AvH6-15, 2010
6th Alexander von Humboldt International Conference

Global change and water resources in the next 100 years

M.C. Larsen and R.M. Hirsch
Water Resources Division, U.S. Geological Survey, Reston, VA, United States (mclarsen@usgs.gov)

We are in the midst of a continental-scale, multi-year experiment in the United States, in which we have not defined our testable hypotheses or set the duration and scope of the experiment, which poses major water-resources challenges for the 21st century. What are we doing? We are expanding population at three times the national growth rate in our most water-scarce region, the southwestern United States, where water stress is already great and modeling predicts decreased streamflow by the middle of this century. We are expanding irrigated agriculture from the west into the east, particularly to the southeastern states, where increased competition for ground and surface water has urban, agricultural, and environmental interests at odds, and increasingly, in court. We are expanding our consumption of pharmaceutical and personal care products to historic high levels and disposing them in surface and groundwater, through sewage treatment plants and individual septic systems. These substances are now detectable at very low concentrations and we have documented significant effects on aquatic species, particularly on fish reproduction function. We don't yet know what effects on human health may emerge, nor do we know if we need to make large investments in water treatment systems, which were not designed to remove these substances. These are a few examples of our national-scale experiment.

In addition to these water resources challenges, over which we have some control, climate change models indicate that precipitation and streamflow patterns will change in coming decades, with western mid-latitude North America generally drier. We have already documented trends in more rain and less snow in western mountains. This has large implications for water supply and storage, and groundwater recharge. We have documented earlier snowmelt peak spring runoff in northeastern and northwestern States, and western montane regions. Peak runoff is now about two weeks earlier than it was in the first half of the 20th century. Decreased summer runoff affects water supply for agriculture, domestic water supply, cooling needs for thermoelectric power generation, and ecosystem needs. In addition to the reduced volume of streamflow during warm summer months, less water results in elevated stream temperature, which also has significant effects on cooling of power generating facilities and on aquatic ecosystem needs.

We are now required to include fish and other aquatic species in negotiation over how much water to leave in the river, rather than, as in the past, how much water we could remove from a river. Additionally, we must pay attention to the quality of that water, including its temperature. This is driven in the US by the Endangered Species Act and the Clean Water Act. Furthermore, we must now better understand and manage the whole hydrograph and the influence of hydrologic variability on aquatic ecosystems. Man has trimmed the tails off the probability distribution of flows. We need to understand how to put the tails back on but can't do that without improved understanding of aquatic ecosystems.

Sea level rise presents challenges for fresh water extraction from coastal aquifers as they are compromised by increased saline intrusion. A related problem faces users of 'run-of-the-river' water-supply intakes that are threatened by a salt front that migrates further upstream because of higher sea level.

We face significant challenges with water infrastructure. The U.S. has among the highest quality drinking water in the world piped to our homes. However, our water and sewage treatment plants and water and sewer pipelines have not had adequate maintenance or investment for decades. The US Environmental Protection Agency estimates that there are up to 3.5M illnesses per year from recreational contact with sewage from sanitary sewage overflows. Infrastructure investment needs have been put at $5 trillion nationally.

Global change and water resources challenges that we face this century include a combination of local and national management problems that are already upon us, as well as emerging and future problems that are closely associated with rising temperature and changes in precipitation distribution in time and space.