6-2 Environment Management Plan

6-2-1 Environmental Improvement Based on the Environment Management Plan

From the view point of the environment management plan, the principal action items are listed below with the detailed tactics of short term, middle term and long term, separately.

The principal action items are;

(1) The establishment of the monitoring system to collect the environmental systems continuously. (herein after indicated as [11])

(2) The rearrangement of administrative rules, regulations and laws regarding the environment protection, to control any discharging materials to proceed the environment management actually. (herein after indicated as [12])

(3) To form a joint system setting every members participation, administrations enterprises and peoples to protect the acceptable environment. (herein after indicated as [13])

(4) To establish the environment indexes acceptable by peoples to encourage them to participate in the environment self-control system. (herein after indicated as [14])

(5) To promote the environment education and training of people for the environment issues.

The itemized targets, each of them have short term, middle term and long term strategies, can start from the most implementable strategies. (herein after indicated as [15])

And the such strategies which require certain amount of budget, the preparatory time and the supports of the third parties should be classified as middle and long term strategies, which are shown belows:

	Short Term	Middle Term	Long Term
Monitoring System [11]	Minimum items	Limited items	Every items
Adjustment of rules, regulations and laws [12]	To give more information about the environment to people.	To prepare the punishment with incentives	Continuous and periodical revision of rules
Formation of joint environment protection organization [13]	The united organization of the every administrative organization for the environment	The unification of people's power for the environment protection	
Establishment of environment indexes [14]	Preparation by administration	Elaboration of the indexes with the participation of people	
Education and training [15]	Training of leaders	Training of people	

6-2-2 Monitoring System

(1) Purpose of Monitoring

Monitoring of the environmental condition means to detect the environment phenomenon numerically employing a scientific technology. Since such numeric data is prepared scientifically, it should be universal and repeatable.

The analysis procedure, instruments and reagents to be used should be based on the standarized methods.

Unfortunately in Potosi Prefecture, the environment management authority (Natural Resources and Environment Department) has no scientific instruments and system to analyze the environmental condition and pollutants of the farming field, which is subject to be verified, to get the scientific evidence or data even for the joint meeting between formers and mining operators.

At this moment, when it is so required, the authority should ask such samples to the laborites of private sector, and only what, Potosi Prefecture has, is the environment analysis data irregularly collected by the international assistance organizations.

So we propose, hereunder Potosi Prefecture to set up the monitoring system enabling the collection of scientific monitoring data and to establish a long term environment protection policy.

(2) Monitoring Implementation

It is requested to the administrative organization of Potosi Prefecture to implement the monitoring activities continuously, for essential items, by obtaining cooperation from the private sector or by the Prefecture itself collaborating with other public institution, based on the environment standard and discharging quality standard with the separately determined interval.

(3) Monitoring Organization

In case the private section is asked to do the monitoring activities, it world be necessary to appoint a specific person to be responsible for the activities, and to report based on the periodical monitoring

activities for the pre-determined items and points at least once a year. And it is necessary to establish an organization for the evaluation of data, including the monitoring data prepared by the responsible entity itself, and in case any problem occur, that entity should have enough authority to conduct any remedial and preventive measures to mitigate effects of the incident.

(4) Monitoring the Budget

As the budget of the prefecture must be monitored, it is essential to prepare and maintain records on the cost of human resources (prefectural employees), required manpower cost for the collection of data, any expenses related to data collection, cost for analysis of samples, cost fo the related analytic equipment, the related equipment maintenance cost, and expenses for test chemicals (reagents).

The following budget is for the reference only and should be studied in detailed from a practical view point.

1) Budget for one officer of Potosi Prefecture

One officer for Potosi Prefecture as monitoring officer:

Yearly about US$10,000.

2) Budget for workers for collection of data and related expenses

One data collection worker and transportation expenses for the data collection:

Yearly about US$10,000.

3) Budget for analysis of samples collected, and the related equipment and test chemicals expenses

Short term target (first year):	about US$1,000.-
Short term target (second year and after):	about US$500.-
Middle term target (first year):	about US$35,000.-～US$332,000.-
Middle term target (second year and after):	about US$3,500.-～US$22,000.-
Long term target (first year):	about US$111,000.-
Long term target (second year and after):	about US$15,000.-

(5) Monitoring Human Resources

Potosi Prefecture should train at least one officer to conduct the monitoring data collection and analysis and in case some trouble has happened, to take any necessary countermeasure to protect the environment, and to give him a position in the division responsible for environment protection.

In practice it is essential to empower one officer for monitoring and establishment of countermeasures in the Natural Resources and Environment Department of Potosi Prefecture.

(6) Items to be monitored and Facilities

1) Short Term Target

As the short term target, it is recommended to monitor the following items contained in the test samples continuously, and by short term it is meant to start immediately.

The technology for the test and analysis has already been transferred to the officers of Potosi Prefecture during the Study Team stationed in Bolivia, and the necessary instruments also have been already donated.

Since the items to be monitored are so limited, the effectiveness of environment management would be limited, but expenditures would be also limited.

Test points: Effluent from the existing ingenios and determined points of the river.

Test items: pH, Conductivity

Sampling method: manual

2) Middle Term Target

As the middle term target, it is recommended to monitor the following items contained in the test samples continuously, and middle term means to be started within three years.

① The idea of this proposal is based on the experience of the Study Team, taking it as a fact that the analytic technology has already been acquired by the counterparts of the University of Tomas Frias and

also knowing the fact that the team of that university, has minimum equipment and instruments for chemical analysis, and will be able to conduct such analysis more efficiently with advanced equipment and instruments.

The proposed equipment and instruments are still limited but they would be adequate enough from the economical point of view.

② Test points for No. 1 group: Effluent from the existing ingenios, San Antonio Tailing Dam, mine, recovery plant, plants for treatment of acid water, and determined points of the river.

③ Test point for No.2 group: Soil at determined river basin.

④ Test items for No.1 group: iron, lead, copper, arsenic, cadmium, as ion and as suspended solids and COD

⑤ Test item for No.2 group: lead, copper, arsenic and cadmium

⑥ Sampling method: for the case of San Antonio Tailing Dam, the automatic monitoring equipment can be used for measuring the pH, conductivity and DO; the other samples are to be collected manually.

In order to avoid delay in the introduction of new equipment and instruments, activities can be started only with multipurpose rapid analyzer, which is more compact and economical, as the first stage of the middle term target period.

3) Long Term Target

As the long term target, it is recommended to monitor the following items contained in the test samples continuously, and long term means to start within six or seven years.

① The proposal for the long-term target too is based on the experience of the Study Team, taking it as a fact that the analytic technology is already confirmed with the counterparts of University of Tomas Frias and also knowing the fact that the team at the university of Tomas Frias, has minimum equipment and instruments for chemical analysis, but can conduct such analysis more efficiently with advanced

equipment and instruments. And if necessary, they will be able to ask for special analyses to be done by other domestic laboratories in La Paz. This means that the authorities can expect more efficient chemical analysis in the future.

The proposed equipment and instruments are almost complete, so it can be considered as complete set in practical terms but on the contrary it is necessary to pay more attention to economize the cost, by controlling the number of samples.

② Test points for No. 1 group: Effluent from the points determined as the middle term targets, and integrated beneficiation plant, afforested fields, plans for recovery of precious metal from waste rock, and determined points of the river.

③ Test point for No.2 group: Soil at determined river basin points.

④ Test point for No.3 group: Soil at determined farming fields, that may be at a point on the west bank of the Tarapaya river at Mondragon, a point polluted area of Vina Pampa, and point of the non polluted area of Miraflores.

⑤ Test items for No.1 group: Ion form and contents in suspended solids as determined as the middle-term targets and zinc, chromium, iron, manganese, mercury, arsenic, sulfur, cyanide, silver, ignition loss and BOD with other specified items as per the national regulation.

⑥ Test items for No.2 group: Items determined as the middle-term targets and zinc, chromium, iron, manganese, mercury, arsenic, sulfur, tin, bismuth, antimony, carbon, silver and ignition loss.

⑦ Test items for No.3 group: copper, lead, zinc, cadmium, chromium, iron, manganese, arsenic, mercury, sulfur, tin, bismuth, antimony, carbon, silver and ignition loss.

⑧ Sampling method: In addition to the case of the San Antonio Tailing Dam, the automatic monitoring equipment can be used for detecting the pH, conductivity and DO at the points of confluence of main rivers, the other samples are to be taken manually.

(7) Monitoring Instrument List

Table 6-2-1 indicates a list of required equipment and instrument for monitoring.

(8) Database and Simulation

The fundamentals of monitoring activities are to collect data constantly, and utilizing such data to enable the forecast of contamination and as the consequence of such works, to protect the environment.

Therefore it is required to understand the importance to implement the monitoring activities, and also the simulation works.

1) Database

(a) Structure

The first step of the database collection was to understand the mechanism of the contamination of the Pilcomayo River. The second step was to prepare the database filing system replying the data base users' requirement.

The structure of database is;

①Registration of the following pollutants of the Pilcomayo River water

-Hydrological data

-Water quality (pH, SS, COD heavy metals, etc.)

-Analysis of sediment (heavy metals)

②Registration of meteorological data (velocity of wind, direction of wind, precipitation, temperature, humidity, volatility)

③Registration of river data

④Other related data (sampling date, sampling interval and sampling number)

⑤Preparation of data in order

⑥Statistic calculation

⑦Filing system of data

(b) Existing Data

During development of the study for evaluation of the environmental impact of the mining sector in the department of Potosi there has been parallel carrying out, with the support of the national counterpart, of taking of water quality samples at 25 different points (refer the Figure 1-2-4) in the area of the basin of the Pilcomayo River, which covers part of the department of Potosi. Of the above-mentioned 25 sampling points, eight are located on the De la Ribera River, four on the Jesus del Valle River, four on the Aljamayu River, one on the Huncarani River, three on the Tarapaya River, three on the Mataca River and two on the Pilcomayo River.

The taking of data on water quality covered the period from January 14, 1998, to December 1 of the same year. Because of the extensiveness of the area only recording of 21 samplings was accomplished in that period. Those samplings do not correspond to the same day since it takes three days to cover that area. There are even sampling points such as that of the Jesus del Valle River before the meeting point with the Aljamayu River where only nine samplings were recorded.

That information has been put into the computation system developed and described in the item corresponding to statistics and data processing. The statistical model used in the simulation has been formulated and used on that structured basis.

In Table 4-1-1 which shown below are detailed the recording number corresponding to the computation file used in the simulation and the name of each of the sampling points:

In the process of obtaining of information also undertaken were sampling of concentrations of solids in suspension and analysis of the respective concentration in parts per million (ppm) of each element in the dissolved solid. However, it was not possible to use that information in the simulation since there were only six values for sampling points No. 25, No. 4 and No. 5.

2) Mathematical simulation of contamination

(a) Basic Understanding

In this section it is described the mathematical simulation undertaken of mining contamination of the the Pilcomayo River in the Department of Potosi for the purpose of studying and seeking a monitoring and forecasting tool that will make it possible initially, given the little existing information, to understand the complex process of contamination of the river with heavy metals.

The simulation process was started with search for an appropriate model that reconstructs the conditions in which such contamination occurs. Normally that is the first question to be raised in that type of analysis and one the answer to which is to be found in all of the existing data, the scope of the study and the purposes of the simulation.

By their nature, the models can be classified as a) deterministic, b) probabilistic and c) conceptual:

a) Deterministic models are described by means of the laws of physics and chemistry and formulated by means of differential equations. Normally that type of modes contains a set of equations and variables that require adjustments since they involve a cause-and-effect relationship between the different variables selected as the input data and the results obtained.

b) In terms of meaning probabilistic models are exactly the opposite of deterministic models. A probabilistic model is formulated by the laws of probability and can be, either statistical or stochastic, i.e. those that require recording of a data base being statistical and those that contain random structures or random data being stochastic.

c) Conceptual models are those that require formulation, experimentation and calibration.

Ideally, the most appropriate model for the case being studied should contain the following aspects: a) hydrological analysis of the area in question for determination of the relationships between the precipitation conditions and the flow conditions of the rivers, b) analysis of the flow of the waters through study of river hydraulics and c) analysis of transport of load of the waters and their contaminants.

However, structuring of a model of that kind involves greater resources, time and information than

that presently available for study of the mining contamination of Potasi. Because of that, more simple models have been selected that also permit quantitative and qualitative analysis of the contamination process, and for that use will be made of statistical tools as explained below.

(b) Structure of the Model

See Figure 6-2-1 for the diagram of the structure of the developed model.

As mentioned above, models of the statistical type, which is shown in the Figure 6-2-1, were chosen on the basis of one year of existing information. The statistical model used was that of multiple linear correlation considering the following theoretical aspects:

① The Mendez Bridge sampling point has been considered the output of the model for the purpose of determining what contamination is brought by the mining activity of Potosi to that section of the river.

② As independent input variables were considered all the headwater tributaries that are not found on the same line of flow so as not to distort the results by correlation of events dependent on one another.

On that theoretical basis and starting formulation of the model from the headwaters of the basin, it was found, for example, that the concentration of a particular metal at No. 4 depends on the contribution to the concentration of that element by No. 2, i.e.: C4 = f(C2). Based on that logic, the process was continued successively downstream, it being determined that the independent control points corresponded to the following stations: No. 1, No. 2, No. 3, No. 7, o. 8, No. 9, No. 13, No. 16, No. 19 and No. 24.

Meantime sampling points No. 1, No. 2, No. 9, and No. 3 did not give the respective information and contamination is minimal for sampling point No. 1. Then the sapling points, No. 4, No. 5 and No. 8 are employed as the independent variables.

In that sense, the resulting model was: C25 = f (C4, C5, C9, C13, C16, C19, C24), which, expressed as a multiple linear correlation, corresponds to the following experience.

$$C_{15}=\alpha_1 C_4+\alpha_2 C_5+\alpha_3 C_8+\alpha_4 C_9+\alpha_5 C_{13}+\alpha_6 C_{15}+\alpha_7 C_{19}+\alpha_8 C_{21}+K$$

Where Ci means heavy metal concentration of sampling point i, αj means coefficient factor relating flow and other variables and K is a constant (revised factor obtained from actual data).

Concentration at Puente Mendez will be calculated when Ci and αj of certain time are introduced to this equation.

(c) Runs of the Model

The above-mentioned model was run for the following heavy metals: antimony (Sb), arsenic (As), cadmium (Cd), copper (Cu), iron (Fe), manganese (Mn) mercury (Hg), lead (Pb) and zinc (Zn). The statistical package SPSS Base 9.0, acquired by JICA, was used for that purpose.

As mentioned above and considering that the compiled did not correspond to the same day, the data was duly imported deemed as only one day for the purposes of simulation. That practical simplification does not affect the results since according to the recorded water speed data, the time that it takes the water to reach Mendez Bridge from the headwaters of the rivers of the area is approximately 3 days (calculation carried out on the basis of an average speed of 0.65 m/s and a distance of 170 km, which corresponds to the course of the Pilcomayo River from its headwaters in the department of Potosi to Mendez Bridge.

Two different runs were carried out for each element: a) one that included all of the selected sampling points and (b) one that did not include No. 2 since it contained only 9 values and that substantially reduced the number of values considered in the correlation. Also, in carrying out the runs of the model with inclusion of all of the control points, it was not possible to use all of the 21 values available because of lack of data for particular dates.

Initially explored in graphic form for each element was possible linearity between the different variables selected in the model for the purpose of determining their relationships and identifying values that might distort the results. There was also analysis of the correlations of each of the variables with

the whole set for the purpose of determining which of them has the greatest influence on the results or to be able to rule out the possibility of zero correlation.

Also analyzed was standard estimation error, comparing it with the standard deviation of each variable, since when the standard estimation error is greater than standard deviation, it can be considered that for a particular regression model the average represents the best value for prediction of the dependent variable. Also applied were statistical tests that explain to what extent variation of the independent variables helps to interpret the behavior of the dependent variable.

Finally, on the basis of the results obtained from the model for each heavy metal considered and using the existing information, the average and maximum values of concentration expected at Mendez Bridge were estimated.

And the models and results obtained for each element are giver in the Table 6-2-2 to the Table 6-2-10.

3) Conclusions and Recommendations

(a) The results of the simulation show that the concentrations of heavy metals recorded at Mendez Bridge for different elements come with the greatest incidence from the following rivers and streams:

① Antimony (Sb) comes in the greatest concentration from the Huaynamayu River and the De la Ribera River.

② Arsenic (As) comes in the greatest concentration from the Hualampaya River and Jayajmayu Stream.

③ Cadmium (Cd) comes in the greatest concentration from the Huancarani River.

④ Copper (Cu) comes in the greatest concentration from the De la Ribera River.

⑤ Iron (Fe) comes in the greatest concentration from the Pilcomayo River in Yocalla and the De la Ribera River.

⑥ Manganese (Mn) comes in the greatest concentration from the De la Ribera River.

⑦ Mercury (Hg) comes in the greatest concentration from the Huaynamayu River, the De la Ribera

River, the Korimayu River and Jayajmayu Stream.

⑧ Lead (Pb) comes in the greatest concentration from the De la Ribera River.

⑨ Zinc (Zn) comes in the greatest concentration from the De la Ribera River, the Korimayu River and the Pilcomayo River in Yocalla.

(b) The statistical model used can be improved by taking a larger quantity of data, for which purpose is recommended continuation and intensification of recording of information that makes possible more detailed analysis. Especially above results shall be able to change, if we utilize concentration data of each element in the suspension solid.

(c) It is recommended in the future to structure a center for compilation, processing and analysis of information for the purpose of carrying out more complex analysis of this theme so as to gain a better knowledge of behavior and on that basis design more reliable solutions. The following are suggested for that:

① Implementation of hydroclimatic stations, preferably with continuous recording, and training of specialized personnel for processing and analysis of such information in order to make possible later analysis and mathematical simulation of the hydraulic aspects.

② Making frequent topographical surveys of the contaminated rivers and tributaries, preferably transverse surveys every 500 meters, for the purpose of analyzing the hydraulic conditions of the rivers and determining the manner of transport of the flow and its sediments.

③ Periodical sampling of sediments both at low waters and at high waters carrying out analysis of grain size in the beds of the rivers in order to analyze the relationships between the transported sediment loads and the flows of the basin.

6-2-3 Adjustments of Rules, Regulation and Laws

Adjustment of laws and regulation is the principal matter for the environmental administration but

such adjustment can only be utilized with effective administrative system.

The proposals listed here, as commented herein can be implemented from the items which are available start from the viewpoint of short, middle and long terms.

(1) Proposal for the Environment Standard and Discharging Quality Standard

1) Harmonization with the Mining Law

The Mining Law was enacted on 1997 (Law No.1777), and is discussed about in section 3-2-7. There are several discrepancy between the Environment Law and Mining Law.

According to the Mining Law, except the protected area, small scale mining activities, including the exploitation, development and the ingenios using the gravity process would be able to get permission by following a simplified procedure, to minimize the cost of application, based on the general environmental protection rule.

It is also reported that currently small scale mining firms can get permission with simplified procedure at the level of prefecture. That means that if the prefecture level control is not well established from the point of view of environment administration, there is a high risk to despoil the valuable water for the agriculture with which many farmers sustain their lives. From this point of view, small scale mining firms also should be controlled as carefully as large scale firms, by creating link between the national level administrative organization and prefecture level administrative organizations.

Meantime, it is reported that the river of Totora D, that people believing the river water is not polluted, use as the source of water for farm irrigation, is now in peril. Since there is no regulation to control the small mining activities at present, even to protect such an important part of the river, the local administration can not control the mining activities.

From this case, it seems the battle between the farmers and mining workers can arise, but to protect the well-being and interests of both, it is proposed to set up a permanent coordination committee participated by both mining agency and environment agency to solve any such conflict smoothly, to find out the point of co-existence.

2) Periodical Review of Environment Standard and Discharging Quality Standard, and Enactment of Regional Environment Administrative Regulation reflecting the Regional Specialty

Normally the environment standard and effluent quality standard are prepared based on the national demand and international tendency of the time when such regulations are enacted. That means there are several differences between countries as to the control items, and this is especially true between developed countries and developing countries. Meantime every developing countries come to be developed countries through industrial development or through international trade, the situation of those countries, regarding for the pollutants required that are to be controlled, can be easily changed. So it is proposed to establish a national level organization to conduct periodical reviews of the environment standard and discharging quality standard, to meet with the actual requirement of the time.

It is obvious, in addition to the national level standard, that it is recommended to establish at the prefecture level or city level a more restricted environment standard, reflecting the local conditions.

Especially when the likes of De la Ribera River, or Haynamayu River, are unsolved, i.e. a river which has a small quantity of water, during the normal seasons, it is proposed to control the effluent of the ingenios not only regarding the effluent quality control but also to control the total volume of pollutants. That is to protect not only the farming activities but also to protect the stockbreeding activities downstream, reflecting the local actual situation, to keep the rive water quality with the Class B, at least, of environment standard.

Naturally, it is reported that the tailing dam of San Antonio, is designed to meet with the Class B criteria at the outlet point of effluent, the Study Team proposes to maintain such rule without any change.

(2)Proposal for the Protection and Implementation of Environment Standard and Discharging Quality Standard

1) Strict Observance of Accomplishment Period and the Establishment of Rational Measure for Relief

As reported elsewhere in this report, FA and MA are important tools for the control of the

environment standard and discharging quality standard defined in the Environment Law and related regulations. Based on the law and regulations, the administrative organization of Potosi Prefecture decided on enforcement and announced to the relevant entities to accomplish such rules by the end of 2001.

We can categorize the mining sector into two groups, one is the ingenios and another is the mining operators.

Regarding the ingenios, of which there are more than 40 units, in Potosi, they are one-tenth or one-hundred smaller than the international level in scale of production capacity, are operated without any pollution prevention facilities. The Potosi Prefecture decision mentioned above means they would be forced to cease operation before the end of 2001.

The Natural Resources and Environment Division of Potosi Prefecture is now struggling to rescue these small ingenios from their closure of business, understanding that these businesses are an important part of the economy of Potosi Prefecture.

One of the alternatives to solve these difficult situation is the operation of the tailing dam at San Antonio (DCSA). The idea of DCSA is to accept all the tailing effluent of the ingenios without there having been any treatment at the plants, and to treat these all the effluent together and to release it after it meets the environment standard. Of course, it is predicted that some of the ingenios would not participate in this plan on economical grounds but in such a case it is strongly recommended by the Study Team to ensure that they comply with the rules.

Regarding the mining operators, to make a plan for the acid effluent treatment from an active mine in a short period, and to realize such plan, it is proposed that a budget for the project should be prepared with the participation of the mine operators.

2) Thoroughness of Field Surveys and Introduction of Police Power

Beside the ingenios, the plants of other types of industry, even if they are only a few in Potosi, it will be necessary to oblige them to comply with the Environment Law and related regulations, and the

administrative organization should conduct periodical field surveys visiting each plant to ensure compliance.

And, it is proposed to establish a system to guarantee that the regulation will be observed, eliminating any injustice, even if it is required to use police force.

3) Introduction of Authorization License for Ingenio Purchase

During the period from the beginning of 1997 to the end of 1998, which corresponds with the period of study for this team, it is reported that the ownership of 16 ingenios out of 42 plants has changed. We understand that the reasons for such change of owners would be from the buyers' side, that these plants generate much profit, and from the sellers' side, it is not reasonable to avoid investment in environment protection devices for the plants, and the cost of technical development, by selling.

It is a matter private sector commercial activities when there is selling and buying of the ingenios but knowing that these plants are a main source of water pollution, the Study Team proposes to establish a new rule not to give any operation permission to the new buyers if there is no prospect that these plants would be operated within the conditions established in the Environment Law and related regulations.

And, it is also very important to consolidate the rules regarding transfer of ownership of ingenios, who have promised to participate in the utilization of DCSA, so that new owners do not withdraw from participation without having alternative measure.

4) Measurement for Environmentally Debt Heritage

The contaminated effluent from the abandoned mines has no specific cost taker for the treatment. To solve these problems it is proposed to form a system and fund with participation of state, prefecture, city and former owner of the mine, COMIBOL.

6-2-4 Formation of Joint Environment Protection Organization

The consolidated organization of public and citizens for the environmental protection can be prepared

with middle and long terms.

(1) State Level Environment Administration Organization

As the national-level organization for environment management, Bolivia has the Viceministry of Sustainable Development and Environment (VMDSMA) in which there are three departments, namely Environment Policies and Rules, Bio-diversities, and Special Program. They have been active since October 1993, mainly for 1) the establishment of a long term national environment protection plan, 2) conservation of natural resources and 3) protection of the environment.

Operational activities of the environment administration is conducted by units of the Department of the Environment Policies and Rules, namely Planning Policies and Rules, Environment Impact Assessment, and Environment Quality Control.

Assessment and issuance of the certificates for Authorization and Declaration of Environment Impact (DIA) and the Declaration of the Environmentally Adequacy (DAA) are done by the relevant prefecture. Only the case of state-level projects and projects which span two prefectures or more, VMDSMA will assess the projects and issue the DIA and DAA.

1) Campaign to Raise Environment Consciousness of Inhabitants

This study is the environment pollution assessment project for mining sector, but the key issue of this project can be understood more clearly by putting the environment administration in the center position of state administration.

As far as putting the environment protection administration at the same level of other administrative issues, the environment would be severely damaged under the name of development of industries.

Up to now the inhabitants who are the real subjects of the issue at hand, could only accept the damaged environment out of necessity to sustain their lives or out of innocence. At this time, however, the government should make efforts so that each person recognizes the actual situation, that is that they themselves are damaging the environment in their very efforts to sustain their lives, and to thereby facilitate their action for the proportion and improvement of the environment.

That means the government should make it clear by understood by the citizens that all activities related to mining, industrial production, and their own lives, government are causing damage to the environment. Beside this, the government, through the education and a campaign, should make the citizens understand what should be expected in the future after such destruction of the environment.

2) Enforcement of Links between Administrative Organizations for Environment

It is possible that if the inhabitants understand the current situation of the destruction of the environment, they will react so as to avoid such destructive activities, or to oppose continuation of such destructive activities. But the way of thinking of owners of enterprises can not be so easily simplified. Even that part of the government concerned directly with industry can not easily modify attitude and behavior of business enterprises so as to make them environmentally friendly. It would not be enough to only prepare regulations. Incentive such as tax exemptions, investment finance support, accelerated depreciation should be prepared to facilitate the introduction of technology, environmentally friendly, and facilities.

The Study Team recommends that the government body concerned with administrative matters related to the environment, understanding the behavior of the owners of the enterprises, keep is close contact with the business and industrial organizations, and organize a supporting scheme jointly with them, to encourage the owners of the enterprises to invest facilities for protection of the environment.

3) Council for the Environment Protection Activities of the Administration

It is difficult to accomplish the mission of environmental protection management for the prefecture-level environment administration organization, Natural Resources and Environment Department, if they have no supporting organization. And provision of a budget for the mission and the enforcement of regulations would not be enough to accomplish the objectives.

To rally the ideas of all sorts of organization to the principle of environment protection management, it is recommendable to form a committee consisting of members who are officers of local government,

experts of institutes and educational entities, owners of private enterprises, and even intellectuals who organize meetings for the nation-wide participatory movement on behalf the environment protection management. All members of the committee proposed above can participate in the preparation of the environment white paper, to affirm objectives, progress, to identify problems, and to raise awareness.

(2) Prefecture Level and City Level Environment Administration Organization

As the prefecture-level organization of the environment management, Potosi has Natural Resources and Environment Department belonging to the Division of Sustainable Development and Planning, which has one manager and two units, namely Environment Management and Territorial Control with one employee for each unit.

The environment-related administration at the prefectural level is conducted by department in consultation with the VMDSMA, in order to establish the environmental rules that specifically meet the unique local conditions.

In the Potosi City there is a environment protection division with four persons to conduct the management of the natural resources, the environment impact assessment and the environment quality control. Their main task is to manage the FA and MA system.

1) Smooth Master of Sprit of Environment Law and the Establishment of Uniformed Administrative Judgements based on the Commonly Possessed Information

Decentralization is a main policy of the Bolivian government and the environment administration is suitable for this policy. As a consequence of the Bolivia's enactment, the Environment Law and related regulations, the counterparts of the Study Team were extremely busy, conducting the training course for the provincial officers, about the concept of the environment law and the administrative procedures.

This training has the purpose of informing the administrative judgements to the applicants of the FA and MA base on the commonly possessed information about the environment administration. And to

keep these uniformed administrative judgement, which is very important for the applicants, the periodical workshops, led by specialist are proposed for the benefit of officials concerned.

2) Nomination of Monitoring Staff for the Monitoring System Consolidation

In the connection with the FA and MA procedure, which are important tasks for the prefecture and municipal level environment officials, the monitoring data is a very important tool to measure the environment impacts of commercial activities. To get the monitoring data it is very important to establish a system of monitoring developing both a manpower and facilities, as proposed in paragraph 6-2-2. The establishment of a monitoring system means the administration organization itself has to have at least one officer who can manage the monitoring system, not only by controlling the subcontractors who collect and analyze the data but who also can assess the results and to give instruction for the countermeasures as required.

It is our proposal to train and to keep at least one officer in the administrative organization for this purpose.

3) Environment White Cater

Even investment of much money and effort, without the support of inhabitants and owners of the enterprises, the effect of the environment protection management effort to be conducted by the administration would be limited. For that reason, to get support from the inhabitants and owners of enterprises, to prepare and publish the environment white paper would be one of options as stated in 6-2-4 (1), 3).

The environment white paper, which could for example; include the following information and be published periodically (once a year or once in two years), can also clarify the effects of the environment protection management to date, which can help to define the policy of the environment protection management of coming years.

①Environment Target

②Environment Protection Measurement

③Progress of Environment Protection

④Financial Status for Environment Administration

⑤Human Resources for Environment Management

4) Environment Institution

① Environment Standard

Even though the central government has defined the environment standard, administrative task of the application and administration of the environment standard are transferred to the local governments, so it is requested to the environmental administration organization of the prefectural government, not only to present its opinion on the improvement of the regulations but also with regard to the application to make more detailed rules for the environment protection, matching with the local needs and local conditions.

② Environment Impact Assessment

One of the important tools for preventing the environmental destruction by new activities would be the Environment Impact Assessment (EIA) requirement, which is defined in detail by the regulation, and to get governmental approval for which is obligation of every entity both for public and private.
It is an important role of the administrative organization to persuade every citizen to understand and to comply with such requirement, rationally, or even by use of force.

③ Environmental Manifestation

Beside the EIA, all entities conducting any kind of activity which may create an environmental impact are obliged, by regulation, to submit the Environmental Manifestation (MA) document in order to get approval to continue the proposed activities. This is to be based on the environment quality control

(CCA) regulation. For the administrative organization, the continuous and strict check and control on such entities is requested.

(3) Participatory Environment Improvement System

In Potosi City and Potosi Prefecture there are several NGOs, whose objectives are abatement of environmental damage, but due to their limited manpower and financial capability, they can not be a leader regarding environmental issues.

Meantime, as emphasized several time in this report, it is also true that collaboration by and suggestion from the citizens would be of great value solving the environmental problems.

1) Introduction of Environment Indexes

The environment indexes proposed in paragraph 6-2-5 would support the implementation of the environment standard and the discharging quality standard of the Environment Law and related regulations. And because of their inherent simplicity, the Environment Indexes can be used as tools of citizens to control pollution.

The administration has to try to organize the inhabitants through the schools, churches and other social organization to help the citizens become familiar with the environment indexes which can be used by themselves, and to report the result to the government, and who should use such data to reflect the environment policy.

The Environment Indexes itself have to be reviewed periodically to get citizens' consensus about it.

2) Establishment of the Organization to Collect and Analyze the Citizens' Opinions on the Environment

To prevent a top sided unilateral flow of information on environment issue, and to get more voluntary participation from the citizens, it is recommended to create a scheme to promote the citizens' formation of opinions on environmental issues.

One method to do this is to give some special reward or recognition to citizens who propose useful

suggestions for the environment protection.

3) Strategic Utilization of Environment Improvement Administration for the Establishment of Renewed City Construction

Potosi is a city, that was originally developed for the exploitation of Cerro Rico silver. As a result there are many ingenios in the city, and these ingenios discard untreated tailings in the rivers of the city, De la Ribera and Haynamayu, and the abandoned waste rock and old tailings are piled up on the hillside of Cerro Rico, as a debt heritage that damages an historical tourist spot that otherwise would attract more travelers.

The Study Team has been informed that the Spanish government has already started to support a tourist campaign by Potosi City, to promote reforming the channel of De la Ribera to so as to make it more attractive. It is obvious that first of all every ingenios in the city should be modified to make them environmentally friendly, and as many as possible should be relocated to an industrial park, while they should be combined or integrated, to retain the economical competitiveness. These ideas have to be consolidated by the key organization of the city concerned with the improvement and maintenance of the environment. In this connection it is also recommendable to invite an proposals, and to seek international assistance.

6-2-5 Establishment of Environment Indexes

The preparation of the Environment Indexes should be made by the hands of administration. But it is obvious that the effects of the utilization of the Environment Indexes only obtainable with the participation of the citizens, in the middle and long terms, the review of the Environment Indexes should be made with the citizens.

An environment standard indicates the acceptable magnitude of pollutant content, this is a standard measured by the scientific method.

But this is not a convenient number for ordinary business operators or citizens. Further since these

numbers are obtained through chemical analysis requiring time and money, there people may be disinterested in such standards. But the environmental problems are basically generated from the commercial activities of human beings, and as a consequence of the environment problems, human beings can not escape from the damages. So it is very natural to understand the necessity to pay more attention to the environmental problems and each of them should try to participate in the movement for mitigation of such pollution using more simple environment indexes to control the local environment condition.

Therefore, hereunder seven items of environment indexes are proposed. There should be efforts at getting the consensus of the related local administration officers to reflect the local conditions, but it should be understand that the improvement of the local environment to a great extent depends on the effort and willingness of the local inhabitants and local administration.

(1) Expansion of Clean Area (without any refuse) along the Banks of the De la Ribera and Huaynamayu River

The banks of De la Ribera and Huaynamayu which can be possible recreation spots for the Potosi citizens, are contaminated with garbage, solid wastes from the ingenios and other matter. The river water is not only to be limited the usage because of contamination but also it is dangerous water to damages the people and animal lives, so it is important for the citizens to eliminate such garbage or refuse from the banks of rivers.

The activity to clean up the banks can be promoted periodically by participation of the citizens who live near there and to control the index with the number of space to be cleaned up.

This is not intended to decrease the volume of tailing of the ingenios directly, but this activity can encourage reduction of the volume of tailings from the ingenios.

(2) Increase of the Number of Families to Participating in the Discriminative Refuse Collection System

The refuse collection system is almost completely established in Potosi city, including not only

garbage but also the industrial and hospital refuse and although on a small, trial basis, the recycling of refuse has been started, to produce the fertilizer.

To introduce the discriminative refuse collection system, including separate collection of garbage for reuse, and disposal only by dumping, would lead to the minimization of volume of refuse and minimization of cost of collection, which lead also the citizens' understanding of importance of the environment protection.

Then this is an index that measures the number of families who participate in the discriminative refuse collection system. Even in the local village where there has not yet been established such a system, the introduction of this concept would serve to raise the citizens' awareness and understanding of the importance of environmental protection.

(3) Expansion of Afforestation Area

The study area is in a dry climate and high above the sea level. As a consequence, there are few trees there, so floods wash away soil from the farming area during the rainy season.

To start the afforestation activities at the hillside of Cerro Rico on the abandoned waste rock and sucu, would minimize the outflow of acid effluent from there, beside reducing the speed of water flow from the mountain, a slowing that would reduce erosion. The area to be afforested would be usable for recreation of the citizens and which can enhance the value to Potosi as a tourist city.

These afforestation activities require a great endeavor, but if funds can be obtained from prefecture and city, and if the long term plan for afforestation can be made, with citizen participation on a voluntary base, one good index for environment management would be the area of afforestation.

Of course in other areas than Potosi, where there are such abandoned waste rock field and abandoned tailing fields governments can introduce the same concept as mentioned above.

(4) Increase of the Number of People to Participating in Environment Event

To promote the participation in environmental events such as events on Earth Day and environment

seminars, to be planned and implemented by the relevant administrative organization, it is important to encourage the citizens' acknowledgement of the importance of environmental protection.

As noted in the item (3) above voluntary participation of citizens in the planting of trees would encourage thoughts of the importance of environmental protection.

The number of participants in such events would be a good index of environment management.

(5) Expansion of Irrigation System Coverage and Effluent Treatment Rate

In Potosi City no effluent treatment system has been installed and the sewerage system is also not complete and not adequately maintained to attain the requirement. Shortcomings include the piping network and pumping capacity. At this moment all sewage of the city and factories are discharged in the De la Ribera and Huaynamayu rivers without any treatment. Potosi City is now in the process, with the assistance of the German government, of investing in a new sewerage system with two treatment facilities.

Now is the right time to help citizens understand the necessity of control of sewage quality to protect the environment, and to promote support for improving the sewage treatment coverage rate, there items would be important environment indexes.

(6) Increase of Recycle Rate of Industrial Water for the Ingenios

The ingenios in Potosi City, of which there are more than 40, use of water of the De la Ribera river and the pure water supplied by the potable water company AAPOS as industrial water for the operation of the plants, and such used water is discharged mainly to De la Ribera and Huaynamayu rivers as drainage with tailing.

This operation damages the environment in two ways. That is, firstly, the ingenios use much potable water which limits water volume an alterable for Potosi citizens, and the volume of discharged water with tailings would increase corresponding with the ingenios production volume.

If however the ingenios can use their discharge water as industrial water, by recycling the processed

discharged water, it is obvious that the polluted drainage would be decreased drastically and at the same time the consumption of the fresh industrial water could be economized, theoretically, to the extent of 80%-90% of actual volume, that permit will effectively increase the availability of potable water to Potosi Citizens.

The water recycle rate of the ingenios water would be good index for the environment management for Potosi City, to be controlled by the owners of the ingenio, administration and citizen.

(7) Increase in Number of Filing of FA and MA by the Responsible Entities

The FA and MA are the basic tools to control the environment, they are defined in the Environment Law and the related regulations where it is specified that no entity is exempt from this system, and that the administration should assure the control of the environment based on this system without exception. In actuality due to the recentness of enactment of the law and regulations, they have not yet been implemented completely.

Now the administration of Potosi City has to fix the dead line to enforce such rules. Then the number of filing of FA and MA can be used as an environment index.

6-2-6 Environmental Impact Assessment

Of a series of proposals, it is required to implement the environment impact assessment in constructing the following facilities having influences on the environment based on the Bolivian environmental law and regulations.

① Environment & Safety Research Center (Including a continuous test facility)

② Tin recovery plant

③ Integrated plant

④ Silver recovery plant from waste rock and Sucu

In the report, the team emphasizes that the implementation of the environment impact assessment

prevents the pollution newly to the environment from occurring, and comes a tool to be the consistent with industry and environment.

According to the procedure of environment impact assessment, the common items applicable to construction works are shown in table 6-2-11.

Table 6-2-1

Monitoring Equipment List for Short Term, Middle Term and Long Term Plan(1/4)

		Item	Equipment	Cost of Equipment	Consumable	Cost of Yearly Operation	Testing Points	Frequency
Short Term								
		pH	Portable pHMeter	Already Donated	Distillated Water		To be defined by	To be defined by
		Electric Conduct	Portable E.C. Meter	Same Above	Distillated Water		Bolivian Side	Bolivian Side
					Main Equipment Maintenance(5%)			
		Short Term		***USD10,000***		***USD500***		
Middle Term								
	First Stage							
	Water	Lead	Multipurpose rapid water analyzer	USD35,000	Test Chemical, Sample Bottle	USD500	1)DCSA Drainage	
		Copper	Multipurpose rapid water analyzer	Same Above	Test Chemical, Sample Bottle	USD500	2)Ingenico Drainage	
		Arsenic	Multipurpose rapid water analyzer	Same Above	Test Chemical, Sample Bottle	USD500	3)Mining Spot Drainage	
		Cadmium	Multipurpose rapid water analyzer	Same Above	Test Chemical, Sample Bottle	USD500	4)Ingenico Waste +	
		COD	Multipurpose rapid water analyzer	Same Above	Test Chemical, Sample Bottle	USD500	Recovery Plant Drainage	
					Main Equipment Maintenance(3%)	USD1,050	5)Treated Acid Water	
		Middle Term/First Stage Total		***USD35,000***		***USD3,550***	6)Others	
	Second Stage							
	Water	pH	Table pH Meter	USD1,200				
		E.C.	Table E.C. Meter	USD1,200				
		Oxidation Meter	Table Oxidation Meter	USD1,100				
		Basic +	Refrigerator	USD3,000				
		Instruments	Distillator	USD8,000				
			Glass Tube Thermometer	USD2,000				
			Beaker	USD2,000				
			Microscope	USD10,000				
			Electric Furnace	USD10,000				
			Test Table	USD1,000				
			Draft Chamber	USD3,000				
			Standard Balance	USD1,000				
			Ultra micro Balance	USD10,000				
			Water Piping	USD2,000				
			Switch Board	USD2,000				
			Air Conditioning	USD2,000				
			Cabinet	USD3,000				
			Atomic Absorption Spectrometer	USD25,000				
			Flow Injection Analyzer	USD25,000				
			Microwave Digester	USD27,000				
			UV-Visible Spectrometer	USD30,000				
			Ion Chromatograph	USD40,000				
			Electrochemical Detector	USD25,000				
			Elemental Analyzer	USD35,000				
			Hydrogen Generator	USD10,000				

Table 6-2-1

Monitoring Equipment List for Short Term, Middle Term and Long Term Plan(2/4)

		Item	Equipment	Cost of Equipment	Consumable	Cost of	Testing Points	Frequency
		Inside Painting (Metal Free)		USD15,000				
					Gases	USD5,000		
		Lead	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Lead	USD500		
					Test Chem. Standard Liquid, S.B.	USD500		
		Copper	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Copper	USD500		
					Test Chem. Standard Liquid, S.B.	USD500		
		Arsenic	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Arsenic	USD500		
					Test Chem. Standard Liquid, S.B.	USD500		
		Cadmium	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Cadmium	USD500		
					Test Chem. Standard Liquid, S.B.	USD500		
		COD	Cooling Tube)	USD5,000	Test Chem. , S.B.	USD500		
			Frasco	USD1,000				
			Heat Panel	USD2,000				
			Ceramic Bowl	USD1,000				
			Temperature Controlled Water Pool	USD8,000				
		sub-total		USD311,500				
	Sediment	Lead	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Lead	Same Above		
			Dryer	USD10,000	Test Chem. Standard Liquid, S.B.	Same Above		
		Copper	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Copper	Same Above		
			Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
		Arsenic	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Arsenic	Same Above		
			Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
		Cadmium	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Cadmium	Same Above		
			Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
		sub-total		USD10,000				
	Monitoring	pH	Automatic Monitoring Instrument	Already Donated	Battery	USD500		
		E.C.	Automatic Monitoring Instrument	Already Donated				
		DO	Automatic Monitoring Instrument	Already Donated				
		Purity	Automatic Monitoring Instrument	Already Donated				
		sub-total						
					Main Equipment Maintenance(3%)	USD9,945+		
						USD1,500		
		Middle Term / Second Stage Total		***USD331,500***		***USD21,445***		
Long Term								
	Basic Instruments		Atomic A. S. Graphite Furnace	USD80,000				
			Digestion Kjeldahl	USD3,000				
			Distillator Kjeldahl	USD3,000				
	Water	BOD	Germiculture Instruments	USD20,000				
		Zinc	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Zinc	USD500	1)Integrated Ingenico	
					Test Chem. Standard Liquid, S.B.	USD500	Drainage	
		Chromium	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Chromium	USD500	2)Drainage from Sucu	

Table 6-2-1

Monitoring Equipment List for Short Term, Middle Term and Long Term Plan(3/4)

	Item	Equipment	Cost of Equipment	Consumable	Cost of	Testing Points	Frequency
	Iron	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Iron	USD500	3)Drainage from	
				Test Chem. Standard Liquid, S.B.	USD500	Vegetation/Land Cover	
	Manganese	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Manganese	USD500		
				Test Chem. Standard Liquid, S.B.	USD500		
	Mercury	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Mercury	USD500		
		Mercury Reduction Vaporizer	USD5,000	Test Chem. Standard Liquid, S.B.	USD500		
	Sulfur	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Sulfur	USD500		
				Test Chem. Standard Liquid, S.B.	USD500		
	Cyanide	Electrochemical Detector	Same Above	Cathode Lamp for Cyanide	USD500		
				Test Chem. Standard Liquid, S.B.	USD500		
	Silver	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
Sediment	Zinc	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Zinc	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Chromium	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Chromium	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Iron	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Iron	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Manganese	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Manganese	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Mercury	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Mercury	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Sulfur	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Sulfur	USD500		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
	Tin(Sn)	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
	Bismuth(Bi)	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
	Antimony(Sb)	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
	Carbon	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
		Electric Furnace	Same Above				
	Silver	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
	Ignition Loss	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	USD500		
		Electric Furnace	Same Above				
Soil	Zinc	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Zinc	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Chromium	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Chromium	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Manganese	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Manganese	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Mercury	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Mercury	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Sulfur	Atomic Absorption Spectrometer	Same Above	Cathode Lamp for Sulfur	Same Above		
		Dryer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Tin(Sn)	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
	Bismuth(Bi)	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		

Table 6-2-1

Monitoring Equipment List for Short Term, Middle Term and Long Term Plan(4/4)

		Item	Equipment	Cost of Equipment	Consumable	Cost of	Testing Points	Frequency
		Antimony(Sb)	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
		Carbon	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
			Electric Furnace	Same Above				
		Silver	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
		Ignition Loss	UV-Visible Spectrometer	Same Above	Test Chem. Standard Liquid, S.B.	Same Above		
			Electric Furnace	Same Above				
		Subtotal						
	Monitoring	pH	Automatic Monitoring Instrument	Already Donated				
		E.C.	Automatic Monitoring Instrument	Already Donated				
		DO	Automatic Monitoring Instrument	Already Donated				
		Purity	Automatic Monitoring Instrument	Already Donated				
		Subtotal						
					Main Equipment Maintenance(3%)	USD3,330		
		Long Term Total		***USD111,000***		***USD14,830***		

Table 6-2-2 Antimony

ANTIMONY(μg/L)
Purified and utilized values; 19
Adjusted model; $C25=0.187C_4+0.856C_{19}+0.0063$
Correlation linear multiple; 0.801
Mean concentration expected at Puente Mendez; 0.3895μg/L
Maximum concentration expected at Puente Mendez; 2.0724μg/L
Observation; Most affected sampling points for Antimony concentration at Puente Mendez are P4IIU(C_4) and P19Y(C_{19}), respectively 51.6% and 70.2%

Reported mean concentration at sampling points Antimony (μg/L)		
Point	Mean	Std. Dev.
C25	0.28917	0.21138
C4	0.45250	0.34067
C5	0.00008	0.00028
C8	0.03133	0.10361
C9	0.12167	0.20008
C13	0.00008	0.00028
C16	0.29917	0.24433
C19	0.22417	0.13097
C24	0.38083	0.30488

Table 6-2-3 Arsenic

ARSENIC (μg/L)
Purified and utilized values; 14
Adjusted model; $C25=0.37C_8+2.751$
Correlation linear multiple; 0.577
Mean concentration expected at Puente Mendez; 7.36282μg/L
Maximum concentration expected at Puente Mendez; 23.71335μg/L
Observation; Most affected sampling points for Arsenic concentration at Puente Mendez are P8HR(C_8) 47.2%

Reported mean concentration at sampling points Arsenic (μg/L)		
Point	Mean	Std. Dev.
C25	7.34429	9.31023
C4	356.025	453.5100
C5	147.494	188.967
C8	12.4114	11.8741
C9	2.61556	4.81708
C13	0.19764	0.30686
C16	6.20357	11.2512
C19	5.97857	8.62919
C24	10.9100	19.5293

Table 6-2-4 Cadmium

CADMIUM (mg/L)
Purified and utilized values; 14
Adjusted model; $C25=0.765C_{19}+0.0095$
Correlation linear multiple; 0.756
Mean concentration expected at Puente Mendez; 0.03042mg/L
Maximum concentration expected at Puente Mendez; 0.23815mg/L
Observation; Most affected sampling point for Cadmium concentration at Puente Mendez is P19Y(C_{19})

Reported mean concentration at sampling points Cadmium(mg/L)

Point	Mean	Std. Dev.
C25	0.01886	0.01845
C4	2.39786	2.31428
C5	0.03229	0.02371
C8	0.02357	0.02098
C9	0.02889	0.20883
C13	0.68500	0.16440
C16	0.01871	0.02616
C19	0.01857	0.01747
C24	10.9100	19.5293

Table 6-2-5 Cupper

CUPPER (mg/L)
Purified and utilized values; 20
Adjusted model; $C25=0.0068C_5+0.113C_{16}+0.0104$
Correlation linear multiple; 0.485
Mean concentration expected at Puente Mendez; 0.02512mg/L
Maximum concentration expected at Puente Mendez; 0.09740mg/L
Observation; Most affected sampling point for Cupper concentration at Puente Mendez is P5RI(C_5) and P16H(C_{16})

Reported mean concentration at sampling points Cupper(mg/L)

Point	Mean	Std. Dev.
C25	0.00220	0.02612
C4	16.4433	12.71550
C5	1.15056	1.26545
C8	0.03333	0.03955
C9	0.00991	0.01987
C13	20.1117	7.98401
C16	0.01250	0.01559
C19	0.01956	0.02717
C24	0.94500	1.43239

Table 6-2-6 Iron

IRON (mg/L)
Purified and utilized values; 21
Adjusted model; $C25=0.74C_5+0.62C_{19}-0.01$
Correlation linear multiple; 0.781
Mean concentration expected at Puente Mendez; 0.23381mg/L
Maximum concentration expected at Puente Mendez; 1.396mg/L
Observation; Most affected sampling points for Iron concentration at Puente Mendez are P19Y(C_{19}) and P5RI(C_5), respectively 76.0% and 37.0%

Reported mean concentration at sampling points
Iron(mg/L)

Point	Mean	Std. Dev.
C25	0.18474	0.28116
C4	537.966	361.10300
C5	0.10947	0.08296
C8	0.31053	0.40998
C9	0.17333	0.32103
C13	304.786	238.361
C16	6.73632	27.2921
C19	0.33947	0.25984
C24	39.1400	115.727

Table 6-2-7 Manganese

MANGANESE (mg/L)
Purified and utilized values; 17
Adjusted model; $C25=0.038C_5+0.769C_{19}+0.382$
Correlation linear multiple; 0.66
Mean concentration expected at Puente Mendez; 0.27825mg/L
Maximum concentration expected at Puente Mendez; 0.88885mg/L
Observation; Most affected sampling point for Manganese concentration at Puente Mendez is P5RI(C_5) and P19Y(C_{19})

Reported mean concentration at sampling points
Manganese (mg/L)

Point	Mean	Std. Dev.
C25	0.28647	0.25916
C4	16.3447	8.87244
C5	0.97776	3.48386
C8	0.36176	0.15171
C9	0.07836	0.07159
C13	41.2152	19.2990
C16	0.06412	0.10137
C19	0.06571	0.09514
C24	15.3364	10.4925

Table 6-2-8 Mercury

MERCURY (μg/L)
Purified and utilized values; 19
Adjusted model; $C25=0.322C_4+0.115C_5+0.0787C_{24}-0.0239$
Correlation linear multiple; 0.914
Mean concentration expected at Puente Mendez; 1.15585μg/L
Maximum concentration expected at Puente Mendez; 6.0368μg/L
Observation; Most affected sampling points for Mercury concentration at Puente Mendez are P4HU(C_4),P5RI(C_5) and P24J(C_{24}), about 83.8%

Reported mean concentration at sampling points
Mercury (μg/L)

Point	Mean	Std. Dev.
C25	1.00000	1.66084
C4	1.88118	2.54108
C5	2.75059	5.79926
C8	0.73588	1.06089
C9	1.34818	2.56561
C13	0.00123	0.00188
C16	1.70647	3.59645
C19	0.61412	1.10564
C24	0.95647	1.92328

Table 6-2-9 Lead

LEAD (mg/L)
Purified and utilized values; 17
Adjusted model; $C25=0.031C_4+0.137$
Correlation linear multiple; 0.122
Mean concentration expected at Puente Mendez; 0.21253μg/L
Maximum concentration expected at Puente Mendez; 0.31463μg/L
Observation; Most affected sampling point for Lead concentration at Puente Mendez is P4HU

Reported mean concentration at sampling points
Lead (mg/L)

Point	Mean	Std. Dev.
C25	0.23529	0.47480
C4	2.47765	1.57713
C5	0.28353	0.18510
C8	0.27235	0.57137
C9	0.19000	0.16583
C13	0.20706	0.14057
C16	0.21882	0.23948
C19	0.17471	0.1679
C24	0.20412	0.14975

Table 6-2-10 Zinc

ZINC (mg/L)
Purified and utilized values; 14
Adjusted model; $C25=0.036C_5+0.249C_{13}+0.0006C_{19}+0.0043$
Correlation linear multiple; 0.469
Mean concentration expected at Puente Mendez; 0.07644 μg/L
Maximum concentration expected at Puente Mendez; 0.115972 μg/L
Observation; Most affected sampling points for Zinc concentration at Puente Mendez are P5RI(C5),P9JV(C9),P13K(C13) and P19Y(C19), about 31%

Reported mean concentration at sampling points
Zinc (mg/L)

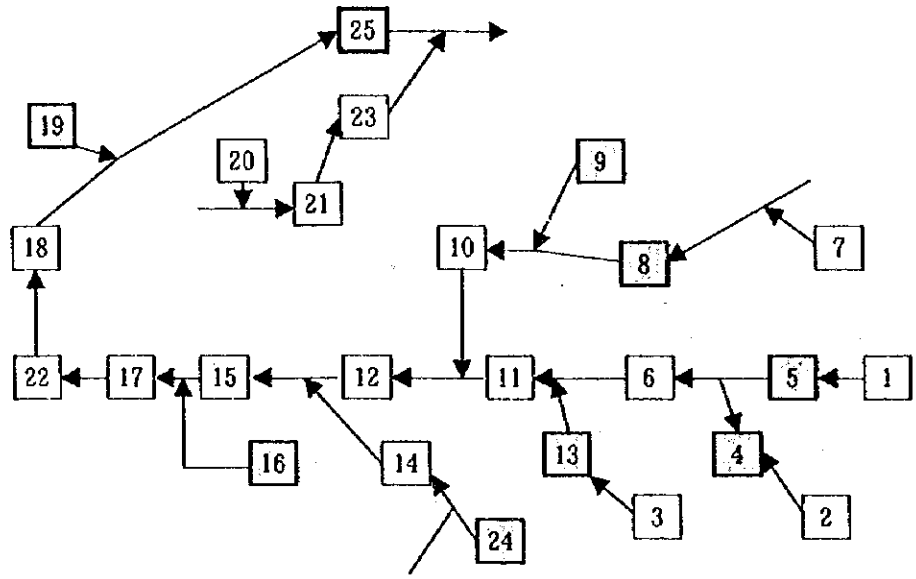
Point	Mean	Std. Dev.
C25	0.08122	0.05338
C4	298.0830	138.3840
C5	1.22944	3.46444
C8	0.14500	0.12118
C9	0.07583	0.07378
C13	119.633	48.6153
C16	4.55944	19.0771
C19	0.07167	0.07524
C24	216.945	153.884

Table 6-2-11 Outline in Environment Impact Assessment Study

(Example of Common Items Applicable to Construction Works)

I. Study: Environmental Pollution Assessment Study Mining Sector in Potosi Prefecture in the Republic of Bolivia
II. Project (1) Background Bolivian government promotes the mitigation plan of the pollution generated from the mine activities and others. Meantime the process for the pollution mitigation is not reasonably smooth since the financial difficulty of nonferrous metals industries due to the international depression of metal prices. Under these circumstance, this Study Team was formed by request of Bolivian government to propose the practical measurements to mitigate the pollution generated from the mine activities and others. (2) Implementing Entity This project would be implemented by the Potosi prefecture and the beneficiary would be not only the Potosi prefecture but also the related private sectors and public sectors, semi-public or private. And the funding study should be carried out more precisely. (3) Outline: Omission (4) Budget: Omission (5) Purpose of Environmental Conservation The facilities would be designed, constructed and operated to meet with the Environment Law and regulation of Bolivia, in terms with water, air, noise and others, including protecting the workers' health, and to get approval of a FA.
III. Environment Impact Assessment (1) Prevision and Assessment As pollutant, the heavy metal to be contained in the effluent from the proposed facilities shall be decreased to less than two third of actual ones, that means such decreased heavy metal be recovered as the products for sales. Since it is not possible to eliminate tailings totally, to mitigate the contamination of pollutants from the effluent, it is necessary to prepare necessary effluent management. Regarding the air pollution, an attention to minimize the dust, which can cause the bronchitis and any troubles of the respiratory organs, to be generated during transportation and loading and unloading, is required. And as the noise, the rotating machine noise and crashing machine noise during the operation is expected so counter measure is requested. To the workers in the plant, some protection of the respiratory organs is essential. (2) Evasion and Abatement Measurement It can raise the question to construct other pollution generating facilities, but these facilities are scheduled to designed based on the concept to minimize the water contamination by all means regardless the type of pollutant, so it is not predicted to cause any environmental impact from these facilities. Meantime the establishment preventive system of contaminated effluent and solid waste should be taken to protection from any unexpected accident. It is recommendable to separate the industrial zone and residential zone to minimize the impact to the peoples, in addition employing the existing environment protection equipment into consideration. So not only to meet with the discharging quality standard but also to meet with the condition which is applied to the existing ingenios for getting the FA approval. That is most reasonable selection for these facility to be constructed nearer from the DCSA and use it as the effluent discharging point. Then the effluent of the proposed facilities would not be discharged to any open water except DCSA. To mitigate the air pollution and noise pollution, the operation in the building would be essential and masks for the workers should be prepared.

Figure 6-2-1 Model for Simulation



The numbres correspond to the respective control points as indicated in Table 4-1-1.

25 Output of the model (dependent variable) at Mendez Bridge

Control points selected as independent variables

Direction of flow of the water

6-3 Education, Enlightenment, Environmental Technology, Human resources Bring Up Plan

Actual system for mine pollution protection and environment conservation of Potosi Prefecture is not enough. The execution of twelve recommendations of the Team (cf. Chapter 8 Execution Plan of Counter measure: General table of Recommendation) related to the counter measures from short term to long term which are mentioned in clauses 6-1 and 6-2 is hard.

It should be necessary to unite objectiveness of wide range from persons of environment management related to inhabitants to execute those countermeasures effectively.

For this purpose, it should also be necessary to make upper level staff (leader class) of the environment management related know in early stage that the mine pollution protection/ environment improvement will be completed by the performance of each person and will be achieved better quality of life. Then, sustainable education and enlightenment should be followed targeting wide range person by the leader class applying systematic way to extend to lower level gradually.

Early establishment of "Environment and Safe Research Center" will contribute to complete the education, enlightenment and environment technical stuff bringing up which indispensable for executing upper mentioned recommendations.

The center will be established in the Autonomous University of Tomas Frias (UATF) centering the Potosi Prefecture, COMIBOL etc. as the core.

Training will be carried out in the Center. Trainees will be leaders of the Potosi City, UATF and other organizations related centering the Potosi Prefecture etc.

Simultaneously, it is desirable to execute education for educational divisions of university, high-school etc. and private organizations as NGO etc., and enlightenment for mass media as TV etc.

6-3-1 Subjects to Environment Protection relating to the Potosi Prefecture

It becomes clear through the survey that the current systems in the Bolivian side with regard to "Environment" and "Safety" is insufficient and have the problems shown below.

The theme related to environment and safe to be solved.

1.Tech-nology	1)Mining Pollution control	(1)Direct counter-measures	①Insufficient understandings of mine pollution control technology as a whole and insufficient study on applicable technology. ②Insufficient approach and study on optimum process conditions of applicable technology. ③Insufficient actual proof of applicable technology.
		(2)Indirect counter-measures	①Insufficient understandings of mineral processing technology as a whole, and insufficient study on applicable technology. ②Insufficient approach and study on optimum process conditions of applicable technology. ③Insufficient actual proof of applicable technology.
	2)Environmental control	(1)Insufficient monitoring system (2)Insufficient laws and regulations (3)Insufficient organization for environmental conservation (4)Insufficient environmental characteristics	
2.Human resources	1)Mine pollution control	・Several dozens of technicians are centering around the mining and chemical departments of UATF, and in private mines and Ingenios. However, they are insufficient in practice due to poor condition of aforesaid item 1.1).	
	2)Environmental control	・Some persons in charge are in the state and prefecture, and insufficient in practice due to poor condition of aforesaid item 1.2). Furthermore, the environmental section in the prefecture has as small as only 3 persons in charge.	
3.Equipment	1)Mine pollution control	・UATF has no continuous test facilities concerning environment and mineral processing, and is poor in other possessing equipment and analytical equipment.	
	2)Environmental control	・Insufficient monitoring equipment	

6-3-2 Theme of Technical Transfer of " The Environment & Safety Research Center"

The theme of the technical transfer, which should be executed at the Environment & Safety Research Center for improving the environmental contamination in Potosi Prefecture caused by activity of mining sector and contributing to protect environment at the area, are shown below.

(1) Tectonics relating to mining pollution protection plan

・Mining pollution protection (Waste water treatment)

・Mineral processing (Improvement of recovery and quality of tailing)

・Tailing treatment

・Waste rock ("Desmonte", "Sucu") treatment

(2) Theme relating to environment management plan

・Review of monitoring system

・Environment management plan, organization・system

- Environment law and regulations
- Analytical technology for environment and safety related

(3) Education, Enlightenment, Environmental technology·Human resources bring up

- Bringing up of environmental technology·Human resources for leaders of environment management related
- Education for leaders of environment management related
- Technology acquisition and education of operation and mine pollution protection
- Enlightenment

6-3-3 Action Plan of "The Environment & Safety Research Center"

The main action of the center is targeting to carry out twelve recommendations connecting each other systematically.

Those twelve items mentioned above as ①～⑫ are recommended to carry out classifying into three terms, short (urgent), middle and long according to the property of each item.

The action of the center is mentioned below following three terms.

(1) Short Term

1) Technology relating to Mine Pollution Protection

As for the theme of technological acquisition relating to mine pollution protection plan, there are two items that should be introduced, technical improvement of mineral processing (dressing) and waste water treatment technology.

① To renovate the process of "ingenio" (processing plant)

This renovation will improve Zn recovery from less than 80% to around 90% which contribute not only to improve economic condition but also to clean the quality of tailings finally. It is the same as in the recovery of Pb, Ag, Sn etc.

② Formation of Monitoring System

- Construction of the Organization and the System of the Monitoring for quick recognition of the condition and feed back as one of the environment managing organization/system ([S]).
- Reinforcement and rearrangement of the monitoring equipment and laboratory equipment for environmental analysis is required ([H]).

③ Enlightenment, Education and Raise of manpower ([S])

Enlightenment and education on wide class from inhabitants to the staff related to the environmental issues, which make recognition that better quality of environment will be obtained by each personal activity, are recommended to begin as early as possible.

As for the know-how on the enlightenment and education, foreign assistant is needed. On the other hand, it is better for the Government of Bolivia and Potosi prefecture themselves also to plan the raise leaders and to practice sustainable enlightenment and education for wide class.

Education is focused on school organization i.e. university, high school, and civilian organizations i.e. NGO in the early period. Enlightenment is carried out through mass-media i.e. TV broadcasting.

Dispatch of the short-term expert is recommended for support the execution of each step mentioned above by the Bolivian side.

(2) Steps to be taken in the Middle Term

○ Steps to be taken in the first half of the middle term period

④ Acid water treatment ([S],[H])

When the separate treatment of alkali tailing is completed, acid water problem will be revealed. Acid discharged water in the study area is abstractly classified into two groups as mine water group and permeable water group from waste rock, tailing dam and "Sucu" which is old tailing of ancient gravity separation activity. The flow rate of mine water does not vary during dry season and rainy season. On the other hand, permeable water is generated in rainy season, in particular, just after heavy rain intensively. KfW of the German has an idea to neutralize some acid waters with alkali tailing, however, other acid waters which are out of sight of KfW plan should be treated respectively each. Treatment method of acid permeable water that contains heavy metal ions is neutralizing precipitation method.

⑤ To establish the Environment And Safe Research Center (tentative titled) ([S],[H])

This recommendation to establish the Environment And Safe Research Center (tentative titled) is the most important in the steps proposed from the short term to long term and will become the core center of general conceptual plan.

The research center of which main objectives are mentioned below is established in the Tomas Frias Autonomic University (UATF), and dispatch of experts related, donation of necessary equipment and apparatus, and capacitating of counter parts (C/P) for four to five years.

C/Ps consist of Potosi prefecture, Potosi city, UATF and other organizations related ("Ingenios" association, NGO etc.) initiated by Potosi prefecture. Counter part personnel are leaders of each organization.

Technical transfer items are as follows.

- Mine pollution protection (waste water treatment)
- Mineral processing (improvement of recovery and tailing quality)

- Monitoring system
- Environment management
- Analytical issues related to environment and safe

Targets of establishment of the center are,

- sustainable water pollution protection and mine pollution protection in the La Rivera river basin around Potosi city to the Pilcomayo river,
- environmental restoration of around water basin which is suffered from the same type contamination,
- sustainable environment management by organization related of Potosi prefecture,
- restoration of environment around Potosi prefecture deepening the inhabitant's recognition for environment protection, and maintenance the environment in comfortable condition,
- and to make the center as the core concerning to environmental pollution remedy of mining sector in the Bolivia.

Dispatch of an expert (short term as around for six month) who will work to carry out this proposal earlier is recommended.

⑥ To arrange environment management system and to review law, regulation for discharge and penal regulation ([S])

The most appropriate and powerful environment management system for local sustainable environmental protection is needed. Furthermore, the most suitable monitoring system will be employed. On the other hand, rearrangement of laws and regulations (regulation for discharge and penal regulation) is necessary.

Employment of subsidize system is also necessary with powerful political instruction for smooth unification of "ingenios".

⑧ Forestation of old tailing dam ([S])

Old tailing dams in the Potosi City i.e. San Miguel should be covered by soil and forested to protect from generation of acid permeable water by precipitation, to recover scenery, to promote ecological immigration. Mine pollution protection and scenery conservation are important elements for the Potosi City, which is particularly trying to shift priority from mining to tourism. Tailing dam, which is conglomeration of non-organic materials, is difficult to be tree-and-grass-planted as it is. Forestation of the tailing dam, therefore, needs to cover fertile soil beforehand. Forestation is indispensable for protection of permeable water even needs large amount of cost.

○ Steps to be taken in the last half of the middle term period

⑨ Installation of tailings reprocessing plant ([S], [II])

Processing plant, which has capacity of 1,000t/d, located upper stream of DCSA, and recovers valuable minerals remained in the tailings reprocessing tailings sent from each "Ingenio" will be installed.

This plant will be assembled into integrated processing plant in the future as a down stream of the plant.

Installation of this plant makes accomplishment of objectives mentioned below.

- To extend life of tailing dam,
- To improve quality of tailing dam effluent,
- To raise surplus income for supplement to environmental protection cost,
- To stabilize and to improve quality of recycle water,
- To stabilize operation of "ingenios" which utilize recycle water,

(3) Steps to be taken in the Long Term Period

⑩ Installation of integrated mineral processing plant ([S], [II])

Integrated mineral processing plant which has capacity of 1,000t/d to 1,500 t/d and has latest equipment for treating lumping together all the minerals mined out from the Cerro Rico de Potosi

mine and processed by "ingenios" in Potosi city and suburbs at the moment will be installed at upper stream area of DCSA. At this step, tailings reprocessing plant, which was installed beforehand, will be assembled as a down stream process.

Minerals of the Cerro Rico de Potosi mine will be treated in world wide recovery level and no pollution for the first time with this integrated plant.

⑪ Installation of silver recovery plant ([S],[II])

Processing plant which has capacity of 200t/d (?) with heap leaching – Zinc powder precipitation (Hl.-Zn PPT) method targeting silver in the waste rock and "Sucu" will be installed at upper stream of DCSA at the same time of installation of integrated plant. This plant will recover silver removing waste rock, "Sucu" etc., which cover on the surface of Mt. Cerro Rico de Potosi losing its beautiful landscape.

Industrial zone will be completed with mineral processing plant as a center at upper stream of DCSA when the steps discussed above realize, and plans and counter measures for mine pollution protection and environment conservation will be carried out systematically and efficiently. On the other hand, there will not be any "ingenios" in the Potosi City area that will make improvement of the quality of life and conservation of excellent scenery.

⑫ Construction of monitoring system of the Pilcomayo river basin

The system, with which all the area of upper stream of the Pilcomayo river basin is monitored and managing plan is fed forward quickly, should be introduced to keep sustainable environmental management for maintaining improved water quality of the upper stream of the Pilcomayo river with the La Rivera river and for protecting mine pollution export.

6-3-4 Estimated Performance of" The Environment & Safety Research Center" Activity

Estimated performance of" The Environment & Safety Research Center" activity are as follows.

① Efficient exploitation and mine life extension applying appropriate mining method to Potosi mine.

② Improvement of mineral processing and lowering operation cost applying appropriate process technology (improvement of operation of Ingenio).

③ Squeeze out environment cost and completion of mine pollution protection by improving operation result.

④ Improvement of water quality of the Ribera River.

⑤ Arrangement of the laws, regulations and environment management system fitting to the Bolivian mining pollution protection.

⑥ Arrangement the environment law which is appropriate to the Bolivian environment condition and easy to sustain.

⑦ Obtain and maintain the better scenery of the Potosi City, improvement of the quality of life.

⑧ Recovering and utilization of resources remained (minerals remained in waste rock, "Sucu") .

⑨ Reduction of origin of acid water treating waste rock, "Sucu" etc.

⑩ Improvement of mine pollution in the Pilcomayo River basin establishing monitoring system and completion of environment management(protection of pollution export).

⑪ Execution of better environment recognizing environment protection conscious of inhabitant's sense (Improvement of total environment quality)

⑫ To be the model case of environment protection to other area where the similar pollution is.

⑬ Technological acquisition applying the third countries training.

7 Financial and Economic Analysis

7-1 Financial Analysis

7-1-1 Introduction

It is considered that the comprehensive mine pollution protection measures including technical evaluation discussed in Chapter 6 contribute to the improvement of water contamination in the field of mining sector in Potosi prefecture.

Of the proposed measures, financial aspect focuses on the improvement on management in ingenios because of the following reason;

(a) Tailings discharged from ingenios are a main cause of water contamination in the rivers,

(b) By utilizing DCSA where construction plan is under way, to treat above tailings is a most suitable method, and

(c) The cost for DCSA is borne by ingenios as beneficiaries.

From the above-mentioned reason, it is necessary for ingenios, as a key industry in Potosi prefecture, to promote the improvement on management, considering mine pollution protection and taking long-term perspective.

In the Study, the construction of integrated plant is proposed as a final goal of long-term plan, and the proposals to attain the goal smoothly at interim stage (short/medium term plan) were prepared.

However, as for the installation of model plant, Bolivian side has passive opinions such as investment scale against plant scale as well as operating the plant while continuing existing plants, therefore, it is required to make a more study for the organization and the utilization of current equipment to reduce investment cost.

Regarding the measures of non-revenue generating in the nature, economic analysis is discussed as mentioned later.

On the basis of available data at this stage, the financial feasibility will be evaluated for different types of measure below.

7-1-2 Methodology of Analysis

(1) Subject of analysis

Based on the results discussed for process improvement at ingenios in paragraph 6-1-2, introduction of

tin recovery plant in paragraph 6-1-4 and introduction of integrated plant in paragraph 6-1-7 out of the improvement plan for ore processing at ingenios, the financial feasibility is evaluated for these measures which refer to as project cases in the analysis and are shown in Table 7-1-1.

(2) Basic assumptions

As the basis of evaluation of the above measures, the following assumptions are made.

1) Construction and operation of the tailing dam

A tailing dam (DCSA) including tailing pumping facilities will be constructed in the near future under the assistance of German Reconstruction Finance Corporation. While dam construction is therefore out of scope of this study, the costs for the dam's operation and management will be borne by ingenios as beneficiaries.

According to the latest report on the dam project, the operation and management costs (hereinafter referred to as the environmental cost) will consist of the cost for tailing treatment (US$1.62 per tailing) and the cost of capital including interest payment, the latter of which is estimated in this analysis.
Note that construction of the DCSA is the prerequisite to this project, so that the analysis assumes that the environmental cost will incur regardless of project implementation.

2) Discussion by 1998 prices

Although the project cases subject to this analysis have different construction periods, all the project costs are estimated at 1998 prices, with no escalation being assumed thereafter for discussion on an equal footing and to reflect current economic conditions.

3) Rough estimate based on key assumptions (sales price, investment cost, etc.)

For project cases B and C, which are at the stage of preliminary cost estimation based on conceptual design and which construction sites are proposed as part of this study, emphasis should be placed on the establishment of a general outlook for the projects and identification of any problems. As a result, only rough estimates are made on the basis of key factors (sales price, investment cost, etc.).

In this connection, standard costs are established for approximately 40 ingenios as it is very difficult to estimate and total individual costs under time constraints.

(3) Methodology of analysis

(a) Case A: Process improvement of existing ingenios

The effect of the project case is measured by comparing net income (revenues minus expenses) expected from the case where process improvement is made ("with" case) and continued operation with minor repairs ("without" case).

(b) Case B: Construction of the tin recovery plant

If the project is not implemented, production of lead and zinc by ingenios will continue. The effect of the project is evaluated by the above with and without approach.

(c) Case C: Construction of the integrated plant

The effect of this project is evaluated as a new project, and existing ingenios will cease their operation.

7-1-3 Assumptions

(1) Capital requirements and funding

Based on the construction costs estimated in Section 6-1, capital required for production of concentrates are estimated and preliminary conditions to finance the capital requirements are established.

In estimating the capital requirements, the US dollar is used as the base currency, and the local current is converted at the following exchange rate that prevailed during the third field survey (June 1998). Again, 1998 prices are used for cost estimation.

Exchange rate: US$1 = 5.5 Bolivianos (Bs)

1) Estimation of investment cost

Investment cost required for the projects is defined as the sum of the construction costs estimated in Section 6-1 and physical contingency (10%). Physical contingency allows for any cost overrun due to unforeseeable factors or any deviation from cost estimation.

Note that the construction cost for Case A includes 212 shaking tables for tin collection and four technical advisers (two expatriate and two local). The construction cost for Case B includes similar technical adviser fee.

2) Interest during construction

It is assumed that the projects will be financed by loans from international financial institutions, as discussed later. The analysis assumes that the interest rate is 6% per annum and that capital requirements are entirely financed by loans.

3) Capital requirements

Capital requirements for each of the three project cases are estimated in Table 7-1-2

Note that the following costs and expenses, which will be required in the detailed design stage, are not estimated in this analysis.

(a) Land acquisition and site preparation costs

(b) Pre-operating expenses

(c) Additional working capital

It is very difficult to estimate these costs at this stage because project sites have not been decided and no geological survey has been conducted in the case of (a), and commissioning costs are included in the construction costs and relatively small costs are required for (b), such as training.

4) Funding

Capital requirements are assumed to be entirely financed by loans from international financial institutions. Loan conditions include the interest rate of 6% per annum and repayment with equal installment over 15 years after a 2-year grace period (construction period).

Any shortage of fund will be financed by short-term loans at the interest rate of 10% per annum and due on the following year.

(2) Production plan

As mentioned earlier, all costs are indicated in the U.S. dollar and are estimated at 1998 prices. The project period is 17 years consisting of 2 years for construction and 15 years of operation. Production volumes of concentrates at full operation under the "without" case and the "with" case for each project are compared in Table 7-1-3.

Production is assumed to be carried out for 330 days annually, at full operation in the first year of operation and onwards. No inventory is made and products are assumed to be immediately sold to the market.

1) Operating costs

For the accounting purpose, operating costs are classified into direct costs (crude ore, supplies, utilities and labor) and indirect costs (maintenance and environmental cost).

The operating costs at full operation under the "without" and "with" cases are summarized in Table 7-1-4.

From the above table, the operating cost related to crude ore is assumed to be $30/ton regardless of grade, and supplies and utilities include chemicals such as floatation separation agents, electricity and water. For Case C, 60 workers are assumed to be required due to energy saving that also brings cost reduction and the maintenance cost is assumed to be equivalent to 3% of the investment cost.

As for the environmental cost, total repayment including the tailing treatment cost (US$1.62) and interest payment is estimated by using the following equation:

(a) Basic assumptions (dam construction costs and loan terms)

* Dam construction cost: US$7,700,000
* Repayment period (n): 15 years
* Interest rate (R): 12% per annum

(b) The equation to determine capital recovery factor (CRF)

On the basis of the above assumptions, the capital recovery factor (repayment rate) including the annual interest payment is determined from the following equation:

$$CRF = \frac{R}{1-(1+R)^{-n}} = 0.14682$$

(c) Prepayment cost per unit of tailing

Under Case C, the annual amount of tailing produced is 390,000 tons. The annual amount of repayment is determined from (a) and (b) above, assuming the repayment of the entire amount, and it is divided by annual tailing production to obtain the repayment cost (C) per ton of tailing.

C = Dam construction cost x CRF/annual amount of tailing produced = US$2.9/ton

(d) Environmental cost

Using the above equation, the environmental cost is estimated at US$4.5/ton.

2) Other costs

Depreciation and income tax are estimated as follows:

(a) Depreciation – straight line over 15 years

(b) Income tax rate – 25%

(3) Sales prices

Sales prices of lead and zinc (including silver) (FOB, concentrates) are estimated by applying the grading method adopted by ingenios and on the basis of applicable 1998 prices at the London Metal Exchange (LME). On the other hand, tin prices are based on purchase prices of Vinto in Oruro. Table 7-1-5 shows LME metal price trends during the past five years.

From the above table, comparison of the 1998 prices with the average prices in the past five years indicate lead 15% lower, zinc more or less the same and silver nearly 11% higher. The purchase price of tin concentrates (15% grade) by Vinto is US$103/ton, much lower than the prices shown in the above table.

Breakdowns of sales prices of lead and zinc, as determined by the grading method adopted by ingenios, are shown in Tables 7-1-7 and 7-1-8.

In overall consideration of the above, sales prices of the metals including tin under each project case are determined as follows.

7-1-4 Results of Analysis

Based on the assumptions discussed above, each project case is evaluated to determine its feasibility by using relevant financial statements and the financial internal rate of return, a major index to measure project profitability by means of discounted cash flow method. The following financial statements of the project cases are attached in ANNEX(7):

*Production and sales plans

*Income statement

*Long-term loan repayment schedule

*FIRR calculation sheet

Note that Cases A and B are on an incremental basis.

On the basis of the results of analysis, economic feasibility is evaluated as shown in Table 7-1-9. The table summarizes key assumptions, average sales prices and production costs per unit quantity of crude ore, and FIRRs. Tables 7-1-10, 7-1-11 and 7-1-12 summarize basic assumptions for each of the project cases.

Finally, for the purpose of this analysis, the benchmark IRR to evaluate the projects is set higher than the opportunity cost of capital that consists of the interest rate (6%) and a risk premium (5%), and the analysis is made by FIRR before tax.

(1) FIRRs

Based on the above set of assumptions, FIRRs for the project cases are determined and presented in Table 7-1-13.

Major findings are summarized for each case as follows.

1) Case A: process improvement of existing ingenios

The FIRR (before tax) in this case is 46.72%, and the case has a highest profitability using minor investments compared with other cases.

In the estimation, new facilities are assumed in terms of safety, however, if secondhand facilities can be supplied in the country, the profitability can be improved more than that of new facilities.

The distribution and arrangement of such facilities to Ingenio are not considered at this stage.

It is necessary to pay attention to have great impacts on the profitability in case of the variation of investment cost in this case.

For example, in case technical advisers consisting of foreign and local staffs are increased from each 2 staffs to 4 staffs, FIRR (before tax) is 39.07%.

2) Case B: construction of the tin recovery plant

The FIRR (before tax) in this case is 0.22%, and indicates that the project is not feasible under the currently assumed conditions. A major reason is the unjustly low tin price. At present, Vinto has a volatilization plant to improve tin grade.

Then, sensitivity analysis related to variation of tin price was conducted and the results are presented in Table 7-1-9. This indicates that the project shows sufficient profitability when tin price reaches the range between US300/ton – US$400/ton. Various experts suggest that it will be technically feasible through a reasonable amount of additional capital investment.

As the project has high potential to make great contribution to Potosh's economic development, further research and study is recommended to find the ways to improve profitability.

3) Case C: construction of the integrated plant

The FIRR (before tax) in this case is 14.26%, and the project shows a reasonably high level of profitability, despite unfavorable factors including the low tin price and the environmental cost.

Therefore, the result indicates a good prospect for the project to justify technological development efforts to promote the project.

2) Conclusion

In addition to various conditions assumed for each project, the projects commonly require financial incentive, particularly availability of low-interest loans (6% level equivalent to LIBOR, as assumed in this analysis) from international financial institutions.

In reality, however, construction of the tailing dam will be financed by loans at 12% per annum, which repayment will presumably make ingenio operation less viable. In this case, availability of low-interest loans will contribute greatly to promotion of the project.

Table 7-1-1 Details of Project Cases

Case No.	Project case	Planning range
A	Process improvement at existing ingenios	Short-term
B	Construction of the tin recovery plant	Medium-term
C	Construction of the integrated plant	Long-term

Table 7-1-2 Breakdown of Capital Requirements

(Unit: US$ million)

Item	Case A	Case B	Case C
Investment Cost	2.02	30.35	48.95
Interest during construction	0.13	1.95	3.13
Total	2.15	32.30	51.72

Table 7-1-3 Details of Concentrates

(Unit: TPD)

Concentrates	"Without"Case	"With" Case		
		Case A	Case B	Case C
Pb*	22.6	24.1	24.1	24.0
Zn*	245.5	252.9	252.9	262.5
Sn	-	7.6	32.8	32.8

(Note) *: Including Ag

Table 7-1-4 Details of Operating Costs

Items	Unit	"Without" Case	"With"Case		
			Case A	Case B	Case C
1) Crude Ore	TPD	1,327	1,327	1,327	1,500
2) Tailing	TPD	1,059	1042	1,017	1,181
3) Direct Costs					
- Crude Ore	$/T	30.0	30.0	30.0	30.0
- Supplies & Utility	$/T	6.5	6.5	6.5	4.5
- Personnel	$/T	1.5	1.5	1.5	0.7
4) Indirect Costs					
- Maintenance Cost	$/T	2.0	2.0	2.0	2.9
- Environmental Cost	$/T-T	4.5	4.5	4.5	4.5

(Note) T: Crude Ore, T-T: Tailing

Table 7-1-5 Trends of Metal Market Price in LME

Year	Pb ($/T)	Zn ($/T)	Sn ($/T)	Ag ($/TOZ)
1994	548	998	5464	5.4
1995	631	1031	6214	5.1
1996	774	1027	6165	5.7
1997	633	1301	5669	4.9
1998	533	1047	5481	6.0
Average for 5 years	624	1081	5799	5.4

(Source) 1) Pb, Zn and Sn: LME 3 month buyer

2) Ag: LME Spot

Table 7-1-6 Details of Sales Price

Products	"Without" Case	"With" Case		
		Case A	Case B	Case C
Pb	578	578	578	705
Zn	246	246	246	260
Sn	—	103	103	103

Table 7-1-7 Calculation for Pb Concentrates FOB Price including Ag in Ingenio

Items	Current	Future (Target)		Remarks
1. Quality Condition				
1) Quality				
- Pb	40,0 %	45,0 %	(60.0%)	
- Ag	4500 g/t	5060 g/t		
2) Market Price (LME)				
- Pb	533 $/t	533 $/t		
- Ag	0,19 $/g	0,19 $/g		
3) Others				
- Moisture	10,0 %	10,0 %		
- Zn	15,0 %	10,0 %		
2. Concentrates Valuation				
1) Pb	180 $/t	205 $/t	(281)	0.95x(Pb Grade−4.5%)xPb Price
2) Ag	804	905		0.95x(Ag Grade−46.66g/t)xAg Price
3) Value after decrease of 1.0 $/T	973	1098	(1186)	0.99x(Pb Value+Ag Value−1.0$/t)
4) T/C	259	259		Pb Price less 550 $/T
5) R/C	63	71		Ag Gradex14.0$/kg
6) Commercial Charge (CC)	9	9		10.0$/wt／1.1t/wt
7) Transportation Charge (TC)	54	54		59.0$/wt／1.1t/wt
8) Zn Penalty over 10%	10	-		2.0$/tx(Zn Grade−10.0%)
9) Total Cost	395	393		Sum of 4)-8)
10) FOB Price	578	705	(793)	3)−9)

Table 7-1-8 Calculation for Zn Concentrates FOB Price including Ag in Ingenio

Items	Current	Future (Target)		Remarks
1. Quality Condition				
1) Quality				
- Zn	50.0 %	51.0 %	(55.0%)	
- Ag	1000 g/t	1040 g/t		
2) Market Price (LME)				
- Zn	1047 $/t	1047 $/t		
- Ag	0.19 $/g	0.19 $/g		
3) Other				
- Moisture	10.0 %	10.0 %		
2. Concentrates Valuation				
1) Zn	440 $/t	450 $/t	(492)	(Zn Grade−8.0%)×Zn Price
2) Ag	108	113		0.65×(Ag Grade−124.41g/t)×Ag Price
3) Value after decrease of 1.0 $/T	542	556	(598)	0.99×(Zn Value+Ag Value−1.0$/t)
4) T/C	233	233		225$/t+0.16×(Zn Price−1000$/t)
5) Commercial Charge (CC)	9	9		10.0$/wt／1.1t/wt
6) Transportation Charge (TC)	54	54		59.0$/wt／1.1t/wt
7) Total Cost	296	296		Sum of 4)-6)
8) FOB Price	246	260	(302)	3)−7)

Table 7-1-9 Summary of Financial Performance

Item	Case A (Process Improvement)		Case B (Sn Recovery)		Case C (Integration)
	With	W/O	With	W/O	With
1. Crude Ore Capacity, TPD	1327	1327	1327	1327	1500
Metal Amount					
-Pb, TPD	15.0	15.0	15.0	15.0	15.0
-Zn, TPD	150.0	150.0	150.0	150.0	150.0
-Ag, kg/T	464.5	464.5	464.5	464.5	464.5
-Sn, TPD	7.5	7.5	7.5	7.5	7.5
2. Products, TPD					
-Pb Concentrates	24.1	22.6	24.1	22.6	24.0
-Zn Concentrates	252.9	245.5	252.9	245.5	262.5
-Sn Concentrates	7.6	-	32.8	-	32.8
3. Capital Requirement, US$, MM	2.15	-	32.3	-	51.72
4. Unit Sale Price, US$/Ton-Ore	58.0	55.3	59.9	55.3	59.0
5. Unit Production Cost, US$/Ton-Ore	44.0	43.6	50.4	43.6	51.7
6. FIRR on Investment, %					
-Before Tax	46.72	-	0.22	-	14.26
-After Tax	(38.66)	-	(0.22)	-	(12.59)
7. Sensitivity Analysis by Before Tax, % (Sn Price in 1998: 103US$/Ton at 15% Grade)					
-Sn Sales Price, 100% up	-	-	5.81	-	16.59
-Sn Sales Price, 200% up	-	-	10.38	-	18.81
-Sn Sales Price, 300% up	-	-	14.40	-	20.94

Table 7-1-10 Project Profile and Assumption for Financial Projection (Case A)

1. Project

Title	:	Mine Pollution Assessment Project
Location	:	Potosi, Bolivia
Project Case	:	Base Case A (Process Improvement)
Products (100%)	:	Pb; 24.1 TPD, Zn; 252.9 TPD
	:	Sn; 7.6 TPD
Operable Days	:	330 DPY
Rated Capacity	:	Crude Ore: 1,327 TPD
Monetary Unit	:	US$ in terms of Fixed Price in 1998
Exchange Rates	:	US$1.00 = 5.5 Bolivianos (Bs)

2. Concentrates Price

Pb	:	578 US$/Ton
Zn	:	246 US$/Ton
Sn	:	103 US$/Ton

3. Financing Required

Plant Construction	:	1.56 US$, MM
Technical Adviser Fee	:	0.46 US$, MM
Interest during Construct	:	0.13 US$, MM
Total		2.15 US$, MM

4. Operating Costs

Crude Ore	:	30.0 US$/Ton
Supplies & Utility	:	6.5 US$/Ton
Personnel	:	1.5 US$/Ton
Maintenance	:	2.0 US$/Ton
Environmental Cost for Tailing Dam	:	4.5 US$/Ton - Tailing

5. Other Assumption

Interest	:	6.0 %
Depreciation	:	15.0 Years
Income Tax	:	25.0 %

Table 7-1-11 Project Proflie and Assumption for Financial Projection (Case B)

1. Project

Title	:	Mine Pollution Assessment Project
Location	:	Potosi, Bolivia
Project Case	:	Base Case B (Sn Recovery Plant)
Products (100%)	:	Pb; 24.1 TPD, Zn; 252.9 TPD
	:	Sn; 32.8 TPD
Operable Days	:	330 DPY
Rated Capacity	:	Crude Ore: 1,327 TPD
Monetary Unit	:	US$ in terms of Fixed Price in 1998
Exchange Rates	:	US$1.00 = 5.5 Bolivianos (Bs)

2. Concentrates Price

Pb	:	578 US$/Ton
Zn	:	246 US$/Ton
Sn	:	103 US$/Ton

3. Financing Required

Plant Construction	:	29.89 US$, MM
Technical Adviser Fee	:	0.46 US$, MM
Interest during Construct	:	1.95 US$, MM
Total		32.30 US$, MM

4. Operating Costs

Crude Ore	:	30.0 US$/Ton
Supplies & Utility	:	6.5 US$/Ton
Personnel	:	1.5 US$/Ton
Maintenance	:	2.0 US$/Ton
Environmental Cost for Tailing Dam	:	4.5 US$/Ton - Tailing

5. Other Assumption

Interest	:	6.0 %
Depreciation	:	15.0 Years
Income Tax	:	25.0 %

Table 7-1-12 Project Profile and Assumption for Financial Projection (Case C)

1. Project

Title	:	Mine Pollution Assessment Project
Location	:	Potosi, Bolivia
Project Case	:	Base Case C (Integrated Plant)
Products (100%)	:	Pb; 24.0 TPD, Zn; 262.5 TPD
	:	Sn; 32.8 TPD
Operable Days	:	330 DPY
Rated Capacity	:	Crude Ore: 1,500 TPD
Monetary Unit	:	US$ in terms of Fixed Price in 1998
Exchange Rates	:	US$1.00 = 5.5 Bolivianos (Bs)

2. Concentrates Price

Pb	:	705 US$/Ton
Zn	:	260 US$/Ton
Sn	:	103 US$/Ton

3. Financing Required

Plant Construction	:	48.59 US$, MM
Technical Adviser Fee	:	- US$, MM
Interest during Construct	:	3.13 US$, MM
Total		51.72 US$, MM

4. Operating Costs

Crude Ore	:	30.0 US$/Ton
Supplies & Utility	:	4.5 US$/Ton
Personnel	:	0.7 US$/Ton
Maintenance	:	2.9 US$/Ton
Environmental Cost for Tailing Dam	:	4.5 US$/Ton - Tailing

5. Other Assumption

Interest	:	6.0 %
Depreciation	:	15.0 Years
Income Tax	:	25.0 %

Table 7-1-13 Results of Financial Internal Rate of Return

(Unit: %)

FIRR	Case A	Case B	Case C
Before Tax	46.72	0.22	14.26
After Tax	36.66	0.22	12.59

7-2 Economic Analysis

7-2-1 Methodology of Analysis

Economic benefits expected from a project are defined as increased national or regional income due to the implementation of a project.

According to the above definition, the quantitative analysis will be made an attempt by adding the effect of foreign currency earning produced by ingenios, to the effect of water improvement brought to the Pilcomayo river basin due to the implementation of the proposed project.

Metal price as export goods can be evaluated by the international price, however, it is not easy to evaluate the water itself directly generated by its improvement involving the difficulty of available data.

In the analysis, the water is evaluated by using the prices of outputs (crops, cattle breeding) which are a base for the calculation of opportunity loss described in Section 4-3.

7-2-2 Subject of Analysis

In the analysis, the quantitative analysis is made an attempt assuming in case the water improvement would be completely attained. The following measures discussed from both aspects of mine pollution protection plan and environmental management plan are selected.

(a) Construction of the integrated plant including tailing dam of DCSA

(b) Acid water treatment in mine

(c) Forestation in old tailing dam

(d) Provision with equipment for analysis related to environment and monitoring

(e) Establishment of environment & safe research center

As for construction of the integrated plant in item (a) of the above measures, financial analysis has been made. Bolivian taxation system has incentives for export oriented project, such as the exemption of import duty and the refund of value added tax in metal price, therefore, these costs are excluded from the calculation of financial analysis. Also, the construction cost of DCSA is appropriated as an environmental cost in the plant.

Accordingly, FIRR (14.26%) in financial analysis can be applied to the result in economic analysis.

In the analysis, after the analysis is made as the subject of measures from item (b) to item (e), the overall analysis is made by adding the construction of the integrated plant in item (a) to the above items.

7-2-3 Assumptions

The major assumptions applied to the analysis are as follows:

(a) Currency, exchange rate and basic prices are used as the same values as financial analysis

(b) Duty, tax and interest are considered as a transferable item on national economy, therefore, they are excluded from economic prices.

(c) In the analysis, export/import goods are used as international prices, while domestic goods are used as market prices without adjusting prices.

7-2-4 Calculation of Benefits

(1) Assumptions

1) Subject of sector

Of the sectors described in Section 4-3, agriculture and stock-breeding are considered as the subject in the analysis, and each amount of opportunity loss is calculated as economic benefits.

Fishery is excluded from the analysis because of no available data in the survey basin. The opportunity loss of labor force is also excluded from the analysis because of a lack of definite information on the relation of cause and effect between pollution and average life.

2) Classification of basin range

The basin range of agriculture and stock-breeding to be utilized as the water is improved is classified below.

Prefecture	Wide Area of Pilcomayo River		Limited Basin of Pilcomayo River	
	Agriculture (ha)	Stock-breeding (km^2)	Agriculture (ha)	Stock-breeding (km^2)
Potosi	42,224	21,500	1,898	4,300*
Others	89,102	27,700	4,007*	5,540*

(Note) *: Assumed value
Others are Chuquisaca and Tarija.

While wide area means the basin of wide range in Pilcomayo river including tributary, limited basin means the survey basin in Pilcomayo river from Rivera river, via Torapaya river, to Mindes bridge.

3) Establishment of contribution rate by water improvement including utilization rate of river

In the analysis, the amounts of opportunity loss are evaluated based on the outputs in agriculture and stock-breeding, therefore, basic contribution rate by the water improvement is to be 50%.

By multiplying utilization rate of river for each basin by the above rate, the contribution rate is established below.

Prefecture	Wide Area of Pilcomayo River	Limited Basin of Pilcomayo River
Potosi	25%=50%×50%	50%=50%×100%
Others	12.5%=50%×25%	25%=50%×50%

(Note) Contribution rate = Basic contribution rate × Utilization rate of river

(2) Calculation of benefits

1) Agriculture

(a) The amounts of opportunity loss in 1993 are calculated by multiplying the applicable arable land by the difference of agriculture production amounts between the country and the prefecture. Note that the average amounts of agriculture production in the country are used in case of newly available arable land.

(b) After the said amounts at local currency are converted into that at US dollar, the amounts of opportunity loss in 1998 are calculated by multiplying the converted amounts by the escalation of 3% p.a. for 5 years from 1993 to 1998.

(c) The net amounts of opportunity loss in 1998 are calculated by multiplying the said amounts by the contribution rate.

2) Stock-breeding

(a) The amounts of opportunity loss in 1993 are calculated by multiplying the polluted basin area reduced productivity by half (i.e. the available area by the water improvement) by the average amounts of stock-breeding.

(b) The net amounts of opportunity loss in 1998 are calculated by using the same method as agriculture.

3) Summary of benefits

Based on the above-mentioned procedure, the net amounts of opportunity loss in 1998 are summarized below, and the details are shown in Table 7-2-1.

(Unit: 1,000US$)

Division	Agriculture	Stock-breeding	Total
Wide Area of Pilcomayo			
Potosi	1,060	511	1,571
Others	1,312	2,370	3,682
Total	2,372	2,881	5,253
Limited Basin of Pilcomayo			
Potosi	162	204	366
Others	185	948	1,133
Total	347	1,152	1,499

7-2-5 Calculation of Costs

(1) Investment cost

The investment cost excluding the integrated plant required for the full attainment of water improvement is shown below.

(Unit: 1,000US$)

Description	Amounts
-Acid Water treatment in Mine	1,670
-Forestation in Old Failing Dam	1,420
-Equipment for Environmental Analysis and Monitoring	910
-Environment & Safe Research Center	2,500
Total	6,500

In the above table, physical contingency is included in the estimation, however, interest during construction is not included because of a transferable item.

(2) Annual operating expenses

The annual operating expenses on each basin required due to the implementation of the project are shown below.

(Unit: 1,000US$)

Prefecture	Wide Area of Pilcomayo River	Limited Basin of Pilcomayo River
Potosi	650	488
Overall	1,300	650

(Note) Overall includes Potosi and other prefectures.

7-2-6 Results of Analysis

Based on the assumptions discussed above, each project case shown below is evaluated to determine its feasibility by using economic internal rate of return (EIRR), and the details of which are shown in Table

7-2-2. Each calculation sheet is attached in ANNEX(7).

As mentioned in paragraph 7-2-2, the EIRR in the integrated plant is 14.26%.

In the analysis, assuming in case the water improvement would be completely attained, economic benefits are calculated as the amounts of opportunity loss in agriculture and stock-breeding sectors (i.e. benefits could be obtained as the water is improved). Furthermore, in order to estimate the impacts in Pilcomayo river basin brought by the water improvement, the basin range on the analysis covers Potosi prefecture, as the survey area, as well as other prefectures such as Chuquisaca and Tarija.

The project cases applied to the analysis are as follows:

Case No.	Project Case
D-1	Wide area of Pilcomayo river in Potosi prefecture
D-2	Limited basin of Pilcomayo river in Potosi prefecture
E-1	Wide area of Pilcomayo river in all the prefectures
E-2	Limited basin of Pilcomayo river in all the prefectures

Note that Case C means the integrated plant as used in financial analysis.

Regarding two cases, i.e. in case each project case including the integrated plant (call as Overall case) and in case each project case not including (call as Single case), the analysis was roughly made.

In case of Single case, in Potosi prefecture, the result of Case D-2 indicates that the project is not feasible, however, that of D-1 indicates that the project has effects more than 11%, while in all the prefectures, that of Case E-1 indicates that the project has effects more than those in Potosi prefecture.

In case of Overall case, in Potosi prefecture, the result of Case D-2 as a worst case indicates that the project has effects more than 11%, while in all the prefectures, the result indicates that the viability of D-1 is slightly less than that of Case C.

Finally, though the analysis is roughly made based on the only quantitative available data in agriculture and stock-breeding as benefits as mentioned above, it is presumed that the project has great benefits brought to Pilcomayo river basin.

Furthermore, the effect of investment in Overall case reveals the integrated plant has a prominent position. It is anticipated that ingenios play an more important part from view-point of particularity in Potosi prefecture.

Table 7-2-1 Calculation of Opportunity Loss Amounts in Agriculture and Stock-breeding Sectors (1/2)

1. Agriculture

	Potosi	Chuquisaca
1) Wide Area of Pilcomayo River		
-Arable Land (10^3ha)	116	149
-Difference of Agriculture Production (Bs/ha)	370	434
-Wide Arable Land of Pilcomayo (10^3ha)	42.2	89.1
-Amounts of Opportunity Loss (10^3Bs, 1993)	15,623	38,669
-Amounts of Opportunity Loss ($10^3$$, 1993)	3,659	9,056
-Amounts of Opportunity Loss ($10^3$$, 1998)	4,240	10,496
-Net Amounts of Opportunity Loss ($10^3$$, 1998)	1,060	1,312
(Contribution Rate)	(25%)	(12.5%)
2) Limited Basin of Pilcomayo River		
-Existing Arable Land (ha)	1,537 (81%)	3,246 (81%)
-Newly Available Land (ha)	361 (19%)	761 (19%)
Total of Basin	1,898 (100%)	4,007 (100%)
-Amounts of Opportunity Loss (1993)		
-Existing (10^3Bs)	569	1,409
-Newly (10^3Bs)	622	1,311
-Total (10^3Bs)	1,191	2,720
-Amounts of Opportunity Loss ($10^3$$, 1993)	279	637
-Amounts of Opportunity Loss ($10^3$$, 1998)	323	738
-Net Amounts of Opportunity Loss ($10^3$$, 1998)	162	185
(Contribution Rate)	(50%)	(25%)

Table 7-2-1 Calculation of Opportunity Loss Amounts in Agriculture and Stock-breeding Sectors (2/2)

2. Stock-breeding

1) Wide Area of Pilcomayo River

	Potosi	Chuquisaca	Tarija
-Annual Breeding Production (10^3Bs, 1993)	33,807	95,904	59,526
-Basin Area (10^3km^2)	43.0 (36.4%)	30.8 (59.8%)	24.6 (65.4%)
Non-pollution	21.5 (18.2%)	15.4 (29.9%)	12.3 (32.7%)
Pollution (Assumed as reduction of productivity by half)	21.5 (18.2%)	15.4 (29.9%)	12.3 (32.7%)
-Out of Basin Area (10^3km^2)	75.2 (63.6%)	20.7 (40.2%)	13.0 (34.6%)
-Available Area (10^3km^2)	96.7 (81.8%)	36.1 (70.1%)	25.3 (67.3%)
-Average Breeding (Bs/km^2)	350	2,657	2,353
-Amounts of Opportunity Loss (10^3Bs, 1993)	7,525	40,918	28,942
-Amounts of Opportunity Loss (103$, 1993)	1,762	9,583	6,778
-Amounts of Opportunity Loss ($10^3$$, 1998)	2,042	11,107	7,856
-Net Amounts of Opportunity Loss ($10^3$$, 1998)	511	1,388	982
(Contribution Rate)	(25%)	(12.5%)	(12.5%)

2) Limited Basin of Pilcomayo River

-Polluted Basin (10^3km^2) (20% of item 1))	4.30	3.08	2.46
-Average Breeding (Bs/km^2)	350	2,657	2,353
-Amounts of Opportunity Loss (10^3Bs, 1993)	1,505	8,184	5,788
-Amounts of Opportunity Loss ($10^3$$, 1993)	352	1,917	1,356
-Amounts of Opportunity Loss ($10^3$$, 1998)	408	2,221	1,571
-Net Amounts of Opportunity Loss ($10^3$$, 1998)	204	555	393
(Contribution Rate)	(50%)	(25%)	(25%)

Table 7-2-2 Details of Economic internal Rate of Return (EIRR)

1. Base Case: Results in case water improvement is completely attained

(Unit: %)

Project Case No.		Overall Case (EIRR 1)	Single Case (EIRR 2)
C	Integrated Plant	14.26	–
D-1	Wide Area of Pilcomayo in Potosi	13.83	11.42
D-2	Limited Basin of Pilcomayo in Potosi	11.78	Negative
E-1	Wide Area of Pilcomayo in All the Prefectures	19.29	48.77
E-2	Limited Basin of Pilcomayo in All the Prefectures	13.69	9.12

8 Recommendation for the Future Steps

Future Steps to be taken are suggested being integrated into Table 8-1. Those steps are classified into two main groups, one is a group of the steps which should be carried out by the Bolivia and Potosi prefecture themselves, and the other is a group which require foreign cooperation technically and financially as the future steps to be taken for renovation the environmental contamination in the field of mining sector in the Potosi prefecture. Those two groups are also arranged separating in three terms, short (urgent), middle and long (required sustainable measure).

Those steps contribute to execution of general conception associating mutual relation between each step, even each step has each effect as itself.

The establishment of the Environment and Safe Research Center will be a core to complete the general conception organizing each step functionally.

It is important to execute each proposed step individually in order, however, the most important way is to execute each proposed item smoothly and to realize the general conception associating mutual relation between each step. The result of the Study is, therefore, to recommend to establish urgently the Environment And Safe Research Center which acts this important.

Detail of the center is explained in Item 6-1-9.

8-1 Steps to be Taken in the Short Term Period (Urgent)

① To quit discharging tailings directly into rivers (require hard ware [H])

To quit discharging tailings from the "ingenios" directly into rivers which have most serious impacts on the contamination of the La Rivera river basin, and treat separately. The "Dique de Colas San Antonio (hereinafter referred to as "DCSA") construction plan is on the way".

② To renovate the process of "ingenio" (processing plant)(require both of soft ware [S] and [H])

This renovation will improve Zn recovery from less than 80% to around 90% which contribute not only to improve economic condition but also to clean the quality of tailings finally. It is the same as in the recovery of Pb, Ag, Sn etc.

③ Formation of Monitoring System ([S],[H])

- Construction of the Organization and the System of the Monitoring for quick recognition of the condition and feed back as one of the environment managing organization/system ([S]).
- Reinforcement and rearrangement of the monitoring equipment and laboratory equipment for environmental analysis is required ([H]).

④ Enlightenment, Education and Raise of manpower ([S])

Enlightenment and education on wide class from inhabitants to the staff related to the environmental issues, which make recognition that better quality of environment will be obtained by each personal activity, are recommended to begin as early as possible.

As for the know-how on the enlightenment and education, foreign assistant is needed. On the other hand, it is better for the Government of Bolivia and Potosi prefecture themselves also to plan the raise leaders and to practice sustainable enlightenment and education for wide class.

Education is focused on school organization i.e. university, high school, and civilian organizations i.e. NGO in the early period. Enlightenment is carried out through mass-media i.e. TV broadcasting.

Dispatch of the short-term expert is recommended for support the execution of each step mentioned above by the Bolivian side.

8-2 Steps to be Taken in the Middle Term

○ Steps to be taken in the first half of the middle term period

⑤ Acid water treatment ([S],[H])

When the separate treatment of alkali tailing is completed, acid water problem will be revealed. Acid discharged water in the study area is abstractly classified into two groups as mine water group and permeable water group from waste rock, tailing dam and "Sucu" which is old tailing of ancient gravity separation activity. The flow rate of mine water does not vary during dry season and rainy season. On the other hand, permeable water is generated in rainy season, in particular, just after heavy rain intensively. KfW of the German has an idea to neutralize some acid waters with alkali tailing, however, other acid waters which are out of sight of KfW plan should be treated respectively each. Treatment method of acid permeable water that contains heavy metal ions is neutralizing precipitation method.

⑥ To establish the Environment And Safe Research Center (tentative titled) ([S],[H])

This recommendation to establish the Environment And Safe Research Center (tentative titled) is the most important in the steps proposed from the short term to long term and will become the core center of general conceptual plan.

The research center of which main objectives are mentioned below is established in the Tomas Frias Autonomic University (UATF), and dispatch of experts related, donation of necessary equipment and apparatus, and capacitating of counter parts (C/P) for four to five years.

C/Ps consist of Potosi prefecture, Potosi city, UATF and other organizations related ("Ingenios" association, NGO etc.) initiated by Potosi prefecture. Counter part personnel are leaders of each organization.

Technical transfer items are as follows.

- Mine pollution protection (waste water treatment)

- Mineral processing (improvement of recovery and tailing quality)
- Monitoring system
- Environment management
- Analytical issues related to environment and safe

Targets of establishment of the center are,

- sustainable water pollution protection and mine pollution protection in the La Rivera river basin around Potosi city to the Pilcomayo river,
- environmental restoration of around water basin which is suffered from the same type contamination,
- sustainable environment management by organization related of Potosi prefecture,
- restoration of environment around Potosi prefecture deepening the inhabitant's recognition for environment protection, and maintenance the environment in comfortable condition,
- and to make the center as the core concerning to environmental pollution remedy of mining sector in the Bolivia.

Dispatch of an expert (short term as around for six month) who will work to carry out this proposal earlier is recommended.

⑦ To arrange environment management system and to review law, regulation for discharge and penal regulation ([S])

The most appropriate and powerful environment management system for local sustainable environmental protection is needed. Furthermore, the most suitable monitoring system will be employed. On the other hand, rearrangement of laws and regulations (regulation for discharge and penal regulation) is necessary. Employment of subsidize system is also necessary with powerful political instruction for smooth unification of "ingenios".

⑧ Forestation of old tailing dam ([S])

Old tailing dams in the Potosi City i.e. San Miguel should be covered by soil and forested to protect from generation of acid permeable water by precipitation, to recover scenery, to promote ecological immigration. Mine pollution protection and scenery conservation are important elements for the Potosi city, which is particularly trying to shift priority from mining to tourism. Tailing dam, which is conglomeration of non-organic materials, is difficult to be tree-and-grass-planted as it is. Forestation of the tailing dam, therefore, needs to cover fertile soil beforehand. Forestation is indispensable for protection of permeable water even needs large amount of cost.

○ Steps to be taken in the last half of the middle term period

⑨ Installation of tailings reprocessing plant ([S], [H])

Processing plant, which has capacity of 1,000t/d, located upper stream of DCSA, and recovers valuable minerals remained in the tailings reprocessing tailings sent from each "Ingenio" will be installed.

This plant will be assembled into integrated processing plant in the future as a down stream of the plant.

Installation of this plant makes accomplishment of objectives mentioned below.

- To extend life of tailing dam,
- To improve quality of tailing dam effluent,
- To raise surplus income for supplement to environmental protection cost,
- To stabilize and to improve quality of recycle water,
- To stabilize operation of "ingenios" which utilize recycle water,

8-3 Steps to be Taken in the Long Term Period

⑩ Installation of integrated mineral processing plant ([S], [H])

Integrated mineral processing plant which has capacity of 1,000t/d to 1,500 t/d and has latest equipment for treating lumping together all the minerals mined out from the Cerro Rico de Potosi mine and processed by "ingenios" in Potosi city and suburbs at the moment will be installed at upper stream area of DCSA. At this step, tailings reprocessing plant, which was installed beforehand, will be assembled as a down stream process.

Minerals of the Cerro Rico de Potosi mine will be treated in world wide recovery level and no pollution for the first time with this integrated plant.

⑪ Installation of silver recovery plant ([S],[H])

Processing plant which has capacity of 200t/d (?) with heap leaching – Zinc powder precipitation (HL-Zn PPT) method targeting silver in the waste rock and "Sucu" will be installed at upper stream of DCSA at the same time of installation of integrated plant. This plant will recover silver removing waste rock, "Sucu" etc., which cover on the surface of Mt. Cerro Rico de Potosi losing its beautiful landscape.

Industrial zone will be completed with mineral processing plant as a center at upper stream of DCSA when the steps discussed above realize, and plans and counter measures for mine pollution protection and environment conservation will be carried out systematically and efficiently. On the other hand, there will not be any "ingenios" in the Potosi City area that will make improvement of the quality of life and conservation of excellent scenery.

⑫ Construction of monitoring system of the Pilcomayo river basin

The system, with which all the area of upper stream of the Pilcomayo river basin is monitored and managing plan is fed forward quickly, should be introduced to keep sustainable environmental

management for maintaining improved water quality of the upper stream of the Pilcomayo river with the La Rivera river and for protecting mine pollution export.

8-4 Summary

As an example for applying the measurements listed above (paragraphs 8-1 to 8-3), we try simulation of cadmium pollution load on the De la Ribera River in the Potosi city area.

The table 8-2 and figure 8-1 shows the situation of pollution charge caused by cadmium before and after taking preventive and corrective measurements.

The figure 8-1 shows the environmental situation of Potosi Prefecture if still continue the actual situation up to year 2015. It can be estimate that will be discharged approximately 610 tons of cadmium to the De la Ribera River during next 15 year period. Nevertheless, if the proposed measurements will be taken, it is possible to estimate that the discharge will be decreased about to 230 tons reducing 380 tons in the same period.

The figure 8-1 shows the example for cadmium, but is possible to estimate similar tendency for other pollutants like heavy metals.

For example, as said in paragraph 4-3-4, the cost of opportunity loss calculated on 5.7 million dollars per year (total for agriculture, stockbreeding and fishery sectors in 1993) will be estimate to accumulate to 85.5 million dollars for the next 15 years up to year 2015. This amount can be correlated to the benefits for applying improvement measurements.

Show table 8-3 for investment and operating cost for each measurement apply.

Table 8-1 Proposals Execution Plan

Proposal		Short Term	Mid Term	Long Term
1. Mining pollution prevention plan	① Tailings drainage suspension	———	———	———→
	② Process improvement at ingenios	———	———	———→
	⑤ Acid effluents treatment (mines and waste deposits)	———	———	———→
	⑧ Minerals waste deposits forestation		———	———→
	⑨ Tailings (from ingenios) treatment plant			———→
	⑩ Integrated concentration plant			———→
	⑪ Value metals recovery from mineral wastes	———	———	———→
2. Environmental management plan	③ Monitoring system organization			
	⑦ Environmental laws and regulations review			———→
	⑫ Pilcomayo basin monitoring system			———→
3. Research Center activities	④ Training and instruction program	———	———	———→
	Activities related to mining pollution prevention plan	① Technical and financial analysis on tailing treatment plant and water recycling system	① Follow up and consulting	
		② Technical and financial analysis on mineral process items	②Follow up and consulting	
		⑤ Technical and financial analysis on effluents treatment	⑤Follow up and consulting	
		⑧Technical and financial analysis on forestation items	⑧Follow up and consulting	
			⑨ Technical and financial analysis on tailings treatment	⑨Follow up and consulting
			⑩ Technical and financial analysis on integrated plant construction	⑩Follow up and consulting
			⑪ Technical and financial analysis on value metals recovery from mineral wastes	⑪Follow up and consulting
	Activities related to environmental management	③ Introduction of monitoring system and simulation techniques (progressive improvement)		
		⑦ Environmental law and regulation review, environment white paper formation, environment indexes application, environmental executive organization improvement, training and instruction program execution (progressive improvement)		
		⑫ Establishment of policy and progressive improvement of Pilcomayo basin integral monitoring system		

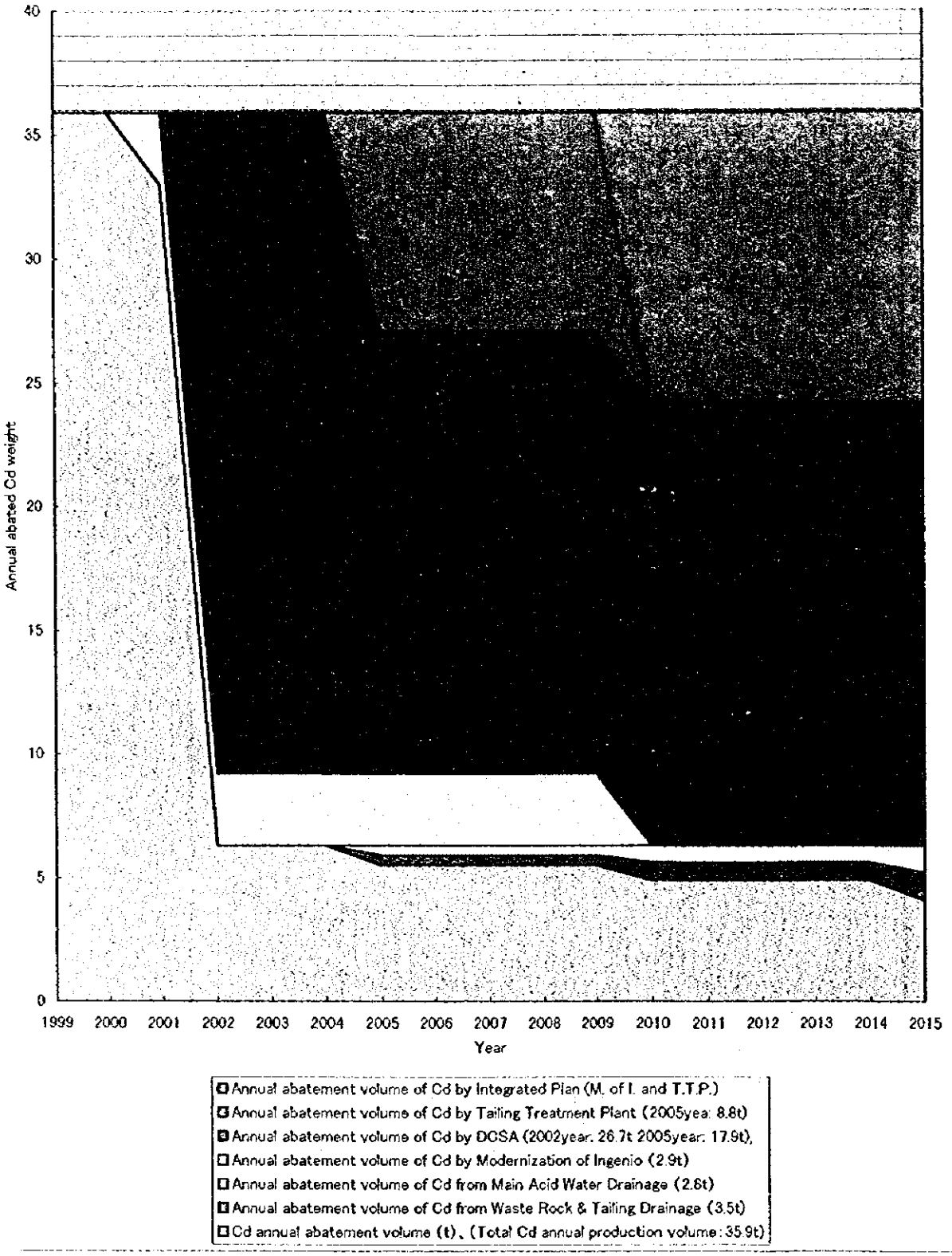
	Origin	Source	Mechanism	Contaminant	Flow	Cd Charge	Cd form	pH	Measurement
1	Concentration plants	Tailings	Non liberated miner	Sludge with metals	6.000ton/d*1	67,5Kg/d*2	SS	11 a 12	1.Process improvement
			Flotation reagents	Reagents and alkali	69lit/s				2.DCSA (KfW)
									3.Environment analysis equip.
									4.Monitoring equipment
									6.Research center
									7.Tailings treatment
									8Effluent recycling
									11.Integrated plant
2	Mine galleries	Rain, filtration	Generation of acids	Solved metals	777ton/d*3	7,8Kg/d*4	ion	1 a 2	5.Acid effluent treatment
			Metal leaching	Acid water	9lit/s	(10mg/lit)			2.DCSA (KfW)
									3.Environment analysis equip.
									4.Monitoring equipment
									6.Research center
3-1	Waste rocks	Rain	Generation of acids	Solved metals	Estiaje:4.320ton/d*5	9,5kg/d*6	ion	2 a 3	5.Acid effluent treatment
			Metal leaching	Acid water	50lit/s	(2,2mg/l)			9.Afforestation
3-2	Old tailing deposits	Rain	Generation of acids	Solved metals	Rain				10.Filling mines/tailings
	Gravimetry of Sn		Metal leaching	Acid water					2.DCSA (KfW)
3-3	Old tailing deposits	Rain	Generation of acids	Remanent metals					3.Environment analysis equip.
	Flotation of Zn, Pb			Alkaline water					4.Monitoring equipment
									6.Research center
									12.Metal recovery plant
4	Population	Modus vivendi	Waste	Organics, bacteria	13.478ton/d				x.Effluent treatment (KfW)
				Ammonium, etc.	156lit/s				
	Total (San Antonio)					99Kg/d*7	Principal. S.S.	6 a 12	
						(2,53mg/l)			
	Environment standart					(0,005mg/l)			

Table 8-2 Pollution Situation at Potosi and its Solution Measurements

	Measurement	Costs		Beneficios
		Initial Investment	Annual Operating Cost	
1	Process improvement	1 to 10 millions yen/Ingenio	240 millions yen	Disminution of value metal loss upto 1/3
				Elimination of SS from effluents
2	DCSA	1billion yen/KfW	1.0 billions yen	Elimination of SS from ingenenios tailings
				Disminution of ingenios effluents
3	Environmental analysis equip	100 millions yen	110 millions yen	Pollution situation study
				Feedback for environmental management
4	Monitoring equipment	10 millions yen	Included in 3	Pollution prevention measurement policy making
				Feedback for environmental management
5	Effluents treatment	2 to 50 millions yen/unidtod	200 millions yen	Elimination of solved heavy metals upto 95%
6	Research center	200 to 300 millions yen	300 millions yen	Integral research
				Integral coordination, training and education
7	Tailings tratment plant	1.3 billions yen	3.6 billions yen	Disminution of value metal loss upto 1/3
8	Effluents recycling	50 millions yen		Eliminiation of effluents form concentration plants
9	Afforestation	5 millions yen	Más de 170 millions yen	Elimination of acid water form mineral waste deposits
				Vegetation and stabilization of old mineral waste deposits
10	Mine filling / tailings	100 millions yen		Elimination of needs to construct tailing deposits dams
				Dam rupture risk elimination
11	Integrated plant	1.2 billions yen	5.83 billions yen	Urban/industrial zone separation, scale economy
		2.5 billions c/retrat. Colas		Environmental cost assumption capacity
12	Ag recovery	300 millions yen		Valuation of mineral waste
				Improvement of panorama

Table 8-3 Proposals Execution Costs and its Benefits

Figure 8-1 Abatement Effect of Cd contamination



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