WATER-RELATED DATA MANAGEMENT IN LAKE SEVAN BASIN

TECHNICAL REPORT

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LIST OF ABBREVIATIONS

ARS	Armenian Rescue Service
AWMIS	Armenian Water Monitoring Information System
BMO	Basin Management Organization
BOD	Biological Oxygen Demand
CENS	Centre for Ecological-Noosphere Studies
COD	Chemical Oxygen Demand
CORINE	Coordination of Information on the Environment
CJSC	Closed Joint-Stock Company
DBMS	Database Management System
DEM	Digital Elevation Model
DRM	Disaster Risk Management
DSS	Decision Support System
EEA	European Environment Agency
EKENG	E-Governance Infrastructure Implementation Unit
EPMIB	Environmental Protection and Mining Inspection Body
EU	European Union
EUWI+	European Union Water Initiative plus Project
GIS	Geographic Information Systems
GIZ	Deutsche Gesellschaft für Internationale Zusammenarbeit
GoA	Government of Armenia
HMC	Hydrometeorology and Monitoring Centre
HPP	Hydropower Plant
HTS	Hydro-technical Structure
ICP	Institute of Chemical Physics after A.B. Nalbandyan
ICT	Information and Communication Technologies
KfW	Kreditanstalt für Wiederaufbau
LAN	Local Area Network
MAC	Maximum Allowable Concentrations
ME	Ministry of Environment
MES	Ministry of Emergency Situations
MNP	Ministry of Nature Protection
MTAI	Ministry of Territorial Administration and Infrastructures
NAS	National Academy of Sciences
NDO	National Disaster Observatory
NCMC	National Crisis Management Centre
NGO	Non-Governmental Organization
OJSC	Open Joint-Stock Company
RA	Republic of Armenia
RBMP	River Basin Management Plan
SCADA	Supervisory Control and Data Acquisition
SEIS	Shared Environmental Information System
SCZH	Scientific Centre of Zoology and Hydroecology
SNCO	State Non-Commercial Organization
SWC	State Water Cadastre
SWCIS	State Water Cadastre Information System
UNDP	United Nations Development Programme
USAID	United States Agency for International Development
WatCom	Water Committee
WFD	Water Framework Directive
WISE	Water Information System for Europe
WRMA	Water Resources Management Agency
WRMD	Water Resources Management Department
WUA	Water Users Association

INTRODUCTION

The EU4Sevan (Environmental Protection of Lake Sevan) Project is co-funded by the European Union (EU) and the German Federal Ministry for Economic Cooperation and Development (BMZ) and jointly implemented under a Multi-Partner Contribution Agreement by Deutsche Gesellschaft für Internationale Zusammenarbeit (GIZ) and the United Nations Development Programme (UNDP). The Project is part of the EU Action "EU4Energy Efficiency and Environment" and the BMZ-funded programme "Management of natural resources and safeguarding of ecosystem services for sustainable rural development in the South Caucasus". The Project's overall objective is to enhance the environmental protection of Lake Sevan.

Lake Sevan is a high-mountain lake located on the altitude of 1900.6 m above the sea level. It is the largest lake in the South Caucasus, and at the same time one of the largest mountainous freshwater lakes in the world. The basin of Lake Sevan makes up one sixth of the total territory of Armenia (16%). Surface area of basin is 4,721 km^2, the area of lake itself is 1,279 km^2. Lake Sevan has environmental, economic, and social significance and is an important multipurpose water reservoir for irrigation, hydropower, and recreational uses.

Data and information on environmental conditions and parameters for Lake Sevan basin are essential for decision making for ensuring the proper management of the basin. The objectives of this study are:

- to review and analyze the current institutional and technical issues in Lake Sevan's environmental data management and exchange between data-producing and stakeholder institutions,
- to develop recommendations, and roadmap for improvement of water-related data management for Lake Sevan basin.

Chapter 1 of this report summarizes the results of the following activities:

- Review of data maintenance by governmental and academic institutions on Lake Sevan
- Analysis of the current status of data management and data flows on Lake Sevan
- Identification of technical and institutional issues and assessment of needs
- Analysis of technical issues in the use of existing platforms for environmental data management

Chapter 2 presents a roadmap on improvement of water-related data management in Lake Sevan basin. The roadmap is based on the analysis of current situation, discussions with stakeholders on their needs and recoomendations on improvement the current situation. The draft set of recommendations were presented and discussed during the round-table discussion helf on November 17, 2021. The comments received during the discussion were incorporated in the roadmap.

CHAPTER 1 SUMMARY OF CURRENT STATE OF WATER-RELATED DATA MANAGEMENT

1.1 Overview of Key Water-related Data Producers for Lake Sevan basin

In Armenia, the following institutions are involved in data gathering and analysis on Lake Sevan basin:

1. Ministry of Environment (ME) of the Republic of Armenia, including its subdivisions
   - *Water Resources Management Departmen*t and its *Sevan Basin Management Organization*
   - *Sevan National Park* State Non-Commercial Organization (SNCO)
   - *Hydrometeorology and Monitoring Center* SNCO
2. *Water Committee* of the Ministry of Territorial Administration and Infrastructures (MTAI)
3. Environmental Protection and Mining Inspection Body of the Republic of Armenia
4. *Statistics Committee* of the Republic of Armenia
5. *National Center for Crisis Management* of the Ministry Emergency Situations of Armenia
6. National Academy of Sciences of Armenia, including its institutes:
   - *Scientific Center of Zoology and Hydroecology (SCZH)*
   - *Institute of Chemical Physics (ICP) after A.B. Nalbandyan*
   - *Center for Ecological-Noosphere Studies (CENS)*
7. Foundation for Restoration of Sevan Trout Stocks and Aquaculture Development
8. *SevaMod* Armenian-German Scientific Project

The following sections of this chapter provide description of the data being gathered/maintained/ exchanged by each of the mentioned institution, including the identified data flows.

1.1.1 Ministry of Environment of Armenia

1.1.1.1 Water Resources Management Department

Water Resources Management Department (WRMD) of ME is a legal accessor of the Water Resources Management Agency (WRMA) established in 2002 as a main authorized body for water resources management in Armenia. The WRMD is responsible for carrying out water resources management and protection responsibilities under the Water Code of Armenia. This entity is charged with estimating water availability and ensuring water use efficiency, through the water use permitting and planning processes. It is also responsible for management of competing water uses and for ensuring that environmental needs are met. Moreover, the WRMD is responsible for development of the river basin management and planning components described in the Water Code.

Sevan Basin Management Organization (BMO) of WRMD is in charge of collection of water use permit applications at the Lake Sevan basin and transferring those to the WRMD office in Yerevan. However, the BMO does not maintain any database or spreadsheet at present.

WRMD also manages the State Water Cadaster (SWC) and the State Water Cadaster Information System (SWCIS), which are developed to combine the different pieces of water monitoring and compliance assurance information into a comprehensive database management system. The SWC is a continuously functioning system, which registers integrated data on water resources quantity and quality indicators, watersheds, materials extracted from river beds, composition of biological resources, water users, water use permits and water system use permits. For detailed description of the datasets included in the SWCIS refer to Section 1.2.1 of this report.

1.1.1.2 Sevan National Park

Sevan National Park SNCO of the ME is an environmental, scientific-research organization. The main function of National Park is ensure the monitoring of natural ecosystems, landscape and biodiversity, natural heritage, reproduction, inventory, as well as sustainable use of natural resources of the National Park area. Organization ensures protection of the landscape and biodiversity of natural ecosystems, gene fund and natural heritage in the Lake Sevan basin, as well as organizes and implements their scientific research, registration of natural ecosystems and their separate components, flora and fauna and preparation of necessary materials for cadaster maintenance and implementation of ecological monitoring and maintenance of chronicle of nature.

Since 2000, Sevan National Park periodically conducts the following monitoring on the lake:

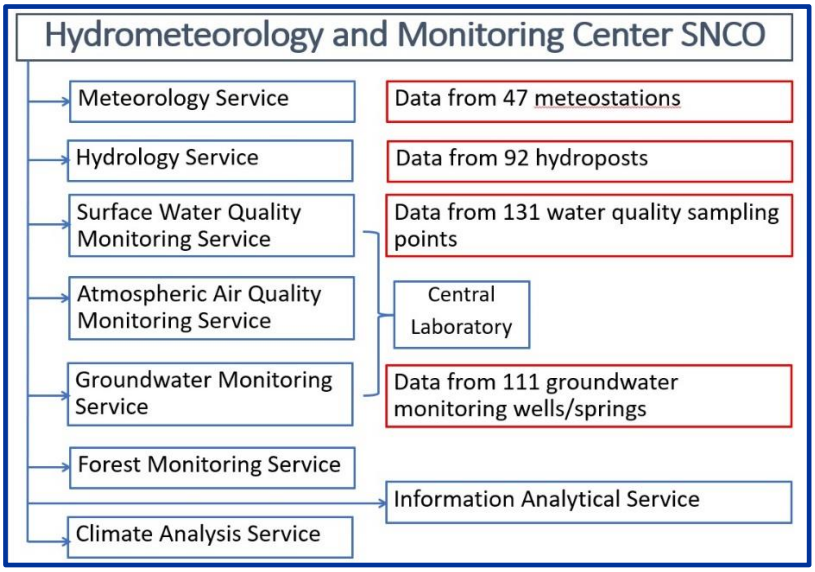
- Microbiological monitoring of Lake Sevan and main rivers flowing into Lake,
- Hydrochemical monitoring of some elements of Lake Sevan and main rivers flowing into Lake
- Monitoring of fishes and crayfishes

Sevan National Park orders the conduction of laboratory analyses for the above-mentioned monitoring to the *Hydrometeorology and Monitoring Center* SNCO of ME. All the results of monitoring are being accumulated in HMC's database and sent to ME quarterly to include in the SWCIS.

1.1.1.3 Hydrometeorology and Monitoring Center

Since January 2020, following the governmental resolution n° 81-N1, the "Environmental Monitoring and Information Center", "Forest Monitoring Center" and "State Hydrometeorology and Atmospheric Activity Impact Assessment Service" were merged into a single Hydrometeorology and Monitoring Center SNCO. The newly established HMC SNCO has a complex structure with a number of Services and a Central laboratory for monitoring analysis.

The scheme below presents the structure of the SNCO with emphasis on water resources data only.



At present the HMC SNCO, among other responsibilities, is in charge of:

- quantitative monitoring of surface water resources, collection, processing, maintenance of the hydrological data, and preparation of official projections and alerts based on analysis of data.
- qualitative monitoring of surface water resources, collection, processing, and maintenance of monitoring datasets

- quantitative and qualitative monitoring of groundwater resources and maintenance of monitoring datasets
- management and analysis of data/information gathered
- maintenance of tabular and geospatial databases/datasets
- reporting and analysis of environmental information
- sharing of environmental information through the web site of the Ministry

Quantitative monitoring of surface waters in Armenia is carried out in 91 hydrologic observation posts. Out of this number, 18 hydroposts are located at Lake Sevan basin, including 4 posts on Lake Sevan. 12 hydroposts are located on the rivers flowing into the lake, and 2 posts - on canals, including one on Hrazdan HPP canal and another one on Arpa-Sevan tunnel.

Observations at 4 lake և 12 river hydroposts in Lake Sevan basin are carried out twice a day (at 8am and 8pm) and include the folowing parameters: (a) lake / river water level; (b) water temperature; and (c) ice phenomena (if any). The amount of water released from Lake Sevan is recorded at the Geghamavan hydropost of the Hrazdan HPP canal, and the amount of water flowing into the lake is recorded at Tsovinar observation point of the Arpa-Sevan water tunnel. In addition to the bars, these hydroposts are also equipped with "Stevens" autographs, which automatically record and transmit encrypted data via satellite. Observations of water discharge are conducted at hydroposts minimum twice a month.

Currently, the HMC SNCO possesses following datasets regarding Lake Sevan:

- water level in the lake (daily)
- water temperature in the lake, ^{o}C
- wave height, water color, water transparency, m
- monthly and annual water balance in the lake
- water discharge in the rivers flowing into the lake
- volume of water flowing into the lake through Arpa-Sevan tunnel
- volume of water flowing out of the lake through Hrazdan HPP canal

Qualitative monitoring of surface waters in Armenia is carried out at 131 sampling points throughout the country, and annually takes 1200 samples from surface water bodies (from each site 6-12 samples are taken per year). For each collected sample analysis of up to 48 parameters is being conducted.

Monitoring of water quality of Lake Sevan and rivers flowing into Lake is implementing since 1977, but list of indicators of water quality, list of observation points, location of the observation points and frequency of observations are different at different times.

Since 2014, monitoring of water quality of Lake Sevan has been implemented together with the Institute of the Hydroecology and Ichthyology of the Scientific Center of Zoology and Hydroecology of the National Academy of Science of Armenia. HMC implements the physico-chemical studies of the water of Lake Sevan and Institute of the Hydroecology and Ichthyology is implementing hydrobiological. One expedition is implemented by state funding.

Since 2016, two expeditions are implemented in frame of Program of Trout Stocks Restoration and Aquaculture Development in Lake Sevan for the Foundation for Restoration of Sevan Trout Stocks and Development for Aquaculture.

At present the monitoring of surface water quality in Lake Sevan basin is carried out at the exit of Arpa-Sevan tunnel and in 8 main rivers flowing into Lake Sevan: Dzknaget, Masrik, Karchaghbyur, Vardenis, Martuni, Argichi, Shoghvag, Tsakqar as well as Sotq tributary of Masrik River. The total number of water quality sampling points at those rivers is 19. In addition, Lake Sevan water quality monitoring is carried out at 17 sampling points at coastal to central parts of the river, with sampling carried out from different depths at each of 17 sampling point. Thus, the total number of locations for sampling in Lake Sevan ammounts to 33.

Currently the following physicochemical indicators are considered for the assessment of water quality of the Lake Sevan and rivers flowing into the lake: (a) general Indicators, including indicators of viable conditions, transparency, indicators of oxygen conditions, indicators of acid conditions and salinity; and (b) special pollutants, including heavy metals and special organic pollutants.

Groundwater resources monitoring in Armenia is carried out at 111 groundwater monitoring points throughout the country, including 11 points in Lake Sevan basin is carried out at out of which 5 are springs and 6 are flowing wells.

Data management: For their activities, the HMC previously managed xls files for hydrological data and one MS Access database on water quality. But they would like to replace these elements with a comprehensive information system facilitating integrated data collection, processing and exploitation of the hydrological data. Therefore a new system, called Armenian Water Monitoring Information System (AWMIS) were constructed in 2020 to facilitate the integrated management of both the hydrological data and water quality data through an application including separated modules for hydrologic datasets and water quality datasets. For detailed description of the AWMIS refer to Section 2.2 of this report.

Data reporting and sharing: HMC prepares daily hydrometeorological bulletin based on the monitoring data and dessiminates it to state bodies and private stakeholders as well as uploads it to ME's website at the URL: http://www.env.am/en/environment/hydro-meteorological-bulletin. HMC also prepares quarterly reports on the results of qualitative monitoring and disseminates it via the website of the organization (URL: http://www.armmonitoring.am/). It also submits annual summary reports to the SWCIS of ME. HMC is responsible for sharing monitoring information via the web site of ME (URL: http://www.env.am/) and the Armenian EcoPortal on Water Resources (URL: http://ecoportal.mnp.am:92/).

1.1.2 Ministry of Territorial Administration and Infrastructures

1.1.2.1 Water Committee

The Water Committee (WatCom) operates under the MTAI as the national core institution for policy making as well as for implementation of water related services. This concerns water resource management, irrigation, water supply and wastewater policy making and organization of respective service provision in Armenia. The objectives of the WatCom are (a) provision of the management and safe use for the state-owned water and non-competitive water supply systems, (b) provision of the National Water Program within the frameworks of its eligibility, and (c) development and implementation of investment policy on water systems, and organization of assessment of investment projects.

At present the WatCom data management component for water system data is insufficient for efficient and proper decision making. WatCom maintains fragmented MS Excel spreadsheets and does not have a single Database management system (DBMS). This is particularly the case as a proper GIS based cadaster for the water and wastewater system does not yet exist or is not unified in one WatCom database structure. Only for irrigation an adequate system, based on GIS, is available in the WatCom. The GIS system on irrigation has been transferred to Water User Associations (WUAs) and is used mainly for controlling the water use payment and billing procedures. The system is physically located at WatCom's server and is accessible from WUAs via "login-password" pair.

Absence of a MIS is considered a fundamental weakness for the WatCom both in terms of management of the water supply and wastewater service lease contracts and for general water sector strategy development.

One of the WatCom's reporting obligations is provision of annual summary data on technical characteristics on hydro-technical structures (HTS) of Armenia to the State Water Cadaster Information System of ME. However, the WatCom does not perform this due to the lack of appropriate databases and georeferenced data on HTSs.

In August 2021, the "Assistance for the Water Committee of Armenia and its Main Structures" KfW-funded project was initiated. One of the objectives of 2-year initiative is to develop Water Committee Management Information System. The WatCom MIS will be physically located on WatCom Server and be comprised of several interconnected DBMSs and geographic information systems (GIS). Those systems will be accessible for various departments of WatCom with different authorization rights. The key components of the WatCom MIS will include:

- Human Resources Management System
- Accounting Management System for procurement process, financial transactions and accounts
- SCADA systems for monitoring of water supply and wastewater discharge for drinking water and irrigation
- Asset Management GIS for both irrigation and water supply and wastewater discharge assets.

WatCom needs equipping headworks of the main canals throughout the country and particularly in Lake Sevan basin with flow meters and data loggers to ensure automatic and online monitoring of water discharge. Appropriate SCADA systems should be built and integrated into the future WatCom MIS.

1.1.3 Environmental Protection and Mining Inspection Body

The Environmental Protection and Mining Inspection Body of Armenia (EPMIB) exercises supervision and may apply sanctions in the field of environmental protection, and regarding the use of mineral resources. The following functions of EPMIB are related to water resources, including in Lake Sevan basin:

- Accounting of actual water use and discharged wastewaters based on the annual reports of economic entities, including enterprises and individual entrepreneurs (based on Soviet-time 2-TP reports).
- Control over the water use of in Lake Sevan and its catchment area, based on the reports on water losses and leakages (based on Soviet-time 2-TP reports).
- Control over the water quality in river water flowing into the lake based on the hydrochemical indicators and norms. In particular, the EPMIB conducts laboratory analysis of the following

parameters in the discharged wastewaters: dissolved oxygen, pH, COD, BOD, dissolved oxygen, pH, dry matter, suspended particles, ammonium ion, nitrogen, phosphate, nitrate, nitrite, surfactants, chloride, sulphate, sulphide, heavy metals. The determined values of the parameters are being compared with environmental norms and maximum allowable concentrations (MAC) adopted in Armenia. This type of monitoring is scheduled to be carried out once a year from one point. The obtained data is compared with the monitoring data of ME to find out whether the pollution is one-time salvo or regular. Such analysis serves an actual basis for calculating the damage to the environment, risk prevention, and impact assessment.

For the above-mentioned activities, the EPMIB uses an outdated MS Access database. However, this database does not provide proper reporting functionality, that is why MS Word files and MS Excel spreadsheets are used for reporting. In 2020 the USAID-funded ASPIRED project provided technical assistance for incorporating the EPMIB's datasets on actual water use with the database on water use permitting of the SWCIS. In 2021, the staff of EPMIB is provided with "login-password" pairs that will allow direct access to the SWCIS to input the values of actual water use and actual wastewater discharge to the SWCIS. No geo-referenced datasets are currently used in EPMIB.

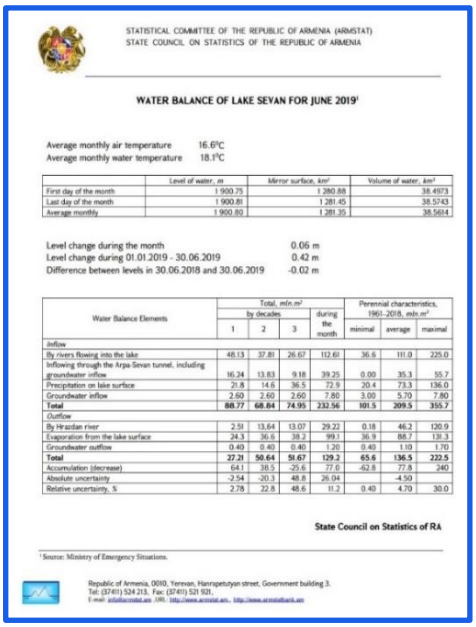
The organization has branches in 10 marzes of Armenia. However, the EPMIB does not possess a computer server to organize proper data management between the Marz branches and central office in Yerevan. The Marz offices of the EPMIB lack cooperation with the appropriate basin management organizations. In particular the Gegharkunik branch office of EPMIB needs establishment closer links with Sevan BMO for proper organization of inspection activities on water use and wastewater discharge occurring in Lake Sevan basin.

1.1.4 Statistics Committee

The Statistics Committee (SC) of Armenia, among other responsibilities, is in charge of (a) developing, production and dissemination of official statistics according to the statistical programs; (b) collecting statistical data (including from administrative registers); and (c) maintaining statistical registers and databases. All the reports of the Statistics Committee are available at the official webpage (URL:www.armstat.am). In addition, a huge database on statistical registers and information by sectors is available at URL: www.armstatbank.am.

Regarding water resources, the SC is not a primary data producer. It summarizes HMC's data from hydroposts and meteostations to produce water balance reports for the main river basins of Armenia. In particular, the SC uses to following datasets to produce reports on Lake Sevan: (a) water flows and outflows based on data from hydrologic observation posts of HMC of the ME; (b) volumes of actual water use and wastewater discharge data from the annual reports of the EPMIB; and (c) monthly and annual water balance of the lake from HMC

The picture at the right-hand side provides for a sample report on water balance of Lake Sevan for 2019.



STATISTICAL COMMITTEE OF THE REPUBLIC OF ARMENIA (ARMSTAT)
STATE COUNCIL ON STATISTICS OF THE REPUBLIC OF ARMENIA

WATER BALANCE OF LAKE SEVAN FOR JUNE 2019[1]

Average monthly air temperature 16.6°C
Average monthly water temperature 18.1°C

	Level of water, m	Mirror surface, km²	Volume of water, km³
First day of the month	1 900.75	1 280.88	38.4973
Last day of the month	1 900.81	1 281.45	38.5743
Average monthly	1 900.80	1 281.35	38.5614

Level change during the month 0.06 m
Level change during 01.01.2019 - 30.06.2019 0.42 m
Difference between levels in 30.06.2018 and 30.06.2019 -0.02 m

Water Balance Elements	Total, mln.m³				Perennial characteristics, 1961-2018, mln.m³		
	by decades			during the month			
	1	2	3		minimal	average	maximal
Inflow							
By rivers flowing into the lake	48.13	37.81	26.67	112.61	36.6	111.0	225.0
Inflowing through the Arpa-Sevan tunnel, including groundwater inflow	16.24	13.83	9.18	39.25	0.00	35.3	55.7
Precipitation on lake surface	21.8	14.6	36.5	72.9	20.4	73.3	136.0
Groundwater inflow	2.60	2.60	2.60	7.80	3.00	5.70	7.80
Total	**88.77**	**68.84**	**74.95**	**232.56**	**101.5**	**209.5**	**355.7**
Outflow							
By Hrazdan river	2.51	13.64	13.07	29.22	0.18	46.2	120.9
Evaporation from the lake surface	24.3	36.6	38.2	99.1	36.9	88.7	131.3
Groundwater outflow	0.40	0.40	0.40	1.20	0.40	1.10	1.70
Total	**27.21**	**50.64**	**51.67**	**129.2**	**65.6**	**136.5**	**222.5**
Accumulation (decrease)	64.1	38.5	25.6	77.6	-62.8	77.8	240
Absolute uncertainty	-2.54	-20.3	48.8	26.04		-4.50	
Relative uncertainty, %	2.78	22.8	48.6	11.2	0.40	4.70	30.0

State Council on Statistics of RA

[1] Source: Ministry of Emergency Situations.

Republic of Armenia, 0010, Yerevan, Hanrapetutyan street, Government building 3.
Tel: (3741) 524 213, Fax: (3741) 521 921,
E-mail: info@armstat.am, URL: http://www.armstat.am, http://www.armstatbank.am

Matching the datasets on water use permitting of SWCIS and actual water use of EPMIB remain one of the challenges in terms of data management of the Statistics Committee.

1.1.5 Ministry Emergency Situations of Armenia

1.1.5.1 National Crisis Management Center

The National Crisis Management Center (NCMC) operates under the Armenian Rescue Service (ARS) of the Ministry of Emergency Situations (MES) of Armenia. In the period of 2011-2012, the National Disaster Observatory (NDO) has been developed for the NCMC under the framework of "Strengthening National Capacities for Disaster Preparedness and Risk Reduction" UNDP Armenia project. The project was aimed at strengthening the legal and institutional framework for disaster risk management (DRM) in Armenia. Establishment of the NDO was a significant input for this work, with the objective to enhance the disaster risk identification, assessment and monitoring system in Armenia.

The NDO hosts comprehensive data maintenance facilities, with enhanced equipment and data management software. The NDO serves as the information system on DRM. It includes two major components, namely a tabular data warehouse and a spatial component based on GIS. Two components are linked one to another. The NCMC creates hazard maps based on the data included in the NDO.

Regarding the water resources, the tabular component of NDO contains event information on natural disasters (landslides, floods, mudflows) with estimation of losses occurred. The GIS component of NDO contains geo-referenced data on the historical events, including natural and anthropogenic disasters.

However, at present the ARS is considered the key actor in the field of information management on emergency situations on Armenia and the main user of the NDO. Therefore, no information is shared by the NCMC with the ME through the NDO. Information on natural disasters (landslides, floods and mudflows) are received mainly from the Hydrologic Service of HMC SNCO.

1.1.6 National Academy of Sciences of Armenia

1.1.6.1 Scientific Center of Zoology and Hydroecology

The Scientific Center of Zoology and Hydroecology (SCZH) is involved in the hydro-ecological and hydrobiological studies of lakes, rivers and reservoirs in Armenia. The target of these studies is recovery, preservation and rational use of water and biological resources of ecosystems; determination of water quality, elaboration of scientific bases and measures on utilization of water and biological resources of hydro-ecosystems based on the criteria required by various areas of water utilization.

Regarding the Lake Sevan, the SCZH has conducted monitoring of hydrobiological parameters of Lake Sevan in the framework of various projects. To save the gene fund of endemic and commercial valuable ichthyofauna, the ecological features of valuable representatives of salmon and carp fish have been investigated. The Institute has implemented complex studies of spawning tributaries of Lake Sevan, the assessment of the state of reproduction conditions of endemic species in the rivers. Special attention is

paid to changes in river courses and compliance of construction of hydraulic structures with environmental standards. Actions on acclimatization new type valuable fish species in Lake Sevan and other lakes of Armenia are recommended. By using mathematical models, the SCZH has revealed the mechanisms of anthropogenic eutrophication of reservoirs with changing morphometry. Measures on de-eutrophication of the lake ecosystem, restoration and rational use of its resources were developed. Using such hydro-ecological regularities as dependence of sedimentation and diffusion rates of organic compounds in the bottom layers on bio-productivity, fluctuation of morphological parameters, the SCZH has justified the necessity of water level increase up to 1903,5 m above sea level.

The SCZH has implemented following projects since 2015 regarding Lake Sevan:

- Lake Sevan and genetic investigations of bioresources of the lake during the period of water level rise and under climate change conditions (2015-2018).
- The Integrated Program of Trout Stocks Restoration and Aquaculture Development in Lake Sevan (2016-2017) (see also Section 1.1.7 of this report)

All the above-mentioned studies and monitoring is being implemented in the framework of scientific-research project carried out by SCZH. Thus, the results of hydro-ecological and hydro-biological monitoring are mainly used for production and publication of scientific articles and papers. No comprehensive database is used to maintain datasets obtained in the frame of different scientific research projects. No geo-spatial databases are used either. All the results of monitoring activities are maintained in isolated and fragmented MS Excel spreadsheets.

1.1.6.2 Institute of Chemical Physics after A.B. Nalbandyan

Since 2016 the Institute of Chemical Physics was engaged in implementation of projects on ecology and biochemistry. In 2016 a center of mass-spectrometric chromatography was founded in the Institute. This allows Institute participation at the investigations and studies of "Restoration of Sevan Trout Stocks and Aquaculture Development" Foundation. The Institute carried out scientific research to determine the concentrations of chloro-organic pesticides and WFD priority pollutants in waters of Lake Sevan, bottom sediments, and in organisms of fishes and crawfishes. The dynamics of the contaminants concentration by location and seasons were studied. About 1000 samples of water were examined.

The Institute implemented following projects on Lake Sevan since 2016:

- Complex study of location of the first grid economy planned by Integrated Program of Trout Stocks Restoration and Aquaculture Development in Lake Sevan, as well as study of the waters and bottom sediments of the southern part of Lake Sevan, near village Karchaghbyur.
- Complex study and assessment of the preliminary pollution of the waters and bottom sediments of Lake Sevan and the river basin by persistent organic pollutants and mercury in frame of Integrated Program of Trout Stocks Restoration and Aquaculture Development.

The results of all the above-mentioned studies and monitoring were transferred to the "Restoration of Sevan Trout Stocks and Aquaculture Development" Foundation. The results of monitoring were used for production and publication of scientific articles and papers. No comprehensive database is used to maintain datasets obtained in the frame of different scientific research projects. No geo-spatial databases are used either.

1.1.6.3 Center for Ecological-Noosphere Studies

The Center for Ecological-Noosphere Studies (CENS) of the National Academy of Sciences of Armenia is a state non-profit organization founded in 1993 and carrying out multidisciplinary investigations oriented to the complex assessment of ecological status of territories and development of scientific-and-methodological fundamentals of ecological expertise and optimization of natural resource management processes. CENS includes a number of problem-oriented laboratories and research teams dealing with environmental geochemistry, biogeochemical cycles, and bioenergy.

CENS has implemented and implements following projects during 2016-2020 regarding Lake Sevan:

- Development of remote systems of the water quality of Lake Sevan (2016-2017). The main aim of the project was development of the methodology to assess and monitor water quality of Lake Sevan (water transparency, total suspended solids, algal bloom, water surface temperature) using remote sensing data and technologies. For this purpose, the open-source satellite images were acquired (Landsat 8OLI, Sentinel-2) and spectral indices were investigated. The spectral signatures of Chlorophyll-a and total suspended solids in the water were developed, which underpin the developing the remote sensing models of the water quality of Lake Sevan.
- Developing remote sensing method for assessing ecological state of mountainous lakes using the high-resolution raster data (2018-2020). The main aim of the project was developing and updating the remote sensing methods of the assessment of the water quality of Lake Sevan. Considering some difficulties of interpretation of satellite images (cloudiness, noises and distortions, which decreases the quantity of usable images) it is proposed to develop a method of the assessment of the ecological state of Lake Sevan using high-resolution imagery.

The results of the above-mentioned studies and projects were kept within the CENS, were mainly used for production and publication of scientific articles and papers, and were not shared with stakeholder institutions. A comprehensive geo-spatial database was compiled during the mentioned activities. There is a need to share the obtained results with scientific community and decision-makers at government level.

1.1.7 Foundation for Restoration of Sevan Trout Stocks and Aquaculture Development

“Sevani Ishkhan” (Sevan Trout) CJSC was founded in 2014 on behalf of the “Foundation for Restoration of Sevan Trout Stocks and Aquaculture Development”. The aim of the project was to restore the population of trout in Lake and solve the environmental problems of the Lake.

The activities started with construction of the fingerling production farm in Karchaghbyur community. The farm started operating in 2016. In the fingerling production farm, fish eggs were fertilized and incubated, and fingerlings were grown. The processing plant, located in Jrarat community in Armavir Marz, also started operating in 2016. The processing plant produced a wide range of ecologically clean fish and (value added) fish products under the brands “Sevani Ishkhan” and “Nairyan”. In 2016, for the first time ever, cage farms were placed in Lake Sevan.

Since 2016, Foundation cooperated with scientific-research institutions of NAS to implement the following monitoring activities: (a) monitoring of the status in Lake Sevan and assessment actual situation of 28 rivers flowing into Lake Sevan; and (b) physical-chemical and biological monitoring for assessment the potential for asymmetry of Lake Sevan basin according to the EU WFD. The results of the mentioned

studies were kept within the Foundation and were not shared with stakeholder institutions. There is a need to share the obtained results with scientific community and decision-makers at government level.

1.1.8 SevaMod Bilateral Scientific Project

The *SevaMod* Armenian-German scientific project has been initiated in April 2020 and is envisaged to be completed by March 2023. The project is aimed at building up science-based management instruments for Lake Sevan. The project goals include: (a) Modeling of nutrient budget for Lake Sevan and preparation of nutrient management concept; (b) Constructing coupled physical-ecological 1D eutrophication model for Lake Sevan (nutrients, plankton, oxygen); (c) use of satellite-based remote sensing for estimation of water quality of Lake Sevan; (d) evaluation of alternative management scenarios and identification of major water quality threats for Lake Sevan; and (e) capacity building in Armenia on use of satellite remote sensing and lake modeling. From the Armenian side the *SevaMod* Project partners include SCZH, CENS and HMC SNCO of ME. For more detailed information of the project refer to URL: https://www.ufz.de/index.php?en=44302.

One of the core activities to reach the goals of the project is monitoring activities that include:

- monthly sampling at the deepest sites of Small and Big Sevan (0.5m, 5m, 10m, 20m, 30m, 55m, 70m, 80m depths in Small Sevan; 0.5m, 5m, 10m, 20m, 25m, 30m depths in Big Sevan)
- Measuring in the field of the dissolved oxygen, pH, temperature and electrical conductivity
- Chemical analysis of the samples for: Sulphate ion, Chloride ion, Nitrate ion, Ammonium ion, Phosphate ion, Total phosphorus, Magnesium, Calcium, Total iron, Total manganese, Aluminum, Titanium, Vanadium, Chromium, Cobalt, Nickel, Copper, Zinc, Arsenic, Molybdenum, Cadmium, Lead, Total carbon, Total inorganic carbon, Total organic carbon, Chlorophyll A.
- Analysis of the samples for phytoplankton and for zooplankton (composition and biomass).

There is a need to share the results of monitoring with all stakeholder organizations, including scientific community and decision-makers on Lake Sevan.

1.2 Analysis of Data Flows among Stakeholder Institutions

At present there is no regulatory mechanism for ensuring proper data flow and information exchange on Lake Sevan among the data producers, decision-makers, academy and other stakeholder institutions. The only legal document that regulates information provision on water resources is the Governmental resolution #68-N (adopted in 02.02.2017) “On approving the procedures on maintaining the State Water Cadaster of the Republic of Armenia”. This resolution approves the structure and content of the SWC, regulates the relations among data producers, data registration procedures in the SWC, requirements to stakeholder institutions on submitting information to the SWC, as well as procedures on information sharing.

However, the provisions of the governmental resolution #68-N are outdated due to several structural changes in ME and Government of Armenia. Those changes include (1) removing the Environmental Inspectorate out of the structure of ME and establishment of the EPMIB within the structure of GoA;

and (2) merging the "Environmental Monitoring and Information Center" SNCO of ME, "Forest Monitoring Center" SNCO of ME and "State Hydrometeorology and Atmospheric Activity Impact Assessment Service" SNCO of MES into a single *Hydrometeorology and Monitoring Center* SNCO under the structure of ME.

The section 1.2.1 below presents details on the structure of SWCIS and established data flows. The section 1.2.2 describes the structure of recently developed Armenian Water Monitoring Information System, that is to be used for maintaining datasets of the recently established HMC of ME.

1.2.1 State Water Cadaster Information System

The State Water Cadaster is established by the Resolution of the GoA in 2003 as an only official repository of water related information in Armenia. The Water Resources Management Department (WRMD) of ME is the only state authorized body to maintain the SWC of Armenia.

The State Water Cadaster Information System (SWCIS) has been developed in 2006-2008 as a digital repository of the SWC of Armenia. The system has been revised and updated in 2015-2019 based on up-to-date requirements and approaches used in water resources management in Armenia.

Under the assistance of USAID-funded ASPIRED project, based on the requirements of the 2018 GoA Resolution #68, several improvements were carried out to the SWCIS Data Warehouse in 2019-2021. Those include technical design of existing and/or new components of the SWCIS. In particular, the SWCIS Data Warehouse were enhanced with the following new components:

- Groundwater resources quantitative and qualitative monitoring data from 128 wells;
- Lake Sevan: including daily water level and analysis of comparative changes in the water level;
- Reservoirs: including monthly updates on the water level in the main reservoirs of Armenia;
- Hydropower plants: including actual water use vs actual energy generation analysis;
- Data on annual water balance for the main river basin of Armenia;
- Data on annual water supply and demand balance for the main river basin of Armenia.

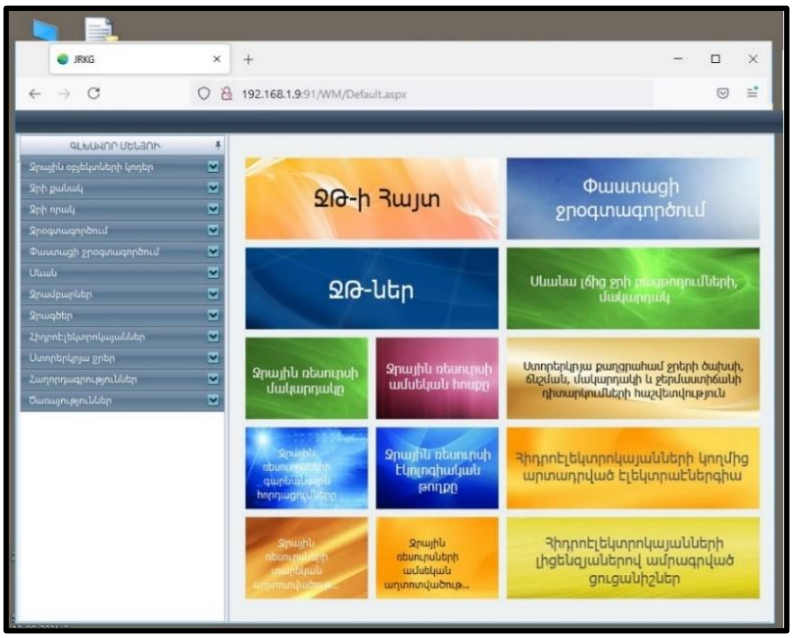
As of 2021, the SWCIS is composed of two interconnected components:

- tabular component - Data Warehouse in the format of MsSQL relational database; and
- geo-spatial component - collection of vector layers and raster images in a single GIS geodatabase.

Tabular component of the SWCIS. As of 2021 the Data Warehouse contains the following 12 sections:

1. *Water Objects Codes*: information on 14 main river basins and 6 basin management areas of Armenia. Key tables on the river network of Armenia, catchment areas of river sections longer than 5 km coded by ERICA system, as well as main lakes, reservoirs and canals.
2. *Water Quantity*: monthly and annual summary data on surface water level and discharge measured at 92 hydrological observation posts of HMC.
3. *Water Quality*: monthly monitoring data on surface water resources quality from 131 water quality observation posts of HMC.
4. *Water Use*: Data on water use permitting application process, and data on water abstraction and wastewater discharge based on the issued water use permits of WRMD of ME.

5. *Actual water use*: Summary data on actual water use and wastewater discharge based on the datasets received from EPMIB.
6. *Lake Sevan*: Daily data on Lake Sevan water level and water discharge from the Lake based on the measurements at 5 hydrologic observation posts of HMC.
7. Reservoirs: Annual summary data on technical characteristics of reservoirs received from WatCom.

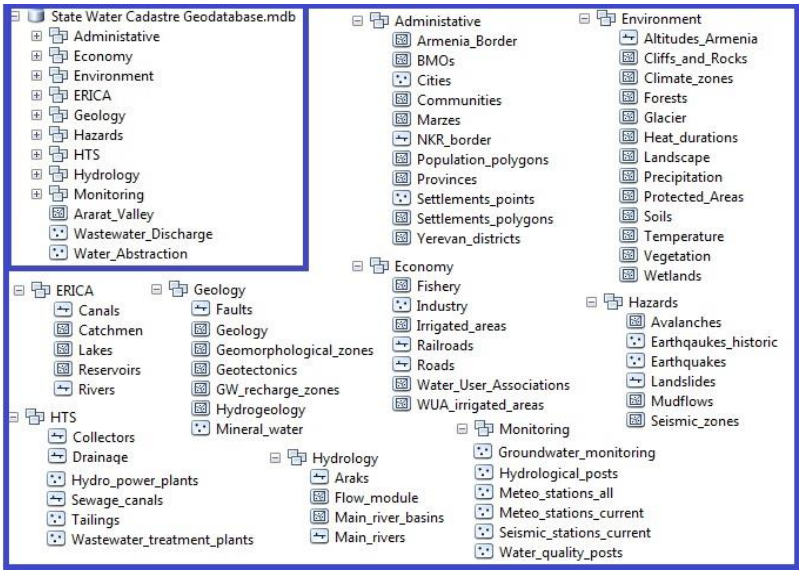


8. *Canals*: Annual summary data on technical characteristics of main canals received from WatCom.
9. *HPPs*: Annual summary data on technical characteristics of HPPs received from MTAI.
10. *Groundwater resources*: Monitoring data on quantity (level) and quality (mainly mineralization) of the groundwater aquifers measured at 102 groundwater monitoring wells and springs of HMC.
11. *Alerts*: a section to track the bags appeared in the process of operation of the SWCIS
12. *Reports:* A section for generating and printing out the annual summary reports prescribed by the GoA Resolution #68 (2017) on approving the procedures on maintaining the State Water Cadaster of the Republic of Armenia.

Geo-spatial component of the SWCIS. The GIS geo-spatial database of SWCIS was developed in 2008 and regularly updated since that time. At present it contains more than 70 GIS layers grouped in 9 dataset feature classes. All the layers have geographic projection of WGS-1984, UTM Zone 38N.

In addition to the vector layers the geo-spatial database of the SWCIS contains the following raster imagery:

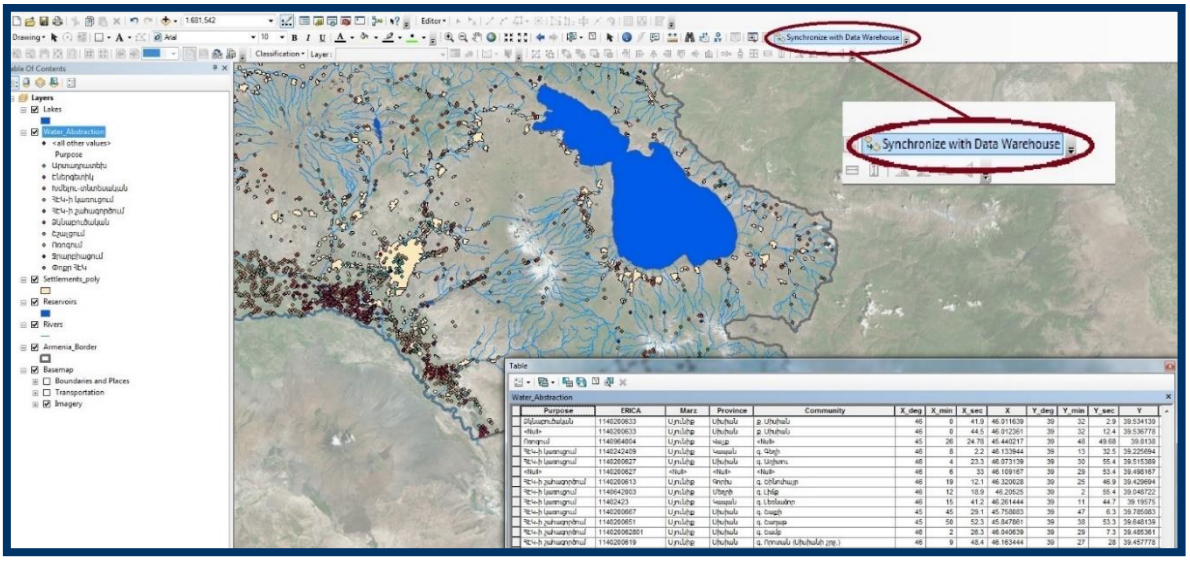
- Digital Elevation Model (DEM) of Armenia (ASTER 27-m);
- Hillshade raster image of Armenia;
- Satellite imagery of Armenia;
- Land cover/use classification imagery for the Southern Basin of Armenia (Syunik Marz);
- Land cover/use classification imagery for the Ararat Valley.



Data flows. The table below summarizes the current requirements of data flows to the SWCIS.

#	*Institution*	*Datasets*	*Current status of data flow*
1	WRMD of ME	Data on water use permits, including data on permitted water abstraction and wastewater discharge	Data is being populated directly into the SWCIS Data Warehouse by WRMD staff
2	HMC of ME	Surface waters: hydrological monitoring data Surface waters: water quality monitoring data Groundwater: quantity and quality data Lake Sevan: data on water level and discharge	The annual summary datasets can be generated through the AWMIS (refer to Section 1.2.2 for details)
3	EPMIB	Data on actual water use/wastewater discharge	Data are received annually by WRMD in the MS Access database format
4	WatCom	Data on technical characteristics of HTSs, water discharges in canals, water volumes in reservoirs	No data is being received
5	MTAI	Data on technical characteristics of HPPs and annual hydropower production volumes	No data is being received

In addition, a data synchronization tool has been developed and has been embedded into the GIS application used in WRMD. By applying the tool, the GIS layers on water abstraction and wastewater discharge are currently being automatically synchronized with the corresponding tables of the SWCIS Data Warehouse. Thus, as soon as a new record on water use appears in the water use permitting database of SWCIS Data Warehouse, there is a built-in tool to insert the appropriate record into the corresponding GIS layer of the SWCIS geo-spatial component.



At present the Lake Sevan database of the SWCIS is being populated based on annual summary datasets on water level and water discharge, received from the Hydrologic Service of HMC. However, the Lake Sevan component needs more improvements in terms of allowing automatic calculation of Lake Sevan basin annual hydrologic balance. This tool can be programmed either directly within the SWCIS or generated in AWMIS and then transferred to SWCIS.

1.2.2 *Armenian Water Monitoring Information System*

Before merging into one organization, a MS Access relational water quality database was used to maintain surface water quality datasets and MS Excel spreadsheets were used for accumulating hydrologic datasets from the Hydrologic observation posts. After the HMC establishment, there was a need to to replace these elements with a comprehensive information system facilitating integrated collection and processing of the surface water and groundwater qualitative and quantitative monitoring data. Therefore a new system - AWMIS (Armenian Water Monitoring Information System) was proposed to ensure the integrated management of both the hydrological data and water quality data through an application including separated modules for the data management by each of HMC units.

The AWMIS was developed in the framework of EUWI+ project in 2020. The system is comprised of two MS Access databases, namely the Water Resources Quality and Piezometry Database and the Hydrologic Monitoring Database. These two MS Access databases are connected to the same central PostgreSQL database and use the same referential datasets.

For each of two MS Access databases the following structural elements were programmed:

- Data manual input forms;
- Automatic data importing tools from water quality lab equipment and automatic hydroposts;
- Built-in reports designed according to the HMC's monthly, quarterly and annual reporting requirements;
- Specific calculation and data analysis tools for assessment of water quality in river basins;
- Access management module to allow different authorization rights for database utilization;
- Tools for synchronization of two MS Access databases with the central PostgreSQL database.

The functionality of the databases allows capturing all data specified by HMC as important and of all complementary fields planned into the database structure. The application is open source without license and without any notion of property by the developer. All data inputting forms and reports were agreed upon and validated with the technical staff of HMC. A "login-password" pair was given to the technical staff members of HMC when opening the MS Access applications, that would allow access to some functionality and limit the access to others depending on their role in data management and data flow maintenance. A process of synchronization was established in order to automatically update the central PostgreSQL database when changes are made in the local access databases.

The AWMIS is hosted on the HMC's server. The administration of the AWMIS was assigned to Information Analysis division of HMC.

There is a separate section within AWMIS related to reporting on Lake Sevan. In particular, the system allows annual reporting on comparative analysis of water level in Lake Sevan. The report generates a table on water level data measured at Lake Sevan four hydrologic observation posts for the given months of the given year. The user is asked to select a date interval in months in the format "from MM/YY to MM/YY". The report calculates the average level based on level measurements at 4 posts and compares this average with data of the same period of the previous 2 years. The report will also have a column on water level deviation from the same day of the previous year. The sample screenshot at the

right-hand side compares the Lake Sevan water level of April 2018, 2019 and 2020 and calculates the deviation of the level of April 2020 compared to April 2019.

	Water Level, m				Water Level by Observation Posts				
April	2018	2019	2020	Deviation with 2019	Sevan Peninsula	Martuni	Karchaghbyur	Shorzha	Average
1	*1900.42*	*1900.39*	*1900.43*	***0.04***	1900.43	1900.42	1900.43	1900.43	**1900.43**
2	*1900.42*	*1900.39*	*1900.43*	***0.04***	1900.43	1900.42	1900.43	1900.43	**1900.43**
3	*1900.42*	*1900.39*	*1900.43*	***0.04***	1900.43	1900.42	1900.43	1900.43	**1900.43**
4	*1900.42*	*1900.39*	*1900.43*	***0.04***	1900.43	1900.43	1900.43	1900.42	**1900.43**
5	*1900.42*	*1900.38*	*1900.43*	***0.05***	1900.43	1900.43	1900.43	1900.42	**1900.43**
6	*1900.42*	*1900.38*	*1900.43*	***0.05***	1900.43	1900.43	1900.43	1900.42	**1900.43**
7	*1900.42*	*1900.38*	*1900.43*	***0.05***	1900.43	1900.43	1900.43	1900.42	**1900.43**
8	*1900.42*	*1900.38*	*1900.43*	***0.05***	1900.43	1900.43	1900.43	1900.42	**1900.43**
9	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.43	1900.42	**1900.43**
10	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
11	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
12	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
13	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
14	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
15	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
16	*1900.42*	*1900.38*	*1900.42*	***0.04***	1900.42	1900.43	1900.42	1900.42	**1900.42**
17	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.43	1900.42	1900.42	**1900.42**
18	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.43	1900.41	1900.42	**1900.42**
19	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.43	1900.41	1900.42	**1900.42**
20	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.43	1900.41	1900.42	**1900.42**
21	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.43	1900.41	1900.42	**1900.42**
22	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.42	1900.41	1900.42	**1900.42**
23	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.42	1900.41	1900.42	**1900.42**
24	*1900.42*	*1900.37*	*1900.42*	***0.05***	1900.42	1900.42	1900.41	1900.42	**1900.42**
25	*1900.42*	*1900.37*	*1900.41*	***0.04***	1900.42	1900.41	1900.41	1900.41	**1900.41**
26	*1900.42*	*1900.37*	*1900.41*	***0.04***	1900.42	1900.41	1900.41	1900.41	**1900.41**
27	*1900.42*	*1900.37*	*1900.41*	***0.04***	1900.42	1900.40	1900.41	1900.41	**1900.41**
28	*1900.42*	*1900.37*	*1900.41*	***0.04***	1900.42	1900.40	1900.41	1900.41	**1900.41**
29	*1900.42*	*1900.37*	*1900.41*	***0.04***	1900.42	1900.40	1900.41	1900.40	**1900.41**
30	*1900.41*	*1900.37*	*1900.41*	***0.04***	1900.42	1900.40	1900.41	1900.40	**1900.41**

Among other functions under “Specific Calculations” module, the AWMIS allows generating an input file to be used to run the Decision Support System for Water Managers (DSS), which enables more flexible water quality class calculation and creating charts on water quality classification in Armenia. After the charts are created in the DSS, they can be easily exported to MS Excel format. The first version of the DSS has been developed as an open-source ArcGIS extension during 2012-2015 within the USAID-funded Clean Energy and Water Program and was then enhanced to version 2 in 2016-2020 in the framework of USAID-funded ASPIRED Project. The DSS has comprised of 3 models, namely Hydrological Model, Climate Change Analysis Model and Economic Analysis Models. The Hydrological Model of DSS includes a component on Water Quality Assessment. It was developed in close collaboration with ME and contains the functionality of generating various combinations of charts based on water quality classification according to adopted water quality norms. The format and diversity of the available charts meets the requirements of HMC. Thus, after discussions with HMC, it had been decided that there was no need of programming the same tools within the AWMIS. Instead, a tool was programmed that transfers the water monitoring datasets of the AWMIS into the format that is required as an input for running the Water Quality Assessment components of DSS.

Linking AWMIS to DSS enabled a functionality of generating water quality assessment reports based on the water quality norms adopted by GoA for the main rivers of Armenia. The report on water quality assessment in Lake Sevan would be enabled as soon as the water quality norms for Lake Sevan are officially adopted by GoA. Those norms have been recently drafted and submitted for expertise and adoption by GoA. After the official adoption of the water quality norms for Lake Sevan, the appropriate table on the norms will be added to the AWMIS and a summary built-in report will be generated.

Both AWMIS and DSS were installed at HMC in 2020 and the AWMIS and DSS User Manuals were distributed to the relevant personnel of HMC. The technical staff members of HMC were trained on the use of AWMIS and DSS.

1.3 Analysis of the Existing Platforms for Environmental Data Management

This section of the report will summarize the current status of the three platforms for environmental data exchange that were built in Armenia during the recent 20 years.

1.3.1 Ecological Monitoring of Lake Sevan Portal

The Portal on ecological monitoring in Lake Sevan was the first chance of integrating all the monitoring datasets in one web site. It was constructed in 2010-2011 by the Institute of Informatics and Automation Problems of NAS RA. The portal is not open for the public and is accessible via the URL: http://emls.grid.am/ only by the following institutions that collect monitoring data on Lake Sevan:

- Environmental Monitoring Impact Center of MNP;
- Hydrometeorology Service of MNP;
- Hydrogeologic Monitoring Center of MNP;
- Sevan National Park;
- Institute of Ichthyology and Hydroecology of NAS.

The Portal is currently not used due to the change of the formats of data collected. It contains data on water quality in Lake Sevan for two years (2011-2012) after which the format of data collection and analysis were changed by EMIC. The appropriate changes were not made in the data inputting forms of the portal. However, the Hydrology Service of HMC have populated the Portal with monitoring data for the period of 2005-2020, including the following parameters: (a) daily water level; (b) daily volume of water released from the lake; (c) average daily water inflow through seven rivers flowing into the lake; (d) water balance of Lake Sevan by months; (e) volume of water flowing into the lake through the Arpa-Sevan water tunnel; and (f) the maximum recorded water temperature in the lake.

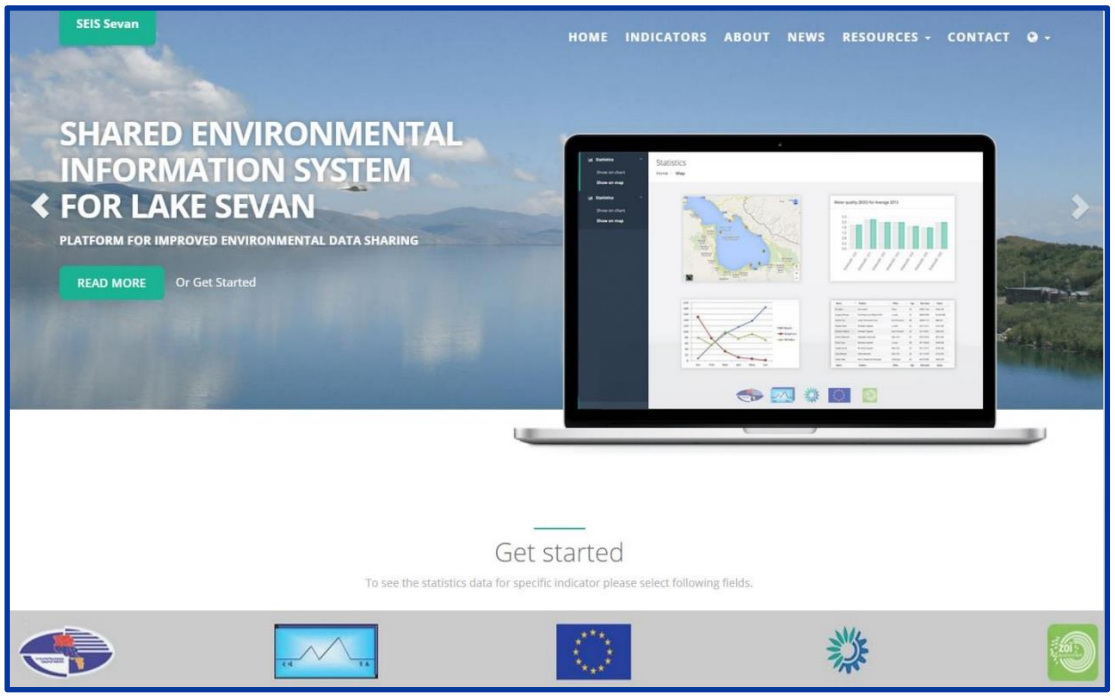
1.3.2 SEIS-Sevan Portal

Another attempt to integrate all the available datasets on Lake Sevan was made in the period of 2010-2015 in the framework of the project titled “Towards a Shared Environmental Information System in the European Neighborhoods” (the ENPI-SEIS project) funded by the European Commission and implemented by the European Environment Agency (EEA). The project was aimed at deepening the EU’s relations with the six Eastern Partnership countries (Armenia, Azerbaijan, Belarus, Georgia, Moldova and Ukraine) and support the promotion of environmental protection by strengthening environmental governance. The project had built capacity in the fields of biodiversity, water, land, air and environmental assessments. From the Armenian side the main stakeholders of the project were MNP (currently ME) and State Statistical Service (currently Statistics Committee).

As part of ENPI-SEIS project, a pilot activity was initiated in 2014 to develop a sustainable and regular data-sharing mechanism among the main data producers and data holders for the Lake Sevan basin in Armenia. An established Lake Sevan SEIS portal should serve as an efficient tool for the collection, presentation, and dissemination of data on environmental indicators in the basin.

The SEIS-Sevan portal grouped the datasets by the following water indicators for Lake Sevan:

- *Hydrometeorology:* temperature, precipitation, evaporation
- *Renewable water resources*: Inflow and outflow of surface waters, water balance of Lake Sevan
- *Freshwater abstraction*: Lake Sevan water abstraction by purposes, basin management areas
- *Domestic water use per capita*
- *Centralized water supply*
- *Access of population to centralized water supply*
- *Water losses*: by water use sectors, by marzes, basin management areas
- *Reuse and recycling of water*
- *Drinking water quality*
- *BOD and concentration of ammonium nitrogen in rivers*
- *Concentration of nutrients in fresh waters*
- *Concentration of pollutants in lake water and in bottom sediments*
- *Population connected to wastewater treatment*
- *Wastewater treatment facilities*
- *Untreated wastewater*



The Portal was available at URL: http://www.seis-sevan.am. However, SEIS-Sevan is currently unreachable, since the ME stopped paying domain maintenance annual fee after ENI SEIS II East Project was over in 2020. The data on the portal has not been updated since 2015.

1.3.3 Armenian EcoPortal on Water Resources

The EcoPortal of Armenia has been developed with the technical support of EEA under the European Union-funded project on “Implementation of the Shared Environmental Information System principles

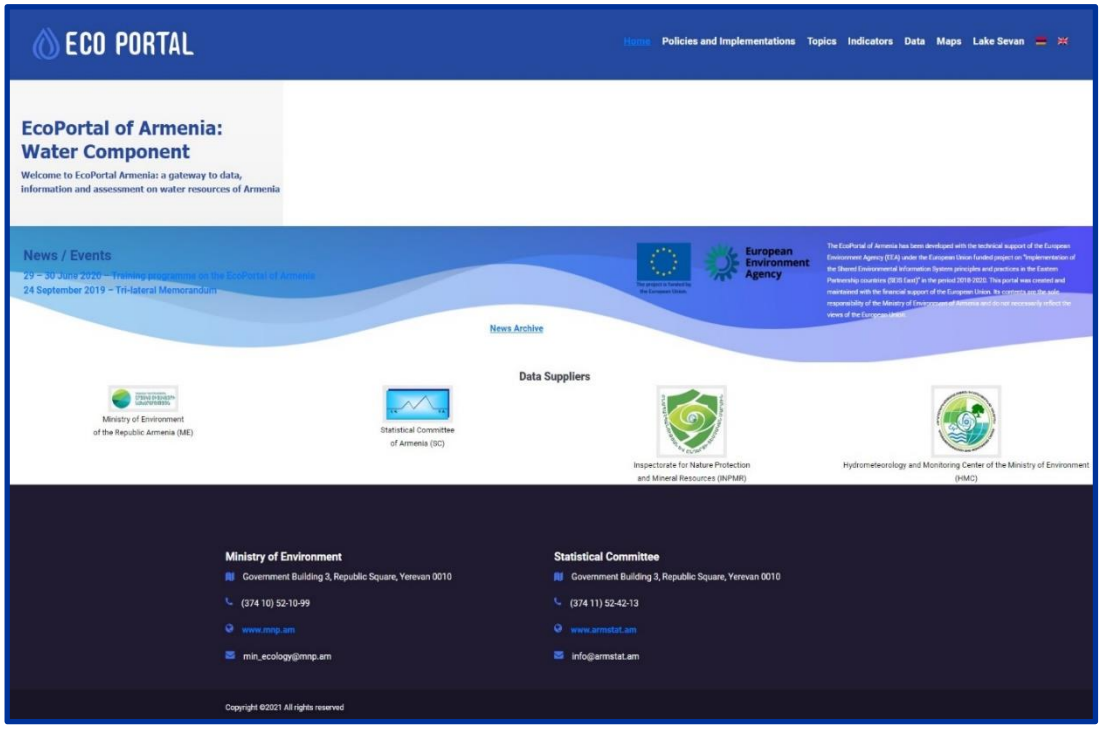
and practices in the Eastern Partnership countries (SEIS East)" in the period of 2018-2020. The project implemented the principles and practices of the SEIS in various environmental domains.

The EcoPortal of Armenia was aimed at supporting sharing data and information among the water agencies to underpin the knowledge-based policy-making in the country. The portal maintains water quality data of Armenia's main rivers and Lake Sevan, that had harmonized in line with the Water Information System Europe (WISE) water quality data dictionary. Similarly, the indicators developed based on the water quality data and published on the EcoPortal follow an indicator template of EEA. That means a comparison between Armenia, any of EU Member State and peer countries in the Eastern Partnership region can be performed for instance on nutrients in freshwater. The system's functionalities and design of the EcoPortal were inspired by WISE, to which all EU Member States report their water data and share information.

The main objective was to develop and deploy a functional, usable and publicly accessible EcoPortal on water resources. It could have served as a national analog of WISE of the EEA. The Eco Portal is based on the data from SWCIS.

EcoPortal presents water datasets, indicators, dynamic maps and reports. It allows for exchanging and sharing the data and information among the national water agencies in line with the SEIS principles and practices. The developed indicators set enable also the public at large to get informed on water availability and the quality of water they rely on in their daily lives and the economy underpinning their wealth and prosperity. The EcoPortal hosts water data and information but also a small component of the biodiversity i.e. indicator on protected areas.

The EcoPortal is now available at URL: http://ecoportal.mnp.am:92. The link to the EcoPortal is included on the home page of ME at URL: www.env.am. The home page of the portal contains short description of the objectives of the product, news section, as well as the structured menu with the separate components of the Water EcoPortal. Below is the screenshot of the EcoPortal's home page:



The EcoPortal has the following structure of web pages by menu items:

- *Policies and implementation:*
  - Overview of water legislation of Armenia (Water Codes, Laws, Governmental resolutions)
  - Overview of environmental conventions Armenia is signatory of
  - State of Environment Reports (overview and downloadable files of available reports)
  - River Basin Management Plans (overview and downloadable files of the available RBMPs)
  - Overview of water use permitting process (with downloadable application templates)
- *Topics:*
  - Water resources of Armenia (brief overview)
  - Reports and publications (selected technical papers and reports relevant to the water resources management in Armenia with overview and downloadable files)
  - Climate change impact (overview with links to available reports on climate change)
  - Information on campaigns and public outreach (brief overview)
- *Indicators:* Annual indicator reports – selection from the UNECE Environmental Indicators
  - C1: Renewable Freshwater Resources
  - C2: Freshwater Abstraction
  - C3: Total water use
  - C4: Household water use per capita
  - C5: Water supply industry and population connected to water supply industry
  - C10: BOD and concentration of ammonium in rivers
  - C11: Nutrients in Freshwater
  - D1: Nationally Designated Protected Areas
- *Data:*
  - Water quantity (overview and link to hydrological bulletin prepared by HMC on daily basis)
  - Water quality (link to online database on two water quality parameters (BOD, ammonium) and three nutrients (phosphate, nitrate, phosphorus measured at 49 water sampling points on major rivers and Lake Sevan)
  - Water use (downloadable datasets on annual actual water abstraction and wastewater discharge for the period of 2014-2020)
- *Maps:*
  - Library of GIS-based Maps on Water Resources of Armenia (downloadable in JPG format)
  - Water Resources Atlas of Armenia (2008) (downloadable in PDF format)
  - An interactive map on indicators from the 49 water quality sampling points on major rivers and Lake Sevan (linkages to datasets on indicator *C10: Water Quality* and indicator *C11: Nutrients in Freshwaters*)
- *Lake Sevan:*
  - The page used to provide the link to SEIS-Sevan Portal (http://seis-sevan.am/). At present, the page is no longer operational due to unavailability of SEIS-Sevan domain.

Currently the Armenian EcoPortal on water resources is operational and up-to-date. It is physically located at the same server as the ME's web site (www.env.am). The administration of the EcoPortal has been assigned to Information Analysis division of HMC, which keeps data/information on the EcoPortal updated. The water quality datasets for the period of 2014-2020 are available in "Data" section, while the indicator reports for 2020 are recently deployed in "Indicator" section of the EcoPortal.

CHAPTER 2 ROADMAP ON DATA MANAGEMENT IMPROVEMENT IN LAKE SEVAN BASIN

The Roadmap on improvement of water-related data management in Lake Sevan basin includes the following sections:

- ***Summary of the Needs for Proper Data Management in Lake Sevan Basin.*** In this section the needs for strengthening data management and facilitating data-driven decision-making in Lake Sevan basin are summarized and presented brief justifications and explanations. The needs analysis is presented in three directions: legislative/regulatory, institutional/capacity building and technical.
- ***Recommended Activities on Improvement of Data Management in Lake Sevan Basin.*** The section presents a list of recommended activities to enhance the water-related data management in the Lake Sevan basin. The recommendations are based on the (a) analysis of the current situation with data gathering, data maintenance and analysis by the main data producers in Lake Sevan basin; (b) data flows and information exchange among the stakeholder institutions; and (c) identified needs of the main stakeholders for proper management of data on Lake Sevan basin. Recommendations are grouped into two areas: (a) regulatory/institutional issues; and (b) technical tools.
- ***Implementation Plan of Recommended Activities.*** The implementation plan is prepared for a three-year period (from January 2022 to December 2024) and includes tentative timeframe the envisaged timeline and for completion of each activitiy by quarters of the years and the institutions/agencies responsible for its implementation.

2.1 Summary of the Needs for Proper Data Management in Lake Sevan Basin

2.1.1 Legislative/regulatory needs

1. The field of environmental data management in Armenia is not regulated yet. There is a need to adopt a legislative act on the Concepts of Environmental Data Management in Armenia. The Concept paper should regulate the roles and responsibilities of all governmental, non-governmental organizations, academia, and private sector in collection, processing and dissemination of environmental information in Armenia. The Concept paper should also provide mechanisms for building and managing environmental DBMS, environmental GIS, data exchange platforms, including procedures to ensure data safety and intellectual property rights.

2. The Governmental resolution #68 on maintaining the State Water Cadaster is outdated. There is a need to update the resolution taking into considerations the requirements of timely decision-making in the field of water resources management and planning. In particular, there is a need to revise the list of stakeholder institutions, change the mechanisms and frequency of updating the system and to define the structure of the geo-spatial component of the SWCIS.

3. A regulatory document on data management on Lake Sevan is missing. Taking into account the strategic importance of Lake Sevan for Armenia and the whole South Caucasus, there is need for a separate regulatory paper on Lake Sevan basin, which will define the mechanisms of making all data on environmental parameters of Lake Sevan basin available and accessible, will apply principles of SEIS (produce data once, use multiple times) for Lake Sevan, ensure using internationally recognized data collection protocols, data maintenance and data analysis approaches. The document should also include provisions on further enhancing the monitoring activities in Lake Sevan basin.

2.1.2 Institutional/capacity building needs

1. The Sevan BMO of the WRMD of ME is currently understaffed. There is a need of institutional strengthening the Sevan BMO of the WRMD of ME. The BMO is responsible for development and implementation of the Lake Sevan Basin Management Plan. However, it has only 2 staff members, which is far enough for proper performance.

2. The HMC SNCO of ME is currently overloaded with tasks and understaffed. In terms of proper data management, there is a need of institutional strengthening of HMC SNCO, particularly its Information Analytical Service, which has 14 staff members at present. The division is currently responsible for administering the AWMIS, Armenian EcoPortal on water resources, web site of ME, as well as providing analytical information on the state of environment, environmental indicators, climate change projections, etc. The current staffing of the division is not enough to implement all the mentioned functions in proper and timely manner.

3. The HMC SNCO of ME is currently underequipped for proper monitoring in Lake Sevan. A list of equipment needed for improvement of meteorologic, hydrologic, hydrochemical, hydrophysical, hydrogeological, and hydrobiological monitoring in Lake Sevan is provided by HMC SNCO.

4. The EPMIB is currently underequipped. The inspection body needs an up-to-date computer server to improve data management and data flow, as well as an electronic control system for the exchange of operative, complex, reliable control, and the exchange of public and non-public information. The server will maintain proper data management between the EPMIB branches in marzes and central office in Yerevan. In particular the Gegharkunik branch office of EPMIB needs establishment closer links with Sevan BMO for proper organization of inspection activities on water use and wastewater discharge occurring in Lake Sevan basin.

5. The WatCom lacks MIS for its operation and assets management. There is a need to equip headworks of the main canals throughout the country and particularly in Lake Sevan basin with flow meters and data loggers to ensure automatic and online monitoring of water discharge. The appropriate SCADA systems should be built and integrated into the future MIS of the Committee.

6. The scientific-research institutes of NAS RA lack IT divisions and DBMSs. The Scientific Centre of Zoology and Hydroecology and the Institute of Chemical Physics after A.B. Nalbandyan of NAS need institutional restructuring to establish IT divisions which will be responsible for maintenance of the databases and web platforms. There is a prerequisite for future proper data organization within the institutions and data sharing on Lake Sevan basin.

7. The staff of WRMD and Sevan BMO of ME has low capacity on DBMSs, GIS and running SWCIS. There is a need of conducting a series of training courses for the technical staff of WRMD and Sevan BMO on the use of DBMSs, GIS and maintenance of SWCIS. New approaches for running SWCIS online should be presented during those trainings. Sevan BMO needs to be involved in maintaining the Lake Sevan basin component of the SWC.

8. The staff of HMC SNCO of ME has low capacity on using modern ICTs. The technical staff of the Hydrologic Service of HMC need advance training on the (a) use of DSS for calculation of water balance in the river basins of Armenia and Lake Sevan basin; (b) climate change modeling for projecting the impact of climate change on water resources of Armenia; and (c) applying GIS spatial analysis tools, high-resolution satellite imagery analysis, and data interpolation methodologies. The staff members of Hydrogeologic Service of HMC need advance training on groundwater modeling.

2.1.3 Technical needs

1. The Armenian EcoPortal on water resources currently lacks data on Lake Sevan. There is a need to reconstruct the Lake Sevan section of the EcoPortal to host datasets from all the data producers on Lake Sevan basin, including governmental organizations, academia and private sector. Datasets and indicators contained in the *portal on ecological monitoring in Lake Sevan* and *SEIS-Sevan portal* should be transferred to the EcoPortal. It is needed to create not just a web page for informing the public, but also an online platform where stakeholder institutions are able to enter their data through the authorized login names and combine all available tabular and geo-spatial datasets on Lake Sevan by using built-in analytical tools.

2. The geo-spatial component of SWCIS is not regularly updated and shared. There is a need of more active sharing of geo-spatial datasets on water resources of Armenia, and particularly on Lake Sevan. This can be achieved by creating a Geonode data sharing platform in the Armenian EcoPortal on water resources.

3. No remote sensing technologies are currently used for analysis in Lake Sevan basin. Remote sensing technologies may be used for (a) monitoring Lake Sevan water quality using multiprobe sensors, data loggers and SCADA software; (b) classification of land cover/ land use Lake Sevan basin according to CORINE methodology developed by EEA.

4. Calculation of annual hydrologic balance of Lake Sevan basin is lacking. There is a need to customize the Hydrologic Model of DSS with the datasets on Lake Sevan basin to calculate the annual water balances in the basin. In addition, more hydrologic modeling tools should be used along with the geo-spatial profile of the lake to calculate the water balance of the Lake itself for any given year.

5. Water monitoring program in Lake Sevan basin is outdated. There is a need to develop a new monitoring program for Lake Sevan basin based on the basin characterization and pressure-impact analysis presented in draft Lake Sevan Basin Management Plan. The new monitoring program will integrate quantitative and qualitative monitoring of surface waters and groundwaters in the Lake Sevan basin as well as biological monitoring in the Lake Sevan.

6. List of monitoring parameters in Lake Sevan is outdated. There is a need to revise and enrich the list of monitoring parameters for Lake Sevan basin. Primary organic pollutants, chlorophyll alpha, phytoplankton, macro-invertebrates are not currently identified in surface waters of the basin. At present, due to technical malfunctioning of the equipment, the analysis of total organic carbon and total bound nitrogen are not carried out. Those studies will allow qualifying and estimating the pressure on organic pollutants on Lake Sevan. There is a need to measure the content of sulfur and carbon in Lake Sevan water samples և bottom sediments as well as to reveal their relationship with the water-sediment contact zone. It is also preferable to carry out observations of water temperature, oxygen and transparency at different depths in Lake Sevan.

7. Water use permit database for Lake Sevan basin contains a lot of inaccuracies. There is a need to revise water use permit database of the SWCIS. In particular, (a) gaps in data describing the geographic coordinates of water abstraction and water discharge points should be fulfilled; (b) errors in presentation of data on permitted volumes of water use and water discharge should be corrected; (c) inconsistencies in daily, monthly, and annual volumes of permitted volumes of water use and water discharge should be corrected; and (d) inconsistencies with the actual volumes of water use and wastewater discharge should be corrected.

8. Water quality norms for Lake Sevan are lacking. There is a need to develop and officially adopt water quality norms for Lake Sevan. In addition, the water quality norms for the rivers of Lake Sevan basin were adopted in 2011 and need updating once in 6 years according to the provision of Law. The adoption of the norms for Lake Sevan and updating the existing norms for the rivers in Lake Sevan basin will allow proper assessment of the Lake Sevan ecosystem and water quality in the basin.

2.2 Recommended Activities on Improvement of Data Management in Lake Sevan Basin

2.2.1 Regulatory/Institutional Issues

- **To develop a Framework Law on the Concepts of Environmental Data Management in Armenia.** The Law should include regulatory provisions on the following issues:
  - Identification of the institutions involved in environmental data management in Armenia
  - Roles and responsibilities of all governmental, non-governmental institutions, academia, and private sector in collection/processing/dissemination of environmental information in Armenia
  - Mechanisms of data flows and information exchange in the field of environment in Armenia
  - Standards for building and managing environmental DBMSs and environmental GIS
  - Concepts for developing and maintaining data exchange platforms in the field of environment, including data safety mechanisms and intellectual property rights.

- **To revise the GoA resolution on Maintaining the State Water Cadaster of the Republic of Armenia.** The revision of the GoA Resolution #68 (02.02.2017) should emphasize the following issues:
  - Identification of the institutions involved in maintaining SWC. Some new institutions should be added. Particularly, NDO of MES should be considered as a entity to provide information on floods, mudflows and landslides.
  - New structure and content of the SWCIS
  - Roles and responsibilities of each institution in running SWC
  - Concepts of online operation of SWCIS
  - Mechanisms and frequency of updating the SWCIS
  - Structure of DBMSs and GIS components of SWCIS and relationships between two components
  - Relationship of SCWIS with other online platforms on environment in Armenia

- **To develop a GoA resolution on Lake Sevan data management.**
  A new GoA resolution should cover the following issues:
  - Identification of the institutions involved in data collection and processing in Lake Sevan basin, including governmental entities, academic organizations, NGOs and private sector.
  - Concepts of maintaining the online platforms for sharing data/information on Lake Sevan basin
  - Roles and responsibilities of each institution on data management and data sharing
  - Mechanisms and frequency of sharing data through the SWCIS and Lake Sevan online platform
  - Relationships of the online platform on Lake Sevan basin with other online platforms on environment in Armenia.

- **To strengthen the Sevan BMO of the WRMD of ME.**
  The following actions are recommended:
  - Revise the staffing of Sevan BMO and Add new positions into the staff list of BMO

- Bring the staffing of Sevan BMO into accordance with the requirements of the BMO Charter
- Revise roles and responsibilities of each staff member of BMO by emphasizing the provision on development of Lake basin management plans
- Train the staff members of BMO on the concepts of basin management planning
- Train the staff members of BMO on data management concepts, running SWCIS and GIS

- **To perform structural changes in the Information Analytical Service of the HMC SNCO of ME.**
  It is proposed to establish the following five divisions within the Information Analytical Service:
  - *Division for monitoring data analysis*: will be responsible for gathering, processing and analyzing environmental monitoring data, developing analytical thematic reports on water resources, air pollution, impacts of climate change, etc.
  - *Division for databases and GIS*: will be responsible for administering and maintenance of DBMSs and GIS applications on environment
  - *Division for information exchange*: will be responsible for maintenance of web sites, electronic data sharing platforms and portals
  - *Division for assessments*: will be responsible for assessing the current status of environment, performing cross-sectoral analysis and reporting
  - *Division for IT administration*: will be responsible for administering the computer servers and LAN of ME.

- **To strengthen the Information Analytical Service of the HMC SNCO of ME.**
  The following actions are recommended:
  - Revise the staffing of the Information Analytical Service and bring it into accordance with the new structure. Add new positions into the staff list of the Service.
  - Revise the Charter of the Service according to new requirements
  - Revise the roles and responsibilities of each staff member according to the revised Charter
  - Upgrade the hardware and software of the Information Analytical Service according to the new functionalities
  - Train the new staff members of the Service on DBMSs, GIS, statistical skills, web-site administration, server maintenance, etc.

- **To strengthen the monitoring capabilities of HMC SNCO of ME.**
  The following actions are recommended:
  - Provide commodity support and equip the HMC NSCO per request of ME
  - Train the appropriate technical staff members of HMC on the use of new equipment provided
  - Train the staff of Hydrologic Service of HMC on the use of DSS for calculation of water balance in the river basins of Armenia and Lake Sevan basin, as well as on applying GIS spatial analysis tools, high-resolution satellite imagery analysis, and data interpolation methodologies.
  - Train the staff of Climate Analysis Service of HMC on climate change modeling for projecting the impact of climate change on water resources of Armenia as well as on applying GIS spatial analysis tools, high-resolution satellite imagery analysis, and data interpolation methodologies.

- **To strengthen monitoring capabilities of other data producers on Lake Sevan**
  The following actions are recommended:
  - Construct a MIS for Water Committee to ensure proper asset management in Lake Sevan basin

- Provide an up-to-date computer server to EPMIB and MIS for EPMIB for proper organization of control functions of the EPMIB branches in marzes and central office in Yerevan
- Equip headworks of the main canals in Lake Sevan basin with flow meters and data loggers to ensure automatic and online monitoring of water discharge using SCADA software
- Develop relational databases for the SCZH and the ICP of NAS RA to maintain the monitoring data on Lake Sevan accumulated in the frame of various scientific research projects.

2.2.2 Technical Tools

The key recommendation in this section is **to enhance Lake Sevan section of the Armenian EcoPortal on Water Resources.** This wide-ranging activity is aimed at transferring the Lake Sevan page of the EcoPortal into the main clearing-house mechanism on the data on Lake Sevan. It should include but not limited to the following functionalities:

- Hosting datasets from all the data producers on Lake Sevan basin, including governmental organizations, academia and private sector
- Integrating all the tabular databases into a single Lake Sevan basin DBMS
- Integrating all geo-spatial datasets, including vector layers and raster imagery into a single Lake Sevan basin geodatabase
- Sharing the geo-spatial datasets on Lake Sevan basin via Geonode data exchange platform
- Maintaining high-resolution satellite imagery used for land cover/land use classification in Lake Sevan basin
- Hosting specialized software and electronic tools on Lake Sevan basin, such as:
    - A customized DSS for Lake Sevan basin
    - A modeling tool to calculate annual Lake Sevan water balance
    - A data importing tool to regular transfer of data on Lake Sevan from the AWMIS
    - A data exporting tool to regular transfer of data on Lake Sevan basin into the SWCIS
    - An open-source GIS to perform geo-spatial analysis on Lake Sevan basin
- Providing authorized access to all stakeholder institutions to use the Lake Sevan basin DBMS Lake Sevan basin Geonode and specialized software and tools.
- Sharing data on Lake Sevan basin with public

A number of sub-activities should be completed in order to achieve the above-mentioned objective. First of all it is needed **to develop a Technical Concept on architecture of the Lake Sevan section of the Armenian EcoPortal**, including defining IT products/tools to be incorporated in it and the relationships among them. Then, based on the agreed Technical Concept, the following activities are needed for full operationalization of the Lake Sevan section of the Armenian EcoPortal on Water Resources:

- **To construct Lake Sevan basin DBMS**

  The following actions are recommended:
  - Identify the structure of the tables and relationships in future Lake Sevan basin DBMS, taking into account the data organization and structures of SWCIS and AWMIS
  - Identify generic data templates to allow transferring Lake Sevan monitoring data/information from the MS Excel spreadsheets of SCZH, ICP and CENS at to the future Lake Sevan basin DBMS
  - Develop the Lake Sevan basin DBMS based on the structure agreed with stakeholders

- Populate the Lake Sevan basin DBMS with historical monitoring data from SWCIS, AWMIS, SCHZ, ICP, CENS, Portal on ecological monitoring in Lake Sevan and SEIS-Sevan portal
- Deploy the Lake Sevan basin DBMS into the Lake Sevan section of the Armenian EcoPortal on Water Resources
- Develop data importing tool for regular data transfer on Lake Sevan from the AWMIS to DBMS
- Develop data exporting tool for regular data transfer on Lake Sevan basin into the SWCIS
- Provide user rights to stakeholder organizations to access the Lake Sevan basin DBMS
- Provide HMC SNCO of the ME with administrator's rights to manage Lake Sevan basin DBMS
- Train the technical staff of stakeholder institutions on the use of Lake Sevan basin DBMS

- **To develop a Geo-spatial data exchange platform for Lake Sevan basin**
  The following actions are recommended:
  - Integrate all geo-spatial datasets, available in stakeholder organizations and SWCIS into the Lake Sevan basin geodatabase
  - Customize a Geonode data exchange platform to host the geodatabase on Lake Sevan basin
  - Update the geo-spatial component of the SWCIS with the vector layers and raster imagery on Lake Sevan basin
  - Provide user rights to stakeholder organizations to access the Lake Sevan basin Geonode
  - Provide HMC SNCO of the ME with administrator's rights to manage Lake Sevan basin Geonode

- **To perform land cover/land use classification in Lake Sevan basin**
  The following actions are recommended:
  - Acquire high-resolution satellite imagery (<=10m) for Lake Sevan basin (SENTINEL or RapidEye)
  - Perform unsupervised classification of the imagery using CORINE methodology
  - Conduct field surveys (groundtruthing) at Lake Sevan basin
  - Perform supervised classification of land cover/land use based on the results of groundtruthing
  - Integrate the outcomes of the classification into the Lake Sevan basin Geodatabase and into the SWCIS
  - Share the land use/land cover classification outcomes and maps via Lake Sevan basin Geonode

- **To fully account for use of surface water and groundwater resources and wastewater discharge in Lake Sevan basin**
  The following actions are recommended:
  - Correct inaccuracies in data on water use permits in Lake Sevan basin. At present, the reports submitted to the state-authorized body on actual volumes of water use and water discharge by legal and physical entities provide one total volume for water use and wastewater discharge. If the water use permit involves more than one water abstraction and water discharge point, the permit should include geographic coordinates and permitted volumes for each water abstraction and water discharge point and not the total volume. This will provide more accurate data to support decision-making processes on water allocation and conservation.
  - Correct discrepancies in the water use permit database among the daily, monthly, and annual volumes of permitted water abstraction and water discharge data in Lake Sevan basin
  - Eliminate gaps in data on actual volumes of water use and water discharge in Lake Sevan basin. The reports on actual volumes of water use and wastewater discharge should include measured volumes of water abstraction and water discharge for each water use and water dis-

charge point. This will enable creation of better links between the database on water use permits and reported actual water use and water discharge, as well as accurate analyses of water resource use.
- If required, initiate changes in procedures for reporting on actual volumes of water use and water discharge, as defined by the legislation of Armenia

- **To use decision-support tools and models to perform cross-sectoral analysis for Lake Sevan basin.**
  The following actions are recommended:
  - Customize the Hydrologic Model of DSS with Lake Sevan basin data of 2020 and calculate water balance
  - Calculate water supply and demand balance of Lake Sevan basin for 2020 using the Hydrologic model of DSS
  - Customize the Climate Change Model of DSS with Lake Sevan basin data of 1961-2020 and run the projections of the values of precipitation, air temperature and natural surface flow for 2040, 2070 and 2100 under various climate change scenarios
  - Develop a modeling tool along with the geo-spatial profile of the lake to calculate annual water balance of Lake Sevan
  - Train the staff members of Hydrologic Service, Meteorologic Service and Climate Analysis Service of HMC to use the developed and calibrated models

- **To enhance environmental monitoring in Lake Sevan and its basin.**
  The following actions are recommended:
  - Identify data gaps in surface water and groundwater quantitative and qualitative monitoring
  - Identify locations for new surface water qualitative and quantitative monitoring points in Lake Sevan basin. Propose additional hydrological observation posts on the sections of the rivers flowing into the Lake to determine surface water inflow into the Lake.
  - Extend the groundwater monitoring network in the Lake Sevan basin since groundwater monitoring wells are distributed unevenly in the basin
  - Conduct inventory of groundwater wells and natural springs in the Lake Sevan basin
  - Initiate monitoring of water quality in Lake Sevan using multiprobe sensors, data loggers and SCADA software
  - Develop a new monitoring program for Lake Sevan basin based on the findings and recommendations in presented in draft Lake Sevan Basin Management Plan. The new monitoring program should integrate quantitative and qualitative monitoring of surface waters and groundwaters in the Lake Sevan basin as well as biological monitoring in the Lake Sevan.
  - Revise and enrich the list of monitoring parameters for Lake Sevan basin as well as update the list of on environmental indicators for Lake Sevan basin. Make the list of parameters and descriptions of indicators accessible via the Lake Sevan section of the EcoPortal.

After completion of the above-mentioned activities and deployment of the Lake Sevan section of the Armenian EcoPortal on water resources, there will be a need to open the data/information to the general public which require increasing its safety requirements. One of the options to do that is to transfer the administration of the EcoPortal to E-Governance Infrastructure Implementation Unit CJSC (URL: www.ekeng.am)

2.3 Implementation Plan of Recommended Activities

#	Activity/Action	Responsible Entity(ies)	2022				2023				2024			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
1.	To improve legislative/regulatory framework for Lake Sevan data management	ME *												
1.1	To develop a Framework Law on the Concepts of Environmental Data Management													
1.2	To revise the GoA resolution on Maintaining the State Water Cadaster of Armenia													
1.3	To develop a GoA resolution on Lake Sevan data management													
2.	To strengthen the Sevan Basin Management Organization	ME and Sevan BMO with the assistance of international donor-funded projects **												
2.1	To revise the staffing of Sevan BMO, add new positions and revise roles and responsibilities of each staff member by emphasizing the need for development of Lake basin management plan													
2.2	To train the staff members of Sevan BMO on (a) concepts of data management; (b) database maintenance; (c) GIS mapping; (d) online operation of SWCIS; (e) DSS customization for Lake Sevan basin; (f) concepts of basin management planning													
3.	To strengthen the Information Analytical Service of the HMC SNCO of ME	ME, HMC SNCO *												
3.1	To perform structural changes in IAS through establishment of the following divisions: (a) Division for monitoring data analysis; (b) Division for database maintenance and GIS; (c) Division for information exchange; (d) Division for environmental assessments; and (e) Division for IT administration													
3.2	To revise the staffing of the Information Analytical Service, add new positions and revise roles and responsibilities of each staff member													
3.3	To upgrade the hardware and software of the Information Analytical Service according to the new functionalities	ME with the assistance of international donor-funded projects **												
3.4	To train the staff members of the Information Analytical Service on (a) DBMSs, (b) GIS mapping and applying GIS spatial analysis tools; (c) online operation of SWCIS; (d) use of DSS for calculation of water balance in the river basins and in Lake Sevan basin; (e) high-resolution satellite imagery analysis and data interpolation methodologies; (f) statistical skills; (g) climate change modeling; (h) web-site administration, (i) server and network admnistration													
4.	To strengthen monitoring capabilities of data producers on Lake Sevan													

#	Activity/Action	Responsible Entity(ies)	2022				2023				2024			
			Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
4.1	To provide commodity support/monitoring equipment to the HMC SNCO of ME and train appropriate technical staff members of HMC on the use of new equipment	ME, EPMIB, WatCom, institutions of NAS with the assistance of international donor-funded projects **												
4.2	To provide an up-to-date computer server to EPMIB and MIS for EPMIB for proper organization of control functions of the EPMIB branches in marzes and central office.													
4.3	To develop MIS for WatCom for ensuring proper management of assets for (a) drinking water supply and sanitation; (b) irrigation water supply; (c) collector-drainage network													
4.4	To equip headworks of the main canals in Lake Sevan basin with flow meters and data loggers to ensure automatic online monitoring of water discharge via SCADA software													
4.5	To develop DBMSs for the scientific-research institutions of NAS to maintain the monitoring data on Lake Sevan accumulated in the frame of scientific research projects													
5	To enhance Lake Sevan section of the Armenian EcoPortal on Water Resources	ME with the assistance of international donor-funded projects **												
5.1	To develop a Technical Concept on Architecture of the Lake Sevan section of the Armenian EcoPortal.													
5.2	To construct and populate the Lake Sevan basin DBMS to be hosted on the EcoPortal and provide access to all stakeholder organizations													
5.3	To develop and regularly update a geo-spatial data exchange platform for Lake Sevan basin to be hosted on the EcoPortal and provide access to all stakeholder organizations													
5.4	To perform land cover/land use classification in Lake Sevan basin and make the results accessible via the EcoPortal													
5.5	To fully account for use of surface water and groundwater resources and wastewater discharge in Lake Sevan basin and make those datasets accessible via the EcoPortal													
5.6	To customize the decision-support tools and models to perform cross-sectoral analysis for Lake Sevan basin and make those tools accessible via the EcoPortal													
5.7	To enhance environmental monitoring in Lake Sevan and its basin and make gathered data and developed datasets accessible via the EcoPortal													
5.8	To deploy the Lake Sevan section of the EcoPortal and transfer the administration of the EcoPortal to E-Governance Infrastructure Implementation Unit CJSC													

*** -** no or low-cost activity/action, to be implemented through the state budget allocations

**** -** high-cost activity/action, to be implemented through the state budget allocations and additional investments from international donors