mg/L	0.0013	0.0012	0.0010	0.0009	0.0010
Molybdenum	mg/L	0.0008	0.0007	0.0011	0.0006	0.0008
Manganese	mg/L	0.0094	0.0113	0.0092	0.0077	0.0148
Vanadium	mg/L	0.0013	0.0022	0.0031	0.0015	0.0015
Cobalt	mg/L	0.0003	0.0002	0.0002	0.0001	0.0002
Antimony	mg/L	0.0000	0.0001	0.0001		0.0002
Selenium	mg/L	0.0005	0.0004	0.0001	0.0001	0.0003
Tin	mg/L	0.00007	0.00001	0.00004		0.0000
Iron	mg/L	0.1514	0.2659	0.1963	0.1832	0.1793
Aluminum	mg/L	0.2642	0.1950	0.1869	0.1312	0.1493
Calcium	mg/L	14.85	15.31	16.33	12.48	14.95
Magnesium	mg/L	2.32	2.60	2.98	2.27	2.80
Potassium	mg/L	1.35	1.07	1.53	0.99	1.13
Sodium	mg/L	5.68	5.27	6.82	4.37	5.55
Sulphate ion	mg/L	3.27	5.27	5.37	4.65	4.73
Chloride ion	mg/L	1.48	1.48	1.86	1.47	1.49
Total Dissolved Solids	mg/L	80.50	73.00	82.00	66.17	72.48

SWQ monitoring site #61: Dzknaget River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.38	10.16	9.17	7.91	7.76
pH	-	7.85	7.98	7.88	7.77	7.67
BOD_5	mgO_2/L	2.36	3.13	2.54	2.56	2.8
COD-Cr	mgO/L	24.57	20.86	20.86	26.71	19
Nitrate nitrogen	mgN/L	0.121	0.780	0.525	0.301	0.355
Nitrite nitrogen	mgN/L	0.006	0.011	0.013	0.009	0.011
Ammonia nitrogen	mgN/L	0.170	0.165	0.114	0.130	0.143
Copper	mg/L	0.0016	0.0016	0.0015	0.0018	0.0017
Zinc	mg/L	0.0011	0.0015	0.0011	0.0019	0.0057
Chromium	mg/L	0.0013	0.0006	0.0004		0.0011
Arsenic	mg/L	0.0009	0.0007	0.0009	0.0007	0.0009
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0002	0.0001	0.0002	0.0002
Nickel	mg/L	0.0017	0.0018	0.0013	0.0014	0.0015
Molybdenum	mg/L	0.0010	0.0010	0.0011	0.0008	0.0010
Manganese	mg/L	0.0242	0.0199	0.0278	0.0133	0.0432
Vanadium	mg/L	0.0021	0.0023	0.0026	0.0019	0.0022
Cobalt	mg/L	0.0002	0.0003	0.0003	0.0001	0.0002
Antimony	mg/L	0.0001	0.0000	0.0001		0.0001
Selenium	mg/L	0.0006	0.0003	0.0003	0.0002	0.0003
Tin	mg/L	0.00005	0.00001	0.00002		0.0000
Iron	mg/L	0.2124	0.2798	0.2389	0.2006	0.2284
Aluminum	mg/L	0.2910	0.1880	0.2060	0.1736	0.1317
Calcium	mg/L	24.41	24.75	28.79	19.78	24.16
Magnesium	mg/L	4.41	4.77	5.58	3.61	4.64
Potassium	mg/L	2.13	1.71	2.01	1.77	1.98
Sodium	mg/L	8.36	7.74	10.21	6.58	7.60
Sulphate ion	mg/L	6.21	9.37	9.84	7.20	7.52
Chloride ion	mg/L	2.39	4.23	4.33	2.92	3.43
Total Dissolved Solids	mg/L	101.00	126.29	142.43	105.86	122.26

SWQ monitoring site #62: Masrik River, 0.5 km upstream of the village Verin Shorja

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	7.93	7.63	8.05	5.75	7.60
pH	-	8.26	8.42	8.41	8.05	8.26
BOD_5	mgO_2/L	2.26	1.90	1.99	2.05	2.4
COD-Cr	mgO/L	16.80	18.00	19.67	18.80	16
Nitrate nitrogen	mgN/L	0.499	1.117	0.803	0.675	0.523
Nitrite nitrogen	mgN/L	0.010	0.009	0.006	0.006	0.004
Ammonia nitrogen	mgN/L	0.130	0.105	0.107	0.110	0.103
Copper	mg/L	0.0015	0.0011	0.0013	0.0014	0.0012
Zinc	mg/L	0.0010	0.0006	0.0010	0.0016	0.0020
Chromium	mg/L	0.0010	0.0004	0.0003		0.0013
Arsenic	mg/L	0.0006	0.0005	0.0006	0.0005	0.0004
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0001	0.0002	0.0001
Nickel	mg/L	0.0018	0.0013	0.0010	0.0011	0.0010
Molybdenum	mg/L	0.0011	0.0009	0.0012	0.0010	0.0010
Manganese	mg/L	0.0084	0.0050	0.0050	0.0040	0.0056
Vanadium	mg/L	0.0022	0.0018	0.0024	0.0020	0.0016
Cobalt	mg/L	0.0002	0.0002	0.0003	0.0001	0.0002
Antimony	mg/L	0.0000	0.0000	0.0001		0.0001
Selenium	mg/L	0.0008	0.0004	0.0002	0.0002	0.0003
Tin	mg/L	0.0000	0.0000	0.0000		0.0000
Iron	mg/L	0.146	0.1746	0.2131	0.1632	0.1223
Aluminum	mg/L	0.261	0.1382	0.0713	0.1487	0.1203
Calcium	mg/L	29.83	29.33	28.99	25.13	25.36
Magnesium	mg/L	4.56	4.81	4.78	3.84	4.26
Potassium	mg/L	2.69	1.96	2.13	1.72	1.63
Sodium	mg/L	7.31	6.73	7.29	6.07	5.99
Sulphate ion	mg/L	4.01	6.92	6.90	6.60	6.10
Chloride ion	mg/L	2.23	2.36	2.44	2.07	1.96
Total Dissolved Solids	mg/L	139	126	129	120	113.32

SWQ monitoring site #63: Masrik River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.56	8.78	9.14	7.44	7.05
pH	-	7.92	8.25	8.38	8.13	8.02
BOD_5	mgO_2/L	2.52	2.65	2.12	2.91	2.7
COD-Cr	mgO/L	21.71	20.00	20.29	17.00	21
Nitrate nitrogen	mgN/L	1.586	2.832	2.101	1.986	1.802
Nitrite nitrogen	mgN/L	0.048	0.038	0.057	0.042	0.046
Ammonia nitrogen	mgN/L	0.230	0.112	0.168	0.130	0.147
Copper	mg/L	0.0016	0.0013	0.0017	0.0014	0.0019
Zinc	mg/L	0.0017	0.0017	0.0021	0.0030	0.0082
Chromium	mg/L	0.0042	0.0023	0.0012		0.0049
Arsenic	mg/L	0.0054	0.0086	0.0073	0.0037	0.0028
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0010	0.0004	0.0004	0.0003	0.0004
Nickel	mg/L	0.0026	0.0022	0.0035	0.0020	0.0027
Molybdenum	mg/L	0.0015	0.0016	0.0017	0.0015	0.0017
Manganese	mg/L	0.0105	0.0074	0.0124	0.0065	0.0091
Vanadium	mg/L	0.0123	0.0113	0.0138	0.0117	0.0118
Cobalt	mg/L	0.0006	0.0002	0.0003	0.0002	0.0003
Antimony	mg/L	0.0009	0.0008	0.0007		0.0007
Selenium	mg/L	0.0010	0.0004	0.0003	0.0003	0.0006
Tin	mg/L	0.0001	0.0000	0.0000		0.0001
Iron	mg/L	0.1368	0.1267	0.1189	0.1259	0.1812
Aluminum	mg/L	0.1305	0.0591	0.0711	0.0919	0.1256
Calcium	mg/L	28.78	31.96	29.56	27.46	30.27
Magnesium	mg/L	9.86	9.44	8.88	7.67	8.49
Potassium	mg/L	4.12	3.65	3.64	3.49	3.86
Sodium	mg/L	10.43	9.41	8.89	7.47	7.84
Sulphate ion	mg/L	11.19	19.28	16.07	15.19	15.86
Chloride ion	mg/L	3.88	4.67	4.13	3.92	3.78
Total Dissolved Solids	mg/L	158	170	161	157	155.71

SWQ monitoring site #64: Sotk River, 1.5km upstream of the viliage Sotk

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.56	7.78	8.07	6.76	7.35
pH	-	7.92	8.47	8.32	8.12	8.36
BOD_5	mgO_2/L	2.52	1.80	2.03	2.16	2.1
COD-Cr	mgO/L	21.71	14.40	15.00	16.83	21
Nitrate nitrogen	mgN/L	1.586	0.212	0.120	0.159	0.218
Nitrite nitrogen	mgN/L	0.048	0.002	0.003	0.001	0.001
Ammonia nitrogen	mgN/L	0.230	0.170	0.162	0.126	0.159
Copper	mg/L	0.0016	0.0007	0.0008	0.0007	0.0007
Zinc	mg/L	0.0017	0.0009	0.0004	0.0010	0.0029
Chromium	mg/L	0.0042	0.0045	0.0055		0.0083
Arsenic	mg/L	0.0054	0.0021	0.0025	0.0023	0.0026
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0010	0.0000	0.0001	0.0000	0.0001
Nickel	mg/L	0.0026	0.0128	0.0084	0.0061	0.0071
Molybdenum	mg/L	0.0015	0.0003	0.0004	0.0002	0.0005
Manganese	mg/L	0.0105	0.0031	0.0038	0.0014	0.0018
Vanadium	mg/L	0.0021	0.0018	0.0021	0.0019	0.0017
Cobalt	mg/L	0.0006	0.0005	0.0003	0.0002	0.0003
Antimony	mg/L	0.0009	0.0009	0.0010		0.0014
Selenium	mg/L	0.0010	0.0003	0.0002	0.0002	0.0004
Tin	mg/L	0.0001	0.0000	0.0000		0.0000
Iron	mg/L	0.1368	0.0613	0.1081	0.0374	0.0469
Aluminum	mg/L	0.0704	0.0209	0.0420	0.0110	0.0160
Calcium	mg/L	28.78	28.41	24.92	21.65	23.90
Magnesium	mg/L	9.86	35.48	34.08	30.68	34.38
Potassium	mg/L	1.56	0.79	0.85	0.65	0.63
Sodium	mg/L	3.94	3.78	3.65	3.20	3.88
Sulphate ion	mg/L	11.19	15.53	12.88	8.88	11.41
Chloride ion	mg/L	3.88	2.34	1.95	2.09	2.47
Total Dissolved Solids	mg/L	158	242	223	221	228

SWQ monitoring site #65: Sotk River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	7.61	9.20	9.51	7.20	7.45
pH	-	8.21	8.55	8.49	8.47	8.45
BOD_5	mgO_2/L	2.58	2.71	2.39	2.86	3.1
COD-Cr	mgO/L	21.43	19.33	18.86	16.71	20
Nitrate nitrogen	mgN/L	2.456	5.606	3.336	4.018	2.721
Nitrite nitrogen	mgN/L	0.026	0.023	0.024	0.048	0.018
Ammonia nitrogen	mgN/L	0.249	0.155	0.150	0.243	0.140
Copper	mg/L	0.0027	0.0016	0.0023	0.0023	0.0020
Zinc	mg/L	0.0019	0.0011	0.0018	0.0018	0.0051
Chromium	mg/L	0.0022	0.0020	0.0029		0.0033
Arsenic	mg/L	0.0095	0.0097	0.0093	0.0100	0.0077
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0003	0.0001	0.0004	0.0001	0.0002
Nickel	mg/L	0.0133	0.0110	0.0097	0.0084	0.0089
Molybdenum	mg/L	0.0007	0.0006	0.0008	0.0006	0.0007
Manganese	mg/L	0.0107	0.0063	0.0084	0.0064	0.0060
Vanadium	mg/L	0.0052	0.0041	0.0060	0.0062	0.0042
Cobalt	mg/L	0.0006	0.0004	0.0005	0.0004	0.0004
Antimony	mg/L	0.0137	0.0160	0.0153		0.0065
Selenium	mg/L	0.0010	0.0004	0.0004	0.0004	0.0005
Tin	mg/L	0.0000	0.0000	0.0000		0.0000
Iron	mg/L	0.3269	0.1523	0.1544	0.1984	0.1731
Aluminum	mg/L	0.3364	0.0874	0.1307	0.1480	0.1238
Calcium	mg/L	47.86	51.25	48.44	41.05	41.20
Magnesium	mg/L	25.68	27.35	28.37	22.84	20.88
Potassium	mg/L	2.24	1.89	2.30	2.45	2.02
Sodium	mg/L	8.84	8.62	11.09	8.56	7.45
Sulphate ion	mg/L	41.64	60.04	54.29	50.63	40.76
Chloride ion	mg/L	5.70	8.51	7.33	7.77	7.02
Total Dissolved Solids	mg/L	257	305	300	269	257.10

SWQ monitoring site #66: Karchaghbyur River, 0.5 km upstream of the village Akhpradzor

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	7.99	7.92	8.14	6.24	7.67
pH	-	7.95	8.40	8.25	8.23	7.89
BOD_5	mgO_2/L	2.01	1.82	1.89	1.70	2.4
COD-Cr	mgO/L	17.20	19.00	13.67	17.20	16
Nitrate nitrogen	mgN/L	0.123	0.086	0.096	0.077	0.067
Nitrite nitrogen	mgN/L	0.002	0.002	0.003	0.003	0.003
Ammonia nitrogen	mgN/L	0.141	0.102	0.094	0.105	0.095
Copper	mg/L	0.0008	0.0005	0.0006	0.0006	0.0005
Zinc	mg/L	0.0009	0.0008	0.0008	0.0005	0.0008
Chromium	mg/L	0.0008	0.0004	0.0006		0.0011
Arsenic	mg/L	0.0009	0.0007	0.0009	0.0010	0.0008
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0008	0.0005	0.0005	0.0005	0.0006
Molybdenum	mg/L	0.0004	0.0004	0.0004	0.0003	0.0005
Manganese	mg/L	0.0053	0.0023	0.0037	0.0022	0.0031
Vanadium	mg/L	0.0037	0.0035	0.0043	0.0043	0.0035
Cobalt	mg/L	0.0002	0.0001	0.0001	0.0001	0.0001
Antimony	mg/L	0.0000	0.0000	0.0000		0.0001
Selenium	mg/L	0.0006	0.0002	0.0002	0.0002	0.0002
Tin	mg/L	0.0000	0.0000	0.0000		0.0000
Iron	mg/L	0.1325	0.1500	0.1367	0.1116	0.1370
Aluminum	mg/L	0.0636	0.0625	0.0692	0.0357	0.0749
Calcium	mg/L	7.35	6.55	6.94	6.48	6.14
Magnesium	mg/L	2.17	2.24	2.35	2.10	2.22
Potassium	mg/L	2.02	1.55	1.89	1.81	1.48
Sodium	mg/L	3.80	3.76	3.94	3.38	3.80
Sulphate ion	mg/L	3.01	1.58	1.82	1.77	1.64
Chloride ion	mg/L	1.33	1.15	1.20	1.16	1.08
Total Dissolved Solids	mg/L	45	41	45	46	40

SWQ monitoring site #67: Karchaghbyur River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.84	9.52	9.59	8.57	7.50
pH	-	7.79	8.10	7.68	7.84	7.60
BOD_5	mgO_2/L	2.33	2.44	2.36	2.68	2.4
COD-Cr	mgO/L	19.71	15.14	15.71	13.86	24
Nitrate nitrogen	mgN/L	0.805	1.936	1.468	1.255	1.099
Nitrite nitrogen	mgN/L	0.013	0.013	0.009	0.010	0.009
Ammonia nitrogen	mgN/L	0.125	0.083	0.069	0.073	0.071
Copper	mg/L	0.0015	0.0012	0.0011	0.0012	0.0013
Zinc	mg/L	0.0012	0.0009	0.0006	0.0011	0.0039
Chromium	mg/L	0.0010	0.0005	0.0006		0.0014
Arsenic	mg/L	0.0017	0.0016	0.0019	0.0018	0.0014
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0003	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0010	0.0007	0.0005	0.0006	0.0007
Molybdenum	mg/L	0.0010	0.0010	0.0010	0.0009	0.0011
Manganese	mg/L	0.0042	0.0023	0.0024	0.0012	0.0029
Vanadium	mg/L	0.0107	0.0094	0.0110	0.0107	0.0088
Cobalt	mg/L	0.0002	0.0002	0.0001	0.0001	0.0001
Antimony	mg/L	0.0001	0.0001	0.0001		0.0001
Selenium	mg/L	0.0007	0.0003	0.0003	0.0002	0.0003
Tin	mg/L	0.0000	0.0000	0.0000		0.0000
Iron	mg/L	0.0801	0.0640	0.0823	0.0441	0.0931
Aluminum	mg/L	0.0966	0.0314	0.0545	0.0280	0.0500
Calcium	mg/L	15.57	16.36	17.19	15.77	14.50
Magnesium	mg/L	4.16	4.23	5.19	4.25	3.82
Potassium	mg/L	3.36	3.12	3.43	2.74	2.94
Sodium	mg/L	6.97	6.40	8.15	6.01	5.93
Sulphate ion	mg/L	4.17	5.95	6.09	6.14	4.76
Chloride ion	mg/L	2.28	2.93	3.55	2.54	2.20
Total Dissolved Solids	mg/L	96	96	91	96	85

SWQ monitoring site #68: Arpa-Sevan tunnel

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.09	8.34	9.54	7.42	6.56
pH	-	7.50	7.75	7.61	7.47	7.34
BOD_5	mgO_2/L	2.21	2.53	2.39	2.43	2.84
COD-Cr	mgO/L	26.29	18.86	20.29	14.86	29.29
Nitrate nitrogen	mgN/L	2.091	3.363	2.853	2.446	2.367
Nitrite nitrogen	mgN/L	0.003	0.004	0.005	0.004	0.002
Ammonia nitrogen	mgN/L	0.135	0.101	0.111	0.073	0.084
Copper	mg/L	0.0015	0.0009	0.0013	0.0013	0.0016
Zinc	mg/L	0.0025	0.0018	0.0021	0.0048	0.0292
Chromium	mg/L	0.0017	0.0010	0.0013	0.0015	0.0026
Arsenic	mg/L	0.0105	0.0094	0.0112	0.0105	0.0095
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0001	0.0001	0.0002
Nickel	mg/L	0.0015	0.0011	0.0010	0.0010	0.0012
Molybdenum	mg/L	0.0011	0.0013	0.0018	0.0014	0.0012
Manganese	mg/L	0.0150	0.0087	0.0278	0.0074	0.0133
Vanadium	mg/L	0.0106	0.0082	0.0123	0.0116	0.0089
Cobalt	mg/L	0.0002	0.0002	0.0002	0.0001	0.0002
Antimony	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001
Selenium	mg/L	0.0009	0.0007	0.0006	0.0005	0.0004
Tin	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Iron	mg/L	0.1756	0.1051	0.1781	0.1186	0.1398
Aluminum	mg/L	0.2808	0.0327	0.1270	0.0719	0.0794
Calcium	mg/L	25.84	24.26	32.27	23.79	23.04
Magnesium	mg/L	8.76	10.81	13.22	11.74	7.21
Potassium	mg/L	4.48	4.95	5.77	5.15	3.96
Sodium	mg/L	21.30	25.22	30.47	26.45	21.01
Sulphate ion	mg/L	14.69	21.62	26.56	18.84	16.08
Chloride ion	mg/L	11.81	20.27	18.94	17.31	12.66
Total Dissolved Solids	mg/L	203	220	242	216	178

SWQ monitoring site #69: Vardenis River, 0.5 km upstream of the village Vardenik

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.33	9.66	9.30	7.98	7.39
pH	-	7.62	7.92	7.93	7.77	7.61
BOD_5	mgO_2/L	2.00	1.72	2.12	2.22	2.50
COD-Cr	mgO/L	20.67	16.40	13.00	14.67	19.00
Nitrate nitrogen	mgN/L	0.169	0.556	0.193	0.293	0.145
Nitrite nitrogen	mgN/L	0.002	0.002	0.003	0.002	0.003
Ammonia nitrogen	mgN/L	0.104	0.066	0.093	0.086	0.051
Copper	mg/L	0.0014	0.0010	0.0014	0.0013	0.0014
Zinc	mg/L	0.0013	0.0017	0.0029	0.0017	0.0108
Chromium	mg/L	0.0006	0.0005	0.0004		0.0009
Arsenic	mg/L	0.0005	0.0004	0.0005	0.0008	0.0005
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0001		0.0001	0.0001	0.0001
Nickel	mg/L	0.0009	0.0006	0.0008	0.0008	0.0008
Molybdenum	mg/L	0.0004	0.0003	0.0004	0.0003	0.0007
Manganese	mg/L	0.0051	0.0033	0.0036	0.0031	0.0052
Vanadium	mg/L	0.0019	0.0017	0.0023	0.0026	0.0024
Cobalt	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001
Antimony	mg/L	0.0001	0.0000	0.0001		0.0001
Selenium	mg/L	0.0006	0.0002	0.0003	0.0001	0.0002
Tin	mg/L	0.0001	0.0000	0.0000		0.0000
Iron	mg/L	0.0991	0.0816	0.1429	0.1118	0.1145
Aluminum	mg/L	0.1541	0.0574	0.1476	0.0785	0.0968
Calcium	mg/L	8.01	7.01	7.62	7.47	6.92
Magnesium	mg/L	1.93	1.80	2.11	2.08	1.98
Potassium	mg/L	2.36	2.15	2.44	2.27	2.23
Sodium	mg/L	2.73	2.57	3.00	3.02	2.91
Sulphate ion	mg/L	5.81	6.90	6.96	6.47	6.88
Chloride ion	mg/L	2.22	2.07	2.21	2.38	2.09
Total Dissolved Solids	mg/L	45	45	47	48	42

SWQ monitoring site #70: Vardenis River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.18	8.54	8.81	8.46	7.08
pH	-	7.46	7.62	7.72	7.61	7.48
BOD_5	mgO_2/L	2.36	3.33	2.45	2.63	2.83
COD-Cr	mgO/L	22.33	21.43	17.60	15.33	20.00
Nitrate nitrogen	mgN/L	0.583	1.415	0.689	0.419	1.003
Nitrite nitrogen	mgN/L	0.141	0.066	0.116	0.010	0.071
Ammonia nitrogen	mgN/L	0.506	0.557	1.758	0.290	0.639
Copper	mg/L	0.0024	0.0012	0.0019	0.0017	0.0016
Zinc	mg/L	0.0025	0.0025	0.0025	0.0038	0.0120
Chromium	mg/L	0.0007	0.0003	0.0005		0.0010
Arsenic	mg/L	0.0010	0.0007	0.0010	0.0006	0.0008
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0014	0.0009	0.0010	0.0008	0.0011
Molybdenum	mg/L	0.0006	0.0005	0.0006	0.0003	0.0006
Manganese	mg/L	0.0050	0.0039	0.0061	0.0026	0.0100
Vanadium	mg/L	0.0035	0.0028	0.0036	0.0027	0.0036
Cobalt	mg/L	0.0004	0.0002	0.0001	0.0001	0.0002
Antimony	mg/L	0.0001	0.0001	0.0001		0.0001
Selenium	mg/L	0.0009	0.0002	0.0004	0.0001	0.0002
Tin	mg/L	0.0001	0.0000	0.0000		0.0001
Iron	mg/L	0.0825	0.0471	0.1236	0.0828	0.1118
Aluminum	mg/L	0.1726	0.0398	0.1131	0.0575	0.0828
Calcium	mg/L	14.81	12.67	15.48	8.05	11.90
Magnesium	mg/L	2.77	2.51	3.05	1.95	2.54
Potassium	mg/L	3.60	2.93	3.89	2.50	3.28
Sodium	mg/L	5.11	3.97	6.37	3.10	5.06
Sulphate ion	mg/L	7.62	9.25	9.22	7.26	7.62
Chloride ion	mg/L	2.56	3.05	3.44	1.73	2.61
Total Dissolved Solids	mg/L	82	78	84	52	69

SWQ monitoring site #71: Martuni River, 0.5 km upstream of the village Geghhovit

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.73	9.87	8.42	8.08	7.96
pH	-	7.44	7.67	7.67	7.52	7.47
BOD_5	mgO_2/L	1.80	1.78	1.88	2.27	2.38
COD-Cr	mgO/L	18.33	14.00	15.33	12.33	13.33
Nitrate nitrogen	mgN/L	0.273	0.529	0.296	0.327	0.237
Nitrite nitrogen	mgN/L	0.003	0.002	0.003	0.003	0.002
Ammonia nitrogen	mgN/L	0.124	0.049	0.071	0.081	0.076
Copper	mg/L	0.0013	0.0007	0.0013	0.0010	0.0013
Zinc	mg/L	0.0018	0.0015	0.0032	0.0016	0.0054
Chromium	mg/L	0.0005	0.0003	0.0004		0.0008
Arsenic	mg/L	0.0005	0.0004	0.0006	0.0005	0.0005
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0015	0.0012	0.0015	0.0017	0.0014
Molybdenum	mg/L	0.0007	0.0005	0.0007	0.0005	0.0005
Manganese	mg/L	0.0071	0.0080	0.0053	0.0049	0.0114
Vanadium	mg/L	0.0021	0.0016	0.0031	0.0025	0.0021
Cobalt	mg/L	0.0002	0.0002	0.0001	0.0001	0.0002
Antimony	mg/L	0.0001	0.0000	0.0001		0.0001
Selenium	mg/L	0.0006	0.0002	0.0002	0.0001	0.0002
Tin	mg/L	0.0001	0.0000	0.0000		0.0000
Iron	mg/L	0.1062	0.1007	0.1246	0.1055	0.1365
Aluminum	mg/L	0.2463	0.1495	0.1369	0.0862	0.2120
Calcium	mg/L	11.45	9.80	11.77	10.95	10.14
Magnesium	mg/L	3.85	3.46	4.19	3.80	3.82
Potassium	mg/L	2.68	1.86	2.91	2.44	2.20
Sodium	mg/L	3.94	3.28	4.19	3.58	3.72
Sulphate ion	mg/L	12.78	20.43	16.79	20.93	20.33
Chloride ion	mg/L	1.50	1.56	1.59	1.44	1.26
Total Dissolved Solids	mg/L	73	71	76	73	68

SWQ monitoring site #72: Martuni River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.49	9.55	10.18	8.75	6.66
pH	-	7.69	7.99	8.05	8.12	7.71
BOD_5	mgO_2/L	2.33	2.52	2.54	2.43	2.61
COD-Cr	mgO/L	23.00	15.67	16.00	18.17	19.29
Nitrate nitrogen	mgN/L	1.373	2.434	1.721	1.822	1.578
Nitrite nitrogen	mgN/L	0.063	0.033	0.011	0.028	0.017
Ammonia nitrogen	mgN/L	0.281	0.654	0.079	0.108	1.259
Copper	mg/L	0.0023	0.0010	0.0014	0.0016	0.0016
Zinc	mg/L	0.0031	0.0020	0.0021	0.0044	0.0092
Chromium	mg/L	0.0011	0.0004	0.0005		0.0013
Arsenic	mg/L	0.0008	0.0006	0.0007	0.0009	0.0007
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0011	0.0001	0.0001	0.0001	0.0002
Nickel	mg/L	0.0022	0.0013	0.0012	0.0013	0.0014
Molybdenum	mg/L	0.0007	0.0006	0.0006	0.0006	0.0008
Manganese	mg/L	0.0088	0.0037	0.0052	0.0059	0.0083
Vanadium	mg/L	0.0032	0.0024	0.0033	0.0033	0.0030
Cobalt	mg/L	0.0003	0.0002	0.0001	0.0001	0.0002
Antimony	mg/L	0.0002	0.0001	0.0001		0.0001
Selenium	mg/L	0.0008	0.0002	0.0003	0.0002	0.0003
Tin	mg/L	0.0001	0.0000	0.0000		0.0000
Iron	mg/L	0.3370	0.0706	0.1301	0.1165	0.1078
Aluminum	mg/L	0.5584	0.0805	0.2095	0.0858	0.1185
Calcium	mg/L	18.33	16.92	15.51	15.25	16.29
Magnesium	mg/L	6.51	5.53	5.26	5.42	5.66
Potassium	mg/L	4.91	3.23	3.50	3.08	3.97
Sodium	mg/L	7.79	5.86	6.35	6.39	6.28
Sulphate ion	mg/L	15.86	19.40	17.46	20.64	17.98
Chloride ion	mg/L	3.30	3.81	2.55	4.10	3.16
Total Dissolved Solids	mg/L	120	118	101	114	109

SWQ monitoring site #73: Argichi River, 0.5 km upstream of the village Lernahovit

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.92	9.60	10.52	6.93	9.27
pH	-	7.51	7.82	8.53	7.54	7.89
BOD_5	mgO_2/L	2.46	2.18	2.71	2.66	2.9
COD-Cr	mgO/L	25.60	17.50	18.00	15.33	13
Nitrate nitrogen	mgN/L	0.122	0.208	0.149	0.153	0.154
Nitrite nitrogen	mgN/L	0.002	0.004	0.003	0.002	0.002
Ammonia nitrogen	mgN/L	0.168	0.127	0.143	0.182	0.130
Copper	mg/L	0.0011	0.0006	0.0010	0.0010	0.0009
Zinc	mg/L	0.0010	0.0007	0.0010	0.0009	0.0028
Chromium	mg/L	0.0005	0.0003	0.0003		0.0009
Arsenic	mg/L	0.0008	0.0007	0.0009	0.0010	0.0008
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0010	0.0009	0.0009	0.0007	0.0011
Molybdenum	mg/L	0.0007	0.0006	0.0007	0.0006	0.0009
Manganese	mg/L	0.0072	0.0081	0.0069	0.0059	0.0090
Vanadium	mg/L	0.0040	0.0029	0.0054	0.0045	0.0041
Cobalt	mg/L	0.0002	0.0001	0.0002	0.0002	0.0002
Antimony	mg/L	0.0000	0.0000	0.0001		0.0001
Selenium	mg/L	0.0005	0.0002	0.0001	0.0000	0.0002
Tin	mg/L	0.0000	0.0000	0.0000		0.0000
Iron	mg/L	0.4562	0.4686	0.5084	0.5578	0.4666
Aluminum	mg/L	0.1261	0.0545	0.2015	0.0447	0.1080
Calcium	mg/L	11.77	12.85	12.89	11.89	12.56
Magnesium	mg/L	3.10	3.45	3.75	3.88	3.70
Potassium	mg/L	2.35	1.74	2.10	2.30	2.19
Sodium	mg/L	4.30	3.81	4.82	4.58	4.62
Sulphate ion	mg/L	1.97	2.41	2.44	2.22	2.25
Chloride ion	mg/L	1.63	1.72	1.72	1.59	1.61
Total Dissolved Solids	mg/L	69	77	73	74	70

SWQ monitoring site #74: Argichi River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	10.15	10.05	10.71	8.82	7.59
pH	-	7.54	7.90	7.93	7.67	7.59
BOD_5	mgO_2/L	2.49	2.64	2.67	3.38	3.2
COD-Cr	mgO/L	21.14	16.29	14.57	27.14	22
Nitrate nitrogen	mgN/L	1.003	1.842	1.766	2.436	1.609
Nitrite nitrogen	mgN/L	0.007	0.006	0.008	0.012	0.005
Ammonia nitrogen	mgN/L	0.177	0.128	0.117	0.114	0.090
Copper	mg/L	0.0018	0.0009	0.0019	0.0016	0.0017
Zinc	mg/L	0.0022	0.0012	0.0023	0.0047	0.0125
Chromium	mg/L	0.0007	0.0004	0.0007		0.0014
Arsenic	mg/L	0.0018	0.0016	0.0021	0.0021	0.0020
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0016	0.0011	0.0009	0.0010	0.0012
Molybdenum	mg/L	0.0010	0.0008	0.0011	0.0011	0.0010
Manganese	mg/L	0.0092	0.0102	0.0068	0.0070	0.0086
Vanadium	mg/L	0.0076	0.0061	0.0096	0.0090	0.0087
Cobalt	mg/L	0.0005	0.0005	0.0002	0.0001	0.0002
Antimony	mg/L	0.0001	0.0000	0.0001		0.0001
Selenium	mg/L	0.0005	0.0002	0.0002	0.0002	0.0004
Tin	mg/L	0.0001	0.0000	0.0000		0.0000
Iron	mg/L	0.2225	0.2699	0.2383	0.2148	0.2733
Aluminum	mg/L	0.1687	0.0362	0.0684	0.0646	0.0581
Calcium	mg/L	18.94	18.41	20.42	20.15	20.42
Magnesium	mg/L	5.72	5.25	6.19	5.83	6.03
Potassium	mg/L	3.20	2.53	3.27	3.19	3.19
Sodium	mg/L	7.18	5.78	7.47	6.79	6.44
Sulphate ion	mg/L	3.58	4.66	4.98	5.82	4.52
Chloride ion	mg/L	2.84	3.19	3.38	3.83	3.08
Total Dissolved Solids	mg/L	113	111	116	123	114

SWQ monitoring site #75: Shogvak River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.29	8.99	10.38	9.10	7.72
pH	-	7.91	8.10	8.31	7.99	8.01
BOD_5	mgO_2/L	2.27	2.56	2.23	3.22	3.34
COD-Cr	mgO/L	26.67	20.29	18.57	18.00	19.17
Nitrate nitrogen	mgN/L	1.011	2.870	2.052	1.858	1.666
Nitrite nitrogen	mgN/L	0.013	0.014	0.012	0.010	0.007
Ammonia nitrogen	mgN/L	0.164	0.084	0.110	0.104	0.069
Copper	mg/L	0.0015	0.0010	0.0016	0.0015	0.0019
Zinc	mg/L	0.0017	0.0021	0.0016	0.0029	0.0138
Chromium	mg/L	0.0010	0.0009	0.0009	0.0007	0.0020
Arsenic	mg/L	0.0011	0.0010	0.0013	0.0010	0.0011
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0001	0.0002	0.0001
Nickel	mg/L	0.0018	0.0011	0.0009	0.0011	0.0015
Molybdenum	mg/L	0.0013	0.0012	0.0013	0.0010	0.0013
Manganese	mg/L	0.0070	0.0038	0.0042	0.0022	0.0048
Vanadium	mg/L	0.0080	0.0071	0.0110	0.0076	0.0084
Cobalt	mg/L	0.0002	0.0002	0.0002	0.0001	0.0002
Antimony	mg/L	0.0001	0.0001	0.0001	0.0001	0.0001
Selenium	mg/L	0.0013	0.0004	0.0002	0.0002	0.0004
Tin	mg/L	0.0001	0.0000	0.0000	0.0000	0.0000
Iron	mg/L	0.1231	0.0467	0.0722	0.0976	0.1312
Aluminum	mg/L	0.1279	0.0251	0.0452	0.0630	0.0654
Calcium	mg/L	20.56	23.74	28.06	24.09	26.67
Magnesium	mg/L	11.79	10.86	11.81	8.02	9.30
Potassium	mg/L	4.89	3.95	4.61	3.75	4.38
Sodium	mg/L	16.19	14.00	16.20	9.85	11.29
Sulphate ion	mg/L	3.80	6.13	5.92	6.01	5.29
Chloride ion	mg/L	9.06	14.68	12.76	8.92	8.26
Total Dissolved Solids	mg/L	170	185	187	149	160

SWQ monitoring site #76: Bakhtak River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	9.94	9.78	10.38	8.87	7.49
pH	-	7.69	8.08	8.31	8.03	7.99
BOD_5	mgO_2/L	2.90	3.09	2.23	3.00	3.23
COD-Cr	mgO/L	24.00	23.43	18.57	19.86	23.33
Nitrate nitrogen	mgN/L	1.253	2.199	2.052	1.762	1.532
Nitrite nitrogen	mgN/L	0.012	0.008	0.012	0.018	0.011
Ammonia nitrogen	mgN/L	0.121	0.110	0.110	0.095	0.073
Copper	mg/L	0.0015	0.0008	0.0016	0.0011	0.0012
Zinc	mg/L	0.0019	0.0011	0.0016	0.0029	0.0156
Chromium	mg/L	0.0008	0.0008	0.0009	0.0010	0.0018
Arsenic	mg/L	0.0011	0.0009	0.0013	0.0015	0.0011
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0003	0.0001	0.0001	0.0001	0.0001
Nickel	mg/L	0.0014	0.0010	0.0009	0.0009	0.0010
Molybdenum	mg/L	0.0011	0.0011	0.0013	0.0012	0.0015
Manganese	mg/L	0.0047	0.0049	0.0042	0.0080	0.0060
Vanadium	mg/L	0.0073	0.0066	0.0110	0.0096	0.0087
Cobalt	mg/L	0.0002	0.0002	0.0002	0.0001	0.0001
Antimony	mg/L	0.0001	0.0000	0.0001	0.0001	0.0001
Selenium	mg/L	0.0007	0.0003	0.0002	0.0003	0.0005
Tin	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Iron	mg/L	0.0799	0.0600	0.0722	0.0718	0.0983
Aluminum	mg/L	0.0738	0.0328	0.0452	0.0375	0.0517
Calcium	mg/L	23.78	19.70	28.06	17.54	18.52
Magnesium	mg/L	10.85	9.77	11.81	11.57	13.39
Potassium	mg/L	4.49	3.57	4.61	3.88	4.45
Sodium	mg/L	14.46	13.09	16.20	16.70	18.11
Sulphate ion	mg/L	4.13	4.96	5.92	4.45	4.10
Chloride ion	mg/L	9.23	14.07	12.76	15.88	16.02
Total Dissolved Solids	mg/L	165	167	187	174	177

SWQ monitoring site #77: Gavaraget River, 0.5 km upstream of the village Tsaghkashen

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	8.00	9.11	11.44	7.37	6.73
pH	-	7.14	7.44	7.71	7.69	7.69
BOD_5	mgO_2/L	2.46	1.69	2.48	2.33	1.9
COD-Cr	mgO/L	18.67	24.00	17.00	22.00	15
Nitrate nitrogen	mgN/L	0.163	0.289	0.274	0.245	0.102
Nitrite nitrogen	mgN/L	0.004	0.006	0.006	0.004	0.003
Ammonia nitrogen	mgN/L	0.163	0.090	0.137	0.131	0.121
Copper	mg/L	0.0015	0.0012	0.0015	0.0014	0.0015
Zinc	mg/L	0.0014	0.0012	0.0013	0.0021	0.0044
Chromium	mg/L	0.0005	0.0004	0.0004		0.0010
Arsenic	mg/L	0.0002	0.0003	0.0002	0.0003	0.0003
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0000	0.0001	0.0002	0.0002
Nickel	mg/L	0.0015	0.0011	0.0010	0.0014	0.0012
Molybdenum	mg/L	0.0002	0.0003	0.0003	0.0003	0.0005
Manganese	mg/L	0.0090	0.0028	0.0023	0.0041	0.0032
Vanadium	mg/L	0.0011	0.0016	0.0013	0.0018	0.0018
Cobalt	mg/L	0.0003	0.0001	0.0001	0.0001	0.0002
Antimony	mg/L	0.0001	0.0001	0.0001		0.0001
Selenium	mg/L	0.0010	0.0002	0.0000	0.0001	0.0002
Tin	mg/L	0.0001	0.0000			0.0000
Iron	mg/L	0.1698	0.3038	0.1214	0.1449	0.1592
Aluminum	mg/L	0.3250	0.0885	0.2106	0.1452	0.1746
Calcium	mg/L	8.11	8.07	5.86	7.33	6.27
Magnesium	mg/L	1.77	2.15	1.54	2.14	2.02
Potassium	mg/L	2.07	2.62	1.75	1.95	1.68
Sodium	mg/L	2.58	2.45	1.95	2.70	2.97
Sulphate ion	mg/L	2.75	2.91	2.72	2.67	2.07
Chloride ion	mg/L	1.62	1.75	1.53	1.71	1.33
Total Dissolved Solids	mg/L	41	42	34	44	35

SWQ monitoring site #78: Gavaraget River, mouth

Water quality parameter	Unit	2015	2016	2017	2018	2019
Dissolved oxygen	mgO_2/L	9.78	9.12	10.32	8.54	7.61
pH	-	7.50	7.66	7.67	7.46	7.56
BOD_5	mgO_2/L	2.91	2.89	2.73	2.65	2.75
COD-Cr	mgO/L	24.00	24.29	20.00	25.14	22.9
Nitrate nitrogen	mgN/L	2.469	4.590	3.018	3.226	2.905
Nitrite nitrogen	mgN/L	0.025	0.031	0.037	0.040	0.030
Ammonia nitrogen	mgN/L	0.510	0.203	0.333	0.237	0.303
Copper	mg/L	0.0017	0.0012	0.0016	0.0015	0.0024
Zinc	mg/L	0.0034	0.0039	0.0028	0.0054	0.0191
Chromium	mg/L	0.0008	0.0010	0.0009		0.0022
Arsenic	mg/L	0.0011	0.0011	0.0012	0.0013	0.0012
Cadmium	mg/L	0.0000	0.0000	0.0000	0.0000	0.0000
Lead	mg/L	0.0002	0.0001	0.0002	0.0001	0.0004
Nickel	mg/L	0.0014	0.0012	0.0010	0.0011	0.0013
Molybdenum	mg/L	0.0019	0.0020	0.0020	0.0021	0.0023
Manganese	mg/L	0.0185	0.0135	0.0155	0.0127	0.0160
Vanadium	mg/L	0.0210	0.0195	0.0242	0.0234	0.0246
Cobalt	mg/L	0.0003	0.0002	0.0002	0.0002	0.0003
Antimony	mg/L	0.0001	0.0001	0.0001		0.0001
Selenium	mg/L	0.0008	0.0005	0.0003	0.0005	0.0006
Tin	mg/L	0.0001	0.0000	0.0000		0.0001
Iron	mg/L	0.1190	0.0600	0.1035	0.0923	0.1085
Aluminum	mg/L	0.0914	0.0241	0.0498	0.0456	0.0345
Calcium	mg/L	20.90	21.78	22.42	21.37	22.87
Magnesium	mg/L	14.05	12.49	13.48	12.25	13.76
Potassium	mg/L	5.28	4.73	5.04	4.95	5.51
Sodium	mg/L	16.05	14.96	17.70	15.88	16.28
Sulphate ion	mg/L	9.75	15.07	13.27	13.11	13.00
Chloride ion	mg/L	10.18	15.83	14.04	14.36	14.00
Total Dissolved Solids	mg/L	182	198	189	192	193

ANNEX 16. CALCULATED VALUES OF MONTHLY ECOLOGICAL FLOW FOR SURFACE WATER BODIES DELINEATED WITHIN SEVAN RBD

WB №	WB Description	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
WB 4-001	The river Dzknaget from the source to the confluence of right tributeries	0.026	0.022	0.028	0.112	0.097	0.057	0.038	0.030	0.030	0.028	0.032	0.026
WB 4-002	Right tributary of the River Dzknaget	0.024	0.020	0.026	0.102	0.088	0.052	0.035	0.027	0.027	0.025	0.029	0.023
WB 4-003	The River Dzknaget-from confluences right tributaries to estuary	0.085	0.071	0.093	0.365	0.317	0.186	0.125	0.098	0.098	0.091	0.103	0.084
WB 4-004	The river Drakhtik with its tributaries Tandzut and Erkaynadzor to village Drakhtik	0.010	0.011	0.020	0.028	0.034	0.026	0.022	0.015	0.010	0.010	0.011	0.009
WB 4-005	The river Drakhtik from village Drakhtik to estuary	0.012	0.014	0.024	0.034	0.042	0.032	0.028	0.019	0.012	0.013	0.014	0.011
WB 4-007	The river Artsataghberq from sourse to confluence tributary Sakavajur-with tributary Sakavajur	0.005	0.006	0.011	0.015	0.018	0.014	0.012	0.008	0.005	0.006	0.006	0.005
WB 4-008	The river Artsataghberq from confluence tributary Sakavajur to estuary	0.008	0.009	0.015	0.022	0.027	0.020	0.017	0.012	0.008	0.008	0.009	0.007
WB 4-009	The river Artanish from source to estuary	0.005	0.006	0.010	0.014	0.017	0.013	0.011	0.008	0.005	0.005	0.006	0.004
WB 4-011	The river Gizhget from source to estuary	0.002	0.003	0.005	0.007	0.009	0.007	0.006	0.004	0.002	0.003	0.003	0.002
WB 4-012	The river Jil from source to estuary	0.040	0.044	0.045	0.055	0.053	0.058	0.055	0.040	0.040	0.040	0.049	0.045
WB 4-014	The river Tsapatagh from source to confluence its tributary Yeghegnadzor-with tributary Yeghegnadzor	0.018	0.020	0.026	0.039	0.048	0.037	0.030	0.029	0.028	0.025	0.025	0.023
WB 4-015	The river Tsapatagh-from confluence tributary Yghdzadzor to estuary	0.042	0.045	0.059	0.089	0.111	0.086	0.070	0.066	0.064	0.057	0.059	0.053
WB 4-017	The river Shampur from source to estuary	0.026	0.028	0.036	0.055	0.069	0.053	0.043	0.041	0.040	0.035	0.036	0.033

WB 4-018	The river Pambak from source to confluence left tributary- with left tributary	0.022	0.024	0.031	0.047	0.058	0.045	0.037	0.035	0.034	0.030	0.031	0.028
WB 4-019	The river Pambak from confluence its left tributary to estuary	0.031	0.033	0.043	0.065	0.081	0.062	0.051	0.048	0.047	0.042	0.043	0.038
WB 4-021	The river Daranak from source to confluence its left tributary Satanakhach-with left tributary Satanakhach	0.028	0.027	0.033	0.035	0.107	0.079	0.041	0.048	0.040	0.037	0.039	0.036
WB 4-022	The river Daranak from confluence its left tributary Satanakhach to estuary	0.030	0.029	0.036	0.038	0.115	0.086	0.045	0.052	0.043	0.040	0.042	0.039
WB 4-023	The river Areguni from source to confluence its left tributary Hovsatagh-with tributary Hovsatagh	0.012	0.013	0.017	0.026	0.032	0.025	0.020	0.019	0.019	0.017	0.017	0.015
WB 4-024	The river Areguni from confluence its tributary Hovsatagh to estuary	0.017	0.018	0.023	0.035	0.044	0.034	0.028	0.026	0.026	0.023	0.023	0.021
WB 4-025	The river Sarinar-Right tributary of the river Geghamasar	0.025	0.026	0.034	0.052	0.064	0.050	0.041	0.038	0.037	0.033	0.034	0.031
WB 4-026	The river Geghamasar from source to village Geghamasar	0.017	0.018	0.023	0.035	0.043	0.033	0.027	0.026	0.025	0.022	0.023	0.021
WB 4-027	The river Geghamasar from village Geghamasar to estuary	0.046	0.049	0.064	0.096	0.121	0.093	0.076	0.071	0.070	0.062	0.063	0.057
WB 4-029	The river Poqr Masrik from source to confluence tributary Norakert-with tributary Norakert	0.017	0.019	0.024	0.037	0.046	0.035	0.029	0.027	0.026	0.024	0.024	0.022
WB 4-030	The river Poqr Masrik from confluence tributary Norakert to estuary	0.081	0.086	0.112	0.169	0.211	0.163	0.133	0.125	0.122	0.109	0.111	0.100
WB 4-028	The river Kaputjur-right tributary of the river Poqr Masrik	0.027	0.029	0.038	0.057	0.072	0.055	0.045	0.042	0.041	0.037	0.038	0.034
WB 4-032	The river Sotk in sources, and its tributaries till village Sotk	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028	0.028
WB 4-033	The river Kut-right tributary of the river Sotk	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027	0.027
WB 4-034	The river Daranak-right tributary of the river Sotk	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050	0.050
WB 4-035	The river Azat-right tributary of the river Sotk	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045	0.045
WB 4-036	The river Masrik from source to	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190	0.190

	village Jaghacdzor												
WB 4-037	The river Masrik from village Jaghacdzor to confluence tributary Sotk	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352	0.352
WB 4-039	The river Sevajur-right tributary of the river Masrik	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036	0.036
WB 4-040	The river Zangik-right tributary of the river Sevajur	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
WB 4-042	The river Akunq-left tributary of the river Masrik	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108	0.108
WB 4-043	The river Karchaghbyur from source to village Akhpradzor	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181	0.181
WB 4-044	The river Karchaghbyur from village Akhpradzor till village Maqenis	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333	0.333
WB 4-045	The river Erpnapor-tributary of the river Karchaghbyur	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098	0.098
WB 4-046	The river Aghotadzor-left tributary of the river Karchaghbyur	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054	0.054
WB 4-047	The river Karchaghbyur from village Maqenis to estuary	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460	0.460
WB 4-048	The river Artsvanist from source to estuary	0.110	0.090	0.131	0.138	0.218	0.209	0.197	0.111	0.072	0.070	0.100	0.098
WB 4-049	The river Eghancujur-tributary of the river Artsvanist	0.034	0.028	0.040	0.042	0.067	0.064	0.060	0.034	0.022	0.021	0.031	0.030
WB 4-050	The river Vardenik from source to confluence tributary Azizner with tributary Azizner	0.070	0.074	0.077	0.118	0.320	0.376	0.205	0.120	0.091	0.079	0.086	0.074
WB 4-051	The river Vardenik from confluence tributary Azizner to village Vardenik	0.100	0.106	0.109	0.169	0.456	0.537	0.293	0.171	0.130	0.113	0.123	0.106
WB 4-053	The river Aknakhar from source to estuary	0.005	0.006	0.006	0.009	0.025	0.029	0.016	0.009	0.007	0.006	0.007	0.006
WB 4-054	The river Zolaqar from source to estuary	0.009	0.009	0.009	0.014	0.039	0.046	0.025	0.015	0.011	0.010	0.010	0.009
WB 4-055	The river Astghadzor from source to estuary	0.029	0.030	0.031	0.048	0.131	0.154	0.084	0.049	0.037	0.032	0.035	0.030
WB 4-056	The river Martuni with its tributary Dashtaget till village Geghhovit	0.220	0.220	0.280	0.345	0.817	1.018	0.435	0.325	0.227	0.240	0.210	0.230
WB 4-061	The river Argichi from source to confluence tributary Poqr Argichi	0.826	0.841	0.922	1.419	2.017	1.607	1.404	1.302	1.257	1.232	1.221	1.145

WB 4-060	The river Poqr Argichi from source to confluence of the river Argichi	0.414	0.422	0.463	0.712	1.012	0.806	0.704	0.653	0.630	0.618	0.613	0.575
WB 4-059	The river Gayladzor right tributary of the river Poqr Argichi, with its tributaries Tsaghkashen, Arvak and Arhanch	0.277	0.270	0.304	0.473	0.554	0.506	0.459	0.425	0.405	0.358	0.331	0.284
WB 4-062	The river Nazarget- left tributary of the river Argichi	0.855	0.855	0.914	1.218	1.759	1.503	1.356	1.277	1.140	1.061	1.022	0.933
WB 4-063	The river Argichi from confluence tributary of the Poqr Masrik to farms of the village Madina	1.398	1.424	1.561	2.402	3.415	2.720	2.376	2.205	2.128	2.085	2.068	1.939
WB 4-064	The river Argichi from farms of the village Madina till village Verin Getashen	1.563	1.592	1.745	2.685	3.817	3.040	2.656	2.465	2.378	2.330	2.311	2.167
WB 4-066	The river Lichk from village Lichk to estuary	0.870	0.870	0.870	0.870	0.870	0.870	0.870	0.870	0.870	0.870	0.870	0.870
WB 4-067	The river Bakhtak from source to village Tazagyugh	0.021	0.030	0.036	0.063	0.191	0.171	0.132	0.068	0.032	0.033	0.033	0.028
WB 4-070	The river Tsakkar from source to village Dzoragyugh	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320	0.320
WB 4-072	The river Shoghvak from source to village Dzoragyugh	0.140	0.140	0.160	0.189	0.274	0.219	0.112	0.096	0.086	0.100	0.097	0.110
WB 4-074	The river Gegharkunikjur with its tributaries from source to village Sarukhan	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386	0.386
WB 4-075	The river Gegharkunikjur from village Sarukhan to confluence of the river Gavaraget	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454	0.454
WB 4-076	The river Gavaraget from source to confluence tributary Gegharkunikjur	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042	0.042
WB 4-078	The river Gridzor from source to estuary with its tributary Gayladzor	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205	0.205
WB 4-077	The river Gavaraget from confluence tributary Gegharqunijur till city Gavar	0.669	0.669	0.669	0.669	0.669	0.669	0.669	0.669	0.669	0.669	0.669	0.669
WB 4-079	The river Geloidzor- left tributary of the river Gavaraget, from source to estuary with its tributaries	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252	0.252
WB 4-080	The river Gumeriget with tributaries	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508	0.508

ANNEX 17. DESCRIPTION OF GROUNDWATER BODIES DELINEATED WITHIN SEVAN RBD

Total Mineralization and Total Hardness Changes in Sevan RBD

Number of Site	Type of the Monitoring Site	Location	River Basin	Discharge (Q) , l/sec or level (below the Earth surface) (S), m		Total Mineralization, mg/l		Total Hardness, mg-equivalent/l	
				May	Nov.	May	Nov.	May	Nov.
31	Spring	Gegharkunik Marz, v. Akunk	Masrik	Q= 547	Q= 407	100	120	1.0	1.1
1809	Fountaining well	Gegharkunik Marz, c. Vardenis	Masrik	Q= 23.1	Q= 25.5	190	233	2.0	1.7
1810	Fountaining well	Gegharkunik Marz, c. Vardenis	Masrik	Q= 8.9	Q= 8.5	128	150	1.4	1.1
2013	Fountaining well	Gegharkunik Marz, v. Gandzak	Gavaraget	Q= 4.13	Q= 4.0	149	187	1.0	1.7
2014	“Fadei” Spring	Gegharkunik Marz, c. Gavar	Gavaraget	Q= 1.54	Q= 1.63	344	392	3.8	3.5

Description of GWBs of Sevan RBD

№	Name of Water-Bearing Complex (Horizon), GWB Name, Code and Number	Name of Water-Bearing Rocks	Depth, m, Capacity, m of GWB Horizon	Pressure Character	Hydraulic Link with Surface Waters	Main Anthropogenic Factors (Pressures)
1	Water-bearing Quaternary– contemporary complex of eluvial-proluvial, alluvial-proluvial and lacustrine-river formations(Q_{1-4}) (Vardenis or Masrik – 3G-4)	Pebbles, piles, debris, sand, clay, loam, loamy sand and clay	2 – 68 8 - 52	Pressure and non-pressure	The connection is mutual, pressure waters fed the rivers, and the non-pressure waters are fed from the rivers	Agriculture, transport and abstraction through wells
2	Water-bearing complex of Pliocene-Quaternary volcanic rocks (N_2^3 - Q) (Lchashen – Gavar- Shatjrek 3G-2)	Dacites, andesites, andesitic dacites, basalts, tuffs and their clastolites	12 – 38 20 - 40	Pressure and non-pressure	The flow is directed toward the river valleys and Lake Sevan	Agriculture, abstraction from springs and through wells
3	Water-bearing complex of Upper Cretaceous sedimentary, mainly carbonate rocks (K_2Sn_2) (Shorja - Sotk – 3G-3)	Limestone, marls with interlayers of sandstones and volcanic rocks	8 – 16.08 ---	Non-pressure	The flow is directed toward the river valleys	Agriculture, abstraction from springs
4	Low water-bearing, low-permeable-impermeable complex of Meso-Cenozoic volcanic, volcanic-sedimentary, metamorphic intrusive rocks (Mz-Kz) (Dzknaget-Areguni 3G-4)	Tuff-conglomerates, tuff-sandstones, tuff-breccias, limestone, clay, clay shales, porphyrites, granodiorites	8 - 20 10 - 12	Non-pressure	The flow is directed toward the river valleys	Agriculture, mining and abstraction from springs
5	Mineral water bodies (Sevan-Gavar – 3G-5, Lichk – 3G-6)	Basalt, sand, debris, sandstones	30 – 260 ---	Non-pressure	The flow is directed toward the river valleys	Agriculture

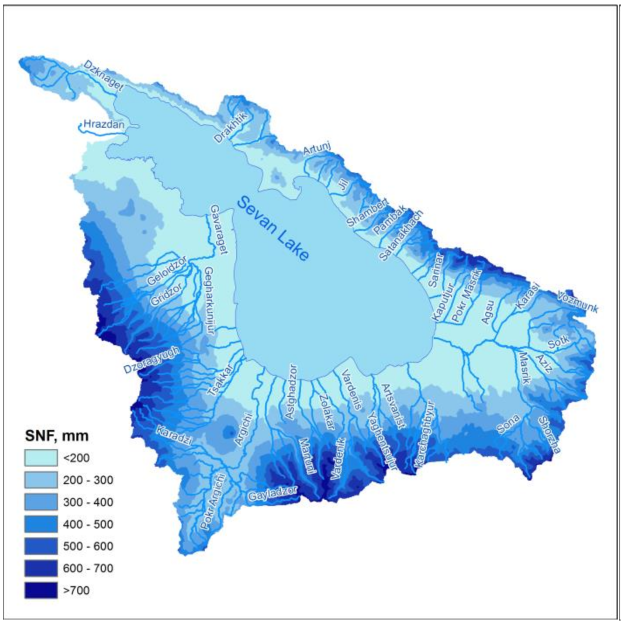
Classification of GWBs within Sevan RBD

№	Name, Code, Number and Index of GWB	Infiltration of Highly Mineralized Water	Interaction Factors between Groundwater and Surface Water	Interaction with Adjacent Land Ecosystems	Protection Measures	The Main Anions and Cations in the Chemical Composition of Water	Trend of Water Level or Discharge Change (decrease or increase)	Pressure Nature	GWB Area, km^2
1	Dzknaget - Areguni 3G-1 Q_{1-4}	No infiltration of high mineralization water	Groundwater is discharged in river valleys. There is no negative impact on surface water.	There is no negative impact on land ecosystems	Used for drinking (without additional measures)	The Ca2+ and HCO3- ions are dominant	Groundwater level fluctuations are natural	Non-Pressure	172
2	Lchashen-Gavar-Shatjrek 3G-2 N_2 - Q	No infiltration of high mineralization water	Groundwater is discharged in river valleys. There is no negative impact on surface water.	There is no negative impact on land ecosystems	Can be used for drinking (without additional measures)	The Mg2+ and HCO3- ions are dominant	Groundwater level fluctuations are natural	Pressure and Non-Pressure	2156
3	Shorja - Sotk 3G-3 K_2Sn_2	No infiltration of high mineralization water	Groundwater is discharged in river valleys. There is no negative impact on surface water.	There is no negative impact on land ecosystems	Can be used for drinking (without additional measures)	The Ca^{2+} and HCO_3- ions are dominant	The fluctuations of discharges of groundwater are natural	Non-Pressure	40
4	Vardenis or Masrik 3G-4 Q_{1-4}	No infiltration of high mineralization water	Groundwater is discharged in river valleys. There is no negative impact on surface water.	There is no negative impact on land ecosystems	Can be used for drinking (without additional measures)	The Ca2+ and HCO3- ions are dominant	Groundwater level fluctuations are natural	Pressure and Non-Pressure	140
5	Sevan-Gavar 3G-5	No infiltration of high	Discharge of water with 3.2 –	There is no negative	Used for	The Na++ K+ and HCO3-	The fluctuations of discharges of	Non-Pressure	0.32

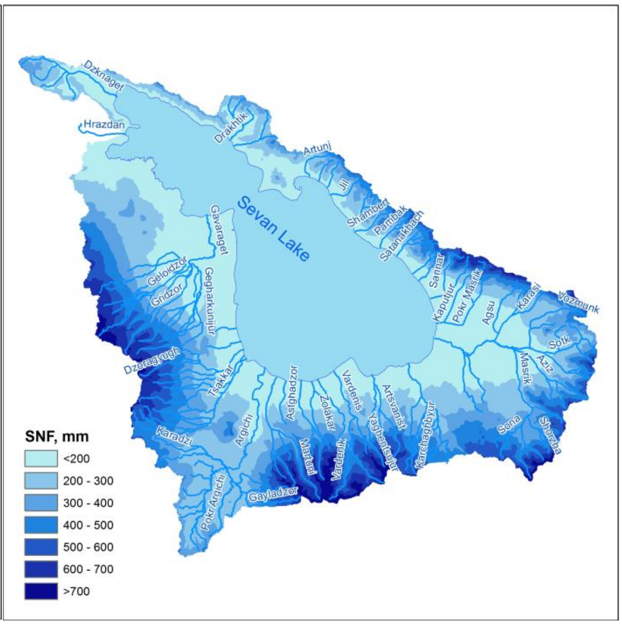
	N_1	mineralization water	3.5g/l total mineralization and 0.1-0.3 l/secrate	impact on land ecosystems	bottling as a table drinking water	ions are dominant	groundwater are natural		
6	Lichk 3G-6 N_1	No infiltration of high mineralization water	Discharge of water with 1.1 – 2.5 g/l total mineralization in river valleys. There is no negative impact on surface water	There is no negative impact on land ecosystems	Used for obtaining the carbon dioxide (CO_2)	The Na++ K+ and HCO3- ions are dominant	The fluctuations of discharges of groundwater are natural	Non-Pressure	0.48

ANNEX 18. PROJECTED CHANGES IN ANNUAL SURFACE NATURAL FLOW HEIGHT (MM) USING DSS CLIMATE CHANGE MODULE

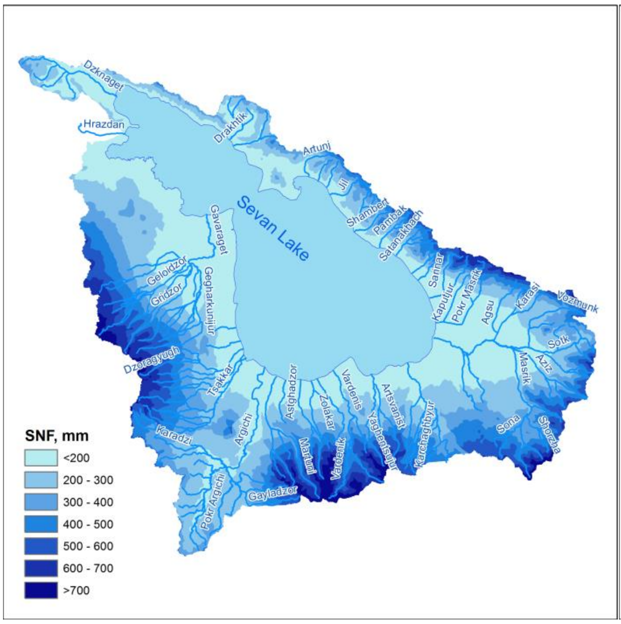
CCSM model, IPCC RCP6.0



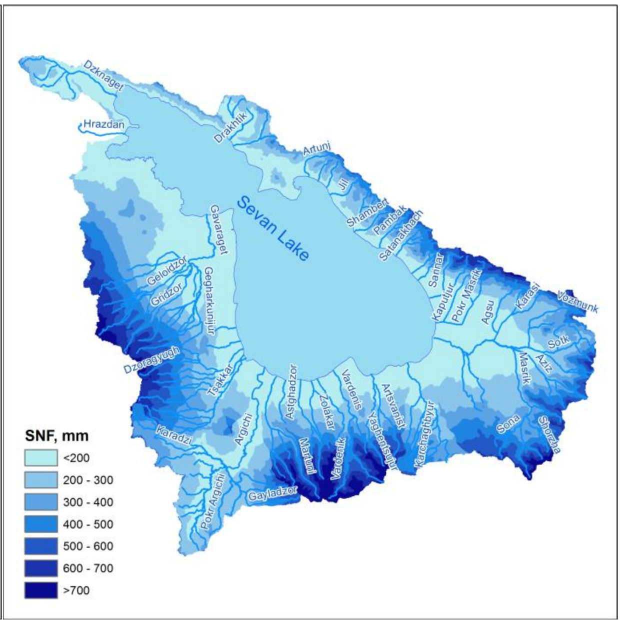
a) 1961-2017



b) 2040

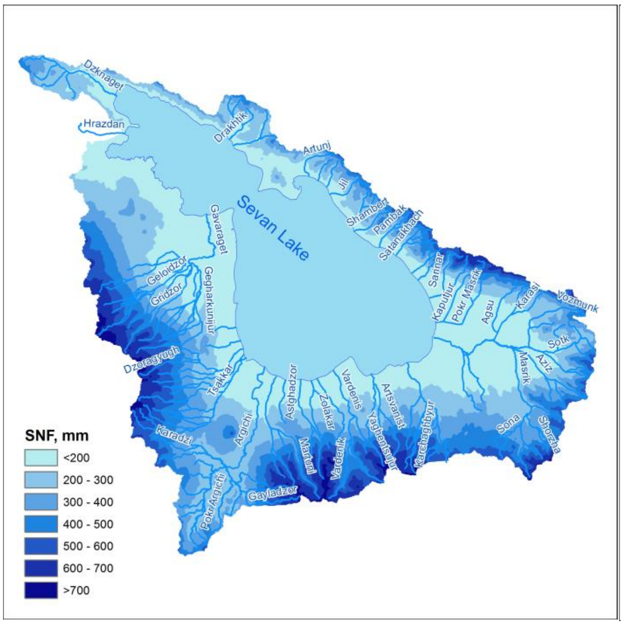


c) 2070

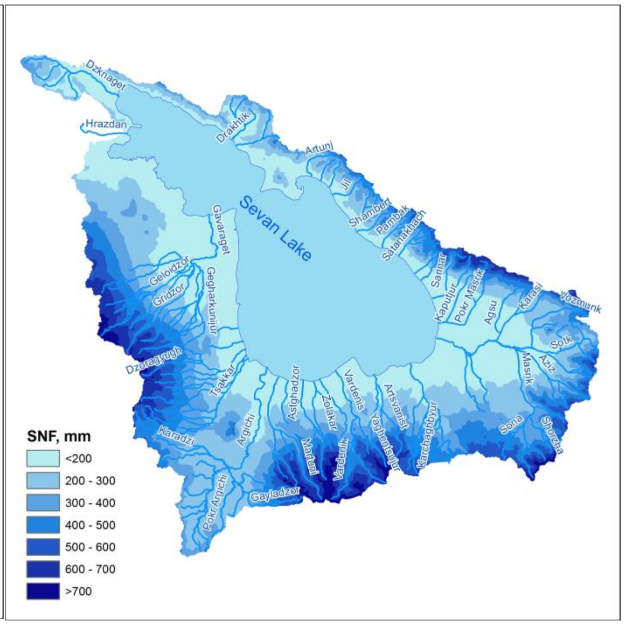


d) 2100

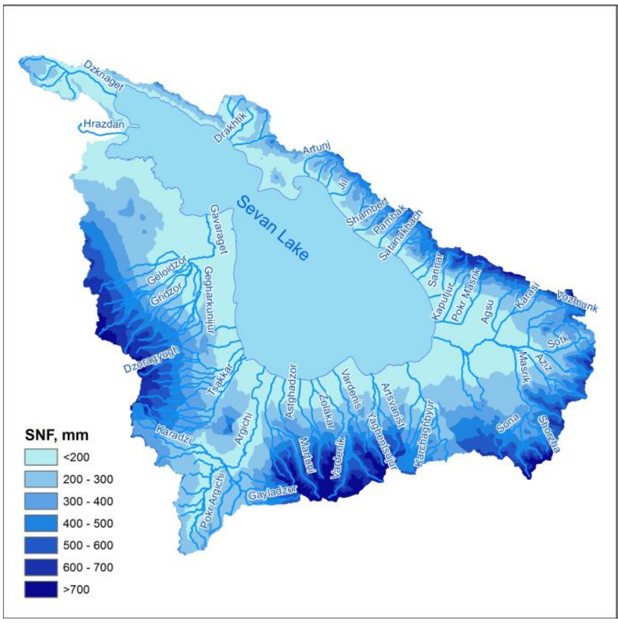
CCSM model, IPCC RCP8.5 scenario



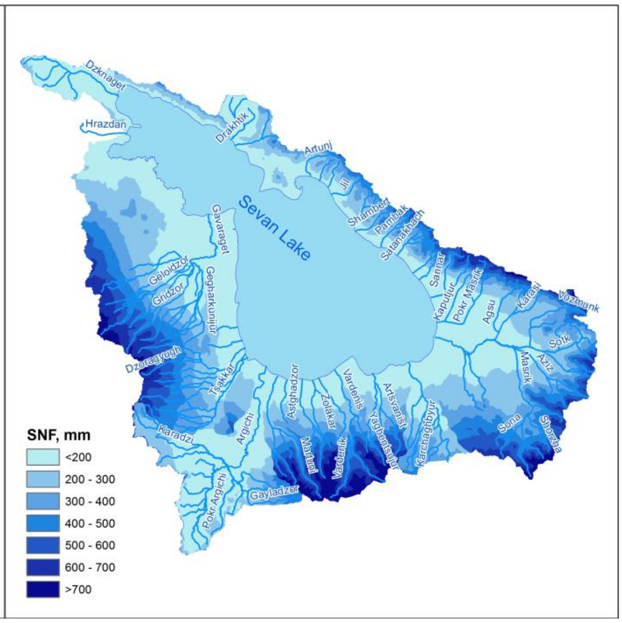
a) 1961-2017



b) 2040

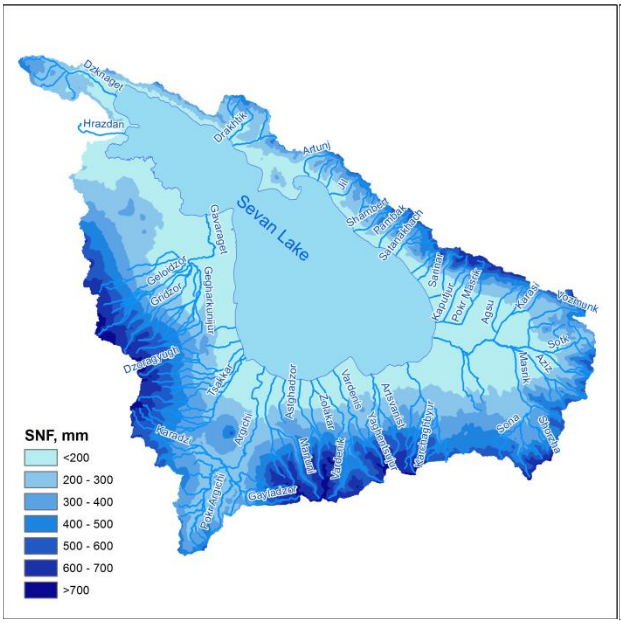


c) 2070

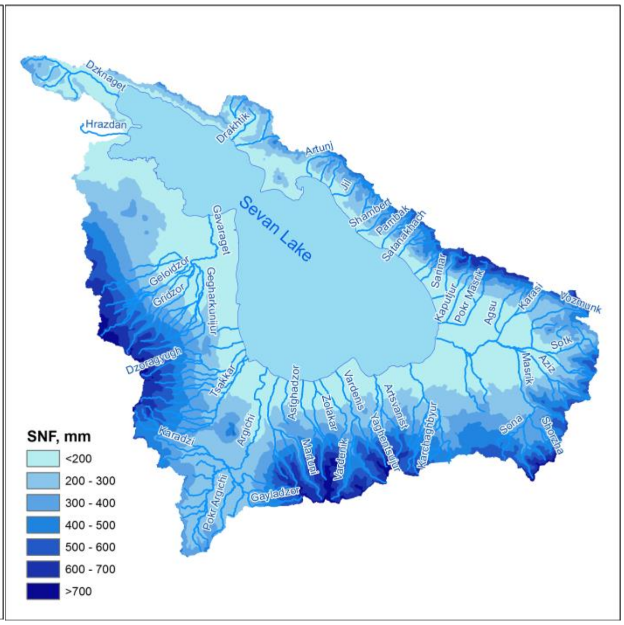


d) 2100

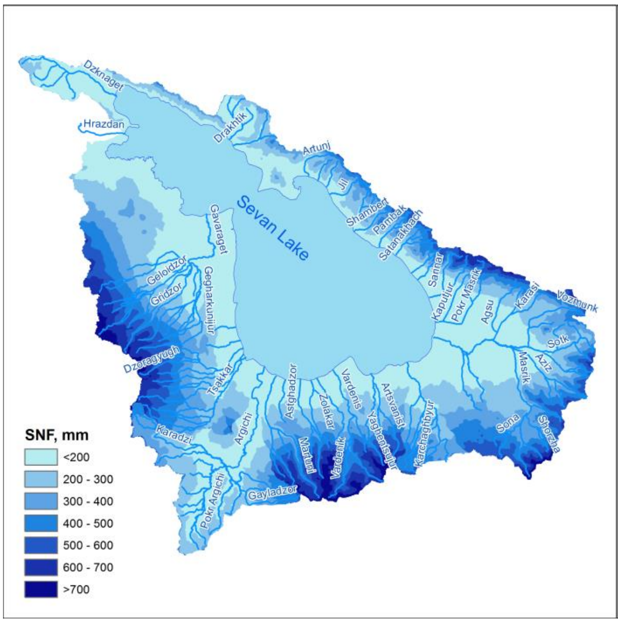
METRAS model, IPCC RCP8.5 scenario



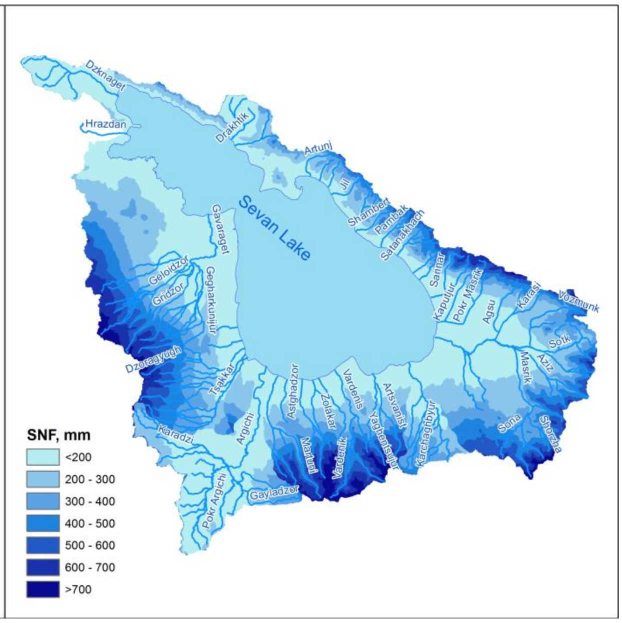
a) 1961-2017



b) 2040



c) 2070



d) 2100

ANNEX 19. ANNUAL OPERATIONAL AND MAINTENANCE COSTS OF WATER SUPPLY SYSTEMS IN SEVAN RBD (OFF-GRID COMMUNITIES)

Item	Name		Water produced, Thous. u3	Variable costs				Fixed costs						Total costs (Thous. AMD/year)
	Region name	Community or village name		Electricity costs	Material costs	Raw water costs	Total	Personnel costs (direct personnel)	Material costs	Maintenance costs			Total	
				Thous. AMD/year	Thous. AMD/year	Thous. AMD/year	Thous. AMD/year	Thous. AMD/year	Thous. AMD/year	Related to main works (Thous. AMD/year)	Related to plant and machinery (Thous. AMD/year)	Thous. AMD/year	Thous. AMD/year	
1	Karmir	Aghberk	18	28.1	46.2	0.9	75	1980	2750	545	113	658	5388	5463
2	Vardenis	Akhpradzor	20	28.1	50.2	1.0	79	1980	2750	268	117	385	5115	5194
3	Vardenis	Akunk	174	28.1	442.3	8.5	479	7920	3300	3870	298	4168	15388	15867
4	Vardenis	Areguni	21	28.1	53.6	1.0	83	1980	2750	859	115	974	5704	5787
5	Vardenis	Arpunk	32	28.1	81.9	1.6	112	1980	2750	884	132	1017	5747	5858
6	Karmir	Artanish	36	28.1	92.3	1.8	122	1980	2750	584	115	699	5429	5551
7	Martuni	Artsvanist	129	28.1	327.8	6.3	362	5940	3300	2962	174	3136	12376	12739
8	Martuni	Astghadzor	458	28.1	1164.7	22.5	1215	5940	3300	6925	246	7170	16410	17625
9	Vardenis	Avazan	22	28.1	56.7	1.1	86	1980	2750	643	127	770	5500	5586
10	Vardenis	Ayrk	29	28.1	74.4	1.4	104	3960	2750	2124	132	2256	8966	9070
11	Vardenis	Azat	16	28.1	40.9	0.8	70	1980	2750	650	103	752	5482	5552
12	Vardenis	Daranak	12	28.1	29.7	0.6	58	1980	2750	526	115	641	5371	5430
13	Karmir	Drakhtik	49	28.1	123.9	2.4	154	1980	2750	1224	151	1375	6105	6259
14	Martuni	Dzoragyugh	197	28.1	500.9	9.7	539	7920	3300	3926	184	4110	15330	15869
15	Vardenis	Geghakar	11	28.1	27.2	0.5	56	1980	2750	202	103	304	5034	5090
16	Vardenis	Geghamabak	10	28.1	26.3	0.5	55	1980	2750	683	103	786	5516	5571
17	Vardenis	Geghamasar	56	28.1	143.0	2.8	174	1980	2750	2210	209	2419	7149	7323
18	Gavar	Gegharkunik	84	28.1	212.9	4.1	245	3960	3300	1517	157	1674	8934	9179
19	Martuni	Geghhovit	249	28.1	632.6	12.2	673	7920	3850	3506	157	3662	15432	16105
20	Vardenis	Jaghatsadzor	11	28.1	28.0	0.5	57	1980	2750	331	37	368	5098	5155
21	Karmir	Jil	33	716.4	83.6	1.6	802	1980	2750	1115	148	1264	5994	6795

22	Vardenis	Kakhakn	26	28.1	66.8	1.3	96	1980	2750	954	132	1087	5817	5913
23	Vardenis	Karchaghbyur	102	28.1	258.6	5.0	292	5940	2750	2197	33	2230	10920	11212
24	Vardenis	Khachaghbyur	121	28.1	308.5	6.0	343	5940	3300	2048	179	2228	11468	11810
25	Vardenis	Kut	15	28.1	37.1	0.7	66	1980	2750	380	115	495	5225	5291
26	Vardenis	Kutakan	15	28.1	38.7	0.7	68	1980	2750	854	103	957	5687	5754
27	Gavar	Lanjaghbyur	98	28.1	248.4	4.8	281	3960	3300	2260	191	2450	9710	9992
28	Vardenis	Lchavan	30	28.1	76.7	1.5	106	1980	2750	900	142	1042	5772	5878
29	Martuni	Lernahovit	17	0.0	43.5	1408.3	1452	1980	2750	253	0	253	4983	6435
30	Vardenis	Lusakunk	63	0.0	0.0	6182.8	6183	3960	0	1191	0	1191	5151	11334
31	Martuni	Madina	73	28.1	184.9	3.6	217	1980	2750	954	85	1039	5769	5986
32	Vardenis	Makenis	27	28.1	69.4	1.3	99	1980	2750	290	103	392	5122	5221
33	Karmir	Martuni	30	28.1	75.4	1.5	105	1980	2750	1363	115	1477	6207	6312
34	Vardenis	Mets Masrik	189	28.1	481.4	9.3	519	5940	3300	1199	125	1324	10564	11082
35	Vardenis	Nerkin Shorzha	6	28.1	16.1	0.3	44	1980	2750	417	103	520	5250	5294
36	Vardenis	Norabak	16	28.1	41.2	0.8	70	1980	2750	468	115	583	5313	5383
37	Vardenis	Norakert	49	28.1	123.7	2.4	154	1980	2750	768	117	886	5616	5770
38	Vardenis	Pambak	32	28.1	81.6	1.6	111	1980	2750	722	120	842	5572	5683
39	Vardenis	Pokr Masrik	41	28.1	105.4	2.0	136	3960	2750	1361	115	1476	8186	8321
40	Sevan	Semyonovka	14	1163.8	36.6	0.7	1201	1980	2750	356	171	527	5257	6458
41	Vardenis	Shatjrek	26	28.1	65.6	13927.0	14021	1980	2750	826	0	826	5556	19577
42	Vardenis	Shatvan	38	28.1	97.8	1.9	128	3960	2750	1489	120	1608	8318	8446
43	Karmir	Shorzha	31	3435.1	78.9	1.5	3516	1980	2750	680	130	810	5540	9055
44	Vardenis	Sotk	51	84.3	130.8	2.5	218	5940	2750	2377	159	2536	11226	11444
45	Vardenis	Torfavan	25	0.0	64.7	2477.7	2542	1980	2750	868	0	868	5598	8140
46	Vardenis	Tretuk	17	28.1	42.0	0.8	71	1980	2750	452	103	554	5284	5355
47	Gavar	Tsaghkashen	33	28.1	83.5	1.6	113	1980	2750	748	120	868	5598	5711
48	Vardenis	Tsapatagh	18	28.1	46.8	0.9	76	1980	2750	904	115	1019	5749	5825
49	Sevan	Tsovagyugh	172	56.2	436.8	8.4	501	7920	3300	2601	381	2982	14202	14703
50	Vardenis	Tsovak	112	28.1	283.9	5.5	317	5940	3300	2390	137	2528	11768	12085
51	Martuni	Tsovasar	127	28.1	322.4	6.2	357	5940	3300	1946	176	2122	11362	11718
52	Martuni	Tsovinar	206	28.1	522.8	10.1	561	7920	3300	3498	197	3695	14915	15476
53	Martuni	Vaghashen	171	28.1	436.0	8.4	473	7920	3300	3996	192	4187	15407	15880
54	Vardenis	Vanevan	21	28.1	53.0	1.0	82	5940	2750	586	103	689	9379	9461
55	Martuni	Vardadzor	121	28.1	307.3	5.9	341	5940	3300	2431	171	2602	11842	12183
56	Martuni	Vardenik	397	28.1	1009.9	19.5	1057	11880	4950	6135	157	6292	23122	24179
57	Martuni	Verin Getashen	210	56.2	534.0	10.3	601	5940	3300	3156	143	3300	12540	13140

58	Vardenis	Verin Shorzha	6	28.1	14.1	0.3	42	1980	2750	292	103	395	5125	5167
59	Martuni	Yeranos	237	56.2	602.4	11.6	670	9900	4400	3972	67	4039	18339	19009
60	Martuni	Zolakar	275	0.0	698.3	10567.3	11266	11880	4400	5429	0	5429	21709	32974
	TOTAL		4,924	6,945	12,364	34,785	54,094	237,600	177,100	99,263	7,670	106,933	521,633	575,727

Source: "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia" developed by the CES and "Jrtuq" LLC, 2015

ANNEX 20. ANNUAL OPERATIONAL AND MAINTENANCE COSTS OF WASTEWATER REMOVAL SYSTEMS IN SEVAN RBD (OFF-GRID COMMUNITIES)

Item	Name		Waste-water generated, thous, m3	Variable costs						Fixed costs						Total costs (Thous. AMD/year)
	Region name	Community or village name		Electricity costs	Sludge disposal costs	Faecal Sludge collec-tion& disposal	Urine collec-tion& disposal	Treated waste-water discharge costs	Total	Personnel costs (direct personnel)	Material costs	Maintenance costs			Total	
				Thous. AMD/ year	Thous. AMD/ year	Thous. AMD/ year	Thous. AMD/ year	Thous. AMD/ year	Thous. AMD/ year	Thous. AMD/ year	Thous. AMD/ year	Related to main works (Thous. AMD/year)	Related to plant and machinery (Thous. AMD/year)	Total (Thous. AMD/ year)	Thous. AMD/ year	
1	Karmir	Aghberk	0	0	0	392.7	294.5	0	687.2	990	0	98.175	0	98.2	1088.2	1775.4
2	Vardenis	Akhpradzor	0	0	0	293.7	220.3	0	514.0	990	0	73.425	0	73.4	1063.4	1577.4
3	Vardenis	Akunk	156.3	4983.2	68.2	0	0.0	84.8	5136.2	15840	247.5	15982.3	1269.3	17251.6	33339.1	38475.3
4	Vardenis	Areguni	0.0	0.0	0.0	424.6	318.5	0.0	743.1	1980	0	106.2	0.0	106.2	2086.2	2829.2
5	Vardenis	Arpunk	0.0	0.0	0.0	427.9	320.9	0.0	748.8	1980	0	107.0	0.0	107.0	2087.0	2835.8
6	Karmir	Artanish	0.0	0.0	0.0	1094.5	820.9	0.0	1915.4	1980	0	273.6	0.0	273.6	2253.6	4169.0
7	Martuni	Artsvanist	115.8	2747.9	50.6	0	0.0	100.8	2899.2	7920	116.3	11532.1	761.4	12293.4	20329.7	23228.9
8	Martuni	Astghadzor	164.8	1538.3	71.9	0	0.0	143.4	1753.6	12686	187.2	13436.4	1238.4	14674.8	27547.7	29301.3
9	Vardenis	Avazan	0.0	0.0	0.0	293.7	220.3	0.0	514.0	1980	0.0	73.4	0.0	73.4	2053.4	2567.4
10	Vardenis	Ayrk	0.0	0.0	0.0	284.9	213.7	0.0	498.6	1980	0.0	71.2	0.0	71.2	2051.2	2549.8
11	Vardenis	Azat	0.0	0.0	0.0	189.2	141.9	0.0	331.1	990	0.0	47.3	0.0	47.3	1037.3	1368.4
12	Vardenis	Daranak	0.0	0.0	0.0	325.6	244.2	0.0	569.8	990	0.0	81.4	0.0	81.4	1071.4	1641.2
13	Karmir	Drakhtik	0.0	0.0	0.0	1292.5	969.4	0.0	2261.9	1980	0.0	323.1	0.0	323.1	2303.1	4565.0
14	Martuni	Dzoragyugh	177.0	7588.4	77.3	0	0.0	96.1	7761.7	11880	275.0	20083.4	2582.7	22666.1	34821.1	42582.7
15	Vardenis	Geghakar	0.0	0.0	0.0	140.8	105.6	0.0	246.4	990	0.0	35.2	0.0	35.2	1025.2	1271.6
16	Vardenis	Geghamabak	0.0	0.0	0.0	115.5	86.6	0.0	202.1	990	0.0	28.9	0.0	28.9	1018.9	1221.0
17	Vardenis	Geghamasar	0.0	0.0	0.0	1244.1	933.1	0.0	2177.2	1980	0.0	311.0	0.0	311.0	2291.0	4468.2

18	Gavar	Geghark unik	75.2	454.3	32.8	0	0.0	40.8	528.0	7920	126.9	5702.3	802.4	6504.7	14551.6	15079.6
19	Martuni	Geghhov it	223.6	6779.6	97.6	0	0.0	121.4	6998.6	17820	302.5	18054.3	2158.6	20212.9	38335.4	45334.0
20	Vardenis	Jaghatsa dzor	0.0	0.0	0.0	169.4	127.1	0.0	296.5	990	0.0	42.4	0.0	42.4	1032.4	1328.8
21	Karmir	Jil	0.0	0.0	0.0	877.8	658.4	0.0	1536.2	1980	0.0	219.5	0.0	219.5	2199.5	3735.6
22	Vardenis	Kakhakn	0.0	0.0	0.0	370.7	278.0	0.0	648.7	1980	0.0	92.7	0.0	92.7	2072.7	2721.4
23	Vardenis	Karchag hbyur	91.4	6015.6	39.9	0	0.0	49.6	6105.1	7920	220.0	11247.6	1388.9	12636.5	20776.5	26881.6
24	Vardenis	Khachag hbyur	51.9	2587.5	22.7	0	0.0	28.2	2638.4	3960	104.8	8029.9	749.7	8779.6	12844.4	15482.7
25	Vardenis	Kut	0.0	0.0	0.0	214.5	160.9	0.0	375.4	990	0.0	53.6	0.0	53.6	1043.6	1419.0
26	Vardenis	Kutakan	0.0	0.0	0.0	246.4	184.8	0.0	431.2	990	0.0	61.6	0.0	61.6	1051.6	1482.8
27	Gavar	Lanjagh byur	87.8	2938.0	38.3	0	0.0	47.6	3024.0	7920	148.1	8328.8	870.3	9199.2	17267.3	20291.2
28	Vardenis	Lchavan	0.0	0.0	0.0	357.5	268.1	0.0	625.6	1980	0.0	89.4	0.0	89.4	2069.4	2695.0
29	Martuni	Lernaho vit	0.0	0.0	0.0	204.6	153.5	0.0	358.1	990	0.0	51.2	0.0	51.2	1041.2	1399.2
30	Vardenis	Lusakun k	57.1	2571.2	24.9	0	0.0	31.0	2627.1	3960	115.2	6305.3	607.5	6912.8	10987.9	13615.1
31	Martuni	Madina	0.0	0.0	0.0	606.1	454.6	0.0	1060.7	1980	0.0	151.5	0.0	151.5	2131.5	3192.2
32	Vardenis	Makenis	0.0	0.0	0.0	284.9	213.7	0.0	498.6	1980	0.0	71.2	0.0	71.2	2051.2	2549.8
33	Karmir	Martuni	0.0	0.0	0.0	540.1	405.1	0.0	945.2	1980	0.0	135.0	0.0	135.0	2115.0	3060.2
34	Vardenis	Mets Masrik	168.0	5076.1	55.1	0	0.0	91.2	5222.4	7920	247.5	13559.3	1263.9	14823.2	22990.7	28213.1
35	Vardenis	Nerkin Shorzha	0.0	0.0	0.0	95.7	71.8	0.0	167.5	990	0.0	23.9	0.0	23.9	1013.9	1181.4
36	Vardenis	Norabak	0.0	0.0	0.0	342.1	256.6	0.0	598.7	990	0.0	85.5	0.0	85.5	1075.5	1674.2
37	Vardenis	Norakert	0.0	0.0	0.0	584.1	438.1	0.0	1022.2	1980	0.0	146.0	0.0	146.0	2126.0	3148.2
38	Vardenis	Pambak	0.0	0.0	0.0	521.4	349.8	0.0	871.2	1980	0.0	130.4	0.0	130.4	2110.4	2981.6
39	Vardenis	Pokr Masrik	0.0	0.0	0.0	753.5	565.1	0.0	1318.6	1980	0.0	188.4	0.0	188.4	2168.4	3487.0
40	Sevan	Semyon ovka	0.0	0.0	0.0	325.6	170.0	0.0	495.6	990	0.0	81.4	0.0	81.4	1071.4	1567.0
41	Vardenis	Shatjrek	0.0	0.0	0.0	568.7	426.5	0.0	995.2	1980	0.0	142.2	0.0	142.2	2122.2	3117.4
42	Vardenis	Shatvan	0.0	0.0	0.0	775.5	581.6	0.0	1357.1	1980	0.0	193.9	0.0	193.9	2173.9	3531.0
43	Karmir	Shorzha	0.0	0.0	0.0	908.6	567.6	0.0	1476.2	1980	0.0	227.2	0.0	227.2	2207.2	3683.4
44	Vardenis	Sotk	0.0	0.0	0.0	871.2	653.4	0.0	1524.6	1980	0.0	217.8	0.0	217.8	2197.8	3722.4
45	Vardenis	Torfavan	0.0	0.0	0.0	414.7	311.0	0.0	725.7	1980	0.0	103.7	0.0	103.7	2083.7	2809.4
46	Vardenis	Tretuk	0.0	0.0	0.0	211.2	158.4	0.0	369.6	990	0.0	52.8	0.0	52.8	1042.8	1412.4
47	Gavar	Tsaghka shen	0.0	0.0	0.0	444.4	318.5	0.0	762.9	1980	0.0	111.1	0.0	111.1	2091.1	2854.0
48	Vardenis	Tsapata gh	0.0	0.0	0.0	644.6	483.5	0.0	1128.1	990	0.0	161.2	0.0	161.2	1151.2	2279.2

49	Sevan	Tsovagy ugh	154.4	6070.7	71.2	0	0.0	83.8	6225.6	15840	275.0	15020.4	1592.7	16613.0	32728	38953.7
50	Vardenis	Tsovak	100.3	5079.5	43.8	0	0.0	54.4	5177.8	7920	220.0	11128.4	1277.9	12406.4	20546	25724.1
51	Martuni	Tsovasa r	114.0	5805.7	49.7	0	0.0	61.9	5917.3	11880	220.0	12174.9	1715.2	13890.1	25990	31907.4
52	Martuni	Tsovinar	184.7	75.7	80.6	0	0.0	160.7	317.1	11880	185.4	9956.7	985.4	10942.1	23008	23324.6
53	Martuni	Vaghash en	154.1	5399.6	67.3	0	0.0	83.6	5550.5	9900	247.5	16505.8	1442.5	17948.3	28096	33646.3
54	Vardenis	Vanevan	0.0	0.0	0.0	354.2	265.7	0.0	619.9	1980	0.0	88.6	0.0	88.6	2068.6	2688.4
55	Martuni	Vardadz or	108.6	791.5	47.4	0	0.0	59.0	897.9	5940	130.1	10204.6	945.9	11150.5	17220.5	18118.4
56	Martuni	Vardenik	356.9	1115.0	155.8	0	0.0	310.5	1581.3	24720	358.3	26285.8	1985.1	28270.9	53348.8	54930.1
57	Martuni	Verin Getashe n	188.4	5826.3	80.1	0	0.0	102.3	6008.7	13860	275.0	15494.7	1828.2	17322.9	31458	37466.6
58	Vardenis	Verin Shorzha	0.0	0.0	0.0	55	41.3	0.0	96.3	990	0.0	13.8	0.0	13.8	1003.8	1100.0
59	Martuni	Yeranos	212.9	4930.7	92.9	0	0.0	115.6	5139.2	11880	254.9	20313.0	1756.4	22069.4	34204	39343.5
60	Martuni	Zolakar	246.8	4883.7	107.7	0	0.0	214.7	5206.1	18994	280.3	22821.5	1715.1	24536.6	43811	49017.4
	TOTAL		3,190	83,259	1,376	18,262	13,452	2081	118,430	299,940	4,538	296,733	28,937	325,670	630,148	748,578

Source: "Feasibility Study on Improving and Developing Water Supply and Sanitation Systems in Rural Communities of Armenia" developed by the CES and "Jrtuq" LLC,2015

ANNEX 21. RECOMMENDED SURVEILLANCE AND OPERATIONAL MONITORING SITES FOR SWB IN THE SEVAN RBD

Recommended surveillance monitoring sites in rivers and lakes of the Sevan RBD

River or Lake / Sampling site	Type	HMWB	SWB	Rationale				Latitude	Longitude	Existing site
				Q/V	B	R	O			
Sotk 5 km above mine	I	N	4-032			+		45.90212	40.20086	yes
Masrik River mouth	II	N	4-041				+	45.63589	40.22329	yes
Gayladzor Tributary of Argichi, above HPP	I	N	4-059			+		45.22278	39.99056	no
Argichi River mouth	II	N	4-065				+	45.28217	40.17635	yes
Gavaraget River mouth	II	N	4-082				+	45.16986	40.38146	yes
Lake Sevan Big Lake Sevan	L VI	Y	4-088	+				45.31550	40.20900	yes

Q = Significant rate of water flow, B = near state border, R = candidate for reference site, O = other criteria (e.g. type)

Recommended operational monitoring sites in rivers and lakes of the Sevan RBD

River or Lake / Sampling site	Type	HMBW	SWB	Latitude	Longitude	exist
Jil 1.2 km upstream of the Jil river mouth	I	N	4-013	45.43281	40.45498	new
Sotq 2.5 km upstream of Mets Masrik	II	N	4-031	45.80340	40.20890	exist
Masrik Mets Masrik	II	N	4-038	45.77492	40.20980	new
Vardenis River mouth	II	N	4-052	45.42780	40.16570	exist
Martuni Geghhovit	I	N	4-057	45.28307	40.09710	new
Bakhtak Tsakqar	II	N	4-068	45.22937	40.18025	new
Bakhtak River mouth	II	N	4-069	45.23490	40.19130	exist
Tsakqar 350 m downstram of tributary Shoghvak	I	N	4-071	45.22594	40.18547	new
Shoghvak River mouth	I	N	4-073	45.17380	40.11150	exist
Gavaraget Bridge between Gawar and Artsvakar	II	N	4-081	45.15215	40.35230	new
Lake Sevan / Small Lake Sevan	L VI	Y	4-089	45.23840	40.47580	exist

Action funded by the
EUROPEAN UNION

EU WATER INITIATIVE
FOR EASTERN PARTNERSHIP

www.euwipluseast.eu