

Gold tailings as a source of waterborne uranium contamination of streams - The Koekemoerspruit# (Klerksdorp goldfield, South Africa) as a case study

Part II of III: Dynamics of groundwater-stream interactions

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Abstract

Dissolved uranium (U) from the tailings deposits of various gold mines in South Africa has been found to migrate via seepage and groundwater into adjacent streams. The extent of the associated non-point pollution depends on the concentration of U in the groundwater as well as the volume and rate of groundwater seepage into the stream channel. Whilst the U concentration in groundwater is relatively constant and comparatively easy to determine, the same is not true for the flux of groundwater into the stream. In order to track the water exchange at the groundwater-stream interface, real-time *in situ* measurements by data-logger controlled probes for gauging heights and electrical conductivity (EC) were taken at 10 min intervals. As a result of a steep hydraulic gradient between water-saturated tailings deposits and the receiving watercourse, exfiltration (base-flow) of contaminated groundwater generally dominates. However, short-term inversions of the flow direction (infiltration of stream water into the groundwater) were also observed. These are attributed to an artificial flow regime of the Koekemoerspruit, which results from a pumping scheme that discharges groundwater from underground mine workings into the stream. Differences in pumping rates lead to pronounced diurnal fluctuations of gauging heights in the stream, which in turn cause even higher fluctuations of the associated groundwater table. The hydraulic mechanisms of the stream-groundwater interaction, as well as implications for the aqueous transport of U are discussed.

Keywords: hydrodynamics, waterborne U transport, hydraulic groundwater-stream interaction, real-time *in situ* measurements, hydraulic gradient, base-flow, infiltration, streamflow, pumping scheme, diurnal fluctuations

Introduction

Due to elevated concentrations of U and other heavy metals in tailings deposits of gold and U mines, seepage from such deposits often leads to diffuse contamination of nearby watercourses. The dissolved metals migrate into the underlying groundwater and eventually seep into the adjacent stream (Winde, 2003). The extent of such non-point pollution systems depends on the concentrations of dissolved contaminants in the groundwater, as well as the volume and rate of groundwater seepage into the stream. Referring to the study area as described in Winde et al. (2004a) this paper

explores the dynamics of hydraulic interactions (hydrodynamics) between the shallow (alluvial) groundwater and the stream.

Since pore water in tailings deposits usually forms a phreatic surface that is often located several tens of meters above the water level in adjacent watercourses, hydraulic gradients result which drive subsurface seepage-flow from tailings towards the stream. The associated non-point stream pollution by exfiltration of contaminated groundwater is usually regarded as a continuous process of more or less constant intensity throughout the year. Fig. 1 illustrates the hydraulic gradients between the Koekemoerspruit and two adjacent sources of diffuse stream pollution.

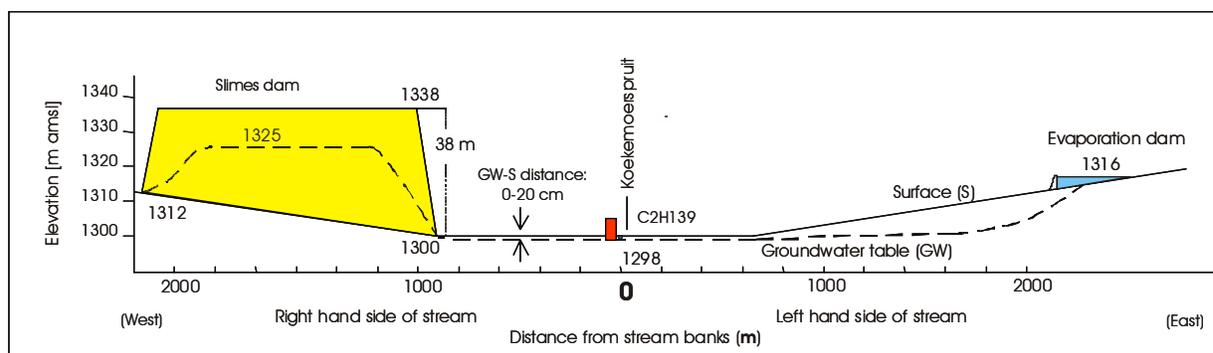


Figure 1

Hydraulic gradient between the Koekemoerspruit and the nearest slimes dam on the right hand side (west) and between the evaporation dam on the left hand side (east)

The Afrikaans word "spruit" can be translated as a creek or small stream.

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