Prepared in cooperation with the Afghanistan Geological Survey
under the auspices of the U.S. Agency for International Development

Availability of Water in the Kabul Basin, Afghanistan

Importance of Water Availability in the Kabul Basin

The availability of water resources is vital to the social and economic well being and rebuilding of Afghanistan. Kabul City currently (2010) has a population of nearly 4 million and is growing rapidly as a result of periods of relative security and the return of refugees. Population growth and recent droughts have placed new stresses on the city's limited water resources and have caused many wells to become contaminated, dry, or inoperable in recent years. The projected vulnerability of Central and West Asia to climate change (Cruz and others, 2007; Milly and others, 2005) and observations of diminishing glaciers in Afghanistan (Molnia, 2009) have heightened concerns for future water availability in the Kabul Basin of Afghanistan.

Role of the USGS in Evaluating Water Availability in the Kabul Basin

The U.S. Geological Survey (USGS), under an agreement funded by the United States Agency for International Development (USAID), has been working with the Afghanistan Geological Survey (AGS) and the Afghanistan Ministry of Energy and Water (MEW) since 2004 to address questions about future water availability in the Kabul Basin that have arisen as a result of population growth in the region and the potential effects of climate change on the basin's water resources. As part of this collaborative and multidisciplinary assessment, to the extent possible in a war-stricken country, a database of groundwater and surface-water information was compiled and data-collection networks were developed to improve understanding of, and provide a scientific basis for, the management of water resources in the Kabul Basin.

Location and Geology of the Kabul Basin

The Kabul Basin is an 80-kilometer-long valley, formed by the Paghman Mountains to the west and the Kohe Safi Mountains to the east, that contains Kabul City and surrounding communities in Afghanistan (figs. 1 and 2). Subbasins of the Kabul Basin, formed by interbasin ridges and river drainages, include Central Kabul, Paghman and Upper Kabul, Logar, Deh Sabz, Shomali, and Panjsher (fig. 1).

The Kabul Basin (fig. 3) is in a "basin and range" setting in which the valleys are filled with sediments consisting of sand and gravel and the mountain ranges are composed of uplifted bedrock. The upper aquifer, which is the primary aquifer, consists of highly permeable sands and gravels that typically are less than 80 meters thick in the valleys. The upper aquifer is underlain by a secondary aquifer consisting of less permeable, densely compacted sands, gravels, and clays that may be as thick as 1,000 meters or more in some parts of the valley.

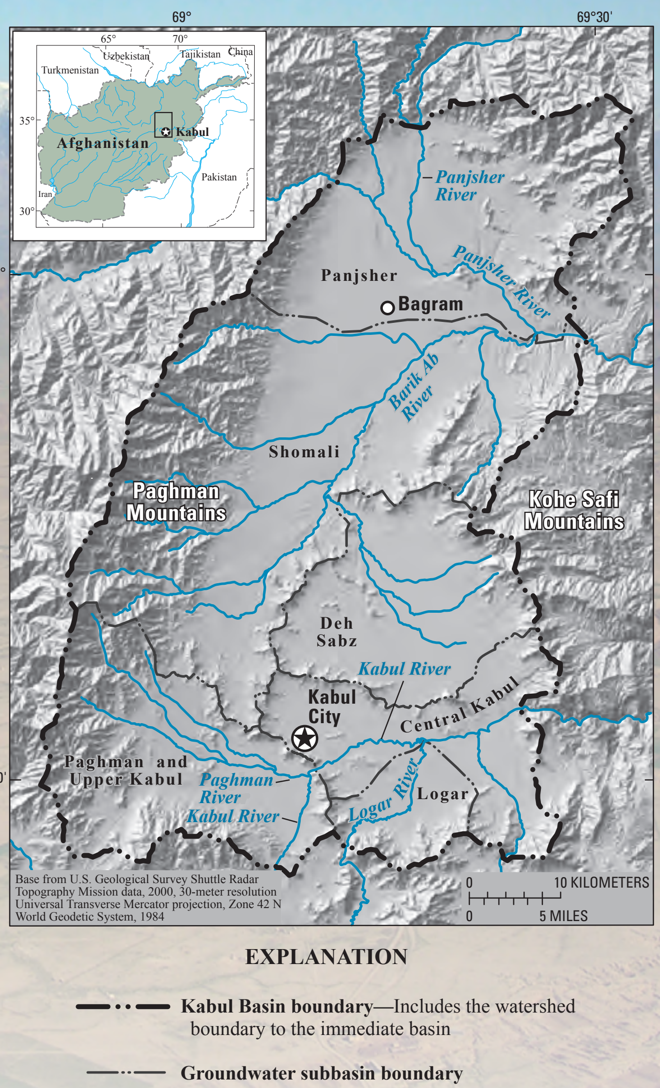

Figure 1. Location of the Kabul Basin, Afghanistan.

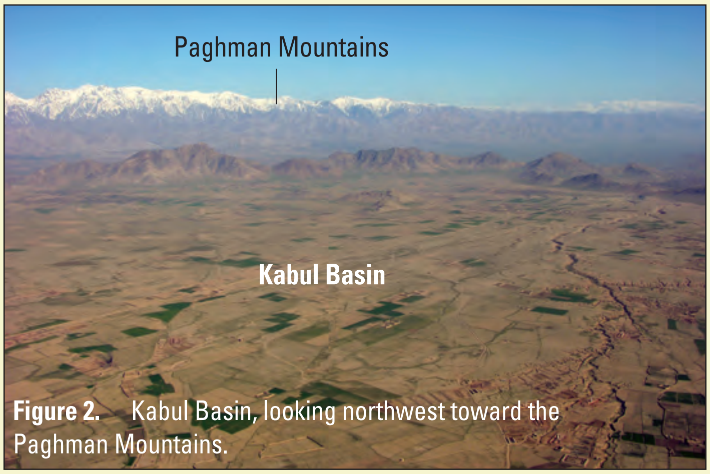

Figure 2. Kabul Basin, looking northwest toward the Paghman Mountains.

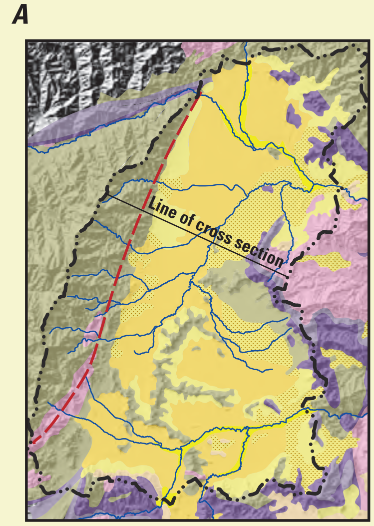
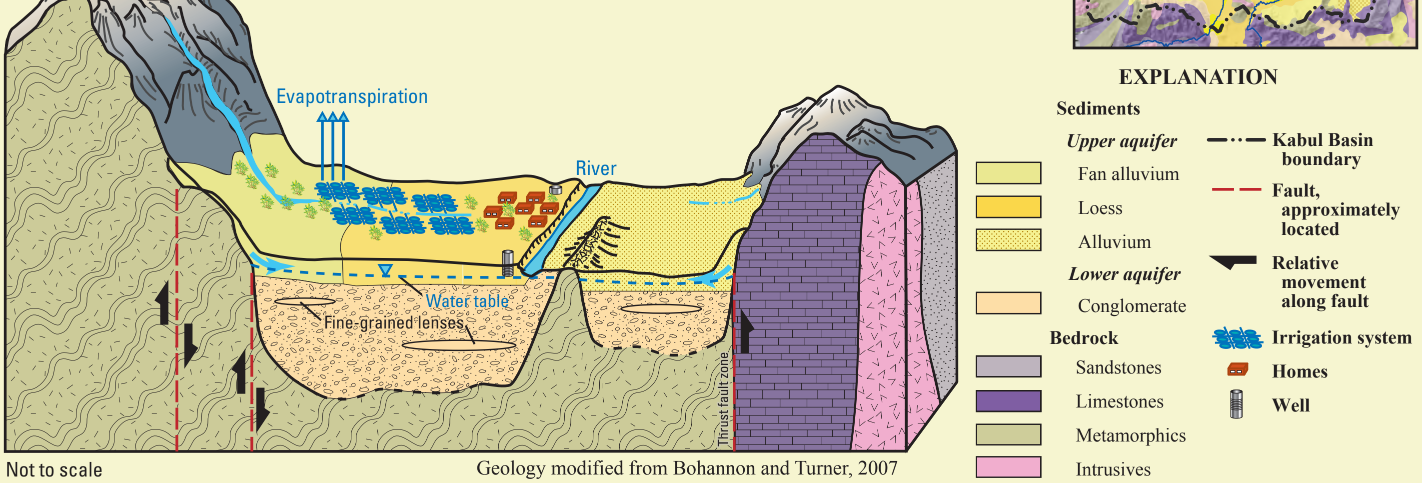

Figure 3. Generalized geology and topography of the Kabul Basin, Afghanistan: *(A)* simplified geologic map and *(B)* schematic cross section. The line of cross section is shown in *(A)*.

Overview of Hydrologic Data Collection and Analysis

Climatic, geologic, and hydrologic data were evaluated for the Kabul Basin. The Afghanistan Geological Survey engineers have been measuring water levels and collecting water-quality and chemical data since 2004 (fig. 4) as a part of a training effort (“capacity building”) by the USGS.

Figure 4. Afghanistan Geological Survey engineers training with U.S. Geological Survey personnel in the Kabul Basin.

Temperature and Groundwater Levels

Average annual precipitation (1957–77 and 2003–06) in the Kabul Basin is about 330 mm/yr (millimeters per year), but annual precipitation has varied considerably in the past few decades, ranging from several years of no precipitation in the early 2000s to about 525 mm/yr in 1959 (Mack and others, 2010; Safi and Vijselaar, 2007; Houben and Tunnermeier, 2005). Observations of past (1961–91) and recent (2003–07) mean monthly temperatures in the basin indicate an apparent warming trend (fig. 5). The rate of temperature increase has been greatest, about 2 degrees Celsius per decade since the early 1960s,

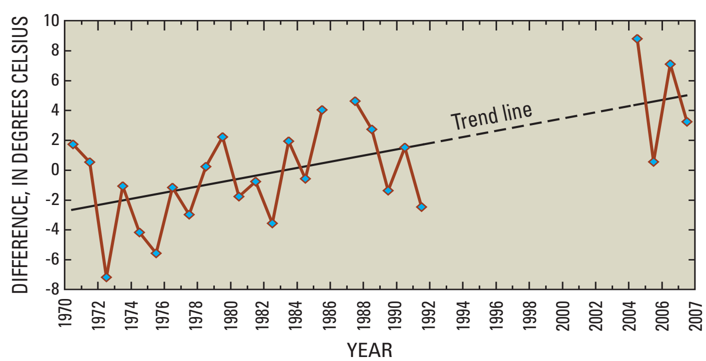

Figure 5. Difference between annual mean February temperature and historical mean February temperature in the Kabul Basin, 1970–2007.

in February. Remotely sensed vegetation data indicate that February temperatures likely increased at the same rate during 1992–2002.

Following a severe drought that affected much of Afghanistan from about 1998 to 2004, annual precipitation increased to normal levels and some groundwater levels have risen (fig. 6, upper line). Groundwater levels in some urban areas, such as Kabul City (Akbari and others, 2007), however, continued to decline (fig. 6, lower line) as groundwater withdrawals increased to meet the water-supply needs of the growing population (Broshears and others, 2005).

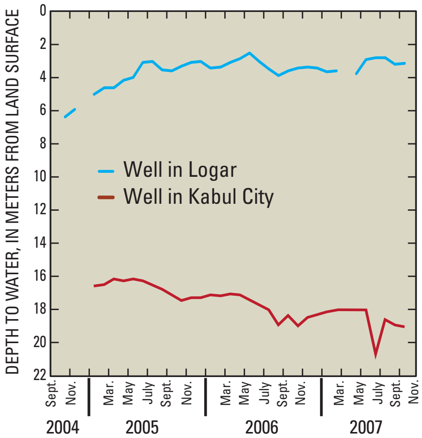

Figure 6. Groundwater levels in two wells in the Kabul Basin, 2004–07.

Water Quality

The Afghanistan Geological Survey collected water-quality samples at 8 surface-water sites and 92 groundwater, spring, and karez sites in the Kabul Basin. (A karez is a tunnel system used to extract shallow groundwater.) Bacterial contamination (total coliform and *E. coli*) commonly was detected in both surface water and groundwater at levels that exceed international drinking-water standards. In the more populated areas of the basin, such as the Central Kabul subbasin (fig. 1), values of several water-quality parameters, such as specific conductance (fig. 7) and concentrations of chloride, nitrate, and boron, indicate contamination from human activities. These findings reflect the absence of waste- and wastewater-treatment facilities in the region, and may also indicate that wells generally were constructed without grouting and may be subject to contamination from surface sources. The quality of water in less populated areas was relatively good.

Origin and Age of Groundwater in the Kabul Basin

Chemical and isotopic analysis of surface-water and groundwater samples indicates that shallow groundwater (less than 100 meters below land surface) typically is 20 to 30 years old, whereas groundwater in deeper aquifers likely is thousands of years old. Most recharge (water that replenishes the groundwater resource) is derived from leakage of streamflow. The availability of groundwater in the Kabul Basin varies considerably among and within its subbasins but primarily depends on:

- surface-water infiltration from rivers and streams,
- water leakage from irrigated areas,
- subsurface groundwater inflows from mountain fronts and,
- groundwater storage in thick sediments.

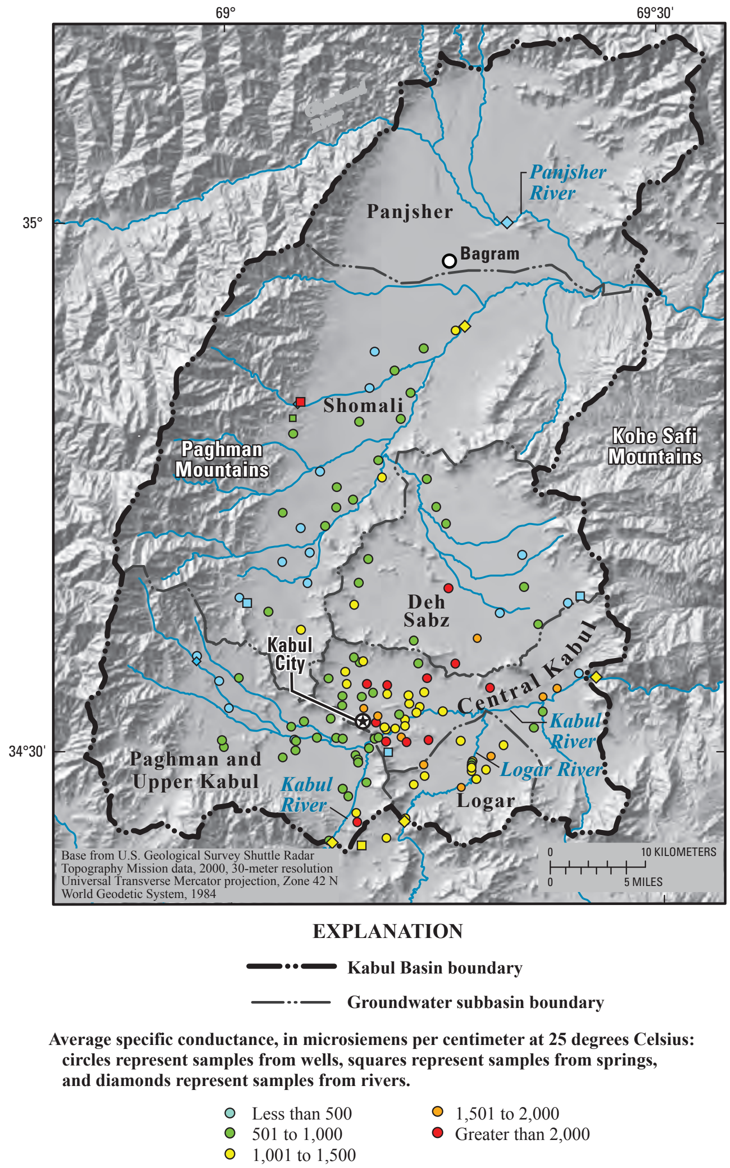

Figure 7. Specific conductance of surface-water and groundwater samples from the Kabul Basin as an indicator of water-quality patterns.

Is Water Availability Adequate to Meet the Increasing Demand?

The population of Kabul City increased at a rate of about 4 percent per year during 2002–07 (Rashid Fahkri, Afghanistan Central Statistics Office, written commun., 2007). High population growth rates in the Kabul Basin are expected to continue; on the basis of United Nations population projections, the population of the Kabul Basin could more than double to 9 million by 2057. Groundwater resources in the upper aquifer during years of normal precipitation and in the northern Kabul Basin are considerable. Existing community water-supply wells that are shallow, or screened near the water table, likely would be affected by increased groundwater withdrawals, however, and could be rendered inoperable or dry during summer months with groundwater-level declines as small as about 1 meter. Simulations of the effects of increasing water use on groundwater levels indicate that a large percentage of existing shallow water-supply wells in urban areas may contain little or no water by 2057 (Mack and others, 2010).

Potential Effects of Climate Change on Availability of Water in the Kabul Basin

The fourth assessment report of the Intergovernmental Panel on Climate Change (2007) identified climate patterns that include warming trends for southwestern Asia. During the next 50 years, a 10-percent reduction in total annual precipitation is anticipated in Afghanistan (Vining and Vecchia, 2007). Increased surface temperatures in mountainous regions would be likely to result in reduced snowpacks and cause snowmelts to occur earlier in the year. A 10-percent reduction in recharge was simulated to assess the hydrologic effect of potential climate change on groundwater resources in the Kabul Basin. This simulation showed that the resulting groundwater-level declines could cause about one quarter of all existing shallow supply wells to become inoperable or dry. In the headwater areas of the Paghman and Upper Kabul and Shomali subbasins, more than 50 percent of the shallow supply wells could become inoperable. Where water use is large and recharge is small—in Kabul City, for example—groundwater-level declines may reach tens of meters. Currently, most of the total annual recharge occurs in late winter and spring, during peak snowmelt periods (fig. 8). Increased temperatures may cause recharge to peak earlier in the year, shifting it away from the summer period, when water is needed most. For example, a comparison of streamflow in the Panjsher River at Shukhi in 2006 with historical monthly streamflow observations (fig. 8) indicates a shift in peak monthly streamflow to earlier in the year, as indicated by the observation of a period-of-record high flow in May and below-normal flows in June and July of that year.

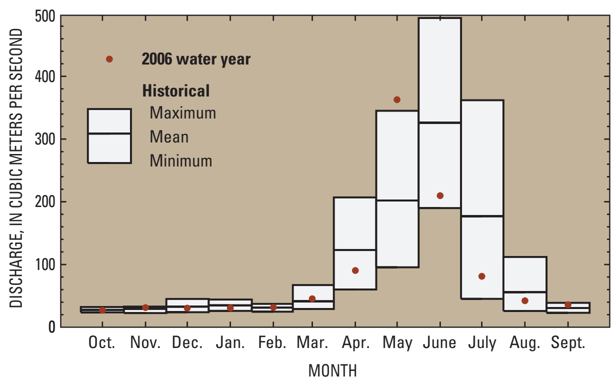

Figure 8. Historical (1966–80) mean and recent (2006) mean monthly streamflow for the Panjsher River at Shukhi in the Kabul Basin.

Potential Sources of Water to Meet Future Water-Supply Needs in the Kabul Basin

Afghanistan has an immediate and growing need for water to meet the demands of the Kabul Basin's rapidly increasing population. Existing water supplies may be adversely affected by increased withdrawals and future climate change. Although existing water supplies in some parts of the basin are adequate for current needs, the quality of that water has deteriorated as a result of human activities. Improvements in sanitation and well construction may improve the quality of drinking water in many parts of the basin. Considerable groundwater reserves may be present in deep, currently unused aquifers; however, this water likely is thousands of years old, and additional study would be needed to determine the sustainability of this water source. Continued training of Afghan scientists and engineers and development of water-resource management plans in coordination with local communities would help to alleviate the water-resource concerns facing Afghanistan and the citizens of the Kabul Basin.

References Cited

Akbari, M.A., Tahir, M., Litke, D.W., and Chornack, M.P., 2007, Ground-water levels in the Kabul Basin, Afghanistan, 2004–07: U.S. Geological Survey Open-File Report 2007–1294, 46 p.

Bohannon, R.G., and Turner, K.J., 2007, Geologic map of quadrangle 3468, Chak Wardak-Syahgerd (509) and Kabul (510) quadrangles, Afghanistan: U.S. Geological Survey Open-File Report 2005–1107–A, 1 sheet, scale 1:250,000.

Broshears, R.E., Akbari, M.A., Chornack, M.P., Mueller, D.K., and Ruddy, B.C., 2005, Inventory of ground-water resources in the Kabul Basin, Afghanistan: U.S. Geological Survey Scientific Investigations Report 2005–5090, 34 p.

Cruz, R.V., Harasawa, H., Lal, M., Wu, S., Anokhin, Y., Punsalmaa, B., Honda, Y., Jafari, M., Li, C., and Huu Ninh, N., 2007: Asia. Climate Change 2007: Impacts, adaptation and vulnerability. Contribution of working group II to the fourth assessment report of the intergovernmental panel on climate change, Parry, M.L., Canziani, O.F., Palutikof, J.P., van der Linden, P.J., and Hanson, C.E., eds., Cambridge, U.K., Cambridge University Press, p. 469–506.

Houben, George, and Tunnermeier, Torge, 2005, Hydrogeology of the Kabul Basin, Part I: Geology, aquifer characteristics, climate and hydrology: Hannover, Germany, Federal Institute for Geosciences and Natural Resources (BGR), p. 45

Intergovernmental Panel on Climate Change, 2007, Climate change 2007: accessed May 2, 2010, at http://www.ipcc.ch/.

Mack, T.J., Akbari, M.A., Ashoor, M.H., Chornack, M.P., Coplen, T.B., Emerson, D.G., Hubbard, B.E., Litke, D.W., Michel, R.L., Plummer, L.N., Rezai, M.T., Senay, G.B., Verdin, J.P., and Verstraeten, I.M., 2010, Conceptual model of water resources in the Kabul Basin, Afghanistan: U.S. Geological Survey Scientific Investigations Report 2009–5262, 240 p.

Milly, P.C.D., Dunne, K.A., and Vecchia, A.V., 2005, Global pattern of trends in streamflow and water availability in a changing climate: Nature, v. 438, p. 347–350.

Molnia, B.F., 2009, Inventorying and monitoring the recent behavior of Afghanistan's glaciers, debris-covered glaciers, supraglacial lakes, and the potential for catastrophic flooding (jökulhlaups): *in* European Geosciences Union General Assembly 2009, Geophysical Research Abstracts, v. 11, EGU2009-13939, Vienna, Austria, April 19–24, 2009.

Safi, Hassan, and Vijselaar, Leendert, 2007, Groundwater monitoring—Evaluation of groundwater data: Kabul, Afghanistan, DACAAR, p. 99.

Vining, K.C., and Vecchia, A.V., 2007, Water-balance simulations of runoff and reservoir storage for the Upper Helmand watershed and Kajakai Reservoir, Central Afghanistan: U.S. Geological Survey Scientific Investigations Report 2007–5148, 16 p.

By T.J. Mack, M.P. Chornack, T.B. Coplen, L.N. Plummer, M.T. Rezai,[1] and I.M. Verstraeten

[1] Afghanistan Geological Survey

Acknowledgments

The authors acknowledge the contributions of M. Amin Akbari (who passed away in 2009) and the staff of the Afghanistan Geological Survey Hydrogeology Group, and M. Hanif Ashoor, of the Afghanistan Ministry of Energy and Water. The authors also acknowledge the contributions of U.S. Geological Survey personnel including Douglas G. Emerson, Bernard E. Hubbard, David W. Litke, Robert L. Michel, Gabriel B. Senay, and James P. Verdin.

Additional Information

USGS Afghanistan Project Product Number 177
The report on which this Fact Sheet is based can be accessed at:
http://pubs.usgs.gov/sir/2009/5262

For additional information on this study, contact:
tjmack@usgs.gov, or
International Water Resources Branch, U.S. Geological Survey
420 National Center
Reston, VA 20192