NAMIBIA:
Assessing Recharge to the Southeast Kalahari Artesian Basin

Overall Goal

To quantify the modern recharge to the aquifers of the Southeast Kalahari Artesian Basin, also known as the Stampriet Artesian Basin, so that groundwater management plans can be formulated to ensure appropriate use of the resource.

Background

The southeast Kalahari artesian basin covers approximately 65,000 square kilometers of east-central Namibia, beneath a semi-arid landscape dominated by Kalahari dunes. Groundwater is the sole source of water for several towns and for farms throughout the region. Groundwater is produced from the Auob and Nossob sandstones under artesian conditions along deeply incised drainages, but water levels have generally declined over the past thirty years and many wells no longer flow without pumping except after exceptional rainfall.

The Geohydrology Division of the Namibian Department of Water Affairs (DWA) is concerned that current usage may be ‘mining’ water from aquifers that have limited modern recharge. And water usage is increasing as rural electrification spreads, allowing irrigation outside the artesian areas along the river valleys. Previous isotope surveys indicate that it can take water 20,000 years or more to move through the aquifer from the recharge areas to discharge points at artesian wells along the rivers. Under these conditions, there is a danger that the resource could be depleted relatively rapidly unless regulations are put in place to limit pumping to appropriate levels. The DWA seeks to better define current recharge and develop a comprehensive model of the aquifer for use as a management tool.

Project Summary

Project activities in Namibia are being implemented in conjunction with a water resource assessment of the Southeast Kalahari Artesian Basin aquifers sponsored by the Japanese International Cooperation Agency (JICA). The DWA is responsible for overall coordination of the investigation. Activities are implemented via a combination of DWA staff, JICA consultants (PCI), and local Namibian consultants hired by the DWA and PCI, as well as IAEA-sponsored experts and laboratory facilities. The IAEA portion of the investigation targets assessment of recharge to the Auob and Nossob aquifers, while the JICA project includes additional tasks intended to support development of a comprehensive water resource management strategy, including a hydrocensus of the over 6000 wells in the region, drilling new test wells, and establishing a detailed geological framework for the basin.
Accurate measurements of present-day recharge are an essential element in modeling the aquifer, and are the focus of Namibian efforts under the IAEA project. Recharge areas being investigated include the western and northern margins of the basin, where the Auob and Nossob aquifers are under unconfined conditions, with the sinkhole features receiving particular attention. New wells, drilled by JICA and the DWA (Figure 1), provide greatly improved geological control and allow the team to collect discrete samples from the individual aquifers, so that differences in the age and composition of the waters can be distinguished. Rainfall, stream water, and spring water are also being analyzed for chemical and isotopic parameters to develop more detailed data on the dynamics of this complex system. To date, 343 samples have been analyzed for stable isotopes, tritium, and/or radiocarbon. Numerous additional $^{18}$O and $^{14}$C analyses are available from the investigations of Vogel et al., completed in the 1970s.

**Preliminary Results**

Stable isotope results for groundwater all lie along an evaporative trend departing the global meteoric water line around a value of -7.5 per mil $\delta^{18}$O and -55 per mil $\delta^2$H (Figure 2). The evaporative signal is seen in all unconfined groundwater, irrespective of aquifer or location in the basin. The confined portions of the Auob and Nossob aquifers fall within the same trend, but generally show limited effects of evaporation. This suggests that the source of recharge to all of the aquifers is similar, but that recharge to the confined systems takes place quickly after heavy rains in the recharge areas without substantial evaporation, while the recharge to the unconfined aquifers is generally slower and often accompanied by extensive evaporation. Sinkholes, recently identified by the DWA from satellite photos of the recharge areas, may provide the mechanism for rapid recharge. Test holes drilled in these areas indicate local dissolution of the calcrete horizon underlying sand-filled depressions and extensive fracturing of the underlying formation, allowing rapid infiltration of surface runoff.

Correlations between stable isotope content and salinity confirm that evaporation is one cause of salinization in the unconfined aquifers, while lack of such correlation in the confined systems is consistent with salinization from dissolution of salts in the aquifer. The refined geological model of the area shows a large pre-Kalahari erosional trough in the south-central part of the study area where extensive salt deposition took place. This area is known as the ‘salt block.’

Rainfall and flood water samples collected during the strong 1999-2000 rainy season were exceptionally depleted in $^{18}$O and $^3$H, with values as low as -24.54 per mil $\delta^{18}$O and -179.6 per mil $\delta^2$H. These anomalous values, more typical of the Antarctic ice sheet than southern Africa, may provide a tracer for monitoring future movement of the water that infiltrated during the 1999-2000 downpours. The isotope results from 1999-2000 also underscore the need for long-term monitoring of climate and rainfall to define ‘average’ conditions in such semi-arid to arid settings where heavy rainfall may only occur once in a decade. Five stations have been established in the project area and one at the Windhoek...
Meteorological Office to monitor rainfall chloride and collect samples for isotope and chloride analysis.

Preliminary results from radiocarbon analyses of samples from the discrete-depth clusters of wells installed by JICA show that the Auob groundwater contains up to 60% modern carbon locally, similar to levels found in the Kalahari aquifer, while the Nossub aquifer has consistently low radiocarbon contents. However, more results and more detailed evaluation of the carbonate geochemistry of the system are needed to better define the movement of groundwater between the various aquifers.

Much more work remains to build the databases necessary to integrate the geological, chemical, isotopic, and climate data being generated with existing data and transform this wealth of information into models that can be used to manage the groundwater resources of the SE Kalahari Artesian basin. The size and complexity of the system defies any quick solution, but considerable progress is being made towards that goal.
Figure 1. Locations of JICA Borehole and Water Level Monitoring Stations
Figure 2. SE Kalihari Aquifer Stable Isotope Data

Deuterium, per mil

O-18, per mil

GMWL

Auob

Nossub

Kalahari

Basalt