SOUTH AFRICA:
Development of the Taaiboschgroet Fault Zone for Sustainable Rural Water Supply in Northern Province, South Africa

**Overall Goal**

The project integrates isotope hydrology techniques into a multidisciplinary development study of the Taaibosch fault zone community water supply in Northern Province, South Africa. The focus of the isotope component is to establish the recharge to the aquifer. The firm yield of groundwater from the fault zone must be better known before plans for community water supply systems can be finalized.

**Background**

Following the political changes in 1994, meeting the basic water needs of communities has become one of the highest government priorities. Already, in a 1994 White Paper on Water Supply and Sanitation Policy, the Government set the objective of supplying 25 liters *per capita* per day of clean, safe water within 200m of every household. Currently, 18 million people out of the total population of 40 million lack such basic water service. Massive national and international investment is underway. The water needs of the first one million people were met during 1997, but the Government seeks to speed up this effort drastically. To accomplish this, in mid 1997 the government implemented a Build, Operate, Train, Transfer (BOTT) strategy in cooperation with the private sector.

Without improvements to the processes used in the past, many of the groundwater projects of this recent, large-scale development will prove unsustainable. Among the major factors leading to failure of earlier systems, especially those constructed during the drought emergency of the early nineties, are poor assessment and planning, design and construction deficiencies, lack of attention to operation and maintenance, and lack of early community participation. During the current BOTT process many of these factors are addressed. What still requires urgent attention is improved resource assessments to plan the hundreds of small to medium-scale groundwater systems needed country-wide. Improved resource assessments would also provide guidance for operation and maintenance, so that sustainability of the water source as well as the infrastructure could be assured.

Environmental isotope techniques can contribute to improved resource assessment methodology. The South African Water Research Commission has compiled existing field experience in South Africa in a development guide for small-scale groundwater supply systems, including guidelines for borehole design, drilling, construction, and pump testing. This project seeks to demonstrate that isotope techniques are a valuable addition to these guidelines, and can substitute for hard-to-implement tests, such as long-term pump tests, water balance estimates, or long-term observation. While South Africa has considerable environmental isotope expertise, the technology has never moved beyond a few specialists, and has mainly been applied to dolomitic aquifers. In contrast, the problem for years to come in South Africa will be community water supply from hard-rock, fracture-flow groundwater systems. Demonstrating the feasibility of environmental isotopes for assessing such groundwater resources will thus have a major national impact.

**Project Scope**

The project focuses on issues of recharge, storage, and groundwater protection for a faulted basalt aquifer, targeted for development along the Taaibosch Fault to supply 20 villages in Northern Province (Figure 1). Pilot-scale work, completed in 1989, suggests that the fault zone collects recharge from a large area and has a total capacity of around 28 million cubic meters per year, enough to supply the projected annual demand of nearly 8 million cubic meters. Confirmation of the recharge rate is needed before the project can move to the construction phase, however. The project consists of three distinct phases; a reconnaissance phase, an implementation phase, and a technology transfer phase. From past experience, a major risk is for the project to be too narrowly focused, producing only a limited, project-specific impact. For this reason, the project has started with up-front involvement of all major stakeholders and must end with appropriate technology transfer strategies and actions involving public and private sector groundwater professionals.
**Preliminary Results**

Preliminary analysis of airborne and down-hole geophysical surveys of the project area and groundwater contour maps reveals a much more complex geological and hydrogeological setting than anticipated. A series of dolerite or diabase dikes have been identified in the Karoo basalts covering the plain between the Taaibosch Fault and the Blauberg, to the south. These faults apparently intercept much of the groundwater recharge coming from the Blauberg and divert it to the west. Groundwater in the central and eastern portions of the fault appears to be recharged primarily from rainfall on the plain, rather than from the mountains. Radon measurements have been successfully used to locate buried portions of the fault with greater precision than with standard geophysical tools. The Taaibosch fault zone itself is a complex structure, with a combination of horizontal movement, normal block faulting, and shearing, creating extensive fracturing and jointing. Large open fractures, seen in down-hole video images, host a population of *Amphipoda*, suggesting significant regional connectivity of the fracture network.

Approximately 150 samples have been analyzed for geochemical and isotopic parameters. Stable isotope results (Figure 2) for many groundwater samples lie to the right of the global meteoric water line, indicating effects of evaporation in small, shallow pans on the plain before infiltration. There are no major regional differences in groundwater composition, consistent with most recharge to the fault system coming from the plain rather than the mountains, where more negative isotope content would be expected.

Radiocarbon and tritium results have been used to estimate the mean residence time (MRT) and recharge rate for the groundwater (Figure 3). Along the fault zone, the MRT is estimated at approximately 500 years. Away from the fault zone, a residence time of approximately 200 years is estimated, although some samples collected after the exceptionally heavy 2000 rains indicate residence times of 50 to 100 years or less. Based on estimates of aquifer dimensions and total porosity, this leads to recharge estimates of 6.4 mm/yr along the fault and 4 mm/yr on the plain. The total potential yield of the water supply wells along the fault zone calculated from these results is 2.2 million cubic meters per year, an order of magnitude lower than the preliminary estimate of 28 million cubic meters per year on which the design of the water supply system was based.

Additional borehole drilling and sampling is planned to better characterize the aquifer underlying the plain, away from the fault zone itself, as well as the deeper structure of the system. Detailed neutron-neutron logging to determine the aquifer porosity is also planned, to help refine estimates of recharge and aquifer yield. Continued monitoring is also being conducted to support development of a numerical model of the system. Nitrogen concentrations have also been found to exceed WHO and South African standards in many wells, and nitrogen isotope studies are being developed to further assess potential impacts on the planned water supply system.
Figure 1. Taaibosch Location Map
Figure 2.
Taaibosch Stable Isotope Results

-12.00 -10.00 -8.00 -6.00 -4.00 -2.00 0.00

D, per mil

-100.0 -80.0 -60.0 -40.0 -20.0 0.0

$\delta^{18}O$, per mil

rain
groundwater 1999
groundwater 2000
GMWL
Figure 3.
Taalbosch Mean Residence Time Estimates

Approximate mean residence time, in years, from the exponential mixing model.