ENVIRONMENTAL AND SOCIAL ASSESSMENT REPORT

156 kWp Capacity Floating Photovoltaic Plant on Yerevan Lake

Yerevan,
September 2021

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LIST OF ABBREVIATIONS

PV	panels photovoltaic panels
RA	Republic of Armenia
MW	megawatt
kW	kilowatt
ESIA	Environmental and Social Impact Assessment
IFIs	International Financial Institutions
ANCA	Armenian National Canoe Federation
NCAA	National Canoeing Association of Armenia
ESMP	Environmental and Social Management Plan
SNCO	State Non Commercial Organization
EIA	Environmental Impact Assessment
OTL	overhead transmission line
HWL	high water level
LWL	low water level
HABs	harmful algal blooms
TSS	total suspended solids
TP	total phosphor
TN	total nitrogen

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1. INTRODUCTION AND PROJECT BACKGROUND

1.1 Introduction

Solar energy is the energy received from the Sun, which is converted into electrical energy (Photovoltaics). Solar energy is the cleanest, most abundant source of renewable energy and Armenia has a significant solar energy potential. The average annual amount of solar energy flow per square meter of horizontal surface is about 1720 kWh. One fourth of the country's territory is endowed with solar energy resources of 1850 kWh/m^2/year).

To promote the development of solar energy, the "Solar PV plant construction Investment Project" was developed and approved by the RA Government at the end of 2016. The first stage of the project envisages the construction of Masrik-1 industrial-scale solar photovoltaic plant with a peak capacity of 55 MW in Masrik region of the RA Gegharkunik marz. This will be followed by the construction of 5 plants with a total capacity of about 60 MW, which will allow generating about 191 GWh of electricity per year, reducing carbon dioxide emissions by about 45428 tons.

The construction of floating photovoltaic plants on water areas has started to develop all over the world, which has certain advantages: construction costs are low; they do not cause the problem of land allocation and change of land category.

1.2 Project background

To expand its capacity to generate electricity from renewable sources, the French engineering company Transénergie has conducted studies to determine the feasibility of developing floating photovoltaic plants in Armenia. Using the reservoirs and grid infrastructure near hydraulic dams, as well as Armenia's remarkable solar potential, the floating photovoltaic power is a promising opportunity for the country. Such technology allows the construction of photovoltaic plants of any size in unusable areas, and it is out of the competition for land use. There are already many designs of floating photovoltaic technologies all over the world; their application in Armenia will enable the use of the renewable energy resources in the country, ensuring the production of low carbon electricity.

The design is being developed within the framework of FASEP Studies and Green Innovation (FASEP: Private Sector Study and Aid Fund from the French Ministry of Economy and Finance). This is a donation fund of the French Ministry of Economy and Finance, which internationally funds technical studies and innovative pilot projects in the field of sustainable development.

The project envisages the installation of a 156 kWp solar photovoltaic plant on Yerevan Lake, for which this ESIA report has been developed.

1.3 ESIA framework

The ESIA framework for the construction of a floating photovoltaics solar plant on Yerevan Lake includes:

- ✓ studies of legal and institutional framework: the regulation framework (local, national, international environmental and social legislation) within which the solar plant is to be built and operated,
- ✓ environmental and social baseline conditions, within the framework of which data were collected on the climatic conditions of the area, geology, soils, terrestrial and aquatic biodiversity (flora and fauna, especially birds), historical and cultural values, socio-economic status, etc.,

- ✓ identification, forecasting and assessment of environmental and social risks, during which the impact of the project on ecologically sensitive, endangered or protected flora and fauna species has been identified,
- ✓ recommendations on appropriate measures to mitigate / enhance the identified environmental and social impacts,
- ✓ comparison and analysis of alternatives considered for the project related to the location of the solar panels / PV Modules and power generation technology,
- ✓ development of an Environmental and Social Management Plan.

The ESIA study was conducted based on:

- ✓ local, national and international laws and regulations,
- ✓ environmental and Social Sustainability Standards (2012) of International Financial Institutions (IFIs),
- ✓ World Bank's Environmental and Social Impact Assessment Guidelines (2017),
- ✓ World Bank's B "Environmental and Social Principles" (2017), as well as its 10 standards.

Important Note: According to the RA Law on Environmental Impact Assessment and Expertise (2014), this project is not subject to environmental expertise, and the design does not require a positive expertise opinion.

1.4 ESIA methodology

The purpose of this Environmental and Social Impact Assessment (ESIA) is to identify and analyze the environmental and social impacts of the floating solar power plant pilot project and develop recommendations for mitigation measures, as well as to create preconditions for the deployment of this new technology in Armenia. The ESIA will follow the typical process of establishing the current baseline conditions of the project area.

- ✓ Identification of specific environmental and social risks that need to be addressed;
- ✓ Description of the project impacts (positive or negative) and determining their significance at different stages of the project;
- ✓ Definition of mitigation and monitoring measures;
- ✓ Management plan summary to ensure effective mitigation and management of potential and (or) anticipated problems.

1.4.1 Scoping

The project team identified the environmental problems associated with the project that the ESIA study should focus on, by reviewing project information and clarifying potential environmental problems related to the project activities. This process helps to ensure that all relevant problems are identified and properly addressed in the ESIA study.

For the ESIA, the scope of the project was defined: the potential impact area for the project (and, respectively, the relevant study area), the identification of possible impacts of the project on the natural resources available in the area, the determination of their intensity and priority. The scoping provides an opportunity to direct the impact assessment to the problems that are most important in terms of decision-making and protection of stakeholders' interests.

1.4.2 Baseline data collection

The baseline data collection allows determining the main environmental, socio-economic status of the project site, the surrounding area, in the context of which the impacts of the project have been assessed.

It helps in environmental and social management planning and strategy to minimize any potential impact on the environment as a result of the project activities.

The project team experts have collected baseline data on the climate, geology, landscape, soils, terrestrial and aquatic biodiversity, historical and cultural areas, protected areas, socio-economic, health status of the population, etc. in the project area with a radius of about 5 km.

Meetings and consultations were held with stakeholders (residents, fishermen, community heads, sports facilities, etc.) to collect information on the socio-economic situation of the study area.

1.4.3. ESIA methodology and approach

The ESIA methodology is based on and developed in accordance with the World Bank's Environmental and Social Policy and Armenia's Environmental Legislation and regulations, through the joint experience and efforts of national environmental and social experts.

The ESIA study of the proposed project was carried out in accordance with the ESIA Data Requirements Memorandum (Appendix 1), the relevant World Bank guidelines, and the requirements of the Ministry of Environment of the Republic of Armenia. The site-specific ESIA study was conducted based on site studies, primary and secondary data analysis and discussions with the main stakeholders on the potential environmental and social impacts of the project.

The area that can be affected at all stages of the project implementation (construction, operation, dismantling) was selected as the project impact assessment area. Physically, the project site is not demarcated by a fence or physical border; it is connected to the surrounding area.

The ESIA was carried out by the working team consisting of hydrologists, botanists, zoologists, aquatic biodiversity, environmental, legal and social experts, who carried out field and office works in the relevant fields to collect preliminary environmental and socio-economic data. Taking into account the baseline study, the environmental, socio-economic description of the project and the analysis of the collected primary and secondary data, the team identified and summarized the possible positive and negative environmental and social impacts of the project and categorized them by size and significance. Mitigation measures have been developed based on the impact assessment, which will allow to maximize the benefits of the project for the local population, and to minimize the negative impacts at all stages of the project implementation. An environmental and social management system has been developed, including an environmental and social management plan, community/staff grievance mechanisms, an appropriate mitigation plan and measures in the construction stage.

The social team identified the stakeholders in the project area, including:

- ✓ RA Ministry of Environment
- ✓ RA Ministry of Territorial Administration and Infrastructure
- ✓ RA Ministry of Education, Culture, Youth and Sports
- ✓ Public Services Regulatory Commission
- ✓ Water Committee
- ✓ Electric Networks of Armenia
- ✓ Erebuni Airport
- ✓ Yerevan Municipality
- ✓ Shengavit administrative district of Yerevan
- ✓ US Embassy
- ✓ Russian Orthodox Church
- ✓ Armenian National Canoe Federation (ARFA)
- ✓ “Water Structures” CJSC
- ✓ National Canoeing Association of Armenia (NACA)

- ✓ Amateur fishermen
- ✓ Business representatives
- ✓ Environmental NGOs
- ✓ National Security Service
- ✓ The French Embassy in Armenia representative of the French Ministry of Economy and Finance
- ✓ Transenergie
- ✓ PJN-Consulting

A consultation on the project was conducted with the stakeholders.

The consultation of the stakeholders was carried out in a formal and informal format. Meetings were held with focus groups - employees of enterprises operating in the area, fishermen, sports facilities. As a result of the discussions, it was revealed that the fishermen are mainly concentrated in the southeastern part of the lake, where there is an opportunity to approach the lake and a flat area. In their opinion, the solar panels should be placed on the lake in a way as not to prevent them from engaging in their hobby.

Discussions were also held with the representatives of the two sports schools located on the shores of the lake and the Hrazdan River: The Armenian National Canoe Federation (ANCA) and the National Canoeing Association of Armenia (NCAA).

The possible impact of the construction of a solar plant on the activity of sports schools was discussed. Discussions revealed that they were using the central part of the lake and it was proposed to place the plant in the northwestern part of the lake.

A public consultation with all project stakeholders was held on October 6, in 2021, during which they were provided with the technical description of the project and the report on the project's environmental and social impact assessment.

The Agenda of the meeting, the List of participants and the Minutes of the meeting are given in Annex 1.

1.4.4 Environmental mitigation and improvement

An Environmental and Social Management Plan (ESMP) was developed to prevent, mitigate and compensate the environmental and social impacts identified within the ESIA.

The environmental and social management plan defines how environmental and social problems will be addressed in a comprehensive and inclusive manner during the construction and operation phases. It also contains measures for occupational safety, protection of life and health of residents.

The ESMP is important also for the fact that it summarizes the requirements of environmental and social measures, thus facilitating their management control.

In accordance with the requirements of the World Bank, the ESMP has the following components: (i) institutional measures to meet environmental and social safeguards requirements; (ii) environmental and social monitoring requirements; and (iii) mitigation measures (ESMP matrix) needed to address the impacts. The ESMP is a dynamic document that may require updates as the work progresses.

The ESMP is an integral part of the detailed design and must be implemented by the contractor and the operator.

The ESMP developed within the project includes a description of possible environmental and social impacts during the implementation and operation phases of the project, a list of measures to prevent and mitigate those impacts to be implemented by the contractor and the operator, the organizations implementing the control and the monitoring of the implementation of the measures, the phases of the control and those responsible.

1.4.5 Environmental monitoring

The purpose of environmental monitoring is to monitor the implementation of ESMP measures, to assess the effectiveness of mitigation measures. The ES monitoring envisages the collection of information on the implementation of measures to mitigate environmental and social impacts. The ESMP contains information on monitoring structures, location, timing and frequency of implementation.

The monitoring organizations within the framework of this project are the Ministry of Environment, the Ministry of Health, Yerevan Municipality, Environmental Protection and Mining Inspection Body, Shengavit Municipality, the Client.

The provision of ESMP during the meeting with the beneficiaries will enable them to independently monitor the implementation of the ES activities envisaged in the plan.

The monitoring will be carried out during the construction, at the construction site, and in its zone of influence, as well as during the operation phase.

2. LEGAL AND INSTITUTIONAL FRAMEWORK

2.1 Summary and decisions

A review of Armenian regulations framework and permitting process has been performed and the key information are detailed below (section 2). This includes the contents of an Environmental and Social Impact Assessment (ESIA), public consultation, the submission of ESIA for the permits (construction & operations, etc.). It appears that the Armenian regulations are consistent with the best international practices and international approaches such as Operational policies of World Bank, European Bank for Reconstruction and Development, the European Union Directive on Environmental Impact Assessment (85/337/EEC).

Decision on the completion of an ESIA for the Floating Photovoltaics demonstrator: An ESIA is required for "solar power stations occupying 40 hectares of territory and more" according to Art. 14 of the Law "On Environmental Impact Assessment and Expertize" (21 June, 2014). Therefore, due to the size of the Floating Photovoltaics demonstrator, there is no need for an ESIA application and associated construction or operation permits. Nevertheless, in the context of future solar floating photovoltaics' projects it has been decided that an ESIA will be performed as a reference. The ESIA will be a guidance for this innovative technology. The ESIA will be disclosed to the Project's stakeholders for transparency without a formal submission process.

Decision on environmental and social standards to be applied. Following the international good practices, the ESIA will be performed by an independent Armenian consultant following the European Directive on Environmental Impact Assessment.

This chapter provides an overview of the national policy within which the Utility-Scale Solar Power Project is being developed. The main source of this chapter is a R2E2's ESIA and discusses the overall policy and legal framework in the Republic of Armenia (RA) with specific sectorial laws on environment, land use, health and safety.

2.2 Main laws and policies in energy sector and main state institutions

Within the framework of the ESIA, the RA laws, regulations and rules, as well as the international obligations undertaken by the country regulating the environmental protection, social impact, occupational safety, public consultations, and other processes during the construction and operation stages of the floating solar plant, were studied.

While developing the ESIA report, the environmental and social assessment principles and policies of the World Bank, the European Bank for Reconstruction and Development, as well as the EU Environmental Impact Assessment Directive (85/337 / EEC) were taken into account.

2.3 Law "On Energy" (2001)

The Energy Law of the Republic of Armenia regulates the whole energy sector of the country. The basic principles of the law are:

a) Efficient use of domestic energy resources and alternative sources of energy and implementation of economic and legal mechanisms for that purpose;

b) Enhancement of the energy independence of the Republic, including the differentiation of domestic and imported energy resources and ensuring the maximum utilization of generating capacities;

c) Enhancement of competition and efficient operation in the energy sector;

d) Encouragement of investments in the energy sector;

e) Ensuring transparency of the licensed operations in the energy sector;

f) Ensuring safety in the energy sector and protection of the environment.

The law regulates licenses for the energy producers and distributors.

2.4 Law "On Energy Saving and Renewable Energy" (2004)

The RA Law on Energy Saving and Renewable Energies is aimed at defining the principles of energy saving, the development of renewable energy and mechanisms for the implementation thereof. The law defines renewable energy resources and renewable energy. The former is defined as a group of consumable energy carriers generated from wind, solar, water, geothermal and biomass renewable resources. Renewable energy is defined as the sector receiving energy carriers and mechanical energy from renewable energy resources. Law on Energy Saving and Renewable Energies defines the principles of energy saving and development of the sector. Ensuring high priority of issues of environmental protection and efficient (economic) usage of natural resources while implementing measures/activities aimed at the development of the energy saving and renewable energy is recognized as a priority in the law.

2.5 Environmental policy and relevant laws

In accordance with article 12 of the Constitution of the Republic of Armenia (adopted in 1995 and amended in 2005 and 2015) "The State stimulates protection, improvement and restoration of the environment and reasonable use of the natural resources based on the principle of steady development and taking into account the responsibility to the future generation. Everybody is obliged to take care of environmental protection". Article 85 of the constitution provides that "Everyone has, in accordance with the law, the right of health protection". Since 1991, more than 25 codes and laws as well as numerous by-laws and regulations have been adopted to protect the environment.

Land Code (2001) : The preamble of the Land Code stipulates that the possession, disposition and use of lands shall not cause damage to the environment, defensibility and security of the country shall not violate the rights and lawful interests of citizens and other persons. The Land Code defines the main directions for use and disposition of the state lands, included those allocated for various purposes, such as agriculture, urban construction, industry and mining, energy production, transmission and communication lines, transport and other purposes.

The Code also defines the lands under the specially protected areas as well as forest, water and reserved lands. It also establishes the measures aimed to the lands protection (including provision of protective and sanitary zones), as well as the rights of state bodies, local authorities and citizens towards the land.

The Government of the Republic of Armenia directly or by means of the authorized bodies implements the State management of the land resources of the RA. Community lands are managed by local self-government bodies.

Following the requirements of this Code, the Governmental decree (08.02.2017, N124-N) "On the establishment of technical regulations for general requirements for protection of lands from contamination, list of substances contaminating the lands, and assessment of level of land pollution and declaring void Governmental Decree N1277-N from 24 August 2006" was adopted.

Water Code (2002) : The main purpose of the Water Code is to provide the legal basis for the protection of the country's water resources, the satisfaction of water needs of citizens and economic sectors through effective management of water resources, and safeguarding the protection of water resources for future generations. The Water Code addresses the following key issues: responsibilities of state/local authorities and public, strategic use, protection and information systems of water resources, water use permits, use and preserving of underground freshwater, licensing of activities in the water sphere, penalties, rendering services to subscribers and guarantees of protection of their interests, use and management of state-owned water systems, wastewater disposal, use of transboundary water resources, water quality standards, participatory management of irrigation system, registration of

documents, economic incentives and payments, prevention and liquidation of harmful effects on water resources, use and protection of water systems in emergency situations, protection and state control of water resources, dispute resolution mechanisms,

Law of RA "On Fundamentals of National Water Policy" (2005) defines the priority principle of water use and, in the process of assessment of demand for water, attributes priority to the issues of environmental protection as an integral part of ecosystem. The scope of this Law shall be to ensure access to adequate quantity and quality of water resources with a view of ensuring human well-being for the development of the country's socio-economic system in order to meet economic and environmental needs in the present and in the future.

Law of RA "On National Water Program" (2006) regulates the relationships related to design and implementation of national water program, including national water reserve, strategic water reserve, assessment of useable water resources, water demand and supply, the problems and perspectives of protection and development of water resources based on the presumption of limited water resources and the vital importance thereof for human life and health, protection of biodiversity.

Law "On Environmental Impact Assessment and Expertise" (2014) provides legal basis for conducting state environmental expertise of planned activities and conceptual documents (policies, strategies, plans, programs schemes etc.) and presents standard steps of EIA process. The Law establishes general legal, economic, and organizational principles for conducting mandatory EIA and expertise (including strategic environmental assessment for conceptual documents) of various types of projects and concepts of sectorial development.

According to this law, activities are classified into 3 categories: A, B and C. The categories are defined on the basis of the scale of the activity, characteristics and the level of impact on environment.

The state expertise procedure consists of 2 stages. During the first stage lasting 1 month the Ministry of Nature Protection and the public are notified on the project (short summary), and the first round of public hearings is held. The Ministry of Environment (through "Environmental Impact Assessment and Expertize" SNCO) undertakes classification of a project and recommends ToR for the EIA, if the EIA is required according to the classification outcome. For category "C" projects either positive or negative environmental impact expertise conclusion is issued at the end of the 1st stage.

At the second stage, an EIA report based on the ToR is submitted to the Ministry of Environment and the Ministry undertakes its review during 60 days for a category "A" project or 40 days for a category "B" project. Two public consultation meetings are required at this stage. The Ministry may extend the review deadline for up to 30 days after which it issues a positive or a negative conclusion of the expert review.

The length and the complexity of the procedure depend on the categorization of the planned activity.

The activities related to solar power plant are included in category C, in case if the power plant occupies 40 hectares and more. Assessment and expertise are implemented prior to the implementation of planned activity. Also, for the activities of category C only the initial stage is exercised. Following the examination of the application at initial stage, the authorized body makes a decision on the issuance of an EIA conclusion for activities under category C.

EIA expertise shall also be conducted for construction of high voltage overhead power lines, which, according to the Law of the RA on EIA and, are the overhead power lines of 110 kV and more voltage. Pursuant to article 14 of the Law, installation of Overhead Transmission Lines (OTLs) is classified as activity of category B. For planned activities of category B EIA expertise shall consist of both initial and main stages.

Currently the works towards elaboration of a new edition of the Law "On Environmental Impact Assessment and Expertize" have launched by the Ministry of Environment of the RA. Although the draft is still under discussion, it is anticipated to further clarify the concepts used in the legislation,

simplify the processes of the EIA and expertise for activities with minor impact on the environment, integrate climate change adaptation considerations into the assessment and expertise process and other matters.

The draft EIA expertise envisages replacing the previous 3 categories (A, B, C) with 2 ones (A and B). For the first time, the activities subject to expertise of environmental impact assessment in the field of energy are planned to include wind power plants with a total capacity of 8 MW and more, solar power plants with an area of 5 hectares and more, which are considered as Category B.

Law "On Flora" (1999) defines RA state policy in the field of maintenance, protection, usage and regeneration of flora. The law defines objectives of flora examination, state monitoring, state inventory, requirements and approaches of red book preparation on flora, conditions, peculiarities, limitations of allocation of flora objects for purposeful usage, basis of termination of the right to use, provisions on flora maintenance, and economic encouragement of usage and implementation of supervision. The law also defines the rights and obligations of the state governance and local governmental bodies in the field of flora maintenance, protection, reproduction and use, mechanisms of state inventory, principles of deciding their indicators.

Law "On Fauna" (2000) defines RA state policy in the field of maintenance, protection, usage and regeneration of fauna. The law defines the objectives of survey of the fauna, state monitoring, state inventory, requirements and approaches of red book preparation on fauna, conditions, peculiarities, limitations of allocation of fauna objects for purposeful usage, basis of termination of the right to use, provisions on fauna maintenance, and economic encouragement of usage and implementation of supervision. The law also defines the rights and obligations of the state governance and local governmental bodies in the field of flora maintenance, protection, reproduction and use.

Law "On Waste" (2004) regulates legal and economic relations connected to the collection, transfer, maintenance, development, reduction of volumes, prevention of negative impact on human health and environment. The law defines the main principles and directions of state policy, the principles of state standardization, inventory, and introduction of statistical data, the implementation of their requirements and mechanisms, the principles of waste processing, the requirements for presenting wastes for the state monitoring, activities to decrease the amount of the waste, including environmental tax, as well as the compensation for the damages caused to the human health and environment by the legal entities and individuals, using waste, as well as requirements for state monitoring and legal violations. The law defines the rights and obligations of the state governmental and local governmental bodies, as well as those of legal entities and individuals.

Law "On Environmental Control" (2005) regulates the issues of organization and enforcement of control over the implementation of environmental legislation of the Republic of Armenia, and defines the legal and economic bases underlying the specifics of control, the relevant procedures, conditions and relations, as well as environmental control in the Republic of Armenia. A range of procedural aspects of general nature applicable to organization and conducting control are enshrined in the Law of RA "On Organizing and Conducting Control in the Republic of Armenia" The existing legal framework governing the use of natural resources and environmental protection includes a large variety of legal documents.

Governmental resolutions are the main legal instruments for implementing the environmental laws. Environmental field is also regulated by presidential orders, Prime Minister's resolutions and ministerial orders. The compliance of all the above requirements with this law is conducted by the Environmental and Mining Inspection Body subordinated to the Government of the RA.

Law "On Specially Protected Natural Areas" (2006) defines legal basis and relations of state policy for development, restoration, maintenance, reproduction and use of natural complex and separate objects, as well as ecosystems of specially protected natural areas of the Republic of Armenia. According to the law, specially protected natural areas are classified into four categories, National parks,

State Reserves, Natural monuments. The Law sets forth that specially protected natural areas can be of international, republican and local significance depending on the protected and/or endangered ecosystems and their elements are included in international or national or local importance.

The Law defines concepts, regimes of maintenance and use, principles of preparation of specially protected natural areas management plans, monitoring, calculation and state registrar, as well as the requirements of usage, limitations and principles, rights and obligations of state governmental and local governmental bodies, maintenance bodies of the protected areas, the rights public to get an information on protected areas, financial sources of protected areas, requirement of supervision and responsibility for violating the Law on Specially Protected Natural Areas.

2.6 Occupational safety and health

Labor Code (2004) protects the rights and interests of employees and employers in collective and individual employment relationships, establishes state guarantees for labor rights and freedoms, and promotes the creation of favorable conditions of work.

The labor relations between the employee and employer are originated on the basis of labor contract concluded in a procedure established by the Labor Code and other normative legal acts containing norms on labor legislation.

Law "On Ensuring Sanitary-epidemiological Security of the RA Population" (1992) sets legal, economic and institutional bases for ensuring sanitary and epidemiological safety of the population, as well as other guaranties provided for by the State to exclude influence of adverse and hazardous factors on human organism and ensure favorable conditions for vital capacity of the present and future generations.

Sanitary-epidemiological conditions for the staff in the workplaces and workstations must comply with the terms of this law.

Law "On Provision of Medical Care and Services to the Population" (1996) establishes the legal, economic and financial guidelines for medical care and service delivery, which ensures the realization of people's constitutional right to preserve their health.

Activities and operations of the project shall be implemented in accordance with the mentioned laws in order to ensure health and safety of the employees as well as of the surrounding population.

Republic of Armenia Health Minister's N 533-N order as of May 17, 2006, "On approving HN N 2.2.4-009-06 vibration hygienic norms at workplaces, residential and public buildings".

The hygienic norms determine the vibration classification, regulation standards, the maximum permissible level of vibration at workplaces, as well as the permissible levels of vibration at residential and public buildings.

2.7 International Agreements

In addition to the national legislation, the international agreements in the field and the obligations of the Republic of Armenia arising from them were studied.

The agreements that were signed but not ratified by the Republic of Armenia are not applicable.

Table 1 presents the international agreements signed by the Republic of Armenia and their current status.

Table 1: International agreements signed by the Republic of Armenia

N	Title, date and place of adoption	In force	Signed by RA	Accessed/ Ratified by RA	Entry into force for RA
	Global Conventions				
1.	Convention on Wetlands of International Importance Especially as Waterfowl Habitat (Ramsar, 1971)	21.12.1975		1993	1993
2.	Convention on Protection of World Cultural and Natural Heritage (Paris, 1972)			1993	1993
3.	UN Convention on Biological Diversity (Rio De Janeiro, 1992)	29.12.1993	1992	31.03.1993	14.05.1993
4.	UN Framework Convention on Climate Change (New York, 1992)	21.03.1994	13.06.1992	14.05.1993	21.03.1994
	Kyoto Protocol (Kyoto, 1997)	16.02.2005		26.12.2005	16.02.2005
	Paris Agreement (Paris, 2016)	04.11.2016	20.09.2016	23.03.2017	22.04.2017
5.	UN Convention on Combating Desertification (Paris, 1994)	20.09.1997	1994	23.06.1997	30.09.1997
	Regional Conventions				
6.	UNECE Convention on Environmental Impact Assessment in Transboundary Context (Espoo, 1991)	10.09.1997		14.05.1996	10.09.1997
	Protocol on Strategic Environmental Assessment (Kiev, 2003)	11.07.2010		25.10.2010	24.04.2011
7.	UNECE Convention on Access to Information, Public Participation in Decision-Making and Access to Justice in Environmental Matters (Aarhus, 1998)	30.10.2001	1998	14.05.2001	01.08.2001
8.	UNECE Convention on Protection and Use of International Lakes and Transboundary Watersheds (Helsinki, 1992)	06.10.1996			
	Protocol on Water and Health (London, 1999)		1999	Pending ratification	
9.	European Landscape Convention (Florence, 2000)	01.03.2004	2003	23.03.2004	01.07.2004
10.	Convention on the Conservation of European Wildlife and Natural Habitats (Bern, 1979)	01.01.1982	2006	26.02.2008	01.08.2008

2.8 Current legal status of the existing project

An ESIA is required for "solar power plants occupying 40 hectares of territory and more" according to Art. 14 of the Law "On Environmental Impact Assessment and Expertize – (21 June, 2014). Therefore, due to the size of the Floating Photovoltaics demonstrator, there is no need for an ESIA application and associated construction or operation permits. Nevertheless, in the context of future solar

floating photovoltaics' projects it has been decided that an ESIA will be performed as a reference. The ESIA will be a guidance for this innovative technology. The ESIA will be disclosed to the Project's stakeholders for transparency without a formal submission process.

The construction and operation of a floating solar photovoltaic plant does not contradict the current national laws and regulations in Armenia, as well as the requirements of international agreements.

3. PROJECT DESCRIPTION

3.1 Project location site

The floating solar photovoltaic plant will be installed on Yerevan Lake. It is an artificial reservoir located south-west of Yerevan, in the Hrazdan river canyon. The lake altitude is 908 m above sea level.

The lake was built in 1970 to regulate the flow of the Hrazdan River and use the water. The dam is earthen, covered with reinforced concrete slabs. The length of the dam is 480 m, maximum height - 29 m. It acts as a bridge between the right and left bank regions of Yerevan.

Figure 1: The appearance of Yerevan Lake

Irrigation water is released through a floor drain built on the right bank. A trench was built along the right bank of the lake (364 m) to create a spillway for floods. The shores of the lake are partially covered with concrete. Lake Yerevan is of great importance for the formation of the surrounding microclimate and urban recreation area. The canals of Etchmiadzin and Parakar start from the lake. It rarely freezes in winter.

3.2 Project components

The project envisages the design of a floating solar photovoltaic plant, environmental and social impact assessment, public consultation with stakeholders, construction, operation and maintenance.

3.3 Detailed description of the project

The project envisages the construction of a 156 kWp floating solar PV plant on Yerevan Lake. The latter consists of:

- ✓ floats made of solar panels (floating island),
- ✓ anchoring system,
- ✓ a photovoltaic inverter on the floating island,

- ✓ power transmission lines.

3.3.1. Solar island

The solar island #1 is composed of 396 panels, plus an additional row of floats is a walkaway to access the modules for maintenance. No additional row is required for buoyancy. The selected product is Hydrelio® aiR 1440mm, considering a 4-in-a-row configuration (units of 4 rows of panels separated by maintenance rows) and a 12° tilt. All the panels are facing the same direction (0° South). The island area is about 1620 m². Panel dimensions are 2000mm * 992mm.

The floating island will be assembled on banks open to the public, and then pulled to its final location by a boat.

The bank, where it is planned to mantle the panels, is devoid of vegetation, it belongs to the municipality, and has vehicle access.

Figure 2: Solar island

3.3.2. Anchoring system

Mooring systems are used as a mean of holding a floating platform against the environmental loads (wind, waves and current).

The mooring system is composed of several mooring lines attached to the floating platform (with connections called “spreader bars”) on one side and anchored to the bottom of the reservoir or to its banks on the other side.

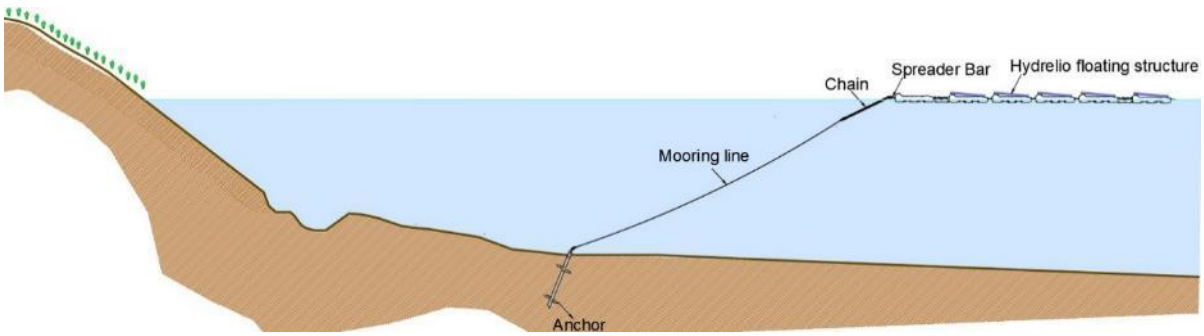


Figure 3: Example of bottom-anchoring (selected technique)

The anchoring calculations are performed for different water levels to ensure the structural integrity of the floating PV plant and mooring system under any site conditions. More precisely, the simulations are carried out for the most extreme water levels – High Water Level (HWL) and Low Water Level (LWL) – and if necessary, at an intermediate level.

Below sketches show the behavior of the anchoring system at HWL and LWL depending on bank or bottom-anchoring.

The spreader bars connect the mooring lines to the floating structure and spread the environmental loads across the Hydrelio® floats. They are distributed across the floating PV plant in such a way to ensure its structural integrity under environmental loading. Spreader bars are the first links in the transmission of environmental loads from the floating structure to the anchoring points.

The mooring lines transmit the environmental loads acting on the floating platform to the anchoring points. Composition and length of the mooring line are set in accordance with the tensile loads they are supposed to withstand, depending on the position of array and anchoring points, so the environmental loads are distributed as homogeneously as possible, under any site conditions.

Combination of soft mooring lines and fine-tuned mooring lines length allow a quite homogenous load distribution in all the mooring lines and anchoring points, preventing several lines from being tightened while other lines of the same side are still loose.

Below approximate quantities of all parts necessary for the anchoring system:

Equipement	Island
Anchoring points	**17 pcs**
Spreader bars	**24 pcs**
Steel cable (SWL > 11.98 kN)	**1370 m**
Polyester rope (SWL > 11.98 kN) **Elongation ΔL ≥ 1m at design load in the mooring line**	**360 m**
Chain (SWL > 11.98 kN)	**36 m**
Shackles (SWL > 11.98 kN)	**96 pcs**

The mooring line lengths are calculated with enough slack to manage the water level variation. Then, depending on the water level, the floating platform will move more or less from its equilibrium position. The anchoring system is designed to mitigate the risk that the floating PV plant collides with the banks, or any obstacles identified in the water area. The maximum island displacement in each direction is 3.6m.

3.3.3 PV inverter

A PV inverter looks like the picture below. The inverter will be installed on the PV island. No equipment will be installed onshore. Its size is about 1,2m x 0,7 m x 0,5 m.

Figure 4: PV inverter

3.4 Area layout

The floating solar photovoltaic station is planned to be located in the central part of Yerevan Lake, more than 500 m away from the US Embassy, 1 km away from the National Security Service building. The installation is planned to be carried out in such a way that it does not disturb the canoe races. See Figure 5.

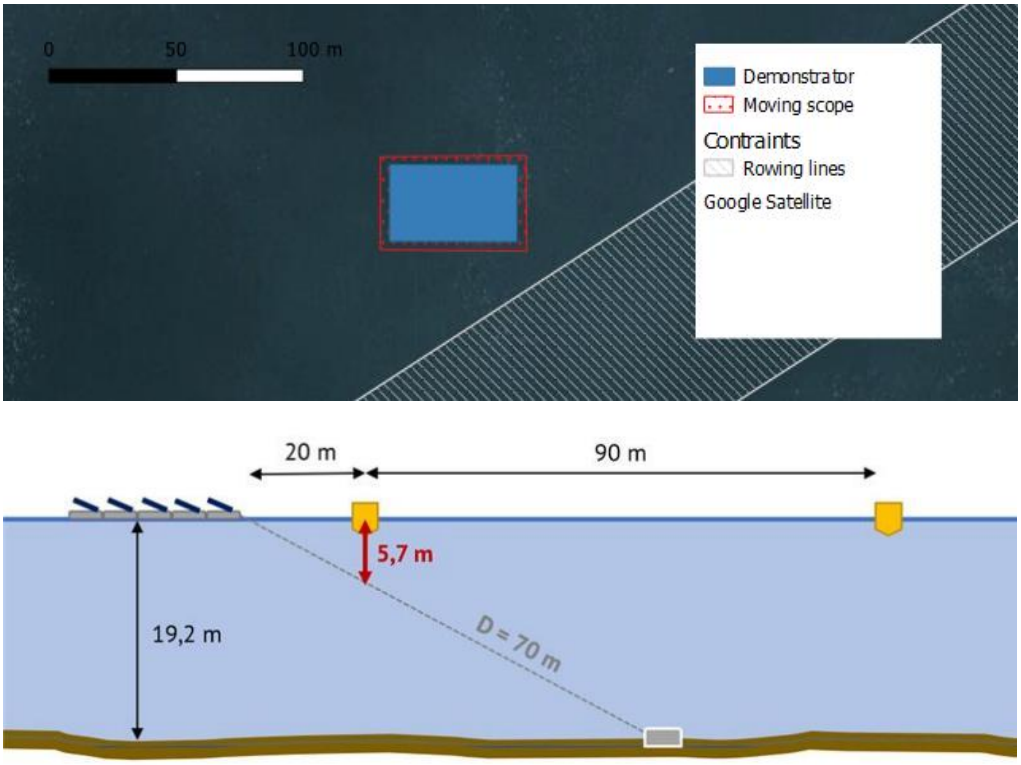


Figure 5: Movement area of the PV island and rowing lines and Sketch of the anchoring system and rowing lines

3.5 Waste disposal and waste generation

Household, construction and industrial wastes may be generated during the construction works, as well as during the operation of the power plant. Garbage bins should be placed on the construction site to collect household waste, and construction waste should be stored away from the lake before disposal.

In order to dispose of the waste, the construction and operating companies will prepare an agreement and/or notification formswith the Municipality of Yerevan, according to which the waste will be disposed of in an appropriate landfill.

3.6 Construction and implementation schedule

3.6.1 Implementation schedule

Due to important level variation, the construction phase will depend on the water level. To ensure maximum water level, construction works would ideally occur in the beginning of summer. This will also ensure optimal weather conditions for the work.

3.6.2 Plant operation and maintenance

The only proven source of water contamination on Ciel&Terre projects is the cleaning agents used during maintenance. Ciel&Terre recommends washing the modules only when needed, and with clear water only, possibly with the water of the lake if cleaned enough.

Ciel&Terre will provide a training to the people in charge of the maintenance of the demonstrator after the commissioning. They will share procedures and advices for cleaning, electrical maintenance, anchoring verification.

After the commissioning, R2E2 will be the owner and operator of the demonstrator: “Following termination of the AGREEMENT, the BENEFICIARY will be the owner of the DEMONSTRATOR and will be responsible for its operation over its entire lifetime. All outcomes of the DEMONSTRATOR must be handled by the BENEFICIARY”. Extract from Cooperation Agreement.

After the withdraw of all reservations following the commissioning, Transénergie will no longer interfere with the power plant.

R2E2 will then be in charge of the maintenance, cleaning and dismantling at the end of the power plant’s lifecycle.

3.7 Monitoring and control

Monitoring and control functions should be performed during the construction and operation of a floating solar power plant.

During the construction phase, monitoring can be carried out by the Client and the representatives of the relevant state authorities, such as the municipality, the City Hall, the Ministry of Health, the Ministry of Environment, the Ministry of Energy and Natural Resources. Public monitoring is also possible by other stakeholders. During the construction phase, daily supervision of construction works is carried out by a technical supervisor.

For the operation phase, the operating company must develop a monitoring plan and be guided by it.

The operating company will also carry out regular monitoring (via online or on-site guard service) of the plant.

3.8 Power transmission lines

Alternative current (AC) cables will first circulate on the surface of the lake, from the PV island to the extreme north point of the spillway. They will be fixed on floats, in other to stay afloat. In other to accommodate both the movement of the floating island (about 4m) and the variations in water levels (about 19m), those distances are added to the distance from PV island to the ground to calculate the cable length. The total length of AC offshore wires is then 315m.Once on ground, the cable will follow

up the spillway up to the dam substation. The cables will thus circulate only on lands belonging to Yerevan Municipality.

The dam substation is connected to the public substation north of the lake. Grip operator must confirm the possibility to connect the demonstrator to the dam substation. Grid reinforcement worked might be mandatory to be able to connect the power plant.

Figure 6: Layout of cables fixed on floats and on the spillway up to the dam substation

AC cables will then join the inverter to the electric substation, using existing electricity poles. The various electrical components are localized on the map below. Their location and technical specificities will be studied more in detail during next project phase: in-depth technical design.

Figure 7: Position of cable on the spillway up to the dam substation

4. BASELINE ENVIRONMENTAL AND SOCIO-ECONOMIC CONDITIONS

4.1 Climate

The climate of Yerevan is arid continental, with hot summers and rather cold winters. The climatic conditions in the central and southern lowlands are more unfavorable: hot, dry and frost-dangerous, while the north and eastern regions have a temperate continental climate, with relatively cool summers and moderately cold and more humid winters.

The territory of the city of Yerevan is under the influence of subtropical air masses during the warm half of the year, and it is under the influence of temperate air masses during the cold half of the year. At the same time, the influence of tropical air in summer and of the arctic air - in winter is not low.

In mid-December, when the average daily temperature steadily drops below zero, winter begins, which lasts 70-75 days in Yerevan. This period is characterized by both mild cold weather and warming (maximum above 0, minimum below 0). The latter averages 50 and more days during the winter. Severe frosty days are rare and are associated with the intrusion of cold air, which accumulates in the depression, cools more with radiation and lasts for quite a long time, causing a cold "lake". That is why the average air temperature in the southern lowlands of Yerevan in winter is lower than on the nearby slopes. This phenomenon is called inversion. The period with stable frosts usually lasts from the last days of December to mid-February. The number of foggy days in winter is quite high, on average 23-32 days. There have been years when fog was observed on almost every day of the month. The heating period in Yerevan is 140 days (06.XI – 27.III), when the average daily air temperature is below 8°C. Thunderstorms are typical for the spring period, in May-June there are 20-25 days of thunderstorms. Summer begins in late May, when rainy and cloudy weather is replaced by dry, clear weather. The relative air humidity is 45-50%. July-August are characterized by the hottest and driest weather. On average, the humidity is less than 30% for about 18-37 days.

4.1.1 Temperature

The air temperature description of the city of Yerevan is presented on the basis of multi-year data from the observations of three meteorological stations (Yerevan Aero, Yerevan Agro and Yerevan Arabkir) of "Hydro-meteorological Monitoring Center" SNCO operating in the vicinity of Yerevan.

The average annual air temperature is 11.5-12.5°C. The warmest period of the year is July-August, the average monthly temperature is 25-26 °C, and the coldest month is January – (-3.0°C)- (-4.0°C). The absolute maximum temperature observed in the city is 41.9 °C, the minimum -30.1°C. The average annual temperature fluctuation is 28-31 °C, and the absolute is 72 °C (Table 2).

Table 2: Average, maximum and minimum air temperature

Characteristics	Month												Year
	1	2	3	4	5	6	7	8	9	10	11	12	
Average air temperature	-2.8	0.1	6.3	12.2	17.1	22.2	25.8	25.7	21.3	14.1	6.3	-0.1	12.3
Maximum air temperature	18.4	19.6	27.5	33.7	34.1	39.0	41.6	41.9	39.0	31.9	23.6	21.4	41.9
Minimum air temperature	-30.1	-26.2	-25.2	-10.9	-0.5	2.1	7.3	7.0	1.0	-5.7	-16.4	-28.3	-30.1

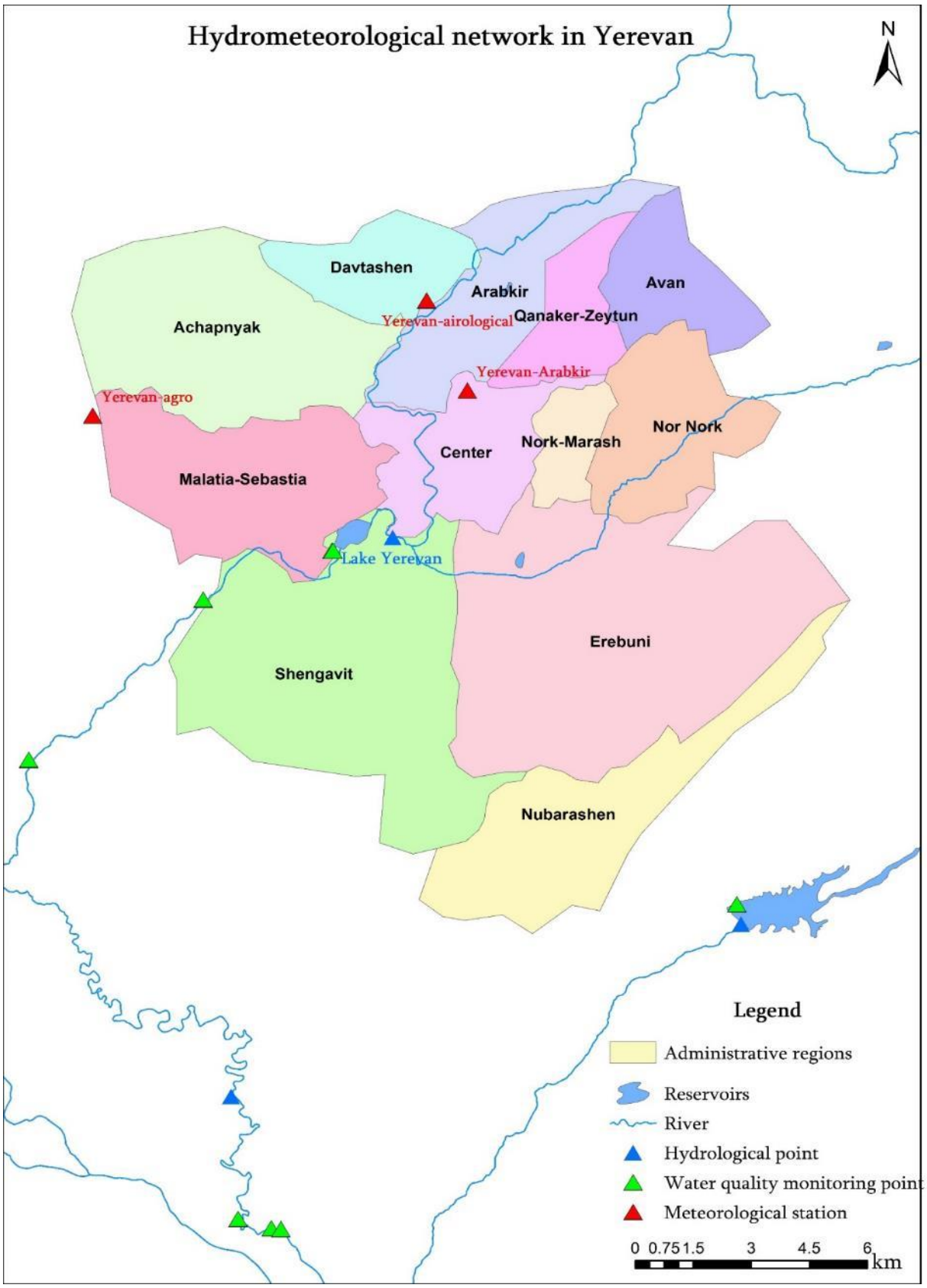


Figure 8: Schematic map of the location of meteorological stations operating in Yerevan

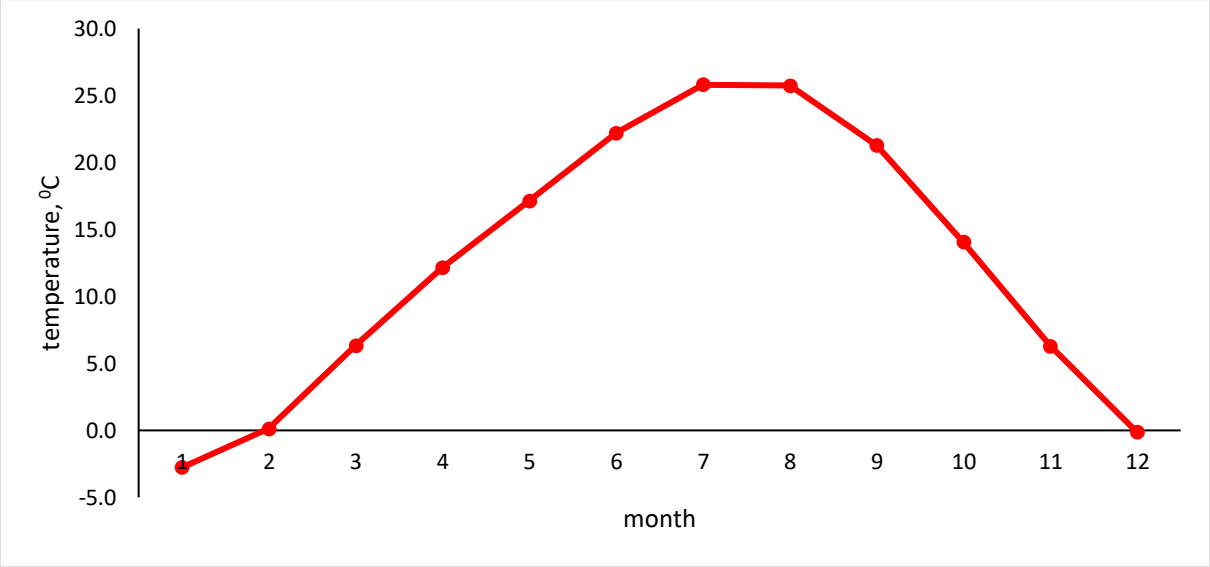


Figure 9: The annual course of the average air temperature

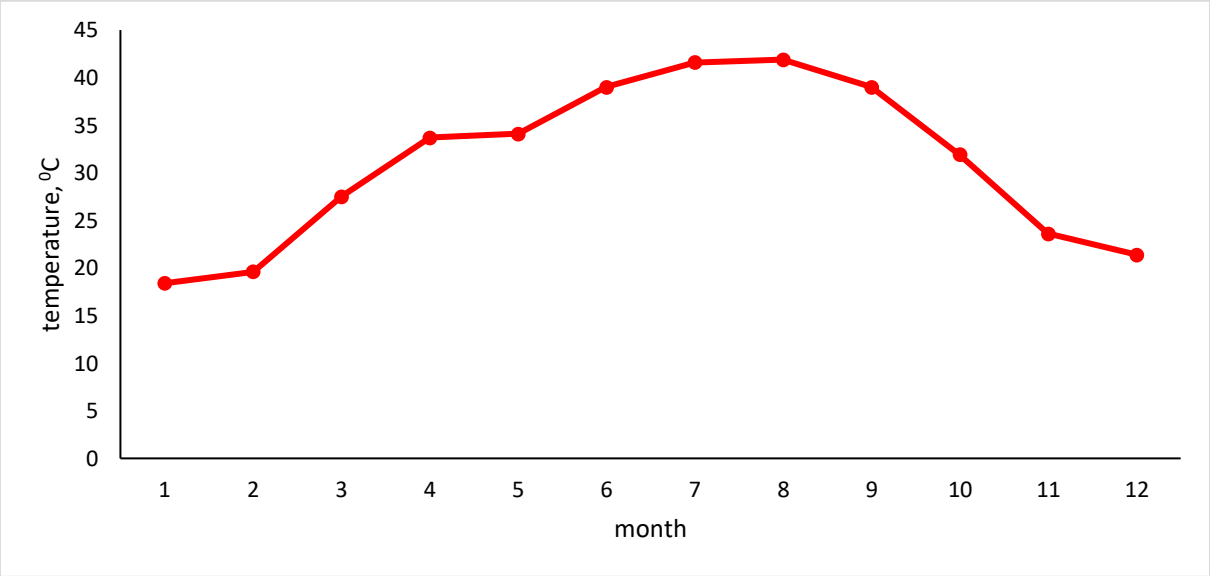


Figure 10: The annual course of the maximum air temperature

Figure 11: The annual course of the minimum air temperature

4.1.2 Precipitation

The annual amount of precipitation is 290-350 mm, the maximum is observed in spring (112-140 mm), which is about 40% of annual precipitation. May is especially rainy - 40-60 mm, and the second high precipitation period is October-November - 50-60 mm. Precipitation is 70-90 mm, mostly in the form of snow. The average height of the snow layer is 15 cm, and the maximum is 50-58 cm. Snow cover usually appears in the first and second ten-days of December and disappears in mid-March. Stable snow cover is observed in January-February, but not every winter. In summer, the amount of precipitation is very small, with the average monthly precipitation of 8-10 mm. Spring is quite humid and rainy. Rainfall is often torrential with high intensity (1.3-1.5 mm / min). In May 1998, 47 mm precipitation was observed in one day, which is 85% of the monthly norm. Thunderstorms are typical for the spring period; in May-June, there are 20-25 days of thunderstorms.

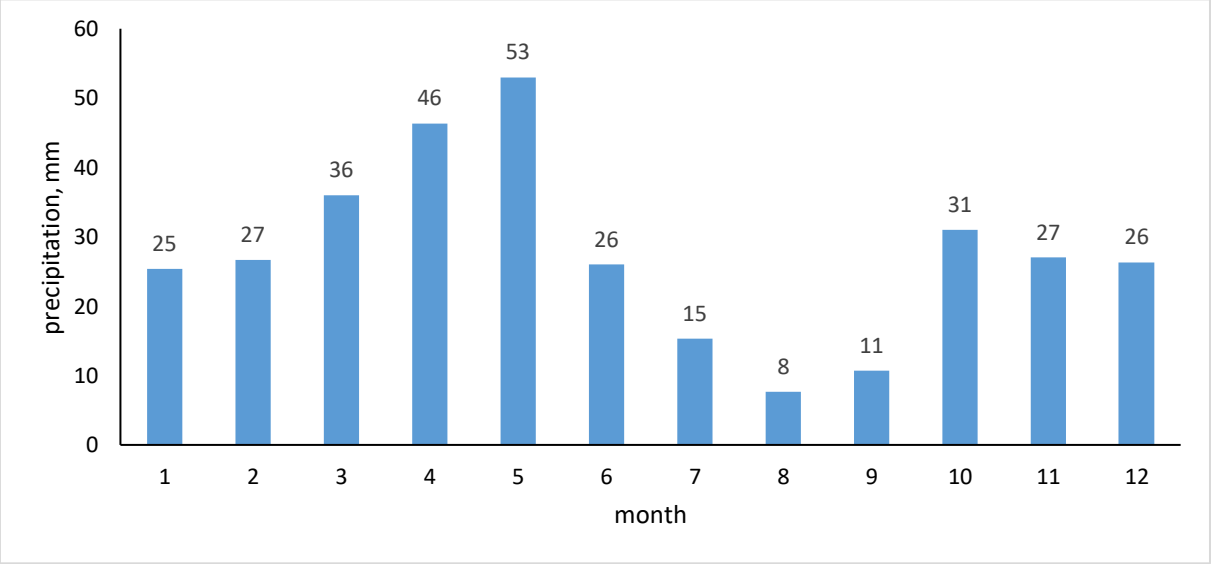


Figure 12: Annual course of precipitation

4.1.3 Wind

The presentation of the wind description in Yerevan was based on the data of multi-year monitoring of meteorological stations operating in Yerevan. The average annual speed is more than 2.0 m / s. The maximum wind speed is 20-25 m / s, and the wind gust is 40.0 m / s. The average wind speed is graphically represented below.

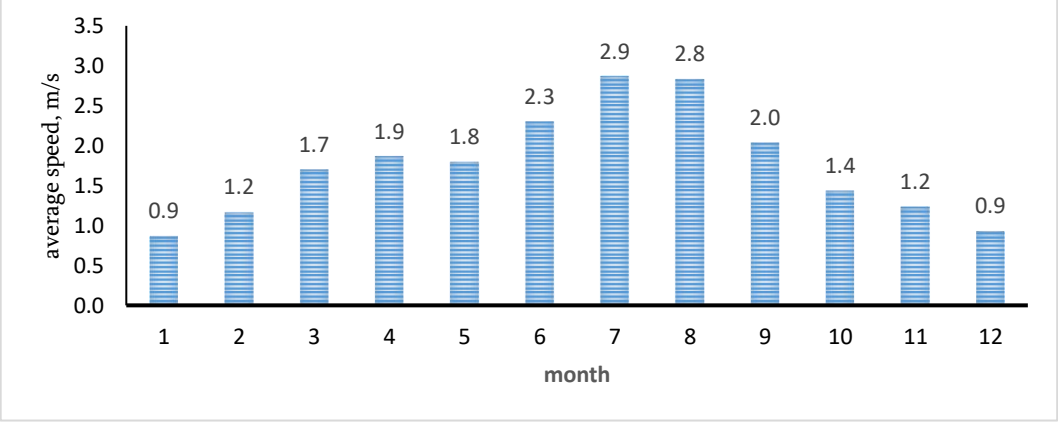


Figure 13: Average monthly wind speeds

Table 3: Average monthly and annual wind speeds

Meteorological station	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Yerevan ”Arabkir”	0.9	1.2	1.9	2.1	2.2	2.7	3.4	3.2	2.3	1.8	1.4	1.0	2.0
Yerevan “Zvartnots”	0.8	1.1	2.2	2.7	2.6	3.0	3.8	3.6	2.4	1.6	1.1	0.8	2.1

Table 4: Maximum wind speed (m) and wind gust (g)

Meteorological station		I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII	Year
Yerevan “Arabkir”	m	14	17	20	20	17	20	24	24	20	18	14	16	24
	g	20	23	24	-	24	28	40	29	27	26	25	20	40
Meteorological station	m	20	20	18	18	20	20	19	20	17	15	16	16	20
	g	27	30	25	25	30	26	28	25	20	21	25	19	30

Table 5: Wind speed by direction

Direction	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Year**
Yerevan “Arabkir”													
N	1.9	2.1	3.1	3.1	3.4	4.7	6.0	5.6	4.2	2.9	2.4	1.9	3.4
NE	1.9	2.1	2.5	2.6	2.8	3.7	4.8	4.4	3.2	2.5	2.4	1.8	2.9
E	1.6	2.0	2.0	2.3	2.2	2.1	1.7	1.9	1.8	2.0	2.2	1.7	2.0
SE	1.7	2.0	2.3	2.2	2.2	2.1	1.7	1.7	1.8	1.9	1.9	1.7	1.9
S	1.8	2.1	2.2	2.5	2.3	2.0	1.7	1.7	1.7	1.7	1.7	1.9	1.9
SW	1.5	1.7	2.2	2.4	2.2	2.1	1.7	1.8	1.8	1.9	1.9	1.6	1.9
W	1.8	2.1	2.4	2.5	2.4	2.3	2.0	2.0	1.9	1.9	2.0	1.6	2.1
NW	1.9	1.9	2.5	2.5	2.8	2.2	2.6	2.7	2.1	2.0	2.0	1.6	2.2
Yerevan “Zvartnots”													
N	2.2	2.4	3.3	3.5	3.6	4.9	6.4	6.2	4.4	2.9	2.4	2.2	3.7
NE	2.8	2.3	3.5	3.7	3.6	4.7	6.5	6.3	4.6	3.2	2.6	2.4	3.9
E	2.3	2.4	2.9	3.1	3.2	3.2	3.1	3.1	2.9	2.6	2.3	2.2	2.8
SE	2.6	2.8	3.4	3.8	3.5	3.0	2.9	2.7	2.7	2.7	2.8	3.6	3.0
S	2.4	2.5	2.9	3.2	3.1	3.7	2.7	2.7	2.4	2.5	2.5	2.6	2.6
SW	2.2	2.3	3.2	3.5	3.3	3.2	2.8	2.8	2.6	2.6	2.6	2.5	2.8
W	2.7	3.1	3.7	4.2	4.0	3.6	3.0	3.1	3.5	3.2	3.1	3.0	3.4
NW	2.4	2.4	3.2	3.3	3.3	3.5	3.5	2.9	3.1	2.7	2.5	2.8	3.0

The analysis shows that the winds of the northeast and the south directions prevail in Yerevan. Below the wind rose in the city of Yerevan is presented according to different months (Figure 14).

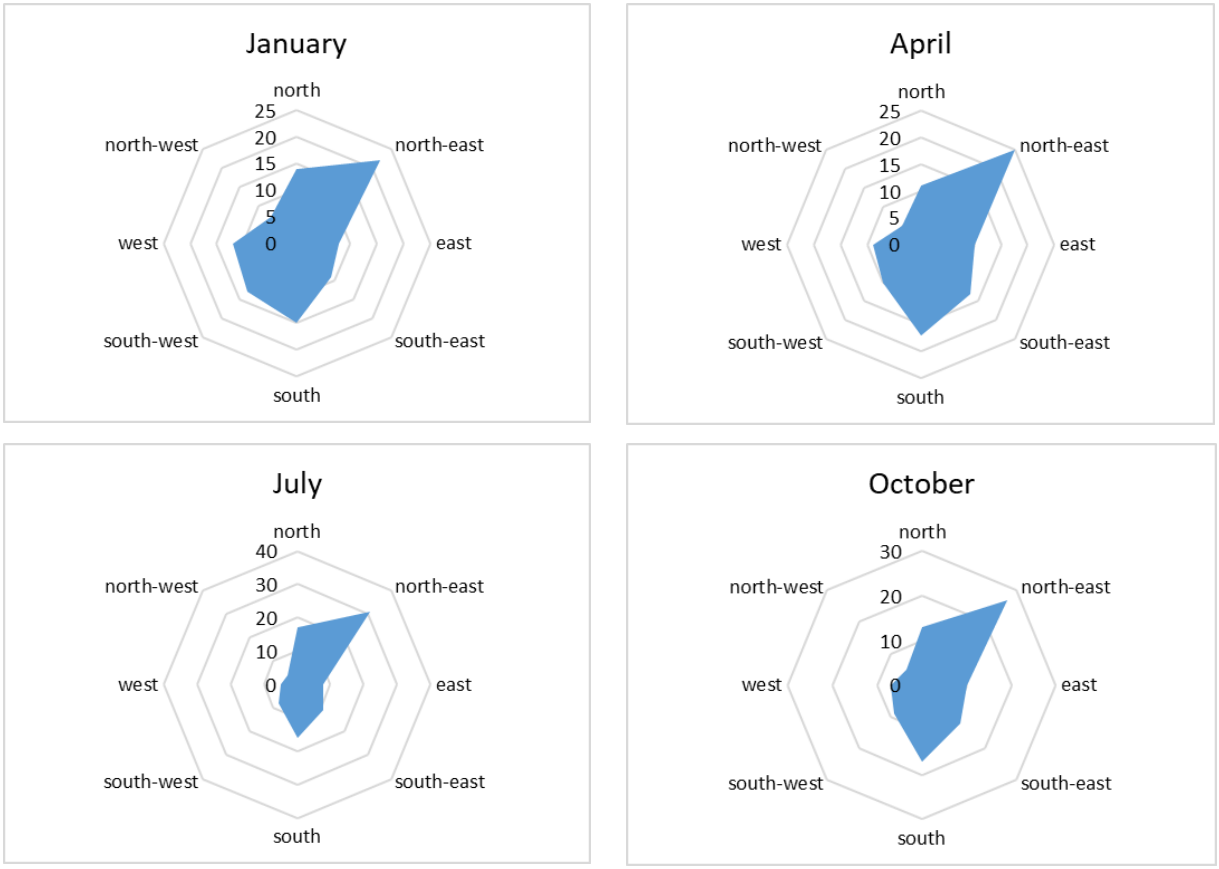


Figure 14: Wind rose according to Yerevan "Zvartntots" meteorological station.

4.1.4 Air quality

The state body conducting air quality monitoring in Yerevan is the Hydro Meteorological Monitoring Center SNCO of ME (hereinafter "HMC" SNCO). As of 2020, atmospheric air quality monitoring in Yerevan was carried out at 51 observation points.

Table 6: Atmospheric air quality monitoring in Yerevan

City	Observation points operating in 2020			Number of samples	
	Active	Passive	Automatic		
Yerevan	7	45	1	Active	6191
				Passive	4102
				Automatic	36012

Source: "HMC" SNCO Bulletin 2020

To assess atmospheric air quality, the content of dust in atmospheric air, metals (about 21 metals), sulfur dioxide, nitrogen oxides, carbon monoxide and ground-level ozone in the dust were determined.

Although the average monthly and average annual dust concentrations in the air of Yerevan are in the maximum allowable range, however, during the month, exceedances are observed in different parts of the city, which is due to both climatic conditions, sources of pollution, and scarcity of green areas. The main sources of air pollution are transport, industry, energy and urban development.

To assess the air quality of the city of Yerevan the content of dust, sulfur dioxide, nitrogen dioxide and ground-level ozone (Figure 15-17) is assessed.

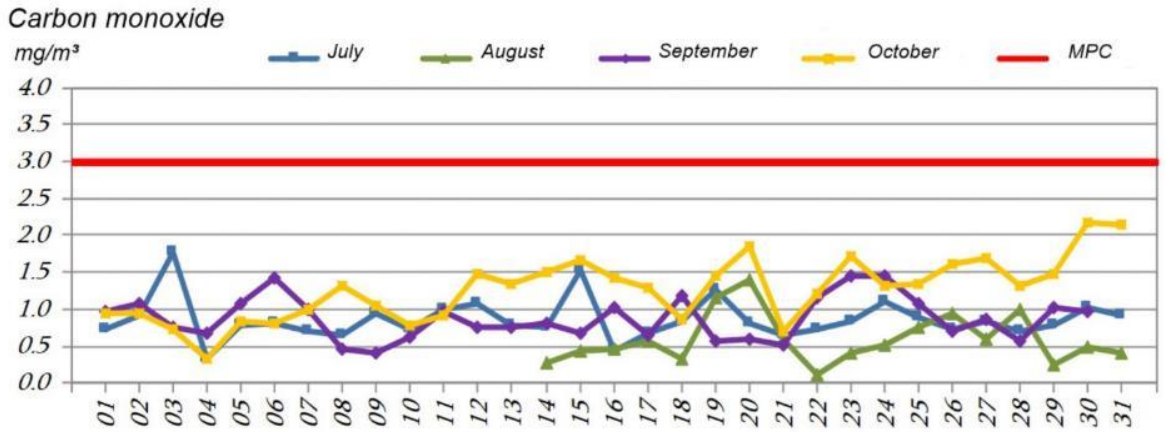
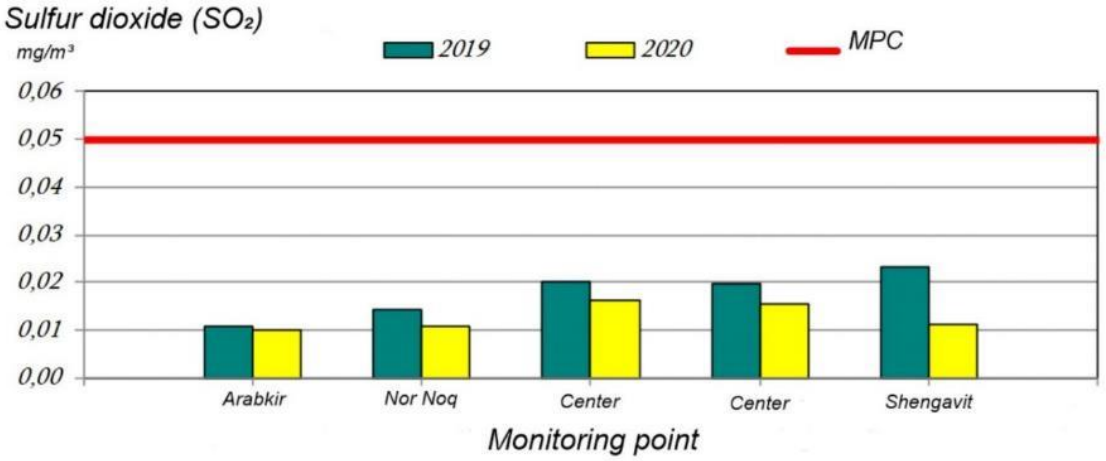


Figure 15: Changes in average monthly carbon monoxide concentrations



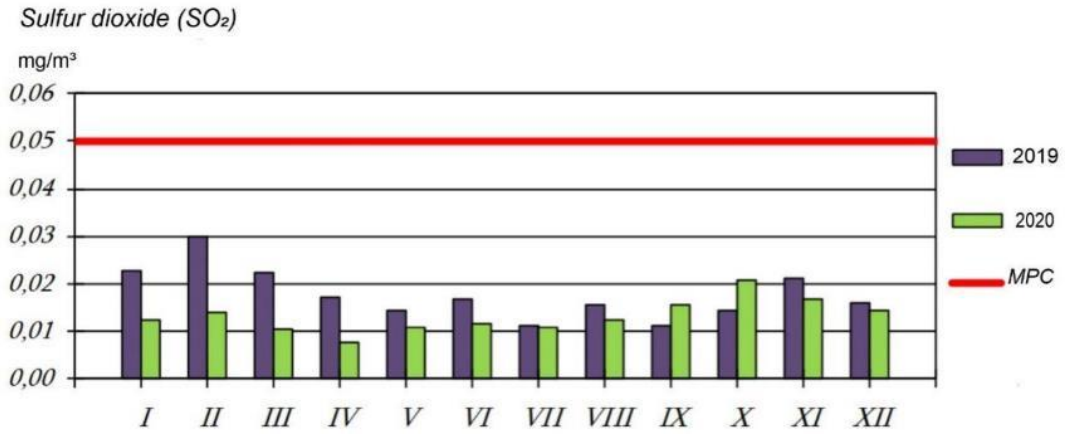
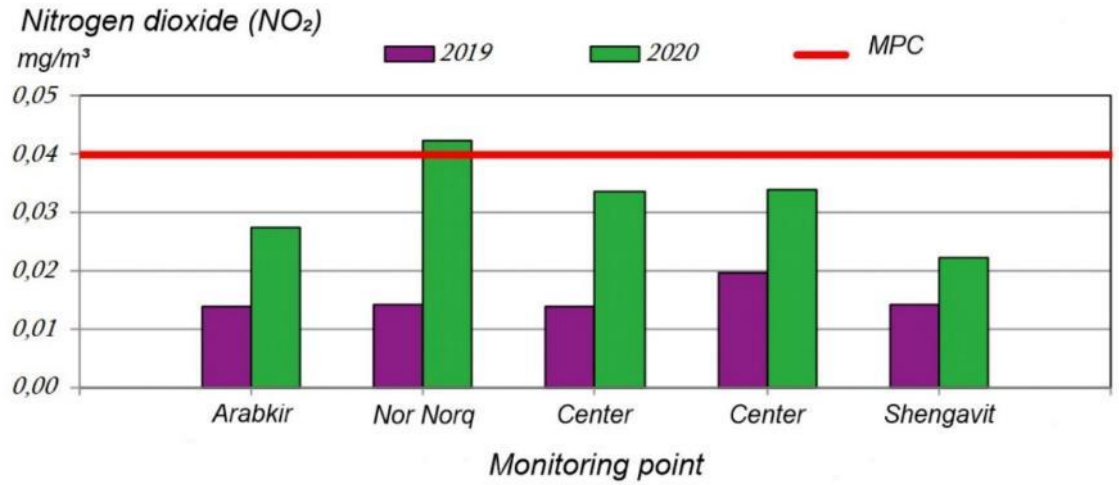


Figure 16: Changes in average annual and average monthly concentrations of sulfur dioxide in the atmospheric air of Yerevan



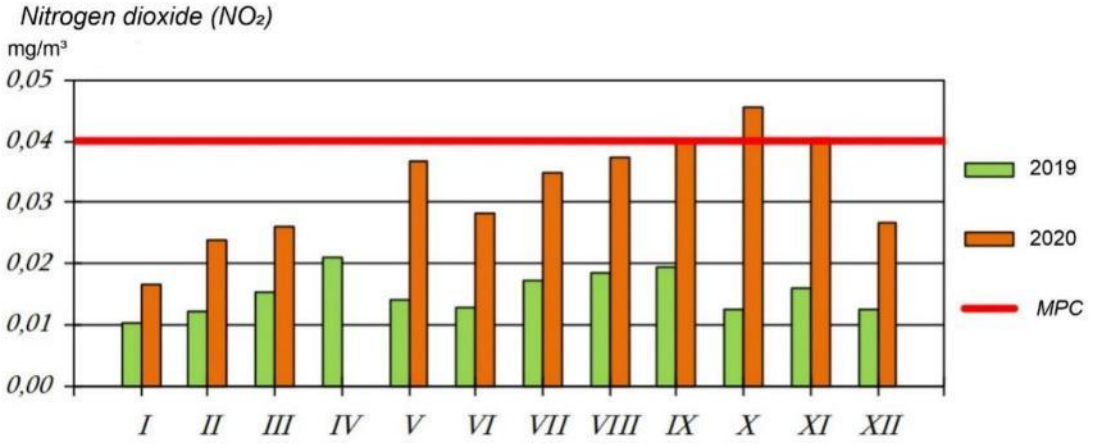
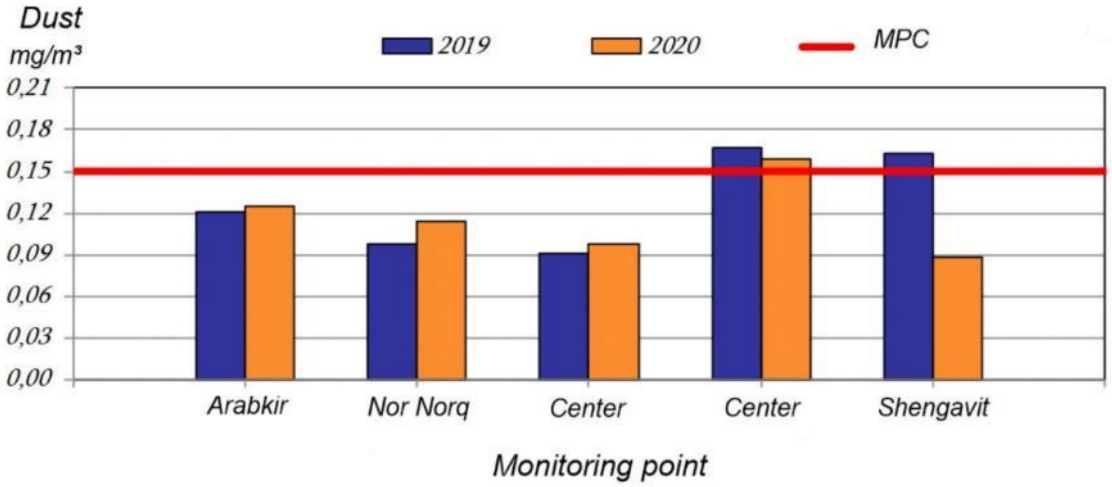


Figure 17: Changes in the average annual and average monthly concentrations of nitrogen dioxide in the atmospheric air of Yerevan



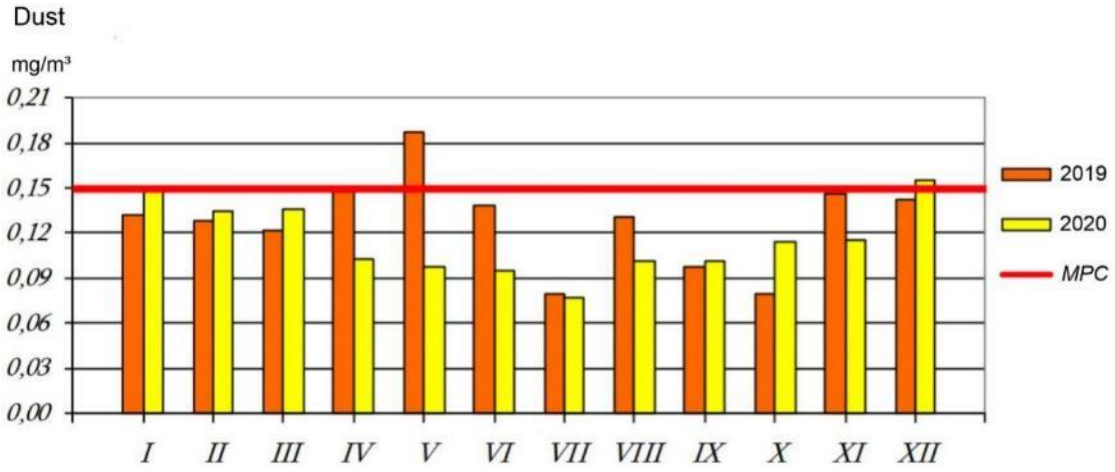


Figure 18: Changes in average annual and average monthly dust concentrations in the atmospheric air of Yerevan

Atmospheric pollution of the city in 2020 (according to 4 pollutants) is below average, the air pollution index (API) is 1.82 (dust - 0.78, sulfur dioxide - 0.25, nitrogen dioxide - 0.75, ground-level ozone - 0.04).

During the recent 5 years a tendency of decrease in sulfur dioxide and ground-level ozone concentrations and increase in dust and nitrogen dioxide concentrations were observed (Table 7).

Table 7: Results of atmospheric air monitoring in Yerevan

Determined compound	Observed maximum concentration, mg / m^3 (for the observation point)	The number of exceedances from the MAC in 2020		Average annual concentration, mg / m^3	Average daily MAC, mg / m^3
		>1	>5		
Sulfur dioxide	0.054	5	-	0.012	0.05
Nitrogen dioxide	0.099	372	35	0.032	0.04
Dust	0.563	316	15	0.116	0.15
Ground-level ozone	0.038	14	14	0.004	0.03

Source: HMC SNCO Bulletin 2020

Table 8: Changes in the average annual concentrations of pollutants (mg / m3) in the atmospheric air of Yerevan in 2016-2020.

Compound	**Characteristics**	**Year**					**Tendency**
		2016	**2017**	**2018**	**2019**	**2020**	
Dust	Average annual concentration	0,095	0,143	0,110	0,128	0,117	0,0027
	Number of samples	2356	2401	1711	1729	1542	
Sulfur dioxide	Average annual concentration	0,028	0,029	0,028	0,018	0,013	-0,0043
	Number of samples	2358	2428	1764	1757	1557	
Nitrogen dioxide	Average annual concentration	0,023	0,022	0,020	0,015	0,032	0,0010
	Number of samples	2393	2403	1762	1751	1556	
Ground-level ozone	Average annual concentration	0,005	0,008	0,007	0,006	0,004	-0,00043
	Number of samples	2402	2394	1763	1738	1536	

Source: HMC SNCO Bulletin 2020

4.1.5 Solar radiation

The number of sunshiny days in Yerevan is quite large - an average of 324 days a year, and the duration during the year is about 2600 hours. The sunshine duration gradually increases from March and reaches 267 hours in May.

Table 9: Sunshine duration according to Yerevan Agro meteo-station

Characteristics	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**	**Year**
Yerevan Agro													
Duration, h	84	109	162	200	267	320	351	332	293	231	144	85	2578
Ratio of the observed and probable durations, %	28	37	44	51	60	71	77	78	79	67	48	29	57
Number of days without sun	11	7	5	2	0,6	0,08	0	0,08	0,1	1	4	10	41

Table 10: Real sun time of sunrise (SR) and sunset (SS) for the 15th day of the month

⊙	**I**	**II**	**III**	**IV**	**V**	**VI**	**VII**	**VIII**	**IX**	**X**	**XI**	**XII**
Yerevan Agro												
SR	7:11	6:39	6:03	5:23	4:49	4:30	4:37	5:06	5:45	6:24	7:01	7:20
SS	16:49	17:21	17:57	18:37	19:11	19:30	19:23	18:54	18:15	17:36	16:59	16:40

4.2 Landscape and geology

Yerevan is distinguished by dissected topography and the variety of terrain forms. The central part is a 900-1000 m high, mildly sloped plain. On the north, west and east, it is bordered by the slopes of Yeghvard, Kotayk, and Nork plateaus, which descend to the Yerevan depression in the form of amphitheater.

Kanaker, Arabkir, Zeytun, Hin and Nor Nork districts are located on cliffs. The southwestern part of the city has a hilly terrain with many gorges, crosses and ravines. The valleys of the Hrazdan, Getar and Jrvezh rivers are among the most important relief forms.

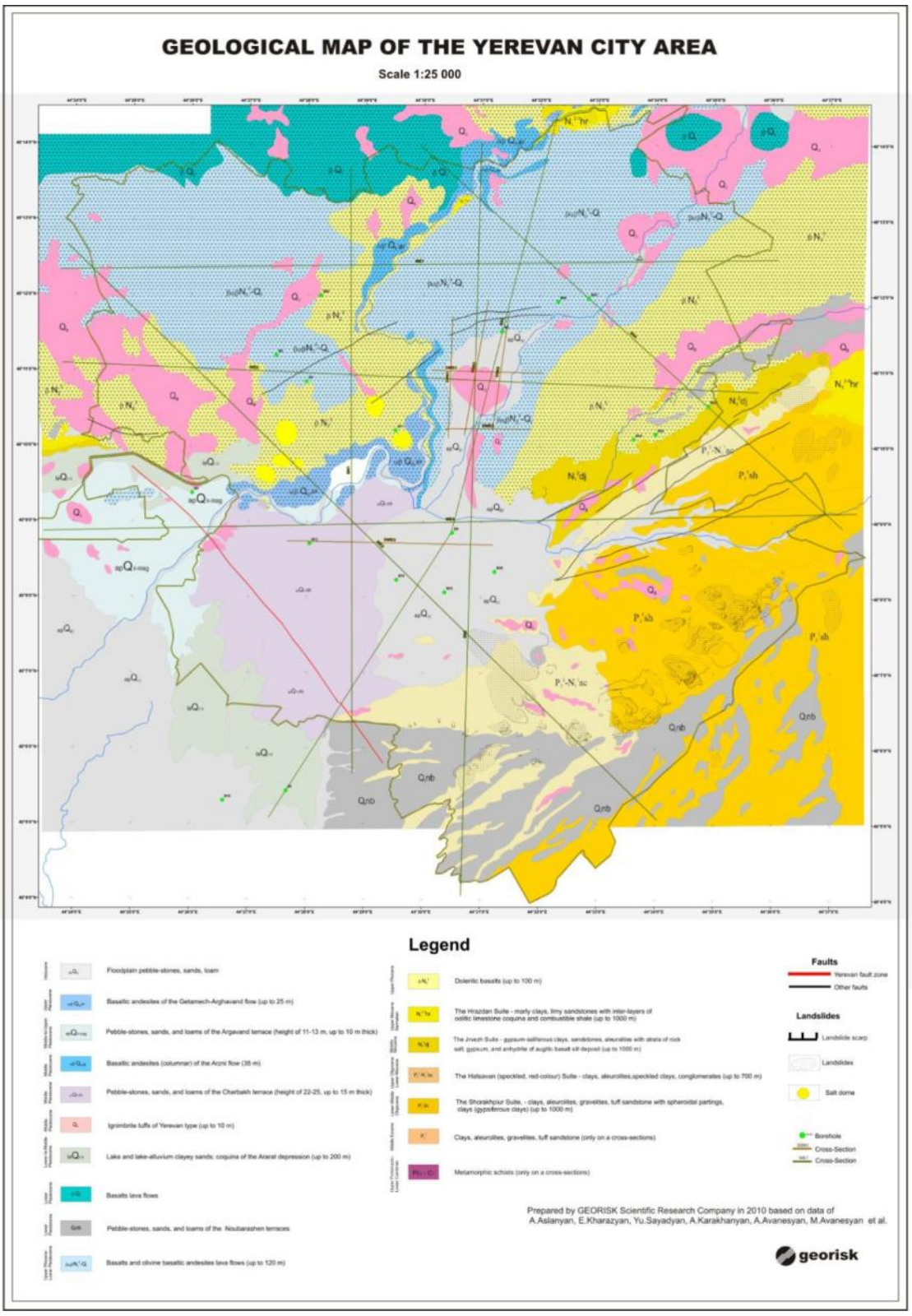
4.2.1 Landscape

The landscape of the city is desert-semi-desert, the climate is arid continental, the semi-desert gray and mountainous brown soils prevail. Artemisia fragrans, Helichrysum, Poa, Teucrium grow here; there are Allactaga elater, hedgehog, wolf, fox, Grass Snake, agama. The soils are suitable for the development of irrigated agriculture, grapes, stone fruits, vegetable crops, subtropical crops.

The area around the Yerevan Reservoir is currently covered mainly with anthropogenic landscapes - roads, buildings, etc. The Isakov Avenue runs along the entire North shore, with the US Embassy building and adjacent ancillary buildings in one section. The coastal area to the south of the embassy building is covered with reed beds. The western shore of the reservoir is occupied by free land covering an area of more than 10 hectares; a road runs along the entire southeastern shore, in different parts of which buildings of different purpose are built.

4.2.2 Geological structure and stratigraphy of the area

Studies of the geological structure and tectonics of the city of Yerevan have been carried out for many years by various organizations. In 2004, Georisk LLC compiled a 1:10000 scale geological map based on both existing information and data from new boreholes (Figure 19).



Source: https://openjicareport.jica.go.jp/pdf/1000008243_03.pdf

Figure 19: Geological map of the territory of the city of Yerevan

The stratigraphy of the city of Yerevan is presented below.

Table 11: Detailed stratigraphy of the city of Yerevan

Geological Ages		**Names of strata**	**Symbols**	**Description**
Quaternary	Holocene	Flood plain deposits	apQIV	Floodplain pebble-stones, sands, loam
	Upper Pleistocene	Getamech-Argavand lava flow	αβQIII ga	Basaltic andesites of the Getamech- Argavand flow (up to 25 m)
	Middle to Upper Pleistocene	Arghavand terrace deposits	apQII-III ag	Pebble-stones, sands, and loams of the Argavand terrace (height of 11-13 m, up to 10 m thick)
	Middle Pleistocene	Arzni lava flow	αβQII ar	Basaltic and sites (columnar) of the Arzni flow (35 m)
	Middle Pleistocene	Charbakh terrace deposits	apQII ch	Pebble-stones, sands, and loams of the Charbakh terrace (height of 22-25 m, up to 15 m thick)
	Middle Pleistocene	Tuff of Yerevan type	QII	Ignimbrite tuffs of Yerevan type (up to 10 m)
	Lower to Middle Pleistocene	Ararat suite	laQI-II	Lacustrine and alluvium clayey sands; coquina of the Ararat depression (up to 200 m)
	Lower Pleistocene	Yeghvard plateau lava and Kotayk plateau lava	βQI	Basalts lava flow
	Lower Pleistocene	Noubarasheu terrace deposits	QI nb	Pebble-stones, sand, and loam (height of 180 m, up to 70 m thick)
Tertiary	Upper Pliocene to Lower Pleistocene	Yeghvard plateau lava and Kotayk plateau lava	β-αβN23 -QI	Basalts and olivin basaltic andesites lava flow (up to 120 m)
	Upper Pliocene	Doleritic basalts	βN23	Doleritic basalts (up to 100 m)
	Upper Miocene Sarmatian Part	The Hrazdan suite	N1 2-3hr	Marly clay, limy sandstone with inter-layers of oolitic limestone coquina and combustible shale
	Middle Miocene	The Jrvezh suite	N12dj	Gypsum-saliferous clay, sandstone, aleurolite with strata of rock salt, gypsum, and anhydrite of augitic basalt sill deposits(up to 1000m)
	Upper Oligocene to Lower Miocene	The Hatsavan suite	P3 2-N1 1 ac	Clay, aleurolite, speckled clay, conglomerate (up to 700m)
	Lower to Middle Oligocene	The Shorakhpiur suite	P3 1sh	Clay, aleurolite, gravelite, tuff sandstone with spheroidal partings, clay(gypsiferous clay) (up to 1000m)
	Middle Eocene	Clay, aleurolite, gravelite, tuff sandstone	P2 2	Clay, aleurolite, gravelite, tuff sandstone (only in the cross sections)
Proterozoic to Paleozoic	Upper Proterozoic to Lower Cambrian	Metamorphic basement	Pr3-C1	Metamorphic schist (only in the cross sections)

Source: https://openjicareport.jica.go.jp/pdf/1000008243_03.pdf

(1) Paleogene rocks and sediments

The volcanogenic-debris Voghjaberd Suite (Meotian-Pontian age) was drilled by boreholes under the lava of the Kotayk volcanic plateau and Yeghvard volcanic plateau. It is exposed in the Jrvezh river gorge region and builds the Voghjaberd mountain range. The suite is rather irregularly built of distributed effusive, pyroclastic and fragmental materials, and is represented by tuff breccias, tuff conglomerates, tuff sandstone, tuff, and pumice-ashy units. The southeastern outskirts of the city area are located within the Shorakhpiur-Noubarashen sloping plain, the principal structural unit of which is the Shorakhpiur anticlinal fold. Approximately, the axis of this fold runs along the line linking the

villages of Shorakhpiur and Ghehadir (Kotayk region). The rocks of the Shorakhpiur suite (P3 1 sh) which exposed that area, are related to the Early Eocene-Oligocene and are represented by aleurolites, tuff sandstone, sandstone, and conglomerates with inter-layers of gypsiferous clays and lenses of reef limestone.

(2) Neogene rocks and sediments

Directly south of the Nork-Marash district and the Jrvezh Village, it is possible to observe exposures of the Early-Middle Miocene rocks that are located above the Shorakhpiur suite (P3 1 sh) by stratigraphy; they are related to the Hatsavan suite (P3 2 -N1 1 ac) composed of unconsolidated conglomerates, sandstones, red-colored clays, aleurolites, and to the Jrvezh suite (N1 2 dj) that is developed extensively over the lava flow in Kanaker area of Kotayk volcanic plateau and includes cloddy sandy clays, sandstones, and argillites with strata and inter-layers of rock salt and gypsum.

Exposures observed in this region demonstrate that the mentioned suite underlies, and alternates with the Sarmatian fresh-water and marine clayey sediments of the Hrazdan Suite (N1 2-3hr), which is also known to have outcrops in other parts of the described area, namely, within the site between Arzni Resort and the Kanaker Hydro Power Plant and in the Parakar Village region. Besides, these deposits were drilled by boreholes almost within the entire Yerevan Depression.

The surface of dolerite basalts βN （2 3） in the Kotayk volcanic plateau and Yeghvard volcanic plateau were overlain with a few flows of single extensive cover of the Late Pliocene-Early Quaternary basalts, and olivine basaltic andesites β-αβN （2 3 -Q1.

(3) Pleistocene of Quaternary rocks and sediments

In the southern and eastern outskirts of Yerevan, Nubarashen and Nor Kharberd, the complexes of the Tertiary rocks are overlain by coarse-fragmental pebble formations with filling of gravel and sand; these are known as the Nubarashen terrace deposits (Q1nb) of an Early Quaternary age.

The sediments are derived from Dzoraghbyur mountains and old volcanoes in Kotayk region. Kotayk volcanic plateau and Yeghvard volcanic plateau are widely covered by basalt and basaltic andesite βQ （1 and β-αβN2 3 -Q1）, which developed a thick (up to 150 m) cover over relatively even surface of the dolerite basalts, olivine basaltic andesites and others. The lower part in the section of volcanic formations of the Kotayk volcanic plateau and Yeghvard volcanic plateau includes dense, porous, grey and dark-grey-colored dolerite basalts βN （2 3） of a Late Pliocene age, which have the average thickness of 20 to 30 m. The mentioned basalts formed a vast polygenic cover, consisting of a series of single-episode lava effusions, which, in fact, did created the lava massif of the Kotayk volcanic plateau and Yeghvard volcanic plateau. Their structure is clearly observed in the gorges of the Hrazdan and Jrvezh rivers, as well as within the exposures located directly in the city limits.

The Arzni lava flow (αβQIIar) of breccia-shaped basaltic andesite, which can be traced along both sides of the Hrazdan river gorge up to the Kanakeravan in Kotayk region, as well as the Yerevan flow of columnar quartz-bearing basaltic andesite, are related to this series. Along the west bank of the Hrazdan River, it is possible to trace individual fragments of the Ghetamech-Argavand lava flow (αβQIIIga), the thickness of which varies in the range of 8-25 m. These young columnar basaltic andesites occur on the Argavand pebble terrace and, along with the latter, are dated to the Late Pleistocene. Individual fragments are traced in the Yerevan Lake area, near the Karmir Blour Fortress (west of Erebuni district) and Argavand village (Ararat region), where the termination (the tongue) of the lava flow is clearly manifested.

The bottom of the Ararat accumulation plain is filled with sedimentary formations of the Early-Middle Quaternary Ararat Suite (laQI-II), represented by lake and lake-alluvial sediments. The thickness of the sediments ranges up to 180-200 m; in the upper part of the section, clayey sediments are followed by gravel and pebble lake-and-alluvial formations.

Argavand terrace of the Hrazdan river is developed in the suburb district of Argavand village, where it has a relative height of 11-13 m; the terrace is built of well-smoothened pebble and has the filling material of gravel-sand-clay composition, named Argavand terrace deposit (apQII-IIIag).

(3) Holocene (Recent sediments)

Recent sediments within the central and southern parts of the territory of Yerevan city are represented by channel deposits (apQIV) of the Hrazdan river, Jrvezh river, Getar river, Dzoraghbyur river, and Shorakhpiur river. Channel and floodplain facies of the listed rivers, including pebble, sand, loamy sand and clays, are well developed in their downstream courses at the entering to the Ararat accumulation plain.

4.3 Seismic activity

Armenia is located in an active earthquake zone. Yerevan is located in the Yerevan-Ordubad seismic zone, where the earth's crust deep fault of Middle Araks/ Yerevan passes.

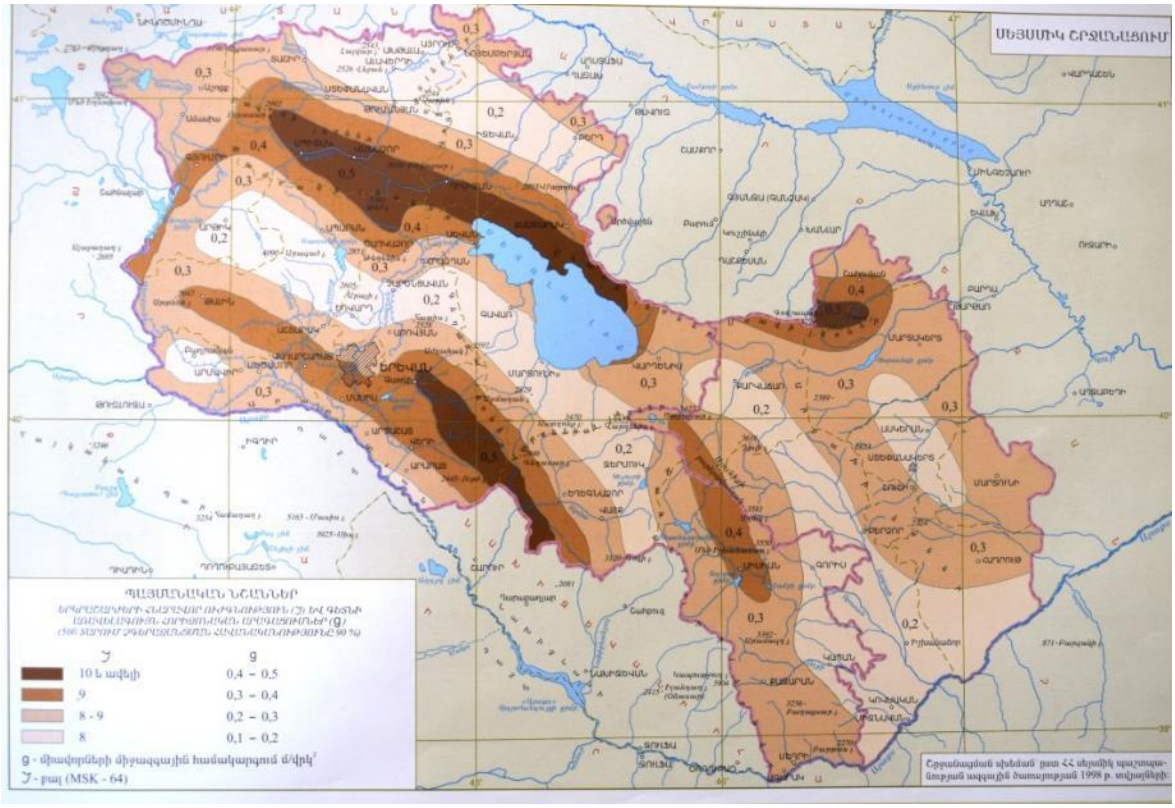


Figure 20: Schematic map of RA seismic zoning

According to the schematic map of the RA seismic zoning, the territory of the country is divided into seismic zones. According to that map, the city of Yerevan is mainly located in a zone with a horizontal ground acceleration of a = 0.2-0.3g, which is equivalent to an earthquake of 8-9 magnitude, and its southwestern part, where Yerevan Lake is located, a = 0.3-0.4g, which is equivalent to an earthquake of 9 magnitudes.

The list of RA settlements by seismic zones is presented in the appendix of Decree HHSHN II-6.02-2006. In the mentioned list, the city of Yerevan is located in 3rd seismic zone.

4.4 Noise

The noise level in the Republic of Armenia is regulated by the sanitary norms N2-III-11.3 "Noise in workplaces, residential-public buildings, and residential construction areas".

The values of maximum permissible noise are given in Table 12.

Table 12: Noise standards established in the RA

Receptor	Hours	Maximum allowable noise level	
		dBL_{AEQ}	dBL_{AMAX}
Near residential and public buildings	06:00-22:00	55	70
	22:00-06:00	45	60

No information is available on noise studies in Yerevan.

4.5 Soils

Since the city landscape is desert-semi-desert, mainly semi-desert gray-brown soils predominate, which are suitable for the development of irrigated agriculture, grapes, stone fruits, vegetables, subtropical crops.

4.6 Water bodies

Yerevan Reservoir is built in the Hrazdan River bed, which is the water resource that feeds the reservoir. The Hrazdan River originates from Lake Sevan; the river mainly flows through a narrow canyon. Downstream Yerevan, the river flows through the Ararat valley and flows into the Araks River. The length of the river is 141 km, the gradient is about 1000 m, the catchment area is 2560 km^2 (without Lake Sevan). The flow of the river is strictly regulated. Multi-year average annual flow, according to Hrazdan-Yerevan hydrological observation point, is- 5.60 m^3 / s, the maximum is 174 m^3 / s.

Observations of the hydrological regime of the Hrazdan River in the territory of Yerevan are carried out at the Hrazdan-Yerevan hydrological observation point of "HMC" SNCO. The multi-year average monthly flow hydrograph of the Hrazdan River is shown in Figure 21.

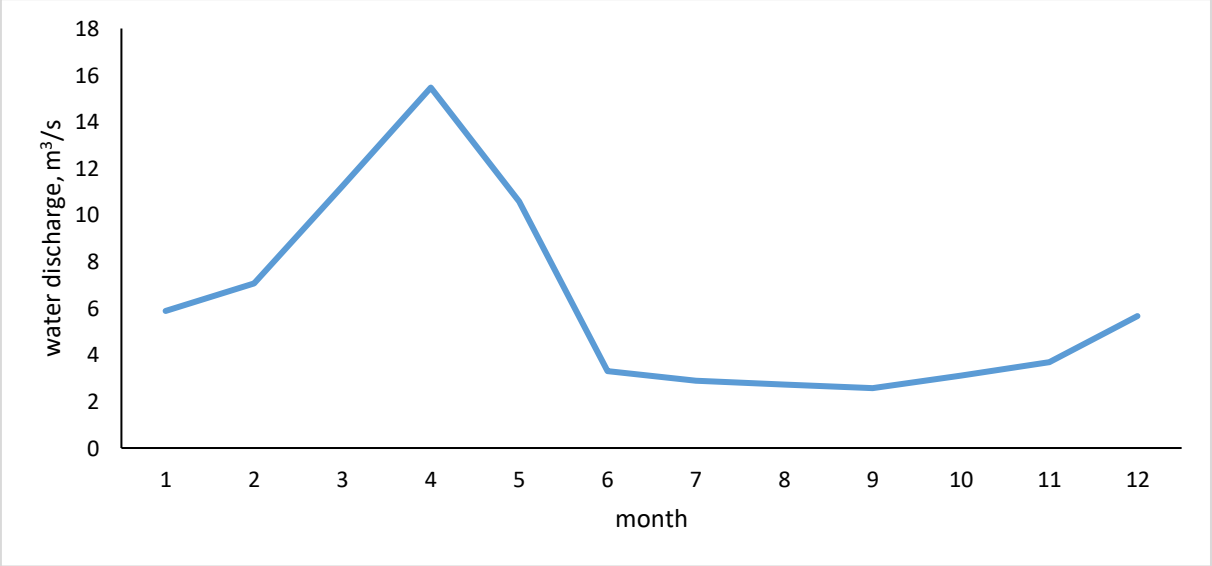


Figure 21: Annual hydrograph of the Hrazdan river according to Hrazdan-Yerevan hydrological observation point

Table 13: The Hrazdan River water quality monitoring points in Yerevan

Water body	River basin management area	Marz	Location
Hrazdan	Hrazdan	Ararat	9 km downstream Yerevan, near Darbnik village
Getar	Hrazdan	Yerevan	Estuary
Yerevan Lake	Hrazdan	Yerevan	At the dam

Source: HMC SNCO Bulletin 2020

Based on 2020 data, the water quality of the Hrazdan River downstream the Arzni HPP, downstream the city of Yerevan, near the village of Darbnik, and in the parts of the estuary and near the village of Geghanist was assessed as "bad" (5th class) conditioned by dissolved oxygen, ammonium and phosphate ions, manganese, vanadium, potassium, total inorganic nitrogen and total phosphorus.

The water quality of the Getar River in the estuary section was assessed as "bad" (5th class) conditioned by ammonium, nitrite, phosphate ions and vanadium.

4.7 Biodiversity

In this section, both terrestrial and aquatic biodiversity adjacent to Yerevan Lake are observed.

4.7.1. Climate conditions of the environment, methods and methodologies

The climate in Yerevan is arid and continental, with hot summers and very cold winters. The climatic conditions in the central and southern lowlands are more unfavorable: hot, dry and frost-dangerous, while the northern and eastern regions have a temperate continental climate, with relatively cool summers and moderately cold and more humid winters.

The data on the biodiversity of the Yerevan Lake area were collected both as a result of on-site studies and previous studies. The data were based on the scientific archival data of NAS RA Institutes of Botany and Zoology and Hydro ecology. Information was collected on both the terrestrial and aquatic biodiversity of Yerevan Lake.

4.7.2 Plant communities, land use

The city of Yerevan is located in the floristic region of Yerevan, where mainly desert-semi-desert vegetation grows: Artemisia fragrans, Helichrysum, Poa, Teucrium, etc. The soils are suitable for the development of irrigated agriculture, grapes, stone fruits, vegetable crops, subtropical crops.

The vegetation of the Yerevan Lake area (the lake and the coastal area) is represented by about 55 species, which are mainly Monocotyledones and Dicotyledones. Among the Monocotyledones plants there are Aegilops cylindrica, Aegilops crassa, Poa annua, Secale ruderalis. The most common are Phragmites communis and Elytrigia repens. The most common of the Dicotyledones are Thlaspi arvense, Convolvulus lineatus L., campestris, Artemisia Armenian, Alhagi , etc.

Aegilops cylindrica

Agropyron repens

Reed beds are mainly spread on the shores of the lake. In the vicinity of Yerevan Lake, the area covered with reeds occupies about 10 hectares.

There are two types of poison ivy.

There are no species of agricultural crops in the coastal area of Yerevan Lake. Population is not engaged in cattle breeding in the city.

There are no homogeneous communities of shrubs and trees in the coastal area of Yerevan Lake. They are presented in random species, including ornamental and fruit species.

From the bushes there are Ligústrum vulgáre Berberis orientalis, Juníperus, Syringa, Rubus caesius, Ficus and other casual species.

L. vulgare

Ficus cárica

Trees are represented by casueal species, such as Plátanus, Fraxinus excelsior, Acer, Salix, Sorbus, Ulmus, Acaciella angustissima, as well as Morus, Pýarm , Mālus, Prunus.

Fraxinus excelsior

Coryloideae caucasica

4.7.3 Summary of the research on fauna species

Among the terrestrial animals in the coastal areas of Yerevan Lake are rabbits, hedgehogs, frogs, toads and vultures. The location of Yerevan reservoir in the Hrazdan river bed which connects the Lake Sevan basin with the Araks River valley, attracts a great abundant of the country's waterbird fauna. This has become especially obvious with the expanding network of artificial fish-farming ponds operating in the close proximity to the river course. Given a significant open water surface, the reservoir began to attract waterbird species during autumn and spring migration. At the same time, the reservoir shores which overgrew with wetland vegetation, especially in the point where Hrazdan River feeds the reservoir has created nesting grounds for some bird species which built their nests in the lushly growing reed cover fringing the reservoir's right banks. If in the early days of its formation the species diversity of nesting birds was measured in single individuals and their numbers were minimal, to the present day their numbers reached two dozen and are currently already measured in tens. The species composition and the number of birds using the reservoir area outside of the nesting season also increased.

During the early days of formation of the reservoir, nearly the entire shoreline shrubby and tree vegetation has been removed to reduce the potential negative impact from flooding. Later on, with the further greening efforts and planting of trees and bushes, a narrow vegetative belt has formed almost along the entire perimeter of the reservoir with its typical birdlife.

By looking at the table we may conclude that a total of 147 species of birds are known to occur in the area of Yerevan reservoir and its vicinities. Of these, 60 species belong to the group of waterbirds. Out of 21 species of birds classified as year-round resident breeder 9 belong to the group of water- and wetland-dependent birds.

Out of 20 species classified as year-round resident non-breeder, 10 are water- and wetland-dependent birds. Of 24 migrating bird sspecies 17 are water and wetland dependent and out of 10 wintering bird species 6 are water- and wetland-dependent.

9 waterbird species are classified as casual, i.e. documented on the reservoir at least 1 to 5 times.

Of 11 waterbird species listed in the Red Data Book of Armenia, 4 are included in the IUCN Red List of Globally Threatened Species.

The total list of the bird species preliminary drawn for the study area is shown in Table 14.

Table 14: The total list of the bird species

English names	Scientific names	RDB1	IUCN2	YR resident br3	YR resident nbr4	SV5	M6	W7	Cas8
Podicipedidae									
Little Grebe	Tachybaptus ruficollis			v					
Great Crested Grebe	Podiceps cristatus			v					
Black-necked Grebe	Podiceps nigricollis							v	
Phalacrocoracidae									
Great Cormorant	Phalacrocorax carbo	+						v	
Pygmy Cormorant	Microcarbo pygmaeus	+			v				
Pelecanidae									
Dalmatian Pelican	Pelecanus crispus	+							v
Ardeidae									
Eurasian Bittern	Botaurus stellaris							v	
Little Bittern	Ixobrychus minutus			v					
Black-crowned Night-heron	Nycticorax nycticorax						v		
Squacco Heron	Ardeola ralloides								v
Cattle Egret	Bubulcus ibis								v
Little Egret	Egretta garzetta						v		
Purple Heron	Ardea purpurea								V
Ciconiidae									
White Stork	Ciconia ciconia				v				
Anatidae									
Ruddy Shelduck	Tadorna ferruginea	+					v		
Eurasian Wigeon	Mareca penelope						v		
Gadwall	Mareca strepera			v					
Common Teal	Anas crecca				v				
Mallard	Anas platyrhynchos			v					
Northern Pintail	Anas acuta						v		
Garganey	Spatula querquedula				v				
Northern Shoveler	Spatula clypeata	+			v				
Red-crested Pochard	Netta rufina							v	
Common Pochard	Aythya ferina		VU						
Ferruginous Duck	Aythya nyroca	+	NT						v
Tufted Duck	Aythya fuligula								
Accipitridae									
Black Kite	Milvus migrans						v		
Western Marsh-harrier	Circus aeruginosus								v
Eurasian Sparrowhawk	Accipiter nisus				v				
Falconidae									
Common Kestrel	Falco tinnunculus				V				

Rallidae									
Water Rail	Rallus aquaticus				v				
Common Moorhen	Gallinula chloropus			v					
Common Coot	Fulica atra			v					
Charadriidae									
Little Ringed Plover	Charadrius dubius								v
Scolopacidae									
Little Stint	Calidris minuta						v		
Ruff	Calidris pugnax						v		
Common Snipe	Gallinago gallinago							v	
Great Snipe	Gallinago media	+	NT				v		
Black-tailed Godwit	Limosa limosa	+	NT				v		
Common Redshank	Tringa totanus			v					
Marsh Sandpiper	Tringa stagnatilis						v		
Green Sandpiper	Tringa ochropus				v				
Wood Sandpiper	Tringa glareola					v			
Common Sandpiper	Actitis hypoleucos					v			
Laridae									
Armenian Gull	Larus armenicus	+			v				
Pallas's Gull	Larus ichthyaetus							v	
Mediterranean Gull	Larus melanocephalus								v
Black-headed Gull	Larus ridibundus				v				
Slender-billed Gull	Larus genei						v		
Common Tern	Sterna hirundo						v		
Little Tern	Sternula albifrons	+					v		
Whiskered Tern	Chlidonias hybrida	+					v		
Black Tern	Chlidonias niger						v		
White-winged Tern	Chlidonias leucopterus						v		
Columbidae									
Rock Pigeon	Columba livia				v				
Laughing Dove	Spilopelia senegalensis				v				
Apodidae									
Alpine Swift	Tachymarptis melba					v			
Common Swift	Apus apus					v			
Alcedinidae									
Common Kingfisher	Alcedo atthis			v					
Meropidae									
European Bee-eater	Merops apiaster								
Upupidae									
Eurasian Hoopoe	Upupa epops					v			
Picidae									
Syrian Woodpecker	Dendrocopos syriacus			v					
Alaudidae									

Calandra Lark	Melanocorypha calandra						v		
Crested Lark	Galerida cristata								
Horned Lark	Eremophila alpestris							v	
Hirundinidae									
Sand Martin	Riparia riparia					v			
Eurasian Crag-martin	Hirundo rupestris					v			
Barn Swallow	Hirundo rustica					v			
Northern House-martin	Delichon urbicum					v			
Motacillidae									
Yellow Wagtail	Motacilla flava						v		
Grey Wagtail	Motacilla cinerea							v	
White Wagtail	Motacilla alba			v					
Cinclidae									
White-throated Dipper	Cinclus cinclus			v					
Troglodytidae									
Winter Wren	Troglodytes troglodytes			v					
Muscicapidae									
European Robin	Erithacus rubecula					v			
Bluethroat	Luscinia svecica						v		
Black Redstart	Phoenicurus ochruros			v					
Isabelline Wheatear	Oenanthe isabellina						v		
Turdidae									
Eurasian Blackbird	Turdus merula			v					
Redwing	Turdus iliacus		NT				v		
Mistle Thrush	Turdus viscivorus					v			
Sylviidae									
Cetti's Warbler	Cettia cetti					v			
Great Reed-warbler	Acrocephalus arundinaceus					v			
Common Whitethroat	Sylvia communis					v			
Mountain Chiffchaff	Phylloscopus sindianus					v			
Muscicapidae									
Spotted Flycatcher	Muscicapa striata					v			
Timaliidae									
Bearded Reedling	Panurus biarmicus				v				
Paridae									
Blue Tit	Cyanistes caeruleus					v			
Great Tit	Parus major			v					
Sittidae									
Western Rock-nuthatch	Sitta neumayer			v					
Laniidae									
Red-backed Shrike	Lanius collurio					v			
Corvidae									

Eurasian Jay	Garrulus glandarius			v					
Black-billed Magpie	Pica pica			v					
Eurasian Jackdaw	Corvus monedula				v				
Rook	Corvus frugilegus				v				
Hooded Crow	Corvus corone			v					
Sturnidae									
Common Starling	Sturnus vulgaris				v				
Rosy Starling	Sturnus roseus					v			
Passeridae									
House Sparrow	Passer domesticus			v					
Spanish Sparrow	Passer hispaniolensis					v			
Eurasian Tree Sparrow	Passer montanus				v				
Fringillidae									
Eurasian Chaffinch	Fringilla coelebs				v				
Brambling	Fringilla montifringilla							v	
European Greenfinch	Carduelis chloris				v				
European Goldfinch	Carduelis carduelis				v				
Common Rosefinch	Carpodacus erythrinus						v		
Emberizidae									
Yellowhammer	Emberiza citrinella							v	
Ortolan Bunting	Emberiza hortulana					v			
Black-headed Bunting	Emberiza melanocephala					v			
Corn Bunting	Miliaria calandra					v			
		11	**5**	**21**	**21**	**23**	**24**	**10**	**8**

1 RDB - Red Data Book of Armenia
2 IUCN - IUCN Red List of Globally Threatened Species
3 YR resident br - Year round resident breeder
4 YR resident nbr - Year round resident non-breeder
5 SV - Summer visitor
6 M - migrant
7 W - winter visitor
8 Cas - Casual

During the implementation of the project, the zone of environmental impact expands also to aquatic biodiversity.

4.7.4 Aquatic biodiversity

Biodiversity of coastal areas (the sunrays penetrate to the bottom sediments). These areas play an important biological role, as they create favorable conditions for the reproduction of algae and invertebrates, which in turn serve as a habitat and food source for fish, waterfowl and other animals.

Planktonic organisms predominate in the coastal areas of the reservoir, and are more prevalent in the areas near the right bank.

Phytoplankton coexistence on the shores of Yerevan Lake is represented by diatomaceous (Bacillariophyta), green (Chlorophyta), bluish-green (Cyanophyta), xanthophyta (Xanthophyta), euglena (Euglenophyta) and dinophytic (Dynophyta) algae. Diatomaceous and green algae are the richest in biodiversity (28 species each), while bluish-green algae (10 species) are sub-dominant species. The other groups have very little representation (1-2 species).

Table 15: Qualitative composition of phytoplankton in the coastal areas of Yerevan Lake

BACILLARIOPHYTA	CHLOROPHYTA	CYANOPHYTA	XANTHOPHYTA	EUGLENOPHYTA	DYNOPHYTA
Aulacoseira granulata	Actinastrum hantzchii	Aphanizomenon flos-aquae	Characiopsis acuta	Trachelomonas hispida	Peridinium sp.
Amphora ovalis	Ankistrodesmus angustus	Aphanothece clathrata	Tribonema monochloron		
Cocconeis placentula	A. falcatus	A. stagnina			
C. pediculus	Binuclearia lauterbornii	Dolichospermum flos-aquae			
Cyclotella comta	Botryococcus sp.	Gloeocapsa sanguinea			
Cymatopleura solea	Characium sp.	Gomphosphaeria lacustris			
Cymbella lanceolata	Chlamydomonas reinhardtii	Microcystis aeruginosa			
C. prostrata	Chlorella vulgaris	Oscillatoria lacustris			
C. ventricosa	Coelastrum microporum	Os. limnetica			
Diatoma vulgare	C. reticulatum	Spirulina sp.			
Fragilaria capucina	C. sphaericum				
F. crotonensis	Cosmarium formosulum				
Melosira varians	Crucigenia tetrapedia				
Navicula cryptocephala	Gloeocystis rupestris				
N. gracilis	Kirchneriella lunaris				
N. linearis	K. obesa				
N. radiosa	Micractinium pusillum				
N. sp.	Monoraphidium contortum				
Nitzschia acicularis	M. griffithii				
N. dissipata	Nephrochlamis subsolitaria				
N. palea	Oocystis lacustris				
N. subtilis	Pandorina morum				

Pinnularia gibba	Scenedesmus acuminatus				
P. viridis	S. quadricauda				
Rhoicosphenia curvata	Tetraedron minimum				
Stephanodiscus astraea	T. muticum				
S. hantzchii	Volvox aureus				
Surirella ovata	Actinastrum hantzchii				

Zooplankton coexistence of the coastal areas of the reservoir is presented by 12 species of Rotifera, 7 species of Copepoda and 33 species of Cladocera (See Table 16).

Table 16. Qualitative composition of zooplankton in the coastal areas of Yerevan Lake

ROTIFERA	COPEPODA	CLADOCERA
Asplanchna herricki	Acanthocyclops vernalis (Fischer, 1853)	Alona rectangula (Sars, 1862)
Asplanchna priodonta (Gosse, 1850)	Cyclops vicinus (Ulyanin, 1875)	Bosmina longirostris (O.F. Müller, 1785)
Asplanchna sp.	Eudiaptomus sp.	Chydorus sphaericus (Müller, 1785)
Brachionus calyciflorus (Pallas, 1776)	Paracyclops sp.	
Brachionus diversicornis (Daday, 1883)	Thermocyclops oithonoides (Sars, 1863)	
Conochilus unicornis (Rousselet, 1892)	Copepodite	
Euchlanis dilatata (Ehrenberg, 1832)	Nauplius	
Filinia terminalis (Plate, 1886)		
Keratella cochlearis (Gosse, 1851)		
Keratella quadrata (Müller, 1786)		
Polyarthra longiremis (Carlin, 1943)		
Bdelloida		

Macrozoobenthos is composed of Amphipoda, Arhynchobdellida, Diptera, Gastropoda, Oligochaeta and Venerida, which are represented by 9 families (See Table 17).

Table 17: Qualitative composition of bottom macro-invertebrates in the coastal areas of Yerevan Lake

Class	**Family**	**Stock**	**Species**
Amphipoda	Gammaridae	Gammarus	Gammarus pulex
Arhynchobdellida	Erpobdellidae	Erpobdella	Erpobdella octoculata
Diptera	Chironomidae		
Gastropoda	Lymnaeidae	Lymnaea	
	Physidae	Costatella (Physa)	Costatella acuta
Oligochaeta	Lumbricidae		
	Naididae		

	Tubificidae		
Venerida	Pisidiidae	Euglesa	

Aquatic area with dominating phytoplankton and zooplankton

The concentration of planktonic algae in Yerevan Lake is subject to seasonal changes. The concentration of algae rises sharply in summer (Figure 22, 23), when algal blooms are recorded in the reservoir water. These summer blooms are stable for the reservoir, beginning in late spring or early summer and continuing until late summer or early fall. They are mainly due to the rapid growth of cyanobacteria, and sometimes there is a succession of flowering algae groups, when different groups of algae (green algae, diatomaceous, and cyanobacteria) dominate at different times in summer. There are 12 species of cyanobacteria in the reservoir plankton: Aphanizomenon flos-aquae, Aphanothece clathrata, A. stagnina, Dolichospermum flos-aquae, D. sp., Gloeocapsa sanguinea, Gomphosphaeria lacustris, Microcystis aeruginosa, Oscillatoria lacustris, Os. limnetica, Planktothrix agardhii, Spirulina sp.

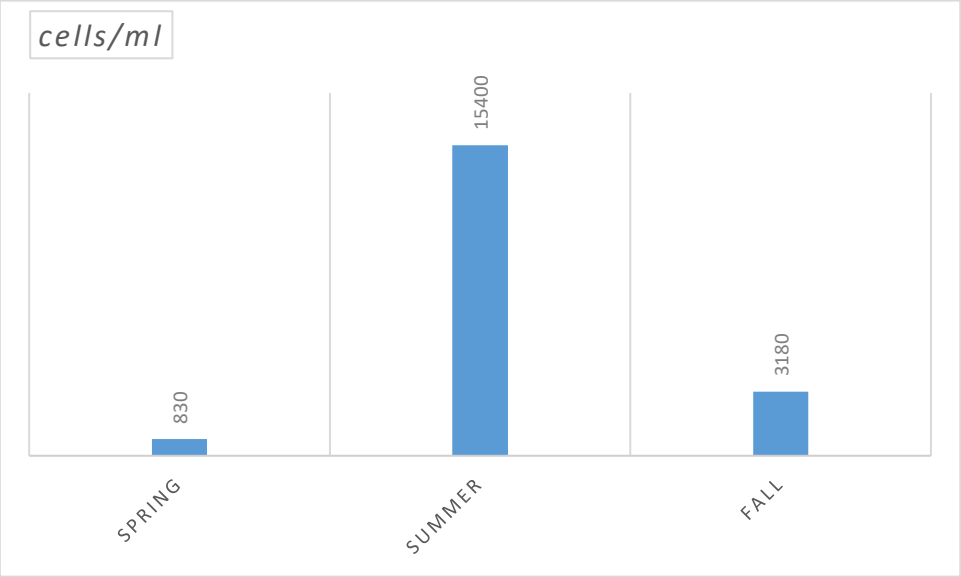


Figure 22: Seasonal average phytoplankton concentration in Yerevan Lake epilimnion

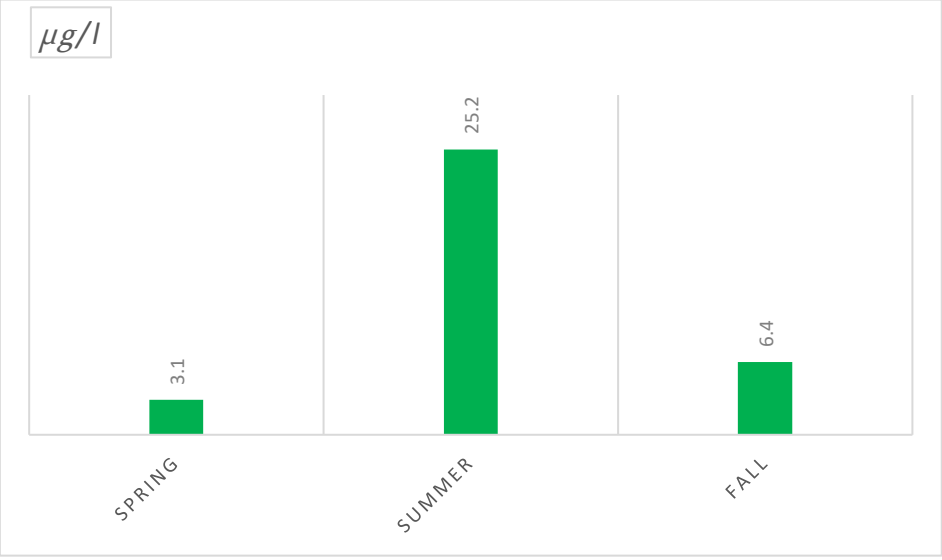


Figure 23: Seasonal average concentration of chlorophyll-a in Yerevan Lake epilimnion

There are 25 species of crustaceans in Yerevan Lake belonging to three main groups of zooplankton: Rotifera, Copepodaand Cladocera (see Table 18). The planktonic crustaceans found in the reservoir, according to the sequence of decreasing diversity, are presented as follows: Rotifera (12 species), Copepodaand (9 species), Cladocera (4 species).

Table 18: Qualitative composition of Yerevan Lake zooplankton

ROTIFERA	**COPEPODA**	**CLADOCERA**
Asplanchna herricki	Acanthocyclops vernalis (Fischer, 1853)	Alona rectangula (Sars, 1862)
Asplanchna priodonta (Gosse, 1850)	Cyclops vicinus (Ulyanin, 1875)	Bosmina longirostris (O.F. Müller,1785)
Asplanchna sp.	Eucyclops serrulatus (Fischer, 1851)	Chydorus sphaericus (Müller, 1785)
Brachionus calyciflorus (Pallas, 1776)	Eudiaptomus sp.	Daphnia longispina (O.F. Müller, 1785)
Brachionus diversicornis (Daday, 1883)	Macrocyclops albidus (Jurine, 1820)	
Conochilus unicornis (Rousselet, 1892)	Paracyclops sp.	
Euchlanis dilatata (Ehrenberg, 1832)	Thermocyclops oithonoides (Sars, 1863)	
Filinia terminalis (Plate, 1886)	Copepodite	
Keratella cochlearis (Gosse, 1851)	Nauplius	
Keratella quadrata (Müller, 1786)		
Polyarthra longiremis (Carlin, 1943)		
Bdelloida		

The fish comminiry of Lake Yerevan is represented by the silver carp - Carassius auratus gibelio, belonging to the family Cyprinidae (Bloch, 1782), wich are found both on the costal and in the depths of the reservoir.

Carassius auratus gibelio

4.8 Historical and cultural resources

Shengavit Eneolithic settlement is located in the southern part of Yerevan Lake, 200 m away from the project implementation area.

Figure 24: Shengavit Eneolithic settlement

The Shengavit archaeological site is an ancient settlement occupied from c. 3500 - c. 2200 BCE. The site is nearly 3 hectares in size. It was originally between 10-12 hectares and lies 30 m above the banks of the Hrazdan River. Considered by many archaeologists to be Armenia's most prominent prehistoric and Early Bronze Age site, the artifacts found at Shengavit attest to the development of an early agricultural settlement of migrating tribes, whose technology and culture later spread outwards from the Armenian highlands into the Caucasus, Mesopotamia.

The site is protected by the state.

The Church of the Exaltation of the Holy Cross of the Russian Orthodox Church is located on Admiral Isakov Avenue, in the northwestern part of Yerevan Lake, at 250 meters from the lake. The church was built in 2010-2017 and is a cultural and religious center of the Orthodox community.

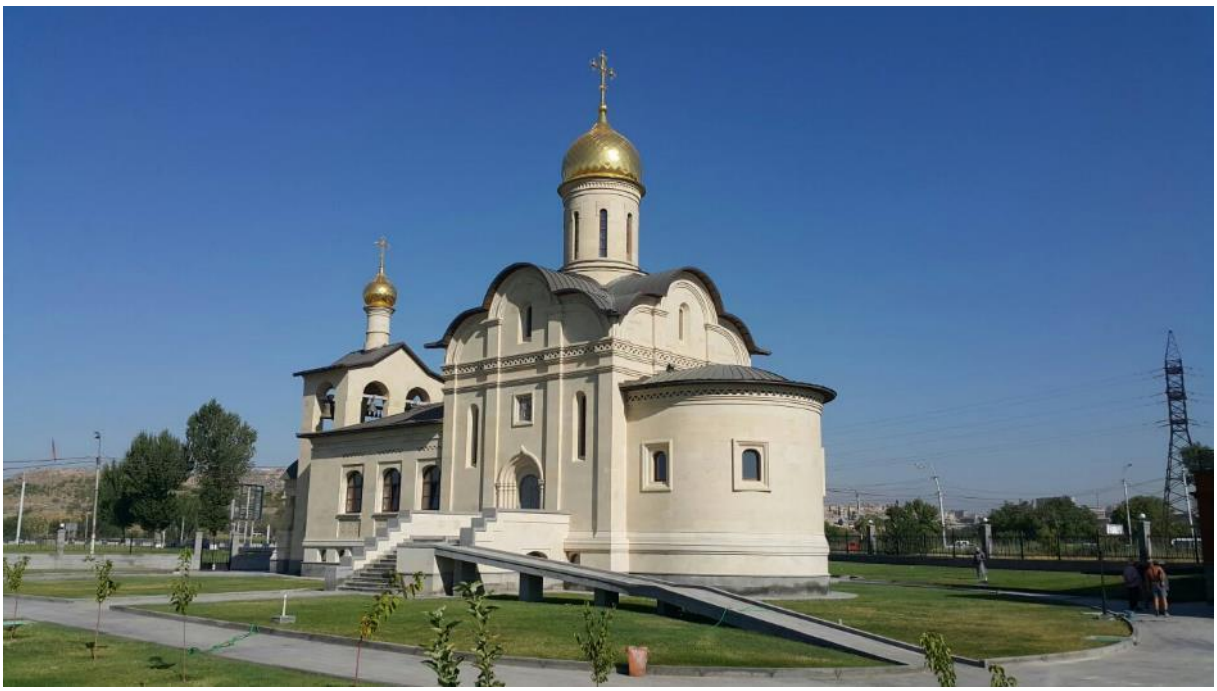


Figure 25: Church of the Exaltation of the Holy Cross

4.9 Socioeconomic conditions

4.9.1 Population and demography

Shengavit administrative district borders with the capital Yerevan's Erebuni, Kentron, Malatia-Sebastia, Nubarashen administrative districts, and Ararat marz. The area of the administrative district is 4060 hectares. The number of population for the last four years is summarized in Table 19.

Table 19: The population of Shengavit administrative district1

Community	Number of population by year			
	2017	2018	2019	2020
Yerevan	1 075 800	1 077 600	1 081 800	1 084 000
Shengavit	139 600	140 000	140 700	141 200
Share of Shengavit population in Yerevan population (%)	12.97	12.99	13.00	13.02

Source: https://www.armstat.am/file/Map/MARZ_01.pdf

Shengavit is the largest in terms of population in the twelve administrative districts of Yerevan. According to the latest statistics (2020), 141,200 people lives in the administrative district, 13.02% of the population of Yerevan. As we can see from the data in the table, the number of population is growing year by year both in Shengavit administrative district and in Yerevan in general.

[1] Based on census data of Republic of Armenia in 2011

Table 20: The main indicators of the natural movement of the population of Shengavit (2019)

Community	Births	Deaths	Natural growth	Marriages	Divorces
Yerevan	14 001	8 675	5 326	6 586	1907
Shengavit	2 135	1 217	918	927	268
Share of Shengavit population in Yerevan population (%)	15.24	14.02	17.23	14.07	14.05

Source: https://www.armstat.am/file/Map/MARZ_01.pdf

The number of births exceeds the number of deaths. Natural growth- 918 people. The share of marriages in the total number of marriages in Yerevan is 14.07%. Divorce accounts for 28.91% of marriages in Shengavit district (Table 20).

4.9.2 Employment

As of January 1, 2021, the number of job seekers in Yerevan was about 12427 people, which is an increase of 1.2% over the same period last year. The picture in Shengavit administrative district is as follows: the number of job seekers is 2023, the growth compared to the previous year is almost the same - 1.1%. The total number of unemployed in the capital is 60.1% of job seekers or 7463 people. The index is a little high in Shengavit administrative district. The unemployed make up 60.9% of job seekers.

Table 21: Number of job seekers, unemployed, employed

Community	Indexes		
	job seekers	unemployed	employed
Yerevan	12 427	7 463	2 253
Shengavit	2023	1232	257
Share of Shengavit population in Yerevan population (%)	16.3	16.5	11.4

Source: https://employment.am/am/372/LinkPage.html

In order to study the labor market situation in Yerevan, the regional centers of the administrative districts closely cooperate not only with the employers in the area, but also with non-governmental organizations, foundations, the municipality, various departments and international organizations, with the support of which state employment programs are implemented.

In general, in the second half of 2020, 2253 job seekers were employed through employment centers in Yerevan, 257 of which (11.4%) in Shengavit community.

4.9.3 Level of economic development

The main directions of Shengavit community economy are industry, agriculture, construction, retail trade, services. The main spheres of industry are the production of food, tobacco, electrical equipment. A number of production enterprises are located in the administrative district: "Grand Tobacco", "Araks Gold", "Grand Candy" joint ventures, "Armenian Electric Car", "Electron", "Armen-Carpet", "Yerevan TPP" State Closed Joint-Stock Company and other companies.

4.9.4 Level of health

There are a number of healthcare organizations in the territory of Shengavit administrative district, including 5 polyclinics, 3 medical centers, 2 dental clinics, as well as the "Yerevan City Center" branch of "National Center for Disease Control and Prevention" SNCO. There are other private clinics that provide medical services.

There are a number of issues related to the health sector in the community, in particular:

- ✓ the need to modernize the healthcare system,
- ✓ the need to improve the building conditions of medical institutions,
- ✓ improving the quality of medical services provided, modernization of equipment and assets, increase of salaries,
- ✓ the need to ensure access to expensive and hard-to-reach surveys guaranteed by the state for the population,
- ✓ training of doctors, nurses and pharmacists working in medical institutions,
- ✓ the need for modernization of medical equipment.

4.9.5 Land use (mapping)

The land fund of Shengavit administrative district, according to the subjects of ownership, is divided into property lands of RA citizens and legal entities, state and community.

According to the intended use, the lands of Shengavit community are divided into:

- ✓ agricultural,
- ✓ residential,
- ✓ facilities of industry, subsoil and other production use,
- ✓ energy, transport, communication, utility infrastructure facilities,
- ✓ specially protected areas,
- ✓ special purpose,
- ✓ forest,
- ✓ water,
- ✓ reserve.

Figure 26: Land use map

4.9.6 Level of development of social infrastructure

There are 29 schools (4 highs, 25 basic schools), 22 kindergartens, 4 libraries, 4 sports schools, 2 music schools, 3 educational and cultural centers in Shengavit administrative district. Three of the district's kindergartens, the libraries, the music schools and the cultural institutions have been renovated.

The region includes Nor Kharberd, Charbakh, N. Charbakh, V. Shengavit, N. Shengavit, Aeratsia, Noragavit districts, Arshakunyats avenue, G. Nzhdeh, Bagratunyats, Artashisyan residential blocks, as well as the blocks branching out on adjacent streets. Shengavit administrative district of Yerevan has 636 apartment buildings, 139 are high-rise, 274 elevators, 14 emergency buildings. 5 underpasses, 3 overpasses are registered. The number of streets is 212, the length is 147.7 km, the area is 210.9 thousand. sq.m:

The water supply of Shengavit is carried out from 5 sources; there is 1 reservoir in the region. The total area of green areas in the region is 30 hectares; there is a total irrigation network of 33931 m.

Passenger transportation is carried out by cars and electric transport. Four of the ten metro stations in Yerevan are located in Shengavit community (Gortsaranayin, Shengavit, Garegin Nzhdeh Square, Charbakh).

There is a charitable canteen in the region under the auspices of "Mission Armenia" NGO, which is used by a number of socially vulnerable families and single elderly people. There are a number of non-governmental and charitable organizations in the administrative district (“Hans Christian Kofoed” Foundation, “Shoghik” CF, “Arda”, “Alex”, “Luysi Astgh”, etc.), as a result of which social programs are targeted at the disabled youth employment and vocational training.

5. ANALYSIS OF ALTERNATIVES

5.1 Site selection

The water surfaces of Yerevan Lake, Aparan Reservoir and Azat Reservoirs were previously proposed for the place of the floating solar plant.

Aparan reservoir

Azat reservoir

Yerevanyan Lake

As a result of the studies, Yerevan Lake was selected because:

- ✓ Yerevan Lake is more suitable for a floating solar plant, since it has access roads, which facilitates construction and operation,
- ✓ Yerevan Lake does not freeze in winter, the bottom is quite flat, the water quality is ranked to 4-5 category and there is no significant valuable biodiversity,
- ✓ the Yerevan site is the best option for the Public accessibility,
- ✓ Aparan reservoir freezes in winter and its surface is covered with an about 30 cm thick layer of ice,
- ✓ water fluctuations are large in Azat Reservoir, the bottom has large depressions and in case of minimal volume of water, the solar panels can be damaged,
- ✓ these two reservoirs (Aparan and Azat) also have a higher biodiversity.

Taking into account different circumstances, different alternatives were also considered for the selection of the area for the installation of solar plant in Yerevan Lake.

According to the project, the "Solar Island" is planned to be located in the central part of the lake (see Figure 27).

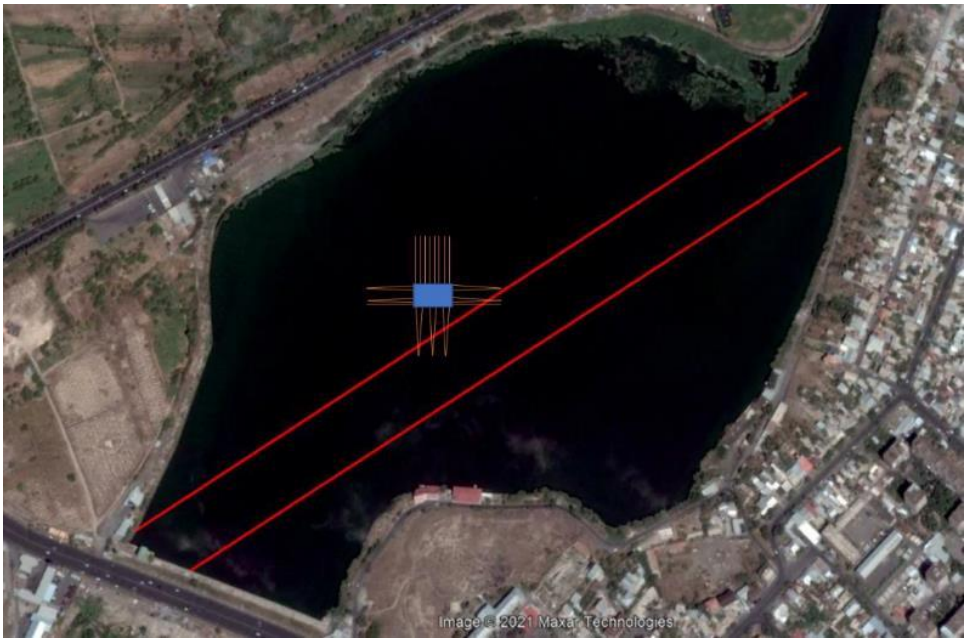


Figure 27: The position of the Solar Island according to the preliminary design

The following options were considered by the designer, which were not accepted:

- ✓ close to the dam, with anchoring on banks and fixation on the dam. The possibility seems extremely unrecommended, due to difficulties of permits obtention for works on a dam,
- ✓ closer to the northern bank, with more frequent grounding, further from building location and grid connection.

During the social surveys, the sports school staff presented a location that would not interfere with athletes training and competing (see Figure 28).

Figure 28: The location of the Solar Island suggested as a result of social survey

The final location of the solar panels will be selected after a public consultation with stakeholders.

5.2 "With the project" and "Without the project" alternatives

Solar plants are quite widespread in Armenia, but floating solar photovoltaic plants are an innovation for our country. This is the first attempt, and the possibility of replication of such plants depends on its success. The implementation of the project will enable the use of renewable solar energy to deliver an additional 156 kWp of "green" electricity to the grid.

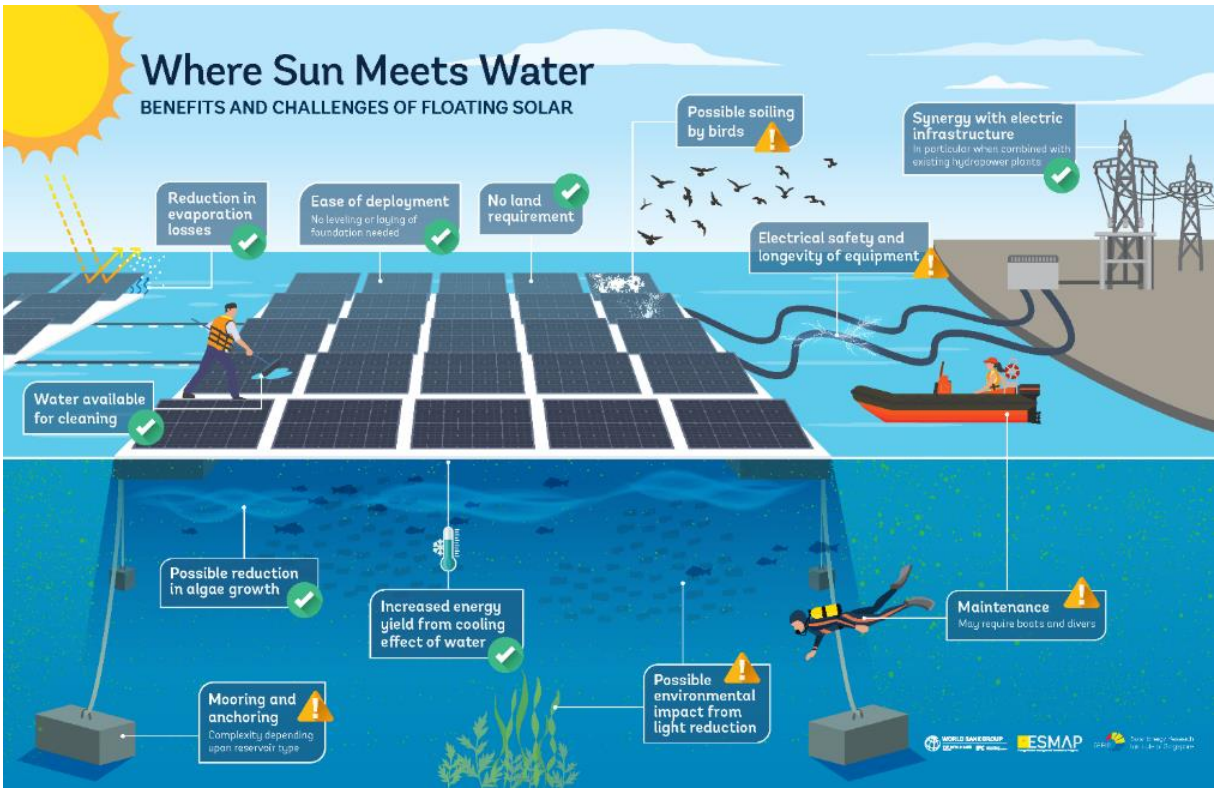
5.3 Alternatives of electricity sources

Two options have been proposed for transmitting the resulting solar energy: to one of the substations closest to the HPP Lake Yerevan area (near the Russian Church) or to the one east of the reservoir.

6. ENVIRONMENTAL AND SOCIAL IMPACT ASSESSMENT AND MITIGATION MEASURES

6.1 Introduction

Floating solar is recent technology, water quality impacts are only starting to be understood but are similar to floating pontoon. Today's platforms or pontoons provide the benefits of shading and cooling but they can also lead to sunlight blocking and depleted oxygen. This section will provide a summary of potential environmental effects or potential impacts. The diagram below presents potential benefits and challenges.



International references are been published such as BioHaven technology that has been proven as a water-quality Best Management Practice over the last 15 years and is readily adaptable as a floating solar pontoon. Environmental benefits are significant and include, but are not limited to:

- ✓ reduction of nutrient loading, especially TSS, TP, TN and ammonia,
- ✓ treatment and prevention of HABs and methane emissions,
- ✓ wave dampening to protect the solar panels and electronic componentry,
- ✓ promotion of biodiversity in the water body and in and around the BioHaven,
- ✓ embedded circulation and aeration technology,
- ✓ water quality finally made affordable by energy production to offset costs,
- ✓ chemical-free, safe, sustainable solution that empowers natural processes (https://www.floatingislandinternational.com/).

The main positive environmental and social impacts of the construction of a floating solar plant on Yerevan Lake are:

- ✓ more environmentally friendly and reliable energy supply,
- ✓ job creation,

- ✓ expanding the community budget:

Environmental and social risks are possible during the construction and operation of the plant, which can be reduced as a result of good construction practices.

Such risks are:

- ✓ impact on flora and fauna during the construction and operation of the plant,
- ✓ damage to lake banks areas,
- ✓ pollution of the site and surroundings with construction and household waste,
- ✓ road congestion and disruption,
- ✓ inconvenience caused for the population (noise, dust, road disturbance, etc.),
- ✓ damage to historical and cultural values.

Preliminary environmental and social assessments under the project indicate that the project will have a low environmental and social impact, which can be prevented, excluded or mitigated by the measures included in the Environmental and Social Management Plan.

It is important to note that the demonstrator covers 1 600 m², meaning less than 0,3% of the lake surface.

6.2 Impact on climate and air quality and mitigation measures

6.2.1 Assessment of impacts on climate and air quality

Transportation trucks on unpaved access road may create atmospheric air pollution by dust. In addition trucks or construction equipment will generate combustion products such as: nitrogen, sulfur, and carbon oxides, solid particles. These effects will be short and they can be prevented, mitigated as a result of appropriate measures.

6.2.2 Mitigation and elimination of impacts on climate and air quality

To prevent impact of dust on air quality the following actions must be implemented:

- ✓ regularly water the construction site and roads,
- ✓ dry, dusty materials are to be transported by trucks with covered carriages and stored in closed containers to avoid spreading,
- ✓ prohibit burning of garbage in the construction site,
- ✓ carry out regular maintenance of all vehicles and equipment.

6.3. Impact on geological condition and mitigation measures

The design of the floating solar plant does not require land leveling, construction of a new access road for the purpose of the project, which could potentially change the topography.

6.4. Impact on soil layer / shores and mitigation measures

Impacts on the soil layer and shores are mainly predicted during the construction and operation phases (e.g. transportation on lake banks). The impact during construction will be short-term and will be prevented or minimized as a result of good construction practice.

6.4.1 Impact on soil layer / shores

During construction, the soil layer and coastal areas can be contaminated with fuel, lubricants from the construction machinery and equipment, used paints and chemicals, as well as household and construction waste. Prevention measures are needed to prevent contamination of soil and coastal areas.

6.4.2 Mitigation and elimination of negative impact on the soil layer

To reduce or suppress the negative impact on soil and lake banks areas:

- ✓ carry out regular maintenance of all vehicles and equipment,
- ✓ wash construction machinery and vehicles and maintain off-site,
- ✓ store fuels and lubricants in closed containers, under cover,
- ✓ respond quickly to leaks, stop them and dispose the contaminated soil as hazardous waste,
- ✓ collect and transport all types of waste in accordance with the waste disposal contract signed preliminary,
- ✓ repair all damaged areas after construction completion,
- ✓ use only the planned access roads during operation.

6.5. Impacts on water bodies and mitigation measures

Within the framework of the report, the possible impacts on Yerevan Lake during the construction and operation phases were assessed. Impacts during construction are related to the use of equipment, vehicles, improper management of household and construction waste. The impact on water resources during the operation of the plant may occur during the washing of the solar panels.

6.5.1 Impact on water resources, quality and its assessment

Yerevan Lake can be contaminated with fuel, lubricants leaking from trucks and equipment (cranes), and construction waste (packaging). During operation, the lake may be contaminated with bird droppings and dust from washing the solar panels, but this will not put additional strain on the lake, since if the solar panels were not installed, the same amount of dust and bird droppings would enter the lake directly. The floats (floating devices) are made of high density polyethylene made for drinking water reservoir without coating or paints that could affect the water quality.

During the operation phase, a possible modification in water temperature is also possible, as all aquatic organisms are adapted to a certain temperature range, beyond which their loss or replacement by other species takes place.

FPV installations provide an increase of shade cover over waterbodies while simultaneously absorbing sunlight which would otherwise be absorbed by the water and increase water temperature especially during summer. The shading effect generated from the FPV installations may create changes to water temperature and dissolved oxygen levels with potential effects on aquatic life and water quality. Water species that are sensitive to water temperature, dissolved oxygen, and sunlight. These changes could be complementary or opposing, depending on the FPV system type and size. Any cooling effect associated by the absorption of solar energy would decrease water temperatures. This drop in temperature would preferentially benefit habitat suitability for native fishes, as well as amphibians. Decreased temperatures and increased shade may also help prevent or reduce the duration of algal blooms which deoxygenate water. Cooler water also has higher dissolved oxygen levels that also can prevent or shorten algal blooms. Currents velocity under the floats may also influence temperature or dissolved oxygen and reduce effects. Overall the installation of FPV installations is expected to be beneficial to any native fishes that might be present.

FPV installations are often a repository for birds creating soiling. Hard support (float) creates an “artificial reef” and may provide a support to enhance benthos and fishes’ production. Balancing the impacts/benefits requires careful observations on a case-by-case basis, therefore this project on Yerevan lake is an opportunity to understand beneficial or detrimental impacts. The FPV installations is specifically placed in the man-made reservoir which do not support sensitive aquatic habitats. It should be noted that the PV panel system occupies only 0.3% of the Reservoir area, therefore the impact of FPV Project on Yerevan lake is considered negligible. No significant impacts on the water quality or water resources is expected.

6.5.2 Mitigation of impact on water resources and their quality

The following measures must be taken to reduce the impact on water resources and their quality:

- ✓ carry out regular maintenance of all vehicles and equipment,
- ✓ wash and maintain construction machinery and vehicles parking at a distance of 50-100 m from the banks areas,
- ✓ store fuels and lubricants offshore in closed containers, under cover,
- ✓ respond quickly to leaks, stop them and dispose contaminated soil as hazardous waste,
- ✓ store dispersible construction materials (cement, sand, etc.) in closed containers to prevent their spread,
- ✓ collect and transport all types of waste in accordance with the preliminarily signed waste disposal contract,
- ✓ repair all damaged areas after construction completion,
- ✓ place the solar panels at a certain distance from each other, allowing air and solar rays to penetrate into the water area.

6.6. Noise impact and mitigation measures

Noise level exceedance is possible during the transportation (trucks) and construction of the plant due to the operation of the equipment used, only assembly of parts and connection are anticipated. The permissible noise level in the workplace is 80 dB (A), and the permissible noise level for residential areas is 55 dB (A) during the day, or an increase of not more than 3 dB (A) in the background.

To reduce the impact of noise:

- ✓ carry out construction works during working hours from 09.00 to 18.00,
- ✓ fully manage vehicle traffic,
- ✓ traffic of trucks only during the day,
- ✓ use low-noise mechanical equipment or silencers if possible,
- ✓ carry out regular maintenance of construction equipment and other vehicles,
- ✓ in case of noise level exceeding 80 dB (A), provide protective equipment to the employees and place warning signs in those places,
- ✓ inform the residents about the noisy actions in advance.

6.7. Impact on aesthetic aspects and mitigation measures

There are no specific studies on the aesthetic effects of floating solar stations. Theoretically, the effects can be at 3 levels:

- ✓ visual, depending on the plant dimensions,
- ✓ integrating with the environment,
- ✓ panel glare.

6.8. Impact on biodiversity and mitigation measures

During the construction of the floating solar plant, the impacts on the fauna (mainly fish) and flora communities of the area will be temporary. During operation the proposed potential environmental impacts of floating solar panels are just assumptions which need verification/rejection by a long term and thorough study. There is currently little knowledge available on the environmental effects of floating solar panels. Several studies have revealed some impacts (e.g., Mathijssen et al., 2020; Härtwich, 2016) others have shown no effects (i.e., de Lima et al., 2015), therefore, the environmental effects of these constructions, in general, are not sufficiently known.

6.8.1 Impact on flora and mitigation measures

Potential impacts on flora are related to the collection and transportation of solar panels in the area.

It is planned to transport the solar panels using the existing road leading to the lake and mantle them at the lake shore. That part of the lake shore is devoid of vegetation.

No impact on the flora is expected during the construction and operation of the plant.

6.8.2 Impact on fauna and mitigation measures

Operation of the floating solar power plant may pose hydro-ecological risks. In particular:

- ✓ changes in water currents and waves can affect sedimentation processes, affecting benthic ecosystems,
- ✓ construction, operation and maintenance of the floating solar power plant can facilitate the penetration of various chemicals into the water system, changing the ecological conditions of the environment.

All construction work should be carried out in areas away from the lake, excluding the entry of construction waste, fuel, lubricating oils, as well as other chemicals into the lake.

Impact on waterfowl: The potential impact on birds given their high likelihood of colliding with the anthropogenic structures.

Some studies concerning impacts of solar technologies on birds are from large Concentrating Solar Power (CSP) technologies use mirrors to concentrate (focus) the sun's light energy and convert it into heat to create steam to drive a turbine that generates electrical power, where bird mortalities caused by collision have been observed. In this Project, non CSP are implemented and only photovoltaics (PV) are installed and the PV are almost horizontal, and therefore collision are not applicable, on contrary the Floating PV are known to be repository for birds. Hence, it is unlikely that different avian species can be affected by solar PV infrastructure.

Based on the very scarce data available in literature, direct impacts of PV solar panels to birds are limited. According to some studies, the unexpectedly detected injured and killed water-associated or water-obligate birds (i.e. species that cannot take flight from land, such as grebes (Podicipediformes)) at solar PV facilities were believed to have been related to these mounted infrastructures, maintaining that these groups of birds mistook a PV solar for water ('lake' effect)[2] especially during moonlit nights. However, the extent of such mortalities is unknown.

Another important observation that needs to be highlighted is a large number of gulls and terns during passage period in the area of Yerevan reservoir, which may cause abundant littering on the panels and reduce the efficacy of energy production as a result.

6.9. Impact on historical and cultural heritage and mitigation measures

Historical and cultural heritage sites are identified in the immediate impact zone of the project. Closer to the project area are the Shengavit Eneolithic settlement (200 m), and the Orthodox community culture center - the Holy Cross Exaltation Cathedral (250 m). They are not expected to be affected during the construction or operation phases of the project.

[2] *Kosciuch K., Riser-Espinoza D., Gerringer M., Kosciuch W.E.. Summary of bird mortality at photovoltaic utility scale solar facilities in the Southwestern U.S. 2020 https://doi.org/10.1371/journal.pone.0232034*

6.10. Impact on society and economy and mitigation measures

Boating sports schools

The lake is actively used by 2 sports schools located on the banks of the Hrazdan River: the Armenian National Canoe Federation (ANCF) and the National Canoeing Association of Armenia (NCAA). The locations of the sports schools are indicated on the map below.

Figure 29: Location of ANCF

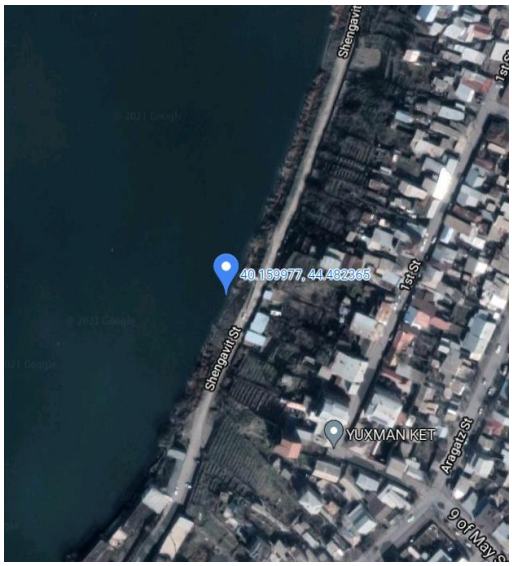


Figure 30: Location of NCAA

The mentioned sports schools use three lanes for trainings and competitions: 200 meters, 500 meters and 1000 meters long. The longest of the lanes, 1000 meters long, starts from the side of the dam (see "Start N1" mark on the map below) and, passing diagonally through the center of the lake, ends on the opposite side of the lake (see "Finish" mark on the map below). According to the head of the ANCF, it is planned to carry out trainings and competitions in the lake together with international federations, for which 9 lanes will be installed in the lake, each 9 meters wide (see the map below).

The short lanes, 200 meters and 500 meters long, start at the southern and south-eastern part of the lake (see "Start N2" and "Start N3" markings on the map below) and end at the same place (see "Finish" marking on the map below).

It should be noted that the representatives of the NCAA suggested considering the area marked on the map as "Zero Impact Location", in which case the planned activities will not have any social impact.

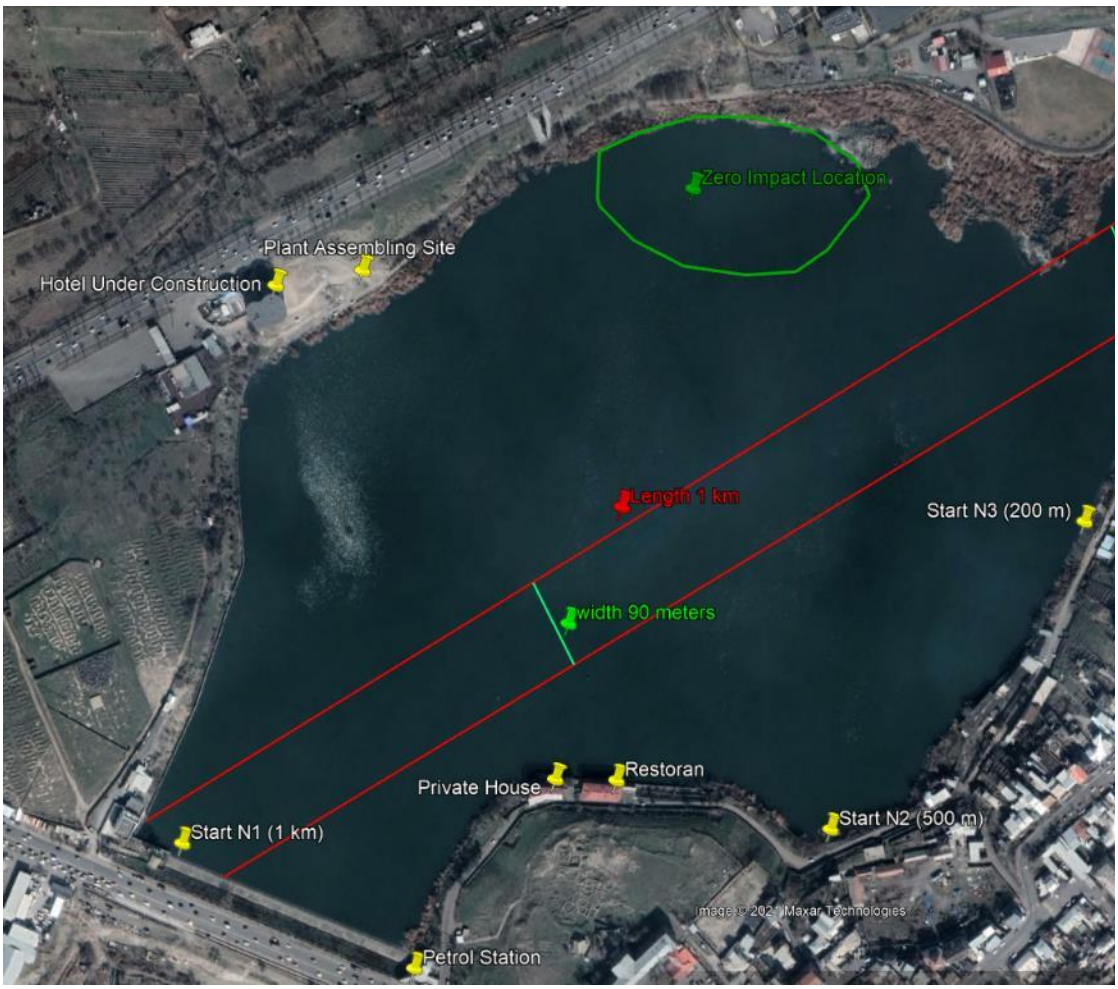


Figure 31: Competition lane

Hotel

According to the design data, the plant consists of 156 kWp power modules, which will be assembled on the shore of the lake, and for that purpose, a flat area is needed. The module assembly process is planned in the northwestern part of the lake, on the shore near the hotel under construction (see "Plant Assembling Site" in Figure 28). The collection process will take about 20 days.

If the hotel starts operation before the plant is assembled, the plant assembly will disrupt the hotel activity.

Mitigation measures

- ✓ the location of the plant will be outside the training lanes,
- ✓ consider the location of the plant in the area of "Zero Impact Location" (according to Figure 31),
- ✓ discuss the final location with the sports schools.
- ✓ if the hotel starts operating in the coming months, then if possible, organize the assembly of the plant during the decline of the tourist season.

6.10.1 Traffic

Isakov Avenue passes on the right side of Yerevan Lake, and Bagratunyats Avenue passes on its left side. The reservoir dam bridges the right and left areas of Yerevan. Traffic on both avenues is quite congested, with long traffic jams at certain hours.

No impact is expected on traffic during the construction and operation of the floating solar plant.

The access to the lake area will be carried out by the already existing road.

6.10.2 Economy and Employment

During the construction phase of the project, it will be possible to provide people with temporary jobs who will acquire knowledge and skills in the construction of floating solar plants, and later, as experienced staff, can participate in the construction of similar plants.

In addition, the project will provide indirect employment for employees or subcontractors of companies providing goods and services.

These works and incomes will be temporary, only during the construction phase.

Employees trained for the operation of the plant will have stable long-term jobs and incomes.

6.10.3 Human health

The key human health and safety risk associated with the operation phase is the unauthorized entry of community members into the Project area. The Project facilities (i.e. transformer, inverters) will be installed on the island to minimize unauthorized access. Similar to construction phase, the security of the Project will be available at the site during the operation phase for Project security and community health and safety through their observation and cautionary communication with any concerned stakeholders. Relevant signage will also be posted at on the Project site – outlining the key health and safety risks to the community as recommended above. There will be minimal traffic generated by the Project during operation, for this reason, safety risks associated with traffic are not expected to be a significant issue.

An emergency response and preparedness procedure will be developed. The procedure will include a communication system for engaging with regional and local emergency and healthcare authorities. The procedure will be developed in consultation with potentially affected stakeholders and local authorities.

6.10.4 Occupational Safety and Health (OSH)

The occupational safety and health issues possible during the construction and operation phases of the plant are mainly related to the effects of dust, noise, machine malfunctions and electromagnetic field (EMF) impact during the maintenance.

During the construction there is a risk for the workers to fall into water, since the solar panels have to be placed on the lake. In addition, they may develop water-borne diseases after falling into the water, as the water quality of the lake is quite low.

The construction contractor must implement an occupational safety and health management system for employees and residents of the affected community.

In order to prevent dangers to the population and the workers during the construction, preventive measures should be taken:

- ✓ carry out all construction activities during the day,
- ✓ provide employees with personal protective equipment (PPE) when relevant, including safety shoes, helmets, goggles, headphones, masks, etc.,
- ✓ fence the construction site with stripped safety ribbon,
- ✓ control the entry of unauthorized persons to the construction site,
- ✓ place warning signs in dangerous places,
- ✓ carry out regular inspections of equipment by qualified personnel,
- ✓ conduct regular safety audits,
- ✓ organize first aid and safety training for workers in charge of safety,
- ✓ cranes and other lifting equipment must be operated by trained and authorized persons,
- ✓ provide an up-to-date first aid kit at the construction site and assign a trained person to use it,
- ✓ ensure the presence of a rescue equipment when working on or near water,

- ✓ do not carry out electrical or technical works during bad weather and lightning.

The Floating PV must be operated by staff trained in occupational health and safety. It is necessary to develop a procedure for employees related to the cleaning of the panels, which they must follow when working. Employees must have a life jacket when cleaning the panels and performing other water-based operations. More than 1 employee must participate in those works.

6.11. Impact on power transmission lines

DC cables (direct current) will connect the PV modules to the inverter, located on the island. AC cables will reach the banks and will be maintained to the surface by floats. If needed, a solution with submerged cables, in order to allow boats circulation, can be studied, but it is more expensive and requires more intensive maintenance.

In the construction phase, there are several reasons causing potential fire exposure, such as electric shock, loose electricity wires or lighting strike.

These incidents may occur during the construction phase at the transmission line. To minimize these unplanned events, all workers and operators will be required to complete the training courses on safety measures.

A lighting strike can cause damage among power distribution components and possibly cause explosion of transmission line. The floating solar power construction is designed with lightning protection so it is not likely to occur lightning strike. Otherwise, it is possible that electricity equipment is damaged by weather conditions. Therefore, it is necessary to have regular inspections right after storm.

No overhead transmission line construction is created.

6.12 Summary of Cumulative Impacts

The environmental and social impacts of the floating solar photovoltaic plant planned on Yerevan Lake are provided in Table 22. Environmental and social impact assessments show that the main impacts (air and water pollution, dust, noise, impact on lake benthic animals, etc.) will be temporary during the construction of the plant, which can be prevented or minimized by good construction practice.

The construction and operation of the plant will not affect the flora and fauna of the area, except for the birds, which may confuse the reflection of the solar "island" with the mirror of the lake in moonlit nights.

The impact of the solar plant on the aquatic biodiversity of the lake is considered as negligible; there is an opportunity for scientists to monitor and record any change.

The main social impact that could occur on the canoe and kayak training and competitions on the lake, which is prevented by choosing the appropriate location for the solar island.

Existence of the plant and the operation will not affect the amateur fishing in the lake.

No significant environmental or social impact is expected during the operation of the plant.

7. ENVIRONMENTAL AND SOCIAL MANAGEMENT PLAN

According to the RA Law "On Environmental Impact Assessment and Expertise" (EIA) of 2014, any activity that may create a negative impact on the environment must be subject to an Environmental Impact Assessment (EIA) and environmental expertise. The activity can be carried out only if there is a positive conclusion of the expertise.

According to the above law, activities are classified into 3 categories: A, B and C. Activities related to a power plant are ranked to category C if the plant occupies an area of 40 hectares (Article 14, paragraph 6.1).

The area planned for the construction of the solar PV floating plant on Yerevan Lake occupies 0.15 ha, which means that the project does not require an EIA report and a conclusion of environmental expertise. Nevertheless, an EIA has been prepared for the purpose of transparency with stakeholders.

An environmental and social assessment has been developed for the project, as well as an Environmental and Social Management Plan (ESMP) for the design, and construction and operation phases of the project. The ESMP envisages measures to prevent, reduce or compensate for the project's environmental and social impacts.

The use of land for access roads to the plant site for construction will be minimized during the design phase.

The company involved in the design and construction will have appropriate authorization and/or license for development of such project.

Pollution of soil and water resources with fuels and lubricants, construction and household waste, air pollution with dust, will be prevented and noise control will be implemented during the construction phase.

After the construction, all the damaged lands should be restored and brought to the initial condition.

A grievance remedy/compensation mechanism should be developed to take into account the grievances of all stakeholders during the construction process.

The construction contractor and/or the project proponent must have (when required by authorities):

- ✓ License in the field of capital construction,
- ✓ Construction permit,
- ✓ Construction garbage and waste disposal permit.

During the operation phase, the plant operation and maintenance company (OMC) must protect the surface of the solar panels from dust, bird droppings (soiling), and snow accumulation, as well as reduce dust in the plant area.

Table 22 presents the environmental and social management plan.

Table 22: Environmental and Social Management Plan

Possible impact	Mitigation measures	Responsible party	Monitoring and supervision	Implementation period
Impacts on climate and air quality	Regularly water the construction site and roads during construction works	CC	Daily	Construction phase
	When transporting loose construction materials (cement, sand, etc.) provide a body cover for trucks; store them in closed containers to avoid scattering.	CC	Daily	Construction phase
	Prohibit outdoor combustion of waste at the construction site	CC	Daily	Construction phase
	Carry out regular maintenance of all vehicles and equipment	CC	Daily	Construction phase
Pollution of soil and coastal areas	Wash construction machines and vehicles and serve off-site	CC	Daily	Construction phase
	Store fuels and lubricants in closed containers under cover	CC	Daily	Construction phase
	Respond quickly to leaks, stop them and dispose contaminated soil as hazardous waste	CC	Daily	Construction phase
	Carry out regular maintenance of all vehicles and equipment	CC	Daily	Construction phase
	Collect and transport all types of waste in accordance with a pre-signed waste disposal contract	CC	Daily	Construction phase
	Use only planned access roads during construction	CC	Daily	Construction phase
	Rehabilitate all damaged areas immediately after construction	CC	Upon construction completion	Construction phase
	Train the employees on the appropriate sanitary rules	CC, MC< IC	Regularly	Regularly
Pollution with household and industrial waste	Carry out waste management according to the following principles: (i) prevent / reduce waste generation (ii) separate and reuse waste (iii) neutralize or dispose of waste (iv) train staff	CC	Daily	Construction phase
	Store all hazardous waste in organized warehouses	CC	Daily	Construction phase
	Collect and transport all types of waste in accordance with a pre-signed waste disposal contract	CC, MC	Daily	Construction phase
	Organize training for employees on handling with waste	CC, MC, IC	Daily	Construction phase
	Sign contracts only with certified waste recycling companies	CC, MC	Before construction commencement	Before construction commencement

Noise	Fully manage vehicle traffic	CC, MC	Daily	Construction and operation phase
	Traffic of trucks only during the day	CC, MC	Daily	Construction and operation phase
	If possible, use low-noise mechanical equipment or mufflers	CC	Daily	Construction phase
	Carry out regular maintenance of construction equipment and other vehicles	CC	Daily	Construction phase
	In case of noise level exceeding 80 dB (A), provide employees with protective equipment, place warning signs in those places	CC, MC	Daily	Construction and operation phase
	Provide a permissible noise level in settlements (≤ 55 dB (A)	CC, MC	Daily	Construction phase
	Inform the residents about the noisy actions in advance	CC, MC	Daily	Construction and operation phase
Pollution of water resources	Park, wash and service construction machines and vehicles at a distance of 50-100m from the coastal areas	CC	Daily	Construction and operation phase
	Store fuels and lubricants outside the coastal area in closed containers under cover	CC	Daily	Construction phase
	Respond quickly to leaks, stop them and dispose of contaminated water as hazardous waste	CC	Daily	Construction phase
	Collect and transport all types of waste in accordance with the pre-signed contract for waste disposal, prohibit the entry of waste into the lake	CC	Daily	Construction phase
Occupational health and occupational safety risks	Fence the construction site with stripped security ribbon	CC	Daily	Construction phase
	Control / prevent outsiders from entering the construction site	CC	Daily	Construction phase
	Place warning signs in dangerous places	CC	Daily	Construction phase
	Regularly inspect equipment by highly qualified staff	CC	Daily	Construction phase
	Operate cranes and other lifting equipment by trained and authorized persons	CC	Daily	
	Conduct regular security audits	CC	Daily	Construction phase
	Provide sanitary conditions and adequate number of sanitary facilities	CC	Included in the construction cost	Before construction works
	Organize first aid and safety training for builders and operators	CC	Daily	Before construction works
	Provide employees with the means necessary for work.	CC	Daily	Before construction works

	Provide employees with personal protective equipment (protective clothing, shoes, hat, headset, respirator, etc.), including safety shoes, helmets, goggles, etc.			
	Organize first aid and safety training for employees	CC,IC	Daily	Construction phase
Occupational health and occupational safety risks	Provide construction sites and vehicles with med kits and fire extinguishers	CC	Daily	Before construction works
	Ensure that injured workers are taken to hospital in the event of an accident	CC	Daily	Construction phase
	Carry out all construction activities during the day	CC	Daily	Construction phase
	Ensure the availability of a rescue service when working on or near water	CC	Daily	Construction and operation phase
	Do not carry out electrical or technical work during bad weather or lightning	CC	Daily	Construction and operation phase
	Record work regime-related violations, as well as all accidents and incidents	CC	Daily	Construction phase
Inconvenience and dangers to the public	Inform the public about the planned construction activities before the start of construction works	CC	Daily	Construction phase
	Place warning signs in visible places on main roads and at construction sites near settlements	CC	Daily	Construction and operation phase
Impact on public and economy	Notify the population of the affected communities about the construction works	CC	Daily	Before construction works
	Prioritize the local population when hiring construction workers	CC	Daily	Construction phase
	Exclude discrimination when hiring employees and setting salaries	CC	Daily	Construction phase
Pollution of solar panel surfaces with dust, bird droppings, snow	When polluting the surface of solar panels with dust and bird droppings, wash with running water and avoid the use of chemicals.	OMC	Regularly	Operation phase
	Avoid washing solar panels during heavy rain to avoid damaging surfaces	OMC	Regularly	Operation phase
	During the winter season, follow technical procedures from manufacturer (e.g. loosen or remove the layer of snow and ice on the panels with an air stream, temperature of which should be 20°C below the panel temperature).	OMC	Regularly	Operation phase

	Follow technical procedures from manufacturer (e.g., Use a special mop with a soft brush to remove a thick layer of snow from the panels)	OMC	Regularly	Operation phase
	Carefully remove large pieces of debris from the panels without damaging the surfaces	OMC	Regularly	Operation phase
	After washing and cleaning the panels, dry the surface of the panels with a soft rag.	OMC	Regularly	Operation phase

ANNEX 1

Agenda, List of participants and Minutes of the meeting

Public hearings on

Environmental and Social Assessment Report on 150 Kw Capacity Floating Photovoltaic Plant on Yerevan Lake

AGENDA
06 October 2021,
Session hall of Shengavit administrative district of Yerevan Municipality

HOUR	*EVENT*
09:30 - 09:45	Registration of participants
09:45 - 09:55	Welcome Speech Karen Asatryan-R2E2 Gevorg Nazaryan - Yerevan Municipality Presentation of the agenda, purpose of the meeting and expectations Arevik Hovsepyan - JINJ LTD
09:55 - 10:20	Project presentation Tigran Karapetyan- R2E2
10:20 - 10:35	Questions and answers
10:35 - 11:05	Presentation of environmental impact of the project and mitigation measures Arevik Hovsepyan - JINJ LTD
11:05 - 11:20	Questions and answers
11:20 - 11:50	Presentation of social impact of the project and mitigation measures Arsen Hayriyan - JINJ LTD
11:50 - 12:05	Questions and answers
12:05 - 12:30	Presentation of stakeholder proposals
12:30 - 12:40	Summing up the meeting

List of participants

R2E2 JINJ

ՄԱՍՆԱԿԻՑՆԵՐԻ ՑԱՆԿ

Երևանյան լճի վրա 156 կՎտ հզորությամբ լողացող ֆոտովոլտային կայանի բնապահպանական ու սոցիալական ազդեցության վերաբերյալ

Հանրային Լսումներ

06 հոկտեմբերի 2021, Երևան համայնքի Շենգավիթ վարչական շրջանի նիստերի դահլիճ

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1	DUMAINE Colin HUSSENOT Manon	Transénergie	colin.dumaine@rspen.fr manon.hussenot@rspen.fr	
2	JEAN Philippe	PJN-Consulting	ph.lippe.jean@pjn-consulting.com	
3	Arevik Hovsepyan	JINJ	091539202	
4	Edvard Mesropyan	JINJ	09142701	
5	Karen Hovsepyan	Ministry of Territ. Administration and Infrast	077 730317	
6	Arsen Hayrigyan	GIN6, Social Expert	093 220992	
7	Kristina Ter-Matevosyan	Ecolur,	091570583	
8			099999054	
9			098909960	
10			091319182	
11			091534343	
12			094-499302	
13			098-68-9040	
14			093-21-25-67	
15			088-00-73-72	
16			011514-264	
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18	[illegible]	[illegible]	093905427	
19	[illegible]	[illegible]	099912127	
20	[illegible]	[illegible]	077220177	
21	[illegible]	R2E2 Fund	093 10 75 00	
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MINITUES OF PUBLIC HEARING

On

Environmental and Social Assessment Report on 150 Kw Capacity Floating Photovoltaic Plant on Yerevan Lake

06 October 2021

On 6 October 2021, a public discussion with the stakeholders on the "Environmental and Social Assessment Report on 150 Kw Capacity Floating Photovoltaic Plant on Yerevan Lake " took place in the hall of the administrative building of Shengavit administrative district of Yerevan (see the list of participants above).

At the beginning of the meeting, Karen Asatryan, Director of R2E2, made a welcoming speech, giving brief information on the project, its initiators, parties involved, goal, and expected results.

Gevorg Nazaryan, Head of the Environment Department of the Municipality of Yerevan, mentioned that the project had been discussed in the City Hall, and thanked the French Government and all parties involved for their support. He emphasized that the opinion of all stakeholders on the project is very important to ensure the success of the project.

Then R2E2 Project Manager Tigran Karapetyan presented the technical part of the project - the design, the implemented phases, limitations and technical solutions.

Subsequent discussions:
Question: Gor Sargsyan - Armenian National Canoe Federation

Gor Sargsyan noted that the location of the plant is different from the one reported. He noted that the rowers of the club use the entire area of the lake, and accidents can occur especially in windy weather. It is an amateur sport, which currently involves 200 people; in the future, it is expected that this number will reach 700-800 people. They use large boats for 7-8 people, and rowing in windy weather is allowed, even desirable for athletes, so in these cases accidents are possible.
He noted that they are in favor of a compromise solution. They suggest that the plant is moved 150 meters to the shore in the direction of the new building under construction and the monument.

Melik Sandrosyan of the Canoeing Association of Armenia also joined Gor Sargsyan's suggestion, arguing that the location of the plant chosen under the project would interfere with the training of his 300 students, as well as with competitions.

Answer: Tigran Karapetyan substantiated the choice of the location of the plant with the topography of the lake bottom and the influence of the minimum lake water level. The water level from the selected location to the shore is low, so the plant may appear on land during the year.

Arsen Hayiryan presented the social impact of the project and the measures to mitigate them. He presented in detail the criteria for the selection of stakeholders, the methods of social studies and the results of meetings with stakeholders, their positions on the project and feedback.

Subsequent discussions:
Question: Melik Sandrosyan - Canoeing Association of Armenia
Sandroyan mentioned that they had marked the optimal area for their rowing in red. If they deviate from that area, they will not be able to provide the 1000 meters they need. The plant is welcome, but if located in this place, they lose the opportunity to prepare their students for their international competitions.
Answer: K. Asatryan. We would also prefer the plant to be as close to the shore of the lake as possible. This would facilitate construction and further maintenance. However, we chose the location taking into account the conditions of the lake, the terrain and the water level. We will review the possibilities once again.
Remark: Vagharshak Vagharshakyan. Yerevan Municipality - Water structures
The lake is expected to dry up this year. In that case, it will be easier for you to explore the bottom of the lake. We will also be happy to participate in the selection of the place. Please let us know about any future discussions so that we can participate.

Question: Khachik Martirosyan, Ministry of Environment, Director of the EIAE Center
Were there any discussions with the residents of private houses on the shore of the lake, considering that the mirror reflection of the plant could hinder them?

Answer: A. Hayriyan. Residents of nearby houses were not considered as affected, as no impact is expected on them. The plant panels will not face to their direction. However, they were invited to today's meeting and they could express their attitude and raise questions during these discussions.

Question: Evelina Ghukasyan , Director of the Institute of Hydro ecology and Ichthyology, NAS RA
Power lines are designed to run over water. Is it possible that they get wet and an electric shock occurs?

Answer: Tigran Karapetyan. Power lines are designed to run even underwater, they are well protected, so there is no risk of electric shock.

Remark: Melik Sandrosyan, Canoeing Association of Armenia
By the way, infrastructure can also interfere with rowing. Therefore, location near the shore would be more appropriate

Answer: Tigran: The anchors can move in a diameter of 3.6 m. This diameter may increase as the water level decreases. However, low water level will be a problem for rowing, so anchors will not be the main problem in rowing.

Remark: Melik Sandrosyan, Canoeing Association of Armenia
Then we use extreme rowing methods, so lowering the water level will not hinder us, the solar panels will hinder.

Question: Khachik Martirosyan, Ministry of Environment, Director of the EIAE Center
Is there an experience in using a similar plant in any other capital of the world?

Answer: Karen Asatryan, Gevorg Nazaryan
It is used in Singapore, as well as in London, on a drinking water reservoir. This is a very small-scale pilot project, the purpose of which is to demonstrate the technology for further use in Armenia as a precedent.

Arevik Hovsepyan, the environmental expert of "JIN" company presented the environmental impact assessment of the project and the mitigation measures.
She presented the scope, methodology, and reporting structure of the ESIA:

- ✓ Legal and institutional framework
- ✓ Environmental baseline conditions
- ✓ Analysis of alternative options
- ✓ Environmental impact assessment and mitigation measures
- ✓ Environmental and social management plan.

She mentioned the scope of possible impacts on the environment, air quality, lake water, biodiversity, coastal areas, flora and fauna, measures for their prevention and mitigation during the construction and operation stages of the project.
She presented the possible impacts on the population of the neighboring area, especially those engaged in amateur fishing and the measures to prevent them. She also presented measures aimed at occupational health and safety.
In conclusion, she noted that the impact of floating solar plants on aquatic ecosystems has not yet been well studied; it could be a good precedent for our scientists to study the ecosystem of Yerevan Lake.

Subsequent discussions:
Question: Vrezh Vardanyan, Ministry of Environment, employee of EIAE Center
As I understand, there will be an inverter on the water. What is it? It would be more expedient to place it in the coastal area; In that case, it would be easier to eliminate and prevent accidents.

Answer: Tigran Karapetyan, Karen Asatryan.
It is a converter between constant and alternating currents. It is completely mechanical, there is nothing related to oil. It is an ordinary inverter with many protection systems. In case of slight fluctuations, it automatically shuts off. It has the ability to monitor online, problems are notified online, and in case of a problem, it is turned off, and, therefore, does not pose a threat.
It is specially designed for operating on water, in the rain, it is hermetically sealed.
The model is selected from a German manufacturer, it is quite high quality. All equipment is imported from Europe, supplied by France.

Question: Naira Avanesyan, Water Committee
The lake water is used for irrigation. It is clear that the plant will not affect the volume of water. The issue is water quality. You mentioned that the panels would be washed regularly. What are the risks to the quality of water used for irrigation?

Answer: Arevik Hovsepyan. The plant will not affect water quality. The panels are made of high quality polyethylene, which is used for drinking water. The panels will be washed with clean water and brushes. No chemicals will be used. The panels will be polluted by dust, bird droppings, which would be the same as falling into the lake, even if the panels were not there. Thus, there will be no additional water pollution.

Question: Christina Ter-Matosyan, "Ecolur" NGO
The panels themselves contain toxic compounds. There are investigations showing that they contain heavy metals, and if placed on the soil, they have been found to cause soil degradation. How will they affect water in this regard? On the other hand, how will the panels be disposed of after the expiration date?

Answer: Arevik Hovsepyan. As already mentioned, they do not contain toxic elements; they are made of glass with aluminum frames. They do not pose a threat to the environment. Recycling is possible, but since the technology is new, there is no experience of implementation in the world yet.

Answer: Karen Asatryan. In the case of any new technology, the investor is required to resolve the issue of its utilization in 20 years. At present, technologies are being developed and changed, and in 20 years, we will have the technology to recycle and use the used panels.

Question: Gevorg Nazaryan, Head of the Environment Department of Yerevan Municipality.
If one of the panels breaks, what will be done with it?

Answer: Arevik Hovsepyan. At the moment we do not even have legislation on this type of waste. They cannot even be classified as hazardous or non-hazardous waste. If it is not hazardous, it can simply be taken to a landfill and left there.

Remark: Gevorg Nazaryan. Next year, it is planned to build a waste separation plant in Yerevan, which will provide a professional approach and, if possible, recycle certain types of waste. You can plan this in your project, so that you can use the professional capabilities of that plant if necessary.

Question: Evelina Ghukasyan, Director of the Institute of Hydro ecology and Ichthyology, NAS RA
Quite a good study has been done, but we do not have to wait 20 years to discover the real effects. Regular monitoring should be carried out to detect the impact of the plant on the lake, as the technology is planned to be replicated in the country. As the plant is small, the impact will not be significant, so monitoring is mandatory.

Answer: Karen Asatryan. The purpose of this pilot project is to identify its impact, to understand how it can be applied. Therefore, monitoring will be provided.

Question: Karen Hovsepyan, Ministry of Territorial Administration and Infrastructure
It would be advisable to have this plant located outside the city. There are several areas in the lake where waste is collected and periodically removed. This plant will become a place for accumulation of artificial waste. What do you think about waste collection?

Answer: Eduard Mesropyan, Director of "JIN". The significance of Yerevan Lake is an important issue. In addition, we all know the quality of the lake water. The plant may even have a positive impact on the lake in terms that it can help divert government attention to water quality of the lake, which is a recreational area.

Remark: Vagharshak Vagharshakyan, Water structures. The Hrazdan River causes the problem of the lake water quality. The quality is really bad; it corresponds to the fifth (highly polluted) class. Let us not link water quality to this project. This is a more serious problem.

Summary:
Karen Asatryan thanked the participants for the positive contribution, noting.
- We still have 1-1.5 years to implement the design, so we will still have opportunities to hold such discussions. You can contact us with your questions or suggestions. Let us hope that next year we will have a plant that will not hinder anyone, and will make our Yerevan Lake more beautiful.

On behalf of JINJ LTD (Armenia):
Eduard Mesropyan, Director

On behalf of R2E2 (Armenia)
Karen Asatryan, Director


R2E2