



**USAID**  
FROM THE AMERICAN PEOPLE

# ADVANCED SCIENCE AND PARTNERSHIPS FOR INTEGRATED RESOURCE DEVELOPMENT PROJECT

## DATA AVAILABILITY AND GAP ANALYSIS REPORT

APRIL 2016

This publication was produced for review by the United States Agency for International Development. It was prepared by Mendez England & Associates.

# Advanced Science and Partnerships for Integrated Resource Development Project

## DATA AVAILABILITY AND GAP ANALYSIS REPORT

April 2016

Contract No. AID-EPP-I-00-05-00010/AID-111-TO-11-00001

**Prepared for:**

United States Agency for International  
Development  
Armenia Mission  
1 American Avenue  
Yerevan 0082, Armenia

**Prepared by:**

Mendez England and Associates (ME&A)  
4300 Montgomery Ave.  
Suite 103  
Bethesda, MD 20814  
Tel: +1 301 652 4334  
Fax: +1 301.652.3733  
[www.mendezengland.com](http://www.mendezengland.com)

Armenian Branch of ME&A  
7/1 Aygedzor Street,  
Yerevan 0019  
Republic of Armenia  
Tel. +374 10 321116

**DISCLAIMER**

This report is made possible by the support of the American people through the United States Agency for International Development (USAID). The contents are the sole responsibility of the Mendez England & Associates and do not necessarily reflect the views of USAID or the United States Government.

## TABLE OF CONTENTS

<b>LIST OF ACRONYMS .....</b>	<b>4</b>
<b>INTRODUCTION .....</b>	<b>5</b>
<b>CHAPTER 1. ASSESSMENT OF DATA AVAILABILITY ON ARARAT VALLEY .....</b>	<b>6</b>
1.1 Stakeholder Institutions .....	6
1.2 Tabular Data Availability.....	7
1.3 Spatial Data Availability .....	9
1.4 Technical Reports and Maps.....	12
<b>CHAPTER 2. IDENTIFIED DATA GAPS .....</b>	<b>14</b>
2.1 Tabular Data .....	14
2.2 Spatial Data.....	15
2.3 Data on the Turkish Section of the Ararat Valley .....	16
<b>CHAPTER 3. RECOMMENDATIONS ON CREATING A COMPREHENSIVE MANAGEMENT INFORMATION SYSTEM FOR THE ARARAT VALLEY .....</b>	<b>18</b>
<b>ANNEX A: STRUCTURE OF THE ARARAT VALLEY MIS.....</b>	<b>20</b>

## LIST OF ACRONYMS

ASH	Armenia's State Hydrometeorological Monitoring Service
ASPIRED	Advanced Science and Partnerships for Integrated Resource Development
BMA	Basin Management Area
BMO	Basin Management Organization
DAI	Development Alternatives Inc.
EIMC	Environmental Impact Monitoring Center
ERICA	European River and Catchment Area Coding System
GA	Geological Agency
GoA	Government of Armenia
GIS	Geographic Information System
GPS	Global Positioning System
JICA	Japan International Cooperation Agency
HMC	Hydrogeological Monitoring Center
MA	Ministry of Agriculture
MES	Ministry of Emergency Situations
MENR	Ministry of Energy and Natural Resources
MIS	Management Information System
MNP	Ministry of Nature Protection
NSS	National Statistical Service of Armenia
RGF	Republican Geological Fund
SCWS	State Committee on Water Systems
SEI	State Environmental Inspectorate
SWC	State Water Cadastre
SWCIS	State Water Cadastre Information System
USAID	United States Agency for International Development
UTM	Universal Transverse Mercator
WGS	World Geodetic System
WRMA	Water Resources Management Agency
WUA	Water Users Association

## INTRODUCTION

The purpose of the USAID-funded Advanced Science & Partnerships for Integrated Resource Development (ASPIRED) Project is to support sustainable water resource management and sustainable practices of water users in the Ararat Valley through the use of science, technology, innovation and partnership initiatives. The ultimate goal is to reduce the rate of groundwater extraction in the Ararat Valley to the sustainable levels.

A comprehensive data and information system on water resources in the Ararat Valley is a prerequisite for evidence-driven sustainable management planning and decision-making. To support development and reinforcements of an integrated management system and technical tools for data-driven decision making across the stakeholders, the Project will be working in improving and strengthening stakeholders' capacities in data collection and maintenance, as well as data processing and analysis. It will result in creating a geo-coded, real time, publicly open data system for the Ararat Valley to include integrated water resource datasets which are currently at possession of multiple stakeholders using data and information currently available with various stakeholder agencies, as well as a tool for hydrogeological modeling and decisions support, together with a publicly accessible system to produce reports based on high-quality, real-time monitoring data.

Data for informed management decisions on groundwater resources in the Ararat Valley is fragmented, and level of data accuracy and reliability is questionable. As the first step, it is essential to assess the datasets available at various stakeholder institutions and analyze data gaps.

This report summarizes the ASPIRED Project findings on the availability of data (both tabular and spatial) on the Ararat Valley and main gaps. The first chapter of the report describes in details the tabular datasets and spatial geodatabase on the Ararat Valley received from the stakeholder institutions, as well as available at ASPIRED Project. Chapter 2 presents the identified data gaps and activities to be implemented for filling in these gaps. Chapter 3 of the report proposes steps towards developing a comprehensive Ararat Valley Management Information System (MIS) that will be further incorporated into the State Water Cadastre Information System of the Water Resources Management Agency (WRMA) of the Ministry of Nature Protection (MNP) and used for applying technical tools to inform management decisions in the Ararat Valley.

## CHAPTER 1. ASSESSMENT OF DATA AVAILABILITY ON ARARAT VALLEY

### 1.1 Stakeholder Institutions

In order to assess the availability of data on Ararat Valley, an initial research on the stakeholder institutions resulted to a list of key governmental organizations that are responsible for collection and maintenance of data and information related to water resources and water systems of Ararat Valley (see Table 1 below for summary information on the type of available data by institution).

**Table 1. Summary of available data on water resources in stakeholder institutions**

#	Stakeholder institution	Acronym	Available Data
1	Water Resources Management Agency of the Ministry of Nature Protection and Basin Management Organizations under WRMA	WRMA BMOs	Data on water use permits (water abstraction and wastewater return)
2	State Environmental Inspectorate of the Ministry of Nature Protection	SEI	Data on actual water use, and payments (water use fee)
3	Environmental Impact Monitoring Center of the Ministry of Nature Protection	EIMC	Surface water quality monitoring data
4	Hydrogeological Monitoring Center of the Ministry of Nature Protection	HMC	Groundwater quantity and quality monitoring data
5	Ministry of Agriculture	MA	Data on currently operational fish farms
6	State Committee on Water Systems of the Ministry Agriculture	SCWS	Data on hydro-technical structures and water systems
7	Armenian State Hydrometeorological Monitoring Service of the Ministry of Emergency Situations	ASH	Meteorological data and hydrological monitoring data
8	Republican Geological Fund of the Ministry of Energy and Natural Resources	RGF MENR	Inventory data on groundwater springs and wells, including lithological structure
9	Ministry of Finance	MF	Data on taxation from fish farms, customs duties, etc.
10	National Statistical Service of Armenia	NSS	Data on aggregate actual water use and wastewater discharge, economic data on fish industry.

The Water Resources Management Agency of the Ministry of Nature Protection is an authorized body to run the State Water Cadastre (SWC). The WRMA collects annual summary data from other state institutions in tabular format and maintains the State Water Cadastre Information System (SWCIS) to generate annual summary reports on the water resources of Armenia. In addition, the WRMA accumulates and maintains a GIS geodatabase on water resources and water systems. Currently the geodatabase is the main sources for spatial data to generate thematic maps on water resources availability and management.

In February 2016, the above-mentioned institutions were requested to provide data and information on Ararat Valley to feed into implementation of the tasks of USAID ASPIRED project. Availability and the format of tabular and spatial data received from the mentioned stakeholder institutions are presented in the next sections of this chapter.

## 1.2 Tabular Data Availability

The table below presents the results of tabular data acquisition from the stakeholder institutions identified in the previous section. The mentioned datasets are essential for development of hydrogeological framework and modeling of surface and groundwater balances in Ararat Valley, as well as constructing a comprehensive Management Information System for the Ararat Valley.

**Table 2. Summary of available data on water resources in stakeholder institutions**

<i>Available datasets by stakeholder institutions</i>		<i>Data format</i>	
		<i>Digital</i>	<i>Hard-copy</i>
<b>MINISTRY OF NATURE PROTECTION</b>			
<b>Water Resources Management Agency and Basin Management Organizations</b>			
Data on surface and groundwater abstraction in Ararat Valley for the period of 2009-2015 according to the issued water use permits	electronically in MsExcel format	✓	
Data on surface and groundwater discharge in Ararat Valley for the period of 2009-2015 according to the issued water use permits	electronically in MsExcel format	✓	
<b>State Environmental Inspectorate</b>			
Quarterly and annual data on actual water use in the Ararat Valley by various water users for the period of 2010-2015	electronically in MsExcel format	✓	
Quarterly and annual data on water use fees paid by various water users for the period of 2010-2015	electronically in MsExcel format	✓	
Quarterly and annual data on environmental (pollution) fees paid by various water users in Ararat Valley for the period of 2010-2015	electronically in MsExcel format	✓	
<b>Environmental Impact Monitoring Center</b>			
Monthly data on surface water quality at the 13 water quality sampling posts in and around Ararat Valley for the period of 2009-2015, Including one sampling post on Yerevan Lake, and one on Azat Reservoir	electronically in MsExcel format	✓	
<b>Hydrogeological Monitoring Center</b>			
Monthly data on groundwater discharge and temperature from the groundwater monitoring wells and springs throughout the country including 52 wells and springs of Ararat Valley for 2015	electronically in MsExcel format	✓	
Quarterly data on groundwater quality from groundwater monitoring wells and springs throughout the country including 52 wells and springs of Ararat Valley for 2015	electronically in MsWord format	✓	
<b>MINISTRY OF AGRICULTURE</b>			
Data on operating fish farms in the Ararat Valley (Ararat and Armavir Marzes) for the period of 2013-2015, including number and area of pools and volume of annual fish production for each fish farm	electronically in MsExcel format	✓	

<b>Available datasets by stakeholder institutions</b>	<b>Data format</b>	
	<b>Digital</b>	<b>Hard-copy</b>
<b>State Committee of Water Systems</b>		
Data on technical characteristics of main and secondary canals and pumping stations under the service by Ararat, Artashat and Vedi water user associations (WUAs)	scanned pages in the PDF file	✓
Data on technical characteristics of water supply and sewage network of the Armenian Water Supply-Sewerage Company in Ararat Valley	scanned pages in the PDF file	✓
<b>MINISTRY OF EMERGENCY SITUATIONS</b>		
<b>Armenian State Hydrometeorological Monitoring Service</b>		
Daily average data on atmospheric air temperature for the period of 1961-2015 from 8 meteorological stations around and in the Ararat Valley	electronically in MsExcel format	✓
Monthly and annual average data on precipitation, atmospheric air temperature, relative humidity and snow cover for the period of 1961-2015 from 8 meteorological stations in and around the Ararat Valley	electronically in MsExcel format	✓
Monthly average data on river discharge for the period of 1961-2014 from the 3 hydrological monitoring posts in and around the Ararat Valley	electronically in MsExcel format	✓
Monthly average data on sun radiation for the period of 2000-2015 from 1 meteorological station (Yerevan Agro)	electronically in MsExcel format	✓
<b>MINISTRY OF FINANCE</b>		
Data on values of fish sales, including export and import of fish and fish feed (by directions and type of fish) for the period of 2013-2015	electronically in MsExcel format	✓
Data on revenue, turnover taxes paid by fish farm for the period of 2013-2015, etc.	electronically in MsExcel format	✓

The National Statistical Service of Armenia responded by sending an internet hyperlink from where reports on summary annual information of actual water abstraction and actual wastewater discharge can be downloaded (URL: [http://armstatbank.am/Menu.aspx?rxid=002cc9e9-1bc8-4ae6-aaa3-40c0e377450a&px\\_db=ArmStatbank&px\\_type=PX&px\\_language=hy](http://armstatbank.am/Menu.aspx?rxid=002cc9e9-1bc8-4ae6-aaa3-40c0e377450a&px_db=ArmStatbank&px_type=PX&px_language=hy)).

In general, the ASPIRED Project has been provided with major datasets that were requested. Most of the digital data is in MS Excel format, which is compatible with GIS geodatabases. Those provided in a hard copy will be digitized by the Project team.

Data on surface and groundwater resources, climatology, water use permits are of a higher level of accuracy and completeness. Those provided by the SCWS of the Ministry of Agriculture, as well as Revenues and Customs Services are incomplete with numerous gaps and inaccuracies. In the process of organizing data in the geocoded database, conducting various analyses to meet the Project objectives, inaccuracies revealed will be corrected and gaps will be filled in consultation with relevant stakeholders, as needed (major data gaps are described in Chapter 2 of this report).



### 1.3 Spatial Data Availability

Use of GIS technologies in Armenia started in early 2000s in the framework of a number of internationally funded projects. The assistance projects funded by USAID and World Bank made first attempts to integrate spatial data into decision-making process in Armenia. One of the first activities was development of State Water Cadastre (SWC) as USAID assistance to the Water Resources Management Agency of the MNP. Since 2004 several projects contributed in development of the SWC Information System, which is based on GIS and is currently used by WRMA. During the last 12 years a huge geo-database on water resources has been developed. The spatial data has been accumulated within a number of national and regional projects on water resource management run by DAI, Inc. and PA Consulting (USAID funded), World Bank, and European Union.

This section presents the main spatial datasets of the SWCIS geodatabase that can be used for water management planning process and groundwater resources modelling in Ararat Valley. All the layers are presented in WGS-84 coordinate system, UTM Zone-38N projection.

The Ararat Valley geodatabase currently consists of 6 dataset feature classes, namely: (1) administrative; (2) Hydrology; (3) Monitoring; (4) Environment; (5) Disasters; and (6) Economy. There are about 40 GIS layers accumulated in the mentioned database feature classes.

The “Administrative” dataset feature class of the geo-database includes ten GIS layers to ensure proper design of the main base map of the Ararat Valley. Mainly the layers presented are constructed using the digitization technique from hard copy maps of the scale 1:25,000. This feature class contains also detailed spatial information on the roads within the Ararat Valley with classification to international highways, national roads, and community roads.

The “Hydrology” dataset feature class contains spatial information on the whole river network of Ararat Valley in polyline format. The layers on river network, catchment areas, lakes, reservoirs and canals are digitized from the hard-copy maps of the scale 1:25000 and then adjusted using satellite images. An internationally known coding system ERICA (European Rivers and Catchment Areas) is used to assign unique identifiers to each river section more than 5 km in length.

The dataset feature class on monitoring covers point layers on different monitoring observation and sampling posts located within and around the Ararat Valley, including hydrological and qualitative monitoring of surface water, quantitative and qualitative monitoring of groundwater, as well as locations of current posts of meteorological monitoring network. The Table 3 below summarizes the characteristics of the GIS layers on Ararat Valley that are currently available in the SWCIS geodatabase and at ASPIRED Project.

**Table 3. Summary of available GIS layers on Ararat Valley**

#	Layer name	Type	Source	Scale	Description
<b>“Administrative” dataset feature class</b>					
1	Armenia_Border	Polygon	Digitized from a hard copy map	1:25,000	State border of Armenia
2	Ararat_Valley	Polygon	Digitized from a hard copy map	1:25,000	Boundary of the Ararat Valley in the Republic of Armenia
3	BMO	Polygon	Digitized from a hard copy map	1:25,000	Boundaries of the three basin management areas that

#	Layer name	Type	Source	Scale	Description
					cover the Ararat Valley
4	Marzes	Polygon	Digitized from a hard copy map	1:25,000	Boundaries of the three marzes and Yerevan City that cover the Ararat Valley
5	Provinces	Polygon		1:25,000	Boundaries of 8 provinces that cover the Ararat Valley
6	Communities	Polygon	Digitized from a hard copy map	1:25,000	Boundaries of 185 communities that are within or intersect the Ararat Valley
7	Roads	Polyline	Digitized from a hard copy map, adjusted using satellite imagery	1:25,000	Roads within the Ararat Valley (national, local international highways,)
8	Settlements	Polygon		1:25,000	Settlements within the Ararat Valley with administrative boundaries
<b>“Hydrology” dataset feature class</b>					
9	River_Basins	Polygon	Digitized from a hard copy map, adjusted by GIS ArcHydro extension	1:25,000	Hydrological boundaries of the main river basins within the Ararat Valley
10	Rivers_ Main	Polyline	Extracted from River network layer	1:25,000	Main rivers of flowing through the Ararat Valley
11	River_ Network	Polyline	Digitized from a hard copy map, adjusted using satellite imagery	1:25,000	Rivers and tributaries of Ararat Valley more than 5 km in length
12	Catchment_Areas	Polygon	Generated from <i>River_Network</i> layer using GIS ArcHydro ext.	1:25,000	Delineated watersheds for all river segments more than 5 km in length in the Ararat Valley
13	Lakes	Polygon	Digitized from a hard copy map, adjusted using satellite imagery	1:25,000	Small lakes within and around the Ararat Valley
14	Reservoirs	Polygon		1:25,000	Pond and reservoirs within and around the Ararat Valley
15	Canals	Polyline		1:25,000	Canals within and around the Ararat Valley
16	Area_Specific_ Flow	Polygon		1:500,000	Average river flow zones of Armenia

#	Layer name	Type	Source	Scale	Description
17	Area_Specific_Flow_Max	Polygon	Digitized from a hard copy map / Hydromet Data	1:500,000	Potential flooding prone areas of Armenia
18	Area_Specific_Flow_Min	Polygon		1:500,000	Potential draught prone areas of Armenia
<b>“Monitoring” dataset feature class</b>					
19	Hydrological_Posts	Point	Data from ASH	GPS-ed	Hydrological monitoring posts within and around the Ararat Valley
20	Water_Quality_Posts	Point	Data from EIMC	GPS-ed	Water quality monitoring posts within and around the Ararat Valley
21	Groundwater_Wells	Point	Data from HMC	GPS-ed	Groundwater monitoring observation wells and springs within and around the Ararat Valley
22	Groundwater_Springs	Point		GPS-ed	
23	Meteo_Stations	Point	Data from ASH	GPS-ed	Meteorological observation stations within and around the Ararat Valley
<b>“Environment” dataset feature class</b>					
24	Air_Temperature	Polygon	Digitized from a hard copy map and data form ASH	1:400,000	Temperature zones based on multi-year average values
25	Climate_Zones	Polygon		1:400,000	Climate zones within and around the Ararat Valley
26	Precipitation	Polygon		1:400,000	Precipitation zones based on multi-annual average values
27	Heat_Durations	Polygon	Digitized from a hard copy map	1:400,000	Zones based on the number of sunny days in a year
28	Landscape	Polygon		1:400,000	Landscape zones within and around the Ararat Valley
29	Protected_Areas	Polygon	Layer from MNP (generated by GIZ project)	1:100,000	Boundaries of protected areas within and around the Ararat Valley
30	Soils	Polygon	Digitized from a hard copy map	1:400,000	Soil types within and around the Ararat Valley
<b>“Disasters” dataset feature class</b>					
31	Hails	Polygon	Digitized from hard copy maps	1:400,000	Zones with the risk of hails
32	Landslides	Polygon	Generated bu the JICA project (2012)	GPS-ed	Inventory of landslide prone zones within and around the Ararat Valley
33	Mudflows	Polygon	Digitized from hard copy maps	1:400,000	Inventory of mudflow zones within and around the Ararat

#	Layer name	Type	Source	Scale	Description
					Valley
34	Seismic_Zones	Polygon	Data from National Seismic Survey	1:100,000	Zones with seismic risk within and around the Ararat Valley
<b>“Economy” dataset feature class</b>					
35	Fish_Farms	Polygon	Digitized from a hard copy map	1:200,000	Fish Farms of the Ararat Valley
36	HPP	Point	Digitized from a hard copy map	1:200,000 coordinates need updating	Hydro-power stations within and around the Ararat Valley
37	Industry	Point	Digitized from a hard copy map		Main industrial enterprises within and around the Ararat Valley
38	Landuse	Polygon	Digitized from a hard copy map	1:400,000	Land use type pattern within and around the Ararat Valley
39	Sewage_Canals	Polyline	Digitized from a hard copy map	1:400,000	Sewage canals within and around the Ararat Valley
40	WUA	Polygon	Obtained from Water User Organizations	1:200,000 need updating	Areas under service and areas under irrigation by WUAs within and around the Ararat Valley

In order to perform the detailed calculations of the water balance in the Ararat Valley, the 27-meter resolution ASTER Digital Elevation Model (DEM) was downloaded and included in the spatial geodatabase. In addition, the hill-shade raster image of the Ararat Valley has been generated based on the ASTER DEM, which provides data for calculation of the sloping pattern of the valley.

#### 1.4 Technical Reports and Maps

The following technical reports and hard-copy maps are currently available at ASPIRED project:

- Technical report on inventory of groundwater springs and wells in Ararat Marz (Ararat Valley), (2009) and Technical report on inventory of groundwater springs and wells in Armavir Marz (Ararat Valley), (2009). Both reports are in PDF format and contain data on the inventory of wells and springs of the Ararat Valley performed by the Institute of Water Problems and Hydro-engineering CJSC during 2007-2009.
- Geological map of the Ararat Valley (scale 1:100,000, made by the Hydrogeological Expedition of the Geological Agency of Armenian SSR in 1983) and the Hydrogeological map of the Ararat Valley (scale 1:50,000, made by the Hydrogeological Expedition of the Geological Agency of Armenian SSR in 1983). Both maps need to be georeferenced and digitized.

In addition to these datasets, the ASPIRED Project has acquired from the National Academy of Sciences paper copies of the well log of nearly 70 groundwater wells in the Ararat Valley. These

well logs contain data on location of the well and detailed lithological structure. These datasheets are being currently digitized by the ASPIRED Project in a format agreed with the USGS and HMC, and will be further used in constructing the hydrogeological framework of the Ararat Valley.

Since the Project launch, the technical team has been conducting a desk work on reviewing studies, reports, articles, scientific papers and other documentation available on the web and other sources for collecting data needed for determining water flow direction, volumes and watershed boundaries of a larger Ararat Valley, including a part on the Turkish territory.

## CHAPTER 2. IDENTIFIED DATA GAPS

### 2.1 Tabular Data

Based on the analysis of the available tabular data on Ararat Valley, several gaps were identified, which are presented below.

In order to calculate the water balance of the Ararat Valley there is a need to obtain **monthly and annual average data on total evaporation** for the period of 1961-2015 from the same eight meteorological stations where the data on precipitation had been received from. Those stations include: (1) Ararat; (2) Urtsadzor; (3) Artashat; (4) Yerevan Agro; (5) Ashtarak; (6) Armavir; (7) Aragats Mountain; (8) Talin.

Another weak component, in terms of data availability, is on compliance assurance. The only authorized agency for compliance assurance is the State Environmental Inspectorate, which, according to legislation supervises the implementation of norms and requirements of water resources use and protection by water users. It includes monitoring of compliance of of water extraction from the surface and ground water resources and quality of wastewater discharges (except of radioactive materials) with volumes and conditions set respectively in the water use permit. Inspection by SEI is performed only once a year for the sampled and prioritized water users and even less often for the non-prioritized sources. No digital spatial data is available since GPS devices have never been used while conducting inspections. Additionally, the SEI is responsible for maintaining the data received from the water users on volume of actual water used and discharged and payments made for water use and pollutants discharged.

However, by analyzing the summary data on water use in the Ararat Valley, it should be mentioned that the database on **actual volumes of monthly and annual groundwater use and discharge** for the period of 2009-2015 is incomplete and it does not provide an accurate picture on actual volumes of groundwater use for various purpose, including drinking and municipal, irrigation, fish farming, industrial, etc.

Other set of data that was not provided is **well logs (“well passports”)**, which contain information on the lithological structure of the wells and data on technical characteristics (such as well casing, captage structure, fittings, etc.) recorded at the time the well was drilled. The hard copy of the well logs is kept in the Republican Geological Fund of the MENR. In addition, there is a need to access the **reports** of the Ministry of Nature Protection on **closure and conservation of the abandoned and illegally operated wells** of Ararat Valley for the period of 2014-2015. Those reports should contain information on the exact locations (GPS-ed geographic coordinates) of all the wells identified as "abandoned" or "illegally operated

There are also gaps on data on water infrastructure for the period of 2009-2015 to be provided the SCWS of the MA:

- monthly and annual discharge water measuring points on the main canals of Ararat Valley;
- discharge of groundwater springs and wells used for irrigation purposes and for drinking-municipal purposes in the Ararat Valley;
- volume of water pumped seasonally and annually from the pumping stations;
- monthly and annual discharge in the measurement points of the drainage network;
- monthly and annual volumes of water release from Azat and Aparan reservoirs.

Data on currently operational fish farms in the Ararat Valley provided by the Ministry of Agriculture is partially inaccurate. There are fish farms mentioned as closed/not operational in the lists, which, in fact are operational.

There are big gaps in a database of the Tax Service on taxes paid by fish farmers in 2013-2015 - about 70% of the database lacks figures. Data on annual volumes of fish feed imported to Armenia provided by the same Service for the period of 2013-2015 are being checked as a part of analyses conducted for determining optimal rate for groundwater resources use in the Ararat Valley for fish farming.

The following efforts will be made by the ASPIRED Project team for filling in the above described data gaps:

- Monthly and average data on total evaporation: in April-May the Project team will work with the State Hydrometeorological Monitoring Service on acquiring these datasets.
- Actual volumes of monthly and annual groundwater use and discharge, groundwater well logs, data on currently operational fish farms in the Ararat Valley: datasets to be generated in a result of inventory of groundwater wells, springs and fish farms which is currently underway will cover these gaps. The results of the inventory are expected to be finalized in September 2016.
- Reports of the Ministry of Nature Protection on closure and conservation of the abandoned and illegally operated wells: the Project team will collaborate with the WRMA in receiving these reports in April-May.
- Data on water infrastructure: the Project team will continue collaborating with the SCWS and WUAs, BMOs, other partner organizations (World Bank, Asian Development Bank, etc.) for filling in the gaps.
- Data on taxes paid by fish farmers in 2013-2015 - the Project team will be conducting survey of the fish farms in the Ararat Valley in March-May, as a part of Project activities targeted at analysis of optimal rates of the groundwater use fee for fish farming in the Ararat Valley. The survey results will be used for filling in this gap.

In the process of organizing the data in the geocoded database, conducting various analyses to meet the Project objectives, inaccuracies revealed in the datasets will be corrected and gaps will be filled in consultation with relevant stakeholders, as needed.

## 2.2 Spatial Data

In present the geodatabase of the SWCIS of the WRMA contains a huge number of GIS layers on water and environment of the country, including the Armenian section of the Ararat Valley. However, in order to perform proper analysis of surface and groundwater resources in the Valley as well as to model the groundwater aquifers, there are specific spatial data needs which are presented in the paragraphs below.

The geographic coordinates of all the groundwater wells and springs in the Ararat Valley are currently identified as part of the inventory conducted by the ASPIRED Project Subcontractor in the Ararat Valley. The results of the inventory will lead to new GIS layers on the **exact locations of all the groundwater wells and springs as well as fish farms in the Ararat Valley**. These locations

will be then linked to the lithological structure of the wells and are essential for the groundwater modeling of the groundwater aquifers in the Ararat Valley.

**Land use** spatial data for the Ararat Valley is scarce and not systemized. Some of the data resides in the communities, and the parameters of data greatly vary from one community to another. The land use data is available within the “community master plans”, which are owned by the State Committee on Real Estate Cadastre. The Committee does not work openly and often tries to “sell” data to anybody interested.

The ASPIRED Project will be collaborating with the USAID Global Development Lab and its GeoCenter in acquiring multi-spectral high-resolution satellite imagery for Ararat Valley (preferably from RapidEye Co) for the summer months of 2016 and **conduct** the land cover classification for the Ararat Valley, including groundtruthing during the spring 2017.

It is also preferable to get the **10-meter resolution DEM** for the whole Ararat Valley, including the Turkish section. Compared to 27-meter ASTER DEM, the use of 10-meter DEM will increase the accuracy of calculations when determining the water balance and water supply and demand balance of the Ararat Valley. There are two approaches to get the 10-meter resolution DEM: (1) to procure the product from RapidEye Co; or (2) obtain contour lines of the Ararat Valley from 1:10,000 scale cadastral maps and then generating DEM of the Ararat Valley using the obtained contour lines.

In addition the following spatial data/maps are still lacking:

- Service areas and irrigation areas of the WUAs within the Ararat Valley;
- Drainage-collector network of the Ararat Valley;
- Irrigation infrastructure in the Ararat Valley, including: map of irrigation infrastructure and geographic coordinates of locations of water measuring points on the main canals,
- Locations of the pumping stations within the Ararat Valley;
- Map on area-specific flow (flow module) of the rivers within the Ararat Valley;
- Map on geological faults within the Ararat Valley.

The ASPIRED Project will work with the SCWS, WUAs and other stakeholder organizations on acquiring data and maps of the water infrastructure. As per the area-specific flow GIS layer, it could alternatively be obtained after calculation of water balances for all catchment areas within the Ararat Valley.

### **2.3 Data on the Turkish Section of the Ararat Valley**

The major part of the Ararat Valley is located in the territory of Turkey. In order to conduct hydrological and hydrogeological analysis of the whole Ararat Valley the minimum required datasets from the Turkish section are as follows:

- Exact boundary of the Turkish section of Ararat Valley and its catchment area;
- Boundaries of administrative units within Turkey;
- River network (rivers and tributaries of more than 5km in length);
- Hydrological boundaries of river basins;
- Catchment areas of the rivers of more than 5km in length;



- Natural lakes and artificial reservoirs;
- Main and secondary canals;
- Settlements (both point type and polygonal with administrative boundaries);
- Road network;
- GPS-ed locations of meteorological stations (Igdir and Kars);
- GPS-ed locations of hydrological and surface water quality monitoring points;
- GPS-ed locations of groundwater quantitative and qualitative monitoring points;
- Locations of the groundwater wells and springs;
- Surface water and groundwater abstraction and wastewater discharge for the recent 5 years.

In addition to the mentioned spatial data, it is desirable to obtain tabular data on multi-annual groundwater flows into the Ararat Artesian Basin from the Turkish territory. This will be used for generating the maps on area-specific flow (flow module) for the whole Ararat Valley. The Project will cooperate with USAID Global Development Lab, Jefferson Fellowship Program, USGS and other partners in the process of acquiring these datasets.

The Project team understands the difficulty of obtaining these datasets. An extensive desk-work has been conducted by the technical team studying various reports, articles, scientific papers and other documentation available on the web for determining groundwater water flow direction, volumes, and boundaries. Data on multiannual average precipitation, air temperature and evaporation data for the Eastern part of Turkey (Igdir and Kars regions) that is available in scientific articles, reports available on the web will be used for generating parameters of water balance of the Ararat Valley.

## CHAPTER 3. RECOMMENDATIONS ON CREATING A COMPREHENSIVE MANAGEMENT INFORMATION SYSTEM FOR THE ARARAT VALLEY

The ASPIRED Project will utilize the datasets available and to be generated during Project implementation on the Ararat Valley to create a comprehensive, reliable data system for informed management decisions. This will include implementation of a number of activities aimed at addressing data gaps and towards creating a comprehensive management information system on Ararat Valley (Ararat Valley MIS) than can be integrated into the SWCIS of the WRMA. The structure and relationships proposed in the Ararat Valley MIS are presented in Annex A.

As an initial phase of constricting the Ararat Valley MIS, a number of technical steps are recommended to be performed as follow:

- **Link** the existing tabular hydrological and meteorological datasets with the corresponding GIS layers under the “Monitoring” dataset feature class within the Ararat Valley geodatabase. Thus, the “Hydrological\_posts” GIS layer will be joined with available historical data on water level and water discharge, while the “Meteo\_stations” GIS layer will be linked with the historical data precipitation, evaporation, atmospheric air temperature, relative humidity and snow cover.
- **Link** the existing groundwater monitoring datasets with the corresponding GIS layers “Groundwater\_wells” and “Groundwater\_springs” under the “Monitoring” dataset feature class within the Ararat Valley geodatabase.
- **Transform** the existing tabular datasets on w7ater abstraction and wastewater discharge according to water use permits in Ararat Valley in GIS layers under the “Economy” dataset feature class within the Ararat Valley geodatabase.
- Based on the results of the inventory of groundwater wells, springs and fish farms of the Ararat Valley **develop** a comprehensive tabular relational database that will include also the lithological structure of the groundwater wells. MsAccess is proposed for the database in order to facilitate its further incorporation in the Ararat Valley geodatabase.
- **Transfer** the datasets on inventory of groundwater wells, springs and fish farms of the Ararat Valley in a separate “Inventory” dataset feature class within the Ararat Valley geodatabase, which will contain three point GIS layers.
- **Digitize** the geological map of the Ararat Valley and **create** a new GIS layer on geological formations under the “Geology” dataset feature class within the Ararat Valley geodatabase.
- **Digitize** the hydrogeological map of the Ararat Valley and **create** a new GIS layer on hydrogeological zones under the “Geology” dataset feature class within the Ararat Valley geodatabase.
- Upon availability, **digitize** the collectors, drainage network, irrigation infrastructure and pumping stations of the Ararat Valley and **create** new GIS layers within the “Hydro\_technical\_structures” dataset feature class of the Ararat Valley geodatabase.
- Upon availability of data on service and irrigation areas of water user associations on the Ararat Valley, **adjust** the existing GIS layer on WUAs under the “Economy” dataset feature class within the Ararat Valley geodatabase.
- **Acquire** a multi-spectral high-resolution satellite imagery for Ararat Valley (preferably from RapidEye Co) for the summer months of 2016 and **conduct** the land cover classification for the Ararat Valley, including groundtruthing during the spring 2017.

- **Adjust** the existing GIS layer on settlements, roads, river basins, river network, ponds and canals. **Incorporate** the results of the landcover classification into the Ararat Valley geodatabase as a separate feature class.

After completed, the Project will work with the WRMA on incorporating the Ararat Valley MIS into the SWCIS. The Project will provide an extensive capacity building program for the representatives of stakeholder agencies, including the WRMA and its Ararat, Hrazdan and Akhuryan BMOs, HMC and SEI in operating and mandating the MIS.

## ANNEX A: STRUCTURE OF THE ARARAT VALLEY MIS

