Case Study

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Mine Water Supply Study

Rio Tinto - QIT Madagascar Minerals Ltd. (QMM)

Project area in the south-east of Madagascar

Highlights:

- QMM needed to determine the feasibility of developing a titanium mine in a highly complex location in Madagascar
- SWS modeled salinity intrusion in both groundwater and surface water
- For adequate water supply, an innovative salinity control structure was proposed
- The Government of Madagascar granted an environmental permit to QMM to proceed with the project

Background

Rio Tinto - QIT Madagascar Minerals Ltd. (QMM) planned to develop a mine on the south-east of Madagascar Island, a few kilometres inland of the seaport of Fort Dauphin. The main mineral to be processed was titanium dioxide (TiO2), abundant in the heavy mineral sands of the area. Ilmenite would be extracted by a sand dredge operating on a gradually moving pond excavated into the sand deposit. The mine will operate for over 40 years and will provide significant economic benefits to an economically depressed area in one of the world's poorest countries.

Schlumberger Water Services (SWS) carried out a broad surface and groundwater study, including detailed field work and personnel training. The purpose of the study was to assess several key components (surface and ground water regimes, water quality, and water uses) to characterize the site and provide recommendations to minimize local and regional potential impacts of the mine operations.

Challenges

The site was higly complex and presented many unique challenges, including:

- over-exploitation of the littoral forests by the local people has put pressure on the local ecosystem
- reliable water supply and control of the dredge pond elevation for flotation
- complex site with freshwater inflows, saline tidal inflows, groundwater/surface water interactions and saline intrusion in the groundwater system
- unique flora and fauna - project under very close worldwide scrutiny by international banks and environmental activist groups
- difficulty mobilizing a drill rig - a hand-carried vibracore system was used for the groundwater investigations and installation of groundwater piezometers

Case Study: Mine Water Supply Study

Solution

SWS modeled the surface water, groundwater, and salinity intrusion separately.

Surface water modeling:
- chose a hydrodynamic model application because of the downstream fluctuating tidal conditions and the capability of modeling salinity changes induced by the tidal flows
- the hydrodynamic model also allowed SWS to simulate the periodic formation of a sand bar across the mouth of the estuary

Groundwater modeling:
- used a 3D model calibrated with data from a comprehensive groundwater field investigation program that was designed to detect evidence of anisotropy in the sand deposit
- field data and modelling demonstrated anisotropy in the sand deposit with horizontal conductivity about 1000 times the vertical hydraulic conductivity
- anisotropy had not previously been detected anywhere in the world in sand mine deposits
- following extraction of the ilmenite, the sands remaining in the sand deposit would be well-mixed and the vertical hydraulic conductivity will decrease - therefore, the groundwater table elevation following mining would be lower than at present

Groundwater and surface water salinity intrusion modeling:
- demonstrated that salinity intrusion in the groundwater would not increase with the dredge pond operations and would not increase salinity in the river/lake/estuary system

The water supply option recommended was to extract water from the river/lake/estuary system with a floating pump barge. However, the salinity modeling indicated that, at the preferred location for the intake, the water would be saline about 80% of the time. To overcome this problem, SWS proposed construction of an innovative salinity control structure. To minimize the environmental impact of the structure, it was desirable that the water level fluctuations in the upstream lakes and rivers would remain similar to current conditions. This was accomplished by developing a floating gate system to minimize the head created over the structure. The structure excludes salinity from the upper end of the river/lake/estuary system while minimizing the impact on water level changes.

Results

The environmental philosophy of QMM is to develop an economically sound project that will help reduce poverty and address some of the root causes of progressive environmental degradation in the region. The Water Study carried out by SWS met this sustainable perspective.

SWS incorporated a conservation zone concept into the water management plan and included an assessment of groundwater flow contribution to sustaining vegetation. As part of the project reclamation plan, QMM planned to plant sustainable forests for harvesting by the local community.

SWS trained local staff in water flow monitoring and water quality sampling. The local staff of QMM are now responsible for all on-site monitoring.

In recognition of the quality of work carried out on the QMM Water Study and other aspects of the environmental assessment, the Government of Madagascar announced a decision in November, 2001 to grant an environmental permit to QMM to proceed with the project.

Sediment runoff from deforested watersheds was quantified to assess water supply sustainability

Periodic formation of a sand bar in the mouth of the estuary was incorporated in the hydrodynamic model

Flood levels were modelled with and without the salinity control structure

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