# Relict River Channels: Corridors of Groundwater Flow & Storage?

Graham Bradley[1], Callist Tindimugaya[2] and Richard Taylor[1]

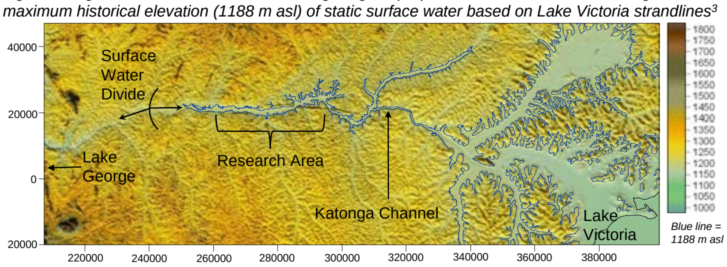
[1]UCL Department of Geography, Pearson Building, Gower Street, London, WC1E 6BT, UK
[2]Directorate of Water Resource Management, Entebbe, Uganda

## Introduction

Development of groundwater in sub-Saharan Africa is greatly constrained by low well yields that are frequently encountered in the weathered crystalline bedrock. Research presented here examines whether sediment-filled, relict river channels in the Great Lakes Region of Africa (Fig. 1) form corridors of enhanced groundwater flow and storage. Current research is focused on the Katonga channel in southwest Uganda (Fig. 2).


*Figure 1: Tectono-geomorphic setting of the research site within the Great Lakes Region of Africa.*

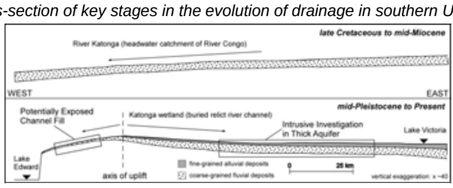
*Figure 2: Digital elevation model of the Katonga region, prepared from SRTM data, showing the maximum historical elevation (1188 m asl) of static surface water based on Lake Victoria strandlines[3]*




## Background and Rationale

In the mid-Miocene, westward flowing rivers in headwater basins of the River Congo were truncated by the western arm of the East African Rift System[1,2] (Fig. 1). By the mid-Pleistocene, uplift parallel to the rift escarpment exceeded the rate of river incision and flow was reversed (Fig. 3). On surfaces of low relief east of the upwarp, now relict channels containing fluvial sands and gravels were overlain by low-energy, fine-grained deposits[3] (Fig. 2), which today support extensive wetlands. Obscured by papyrus filled swamps (Fig. 7), the geomorphological significance and aquifer potential of the underlying coarse-grained relict channel fills have yet to be examined. The existence of fluvial deposits in relict drainage channels, implied by the tectono-geomorphic model, has recently been confirmed in southwestern Uganda[4], but the dimensions, distribution and characteristics of these relict river channel fills are unknown.

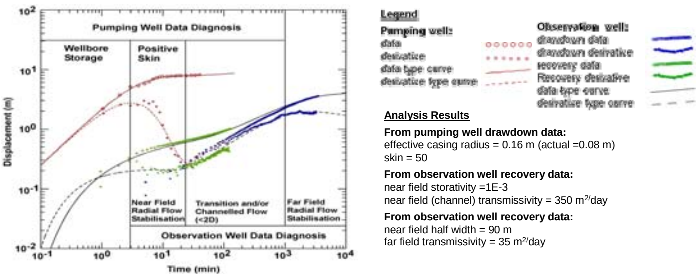
*Figure 3: Cross-section of key stages in the evolution of drainage in southern Uganda*




## Previous Relict Channel Research in Uganda

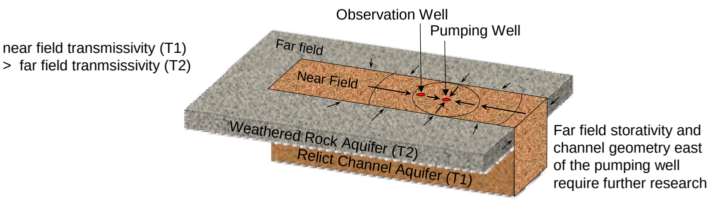
The hydrogeological characteristics of the relict channel aquifer at Rukungiri were diagnosed using modern aquifer test analysis techniques including log-log derivative plots and simultaneous type curve analysis of drawdown and recovery data from multiple wells using Agarwal time (Fig. 4).

*Figure 4: Analysis of pumping test in relict channel aquifer at Rukungiri*




The simultaneous analysis of multiple flow periods and wells overcame the practical limitations of individual datasets and revealed a flow geometry that is consistent with a conceptual model based on the electrical resistivity surveys and drilling logs (Fig. 7).

*Figure 7: Simplified conceptualisation of the hydrogeological units at Rukungiri, based on pumping test interpretation, electrical resistivity surveys and drilling logs*




## Aim and Objectives

The overall aim is to characterise the hydrogeology of the Katonga channel in order to understand its groundwater resource potential and facilitate management of the wetland environment.

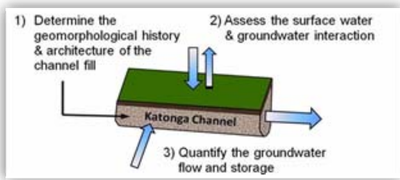



*Figure 5: Schematic drawing showing relationship between research objectives*

## Methodology

The methodology is focused on achieving a holistic understanding of subsurface channel hydrology by addressing the key objectives outlined in Figure 5. Specific methods include:

1.Remote sensing (Digital elevation model / Landsat ETM+ / Africover land classification)
2.Field observations, including logging sediment outcrops
3.High resolution electrical resistivity survey to establish the architecture of the channel fill
4.Drilling and sampling to establish stratigraphy and lithology
5.Well installation and pumping tests to determine the flow geometry, transmissivity and storage
6.Groundwater level and chemistry monitoring to investigate the surface groundwater interaction.

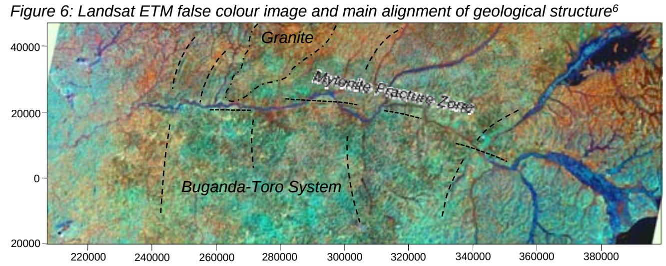
Whenever possible, state-of-the-art methods will be applied, including 2D resistivity imaging, low disturbance sediment sampling and stable isotope analysis. During the pumping tests, surface readout pressure transducers will be employed to facilitate real time decision making and ensure that the test design is optimised to take full advantage of available advanced analysis techniques.

## Ground Characteristics in the Katonga Basin

The geomorphology, vegetation and land use have been assessed using a Landsat ETM image and the Africover[5] land cover classification prepared by the Ministry of Surveys and Mapping in Uganda.

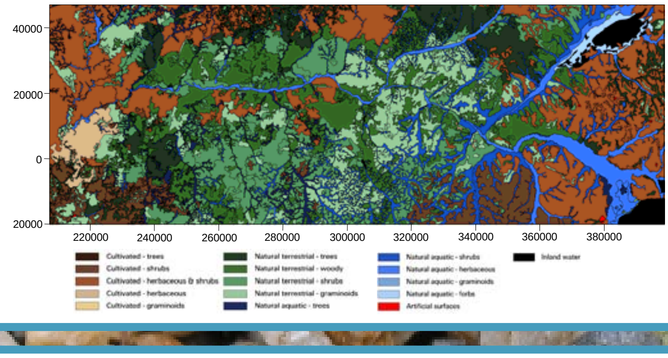
The wetland distribution and upstream lower order channels are visible in Figure 6. Geological features with geomorphological expression may also be discerned, including the structural alignment and lithological variations in the Proterozoic metamorphic Buganda-Toro System, and the mylonite fracture zone which appears to follow the fold axis and control the Katonga channel alignment[6].

*Figure 6: Landsat ETM false colour image and main alignment of geological structure[6]*




The Katonga wetlands are identified as natural aquatic vegetation (blue) in Figure 7. Much of the area adjacent to the central Katonga region is classified as natural terrestrial vegetation (green). The distribution of cultivated land (brown) appears to be related to the location of main roads.

*Figure 7: Africover[5] land cover classification*




## Anticipated Outcomes

1.Identification and characterisation of the relict channel aquifers
2.Better understanding of wetland ground/surface water interaction
3.Improved theory of the relationship between landscape evolution and present day hydrology

Confirmation of the existence of sustainable relict channel aquifers will provide improved water management options and increased capacity to enable adjacent communities to adapt to future pressure on the availability of freshwater brought about by increasing demand and the impact of climate change.

The ultimate beneficiaries of the proposed research are water-stressed communities in the Great Lakes Region of Africa.

References: 1: Taylor, R. & Howard, K., 2000, 'A tectono-geomorphic model of the hydrogeology of deeply weathered crystalline rock: Evidence from Uganda', Hydrogeology Journal, vol. 8, no. 3, pp. 279-294. 2: Doornkamp J.C. & Temple, P. H., 1966, "Surface Drainage and Tectonic Instability in Part of Southern Uganda", Geographical Journal, vol. 132, p. 238-&. 3: Temple, P.H. & Doornkamp, J.C., 1970, 'Influences controlling lacustrine overlap along the north-western margins of Lake Victoria', Zeitschrift für Geomorph. N.F. Bd 14, Heft 3, p. 301-317. 4: Tindimugaya, C., 2008. 'Groundwater flow and storage in weathered crystalline rock aquifer systems of Uganda: evidence from environmental tracers and aquifer responses to hydraulic stress', PhD Thesis (UCL). 5: www.africover.org. 6: Schlüter, T., 1997, 'Geology of East Africa, Gerbrüder Borntraeger, Berlin-Stuttgart.