Lessons Learned in Armenia

By Robert Kurkjian and Matthew Karanian

June 2008, “Water Efficiency” magazine, The Journal for Water Conservation Professionals

---

“Water is the best of all things,”—Pindar, Greek poet, circa 500 B.C.

Access to safe water is essential for human health and development. Early civilizations settled in areas where there was enough water to support their populations, or they wandered from place to place in search of water. Today, industrial societies use water excessively, and, often indiscriminately, for bathing, landscaping, irrigating crops, manufacturing, generating power, and for recreation. Adequate water is not only necessary for humans, however, but also to sustain ecosystems. Wetlands and other ecosystems must receive sufficient water supplies to maintain a healthy environment for the species they support.

In the US and around the world, water shortages have become a critical issue that local and national governments must immediately address. In Armenia, the drinking water and wastewater infrastructure has deteriorated and irrigation systems have degraded since Armenia’s independence in 1991. Consequently, there is pollution of potable water sources, a lack of rational allocation of water resources, and inadequate management of trans-boundary waters. However, Armenia is in a position to address and mitigate many water problems, by promoting conservation, and by implementing institutional controls and financial incentives.

Figure 1.

Figure 2

Quantity and Distribution

Armenia is a landlocked country [Figure 1] and the smallest among the republics of the Former Soviet Union; yet, it is relatively rich in water resources [Figure 2]. If all water resources are considered, Armenia has a water supply of more than 3,000 cubic meters per capita per year. The water is unevenly distributed throughout the country, however, and, according to government reports, there are water shortages in certain areas throughout Armenia. It is estimated that 5% of the population live in these areas with water shortages. Other parts of the country have available water resources, but they have inadequate water storage and infrastructure facilities, deficient maintenance practices to address leakage in the systems, and inadequate conservation initiatives.

Melting snow, rainfall, and groundwater seasonally replenish Armenia's surface water resources. Because of this, river flow in Armenia fluctuates widely throughout the year. In the summer months, June through August, when the water demand is highest, only about one fourth of the yearly flow is available. In the winter months from December through March, the flow is around 10% of the yearly total. River flow during spring accounts for between 55% and 70% of the yearly flow.

Reservoirs have been constructed throughout Armenia to store water in an effort to help alleviate seasonal shortages, to regulate river flow, and to serve the needs of the energy sector, the fishing industry, and recreation. According to Armenia's Ministry of Nature Protection, there are more than 70 reservoirs, which have a total water storage capacity of more than 990 million cubic meters. The largest reservoir is the Akhurian Reservoir in northwestern Armenia, which has a capacity of 535 million cubic meters.

Photo: Robert Kurkjian

The Hrazdan River, the only river from which Lake Sevan's waters are discharged, is channeled and used for the generation of hydroelectric power and for agricultural irrigation.

Photo: Robert Kurkjian

A young boy collects drinking water from the community spigot in his village.

There are thousands of rivers in Armenia, but only six are more than 100 kilometers in length. There are two main watersheds: the Kura River system in the north, which drains about 40% of the waters, and the Araks River system in the west, which drains roughly 60%. Both of these rivers ultimately drain into the Caspian Sea. Irrigation is by far the largest water use sector, and accounts for roughly 70% of the water withdrawn each year in Armenia. During the 1980s, nearly 80% of the agricultural lands were irrigated. In the years immediately following Armenia's independence in 1991, irrigation of agricultural lands decreased by an estimated 45%. This occurred largely because there was not enough electricity being generated to pump the water to higher elevations. Industrial water use also peaked in the 1980s, but decreased by as much as 60% during the 1990s, due to the economic crisis and the associated decline in industrial operations.

The Challenge of Lake Sevan

The natural lakes in Armenia are relatively small, with the exception of Lake Sevan, which has a surface area of 1,250 square kilometers and occupies about 4% of Armenia's total land area. The Lake Sevan basin lies at an elevation of 1,916 meters and occupies about 4,900 square kilometers, which is approximately 16% of the Armenian territory. The volume of lake water is roughly 35 billion cubic meters. Consequently, the lake has a central hydrological role in Armenia.

Despite its importance to the nation's ecology and economy, the health of Lake Sevan has been allowed to fall into great peril. Beginning in the 1930s, the Soviet government embarked on a scheme to reduce the surface area of the lake as a means of reducing evaporation and thus increasing the commercial availability of its water. The lake bottom could also be farmed, or so it was thought. For several decades, vast quantities of water were released from the lake. By the 1970s, the water level of the lake had decreased by about 19 meters (more than 62 feet), and the water volume had been reduced by more than 40%. The consequences of this plan are still being dealt with today.

There are 28 rivers that flow into the lake, but only one that flows out, the Hrazdan River. By intentionally increasing the flow into the Hrazdan River, the water generated energy by cascading through six hydroelectric stations, before draining to the Ararat Valley for use in irrigation. Water quality at Lake Sevan has been deteriorating for decades, because of the intentional lowering of the lake's water level and from external pollution loads. The lowering of the water level resulted in increasing the average water temperature. The rise in water temperature, in turn, disrupted the ecology of the lake. Furthermore, agricultural runoff and sewage discharges have increased nutrient levels, causing eutrophication. The lake's water quality and ecosystem continue to be threatened by pollution from point sources, such as sewage and industrial discharges, and from nonpoint sources, such as agricultural pollution runoff. The condition of the lake is a matter of widespread national concern, and scientists have been studying how to best restore the delicate balance of its ecology.

It is not expected that the lake will, or can, be restored to its pre-1930 level. To help compensate for the excessive water withdrawals and to restore the lake's ecological condition, however, water has, since 1982, been transferred to the lake through a 48-kilometer tunnel from the Arpa and Yeghegis Rivers. An average of about 250 million cubic meters of water per year has been diverted to the lake through this tunnel. In 1981, the construction of another tunnel was begun. The 21-kilometer-long tunnel was designed to supply an additional 165 million cubic meters of water per year to the lake from the upper Vorotan River. Construction was stopped in the 1990s because of lack of funds, but was completed a decade later. The consequences of redirecting water to Lake Sevan from other streams have not been well studied.

Photo: Matthew Karanian

The Shaki Waterfall in central Armenia is one of the country's many sources of hydroelectricity.

Photo: Robert Kurkjian

Most drinking fountains throughout Armenia are always flowing, resulting in wasted water.

Many regulations and laws have been promulgated to protect the quantity and quality of the lake's water, including, in 2001, the Law on Lake Sevan, which treats the lake as a resource of strategic significance. According to this law, it is envisaged that the water level should rise by 20 centimeters each year for about 30 years. Under this law, the water level of the lake is projected to rise, roughly by the year 2030, to 1,903 meters above sea level. By the end of 2007, the level had already reached 1,898 meters, and some observers expect the projected level of 1,903 meters will be reached in half the projected 30-year timeline, thanks in part to unexpectedly high levels of annual precipitation.

A larger Lake Sevan with a higher surface water level is expected to decrease eutrophication and improve the water quality of the lake. The government has budgeted funds to deforest the areas subject to inundation, to limit the amount of organic matter that enters the lake. There are social costs, however, and these are presenting an obstacle to the lake's recovery. Raising the lake's water level would flood many roads and developed areas, in addition to the forested areas that the government plans to clear. A dispute has arisen from the interests of the owners of improved properties along the lakeshore—properties that will be submerged beneath the expanded lake under the law's plan. Although properties built within six meters of the lake's shore lie within an exclusion zone—an area within which no buildings could ever lawfully have been erected—the owners of these hotels, lodges, and private homes are lobbying Armenia's government to restrict the rise of the water level to only 2 meters, rather than 6. The lower water level would save many of their homes and businesses from inundation.

Scientists who have studied the lake ecosystem insist, however, that a water level rise of less than 6 meters would be inadequate to improving the ecological situation and water quality of the lake. Since 1999, more than 1,000 acres of land have become submerged beneath the lake's higher waters. By the time the lake reaches its target level of 1,903 meters, roughly 10,000 acres will have become submerged.

Groundwater Resources

Groundwater resources are also distributed unevenly in Armenia. It is estimated that 300 million cubic meters of ground water is available for use throughout the country. Deep ground water resources are generally of high quality, but the shallow aquifers are at risk of contamination or have been impacted by anthropogenic activities. This is the case for large areas in the Ararat Valley, a significant agricultural zone, where industrial discharges and agricultural practices have impacted water resources.

Poor drainage and leaking irrigation systems have flooded low-lying areas in the Ararat Valley and have led to a rise of the water table. This, in turn, has provided breeding grounds for mosquitoes and has resulted in a resurgence of malaria during the past decade. The waterlogged land is also partly responsible for the salinization and alkalization of the soils in the Ararat Valley. Rehabilitation of irrigation systems throughout Armenia is essential to decrease leakage, as well as to reduce the deterioration of soils from water logging, salinization, and alkalization. Irrigation efficiency in the 1990s was estimated at less than 55%, and was much lower in some areas, reflecting the poor condition of pumps, canals, and pipes.

Photo: Matthew Karanian

Melted Snow forms an intermittent stream down Mt. Aragats, Armenia's highest mountain (13,435 feet).

Photo: Robert Kurkjian

The waters of Lake Sevan cover 4% of the land area of Armenia. If a plan to partly restore the water of the diminished lake is fulfilled, some 10,000 acres will be submerged for the first time since the 1930s.

In the Ararat valley, contaminants in the shallow aquifer often exceed drinking water quality limits. This water, however, is used primarily for irrigation and not for drinking purposes. Presently, Armenia does not have water quality standards for irrigation water, and the development of stringent water quality standards are fundamental to ensure human health and to preserve soil and water quality. Leaks from water distribution pipes in municipal water supplies have been estimated to account for 30% to 55% of water losses in domestic supply systems.

The World Bank recently supported a project to upgrade Yerevan’s drinking water distribution system by installing new pipes, water pumps, and, for the first time, water meters. Water service has improved and most households in Yerevan now have 24-hour water supply. Meters are almost universal in Yerevan and revenue collection for water has increased significantly. The meters provide a motive for conservation of water in individual households. The outdoor water fountains that run continuously could be fitted with spring-loaded valves, thereby wasting very little water. Methods used in the US, such as education of consumers and installation of water-efficient appliances would also greatly reduce the water demand. Additionally, industrial water needs to be conserved, recycled, and appropriately treated prior to discharge.

Deep ground water resources in Armenia are generally of high quality and are well protected from contaminants, due to favorable geologic conditions. These conditions include the depth of the aquifers, which often have clay layers above them that act as barriers. In some areas, upward pressure prevents contaminants from infiltrating the groundwater. Shallow aquifers, however, may become contaminated from industrial discharges, from agricultural activities such as the application of pesticides, and from waste dumps, improper land filling, and industrial activities. Fortunately, only the deeper aquifers in Ararat Valley are used for drinking water.

Groundwater accounts for approximately 96% of the drinking water supplied to the public. The drinking water sources are of relatively high quality. However, once the water is distributed through the aging municipal piping systems in Armenia, it can be contaminated with various pollutants from untreated sewage. Because of the lack of financial resources, there is not adequate maintenance, monitoring, or treatment of drinking water to prevent water-borne disease.

During the 1990s, the discharge of industrial waste into surface waters significantly decreased because of Armenia’s economic crisis. Waters have continued to receive inadequately treated sewage, and urban and agricultural runoff, however. Drinking water, groundwater, and surface water quality have not been adequately monitored since Armenia’s independence. Furthermore, the full extent of groundwater and surface water contamination has not been accurately delineated, due to insufficient environmental assessments and lack of reliable data.

Water, Wetlands, Biodiversity

Wetlands, which are the transitional zones between land and water, have been long recognized for their ecological importance. Wetlands are particularly species-rich systems and are valued because of their high biodiversity. Wetland plants also filter and cleanse surface waters by consuming nutrients, including natural and chemical fertilizers, and by trapping solids, metals, and bacteria.

Human activities have severely impacted wetlands worldwide. In Armenia, water drainage and peat mining have adversely affected wetlands. About 20,000 hectares of wetlands have been drained, which threatens Armenia's biodiversity. It is estimated that 140 species of vertebrates are ecologically dependent on wetlands. There are also approximately 100 species of wetland birds in Armenia.

In 1993, Armenia became a signatory to the Ramsar Convention on Wetlands of International Importance. The sites included on the Ramsar list are Lake Sevan and its basin (489,100 hectares), and Lake Arpi and its surrounding bogs (3,139 hectares). No other ecosystem type has an international treaty signed by more than 130 countries to ensure its protection. This attests to the importance of wetlands in water resources management and biodiversity conservation.

The Lake Gilli watershed, located in the southeastern corner of the Sevan basin, is one of Armenia's most popular birding sites. This area was once a complex wetland ecosystem. Lake Gilli was the focal point of the watershed and had a water surface area of about 860 hectares. It had been a major habitat for migratory waterfowl and aquatic species until the early 1960s, when the lake was drained so that the lake bottom could be used for agriculture.

Today, the area is mostly dry with open peat mines and croplands. As a result, the entire Sevan basin now has fewer bird species than had previously existed in the Gilli area alone. Many wetland bird species are now registered in the Armenian Red Book of endangered species. Despite the loss of this wetland area, the Gilli area is still considered an important birding location, because it is located on the international flyway of many migratory waterfowl species. Thus, many species had stopped at Gilli for weeks at a time to feed on the flyway. The reed overgrowth provided an important nesting place for a numerous bird species. Scientists believe that if Gilli is restored, many bird species will return and that Gilli would once again play a major role in conserving Armenia's biological diversity. Further, Gilli's ecosystem, which had acted as a cleaning reservoir where rivers deposited their sediments, might once again act as a wetlands filter that biologically cleans the water before it flows into Lake Sevan.

In the Ararat Valley, the shallow groundwater and flooding of the Araks River created more than 150,000 hectares of swamps and wetlands. These wetlands, which existed until about 50 years ago, were breeding grounds for mosquitoes carrying malaria. During the 1950s, the wetlands were drained and the land was transformed for agricultural use. With the disappearance of these wetlands, mosquitoes perished and malaria all but disappeared. There were undesirable environmental consequences, such as the disappearance of wildlife species and significant changes in the habitat and distribution of migrating birds. During the past decade, there has also been a resurgence of malaria due to extensive agricultural water leaks and inefficient water practices.

Historically, limited attention has been given to the ecological need for water resources in Armenia. This includes maintenance of wetlands and protection of other ecosystems. Cooperation among governments, non-governmental organizations, universities, and lending institutions, regarding local and regional wetland conservation issues, is necessary to protect the region's diverse plant and animal species.

Water Law and Conservation Policy

A new Water Code was adopted in 2002, to replace the version that had been inherited from the Soviet era. The main purposes of the Code are the conservation of the national water reserve, and the satisfaction of the water needs of citizens and of the economy, through effective management of usable water resources.

In accordance with the new code, a Water Resources Management Agency and five River Basis Management Organizations were formed and operate under the mandate of the Ministry of Nature Protection. A National Water Policy was instituted in 2005 and a draft National Water Program was developed one year later. These laws serve as the basis for an integrated water resources management plan.

Clearly, legislative efforts are underway to develop a comprehensive water conservation and management scheme in Armenia. The efforts have met some criticism for having created too much government. The management challenge, say critics, will be to find a way to streamline cooperation among the overlapping mandates of the various monitoring and enforcement agencies.

Water resources are expected to play a key role in Armenia's continued economic development, and competition for water between hydropower, irrigation, industry, and the environment will increase. Predicted reductions in precipitation resulting from global climate change will only reduce the amount of available water. However, an integrated water resources management plan coupled with a water conservation education campaign would provide Armenia with sufficient water resources for all sectors of the economy and the environment for the foreseeable future, and safe drinking water supply for its population.

Robert Kurkjian, PhD, is an environmental consultant in Pasadena, CA. Matthew Karanian is a lawyer in Los Angeles. They are both the authors of numerous books and articles on Armenia, and are coauthors of "The Stone Garden Guide: Armenia and Karabagh," a travel guide that promotes eco-tourism and environmental conservation. For more information about the book, go to www.StoneGardenProductions.com

References

Adamian, M.S. and D. Klem. 1999. *Handbook of the Birds of Armenia*. American University of Armenia, Yerevan.
Economic Commission for Europe. 2000. *Environmental Performance Reviews Armenia, United Nations*. New York and Geneva.
Gleick, P, H. 1993. *Editor of Water in Crisis: A Guide to the World's Fresh Water Resources*. Oxford University Press.
International Development Association. 2006. *Armenia: Reaping the Benefits of Steady Reforms.*
Karanian, M. and R. Kurkjian. 2006. Stone Garden Guide: Armenia and Karabagh. Stone Garden Productions, Los Angeles, California.
Kurkjian, R., et al. 2004. Long-range downstream effects of urban runoff and acid mine drainage in the Debed River, Armenia: new insights from lead isotope modeling, *Applied Geochemistry*, 19(10), 1567-1580.
Kurkjian, R. 2000. Metal Contamination in the Republic of Armenia, *Environmental Management* 25 (5): 447-483.
Ministry of Nature Protection of the Republic of Armenia. 2002. *National Report, State of the Environment*, Yerevan.
UNDP. 2006. A*rmenia–New Water Code, National Water Policy and National Water Program*.
Vardanyan, M., et al. 2005. *Towards Integrated Water Resources Management in Armenia*.
Water Code of the Republic of Armenia. Adopted by the National Assembly of the Republic of Armenia on June 4, 2002.
World Bank. 1999. *Lake Sevan Action Program*.

Article and photographs provided courtesy of Robert Kurkjian and Matthew Karanian.

Their ecology and conservation images from Armenia can be viewed at www. ArmenianPhotography.com and at www.StoneGardenProductions.com