



**USAID**  
FROM THE AMERICAN PEOPLE

**Advanced Science & Partnerships for  
Integrated Resource Development  
(ASPIRED) Project**

## **Decision Support Tools, including Ararat Valley Groundwater Basin Modeling**

***Lilith Harutyunyan***  
***Project Specialist***

**Armenia Marriott Hotel**  
**22 March 2019**



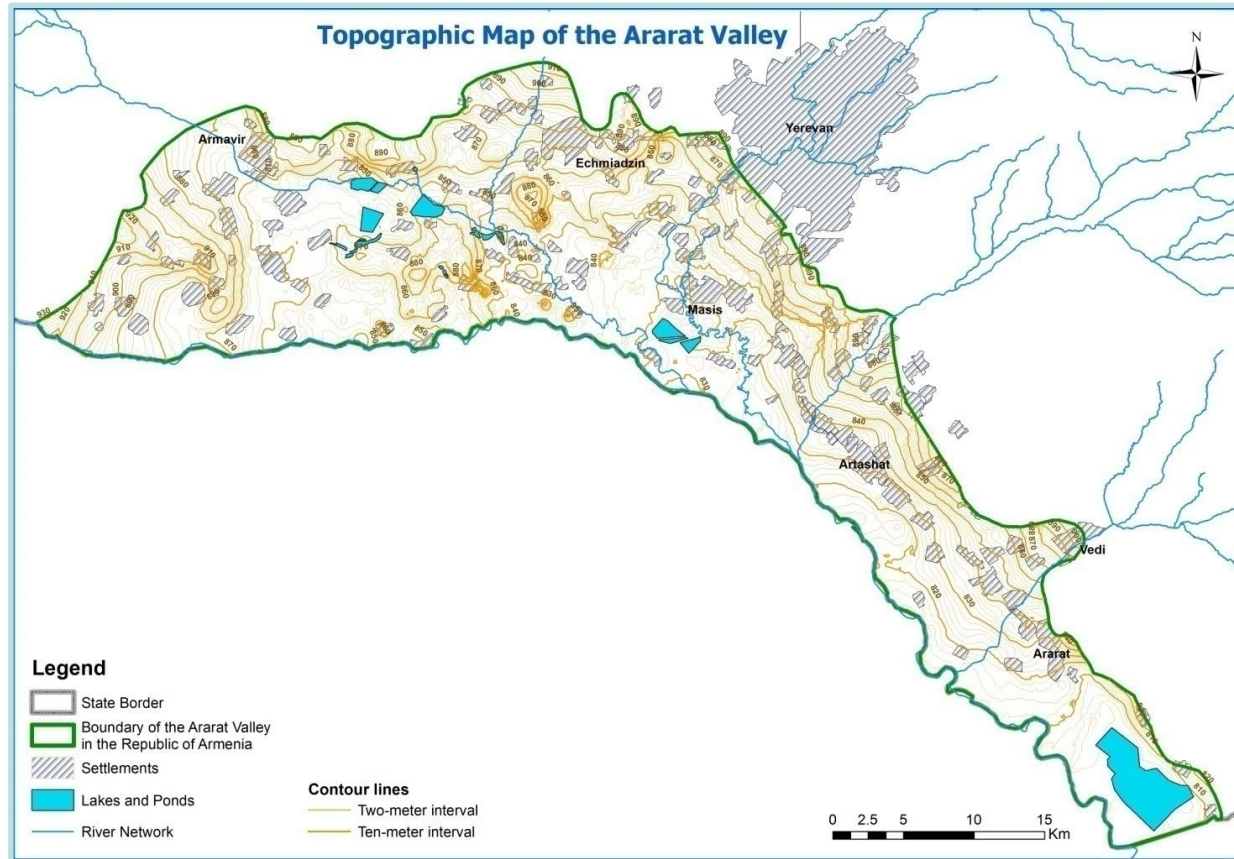
**USAID**  
FROM THE AMERICAN PEOPLE

## Decision Support Tools

- ✓ Customizing the Decision Support System (DSS) for Ararat Valley
  - Water balance
  - Climate change assessment
  - Water supply and demand balance, including calculation of ecological flow values
- ✓ Developing the 3D model of the Ararat Valley groundwater basin
- ✓ Constructing the numeric groundwater flow model of the Ararat Valley

***Activities are implemented in close collaboration with the US-based CADI and AQUAVEO organizations and the US Geological Survey***

## Study area



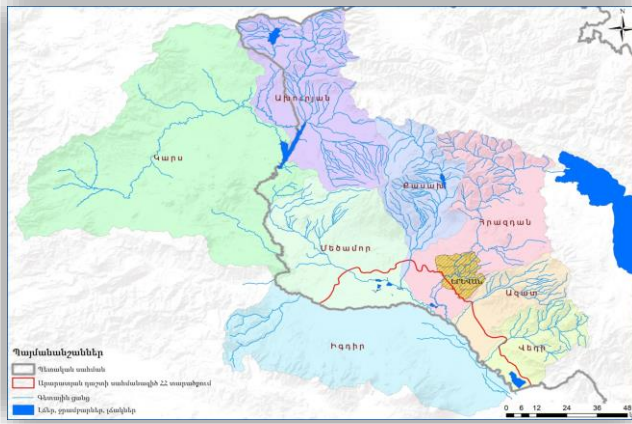
Ararat Valley is located at elevations ranging from 800 to 930 m above sea level and occupies an area of 1177 km<sup>2</sup> in Armenia



**USAID**  
FROM THE AMERICAN PEOPLE

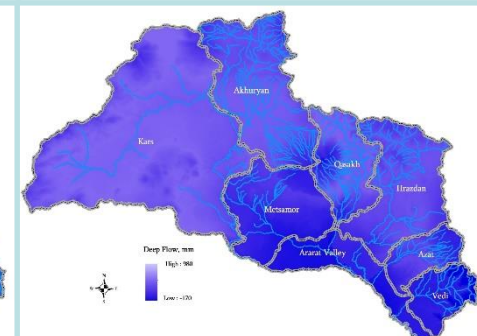
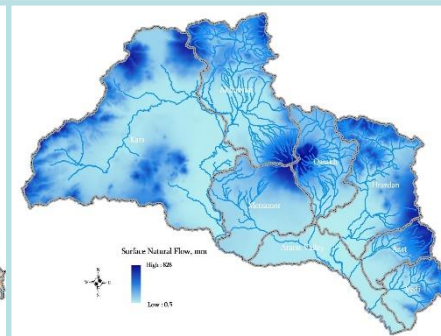
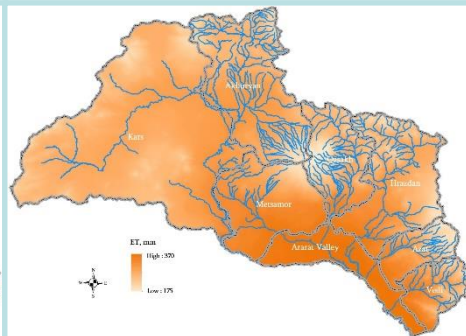
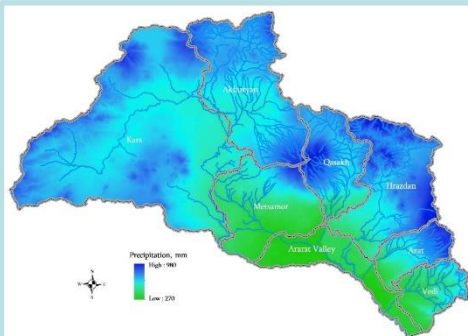
## Customizing the DSS for the Ararat Valley

**Ararat Valley catchment area:** annual water balance for 2016 and multiannual average water balance for the period of 1961-2016



**Ararat Valley catchment area:**

Akhuryan (including Kars), Metsamor (including Qasakh), Hrazdan, Azat, Vedi river basins

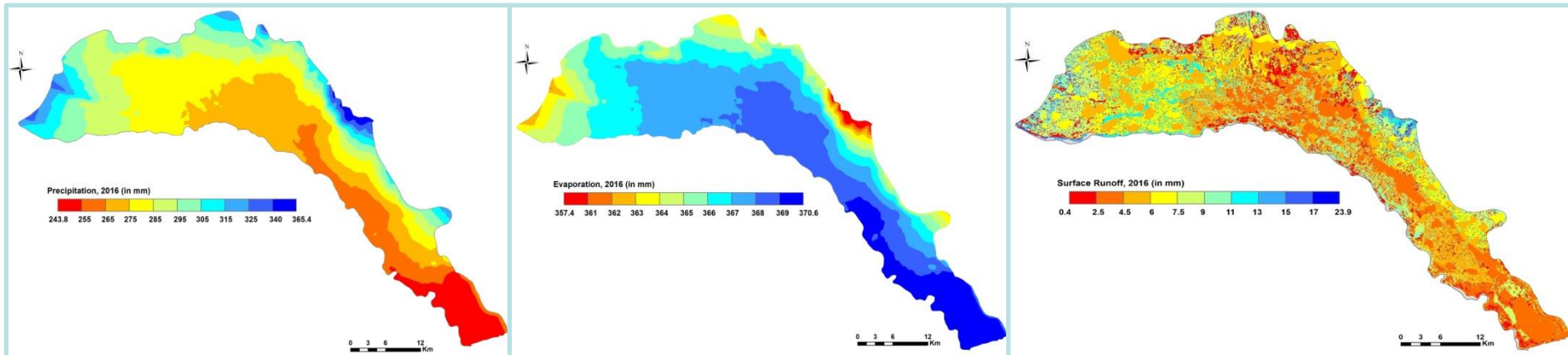




**USAID**  
FROM THE AMERICAN PEOPLE

## Customizing the DSS for the Ararat Valley

**Ararat Valley:** annual water balance of the for 2016 and multiannual average water balance for the period of 1961-2016



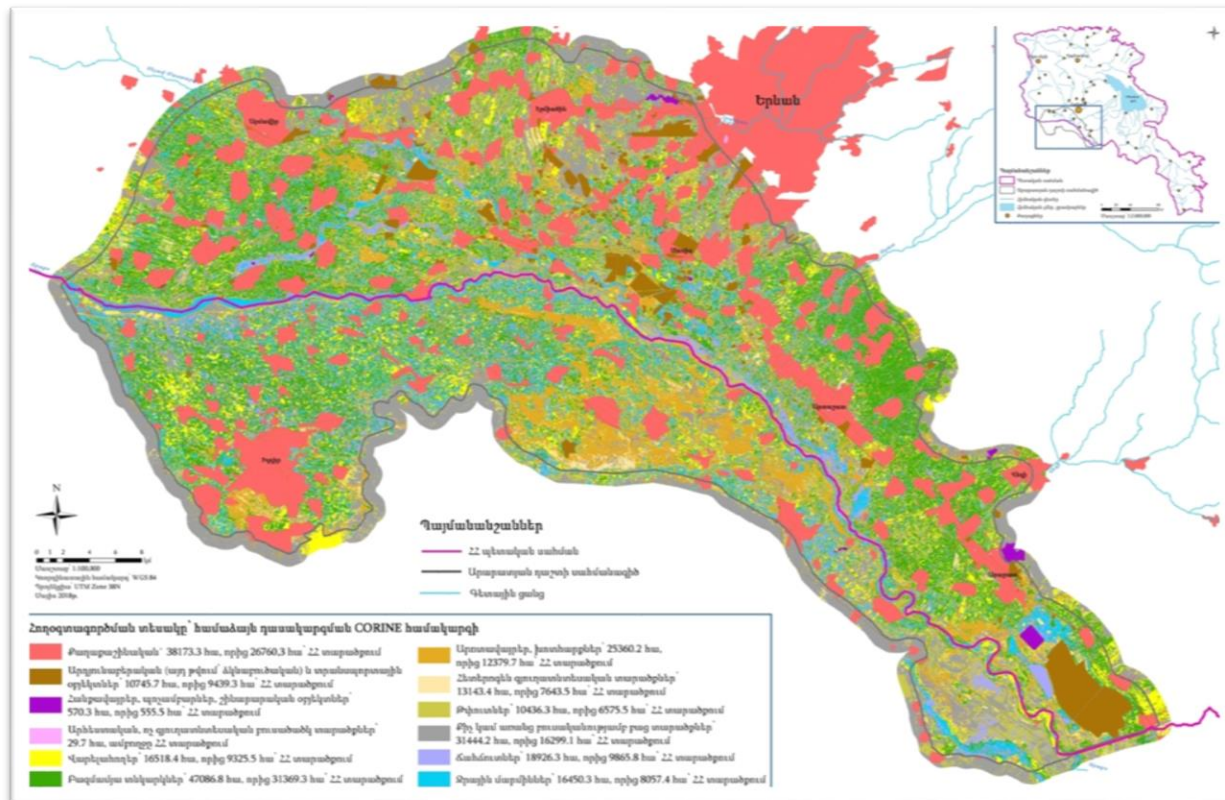
### **Data sources:**

- Service of Hydrometeorology and Active Influence on Atmospheric Phenomena of the Ministry of Emergency Situations of Armenia
- Water Resources Management Agency of the Ministry of Nature Protection of Armenia
- Water Committee of the Ministry of Energy Infrastructures and Natural Resources of Armenia



## Customizing the DSS for the Ararat Valley

Classification of the actual landcover/use of the Ararat Valley for 2016, applying remote sensing analysis of the high-resolution satellite images

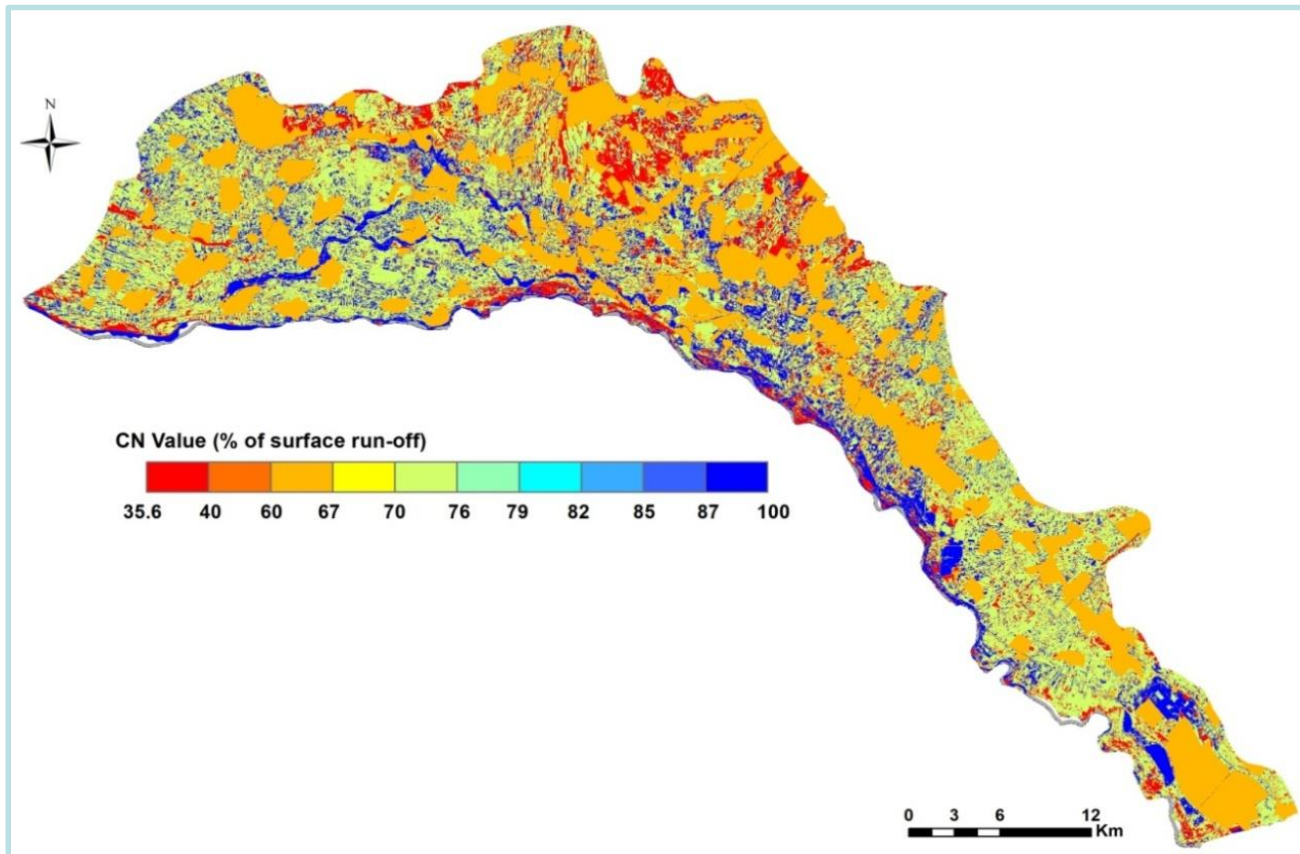




**USAID**  
FROM THE AMERICAN PEOPLE

## Customizing the DSS for the Ararat Valley

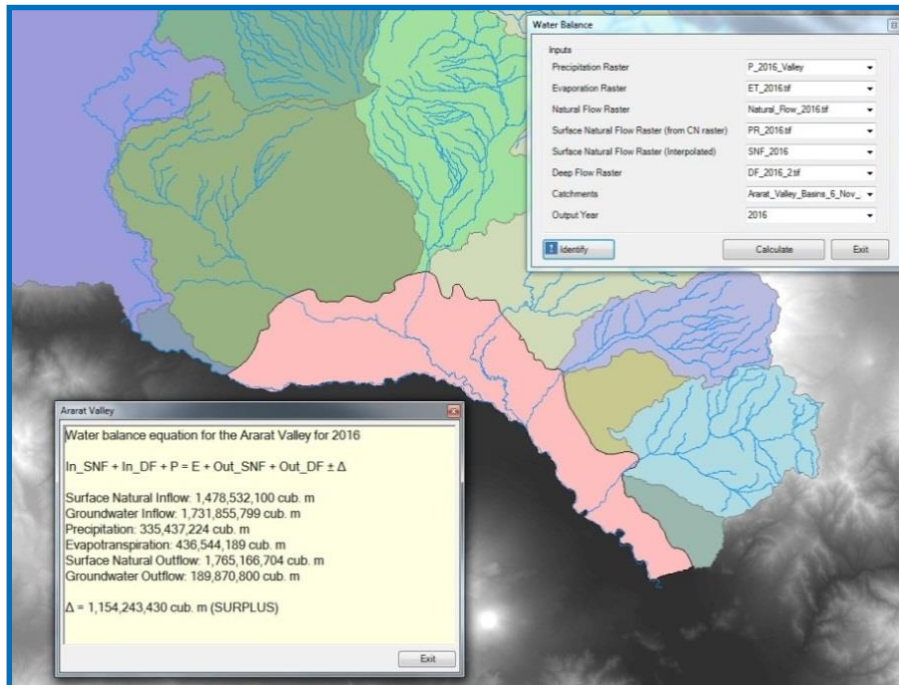
Generating precipitation-runoff raster image of the Ararat Valley for 2016



## Customizing the DSS for the Ararat Valley

Annual water balance of the Ararat Valley for 2016

$$P + SW_{in} + GW_{in} = ET + SW_{out} + GW_{out} + \Delta$$



$$P = 335.4 \text{ million m}^3$$

$$SW_{in} = 1,478.5 \text{ million m}^3$$

$$GW_{in} = 1,731.9 \text{ million m}^3$$

$$ET = 436.5 \text{ million m}^3$$

$$SW_{out} = 1,765.2 \text{ million m}^3$$

$$GW_{out} = 189.9 \text{ million m}^3$$

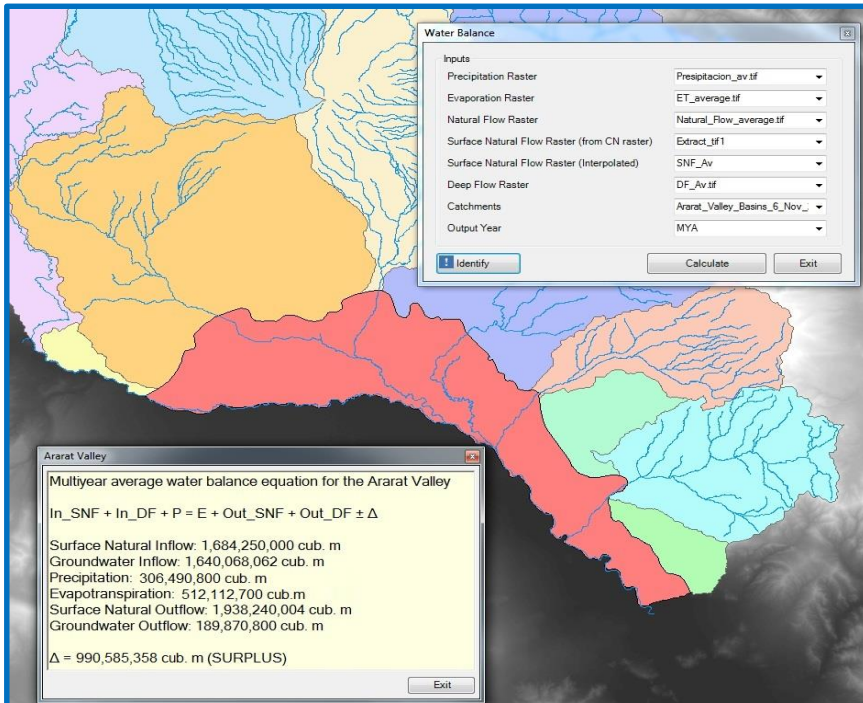
$$\Delta = 1,154.3 \text{ million m}^3$$



## Customizing the DSS for the Ararat Valley

Multiannual average water balance of the Ararat Valley for the period of 1961-2016

$$P + SW_{in} + GW_{in} = ET + SW_{out} + GW_{out} + \Delta$$



$$P = 306.5 \text{ million m}^3$$

$$SW_{in} = 1,684.3 \text{ million m}^3$$

$$GW_{in} = 1,640.0 \text{ million m}^3$$

$$ET = 512.1 \text{ million m}^3$$

$$SW_{out} = 1938.2 \text{ million m}^3$$

$$GW_{out} = 189.9 \text{ million m}^3$$

$$\Delta = 990.6 \text{ million m}^3$$



**USAID**  
FROM THE AMERICAN PEOPLE

## Customizing the DSS for the Ararat Valley

### Climate change assessment: trends

Deviations in climatic and hydrological parameters occurred in the period of 1991-2016 against the average values in the base period (1961-1990)

- ✓ Annual mean air temperature: from +0.3 °C to +0.6 °C
- ✓ Annual mean precipitation: -3.0 mm
- ✓ Runoff depth: from -0.2% to -19.4 %



**USAID**  
FROM THE AMERICAN PEOPLE

## Customizing the DSS for the Ararat Valley

### *Climate change assessment: projections*

- Projection of values of the natural surface inflow and outflow and groundwater inflow and outflow for the Ararat Valley under the different climate change scenarios (A2, B1).



**USAID**  
FROM THE AMERICAN PEOPLE

## Customizing the DSS for the Ararat Valley

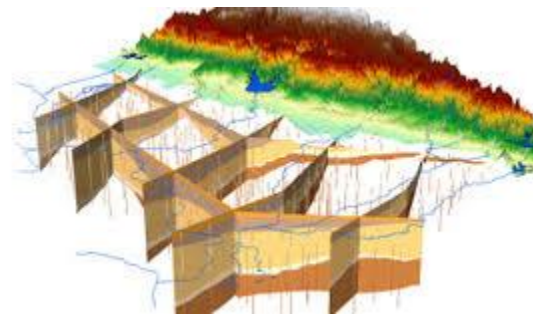
- ✓ Calculation of the water supply and demand balance of the Ararat Valley for 2016 to estimate surplus or deficit of water resources in conditions of water use
- ✓ Calculation of ecological flow at hydrological observation posts and water abstraction points



**USAID**  
FROM THE AMERICAN PEOPLE

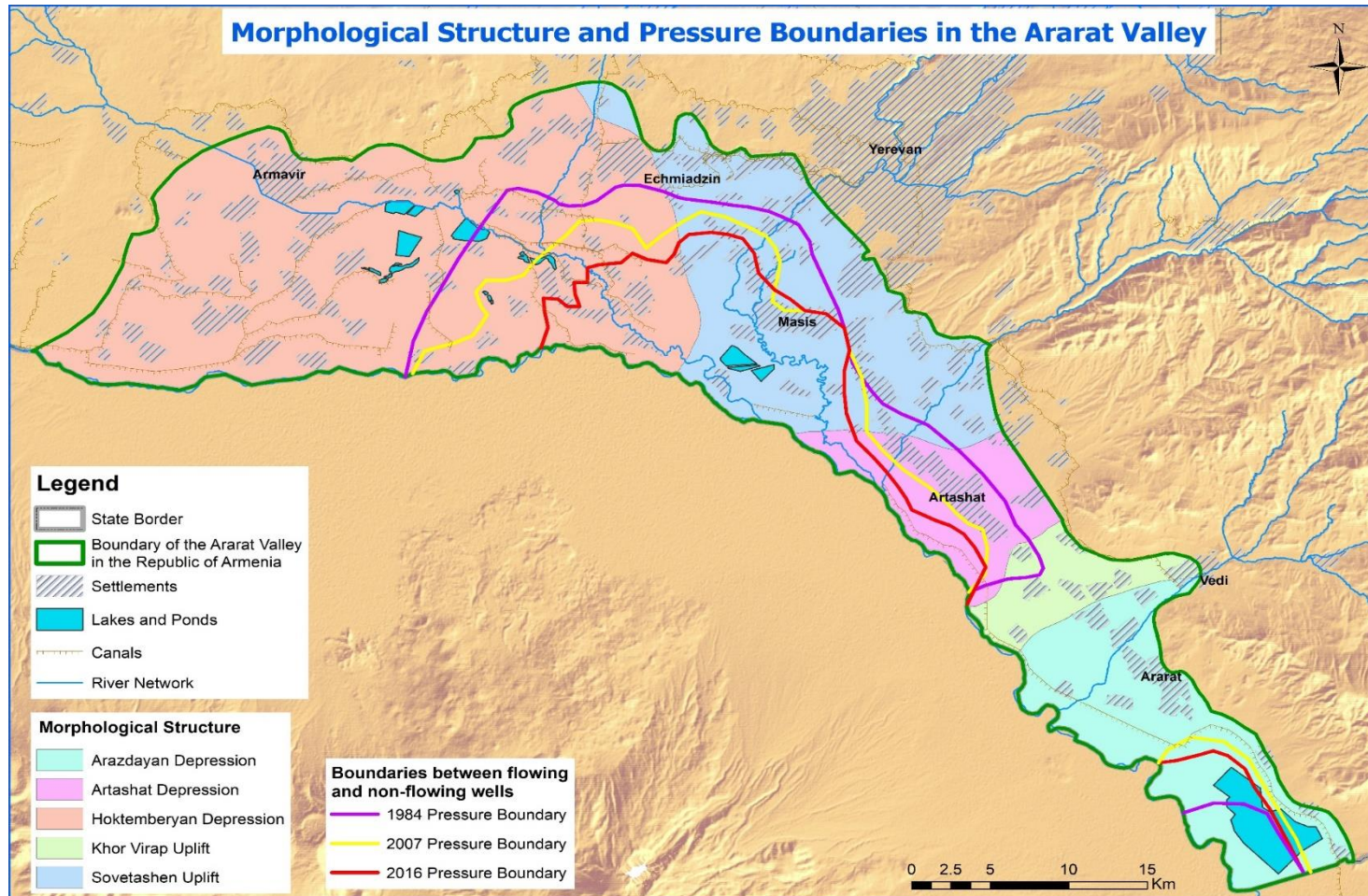
# 3D Model of the Ararat Valley Groundwater Basin

**ArcGIS and Arc Hydro Groundwater Tools**





## Pressure Boundaries in the Ararat Valley



1984 - 42298 ha

2007 - 32107 ha

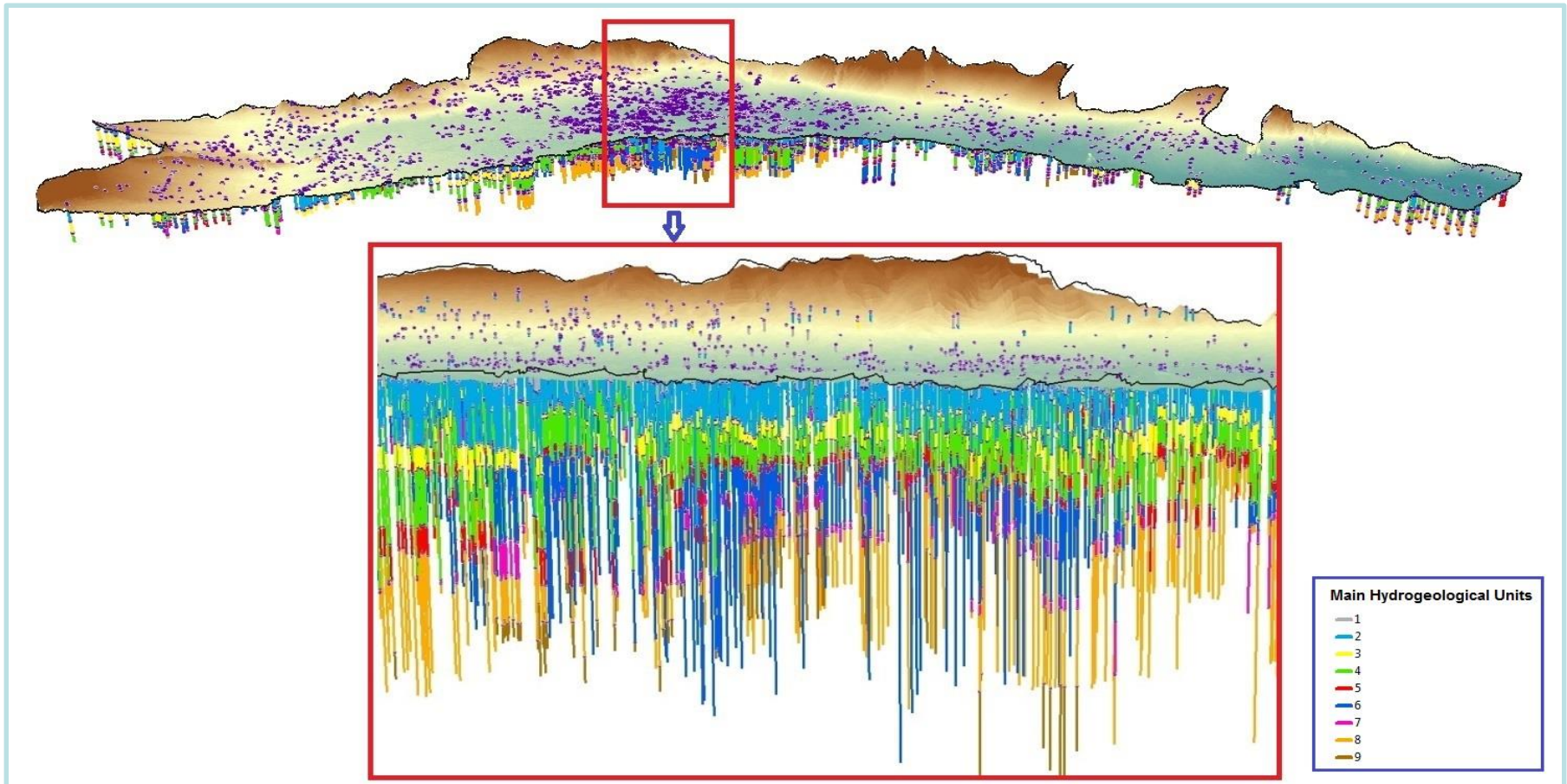
2016 - 22366 ha



**USAID**  
FROM THE AMERICAN PEOPLE

# Constructing the 3D Model of the Ararat Valley Groundwater Basin

Based on the 2016 inventory data on 2800 wells

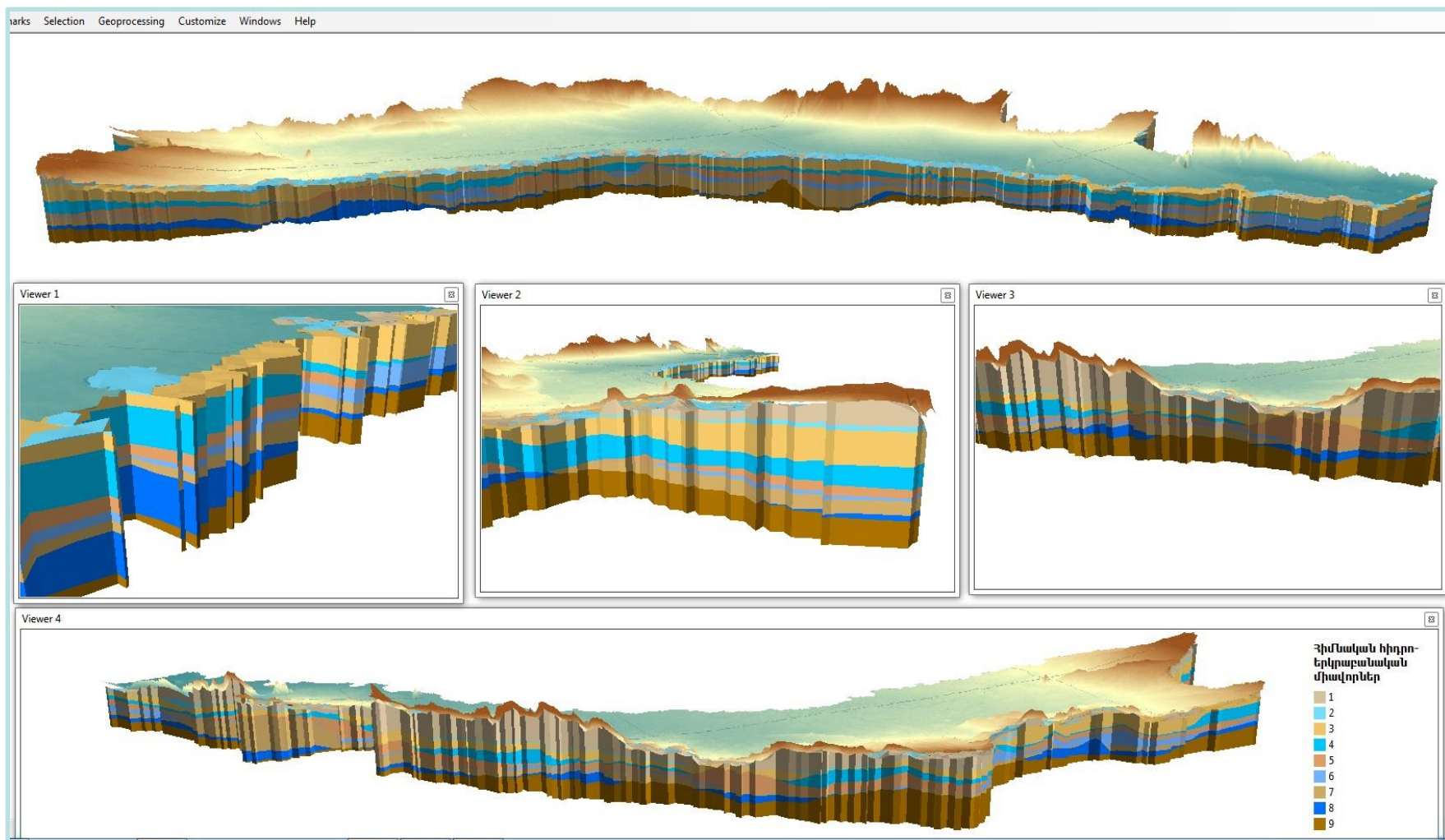






**USAID**  
FROM THE AMERICAN PEOPLE

## Main Hydrogeological Units of the Ararat Valley Groundwater Basin





## Main Hydrogeological Units of the Ararat Valley and the Potential Volumes

- ✓ Volume of 4 layers with **high** water bearing potential: 56 billion m<sup>3</sup>
- ✓ Volume of 5 layers with **low** water bearing potential: 149.5 billion m<sup>3</sup>
- ✓ Total potential volume of all 9 layers: 205.5 billion m<sup>3</sup>

Unit ID	Primary geological material	Lowest absolute altitude of the bottom of the layer (m)	Highest absolute altitude of the bottom of the layer (m)	Average thickness of the unit (m)	Water-bearing potential	Volume (m <sup>3</sup> )
1	Loam/clay	800.1	940.8	8	Low	6,330,194,705.51
2	Gravel	781.3	933.7	32	High	6,209,862,654.76
3	Clay	745.1	912.7	14	Low	39,370,744,226.27
4	Gravel	738.1	887.5	27	High	20,747,927,834.63
5	Dense basalt/clay	731.2	869.1	9	Low	26,290,435,682.97
6	Gravel	705.1	879.9	17	High	12,987,106,831.46
7	Dense basalt/clay	642.7	826.8	10	Low	33,278,242,350.14
8	Gravel/fractured basalt	638.5	828.5	23	High	16,109,360,935.98
9	Dense clay	630.0	756.6	22	Low	50,605,160,940.10
Total volume of the layers with <b>high</b> water-bearing potential						<b>56,054,258,256.83</b>
Total volume of the layers with <b>low</b> water-bearing potential						<b>149,544,583,199.48</b>
Grand total volume						<b>205,598,841,456.31</b>



**USAID**  
FROM THE AMERICAN PEOPLE

## **Constructing the Numeric Groundwater Flow Model of the Ararat Valley**

This will allow determining:

- ✓ Groundwater reserve
- ✓ Recharge rate and changes in groundwater reserve, conditioned by water use in the Ararat Valley for various purposes
- ✓ Operational groundwater resources (sustainable rate of groundwater use)

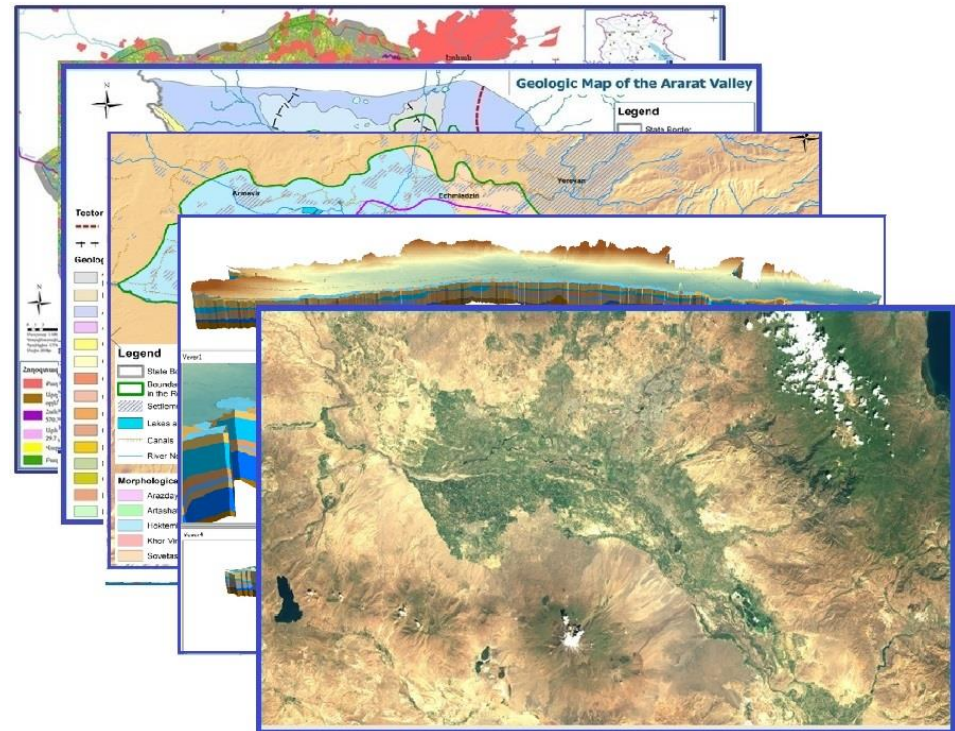




**USAID**  
FROM THE AMERICAN PEOPLE

## Building Stakeholders Capacities

- ✓ Continuous training on ArcGIS mapping, modeling with DSS ArcHydroGroundwater, GMS and MODFLOW tools
- ✓ Preparing the Ararat Valley Atlas, using geospatial data and maps





**USAID**  
FROM THE AMERICAN PEOPLE

**Thank you**