Chapter 2 Lake Sevan

General overview of the problem

Lake Sevan is in the central part of the Republic of Armenia, at an altitude of 1900m above sea level. The total surface area of its catchment basin is about 5000 km^2, the lake surface itself is 1200 km^2, and the volume is 35.8 billion cubic meters. The lake is fed by 28 rivers in its catchment area, and only one, the Hrazdan River, flows out of the lake.

Lake Sevan is the only large water body of Armenia and has an important role in the water balance of the whole South Caucasus as well as the northern regions of Iran and Turkey. It is the main strategic supply source of drinking water for Armenia and neighboring countries.

The use of lake waters for irrigation started in 19th century, and from the beginning of 20th century its waters were also used for energy production, to address the country's energy deficit. Drawdown of the water level in the lake began in the 1930s.

The original scheme at this time planned to direct lake waters through the Hrazdan River to the Ararat Valley, to irrigate 100 000 ha of land. Over 50-60 years, the water level in the lake was expected to fall up to 50 meters, corresponding to 93% of its volume (54.55 cubic meters), and completely draining the Big Sevan. If this plan had been followed, the water level would have fallen by 6 times.

Based on this scheme, facilities to use Lake Sevan's water were built, including an irrigation system for 80 000 ha; the Sevan-Hrazdan hydroelectric power station, with total power of 556 000 kilowatt, was finished in 1962 with the completion of last step of a series of hydroelectric power stations for Yerevan.

The Lake's water level started falling in 1933, when the drainage of its waters for economic use exceeded the natural yearly inflow. More intensive use began in 1949. In 1953, 1.75 billion cubic meters were taken.

Before the water level of Sevan started falling, the lake was an oligotrophic reservoir with a slow release of its waters, with a complete renewal every 44.3 years, high water clarity (average of 13-14 meters) and high oxygen levels during the year.

As a result of this brutal use of water, the level of the lake has fallen by 19.6 meters, its volume of water from 58.5 billion cubic meters to 33.0 billion cubic meters, and its area from 1416.2 km^2 to 1238.1 km^2. During the years of most intensive water use (1949-1962), the water level fell 13 meters (1m per year).

From an environmental point of view, this quick reduction in water level played a key role in the destabilization of the lake's ecological indicators, which led to the following negative consequences: reduction in water temperature stratification, reducing the hypolimnion volume up to 50% in the Small Sevan (from 13 km^2 up to 6 km^2) and its complete disappearing in the Big Sevan.

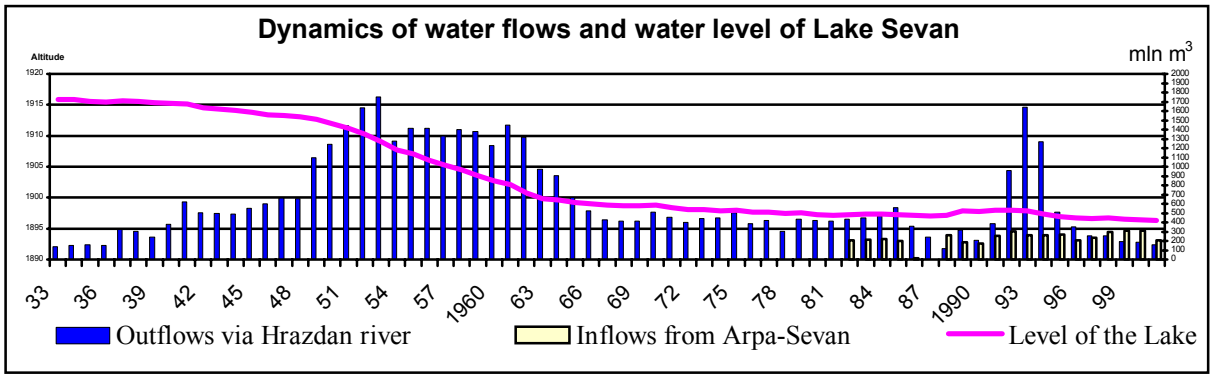

Figure 4.2.1
Source of Information: Ministry of Nature Protection;

The reduction in the hypolimnion raised the average temperature of the lake by up to two degrees, increasing the longevity and intensity of horizontal and vertical flows. As a consequence, concentrations of suspended and dissolved organic substances increased several times in the upper and middle water layers of the lake; during their oxidation, the concentration of dissolved oxygen in the lake falls from 8.0 to 3.0 mg O^2/l. Concentrations of minerals and general nitrogen in the lake increased up to 30 times (from 0.01 till 0.32 g/m^3), and the concentration of phosphorus decreased 20 times (from 0.32 to 0.017 g/m^3). This led to the intense assimilation of oxygen and phosphorus by macroalgae, which promoted to the height increase. Water clarity, which plays crucial role in physical-chemical and biological processes, decreased by four times (from 13 to 3 m).

Major changes in biodiversity occurred in the biota of the lake's ecotones, where many species of aquatic and terrestrial flora and fauna lived, supporting the trophic level of the littoral zone of the lake.

Because the lake has a rocky bed, spawning Sevan trout disappeared in the aquatic part of the ecotone: this is one of the main reasons for the irreversibility of the loss of generative lake species.

In the period from 1993 till 1995, a mass death of whitefish was observed, due mainly to the reduction of their food base within the framework of the general ecological situation in the Sevan ecosystems.

In the shore part of the ecotone of the lake, as consequence of the drying of more than 1000 ha of wetland areas, out of the 167 species of endemic and migrating birds once present 18 are now found. The number of mammal species has fallen sharply.

At present, there is an intensive process of desertification.

The reintroduction of lost elements is a very important precondition for the ecological restoration of the lake. Even if the water level achieves some stability, the increasing inflow of organic elements sooner or later will result in the super saturation of organic substances of the lake. At the present stage, the lake is in a mesotronic condition, close to eutrophication. The main consequence of this process, which began in the 1970s, is the reduction in dissolved oxygen at the near-bottom layer of the lake: and in 1975, oxygen starvation was observed, accompanied by the appearance of methane and hydrogen sulphide.

As a result, very deep, in some cases even irreversible changes took place: for example, a sharp reduction in the biomass of large water plants (macrophytes). Because of aforementioned changes in the lake, deep abnormalities of ecosystem took place, and in the middle of 1970s the lake began to blossom with macroalgae. This started the eutrophication of the Sevan.

Studying the mechanism of eutrophication has shown that to slow this process, it is necessary to use ecosystem regulation for both the lake and its catchment basin, by which the inflow of biogenic substances into the lake will be reduced.

It has been shown that for the de-eutrophication of the lake, it is necessary to:

- increase the level of the lake by 6 meters, to the level that will bring the reappearance of the hypolimnion;
- review and from the ecological point of view regulate all socio-economic activity on the territory of the lake's catchment basin, because pollution in drainage waters is also a serious problem;

Activities to manage Lake Sevan issues

To increase the water level of the lake, it is necessary to increase water inflows, using flows from neighboring water basins, and to reduce outflows of water. For this purpose, in 1962 major construction was started for infrastructure to transfer part of the Arpa River flow to the lake. It was planned to transfer about 250 million of cubic meters of water per year to the lake. The Arpa-Sevan Tunnel was inaugurated in 1981.

To change the output of the Sevan-Hrazdan system, a new hydroelectric power station was built. For irrigation, part of the water coming from the lake was exchanged with waters from the Ararat Valley. These measures allowed, beginning in 1965, a significant reduction of lake water outflows, bringing outflows of water down to 500 million cubic meters per year, of which 380 million cubic meters were used for irrigation and 120 million cubic meters for energy production. Energy use stopped in 1978. After these measures, the lake level increased to 0.9 meters from 1981-1990.

From 1991 to 2000, as the result of use of water during the energy crisis, the level of the lake again decreased by 1.5 meters.

To increase water inflows to the lake, after the completion of the Arpa-Sevan Tunnel, construction of the Vorotan-Arpa Tunnel began. This should supplement the lake with 165 million cubic meters of water per year. Construction of the Vorotan-Arpa Tunnel is planned to finish in 2003.

According to the yearly water balance of the lake, because of the above-mentioned transfers, and without other changes in the balance water, the lake's level should increase up to 12 cm per year.

To improve Lake Sevan's conditions, from 1996 to 1998, with the financial help of World Bank, the ***Program of Reconstruction of the Ecological Balance of Lake Sevan*** was prepared. This included improvements in legislation and management to increase the lake's water level, reduce pollution in the drainage basin, improve industrial and other waste management, reduce of non-point source pollution, protect the reproduction of fish supplies and provide biodiversity protection.

Considering the importance of Sevan for the Republic, in 2001 the National Parliament of the Republic of Armenia adopted the Law on Lake Sevan. Based on this law, Lake Sevan is now considered an environmental, economic, social, scientific, historical-cultural, esthetic, health, climatic, recreational and cultural entity that has strategic significance as a source of drinking water. Each year, complex programs of measures with regard to the ecosystem, reconstruction, protection, reproduction and use of Lake Sevan are to be elaborated and adopted.

In 2002, outflows from the Sevan were only 98.3 million cubic meters of water. Since the 1930s, massive outflows from Lake Sevan began, there hasn't been such a low removal of water. Comparison with 2001, Lake Sevan's water level increased 44-45cm.

Anticipated results.

A 6-meter increase in the level of the Lake would mean an additional 9 billion cubic meters of water in the Lake, deemed a strategic natural resource for energy and other branches of the economy.

Gradually, the exogenous pollution of the Lake will diminish, and favorable conditions will be created for the Lake to purify itself and for biological features to be restored.

An integrated and controllable system of water use management will be developed as a result of improving the water supply and sewage networks in the settlements in the catchment basin of the Lake and implementing outflow and inflow measures.

Efficient mechanisms will be established for basin biological diversity preservation and sustainable use, to ensure the normal development of the ecosystem and its components.

A realistic opportunity will emerge to introduce a consolidated system for the recreation sector in the Lake and in its catchment basin: an income generating, labor intensive and environmentally friendly sector for the region.