EL MOLINO HYDROELECTRIC PROJECT

ENVIRONMENTAL IMPACT STUDY

VOLUME I OF V

CHAPTER 2

DOCUMENT 2148-04-EV-ST-020-02

REVIEW No. 0

Review	Modifications	Date
0	Original Version	12/23/2011

Elaboration - Review - Approval

Review	Developed by:		Reviewed by:		Approved by:	
	Name	Signature	Name	Signature	Name	Signature
0	SAG/HMV		HMV		HMV	

The copyright of this document is from HMV ENGINEERS LTDA, which are exempt from any liability if this document is altered or modified. Not authorize its use or reproduction in whole or in part for purposes other than contracted.

GENERAL CONTENT

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF CARTOGRAPHY

2148-04-CV-DW-014	General location of the Project
2148-04-CV-DW-015	General facilities Cartography
2148-04-CV-DW-015	Locating offices, camps and plants
2148-04-CV-DW-017	Locations of minor streams
2148-04-CV-DW-022	Weir - Plant and sections
2148-04-CV-DW-023	Collection - Plant and sections
2148-04-CV-DW-024	Sand removal - Plant and sections
2148-04-CV-DW-032	Conduction tunnel - Plant and profile
2148-04-CV-DW-033	Conduction tunnel- Typical Sections
2148-04-CV-DW-044	Pressure piping - Profile and sections
2148-04-CV-DW-050	Engine house - Overall settlement
2148-04-CV-DW-051	Engine house - Adequacy
2148-04-CV-DW-052	Discharge Channel - Profile and sections
2148-04-CV-DW-063	Access roads to collection
2148-04-CV-DW-064	Access roads to relief pipeline and exit portal of tunnel
2148-04-CV-DW-065	Access roads - Typical hydraulic facilities
2148-04-CV-DW-076	Reservoirs - General Location
2148-04-CV-DW-077	Reservoirs - Plant and profile
2148-04-THE-DW-021	Transmission Line

2 PROJECT DESCRIPTION

2.1 LOCATION

The El Molino Hydroelectric Project (formerly known as El Molino) is located east of the department of Antioquia, about 95 km from the city of Medellin in the jurisdiction of the municipalities of Cocorná and Granada, in the Veredas (Political and administrative division of the municipality located in the rural area) El Molino, Campo Alegre, Los Mangos, La Inmaculada and San Lorenzo from the first municipality and in the Veredas (Political and administrative division of the municipality located in the rural area) of Quebrada Abajo and Las Faldas de Granada. Cartography 2148-04-CV-DW presents the general location of the project.

2.2 TECHNICAL DESCRIPTION OF THE PROJECT

The El Molino Hydroelectric Project will be water edge type without a water reservoir; it will have a capacity of 21 MW, for a design flow of 10 m³ /s and a net leap of 238.4 m. The conduction facilities are approximately 3.4 km in total length.

The El Molino Hydroelectric Project is part of a chain system in conjunction with the San Matías hydroelectric project (formerly named El Molino II), for this reason, turbine water from project El Molino will be delivered to a settling tank, which in normal conditions carries water to the San Matias Hydroelectric Project .

In general terms, the Project consists of a concrete weir of low- height, a collection side, a sand removal for sediment retention, a box culvert, a conduction tunnel, a relief pipeline, a house of valves, the pressure line, the power house on soil surface, a settling tank and finally a discharge channel to deliver turbine water into the San Matias River when the project San Matías does not operate, elements that are described in more detail ahead in the documents. The general outline of the facilities can be seen in Cartography 2148-04-CV-DW-015.

2.2.1 Collection facilities

The bypass facilities or collection will be placed in the coordinates 880,829 and 1,162,570 N, height 1,260 Meters above sea level, where the San Matias River presents favorable conditions for the location of these structures.

The bypass flow rates will be based on the construction of a concrete weir approximately 4.0 m in height and 39.0 m in length, a crest with an elevation of 1,264 Meters above sea level, which will be on the right side, with a background discharge composed of a radial gate of 5.0 x 5.0m. The area that will occupy the pondage generated by the weir will be of 1.2 ha. The plant and weir profile are presented in Cartography 2148-04-CV-DW-022.

The spillway section of the weir will allow the passage of rising water of 1,246 m³ /s, corresponding to a return period of 100 years.

A side type jack has been prepared for the collection on the right side of the weir, composed of rectangular openings sized to derive the flow to the conduction system. Passing the water inflow openings it reaches a channel that works as gravels traps that connects with the conduction channel through a second openings or holes. The first opening system is composed by two orifices of 2,50 m. wide and 2,15 m, height, and the second system by

three orifices of 1,80 m .wide and 1,70 m. high. At the end of the gravel removal channel, a gate has been prepared of 2.50 m wide and 2.50 m high.

Cartography 2148-04-CV-DW-023 presents the plant and collection sections.

2.2.2 Conduction Channel

Adjacent to the gravel removal channel there is a channel that carries the collected waters to the sand remover. This channel is 4.0 m wide, 3.60 m high and a longitudinal slope of one per thousand. At 38.0 m of the channel a gate has been prepared for regulating the flow that enters for generation. Following this gate, a discharge canal for evacuation has been provided for the surplus that could enter the system. This has a length of 30 m.

Cartography 2148-04-CV-DW-023 presents the plant and sections of the conduction channel.

2.2.2.1 Facilities for the instream flow as environmental guaranty

In order to ensure the proposed instream flow as environmental guaranty (CGA), it will be constructed a square hole of 0.8 m in the conduction channel, about 33.0 m after the water collection and immediately before the regulation flow gate for generation.

Given that the CGA has proposed a flow which varies from month to month, it has been prepared some regulatory elements and measures that will allow the compliance of the CGA defined each month. For this it has been prepared that the flow comes out of the orifice provided for that purpose, going towards a shock absorber tank in which a rectangular type dam will enable us to measure the flow rate to be handed over to the river. The rectangular dam has a length of 1.50 m and a discharge height of 1.0 m. The flow through the hole will be regulated by a gate of equal dimensions that allows making adjustments every month.

The plant and work section of the CGA is presented in Cartography 214804CVDW023.

2.2.3 Sand remover

The sand remover, located on the right margin of the San Matias River, will be a *Dufour* type of three chambers, which allows its cleaning per chamber, without having to stop the operation of the plant. Each chamber has 43 m long by 6.0m wide.

For cleaning the material deposited in each chamber, the sand remover will have two drainage channels at the bottom, located in a perpendicular orientation to the chambers. These channels have a width of 1.20 m and a height varying between 1.10 m and 1.30 m, with a gradient of 1% along its route.

At the bottom of the sand remover there will also be the discharge of the settled material to the river, which will be done by using a venting channel that receives, from the two discharge channels mentioned above, the material deposited in the chambers. This venting channel will be of 1.20m. Wide, 1.20 m in height and slope of 1.0 %, this will deliver the waters to a cyclopean concrete slab.

The sand remover shall have the following electromechanical equipment:

- **Floodgates**

The sand remover will be equipped with a set of input and output gates that will isolate each chamber for cleaning purposes. The entry floodgates will be flat. One per chamber, three in total and will be 2.0 m. wide by 4.50 m in height. The output gates will be flat with 3.0 m wide by 2.3 m of height, handled by servo motors and will locate two per chamber, for a total of 6 gates.

In addition, in each house of the sand remover there is a bottom channel to discharge the settled material to the river. At the end of each channel, there will be a flat bottom manual gate of 0.7 m wide by 0.7 m in height, for a total of 6 gates in the backside.

- **Coulters**

After the flat gates entrance, there will be a system of 6 bars of 2.8 m wide by 7.4 m of height, whose purpose is to prevent the entry of garbage that could have managed to enter into the collection area.

The plant, profile, and sections of the sand remover are presented in Cartography 2148-04-CV-DW-024.

2.2.4 Conduction Facilities

2.2.4.1 Conduction Tunnel

After the sand removal, the conduction continues with a pressured system composed of a square box culvert of 2.50 m on the side, 15 m in length and longitudinal slope of 0.2 %.

After the box culvert, the pressure system continues with a tunnel of 2,651.6 m in length with a modified horseshoe section, 3.1 m diameter of excavation and with a slope of 0.7 %. The first 100 m of tunnel will have a lining in reinforced hydraulic concrete, forming an effective circular cross-section of 2.5 m in diameter (see Cartography 2148-04-CV-DW-032).

In abscissa 2415.2 m starts a stretch with a coating in reinforced hydraulic concrete, of 186 m in length, which then continues with a stretch of 50 m in length with a steel shield of 1.60 m in diameter going up to the house of valves, where the butterfly valve will be located in order to isolate the tunnel with the pressurized tubing in maintenance cases.

Before the stage of coating in reinforced hydraulic concrete, a trap of gravels of 8.0 m in length and 1.65 m deep will be built to prevent the passage of stones or pieces of rock that eventually become dislodged from the walls of the tunnel during its operation.

Depending on the rock conditions of the different sections of the tunnel, the incorporation of temporary supports as concrete, steel bolts or timbering metal will be necessary (see Cartography 2148-04-CV-DW-033).

The relief pipeline (Almenara), whose role will be to absorb the pressures generated in transitory regime because of the water hammer, as well as to ensure better conditions for the regulation of the turbines, will consist of a relief line in Reinforced Glass Polyester (GRP), which will be detached from the false tunnel on the abscissa 2,649.57 m and will have a total length of 127 m with internal diameters of 1.8 and 2.4 m.

The relief line will be buried in its entire length, at the horizontal and vertical inflection points; it will have anchors to control generated hydraulic forces and it will consist of three

characteristic stages: the first will be a pipe line of 1.8 m in diameter with an orientation almost perpendicular to the conduction tunnel and will serve as a connection between the conduction tunnel and the main oscillating pipeline, which will have a length of 25.4 m and a tilt angle of 6.8 °; the second stretch will be 37.9 m long, a diameter of 2.4 m and a tilt angle of 20.5 °; and the third section will have a length 55.4 m, a Diameter of 2.4 m and a tilt angle of 25.3 °. The second and third section will have an orientation almost parallel to the conduction tunnel. At the end of the line it has been foreseen a venting line in vertical orientation of 1 m in diameter and about 8.0m in length (see Cartography 2148-04-CV-DW-032).

2.2.4.2 Pressure pipeline

After the tunnel, the conduction continues with a pressurized tubing of Reinforced Glass Polyester (RGP), which starts in the house of valves located in the exit gate of the tunnel, it descends through the natural hillside and ends in the power house. The pipeline shall be buried in virtually all of its length, leaving exposed only its final stretch in the idem slope of the power house.

The pressure line will have a first stretch of 1.90 m internal diameter and 213.7 m in length, followed by a stretch of 394.5 m in length and 1.80 m. in diameter. In its final end, the RGP pipe will be connected to a steel line of 1.80 m. in diameter and 8.79 m. in length, after there will be the trifurcation toward the two turbines in the power house as wellas to the pressure relief valve. The three branches will have 1.20 m in diameter and those that are directed toward the turbines will be of 22.17 m and 16.63 m in length, until reaching the butterfly valve in the power house.

At the horizontal and vertical inflection points, the line will have anchors to control generated hydraulic forces. All the line alignment will be located on the small town of Los Mangos in the municipality of Cocorná. Cartography 2148-04-CV-DW-044 presents the plant and the profile of the pressurized tubing.

2.2.5 Power house

The power house will be on soil surface and it is projected on the right margin of the San Matias River, approximately 3.5 km upstream from the confluence of the San Matias River with the Cocorná River, on a small square in the elevation of 1,018.60 meters above sea level, in a point where you can obtain good founding conditions, both for the power house, as for the main equipment, and with moderate excavations for the square and the substructure. The access will be through a road about 6.5 km from the highway Medellin - Bogota, about 95 km from the city of Medellin, in the jurisdiction of the municipality of Cocorná. The discharge system of turbine water will be performed at a cargo tank to conduct it to a second development, the San Matias Hydroelectric Project, adjacent to the hydroelectric plant El Popal (under construction) or from the tank it will be disposed to a free flow channel and to lead this discharge system back to the San Matias River in a height 947.0 meters above sea level. Cartography 2148-04-CV-DW-050 shows the general plant of the power house and tank.

The scheme of the power house consists of a building with two adjacent galleries where in the first or main gallery, there are two generating units equipped with Francis type turbines of horizontal axis with their corresponding synchronous generators and intake valves,

additionally hosting a relieve valve which allows to discharge the flow rate of any of the generating units when it gets out of service for the operation of the San Matías project. The second gallery will accommodate a small workshop, the room for auxiliary services, control room and office, kitchenette and sanitary services. In Cartography 2148-04-CV-DW-051, pages 1 to 4 are shown the main features of the concrete and the distribution of the power house main equipment.

The main gallery, formed by the assemblage room and the unit's area, was set up as follows: Based on the studies of leap and flow of the project, the main equipment characteristics (see section below) and the required spaces for their installation and operation were defined. It was also defined the area for the assemblage room, being in its whole a gallery of 42.4 m long, 10.6 m wide and 14.5 m in height, measured between the level of the floor of engines and the upper level of the cover. The distance between the units axis was defined in 11 m. determined by the installation requirements of the generating units and by the circulating spaces between them, and by the distance between the second unit, the relief valve was defined in 9 m. which allows the construction of the relief valve tank.

The assemblage room area is located in one of the ends of the power house building, at the south side of the small square at 1918.80 meters above sea level. It is the site of arrival and discharge of all the top equipments of the Central and mounting location and maintenance of the equipments prior to their installation in the enclosures where they will be during the operation.

The unit's area or engines room is located next to the assemblage room in a four meters level below this at 1.014, 80 m. above sea level. In this area there are conformed the structures that will support and lashed the two sets of admission valves, turbines, generators, suction and discharge tubes. In addition there are some of the main auxiliary mechanical and electromechanical equipments and the stairs to access between floors.

Following the units area, there is the required space to install a control valve, equal to the admission valves of the units, and the relief valve, as well as the corresponding discharge pit to absorb pressure and stabilize the flow to the outlet of the valve.

On the level of the elevation 1,018.80 meters above sea level, and along the main gallery, on both side walls and covering the areas of units and the assemblage room, there are two gateways of concrete arranged to install an overhead bridge crane with a capacity of 500 KN, for the operation of the equipment.

The auxiliary gallery, adjacent to the main gallery, was configured at the same floor level of the assemblage room, in such a way that it allows the location of the areas for the workshop and warehouse; for the kitchenette and the sanitary services; for the office, and for the rooms of batteries, of panels of electrical ancillary services and control room.

The architecture of the entire plant is simple and is composed by masonry walls in adobes brick, window frames in aluminum and glass and covered in clay tile.

The discharge from each unit is made through the suction tube and a channel - tank which ensures the submergence required by the turbine. These structures delivered the waters to a cargo tank that feeds the conduction pressure of the San Matias Hydroelectric Project, which would be built downstream. Likewise, when the San Matías project is not generating partially or totally, the tank has a level control that allows to take the waters, not used, downstream, to

a discharge channel where then passes to the San Matias river in elevation of 947.0 meters above sea level, at the point of coordinates 883,034 E and 1 '160,806 N, measured at the intersection of the axis of the channel and the shore of the river.

The water supply for general services and for the anti-fire system will be done by means of storing in concrete tanks, fed from the pressure line and installed on the exterior of the power house and high enough to ensure the required pressure. The potable water for human consumption shall be in decanters, or a small water-treatment plant will be installed.

In case of an accidental spill of oil-filled transformers, each cell will be configured with a moat for the oil pickup, which is connected by a line to a separator tank of water and oil. The separator tank of water and oil will retain the entire amount of oil of a transformer by only allowing the passage of the waters that enter into it toward natural drains. The oil collected in the separator will be removed with a manual pump and will be prepared and treated according to safety and environmental standards.

Wastewater from the sanitary services and the kitchenette will be taken to a treatment system, consisting of a septic tank and an anaerobic filter.

2.2.5.1 Main Equipment

The house of machines would be equipped with two sets of generating units, which are defined on the basis of a net leap design of 238.1 m and a unitary flow of 10 m^3 /s , using statistical methods and information from other similar plants already built.

In this way, the main electromechanical equipment for each unit would be formed by:

- A butterfly admission valve of 1.2 m in diameter.
- A Francis type turbine of horizontal axis of 10.4 MW, whose rotation speed would be 900 RPM.
- A synchronous generator with a rated capacity of 11.5 MVA, with power factor of 0.90, a nominal voltage of 13.8 kV and frequency of 60 Hz.
- A three-phase transformer with a nominal capacity of 11.5 MVA, whose low voltage will be of 13.8kV and the high voltage, will be 110 kV.

In addition, for the operation of the equipment, the home of engines would be endowed with an overhead bridge crane with a capacity of 500 kN.

2.2.5.2 Auxiliary Equipment

For the cooling of the oil from the bearings of the units and the air of the generators, it has been considered the use of a water dual-circuit cooling system; one closed of treated water and one opened of raw water, which is nourished and discharged in the discharge tank; both circuits pass through a system of heat exchangers of the plate type.

To drain out the water of each unit during a maintenance and for pumping the water filtration and maintenance, it has been implemented the equipment of a system of pumps with capacities in accordance with each use.

It has been considered the use of a compressed air system for the regulators in the turbine and for general services.

The electrical auxiliary services shall be confirmed by electrical auxiliary services from each unit, general services of the central, services of continuous current connected to banks of batteries, ancillary services of support received from external sources and supportive services to control and communications systems using UPS.

The supervisory and control systems of the Central will be composed of hierarchical control systems

The protection systems will be confirmed by protective relays and auxiliary relays of the digital type.

Communications must be made through fiber optic cabling and structured cabling.

2.2.6 Discharge facilities

The discharge facilities of the project are formed by a tank of 2 m in length and 8 m wide, which receives the waters of the channel - tank (Settling tank) located in the power house, by means of a level control of 8 m in length. Back to the tank, there are plans for a ramp up of 1 m in height, and then continue with a box culvert of 163 m, which takes the water to the San Matias River in hydraulic conditions to free flow.

The box culvert is divided into five sections with slopes of 9.9 % in 15.7m in length, 28.5 % in 17.7 m, 9.4 % in 36.4m, 72.7 % in 52.9 m and 95.9 % at 40.5 m. The box culvert will be square with 1.5 m on the side and the flow regime in the same shall be super critic, with speeds between 10 m/s in the initial section (lower gradient) and 25 m/s in the final stretch (increased slope).

The box culvert will have anchor keys in its entire length, each 10 m, and on the third section will conform a viaduct of 8 m of light, which will allow a minor current to cross. In the viaduct, the box culvert will be supported by two batteries of 1.2 m in diameter with support in rock. On the final part of the discharge structure, it is expected a rock fill that will allow the support of the concrete structure in the form of ski jumping, which will expel the waters into the San Matias river (see drawing 2148-04-CV-DW-052).

2.2.7 Substation and connecting line

The electrical substation of the project will be built in the left margin of the path to the power house, on a small square of 42 m by 30 m, composed in the elevation of 1,002 Meters above sea level and located at 120 m from the power house, in simple bar configuration, with the fields of arrival for the generating units and line-out toward the connection substation. Also will be equipped with the high-voltage equipment and a control building. This substation will be property of the project.

The connection of the power house with the substation will be carried out through two circuits of 120 m in length to 110 kV, formed by four gateways, two at the output of the transformers and two at the arrival of the substation, and an intermediate tower auto supported lattice type. Guard cable OPGW will be used in this line and a steel cable 3/8, in order to use optic fiber for the communications system and shields and screened. The strip of bondage is of 10 m on each side in accordance with the requirements of security of the Technical Regulation of electrical installations (RETIE).

From the substation of El Molino, a simple circuit line of 110 kV of 2,200 m in 12 auto supported structures lattice type, comes out up to the gateway of the connection substation to the National Grid -SIN-. Just like the previous line, in this line will be used guard cable OPGW and a steel cable 3/8, in order to use optic fiber for the communications system and shields and unscreened. The strip of bondage is of 10 m on each side, in accordance with the requirements of security of the RETIE.

The connection substation to the SIN will be property of the network operator or of a designated operator by the Mining and Energy Planning Unit -UPME-, with the exception of the arrival bay of the line from the substation El Molino, which shall be the property of the project. The area required for this substation was presented in the study of environmental impact of hydroelectric project El Popal, which counts with environmental license granted by Cornare.

Cartography 2148-04-CV-DW-065, page 5, shows the location and in Cartography 2148-04-THE-DW-010 presents the general plant of substation El Molino. In Cartography 2148-04-THE-DW-021 presents the plant profile of the connecting line to the substation of connection to the SIN.

2.2.8 Access Roads

2.2.8.1 General Information

To access the Project area, there is nowadays the Medellin - Bogota highway in the vicinity of the municipality of Cocorná. The other existing roads that will be used are:

- To reach the collection area and the exit gate of the tunnel: paved road that goes from the Medellin - Bogotá highway to the municipal head of Cocorná; an unpaved road that communicates the municipalities of Cocorná and Granada (up to the center of the village El Chocó); unpaved track that communicates the village El Chocó with the village El Molino.
- To reach the area of the power house: a road previously built for the project El Popal, coming from the Medellin - Bogota highway, in the place known as La Mañosa.

In Cartography 2148-04-CV-DW-015, can be seen these tracks.

The studies and work carried out at this stage for the access roads required for the construction and subsequent operation of the project El Molino, includes the setting of the design parameters and the determination of the most important aspects, such as structures and structures along the road, storage areas and volumes.

The design of the track was based on the topography of field scale 1:1, carried out in June 2011

In accordance with the needs of access to certain areas or pathways necessary for the construction, there are three new roads proposed, which, according to its purpose, have been cataloged into the following groups:

- **Main routes:** Include some way necessary in the process of construction of the main facilities and in the operation stage of the plant, which corresponds with the access path to the power house.

- **Secondary roads:** These are the necessary roads in the process of construction of the main facilities and in the stage of operation of the plant. Correspond with the access path to the collection area, the access path to the entrance portal of the conduction tunnel and access path to the exit gate of the conduction tunnel and relief pipeline.

2.2.8.2 Design Criteria

The design criteria, presented in Table 2- 1, is focused to roads in rugged terrain, with functional specifications necessary for the construction and operation of the project. The design has been targeted to obtain the slightest movement of land as possible.

Table 2- 1: Design Criteria for the access roads

Criterion	Main Road	Secondary Pathway
Type of terrain	Rugged	Rugged
Design speed (km/h)	30	20
Class of pavement	Firm	Firm
The carriageway width (m)	4.00	4.00
Pumping	-2.0% / 2.0 %	-2.0% / 2.0 %
Minimum curve radius (m)	12.00	10.00
Type of curves	Circulars	Circulars
Maximum Slope	12%	14%
Minimal Slope	0.5%	0.5%
Minimum length of vertical curve (m)	30.00	10.00
Width concrete ditches (m)	0.60	0.60
Sectional slopes	1V:0.5 H up to 8.00 m	1V:0.5 H up to 8.00 m
Slopes in full	1V:1.5 H	1V:1.5 H

For the estimation and design of hydraulic facilities of the currents that cross the access roads, used the mapping 1:10 for the delimitation of the basins of the ravines. The flow rates are calculated using the Rational Method and rainfall-runoff models, as the case may be.

2.2.8.3 Lengths and excavation volumes

Set the horizontal and vertical alignments of roads and the typical sections and with the help of the program AutoCAD Civil 3D, were obtained the excavation volumes, full and lengths of tracks submitted in Table 2-2.

Table 2-2: Lengths, sections and filling of tracks

Track	Length (m)	Volume (m 3)	
		Sections	Full
New access road			
Access road to collection	2,620	131,505	1,995
Access road to enter the tunnel gate	120	5,170	115
Access road to relief pipeline and exit gate of tunnel	2,020	94,610	3,015
Access road to the power house	2,225	89,935	1,190
Subtotal	**6,985**	**321,220**	**6,315**
Improving existing road			
Improving existing road Cocorná - El Chocó	3,135	-	-
Improving existing road El Choco - El Molino	2,085	-	-
Subtotal	**5,220**	**-**	**-**
TOTAL	**12,205**	**321,220**	**6,315**

2.2.8.4 Description of roads in the project area

- **Track to collection** This separates from the road that connects the small towns of El Choco and El Molino, about 1.50 Kms. from the first. To access the small town of El Choco, a dirt road is used a coming from the municipal seat of Cocorná, whose length is 3.14 km.

  The new pathway, which reaches the collection area, has a length of 2.6 km and an average gradient of 8 %. The road crosses over the access gate of the conduction tunnel, then passes along to the collection and finally arrives at the sand removal in elevation of 1,264.5 meters above sea level. In Cartography 2148-04-CV-DW-063 presents its alignment. This road presents specifications of a secondary route and for its construction requires an excavation of 131,505 m^3.

- **Road access to the gate at the tunnel entrance.** This road, is presented in Cartography 2148-04-CV-DW-063, it separates from the collection road, in the abscissa 2Km +288m; and has a length of 0.12 km and presents specifications for a secondary route.

- **Path to relief pipeline and exit gate from the tunnel.** This track, which is presented in Cartography 2148-04-CV-DW-064, separates from the existing road that goes from the center of the village The Chocó to El Molino, about 1.80 Km. from the site where the road to the collection area separates. The track has a total length of 2.02 km and reaches up to the exit gate of the tunnel. The road passes through the site where the relief pipeline is located, and is located in the abscissa 1Km+480m.

  According to the characteristics of the traffic that is going to hold throughout the life spawn of the project, the specifications are of a secondary route. The road has an average gradient of 8 %.

- **Access path to the power house.** To reach the power house of the El Molino Hydroelectric Project, it will be of great advantage the roads built by the hydroelectric project El Popal. The road will be used for 3.3 km which separates from the Medellin -

Bogota highway, in the sector of La Mañosa, and that leads to the power house of project El Popal. In addition to a stretch of the road that leads from the power house of El Popal to the relief pipeline (1.0 km). The new road up to the power house has 2.2 km in length, an average gradient of 10% and according to the characteristics of the transit that will use it throughout the life of the project; it will have design specifications of a main route.

In Cartography 2148-04-CV-DW-065 it can be seen the plant and its features.

- **Improvement of existing road Cocorná - El Chocó.** Is the road that leads from the municipal seat of Cocorná until the center of the village El Chocó, and which serves as a gateway to the sites of collection, relief line and small squares of access and exit of the tunnel. It will be improved in a length of 3.1 km, building ditches and drainage facilities where it is needed, improving the surface layer and grinding curves on the road which may not have optimal radios. Cartography 2148-04-CV-DW-014 includes its alignment.
- **Improvement of existing track El Chocó - El Molino.** It is the existing road that is used to access the village El Molino coming out of the village El Chocó. This track will be used in 3.4 km, to which there will be an improvement of its surface layer where necessary. Cartography 2148-04-CV-DW-014 includes its alignment.

2.2.9 Camps, offices and workshops

For the construction of the Project, there will be camps in the area of power house, both for the contractor and for supervision.

In the collection area there will be an area for the offices, the crushing plant and warehouse of 2,5 ha. There are not programmed camps in this area due to the close proximity of this area with the urban center of Cocorná, which will facilitate the accommodation of a substantial part of the staff in homes and hotels in the municipal seat

The camps of the administrative staff and auditory for the area of power house, will occupy an area of 1.0 ha and the camp site of contractor staff must have an area of 1.5 ha, both will be located on the right margin of the Cocorná river, on the right side of the road projected by the project El Popal and that goes from the Medellin - Bogotá highway until the power house of this project. Both sites were chosen for offering adequate conditions with regard to ground slope, proximity to the fronts of work and possibilities of wastewater disposal. For offices, warehouse and workshops in the area of the power house there will be another area of 1.0 ha.

The precise location of these facilities can be found in Cartography 2148 04-CV-DW-015.

These camps will also be used by the San Matías hydroelectric project during its construction.

Table 2-3 shows the estimated staffing required for the construction of the project at the time of peak demand. It is considered that unskilled workers can be hired in the area and therefore does not require accommodation.

Table 2-3: Labor force for construction

Location	Qualified	Not Qualified	Total
Contractor Staff			
Collection	20	50	70
Tunnel	100	30	130
Power house	20	50	70
Total	**140**	**130**	**270**
Staff of the owner (Management and supervision)			
The entire project	15	10	25
Total	**15**	**10**	**25**

2.2.10 Loan areas and deposit sites for materials

2.2.10.1 Loan areas

The thick-granular and fine-granular material necessary for the construction of the facilities that make up the project will come mainly from the holdings legally established in the area and which have their licenses and mining and environmental permits up to date. In addition, there will be an advantage of using the coarse-granular material obtained in the underground excavations of the Project, which is estimated in 20,000 m³ and will be processed in two crushing plants located in the area at the end of the conducting tunnel and in the collection area; each may crush up to 6,500 cu m.

It is not scheduled to open new fronts of exploitation in the area, or perform removal of dragging material from the channels of water flows.

It is estimated a total demand of 6,000 m^3 of sand, 8,000 m³ of aggregate for concrete and 5,600 m^3 of granular base material for the roads.

2.2.10.2 Deposit materials site

The El Molino Hydroelectric Project is located in an area of slopes from medium to high average, formed by the course of the San Matias River, which means that there are few spaces available for the storage of large quantities of material.

Access to the collection of the project is done by the right bank of the San Matias River, from the village El Molino. Therefore, for the disposal of the surplus materials from the excavations in this sector, three deposits in the path of the road were placed.

For the disposition of surplus materials from the excavations from the sector of the relief pipeline and the exit gate of the tunnel, two deposits to the south of the village El Molino will be used.

On the access road to the power house, three tanks along the way were placed for the disposal of the surplus materials from the excavation of this sector.

Cartography 2148-04-CV-DW-76 gives the general location of the deposits. The following is a description of the main features of each of the deposits and its location

- **Deposit Area M1**

This deposit will be used for materials from the excavation of the access road to the exit gate of the tunnel and the conduction tunnel. It is located on the top of the hill, in the right margin of the road which leads to the village El Molino, close to 300 m from the start of the road for the collection. The storage volume is approximately 200,000 m^3. The deposit area of bare soil will be 30,000 m^2. It will be shaped with a slope of 2H:1V starting in elevation of 1,356 meters above sea level, up to the elevation of 1,428 Meters above sea level and six berms will be constructed 5.0 m each and 10 m in height.

In Cartography 2148-04-CV-DA-77, sheet 1, presents the plant and the sections of the materials reservoir M1.

- **Deposit Area M2**

This deposit will be used for materials from the excavation of the access road to the exit gate of the tunnel and the conduction tunnel. It is located south of the village El Molino and to the east of deposit M1.

The bare soil deposit area will be of 55,000 m^2 , and it will be conformed with a slope of 2H:1V, starting in the elevation of 1338 Meters above sea level until the elevation of 1418 Meters above sea level, with berms of 5.0 m each 10 m in height. According to the above, the deposit, with elongated shape, will have a maximum height of 50 m and a storage capacity of approximately 230,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 2, presents the plant and the sections of the materials reservoir M2.

- **Deposit Area M3**

This deposit is located in the abscissa 0Km+690m of the collection road, and it is focused on storing materials obtained from the excavation of this road and the materials from the bare soil.

The bare soil area will include 24,000 m^2, and will be used for compilation with a slope 2H: 1V, starting in the elevation of 1,346 meters above sea level, up to the elevation of 1,396 Meters above sea level and four berms will be constructed of 5.0 m in elevations of 1356 Meters above sea level, 1366 Meters above sea level, 1376 Meters above sea level, 1386 Meters above sea level. The filling will reach a height of 50 m and a storage capacity of approximately 235,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 3, presents the plant and the sections of the materials reservoir M3.

- **Deposit Area M4**

Deposit located in the abscissa 1Km+100m of the collection access road and will be filled with materials from the collective excavations.

The bare soil deposit area will be of 18,000 m^2 , and will be used for compilation with a slope 2H:1V, starting in the elevation of 1,292 meters above sea level, up to the elevation of 1,351 Meters above sea level and berms will be constructed of five 5.0 m every 10 meters. The volume calculated for this storage area of is approximately 120,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 4, presents the plant and the materials reservoir sections M4.

- **Deposit Area M5**

This deposit, which will be used for materials from the excavation of the tunnel, presents a strategic location because it's next to the entrance gate of the tunnel. The bare soil deposit area the will be 11,000 m^2, and will be used for the compilation of the slopes with a slope 2H: 1V, starting in the elevation of 1,272 meters above sea level, up to the elevation of 1,298 Meters above sea level and there a berm will be built of 10 m in elevation of 1290 Meters above sea level this deposit will have a height of 26 m and a storage capacity of approximately 65,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 5, presents the plant and the materials reservoir sections M5.

- **Deposit Area SM2**

Because of its size, this deposit is focused to store materials obtained from the excavation of the road and bare soil materials. It is located toward the bottom of the road of power house, close to the abscissa 0Km+400m.

The bare soil deposit area will be 6,500 m^2, and will be used for compilation with a slope 2H: 1V, starting in the elevation of 864 meters above sea level, up to the elevation of 890 meters above sea level and their two berms will be built of 5.0 m in elevations of 874 meters above sea level and 884 meters above sea level. The storage volume calculated for this storage area is approximately 23,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 6, presents the plant and materials reservoir sections SM2.

- **Deposit Area SM3**

Deposit for materials from the excavation of the adequacy in the area of power house; it is located toward the top of the road to power house, close to the abscissa 0Km+750m.

The deposit bare soil area will be of 20,000 m^2, and will be used for compilation with a slope 2H: 1V, starting in the elevation of 950 meters above sea level, up to the elevations of 990 Meters above sea level and building three berms of 5.0 m in the heights 960, 970 and 980 meters above sea level. The storage volume calculated for this storage area is approximately 100,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 7, presents the plant and the materials reservoir sections SM3.

- **Deposit Area SM4**

The zone that corresponds to this deposit is located on the way to the power house, close to the abscissa 1Km+490m. It is a deposit for materials from the excavations of this road, the adequacy of the small square at the power house and the substation.

The deposit bare soil area will be 17,000 m^2, and will be used for compilation with a slope 2H: 1V, beginning in the elevation of 918 meters above sea level, up to the elevation of 960 Meters above sea level and building three berms of 5.0 m in elevation of 930 Meters above sea level, 950 meters above sea level and 970 meters above sea level. The storage volume calculated for this storage area is approximately 85,000 m^3.

Cartography 2148-04-CV-DA-77, sheet 8, presents the plant and the materials reservoir sections SM4.

Table 2-4 summary of the main features of each deposit zone:

Table 2-4: Basic Characteristics of the reservoir zones

Deposit	Bare soil (m^3)	Capacity (m^3)
M1	9,000	200,000
M2	16,500	230,000
M3	7.2000	235,000
M4	5,400	120,000
M5	3,300	65,000
SM2	1,950	23,000
SM3	6,000	100,000
SM4	5,100	85,000
Total	**54,450**	**1,058,000**

2.2.11 Volumes of bare soil, sections and fillings.

The volumes of bare soil, sections and fillings of the project, were calculated based on the designs of each of the projected structures as shown in. Table 2-5 with this information requirements were determined the external sources of materials.

Table 2-5: Excavation and filling Volumes

Structure	Bare soil (m³)	Sections (m 3)	Fillings (m 3)
New access roads	12,600	385,000	6,950
Adequacy of existing roads	3,600	6,300	2,000
Adequacy of camps areas	4,500	-	-
Weir	-	4,890	1,000
Collection	-	5,105	475
Sand removal	-	20,860	4,620
Box culvert toward the tunnel	-	375	375
Conduction Tunnel	-	32,700	-
Gates	-	7,200	-
Relief pipeline and small square	-	1,100	-
GRP Pipe line	100	26,800	4,870
Power house	-	44,000	5,000
Discharge Channel	-	100	-
Substation	265	2,400	150
Adequacy of reservoir zones	54,450	0	0
Total	**75,515**	**536,830**	**25,440**

The excavation volumes presented in Table 2-5 , correspond to amounts in the river bank. Therefore, for mass balances were considered factors of expansion, product of volumetric changes produced during the excavation process and transport to deposit areas.

Due to the fact that only a part of the excavation material complies with the technical requirements for use as material of filling or elaboration of concrete, the rest of the necessary materials will be acquired in the quarries authorized for such purpose. The excess material will be located in the areas of deposit.

When required to collect material for the facilities, this will be covered with geotextiles, plastics or other type of material. In order to reduce the emission of particular solids, the batteries of material must be covered on a permanent basis.

2.2.12 Energy for construction

It has been estimated that the construction of underground facilities, jointly with the collection and power house facilities, will require 400 kVA for each front, which will be delivered through the extension of the existing local distribution system of 13.2 kV. In addition, there will be a backup diesel plant with a power of 300 kVA, both in collecting and house engines area.

Once the project is built, during operation, this same energy will be used to feed the different equipments, like gates, sensors, ancillary services of the power house, lighting, among others.

2.2.13 Water for construction

It is planned the construction of two independent aqueducts for the collection and power house area, where the water would be necessary both in construction and operation, in accordance with the points raised in the Environmental Management Plan of the project.

2.3 CONSTRUCTION PROCESS

For the construction of the Project El Molino the following activities are expected:

2.3.1 Construction Design and Bidding

The designs that are presented in the Cartography annexed to this study will be specified to carry them in detail of construction drawings.

With the construction detail designs of the construction, the invitation will begin the bidding for the construction of civil facilities and the equipment supply, where its specifications contain the obligations established in the Environmental Management Plan of the project.

2.3.2 Mobilization

The work will begin with the activity called mobilization, with a duration of approximately three months, and consists in arriving to the area, build the temporary holding facilities for camps, warehouse, workshops and offices, which are to be placed in the designated areas.

Offices and camps will be container type or temporary facilities will be built in wood, reinforced plastic or using other materials, in accordance with minimum requirements for an adequate comfort for personnel who work there. Likewise, the restaurants, the clinics and the tools warehouses of spare parts will be adapted.

2.3.3 Initial Adaptations

Before starting the land movements, the deposit areas will be adequate so they are prepared to receive the materials from the excavation. In addition, the work areas will be isolated by means of a wall enclosure or wire fence.

The first land movements will be in the access to the main work areas: collection, exit gate and power house. Subsequently, the areas of small squares plaza, both in the collection site as in the power house and tunnel gate will conformed.

It is envisaged that the exterior work is carried out with conventional equipment of land movement, such as bulldozers, backhoes, double swap dump trucks, pneumatic drills, bilge pumps.

It is likely to be required to do some controlled blasting for rock excavation. Before its execution, all traffic will be suspended and any pedestrian around will be safeguarded in the risky area.

2.3.4 Land movements

One of the major activities in the work areas of the Project will be the excavations of the facilities, which will be implemented with heavy equipment constructed for that purpose.

Minor excavations and the profiled end for the facilities foundation, will be implemented with manual procedures.

All the digging is done primarily with backhoes, which will deposit the material into the dump trucks, which will transport it to the deposit zones; in addition pneumatic drills will be used for blasting rocks. The draining of the concrete will require bilge pumps, concrete pumps, tools for manufacture and carts for the transportation of concrete between the production plant and the facilities.

The fillings will be performed with bare soil previously taken from the terrain and by placing layers of selected material that will be compacted in accordance with the geotechnical recommendations.

The slopes of sections will be covered with decorative green designs and those with greater height of 5.0 m or where the materials are quite susceptible to erosion, there will be protective covers or other techniques which will be implemented to revegetalize the field. There will also be rounds of coronation and ditches of concrete in roads and squares plazas.

2.3.5 Construction of access roads

The access roads will be located in the field, making the flat surfaces of demarcation, which will serve to delimit the area where the excavation will take place. After the processes of conventional excavation, the base material to the tread will be irrigated. The drainage facilities such as piping, pontoons, box culverts, filters, and protection slopes with covering material and ditches will complement the work to ensure the stability of the structure and minimize environmental impacts.

2.3.6 Construction of the substation

The square local with the substation will be conformed to backhoes which will deposit the material in dump trucks, to then be transported to deposit areas. For the draining of the concrete tools are required pre-formed structures and cars to transport the concrete between the production plant and the facilities.

2.3.7 Tunnels excavation

It is expected that the tunnels dug with the conventional procedure of blasting and lingers, which consists of drilling holes of up to 3.0 m approximately on the front of the tunnel using pneumatic excavators, installing the explosives to make the controlled blasting, remove material, place temporary supports in case they could be required and begin a new cycle with new drilling.

These tasks require that the tunnel has installed equipment and ventilation ducts to remove the fumes of from blasting and renewal of the air, auxiliary equipment such as air compressors for pneumatic equipment for drilling, water pumps and pipes for drainage of the infiltration waters. It is also required the installation of electrical equipment for lighting. The Contractor must ensure a minimum oxygen content of 19% in all fronts. The output of the air duct must be maintained at no less than 10 m of each advanced front.

The blasting materials shall be removed through dump trucks and will be brought to reservoir areas or to the grinding plant, depending on the quality of the material.

During the excavation an adequate drainage of the tunnel will be maintained. In the case of the excavated tunnel by the entry gate it will be required the construction of niches to collect the infiltration waters, in the event that this happens, it will be placed drainage pumps through the tube lines attached to the wall this will take the waters up to the surface.

For the excavated tunnel by the exit gate a provisional ditch will be adapted to evacuate the waters going to the exit.

Subsequently the coatings will be built in hydraulic concrete that are established in accordance with what was found in the excavations, and finally, the armor plating will be installed in the required area.

In the gates of the tunnel there will be a settler which will have a built-in grease trap. Subsequently, the water will be driven toward the rain collectors and then driven to a site in the creek number six, in the coordinates 882,204 E and 1,160,688 N. Sludge and sands and the oils deposited will be disposed in accordance with the requirements of the project Environmental Management Plan for these types of items.

2.3.8 Construction and assembly of the pressurized tubing and relief

Initially the banking of the line will be adequate, by means of procedures and conventional excavation equipment already mentioned. Then the anchors and fillings are constructed, according to the requirements of the design.

Finally the pressure line is installed in accordance with plans, and emptied, if required, the secondary concrete anchors and minor forms or the fillings in the tranches with buried pipe.

2.3.9 Construction of the weir and collection

The derivation of the design flow will be carried out through the construction of a concrete weir of 4.0 m in height and 39.0 m long located on the San Matias river bed. Its top side is curved which increases the efficiency of the discharge and just to the output it has a ski-jump ramp, which allows to dissipate the energy of the flow to an appropriate discharge.

The management of the waters of the San Matias River during the construction of the derivation and the collection, shall be carried out by means of a cofferdam conformed by alluvial material. Initially it will be located to the middle of the flow to the right margin, while the collection and the discharge channel site are being built; at least 10 m off the weir of adjacent derivation and the radial gates are installed. Once facilities mentioned are built , shall proceed to relocate the cofferdam, so that the flow of the river flow by the collection, proceeding then to build the weir of remaining derivation and the walls of the left buttress.

The levels of the Foundation shall be determined in the final designs, however, in the work site, it will necessary to adjust them to the soil materials that are found.

Cartography 2148-04-CV-DW-022 and 2148-04-CV-DW-023 present the plant and sections of the weir and collection.

2.3.10 Construction of the power house

After the access road is built, the adequacy of the area where the power house will be located will take place, for which the equipment mentioned above as bulldozer, backhoe, and dump

trucks will be used. It is possible that dynamite use may be required to perform some blasting in areas with healthy rocks or moderately fractured.

Then the filters and drainage systems will be built and will begin the casting of the concrete, using a small mixtures dosing plant. The concrete will be mobilized to the draining sites through a Turre - crane, which will also be the transport means of iron, aggregates and other construction materials.

For mounting the equipment such as turbine and generator, we will use a bridge crane that for this purpose will be installed in the power house. It will also be used a smaller crane, mounted on a monorail installed in one of the beams of the bridge crane, for the assembly of smaller equipment.

2.3.11 Equipment requirements

2.3.11.1 Concrete machines

The concrete machines will be of two bags each, with useful mixing capacity of 255 l, they will be located in the collection area, tunnel access gate and power house. Its technical specifications are presented in Table 2-6 .

Table 2-6: Technical specifications of the concrete machines

Three internal-bladed System
Chassis made of structural steel and motor carrier in foil caliber 18 and door to prevent accidents at work
Break type pedal system to operate the steering wheel with both hands to achieve greater efficiency and safety
Rotational speed of the drum 33 RPM
Equipped with a diesel engine, brand KAMA of 6.1 HP at 1800 RPM

2.3.11.2 Grinding plant

Two grinding plants will be located, one in the collection area and the other in the area at the end of the conduction tunnel. Each plant will consist of two crushers, one primary and one secondary. The primary, whose technical specifications are presented in Table 2-7 , shall consist of a hopper for receiving materials and a jaw grinder that works in stones and rocks.

Table 2-7: Technical specifications of primary grinding plant

1. Bar vibratory feeder size 46" X 16 '. Specifications: • VGF Type ("VIBRATING GRIZZLY FEEDER") Brand TRIO • For heavy duty usage (HEAVY DUTY) • Engine of 25 HP, pulleys and bands in V
2. Jaw Crusher Brand TRIO • Size 24" X 36" for stone up to 19 ", for heavy duty usage • Engine of 100 HP, 440 V, 3 phase with its pulleys and bands in V • Mounted on two axis chassis, with exit conveyor, below the primary crusher, hopper feed.
3. Conveyor 24" wide x 70' long with charging stations of three rollers to 35 degrees, with the following specifications: • Engine of 10 HP, Dodge reducer type • Two ply conveyor • Rolls of the charging stations of 4" • Motor pulley with rubber cover • Pulley of queue, type spider with blocks type "adjustable" or take up (3 final products and output of the power bars)
4. Conveyor 36" wide x 70' long with charging stations of three rollers at 35 degrees and rolls of impact of rubber, with the following specifications: • Engine of 10 HP, Dodge reducer type • Three ply conveyor • Rolls of the charging stations of 4" • Motor pulley with rubber cover • Pulley of queue, type spider with blocks type "adjustable" or take up (sieve and return to primary)
5. Soft Starter SIEMENS for engine of 100 HP for use in primary crusher

After passing through the primary crusher, aggregates will go through the conveyors to the secondary plant, which is composed of a sieve or vibratory sieve and a cone.

The vibratory sieve, which specifications are presented in Table 2-8 , is used in order to classify and filter the material that has already been crushed.

Table 2-8: Technical specifications of chaffer sieve or screen

Chaffer Sorter Trio of 3 floors of 6' X 20'
Size 6' x 20' 3 floors
Bearings for heavy duty
Electric Motor 40HP
Security Guards
Power supply box in steel anti-wear type AR-400
Lips of download of 6" in each floor
Conveyor for fines under the sieve of 42" wide with engine of 10 HP, 1800 RPM, TEFC. Guards and safety accessories. Rolls of 5" diameter CEMA C. motor pulley with rubber cover to improve traction. Will discharge to one side of the plant.
Conveyor under the shredder of cone of 36" in width with engine of 10 HP, 1800 RPM. Guards and safety accessories. Rolls of 5" diameter CEMA C. motor pulley with rubber cover to improve traction. Downloaded by the rear of the plant.

Finally, the aggregates after being classified passed to a cone of crushing that adapts to grind various types of rocks. Its technical specifications are presented in Table 2-9 .

Table 2-9: Technical specifications of the grinding cone

MRA Symons cone 4' STD
Electric motor of 200 HP, 1200 RPM
Allow a more efficient operation
Decreases the heat generation, which eliminates the use of chillers
Allows you to work at low temperatures for a longer period of time and with much less friction

The areas of benefit for the crushing plants will be 3,000 m^2 for the collection area and 2,500 m^2 for the area at the end of the conduction tunnel.

2.4 BUDGET AND PROJECT SCHEDULE

2.4.1 Construction Schedule

According tto the characteristics of the project, it is estimated that the construction will be carried out in 31 months, by entering the first unit to the system in month 29 and the second in the 31 month. The duration of the activities was estimated based on yields of similar work undertaken or currently under construction, taking into account the interrelationship that the activities have among themselves. In Figure 2-1 it is presented the construction schedule of the project.

PROYECTO HIDROELÉCTRICO EL MOLINO
CRONOGRAMA DE CONSTRUCCIÓN

Id	Task Name	Duración	Comienzo	Fin
1	**PROYECTO HIDROELÉCTRICO EL MOLINO**	**661 d**	**lun 01/01/01**	**mar 15/07/03**
2	**ORDEN DE INICIO**	0 d	lun 01/01/01	lun 01/01/01
3	**GESTIÓN AMBIENTAL**	910 dt	lun 01/01/01	lun 30/06/03
4	**MOVILIZACIÓN E INSTALACIÓN**	89 dt	lun 01/01/01	sáb 31/03/01
5	**ADQUISICIÓN DE PREDIOS**	180 dt	lun 01/01/01	sáb 30/06/01
6	**VÍAS DE ACCESO**	**194 d**	**jue 01/02/01**	**mié 31/10/01**
7	Captación	272 dt	jue 01/02/01	mié 31/10/01
8	Portal de salida del túnel	211 dt	jue 01/02/01	vie 31/08/01
9	Casa de máquinas	241 dt	jue 01/02/01	dom 30/09/01
10	**ENERGÍA PARA CONSTRUCCIÓN**	**108 d**	**lun 01/01/01**	**jue 31/05/01**
11	Energía para construcción	150 dt	lun 01/01/01	jue 31/05/01
12	**AZUD Y OBRAS DE CAPTACIÓN**	**469 d**	**mar 01/05/01**	**sáb 15/02/03**
13	Excavación de la plazoleta	91 dt	mar 01/05/01	mar 31/07/01
14	Primera etapa azud	182 dt	vie 01/06/01	vie 30/11/01
15	Segunda etapa azud	180 dt	mar 01/01/02	dom 30/06/02
16	Captación	364 dt	dom 01/07/01	dom 30/06/02
17	Desarenador	365 dt	mar 31/07/01	mié 31/07/02
18	Box culvert	92 dt	vie 15/11/02	sáb 15/02/03
19	**Equipos captación**	**469 d**	**mar 01/05/01**	**sáb 15/02/03**
34	**TÚNEL Y TUBERÍA DE CONDUCCIÓN**	**521 d**	**lun 16/04/01**	**mar 15/04/03**
35	**Excavaciones**	**370 d**	**lun 16/04/01**	**dom 15/09/02**
36	Portan entrada	61 dt	dom 01/07/01	vie 31/08/01
37	Excavación túnel desde portal de entrada	380 dt	vie 31/08/01	dom 15/09/02
38	Plazoleta y portal de salida	90 dt	lun 16/04/01	dom 15/07/01
39	Excavación túnel desde portal de salida	427 dt	dom 15/07/01	dom 15/09/02
40	**Concretos**	**109 d**	**dom 16/06/02**	**vie 15/11/02**
41	Concretos túnel desde portal de entrada	122 dt	mar 16/07/02	vie 15/11/02
42	Concretos túnel desde portal de salida	121 dt	dom 16/06/02	mar 15/10/02
43	**Inyeciones, Revestimiento y blindaje**	**109 d**	**mar 15/10/02**	**sáb 15/03/03**
44	Inyecciones	92 dt	mar 15/10/02	mié 15/01/03
45	Revestimiento en concreto	60 dt	sáb 16/11/02	mié 15/01/03
46	Blindaje	59 dt	mié 15/01/03	sáb 15/03/03
47	**Almenara y tubería**	**108 d**	**mié 16/10/02**	**sáb 15/03/03**
48	Almenara	90 dt	dom 15/12/02	sáb 15/03/03
49	Tubería superficial	150 dt	mié 16/10/02	sáb 15/03/03
50	**Llenado conducción**	31 dt	sáb 15/03/03	mar 15/04/03
51	**CASA DE MÁQUINAS**	**490 d**	**dom 01/04/01**	**sáb 15/02/03**
52	Excavación de la plazoleta	90 dt	dom 01/04/01	sáb 30/06/01
53	Excavación subestructura y fundación	91 dt	vie 01/06/01	vie 31/08/01
54	Concretos primarios subestructura	91 dt	mié 01/08/01	mié 31/10/01
55	Concretos superestructura	91 dt	lun 01/10/01	lun 31/12/01
56	Concretos secundarios subestructura	273 dt	lun 31/12/01	lun 30/09/02
57	Mamposteria	182 dt	lun 31/12/01	lun 01/07/02
58	Acabados	275 dt	jue 16/05/02	sáb 15/02/03
59	Obras de descarga	180 dt	vie 31/08/01	mié 27/02/02
60	**EQUIPOS ELECTROMECÁNICOS**	**627 d**	**vie 16/02/01**	**mar 15/07/03**
61	**Puente grua**	**240 d**	**lun 16/04/01**	**sáb 16/03/02**
62	Fabricación y transporte	275 dt	lun 16/04/01	mié 16/01/02
63	Motaje y pruebas	59 dt	mié 16/01/02	sáb 16/03/02
64	**Turbinas, válvulas, reguladores, otros**	**521 d**	**vie 16/02/01**	**sáb 15/02/03**
65	Fabricación y transporte	545 dt	vie 16/02/01	jue 15/08/02
66	Turbina No. 1	244 dt	sáb 16/03/02	vie 15/11/02
67	Turbina No. 2	244 dt	dom 16/06/02	sáb 15/02/03
68	**Equipos auxiliares mecánicos**	**325 d**	**dom 16/12/01**	**dom 16/03/03**
69	Fabricación y transporte	274 dt	dom 16/12/01	lun 16/09/02
70	Motaje y pruebas	181 dt	lun 16/09/02	dom 16/03/03
71	**Generadores**	**458 d**	**mié 16/05/01**	**sáb 15/02/03**
72	Fabricación y transporte	457 dt	mié 16/05/01	vie 16/08/02
73	Montaje generador No. 1	183 dt	jue 16/05/02	vie 15/11/02
74	Montaje generador No. 2	183 dt	vie 16/08/02	sáb 15/02/03
75	**Transformadores**	**369 d**	**mar 16/10/01**	**dom 16/03/03**
76	Fabricación y transporte	365 dt	mar 16/10/01	mié 16/10/02
77	Motaje y pruebas	151 dt	mié 16/10/02	dom 16/03/03
78	**Equipos eléctricos auxiliares**	**260 d**	**sáb 16/03/02**	**dom 16/03/03**
79	Fabricación y transporte	183 dt	sáb 16/03/02	dom 15/09/02
80	Motaje y pruebas	182 dt	dom 15/09/02	dom 16/03/03
81	**Equipos de control, comunicación y protección**	**240 d**	**lun 15/04/02**	**dom 16/03/03**
82	Fabricación y transporte	184 dt	lun 15/04/02	mié 16/10/02
83	Motaje y pruebas	151 dt	mié 16/10/02	dom 16/03/03
84	**Subestación El Molino**	**239 d**	**mar 16/04/02**	**dom 16/03/03**
85	Fabricación y transporte	183 dt	mar 16/04/02	mié 16/10/02
86	Motaje y pruebas	151 dt	mié 16/10/02	dom 16/03/03
87	**Línea 110 kV subestación El Molino - subestación de conexión**	**239 d**	**mar 16/04/02**	**dom 16/03/03**
88	Fabricación y transporte	183 dt	mar 16/04/02	mié 16/10/02
89	Motaje y pruebas	151 dt	mié 16/10/02	dom 16/03/03
90	**Equipos subestación de conexión**	**195 d**	**dom 16/06/02**	**dom 16/03/03**
91	Fabricación y transporte	153 dt	dom 16/06/02	sáb 16/11/02
92	Motaje y pruebas	120 dt	sáb 16/11/02	dom 16/03/03
93	**Pruebas finales**	**86 d**	**dom 16/03/03**	**mar 15/07/03**
94	Pruebas unidad No. 1	60 dt	dom 16/03/03	jue 15/05/03
95	Operación comercial unidad No. 1	0 d	jue 15/05/03	jue 15/05/03
96	Pruebas unidad No. 2	61 dt	jue 15/05/03	mar 15/07/03
97	Operación comercial unidad No. 2	0 d	mar 15/07/03	mar 15/07/03

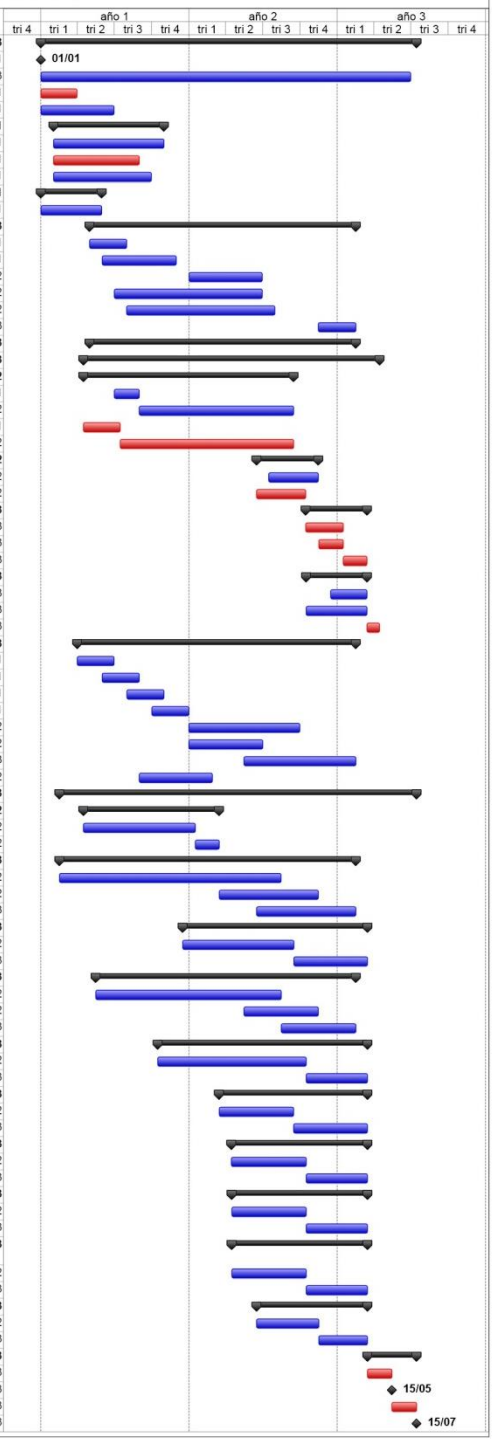

Figure 2-1: Construction schedule

2.4.2 Project Budget

- **Work Quantities**

The quantity of the facilities and the main equipments were calculated on the basis of designs of the project, taking minor items in a comprehensive manner as a percentage of the major items that are part of it.

Unit prices were taken from the information that HMV has for similar projects that are currently under construction or recently inaugurated, updated with the IPP.

- **Budget of the Project**

The total project cost is estimated at US$ 51,527,773, distributed for each of the items, such as shown in Table 2-10 .

Table 2-10: Costs of the Project

Item	Cost (USD)
Previous studies (identification, pre-engineering and environmental licenses)	560,966
Lands and easements	348,315
Environmental Management Plan	2,529,536
Investment of 1% (Law 99/1993 - Article 43)	294,984
Civil Facilities	29,150,056
Electromechanical equipment	15,727,250
Engineering, supervision and Management	2,916,666
TOTAL	**51,527,773**

The cost of the project for the investment of 1% in the basin, in accordance with Law 99 of 1993 and its regulatory Decree 1900 of 2006 is US$ 294,984, which corresponds to the investment in land acquisition, creation of easements, civil facilities and acquisition and rental of machinery and equipment used in the civilian workforce.

2.5 OPERATION AND MAINTENANCE OF THE HYDROELECTRIC

2.5.1 Operation

The operation of the hydroelectric plant El Molino, as part of a wholesale energy market established in Colombia, and connected to a national transmission system (STN), that must comply with certain technical type conditions imposed by the national dispatch center (CND) and the Committee on Energy and Gas Regulation (CREG), as stipulated in Law 143 of 1994.

In addition to these external conditions, Plant operation is performed in accordance to the conditions of existing hydrology in the area. During the winter, it seeks to have the maximum generation, i.e. 21 MW and in summer times, the control of the generation will be performed manually or automatically, where the generation level varies according to the flow rates available. This operational set point reflects the social and environmental commitment to ensure the ecological flow, during all the time on the plants part.

For this purpose, the plant will have an engineer in charge (who will make periodic visits), two operators in eight-hour shifts and whose primary function is to monitor and operate all the

electromechanical equipment associated with this. Also, there will be three auxiliary operation (bocatomeros), who will follow the instructions of the shift operator with respect to cleaning the screens cleansers and sand removal tanks, in addition to the opening and closing of the gates.

In addition there will be two guards on each shift, in the houses of engine and collection areas for various services and monitoring.

2.5.2 Maintenance

The maintenance to be carried out in the plant is characterized by the search for tasks that allow removing or minimizing the occurrence of failures, and in turn reducing the consequences of the same, considering all the risky factors. The maintenance seeks to ensure the service of the central continuously, taking advantage of the water resources efficiently.

The types of maintenance that are performed in the plants are preventive and corrective. Preventive maintenance seeks, through regular inspections, determine when to change or rebuild equipment or any part of this in relation to its current state, while the corrective maintenance consists in the restitution of the equipment to an optimal operating state, after the occurrence of a failure.

All maintenance activities will be coordinated with the chief of operation and maintenance and will be scheduled in due course. These activities will be provided with the total availability of the staff working in the central.

Maintenance will be taken place every six months in a preventive manner, although inspections are carried out daily, weekly and monthly to the electromechanical equipment, following the recommendations established by the manufacturers.

2.5.3 Description of the technical characteristics of the operation

2.5.3.1 Camps, offices, warehouses and workshops required during operation

The stage of operation requires a booth with capacity for one person and a constructed area of 16.0 m^2, which will be located in the site of water intake and sand removal On the other hand, the power house, will host the staff responsible for this building.

For the management of domestic liquid waste from the power house, there will be a septic tank (see Figure 2-2 and Figure 2-3), that will discharge their waters subsequently to the San Matias River. The handling of domestic solid waste shall comply with the established in the Management Plan for this study.

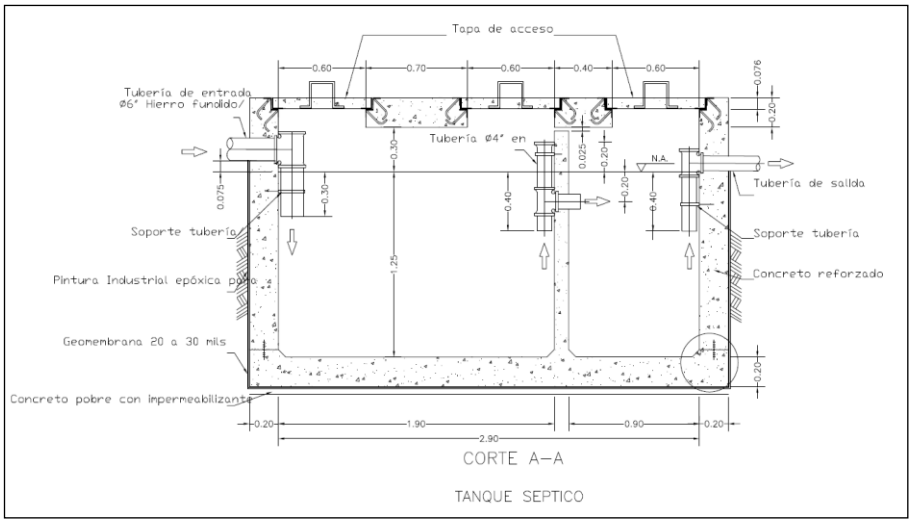

Figure 2-2: Septic tank section

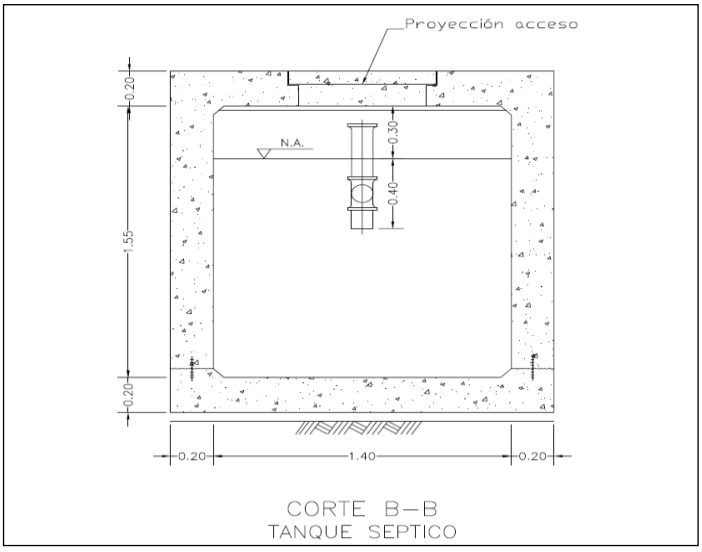

Figure 2-3: Septic tank section

The warehouse and workshop are to be placed in the site on the left margin of the way to the power house, in the abscissa 1Km+550m and have an approximate area of 450 m^2. The workshop will have a site for the collection of oils, greases, batteries, and perimeter channels for spill control. The liquids wastes that are gathered in the perimeter channels will be stored temporarily and subsequently delivered to an authorized operator.

2.5.3.2 Ecological instream flow

Before capturing the waters for the generation, it is necessary to ensure the passage of ecological flow or instream flow (CGA), by means of the work described in section2.2.2.1

Given that the CGA is proposed as a flow which varies month to month, some regulatory and measure elements have been prepared which will allow the compliance of the CGA defined each month. For this it has been arranged that the flow that comes out of the hole provided for that purpose, continue toward a shock absorber tank, to a rectangular type dam which will enable to measure the flow rate to be handed over to the river. The rectangular dump has a length of 1.50 m and a height of discharge of 1.0 m. The flow through the orifice will be regulated by a gate of equal dimensions, which will allow the making adjustments every month.

For the correct determination of the opening, has been prepared after the hole a rectangular thin crest canal, a level sensor and scope for direct reading. The drain canal was chosen for this type of element and is widely recognized for the measurement of flow rates, being its use very extensive in hydraulic laboratories where the precise measures of flow rates is required. The calibration of the drain canal is presented in Figure 2-4.

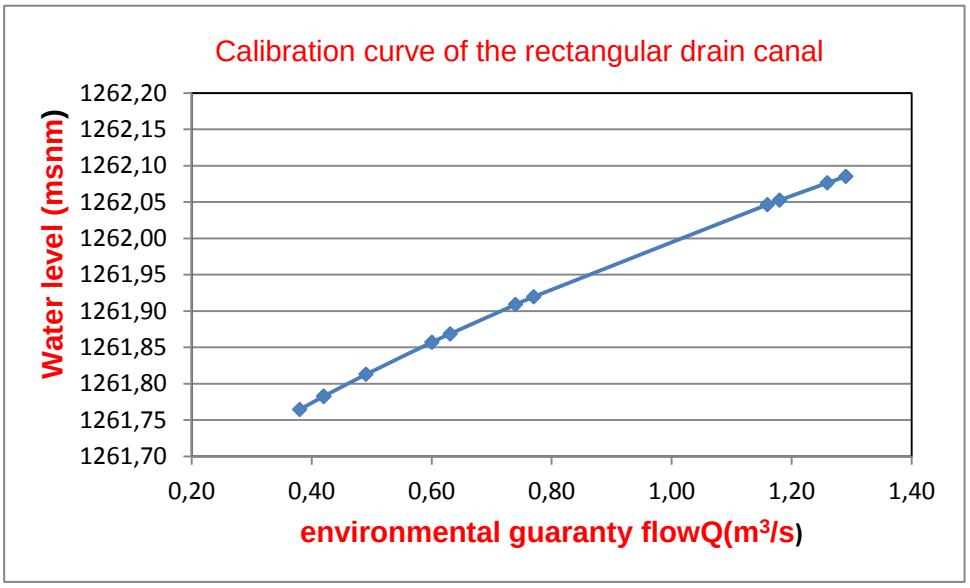

Figure 2-4: Calibration curve of rectangular drain canal

It can be seen that the necessary height to the level which gives the maximum flow rate which is 1.29 m^3 /s is 0.60 m, and the drained canal has a discharge height of 1.00 m, i.e. adequate facilities for approved flows.

As it has been already said the tank will have a sensor level and a scope or rule that allows monitoring the levels and adjusting the flow rate delivered into the river at the same time. There will be a biannual report of levels and flows, which will serve the Corporation to facilitate verification. Table 2-11 shows, for each month, the instream flow proposed and the required level in the rectangular drain canal for each one of these flows.

Table 2-11: Environmental instream flow required levels in the rectangular drain canal month by month

Month	Flow (m^3/s)	Water levels (msnm)
January	0.60	1261.86
February	0.49	1261.81
March	0.77	1261.92
April	1.16	1262.05
May	0.74	1261.91
June	0.63	1261.87
July	0.38	1261.76
August	0.42	1261.78
September	0.42	1261.78
October	1.29	1262.09
November	1.26	1262.08
December	1.18	1262.05

The plant and section facilities of CGA are presented in Cartography 214804CVDW023.

2.5.3.3 Water collection

The flow design that will be taken from San Matias River for the project will be 10 m^3/s, which is necessary for the generation. As it has been mentioned, there will be some days of the year in which the flow captured will be less than this value in order to ensure that the Instream flow elapses downstream of the collection point.

The generation system will be controlled through sensors arranged in the collection and in the sand removal, which will record the levels of operation and will determine the correspondence between the flow provided by the river and the turbinated flow rates. The level variations will be monitored by the control system, allowing adjusting the turbine flow according to the contributions of the river, and at the same time maintaining the levels in the estimated ranges for the operation. If the flow captured exceeds the design flow of the generation system, the excess water will be discharged again to the river by the rectangular drain canal.

These regulators are part of the control system of the turbines, and the operator, typically, does not exercise different functions than that of monitoring.

2.5.3.4 Power Generation

During its operation, the hydroelectric plant will produce a continuous conversion of hydraulic energy into mechanical energy in the turbine, and mechanical energy into electrical energy in the generator.

The process of generation of energy occurs in what is known as turbo generator group, which consists of a turbine and an electric generator coupled by the same shaft; this turbo generator group is located in the power house.

In this case, the turbine is Francis type of horizontal axis (turbine of reaction, centripetal mixed flow, total and radial intake), which has three basic elements which are the distributor

(directs and regulates the water toward the impeller), diffuser (fluid outlet, it has the shape of suction tube) and the impeller (composed of mobile vanes).

The turbine receives the water flow at high pressure toward its vanes through the charge line and takes advantage of the kinetic and potential energy of the water to produce a rotation movement that, transferred through a shaft, directly moves the generator, which in turn transforms the mechanical energy into electrical energy.

The generator, for its part, consists of the rotor (rotating part) and the stator (static part), which produces a magnetic field passing through the rotor coils, conformed by windings of copper wires, which are connected among themselves, and of which finally is generated electrical energy, which has as basic parameters of output voltage and a electric current as a function of time, which will be delivered to the electrical substation of the project. This last function is to raise the voltage output of the generator, in order to reduce the amount of current generated; however, the energy will remain approximately at the same amount. This process is performed with the objective to be able to transmit the energy over long distances.

2.5.3.5 Water Discharge to the San Matias River

The turbine waters emanating from the power house of the El Molino Hydroelectric Project will be delivered to a Settling tank, which, under normal conditions, carries the water to the San Matias Hydroelectric Project.

During the scheduled and unscheduled stops of the generating units, will operate a relief valve which allows the discharge of the flow of these units toward the tank standpipes, to ensure the permanent flow toward the San Matias project. In times that are not turbine in the San Matias project, the turbine waters by the project El Molino will be delivered to the San Matias River by means of the discharge channel.

The discharge canal is located to the side of the power house, whose path has been arranged to pour the waters of the river with the slowest speed possible, through the implementation of structures of power dissipation, achieving an average speed of 1.5 m/s. This will prevent the undermining hole at the banks and in the river bed, product of the energy and speed accumulated by the gap between the power house and the river at the point of discharge.

The sediment load of this water is expected to be minimal because these will be retained in the sand remover; in addition the industrial use in the generation of energy does not add pollution to the water.

2.5.3.6 Water for operation

It is planned the construction of two independent aqueducts for the collection area and the power house area, where the water would be necessary both in construction and operation, as proposed in the Environmental Management Plan.

2.5.3.7 Maintenance of access roads

The maintenance of access roads during the operational phase ensures the proper transport of the operational staff and materials and equipment for the maintenance of the system or an eventual repair in case of damage.

For this there will be unskilled workers to repair and make periodic cleaning of drainage ditches.

The material that is removed as a result of these activities, as well as any landslides in the slopes of the access roads during the operation may be delivered to third parties for their final disposition, as set out in the Management Plan.

2.5.3.8 Inspection and maintenance of the inner lining of the conduction tunnel and the relief pipeline

This activity consists in carrying out the control of the instrumentation data to measure the turbidity of water, control of flow both at the exit and at the entrance of the tunnel, and other activities performed to establish a visual inspection of the condition of the coatings, through equipment of television cameras from remote control. In case of major problems, staff must enter to carry out a detailed visual inspection, identifying the affected tranches of the inner lining, to plan subsequently the maintenance and repair work, and carry out tests on the pressure, taking readings of pressure and flow at the entrance and exit of the conduction.

2.5.3.9 Check the status of the collection structure

This operational activity is to check the general condition of the structure of collection, the weir up and down waters, the walls of channeling and containment of the adjacent slopes, the state of the framework and metal bars of the grids and their anchoring devices, verification of the state of the control gates and washing the material deposited in the channel of adduction and carry out the work for cleaning the grate, and adduction channel.

2.5.3.10 Check the status of the sand remover and its items for sludge cleaning

This activity is to make a verification of the structural state of the system to discharge the excess, compartments for storage of sludge, system of continuous discharge of sludge, gates to control the entry for each of the modules and inspection manholes. There will also be cleaning work on each of the compartments and elements that make up the structure.

2.5.3.11 Verification of the status of the wheelhouse valves and control valve

This activity is essentially to periodically check the general condition of the house of valve (structural aspect and of finishes). In regard to the valve, we will verify its mechanism for mechanical and remote control opening and closing. It is important to verify its permanent sealing to detect and repair any possibility of leakage in the system.

2.5.3.12 Checking the status of the power house

There will be technical and visual verification of the general condition of the power house, including its structural aspect, state of the anchorages and support points on the equipment and electrical systems, hydraulic systems and drains, among others.

2.5.3.13 Check the measurement status of control systems, electrical systems, lighting and refrigeration

This activity consists in the review remote or manual, carried out by the plant chief with the help of the operation and maintenance staff, the values supplied in panels and systems of measurement and control and detected by the Programming Logic Control (PLC) of the

computerized system of the plant. Will be confirmed at the site, possible leaks of the fluids of the primary system and the operating mechanisms of the whole turbo generator, complementary and auxiliary devices, among others.

2.5.3.14 Check the status of the turbo generator equipment in the power house

Will be taken into account mainly the operational and maintenance recommendations given by the manufacturers of the turbo generator, following a maintenance log. In accordance with the number of hours of service per year, you must check with the instruments of measurement and control the vibrations, operating temperature, operating status of the auxiliary equipment, of protection systems in case of surges, emergency and line break, and its subsequent racing or on speed.

2.5.3.15 Verification of the electrical substation

For the proper functioning of the electrical transmission and distribution system and, we will verify the general condition of the electrical substation in visual form, checking the control devices to measure and detect anomalies produced in the system, in response to the recommendations of the manufacturers of the equipment. When damages occur caused by line breaks and voltage surges or ray strikes in the system, the electrical engineers will carry out work of visual verification, and maintenance.

2.5.3.16 Verification of the structural state of the discharge channel and protection facilities in the river margin.

It will be checked periodically the good condition of the discharge channel and the protection facilities in the margin of the San Matias River, since their operating conditions can be affected by the stability of the masses of surrounding soil to the structure and quality of the materials of the foundations.

2.5.3.17 Clean-up activities of sediments and drag material in the collection structures

This activity is to make the discharge and cleaning of the sediment and solid material deposited drag in the face of the weir upstream, in the collection grid and in the sand remover

Sediments that accumulate upstream of the collection weir are passed by a structure or clean channel with radial gates, which eventually will be opened, depending on the amount of sediment accumulated.

In the collection, after the entry holes, there will be a system of bars for the cleaning of the wastes that may enter the conduction. The material obtained from the cleaning will be temporarily stored and will be subsequently handed over to third parties for their disposal, as set out in the Management Plan.

The sand removal will retain the fine sands that may enter the system. For the cleaning of the material deposited in each chamber, the sand remover will have two drainage channels in the bottom, located in a perpendicular orientation to the chambers, which are connected to a venting channel to the river. These activities will be undertaken on a regular basis, as well as during minor water risings or after important water risings of the river in the rainy season.

2.5.3.18 Labor force required

For the commercial operation phase it is estimated the creation of about 14 jobs for the operational work. It is considered that an important part of these positions can be covered by staff from the area.

2.5.3.19 Annual cost of operation

Administration, operating and maintenance costs have been estimated at USD 700,000 per year in accordance with the experience for similar projects.