



**Project: KELIAN GROUNDWATER MONITORING PROGRAM**

**Location: Kelian Gold Mine, East Kalimantan, Indonesia**

**Client: Kelian Equatorial Mining, a member of the Rio Tinto Group**

## **Highlights**

- One of the largest gold producing mines in Indonesia.
- Several areas of concern including a large potentially acid forming (PAF) waste rock storage impoundment, an equally large tailings impoundment and associated containment facilities, a complex series of polishing ponds, and a series of uncovered stockpiles comprising both barren and potentially PAF producing rock.
- Geologically complex terrain located in the centre of Kalimantan; part of the Central Kalimantan Arc and Kutai Basin deposits which have locally been intruded by a series of andesitic bodies.
- Equally complex hydrogeological model.
- Potential for onsite activities to impact on the nearby Kelian River, an important source of drinking water for several local communities.
- Introduction of a relatively complex yet cost effective system of groundwater sampling into a very remote and difficult area.
- Part of an ongoing collage of projects designed to meet environmental compliance set by the East Kalimantan Regency and Indonesian Government as part of the mine closure program.

## **Background**

C. M. Jewell & Associates was commissioned by Kelian Equatorial Mining (KEM) to undertake a review of a pre-existing groundwater monitoring network and provide comment as to whether the network was suitable to ensure that environmental compliance was able to be sufficiently monitored and met, or whether deficiencies in system existed that would allow for the undetected migration of leachate impacted waters from the site and into nearby receptors such as the Kelian River, which is an important source of drinking water for several local communities.

The appraisal identified a number of areas, in areas of both natural abutments and constructed containment facilities, where containment of known and potentially impacted waters could not be guaranteed. As a result, a plan detailing the enhancement of the monitoring network via the installation of a series of new and replacement monitoring wells was submitted to KEM, and the proposed scope of works commissioned by KEM.

## **Geological Environment**

The geology encountered at the site consists of a complex sequence of silicic pyroclastics and sediments which have been intruded by a number of andesitic bodies. The pyroclastics range from fine-grained ash tuff to coarse lithic tuffs, and grade upwards into a sequence of siltstones, sandstones, minor limestones and carbonaceous units. Economic mineralisation is believed to have been introduced in the area following the emplacement of the andesites, whilst younger basalts occur as dykes and sills within the north-western corner of the current extraction pit, and top a series of surrounding plateaus to the west of the site.

### **Hydrogeological Environment**

The site is situated predominantly on hard-rock terrain encompassing the lower foothills and ridgelines which dominate the western embankment of the Kelian River. Groundwater movement beneath the site occurs predominantly through a series of secondary features such as fracturing associated with the network of joints and features, whilst in comparison only a relatively small volume of water is thought to migrate via primary porosity (i.e. through the interconnected pore spaces between individual grains) within areas dominated by sedimentary sequences. Secondary porosity, formed by joints, fractures and fault zones within the rock mass, is considered to be the major component of the effective porosity of the aquifer. Thus secondary porosity and permeability constitute the major component of the aquifer's transmissivity, and a significant component of the aquifer's storage. The joints and fractures within the sedimentary rock pile are predominantly sub-vertical whilst the bedding plane openings and fractures are predominantly sub-horizontal.

The site forms part of the regional groundwater recharge zone, with recharge to the aquifer occurring by direct rainfall infiltration through the various soil horizons before entering the secondary fractures within the aquifer. Discharge from the aquifer occurs primarily through natural dewatering via springs and base flow into local watercourses which predominantly form first and second order tributaries of the Kelian River. The groundwater flow volume (i.e. groundwater flux) at the site is relatively small in comparison with surface runoff volume, however groundwater flow occurs in most places around the site, and is considered to have a significant potential role in contaminant transport.

### **Scope of Work**

Following the acceptance of the proposed network, a drilling program was undertaken at the site where twenty-seven additional piezometers were installed piezometers at preselected locations within and around the waste-rock impoundment, mine site, and tailings storage facility, which was promptly followed by the installation of a dedicated groundwater-sampling pump within each of the boreholes. This was followed by a hands-on training session designed to allow field technicians from the mine site to collect groundwater samples from each of the newly installed wells as part of the ongoing commitment to the groundwater-monitoring program.

On completion of the fieldworks, a detailed report describing the works undertaken, geological and hydrogeological conditions observed within each borehole, an appraisal of groundwater data, and mathematical modelling of solute transport in groundwater (which was modelled using the specialist packages PHREEQC and PRINCE), was prepared and submitted to KEM as an ongoing appraisal of the hydrogeological conditions at the site.