THE EFFECTS OF MINING CAPÃO XAVIER IRON ORE DEPOSIT ON THE WATER SUPPLY OF BELO HORIZONTE, MINAS GERAIS, BRAZIL

Leandro Quadros Amorím[1], Rafael Fernández Rubio[2] and Fernando Flecha Alkmin[3]

[1] Minerações Brasileiras Reunidas – MBR
Av. Ligaçao, 3580. 34000 Nova Lima (MG), Brazil
Phone: + 55 312 893120, Fax: +55 312 893147
e-mail: lqa@mbr.com.br
[2] FRASA Ingenieros Consultores, S.L.
Luna, 45. 28120 Ciudad Santo Domingo (Madrid), Spain
Phone: + 34 91 6221078, Fax: +34 91 6221983
e-mail: frasaing@mx4.redestb.es
[3] Department of Geology EM-UFOP
Pça. Tiradentes, 20. 35400 Ouro Preto (MG), Brazil

ABSTRACT

Capão Xavier is an iron ore deposit located near the city of Belo Horizonte, Brazil. The mine site is surrounded by catchment areas where the water is collected to supply this large city as well as other minor villages.
As it will be necessary to proceed with the dewatering of the mine, a comprehensive hydrogeologial study was carried out in order to assess the environmental effects of the mining activity on the water supply system. The general aspects of this study are presented in this paper.
The compatibility between the two activities - mining and water supply – is demonstrated based on the (water) resource conservation concept, which is the basis of sustainable development. Additionally, by managing the mine's interference with the groundwater, the project will bring environmental benefits to the water supply system that will contribute to the maintenance of the environmental capital at current levels, despite the removal of the non-renewable natural resources (iron ore).

INTRODUCTION

The Capão Xavier iron ore deposit is located in the northern portion of the "Quadrilátero Ferrífero", a major iron ore mining district in southeastern Brazil. The deposit is located 15 km to the south of Belo Horizonte, the capital of the State of Minas Gerais, with a population of about 3 million people.

This deposit will be developed in order to replace the production of the nearby Mutuca Mine, to be depleted by the year 2003.

Capão Xavier deposit is surrounded by catchment areas where the water is collected to supply the city of Belo Horizonte (representing around 5% of the total supply). A comprehensive hydrogeologial study was carried out in order to assess the environmental effects of mining Capão Xavier on the water supply system.

The aim of this paper is to demonstrate the environmental sustainability of this project related to the water supply aspects, based on the concept of environmental capital.

HISTORICAL ASPECTS

The mineral rights of Capão Xavier belong to Minerações Brasileiras Reunidas S.A. (MBR), a major Brazilian iron ore producer. The water supply system belongs to the municipality of Belo Horizonte and is administrated by COPASA, the water company of the Minas Gerais State.

In 1992, MBR and COPASA decided to develop a joint hydrogeological study in the area, aiming to technically evaluate the possibility of the co-existence of the two activities: mining and water supply.

Started in 1993, these studies were developed by FRASA, a Spanish consulting company, with the participation of the Department of Geology of the Federal University of Ouro Preto (UFOP) and the technical staff of both COPASA and MBR.

The study confirming the compatibility of the two activities was concluded in 1997 (Fernández-Rubio *et al.*, 1997, 1998). As a consequence of this, an agreement establishing the procedures to be adopted as well as the guarantees offered by MBR in order to maintain the quality and quantity of the water resources was formalised by MBR and COPASA in 1998.

EXISTING WATER SUPPLY FACILITIES

There are four hydrographic basins around the Capão Xavier deposit: **Mutuca** to the north; **Fechos** to the southeast; **Catarina** to the southwest and **Barreiro** to the northwest (Figure 1). Immediately to the south of the future mine site, there is a seasonal streamlet named "Córrego Seco" ("dry creek") where the water is not collected.

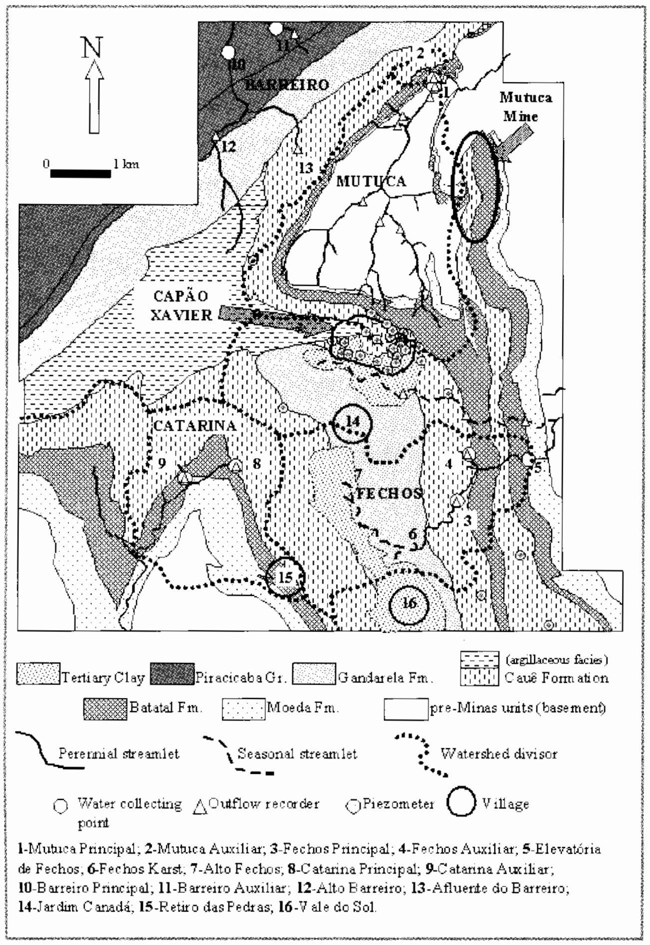

Figure 1. Simplifyed geological map (after Alkmin et al. 1996); waters heads/mines location and environmental control system (MBR/COPASA/FRASA).

The water in the **Mutuca basin** is collected from two small dams (Figure 1, points 1 and 2). The first dam collects water from the Mutuca creek, which is formed by the junction of three major streams located to the north of the Capão Xavier deposit. The water of the second dam comes from a small tributary stream on the left bank of Mutuca creek. The historical outflows from these points are shown on Figure 2.

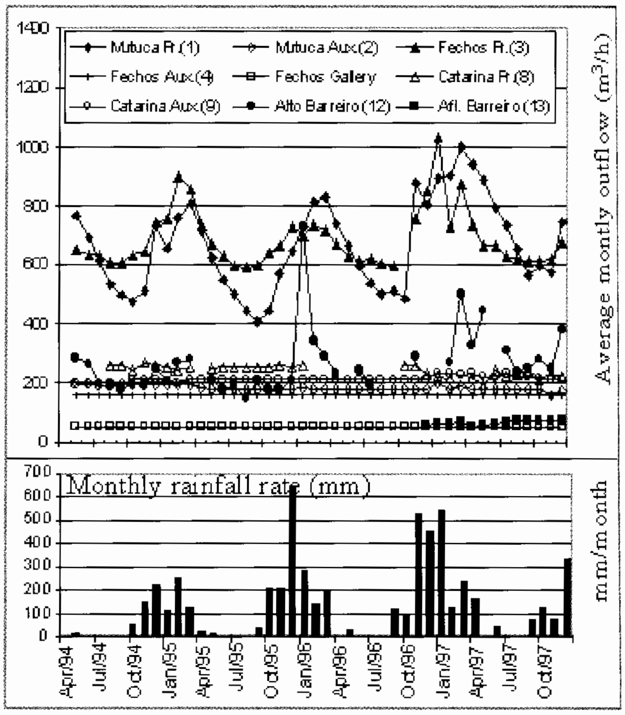

Figure 2. Outflow control and rainfall rates.

There are four water-collecting points in the **Fechos basin**. The major one (Figure 1, point 3) is a small dam that collects water from the Fechos creek. This stream is fed by a group of seasonal springs (Figure 1, point 7) located close to the village of Jardim Canada and a perennial tributary karstic spring (Figure 1, point 6). On the right bank of the Fechos creek, a few metres downstream of the major dam, there is a small gallery where the water is also collected. The second small dam (Figure 1, point 4) collects water from a tributary stream which enters Fechos creek from the left bank. The outflow diagrams of the above mentioned points are shown on Figure 2. The third existing dam in this watershed (Figure 1, point 5) is also located in Fechos creek at about 1.5 km downstream from the major dam. It is a complementary system used only in the dry season.

The waters from these two systems (Mutuca and Fechos) are treated in "Morro Redondo" plant, which supplies the highest part of the city of Belo Horizonte.

The **Catarina basin**, to the southwest of the Capão Xavier deposit, has two major water collecting points (Figure 1, points 8 and 9), both located very close to source springs of the Catarina creek. The outflows of these two points are presented in Figure 2. There is a complex distribution net at this site. The water is used to supply the "Retiro das Pedras" village (Figure 1, point 15) and, at the moment, COPASA is implementing the required infrastructure to supply the "Jardim Canada" village (Figure 1, point 14), both by water raising pumps. Part of the water collected in Catarina is also utilised to supply the lowlands of Belo Horizonte.

Finally, the **Barreiro basin**, located to the northwest of the future mine site, has two collecting points: the major one (Figure 1, point 10) collects water from the Barreiro creek, and the second one is presently deactivated (Figure 1, point 11). The junction of two major tributaries where gauging stations were installed (Figure 1, points 12 and 13), forms the Barreiro creek. The outflows of these two points are shown in Figure 2.

THE HYDROGEOLOGICAL MODEL

Despite the complex geological structure of the study area, the hydrogeological system is relatively simple. The structural picture is dominated by a faulted and refolded syncline, the Moeda syncline, affecting Archean and Paleoproterozoic metasediments (Alkmim *et al.*, 1996). The different rock types that occur in the region interact differentially with the hydrogeological system. Quartzites, banded iron formations (itabirites) and dolomites, respectively of the Paleoproterozoic Moeda, Cauê and Gandarela formations, as well as the cover units (laterite crust, "talus" deposits and soil) behave as aquifers. On the other hand, schists of the Archean Nova Lima Group and phyllites of the Paleoproterozoic Batatal formation as well as impermeable facies within the Cauê Iron Formation and Tertiary clay horizons are impermeable, behaving as aquicludes (FRASA, 1995; Amorim *et al.*, 1997).

The aquifers of the region can be classified in **superficial** and **deep**.

Permeable cover materials like soils, laterite crust ("cangas") and detrital deposits form the superficial aquifers. They behave as unconfined granular aquifers, showing high seasonal outflow variations.

The *superficial aquifers related to canga and soil* correspond to Tertiary and Quaternary deposits, which occur in the highest portions of the study area. Impermeable layers of Tertiary clays underlie these materials and Precambrian rocks. Superficial aquifers are directly recharged by rainwater. Their discharges occur through seasonal springs and by infiltration into the subjacent aquifers.

Within the studied area, the superficial aquifers are responsible for two seasonal streams: the "Corrego Seco", to the south of Capão Xavier and "Alto Fechos" (Figure 1, point 7).

The *superficial aquifers related to talus deposits* are also unconfined aquifers with high permeability, showing high seasonal variability in outflows and their recharge occurs by direct infiltration of rainwater. Talus deposits occur over impermeable basement along the valleys of the study area. Discharge is in the form of streamflows converging to the large valleys. Due to these particular characteristics, this type of aquifer behaves as a series of isolated systems not subjected to external influences since they are not connected to any other aquifer. The Mutuca Creek, and the main tributary of Barreiro Creek are fed by this type of aquifer.

The *deep aquifers* typically show low variability in outflow, which is almost independent from the rainfall seasons. This type of aquifer provides the principal media for recharge, trapping and transmitting groundwater in the region.

The *aquifer related to the Gandarela Formation* corresponds to a karstic system developed in dolomites, which form the core of the dominant syncline of the study area. This system has only one discharge point located at some 1600 m upstream of the major dam of Fechos: the "karstic spring of Fechos" (Figure 1, point 6). This point contributes with an almost constant outflow of about 600 m^3/h to the Fechos Creek. The recharge occurs by direct infiltration of rainwater, coming from the upper aquifers and from the "lateral" Cauê aquifer (Amorim *et al.*, 1997).

The *aquifers related to the Cauê Iron Formation* constitute a more complex system. Depending on the degree of alteration, sedimentary facies and depth, itabirites show characteristics of porous media (with variable permeability), fractured aquifers (in fresh rocks with open fractures) and aquicludes (fresh rocks with closed fractures and argillaceous facies).

Rocks of the Cauê Formation outline the complex geometry of the Moeda Syncline and are enveloped by the impermeable phyllites of the Batatal Formation. These permeability barriers block the outflow from the highlands to the lowlands, except at some particular discharge points, where erosion has exposed the water table, generating springs with very low seasonal outflow variations (Figure 1, points 2, 4, 8, 9 and 13). The recharge occurs in the area of the Jardim Canada village as well as the adjacent ridges underlain by the iron formation, including the Capão Xavier mine site.

THE MINING PROJECT

Capão Xavier Mine will be an open pit iron ore operation designed to replace the production of the Mutuca Mine, which will be depleted by the year 2003. The existing facilities of the Mutuca Mine will be used to treat and load the ore from Capão Xavier. The exhausted Mutuca pit will be filled with part of the waste and tailings from Capão Xavier.

The mineable reserve of Capão Xavier is in the order of 140 million tonnes of ore, being 40 million tonnes above the water table and 100 million tonnes below it. According to the present mining plan for Capão Xavier, it will take about eight years of production to reach the groundwater level, when the mine dewatering will start.

A battery of 10 wells has been designed for pumping the groundwater from the mine site with a total outflow of 616 m^3/h. The assessment of the impact of this dewatering operation on the springs of the region was the major goal of the hydrogeological study.

IMPACTS ON THE WATER RESOURCES

The effects of the proposed mining activity in Capão Xavier Mine will vary according to the following stages: 1) pre-mining, 2) mining above the water table, 3) mining below the water table, 4) mine depletion and flooding the pit and 5) decomissioning.

The **pre-mining** stage is the present one, ideal for the characterisation of the environmental conditions of the area. A hydrological monitoring programme was designed and implemented with the production of annual reports since 1995. The available database includes hydrochemistry information since 1972; rainfall records, since 1855; piezometric control, since 1991 and streamflow control, since 1994. These informations allow a detailed characterisation of the natural media.

During the **mining above the water table** stage, there will be no interference to the natural groundwater system. Thus, there will be no change in the outflows as a consequence of the mining operation. In fact, a more accurate characterisation of the natural conditions will be possible when the data from the monitoring programme of this eight years period is added to the pre-mining database.

Since the future pit is partially located within the Mutuca basin, the only possibilities of interference with the water resource at this stage would be: 1) to silt up the watershed with materials carried from the mine by effluents during rainfalls and 2) to reduce the streamflows due to a net reduction in the watershed area.

To avoid the first problem, a system of peripheral drainage channels has been designed in order to conduct the eventual effluents to a deposition site located outside the Mutuca basin. The second issue is negligible since the area of the pit inside the Mutuca basin is small (less than 2%) compared to the total area of the basin.

The possibilities of interference with natural outflows will start during the mining **below the water table stage**, when it will be necessary to proceed with the dewatering of the Cauê aquifer. At this stage, the possibilities of impact on the springs will vary according to the individual characteristics of the different aquifers in the area.

Despite the proximity of the Mutuca Creek springs to the mine site, the dewatering will cause no impact in the superficial aquifers related to talus – *Mutuca* and *Barreiro creeks* – due to the fact that these aquifers are not connected with the Cauê aquifer. Besides this theoretical assumption, there is practical evidence of this fact: the already developed dewatering of Mutuca Mine. From a hydrogeological point of view, the Mutuca Mine is similar to Capão Xavier (see Figure 1). The dewatering of Mutuca Mine started in 1988 and, by 1998 the water table has been lowered to 200 m below its original position, which means it is 140 m below the altitude of the nearby Mutuca Streamlet springs. Despite this, no change has occurred in the natural outflow of these springs (Figure 3).

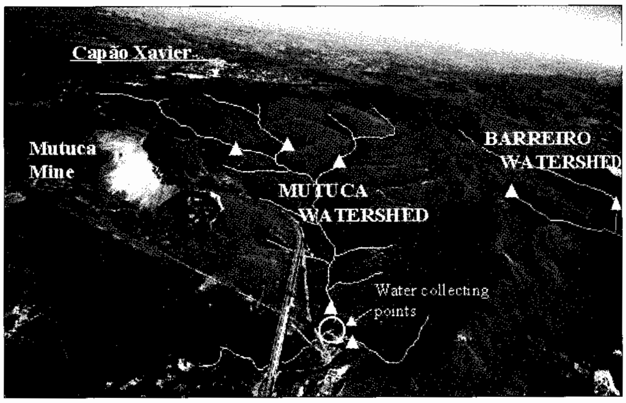

Figure 3. Types of flooded mines (FRASA, 1995).

The *karstic spring of Fechos* as well as all the springs associated with the Cauê aquifer can, theoretically, suffer some influence from the dewatering of Capão Xavier in different intensities. Two statements have to be made at this point:

1) *The reduction in the outflows caused by the dewatering of Capão Xavier, if it occurs, will be progressive, starting from zero at the beginning of the dewatering, up to a maximum value at the end of the mining operation and,*

2) *The amount of water to be pumped from the aquifers will be always bigger than the maximum value of the eventual reduction in the outflows of the springs* (FRASA, 1995).

The next stage will be the **mine depletion and flooding the pit**. The flooding will occur as a consequence of stopping (or reducing) the pumping, resulting in the inflow of groundwater, rainwater and surface water (collected in drainage channels) into the pit.

Due to the geometrical characteristics of the Capão Xavier ultimate pit, the water table will return to its original position when the pit is completely flooded. This will generate a lake with maximum and average depths of 140 m and 75 m, respectively, and with a storage capacity of 60 million cubic meters of water. Here, a third statement shall be pointed out:

3) *If the dewatering of Capão Xavier had caused any reduction in the natural outflows, the lake will (at least) restore the original conditions after being completely filled* (FRASA, 1995).

In fact, as the pit is located in the recharge area of the deep aquifers, the existence of the flooded pit will improve recharge conditions which may even increase the original outflows of the springs. In any event, this improved recharge guarantees maintenance of the availability of the water resources in the region on a permanent basis.

Finally, after the lake is filled, the original outflows restored and the area has been rehabilitated, there will be the **decomissioning** phase. At this stage the mine site will be reincorporated into the natural environment.

QUANTITATIVE IMPACTS

Detailed geological mapping was carried out as part of this investigation programme by the Ouro Preto Federal University (Alkmim *et al.*, 1996), clarifying the geological structure as well as the contacts between formations. Despite this, the local intrinsic characteristics – such as transmissivity and permeability – of the Cauê and Gandarela aquifers over an area of about 60 km^2 are very difficult to evaluate at a reasonable cost, due to their natural heterogeneity and complexity. Therefore, it is not possible to predict if the dewatering of Capão Xavier will or will not cause any reduction in the natural outflows.

Thus, in order to quantify the possible impacts, the *theoretical maximum impacts* on the springs have been calculated, based on a pessimistic mathematical model. Using the software "Visual Modflow" a model was created to simulate the "worst case scenario", therefore, the results are always considered to be conservative (i.e. on the "safe side").

The modelling was carried out by FRASA (Fernández-Rubio *et al.*, 1997, 1998) and detailed discussion is outside the scope of this work. The main outputs of the model were *1) the maximum dewatering scenario*, where the mine is assumed to be drained to its maximum depth, and remains so indefinitely and *2) the flooded mine scenario*, where the "lake" is assumed to be completely filled.

The results of these two stages are presented in Tables 1 and 2. In the first case, an overall reduction of 7% in natural outflows is expected and in the second, an increment of 7% would occur, both compared with the original average figures.

Spring/stream (point figure1)	*Average outflow (m^3/h)*	*Predict outflow (m^3/h)*	*Difference (m^3/h)*
Mutuca Aux.(2)	192	140	-52
Afl.Barreiro(13)	68	60	-8
Catarina Aux.(9)	212	212	0
Catarina Pr.(8)	252	252	0
Fechos Aux.(4)	158	143	-15
Fechos Gallery	52	52	0
Fechos Karst (6)	606	497	-109
Subtotal modelled	**1,540**	**1,356**	**-184**
Mutuca Pr.(1)	667	667	0
Alto Barr.(12)	265	265	0
Alto Fechos (7)	79	79	0
Grand total	**2,551**	**2,367**	**-184**

Table 1. Predicted outflows for the maximum dewatering scenario.

According to the model, a battery of 10 wells pumping at a rate of 616 m^3/h will be required to dewater the mine. This amount of water is more than three times the maximum theoretical impact, which means that it is always possible to make up for any reduction in the natural outflows and even to provide increased water supplies utilising mine water.

Spring/stream (point figure1)	*Average outflow (m^3/h)*	*Predict outflow (m^3/h)*	*Difference (m^3/h)*
Mutuca Aux.(2)	192	159	-33
Afl.Barreiro(13)	68	74	+6
Catarina Aux.(9)	212	212	0
Catarina Pr.(8)	252	252	0
Fechos Aux.(4)	158	249	+91
Fechos Gallery	52	52	0
Fechos Karst (6)	606	724	+118
Subtotal modelled	**1,540**	**1,722**	**+182**
Mutuca Pr.(1)	667	667	0
Alto Barr.(12)	265	265	0
Alto Fechos (7)	79	79	0
Grand total	**2,551**	**2,733**	**+182**

Table 2. Predicted outflows for the flooded mine scenario

Again, according to the model, the Capão Xavier "lake" when filled, would slightly increase the natural outflows compared to the original figures.

Obviously, the above values must be considered only as indicators, being useful to assess the magnitude of the impacts. Taking into account that the model is "conservative", the real (negative and positive) impacts are expected to be smaller than the figures presented in Tables 1 and 2, or even no impacts at all may occur as a consequence of the dewatering of Capão Xavier Mine.

The model confirms the previous conclusions about the water balance and the "reversibility" of the impacts after the lake is filled. An additional conclusion arising from this topic would be:

The quantitative impact on the streamflows produced by the dewatering of Capão Xavier will be nil or of low magnitude, compared with the total outflow.

QUALITATIVE IMPACTS

Once the proposed mining operation interferes with the groundwater system, the possibility of water contamination becomes an important issue. In all iron ore mines of the "Quadrilátero Ferrífero" and particularly in this case, unstable or soluble minerals (like sulphides or salts) are virtually absent in the ore and waste rocks, avoiding the risk of groundwater contamination.

Due to the same reason and, as observed in many other iron ore mines of the region, the mine water produced from the dewatering wells would not present any quality problem. The discharge into the streams is perfectly compatible with the natural environment.

Under these conditions, the ordinary procedures adopted to control the discharge into surface waters as well as dust dissipation, if correctly applied, will guarantee the maintenance of the standard of water quality until the depletion of the mine.

From a qualitative point of view, the main aspect will be, therefore, the quality of the water of the Capão Xavier "lake" after flooding the mine.

Since the lake will be located in the recharge area of the deep aquifers, the maintenance of the quality of its waters to good standards during the post-closure stage is an important issue. This subject was studied in detail, taking into account two major aspects: **salination** and **eutrophication** (FRASA, 1995).

The flooded mine will behave like a natural lake. In this case, the **salinity** will depend on the hydrogeological and climatic characteristics of the area. The hydrogeological conditions can be simplified into three possible situations: *1) groundwater flowing to the pit, 2) groundwater passing through the pit* and *3) groundwater flowing from the pit* (Figure 4). The major climatic aspect to be considered is *the balance between precipitation and evaporation.*

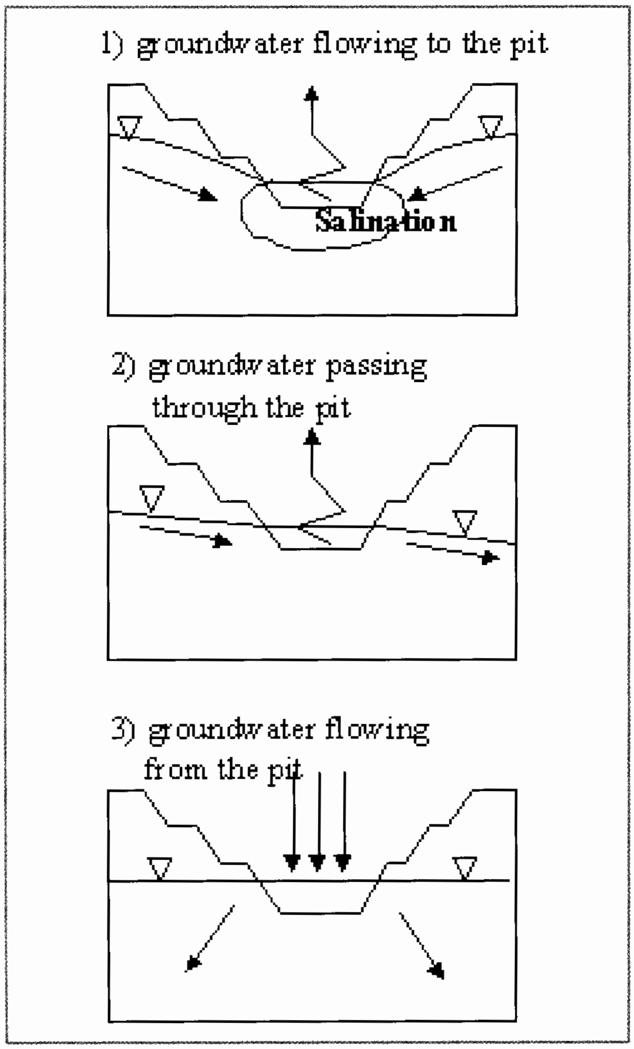

Figure 4. Types of flooded mines (FRASA, 1995).

The first case leads to a progressive salination of the lake. The rate of salination will depend on the precipitation/evaporation ratio. In the other two cases, the increment in salinity, if it occurs, is in general low and will depend on the time of residence of the water within the pit, compared to the precipitation - evaporation ratio.

In the particular case of Capão Xavier (case 3), the precipitation and evaporation data have been compared during a continuous period of 6 years of observation. The average precipitation rate for this period was 1668 mm/year and the average evaporation rate was 963 mm/year, meaning an average difference of 706 mm/year in favour of the precipitation.

The evaporation figures considered in these calculations were the ones directly registered in an evaporimeter tank without any reduction factor (usually this factor falls in the range of 0.5 to 0.7). This has been done in order to be on the "safe side". According to this hydrological balance, with a dominance of precipitation over evaporation, the Capão Xavier Lake will not show salination problems.

Eutrophication results from the excessive growth of aquatic vegetation damaging the balance of oxygen in the water body. The causes can be inherent to the mass of water itself, like the decomposition of dead organisms and dissolution of sediments, or external to it, like inflow of organic matter.

The enrichment of the water in nutrients creates an increment of plantonic algae. As a consequence of photosynthesis, a eutrophic zone with high levels of oxygen and organic matter is produced close to the surface. On the contrary, the dissolved oxygen is exhausted on the bottom, due to breathing of the organisms and to the mineralisation of the organic matter produced in the upper zones.

In the particular case of Capão Xavier, the most important factors that can lead to eutrophication are related to human activities, like domestic and industrial wastes as well as inflows from paved surfaces. Thus, eutrophication can be avoided by simple measures within the watershed area and lake, deflecting possible contaminant sources, and monitoring and managing the exploitation of the waters of the lake, mainly by collecting water from the bottom (Sperling, 1996).

It is possible to conclude here, that *due to the hydrogeological and climatic characteristics of this area, contamination of the water resources can be avoided in all stages of the project by using relatively simple control actions. These actions, if taken, will guarantee the maintenance of the water quality standards.*

SUSTAINABILITY OF THE PROJECT

From the subjects discussed so far, it is possible to extract the following major points:

1) *The quantitative impact on streamflows produced by the dewatering of Capão Xavier will be nil or of low magnitude, compared with the total outflow.*
2) *The required quantity of water to be pumped from the aquifers to dewater the mine is much higher than the eventual total reduction in spring outflow, making it possible to compensate for spring flow reductions by redistribution of the mine water. At the post closure stage, the mine will be naturally flooded generating a water reservoir with a storage capacity of 60 million cubic metres.*

3) *By flooding the pit, the natural outflows of the springs will be at least restored to their original values (if any alteration had occurred) or even increased.*
4) *There is no risk of chemical contamination of the waters and, physical contamination can easily be avoided by simple control measures.*

The above issues indicate that the mining project is technically compatible with the water supply activities if the correct control procedures are adopted. Taking this into account, the next step was to establish legal ways to guarantee the environmental management of the system in order to preserve the water resources on a permanent basis.

An **environmental management system (EMS)** has been designed for the project. The legal warranties for its execution (in addition to the rigid Brazilian environmental legislation) were embodied in an agreement between MBR and COPASA. This EMS *aims to maintain the environmental conditions (water resources) of the site, at least in the same situation, as it would be without the development of the mine.*

Considering that it is technically and economically feasible to mine the Capão Xavier deposit without "damaging" the water supply system, an important feature must be pointed out: **the positive effects of the project on the water resources.**

Due to its nature, the mining project will interfere with the groundwater system which may or not cause a (reversible) change in the outflows of some springs. Independently of this fact, the environmental effect of this interference has a potential benefit for the water supply system as will be discussed.

At the **pre-mining** and **mining above the water table** stages, no interference with the groundwater system will occur and consequently no effect will be observed.

During the **mining below the water table** stage, starting at around the eighth year of operation, the water pumped by the dewatering wells will by far cover the MBR´s water needs and also the requirements to compensate any (eventual) reduction in the natural outflows.

This excess can be used to regularise the general output of the water supply system which could be optimised with correct management (i.e. concentrating the pumping in the dry seasons, when there is a natural decrease of the outflows - see Figure 2). *This would maintain the existing water supply system working at full capacity all year round during a period of about 17 years.*

The mine closure will occur after about 25 years of operation, starting the **mine depletion and flooding the pit** stage. At this time, there will be some wells located outside the pit that can continue to operate (during the dry seasons) contributing to the regularisation of water output. Obviously, at this stage there will be a decrease in groundwater availability compared to the previous phase. However, the total output can still be higher (and more regular) than it would be without having had the mine.

During this phase, the ideal water-pumping rate will be a future decision. It should be planned taking into account a balancing between the future demand for water and the time desired to flood the pit. The greater the water-pumping rate, the more time will be taken to flood the mine. Without any pumping, this time was estimated to be about eight years (FRASA, 1995).

Finally, at the **decomissioning** stage, there will exist a water reservoir with a capacity of 60 million cubic meters as part of the water supply system. It can be used to regularise the outflows and also to increase the total water output, compared with the original (pre-mining) conditions.

The above reasons lead to the conclusion that *the interference of the mining project on the groundwater system will promote a general improvement in the water supply system on a permanent basis.*

Since ore is a non-renewable resource, the concept of resource conservation, which is the basis of **sustainable development**, cannot be applied to mining. Issues relating to sustainability of the mining industry may therefore focus on the concepts of **environmental capital (**Foster, 1998).

Environmental sustainability can be demonstrated as maintenance of current levels of environmental capital, despite the removal or non-renewable natural resources. This approach allows adverse environmental impacts to be compensated by the provision of alternative environmental benefits and is not solely dependent on the prevention or mitigation of all environmental effects that would have a negative impact.

From the water resources point of view, the sustainability of Capão Xavier project can be demonstrated based on the resource conservation concept, since the (water) resource will be preserved on a permanent basis. For the other environmental issues, however, the principle of environmental capital shall be adopted.

Under these conditions, if any loss of water occurs, its replacement would be a simple (and obligatory) mitigation measure. The additional benefits to the water resources, on the other hand, represent effective environmental gains that must be accounted as part of the compensation measures. It is a measurable benefit (once it has economic value) that will contribute to the maintenance of the environmental capital at its present level and consequently to the demonstration of the sustainability of the project.

CONCLUSION

Taking into account the level of detail and the amount of available data, the hydrogeological study for Capão Xavier Mine project represents the most comprehensive assessment of this nature ever carried out in Brazil.

The study demonstrates that mining and water supply are compatible, which means that the mining project is sustainable under each of the following conservation concepts:

1) **The (water) resource conservation**, technically guaranteed on a permanent basis by the mitigation measures and,

2) the maintenance of **the environmental capital** at the present level, guaranteed by the environmental compensations, which include the improvements to be obtained in the availability of the water resources.

What was supposed to be a problem - the proximity of the project to part of the water supply system of a large city - is in fact an advantage. This proximity and the particular environmental conditions, required a study to a very high level of detail which was made possible because there was a large volume of available data from both companies (MBR and COPASA). Finally, this proximity will allow society to reap benefits from the project's interference with the groundwater system.

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