A Water Resources Management System as a tool to guarantee the water supply of an iron ore mining project in Brazil

Leonardo Mitre Alvim de Castro, José Roberto Centeno Cordeiro,
Ana Katiuscia Pastana de Souza, Gilcimar Pires Cabral Oliveira

Anglo American plc., Iron Ore Brazil, Rua Guaicuí, 20, 10º Andar, CEP.: 30.380—380. Belo Horizonte/MG – Brazil. leonardo.mitre@angloferrous.com.br; jose.centeno@angloferrous.com.br; ana.katiuscia@angloferrous.com.br; gilcimar.oliveira@angloferrous.com.br

Abstract This paper presents the proposed water management system developed for an iron ore mining project in Brazil, with the main aim to guarantee the water supply during its expected life at less pumping costs and without conflicts with other users. Studies considered all the hydrologic and hydrogeologic potential of the catchment basin and also all of the water demands of the mining project. Other mining projects and water users on the same basin were also assessed. The system presents good results and conclusions as the water demands of the mine could be attended at the best costs and without conflicts.

Key Words Water resources management system, iron ore mine, water supply

Introduction

While a mine is operational the act of mining itself can have a significant impact on the natural environment. This is because mining activities inevitably disrupt preexisting hydrological pathways (Younger and Wolkersdorfer 2004). So, according to Kumar et al. (2010), understanding the geology, physiography and hydrology is critical to plan and design water practices in a large water basin. This fact has to be considered when developing a water management system and so, the baseline for this study was the knowledge of all the technical information of the catchment basin. Mudd (2008) also highlights that a major strategic issue for all sectors of the global mining industry is the use and management of water resources.

The Minas-Rio Iron-Ore Mining Project is the biggest of the kind being under implementation by the Anglo American group, located in the state of Minas Gerais, Brazil. It projects the production of 26.5 million tones of iron ore per annum, the formation of a pulp and its adduction in a pipeline of 525 km of extension, to the port of Açu in the north of the state of Rio de Janeiro.

Considering the use of a pipeline and the process installations, the water use of this project is high, demanding a lot in terms of abstraction points and so, per consequence, the water resources management gets a great relevance. The catchment basin where the project is located has already a potential for a water conflict, as there are some other big mining projects and hydroelectric plants under implementation. In this context, it is important to remember that water may be everywhere, but its use has always been dictated by its availability in terms of quantity and quality (Biswas 2008). This is another reason for the efficient management of water resources so as to enable its use.

This paper presents the proposed water management system for the Minas-Rio Iron-Ore project, which was studied and developed with the main aim to guarantee its water supply during all its lifetime, reducing the risks of failure due to lack of water.

Methods

The development of a water management system for a mining project passes through various steps, considering the knowledge of the problem, water demands of the mine and process and also all the necessary technical studies. This system was developed considering 9 steps:

1. Definition of the scale of the studies;
2. Technical visit and knowledge of the whole area of assessment;
3. Survey, compilation and systematization of all available information of surface and groundwater of the catchment basin and also the water demands;
4. Critical analysis and treatment of the available data;
5. Characterization of the water demands;
6. Characterization of the water availability;

7. Water balance of the whole basin;
8. Development of technical indicators and the decision support system;
9. Development of the operational water management system.

The most important steps of the study could be considered the fifth and sixth ones, which have to have some base studies done before (steps 1 to 4) and also the development of the main system at the following steps. The step five has to consider all the fresh water demands, taking into account the beneficiation plant process requirements, mine and road watering (dust allaying), slurry pipeline and water services. Also the following step has a main relevance as the water availability relates to all feasible sources at the catchment basin that are going to be assessed with the implementation, maintenance and operational costs.

Results

As presented before, considering important mining projects, the scale of the studies has to be the main catchment basin where all the impacts can be verified by other water users. So, the scale of the studies was defined as the Santo Antônio river basin. This basin, with drainage area of near 10,500 square kilometers, was chosen as all the interferences of the project during all its lifetime will be done within its area. Figure 1 presents the relation of the basin and the Minas-Rio Iron-Ore Project.

The next step consisted on the estimation of the water demands for the mining project. The main uses assessed to the mining project were the beneficiation plant process requirements, mine and road watering (dust allaying), slurry pipeline and water services. Considering these water uses, the total fresh water demand to the project amounts to 2.500m^3/h.

The hydrologic and hydrogeologic studies were then performed in order to estimate all the important hydrologic variables. After that, it was possible to obtain the water availability run-of-river or to build dams to regularize the water flows. The main affluent of the Santo Antônio river is the Peixe river.

The results of the study for this basin are highlighted on this paper, as it was closer to the project area and was the chosen alternative. The Peixe river basin presents an average precipitation of 1,540mm per annum and an average evapotranspiration and other water losses of 979mm per annum. Based on these results, the average runoff was obtained as being equal 561mm per annum. The catchment basin of the Peixe river at the studied section is equal 1,145km^2, which means an average runoff of 20.3m^3/s.

The criteria to define the environmental flows from the rivers of this basin was established by the state water resources organization and indicate that the minimum inflow drained on each watercourse should correspond to 70% of the Q_{7-10} (minimum flow for seven days with 10 years of return period). The Q_{7-10} was estimated for the defined section and is equal 2.86m^3/s (10,300m^3/h). So, the minimum water flow in the river during dry spells was estimated as 7,200m^3/h (70% of the Q_{7-10}), which means that during these periods, the maximum flow for run-of-river abstractions is 3,100m^3/h. The table 1 presents the main results of the hydrologic studies for this section of the Peixe river.

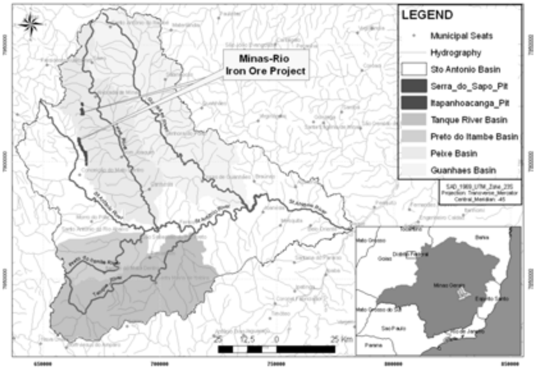

Figure 1 *Santo Antônio catchment basin and the Minas-Rio Iron-Ore Project*

***Table 1** Basic hydrologic figures from the Peixe river Basin on the defined section.*

Average annum precipitation (mm)	Average annum evapotranspiration (mm)	Runoff (mm)	Catchment basin (km²)	Average flow (m³/s)	Q_{7-10} (m³/h)	70% Q_{7-10} (m³/h)	30% Q_{7-10} (m³/h)
1,540	979	561	1,145	20.3	10,500	7,200	3,100

All the other water uses of the basin were then estimated. Using primary and secondary information from database from state organizations, industrial and agricultural censuses and the population counts from the urban areas, the water demands for the public supply, watering animals, other mining industries, irrigation and the hydroelectric plants were then obtained for all the section points of the basin. The Table 2 presents the actual demands from the whole Peixe river basin, which had also its growth scenarios studied, with the main aim of evaluating the potential water use conflicts during the mine lifetime. The figure 2 presents the main water users on the Santo Antônio catchment basin.

Continuing the studies, after assessing the water availability and the users' demands, it was then executed water balance for the whole basin and the reference points. Based on the results presented on the tables 1 and 2, it would be possible to consider the availability of a run-of-river abstraction of 2,827m³/h during the dry spells. However, the growth potential of the other water uses on the basin was studied and the main availability was fixed on 2,500m³/h.

The water balance of the tailings dam and the dike to contain sediments was also evaluated, in order to obtain additional water availability, with the use of the same methodology, obtaining the reference water flows. The only difference is that the water abstraction in the reservoir of these dams could use its hydrologic potential, though the flows downstream are limited to the minimum flow of 70% Q_{7-10}. This water balance indicated the potential of additional 625m³/h at the tailings dam and 80m³/h at the dike. The figure 3 presents the alternative sources which availability was studied for the supply of the mining project demands: tailings dam, dike to contain sediments, the set of boreholes for lowering the water level in the mining pit and a Run-of-river abstraction from the Peixe river.

The next step of the study was the proposal and development of performance indicators to give support for the choice of the best alternatives for the water supply of the mine. The main proposed indicators were: water availability of each abstraction point every month, according to legislation; implementation costs of the abstraction systems, tailing dams, dikes, wells provided for the dewatering system and lowering the water level; distances and costs for implementation of the water pipelines; energy costs for pumping; water consumption per production and water

***Table 2** Water demands on the Peixe river basin*

Water Use	Public Supply	Industrial	Irrigation and watering animals	Total
Abstraction flow (m³/h)	171	34	68	**273**

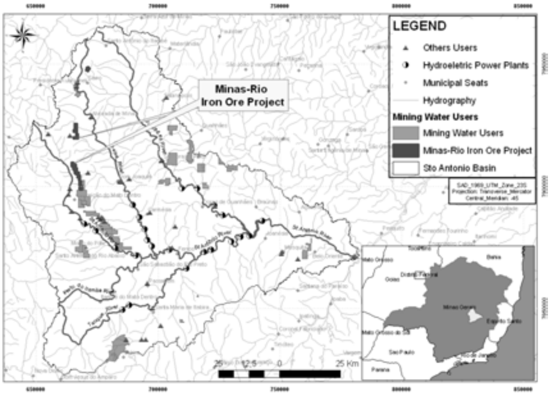

***Figure 2** Main water users at the Santo Antônio catchment basin*

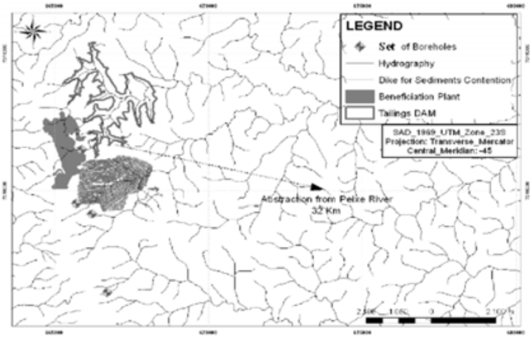

Figure 3 *Alternative sources to the water supply of the project*

consumption per each use in the mine. All the proposed indicators were used to define priorities between the feasible sources. The result indicated as the best priorities, the closest abstractions to the beneficiation plant process, so that to spend less energy and less costs. The Table 3 presents the best sources to attend the total water demand of 2.500m^3/h for the project, with its priorities. This availability and priorities were used to the development of the management system.

The last step consisted on the development of the operational water management system, which will connect all the points of water availability to the demands of the project. With the use of monitoring information and hydrologic simulations and predictions, the system can indicate, for each month, the best sources to be used to supply the demands. The proposed system has also the possibility to assess other water uses in the catchment basin and evaluate potential conflicts. This way, the Minas-Rio project can have alternatives to choose at any moment, the best abstracting sources.

Table 3 *Best evaluated sources, its availabilities and priorities in the management system*

Source	Availaibility (m^3/h)	Main Priority
Run-of-river abstraction from the Peixe river	2.500	4
Set of boreholes for lowering the water level in the mining pit	250	2
Hydrologic potential of the dike to contain sediments	80	3
Hydrologic potential of the tailings dam	625	1
Total	**3.455**	

Conclusions

The system developed and being implemented at the Minas-Rio Iron-Ore Project had its studies done for the whole catchment basin where the interferences could be verified. One important conclusion from the development of the system is that it will take to important economies for the project. The opportunity to use water from sources with less energy costs for pumping was enough to pay the development of the system and its operation will take to greater economies to the mining project.

Other conclusion of the system was the possibility to guarantee the water supply of the project during its lifetime, without causing conflicts with other users. That's also important as water resources were changed from a weakness of the project to an opportunity.

Finally, it's important to highlight that this system can be developed for any mining project, with the same objectives of guaranteeing the water supply and not taking to conflicts with other water users.

References

Biswas A. K. (2008) Integrated water resources management: Is it working? Water Resources Development Journal. Vol. 24. (1): 5—22.

Kumar V.R., Sahay S. N., Periasamy N., Prasad S. S., Karthikeyan S. (2010) Ground water basin management at the Neyvely Lignite Mines. Mine Water Environ 29(1):23—28.

Mudd G. M. (2008) Sustainability reporting and water resources: a preliminary assessment of embodied water and sustainable mining. Mine Water Environ 27(3):136—144.

Younger P. L. & Wolkersdorfer C. (2004). Mining impacts on the fresh water environment: technical and managerial guidelines for catchment scale management. Mine Water Environ. 2: S2—S80.