SURVEY at IRON MINE DAM – 10 YEARS of MONITORING

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SUMMARY

The facility of Carajás, the world greatest iron mine, has six dams: four for the sediments, one for the water adjustment and one for the reclaiming. All of them are monitored by a dam management and control system, groundwater table, water gauge, bathymetric surveys, regular inspections and control of the discharge of the drains and spillways. Moreover, there are controls by satellite imagery/remote sensing and the use of dam fill simulations, which provide the discussion about spatial distribution of clearance and further increases.
The name of the dam is called *Geladinho*. It is a dam for sediments which will be use in the future. The main focus of this study is the monitoring of the water volume and compared to the regular results of bathymetric surveys since 1999. The developments of equipment and software improved the results of surveys, it allowed better visualization and more precise control of dredge works.
In 2006, the dredge works at the dam area had begun. Done by suction dredgers and pumps, the work process was also monitored by bathymetric surveys.

1. INTRODUCTION

The Carajás mineral province is one of the most important Brazilian mineral reserves, which has the largest deposits of iron in the world. Also there are deposits of Au, Cu, Mn, Ni and Pt. The Carajás iron mine was discovered around 1967 and is located in the Serra dos Carajas in the municipality of Parauapebas, state of Pará – Brazil.
The facility of Carajás, is owned by the Brazilian mine company Vale (CVRD). Within this complex there are six dams, used for different purposes. Being four for the sediments, one for the water adjustment and one for the reclaiming of the iron ore.

All of these dams have a dam management system which is used in a series of frequent observations by piezometer, tide gauge, bathymetric surveys, periodic inspections and control of the discharge of the drains and spillways. In addition, controls are done with satellite imagery and the use of dam fill simulations, which provide the discussion about spatial distribution of clearance and further increase.

The dam of this study is known as *Geladinho.* It has the purpose to be the dump for

sediments, which will be treated in the future. The main focus of this study is to monitor the volume of water and to reject the results of bathymetric surveys conducted from year 1999 until 2009 by condensing the results of a ten-years study at the dam. Within this period, more precisely in 2006, the dredge works at the dam began. Done by suction dredges and pumps, the work process was also monitored by bathymetric surveys. The development of equipment and software improved the results of surveys, allowing better visualization and more precise control of the dredged material. Moreover, throughout the implementation of the bathymetric surveys, it was possible to notice the evolution of the sediment and the reduction of the depth along the control activities of the dam.

2. METHOD

2.1 Survey

The bathymetric surveys were performed by according to the standard A-06A, adopted by the Brazilian Directorate of Hydrography and Navigation (DHN) for hydrographic surveys carried out without the purpose of producing elements that serve to update nautical charts and publications called surveys of category "B". The horizontal datum during the survey was taken as the World Geodetic System 1984 (WGS84).

The calibration of the echo sounder was performed by using a stainless steel plate (method of bar check), graduated in the initial depth of 2 meters and successive each meter until the maximum depth at the area of work.

The navigation of the vessel was based on planned lines guided by the Differential Global Positioning System (DGPS). The DGPS was installed center above the transducer of the echo sounder. Throughout the surveys, high frequented bathymetric depth data were collected simultaneously and automatically positioned with DGPS by using the software HYPACK, developed by Coastal Oceanographics in different versions over time.

2.2 Processing

The pre-processing and post-processing of the hydrographic project was done by HYPACK software.

During the data processing, the digital profiles were compared with those, which were recorded by the analog echogram (echo sounder paper registration), and eliminated all spurious data, including the dense characterized vegetation that distort the calculations of water volume.

After edit the data in pre-processing, the final processing was performed to consist of scaled and edited depths from the echogram, the selection of sounding and the production of bathymetric charts.

3. VOLUME CALCULATION

3.1 Results

Throughout the study it is perceived that the water volume of the dam *Geladinho* has decreased steadily until July 2006. But since this month there is a variation of the water volume which rises and declines at several times. This behavior reflects to the dredge works that have been started during the year of 2006. Dredging at the dam is aimed to control the utilizable area in contrast to the water volume. The largest water volume in the dam was measured at the beginning of the monitoring project and reached the value of 2095332.3 m³. The lowest level was found at the bathymetric survey performed in November 2008 where the value was just 457406.4 m³ (Table 01).

Table 01: Volumes of the water in m^3 and m^2 in submerged areas valued by calculating the volume based on performed data collection during the bathymetric surveys.

Year of survey	Month of survey	Volume (m^3)	Area (m^2)
1999	November	2095332.3	394866.7
2002	November	1768014.5	386874.4
2003	February	1779259.9	374138.5
	November	1492371.5	342571.6
2004	May	1275783.8	301956.3
2005	July	805838.3	219652.6
	September	790596.2	222742.0
	October	755726.6	213806.2
	December	724793.7	219480.1
2006	January	680992.2	213487.8
	March	605470.6	217914.4
	May	604187.9	227453.5
	June	541662.5	192233.3
	August	567026.6	216842.5
	December	605165.6	194273.6
2007	March	685215.5	232199.6
	May	555420.4	222095.9
	August	660900.0	242790.0
	October	694092.6	262977.4
	December	721814.3	258473.4
2008	February	638266.6	247340.3
	April	563735.5	217962.7
	July	532569.6	211511.3
	November	457406.4	213399.2
2009	May	550847.3	228937.0
	October	489851.0	230221.2

At the chart below (Figure 02) one can observe the variation of the water volume throughout the study. The comparison with the first survey in November 1999 and the last one in October 2009, has the result, that the dam did reduce its volume of water about 76.6 %, reflecting to the loss of area for the advancement of deposited material on it.

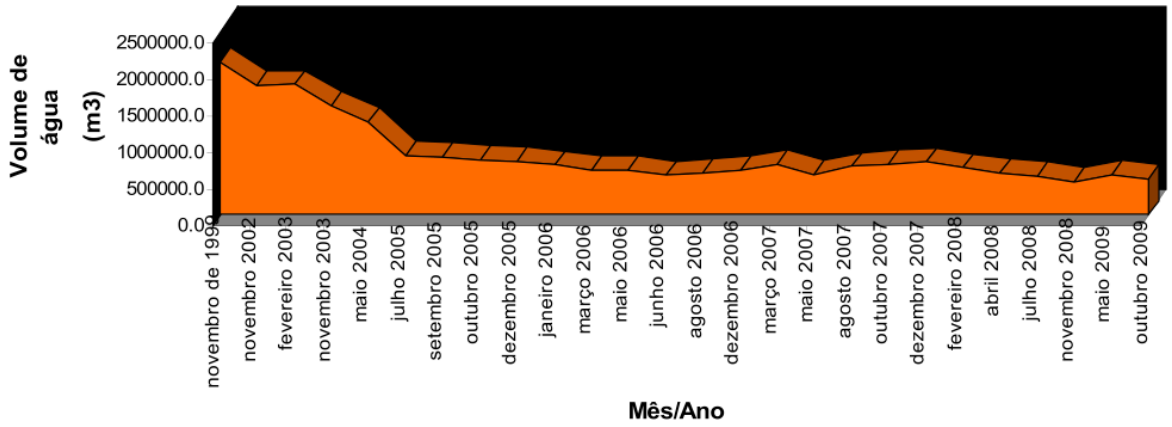

Figure 02: Graph of volume variation throughout the study

The same can be seen at the subsequently figures. The reduction of the area and water volume at the dam is a direct function of the shallower depths. It can be observed in the sequence of pictures below that the dam lost its depth over the time. In the period from November 1999 (Figure 03) until October 2005 (Figure 04) were still depths found with above 10 meters.

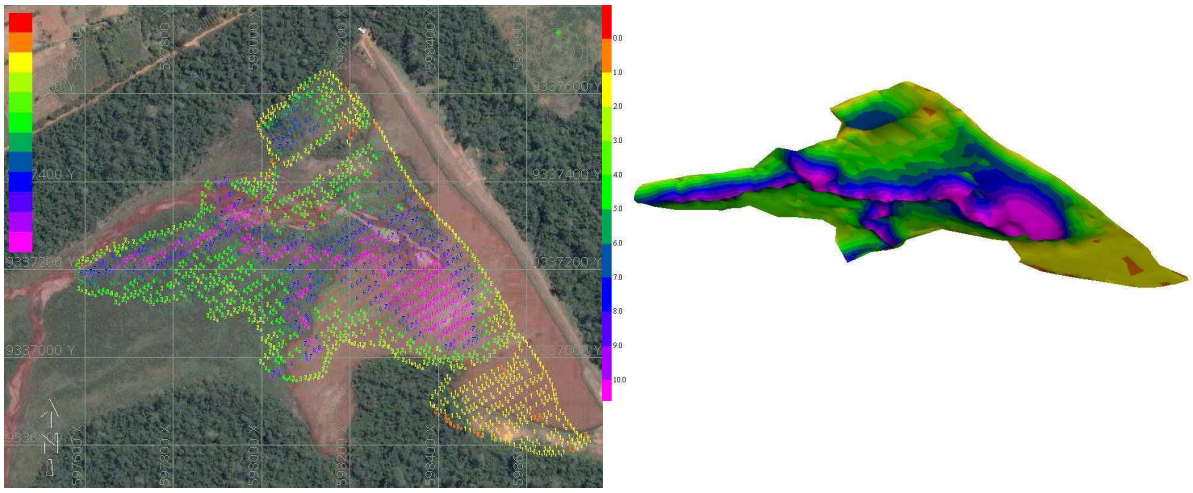

Figure 03: Bathymetric data and 3D graphic of the dam Geladinho in November 1999

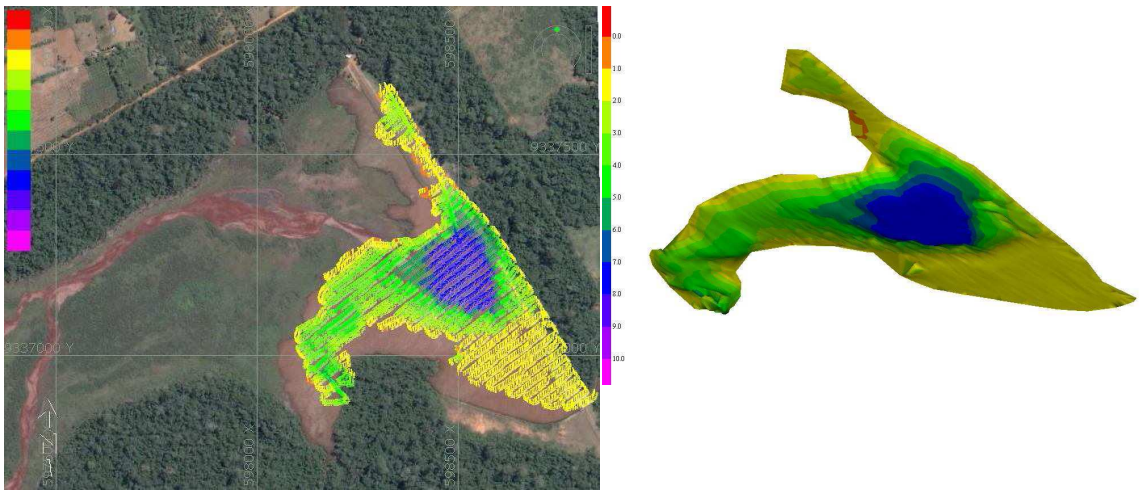

Figure 04: Bathymetric data and 3D graphic of the dam Geladinho in December 2005

Since December 2005 (Figure 04) there are any areas with depths more than 10 meters. The maximum depth was found with eight meters. But one can see that from December 2005 until April 2008 (Figure 05) there is still an area with 8 meters depth located, but it decreases continuously until his disappearance.

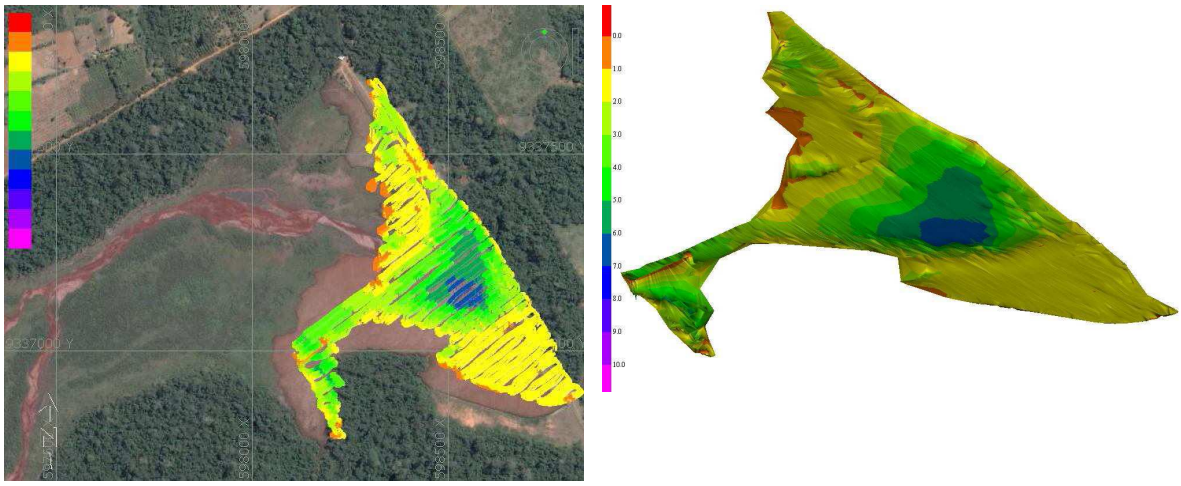

Figure 05: Bathymetric data and 3D graphic of the dam Geladinho in April 2008

In July 2008 (Figure 06) the maximum depth was found with 6 meters. The area with these depths decreased until October 2009 (Figure 07) when the dam reached the shallowest depth of 5 meters.

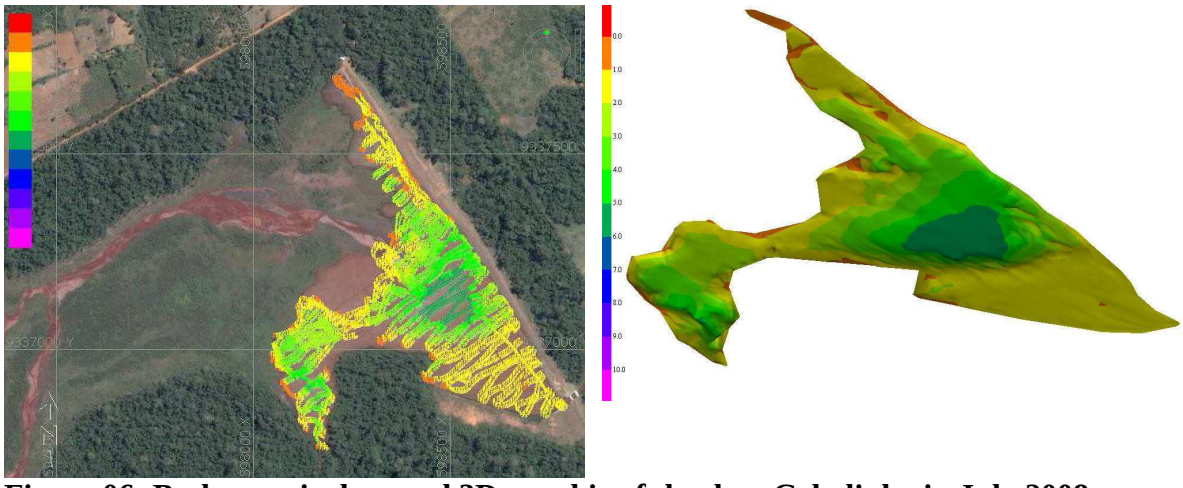

Figure 06: Bathymetric data and 3D graphic of the dam Geladinho in July 2008

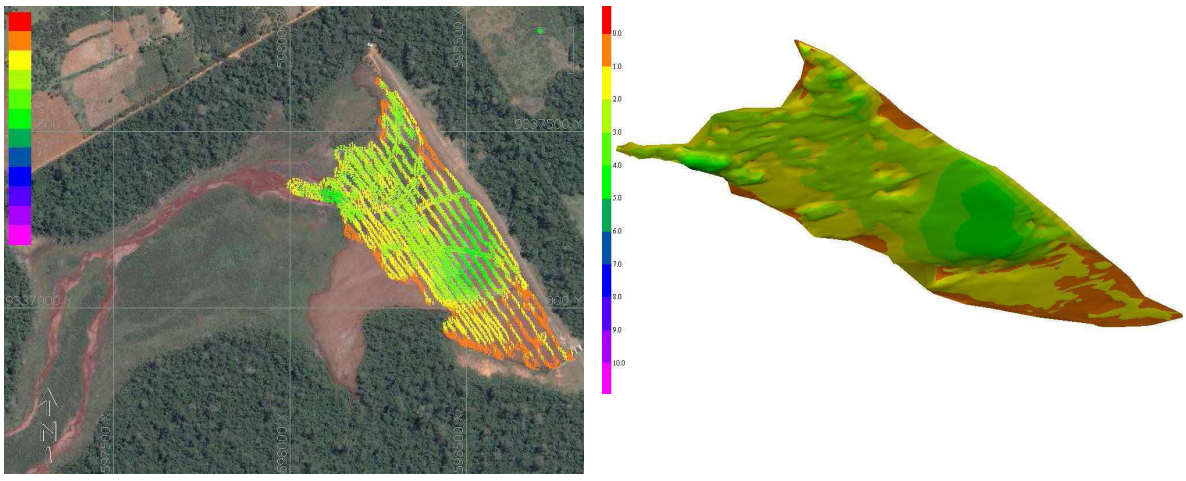

Figure 07: Bathymetric data and 3D graphic of the dam Geladinho in October 2009

4. FINAL CONSIDERATION

It is important to point out, although there are the loss of water volume and area, the dam *Geladinho* will be continuously and without any interruption monitored. The loss are an intrinsic part of its management and administration until the deposited material will be salvaged one day.

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