HMV INGENIEROS

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SERVICIOS AMBIENTALES Y GEOGRÁFICOS S.A

SAN MATIAS HYDROELECTRIC PROJECT

ENVIRONMENTAL IMPACT STUDY

VOLUME I OF VI

CHAPTER 2

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2.1 LOCATION

The San Matías Hydroelectric Project (formerly known as El Molino II) is located in the middle of the department of Antioquia, about 95 km from the city of Medellin, in the jurisdiction of the municipalities of Cocorná and Granada, on the Vereda (Political and administrative division of the municipality located in the rural area) Los Mangos y la Inmaculada of the first municipality; and on the Vereda (Political and administrative division of the municipality located in the rural area) La Arenosa and Las Faldas of Granada. Cartography 2148-12-CV-DW-010 presents the general location of the project.

2.2 TECHNICAL DESCRIPTION OF THE PROJECT

The hydroelectric project San Matías is located immediately after El Molino hydroelectric project (formerly known as El Molino I); both are part of a chain system on the San Matias River.

The San Matías Hydroelectric Project will supply from the turbined waters of the El Molino hydroelectric project, which captures a percentage of the San Matias River flow for electric power generation.

At the exit of the power house of the El Molino hydroelectric project will be located a tank that will serve two functions, the first is settle down the turbined water to bring it to the discharge channel of the central El Molino in the event that the central San Matías is not in operation (tank of settlement) and the second function is to supply the project San Matias, as you can see in Cartography 2148-12-CV-DW-020.

El Molino and San Matias Hydroelectric Projects will have a capacity of 21 MW, for a design flow of 10 m^3 /s and a net leap of 239.2 m. The conduction facilities are approximately 3.4 km in total length.

In general terms, the project consists of: Settlement tank, a box culvert, a conduction tunnel, a relief pipeline, a house of valves, the pressure pipe line, power house and finally a discharge channel to deliver turbined water to the San Matias River, elements that are described in more detail later. The general outline of the facilities can be seen in Cartography 2148-12-CV-DW-011.

2.2.1 Collection Facilities

The settlement tank ensures the level of submergence of the turbines in the El Molino hydroelectric project; it will also be the cargo tank of the San Matias hydroelectric project. This tank is 31.7 m in length, 8.0 m in width, a normal level of water in the altitude 1,016.8 MASL and at ground level the dimension 1,011.3 MASL, while the walls of the tank are provided for up to the altitude 1,018.2 MASL (see Cartography 2148-12-CV-DW-20).

The settlement tank is conditioned to receive the turbined water of el Molino hydroelectric project (10 m^3 /s) by either the passage of the water through the turbines, or by opening the relief valve located in the power house of the project El Molino, which will operate when the generation units in the project El Molino are not working. When the project San Matias does not operate and the project El Molino is operating, the waters will be delivered to the discharge channel of project El Molino. The tank will be located at coordinates 882,957 1,160,679 E and N.

In one of the edges of the tank, there is a descending ramp with a slope 2 H:1V, in order to move from altitude 1011.3 MASL to the altitude 1010.7 meters in 1.2 m in length, and in this way ensure a level of submergence to prevent the development of vortex at the entrance to the pressure system.

2.2.2 Conduction Facilities

2.2.2.1 Conduction Tunnel

Conduction starts at one end of the settlement tank by means of a square box culvert of 3.9 m on the side, 15.8 m in length and longitudinal slope of 0.8 %. The box culvert or conduction gallery crosses perpendicularly to the width of the power house of the project El Molino, passing under the montage room.

The last two meters of the box culvert are conformed by a transition of 2.0m in length, passing through a square section of 3.9m on the side to a modified horseshoe section 3.1 m of excavation diameter . The tunnel will be 2,249.6 m in length with a slope of 0.8 %. The first 100 m of tunnel will have reinforced hydraulic concrete, forming an effective circular cross-section of 2.5 m in diameter (see Cartography 2148-12-CV-DW-021).

In the Abscissa 2,020 m starts a coating section in reinforced hydraulic concrete of 180 m in length, which then continues with a stretch of 50 m in length, with a steel shield of 1.60 m in diameter up to the house of valves, where will host the butterfly valve to isolate the tunnel with the pressurized tubing in cases of maintenance.

Before the section with 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 in the different sections of the tunnel, it will be necessary the incorporation of temporary supports as launched concrete, steel bolts or timbering metal (see Cartography 2148-12-CV-DW-022).

The relief pipeline, whose role will be to absorb the pressure spikes generated in the transitory regime because the impact of the water hammer, as well as to ensure better conditions for regulation of the turbines, this will consist of a relief line in Glass Reinforced Polyester (GRP), which will release from the false tunnel on the abscissa 2,248.58 m and will have a total length of 150 m with internal diameters of 1.8 and 2.2 m.

The relief pipeline will be buried in its entire length, at the inflection points of horizontal and vertical anchors will have to control the hydraulic forces that are generated and will consist of three characteristic stages: the first will be a line of 1.8 m in diameter with perpendicular orientation to the conduction tunnel and that will serve as a connection between the conduction tunnel and the main oscillation line, it will be horizontal and 10.6 m in length; the second section also will serve as a connection between the conduction tunnel and the main line of oscillation with a length of 29.7 m, a diameter of 1.8 m and a tilt angle of 15.6°; and the third section, which An orientation almost parallel to the conduction tunnel, will be 102.0 m long, a diameter of 2.2 m and a tilt angle of 15.6 °. At the end of the line it is foreseen an ventilation pipe line in a vertical orientation of 1 m in diameter and about 8.0m in length (see Cartography 2148-12-CV-DW-021).

2.2.2.2 Pressure Pipe Line:

After the tunnel, the conduction continuous with a pressurized tubing of Glass Reinforced Polyester (GRP) of 1,131.6 m in length, that starts in the exit portal of the conduction tunnel and descends down the natural hillside toward the power house. The pipe shall be buried almost all the trail and will have a first tranche of 1.90 m of internal diameter and 865.2 m in length, followed by a stretch of 266.4 m in length and 1.80 m in diameter.

The first 125 m of pipe length shall be buried on a natural topographic nose, until it reaches the cut slope of the plaza in the exit portal of the conduction tunnel of the Popal Hydroelectric Project, area where the piping will be above ground. From there, the alignment is once again buried and parallel to the pressure line alignment of the mentioned project. In the final stretch, both alignments are separated toward the orientation of their respective power house.

In the end, the GRP pipe will be connected with a steel line of 1.80 m in diameter and 10.0 m in length, at the end of which will be the bifurcation toward the two turbines in the power house. Each branch of the bifurcation will be 1.20 m in diameter and 21.9 m and 20.3 m in length, until it reaches each butterfly valve.

In the breaks of horizontal and vertical alignment, the pipe will have anchors for controlling hydraulic forces that are generated there. All the alignment of the pipe line will be located on the Vereda La Inmaculada in the municipality of Cocorná. Cartography 2148-12-CV-DW-023 presents the plant and the profile of the pressure pipe.

2.2.3 Power house

The power house will be above ground and is planned for an mountain area, formed at the confluence of the San Matias River with the river Cocorná, on a small plaza of dimensions 768.00 MASL, at a point where it can be obtained good founding conditions, both for the power house as for the main equipment, and with moderate excavations for the square plaza and the substructure. The building of the power house was defined as a continuation of the power house of the Popal Hydroelectric Project, currently under construction. The entrance will be on a road about 3.3km from the highway call Medellin - Bogota, about 95 km from the city of Medellin, in the jurisdiction of the municipality of Cocorná. The discharge system of turbined water will be performed at a free flow channel, and to lead the water back to the San Matias River in an altitude 752.0 MASL. Cartography 2148-12-CV-DW-040 shows the general plant of the power house and the channel.

The schematic of the power house is composed of a building with two adjacent galleries, where in the first one or main, will hosts two generating units equipped with Francis type turbines of horizontal axis 10.5 MW each, with their corresponding synchronous generators and intake valves. In the second gallery will accommodate the auxiliary services room, control room and office, kitchen and health services. In Cartography 2148-12-CV-DW-041, sheets 1-3, is showed the main characteristics of the concrete and the distribution of the main equipment of the power house.

The main gallery for the units area is adjacent to the montage room of the Popal Hydroelectric Project, to take advantage of this same area. The configuration was made as follows: Based on the studies of leap and own flow of the project , it was determined the characteristics of the main equipment (see section below) and the spaces required for its installation and operation, and has been defined a gallery of 24.4 m long, 12.5 m wide and 13.4 m in height, measured between the level of the floor of machines and the top level of the cover. The distance between the units axis was defined in 11 m, determined by the installation requirements of the joint turbine-generator and the movement spaces between them.

As already indicated, the area of the montage room is the same as in Popal Hydroelectric Project and is located in one of the building ends of the power house, in the south-east side on the altitude 768.20 MASL. It is the landing site and unloading of all the main equipment of the Central, place of assembly and maintenance of the equipment before their installation in the enclosures that will accommodate them during the operation.

The units area or machine room is located next to the montage room, in a level three meters below this, on the altitude 765.25 MASL. In it conforms the structures that support and anchor the two sets of admission valves, turbines, generators, suction and discharge pipes. In addition, there are some of the main mechanical and electromechanical auxiliary equipment and access stairs between the floors.

On the level of the altitude 765.25 MASL and along the main gallery, on both side walls and covering the units areas, are arranged two separate porches of concrete to install an overhead bridge crane with a capacity of 500 kN, for the equipment operation.

The auxiliary gallery, adjacent to the main gallery, was configured to the same floor level of the montage room, in such way that it allows the location of the kitchen area, health services, for the office and for the batteries rooms, panels of auxiliary electrical services and control room.

The architecture of the entire plant is simple and is composed by masonry walls in brick, windows in aluminum and glass and tile cover on the roof.

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 deliver the waters to a discharge channel, where they later go to the San Matias River in an altitude of 752.0 MASL, at the coordinates 885,088 E and 1,159,736 N, measured at the intersection axis of the channel and the river bank.

The water supply for general service and the anti-fire system will be done through a storage in concrete tanks, fed from the pressure line and installed on the exterior of the power house and placed high enough to ensure the required pressure. The potable water for human consumption shall be delivered in large plastic containers, or a small water-treatment plant could be installed.

In the case of an accidental oil spill from the transformers, each cell will be configured with a drainage for the oil pickup, which is connected by a pipe line to a water and oil separator tank. The water and oil separator tank will contain the entire oil amount of a transformer, allowing only the passage of waters that enter in 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 health services and the kitchen will be taken to a treatment system, consisting of a septic tank and an anaerobic filter.

2.2.3.1 Main Equipment

The power house will be equipped with two sets of generating units, which are defined on the basis on a design of 240.0 m and a unitary flow of 10 m^3/s by using statistical methods and information from other similar plants that are already built.

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

- A butterfly intake valve of 1.2meters in diameter.
- A Francis type turbine with a horizontal axis of 10.5 MW, with a rotation speed of 900 RPM.
- A synchronous generator with a rated capacity of 11.5 MVA, with a 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 voltage will be 13.8kV and the high voltage will be 110 kV.

In addition, for the operation of the equipment, the power house would be staffed with an overhead crane with a capacity of 500 kN.

2.2.3.2 Auxiliary Equipment

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

To drain out the water of each unit during maintenance and for pumping the water filtration system has been laid down 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 auxiliary electrical services shall be made up of, its own auxiliary services for each unit, general services of the Central and services of continuous current connected to banks of batteries, auxiliary services of support received from external sources and supportive services of control and communications using UPS systems.

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

The protection systems will be shaped by digital type protective relays and auxiliary relays.

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

2.2.4 Facilities of discharge

The turbined water will be delivered to the San Matias River in the site with coordinates and 885,088 and 1,159,736 N, and in the altitude 752.0 MASL. Initially the waters shall be conducted by two box culvert of 15.6 m and 5.7 m in length and 2.8 m in width and 2 m in height, one per unit with slope of 0.2 %. Downstream of the connection point between the two box culvert, the water will be driven by a box culvert square of 1.8 m on the side and the slope of the 1 %, in a length of 268.8 m, with operation to free flow and supercritical regime.

The next stage will be an open channel of 11.8 m with a slope of 0.4 %, where it is anticipated the formation of a hydraulic jump, and the establishment of a sub critical flow regime in the structure before the discharge, which consists of a transition to an open channel of 5 m in width, a descendant ramp 4.0 m, a settlement pool of 5.0 m and a structure of power dissipation of 30.4m, with a gradient of 50% and for the base is provided a series of concrete blocks for the dissipation of energy (see Cartography 2148-12-CV-DW-042).

2.2.5 Connection to the grid

The project will connect to the new substation Cocorná through two aerial circuits to 110 kV of 80 m in length, to be derived from the transformers. This connection substation at SIN is located in the vicinity of the power house and will be owned by the network operator or one designated by the Mining and Energy Planning Unit -UPME-, with the exception of the bays arrival lines, 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 The Popal, which accounts with environmental license granted by CORNARE.

2.2.6 Access Roads

To access the Project area, there is now a Highway Medellin - Bogota in the vicinity of the Cocorná municipality .

To reach the entrance area to the conduction tunnel, taking into account that the water intake for the energy generation from the central San Matias corresponds to turbined water of the project El Molino, and the portal of entry of the conduction tunnel will be used the road projected by the El Molino hydroelectric project, which goes toward the power house.

To reach the area of the power house will be used the roadway previously built for the project Popal, coming from the Highway Medellin - Bogota, in the place known as la Mañosa.

In Cartography 2148-08-CV-DW-01 these roads can be seen

The project will only require the construction of 610 m of road toward the exit portal of the conduction tunnel, which will depart from the exit portal of the conduction tunnel of the project El Popal, with an average gradient of 11 %. According to the traffic characteristics that is going to endure throughout the life of the project, the specifications are of secondary route.

The studies and facilities carried out for this road include the fixing of design parameters and the determination of the most important aspects, such as structures along the road, storage areas and volumes.

The design of the road was based on the field topography scale 1:1 , prepared in June 2011.

The road is presented in Cartography 2148-12-CV-DW-051.

2.2.6.1 Design Criteria

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

Table 2-1 Design Criteria for the access roads 2-13

Criteria	Secondary Road
Type of terrain	**Rugged**
Design speed (km/h)	**20**
Class of pavement	**Stated**
The Road width (m)	**4.00**
Pumping	**-2,0% / 2,0%**
Minimum curve radius (m)	**10.00**
Type of curves	**Circulars**
Maximum Slope	**14%**
Minimal Slope	**0.5%**
Minimum length of vertical curve (m)	**10.00**
Width concrete ditches (m)	**0.60**
Slopes in idem	**1V:0.5 H up to 8.00 m**
Slopes in full	**1V:1.5 H**

For the estimation and design of hydraulic facilities of currents that cross the road was used in a mapping scale of 1:10 for the delimitation of the basins of the creeks. The flow rates were determined using the rational method and rainfall-runoff models as the case may be.

2.2.6.2 Lengths and volumes of excavation

Set the horizontal and vertical alignments of roads and the typical sections, and with the help of the software Autocad Civil 3D, were obtained the excavation volumes, filling and lengths of roads submitted Table 2-2.

Table 2-2 Lengths, cuts and filling of tracks

New road	Length (m)	Volume (m^3)	
		Short	Full
Road to exit portal of tunnel	610	15,610	520
Subtotal	**610**	**15,610**	**520**
Total	**610**	**15,610**	**520**

2.2.7 Camps

For the construction of the project will be used the camps built by El molino hydroelectric project, both for the contractor and for supervising, which are enough to accommodate and attend the staff linked to the construction of both projects, in accordance with the magnitude of the facilities to develop and with the recent experience on the number of people required for the construction of similar projects.

The camps are located on the right bank of the river Cocorná, on the right side of the projected road by the project El Popal and going from the Highway Medellin - Bogotá until the projects power house. For offices, warehouse and workshops in the power house area there will be another area of 0.2 ha.

The precise location of these facilities can be found in the Cartography 2148-12-CV-DW-012.

Table 2-3 presents the estimated staff required for the project construction at the time of peak demand. It is considered that unskilled workers can be local to the area and therefore does not require accommodation.

Table 2-3 Labor for construction

Location	Qualified	Not Qualified	Total
Contractor Staff			
Tunnel	100	30	**130**
Power house	15	30	**45**
Total	**115**	**60**	**175**
Staff of the owner (Management and supervising)			
The entire project	10	5	**15**
Total	**10**	**5**	**15**

2.2.8 Areas of loan and sites for material deposit

2.2.8.1 Areas of loan

The thick and fine granular material necessary for the construction of the project, will come mainly from the holdings legally established in the area and must have their mining permits and environmental licenses up to date. In addition, the granular - material obtained in the underground excavations of the project, which is estimated at 10,000 m^3 will be processed in one grinding plant located at the end of the conduction tunnel.

It is estimated a total demand of 5,500 m^3 of sand and 7,000 m^3 of aggregate.

2.2.8.2 Materials Deposit Sites

The San Matías hydroelectric project is located in an area of slopes of mid to high average, there are few spaces available for the storage of large quantities of material.

By the terms and conditions of the project, the leftover materials from the excavations will be stored in a single deposit, located in the road to the tunnel exit portal.

Below is a description of the location and the main characteristics of the material deposit SM1:

- **Deposit area sm1**

This deposit is located in the middle of the hill, on the left margin of the road that leads to the tunnel exit portal, 500 meters from where it follows the road to the Power house. The storage volume is approximately 158,000 m^3 . The deposit bare soil area will be 30,000 $m^{2.}$ It will shape the slopes with a inclination of 2H:1V starting in the altitude 882 MASL, up to the altitude 912 MASL and will be built two berms of 5.0 m each and 10 m in height.

In Cartography 2148-12-CV-DW-023 presents the central plant and the material deposit sections.

2.2.9 Bare soil Volumes, cuts and filling

The bare soil volumes, cuts and filling of the project were calculated based on the designs of each of the planned structures, as shown in Table 2-4. With this information was determined the requirements for external sources of materials.

Table 2-4 Volumes of excavation and filling

Structure	Bare soil	Cut		Filling
		Soil	Rock	
Power house	648	10,700	1,300	600
Conduction Tunnel	0	2,919	16,542	0
Relief pipeline	216	5,772	0	1,071
Entry Portal	0	8,000	2,000	0
Exit Portal	450	4,665	1,162	0
Discharge Channel	405	7,041	0	4,381
Access Roads	1,833	16,367	1,561	520
Pressure Pipe Line:	2,038	49,502	0	9,181
DEPOSIT AREAS	7,800	0	0	0
Subtotal	13,390	104,968	22,565	15,752
Unforeseen	1,339	10,497	2,256	1,575
Total	14,729	115,464	24,821	17,327
Total expanded	**18,411**	**144,330**	**37,232**	**17,327**

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

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

When it is required to collect material for the facilities, this will be covered with geo textiles, plastics or another type of material. In order to reduce the emission of particulate solids, the piles of material must be covered on a permanent basis.

2.2.10 Energy for Construction

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

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

2.2.11 Water for Construction

It is planned to use during the construction and operation of the project the aqueducts located in the power house areas of the projects El Molino and El Popal, the first for the area of collection and the second for the machines area.

2.3 CONSTRUCTION PROCESS

For the construction of Project San Matias is expected the following activities:

2.3.1 Design and bidding of construction

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

With the designs of construction detail, will be the bidding for the construction of civil facilities and the supply of equipment, whose specifications contain the obligations laid down in the project Environmental Management Plan.

2.3.2 Mobilization

The work will begin with the activity called mobilization, whose duration is estimated at approximately three months, and consists to 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 the minimum requirements for an adequate comfort of workers. Likewise, food stores will be adequate, the warehouses of tools and spare parts.

2.3.3 Initial Adjustments

Before the beginning of land movements, areas for the deposits should be prepared in order to be ready to receive materials from the excavation. In addition, the work areas shall be isolated through a enclosure fence or barbed wire fence.

The first land movements will be in the access to the main work areas: entrance portal of the conduction tunnel, exit portal and power house. Subsequently the small plaza square will be built , in both the power house site and in the tunnel portal.

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

It is likely to be required the controlled blasting for rock excavation. Before its execution, all traffic will be suspended and any pedestrian in the risk area will be place in a safe.

2.3.4 Land Movements

One of the major activities in the work areas of the project will be the excavations which will be implemented with heavy equipment constructed for that purpose. Minor excavations and the profiled end for the foundation of the facilities, will be carried out with manual procedures.

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

The fillings will be done by the bare soil of the field and by placing layers of selected material that will be compacted in accordance with the geotechnical recommendations.

The cut slopes will be lawn-covered and those with a greater height of 5.0 m or where the materials are susceptible to erosion will be placed a covering membrane or other techniques will be implemented for the revegetation of the field. Also there will be constructed 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 field, setting the chamfers of demarcation, which will serve to delimit the area where the excavation will take place. After the processes of conventional excavation, the base material will be spread to the tread. The drainage facilities such as piping, pontoons, box culverts, filters, and protection of slopes with covering membrane and ditches will be the complement the work to ensure the stability of the structure and minimize environmental impacts.

2.3.6 Excavation of tunnels

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

For these works it is required that the tunnel has installed equipment and ventilation ducts to remove the fumes of the blasting and renew the air, auxiliary equipment such as air compressors for pneumatic equipment for drilling, water pumps and pipes for drainage of the infiltration waters. It also requires the installation of electrical equipment for the lighting. The Contractor shall ensure a minimum oxygen content of 19% on all fronts. The output of the air duct must be maintained at no less than 10 m of advance front.

The blasting material shall be removed by dump trucks will be brought to deposit areas or to the grinding plant, depending on the quality of the material.

During the excavation it will maintain an adequate drainage of the tunnel. In the case of the tunnel excavated by the portal of entry, it will be necessary to build niches to collect the infiltration waters, in the event that these are submitted, and place drainage pumps that will carry waters up to the surface. For the tunnel excavated by the exit portal or construction windows, which will adapt a provisional ditch to evacuate the waters until the output.

In the portals of the tunnel there will be a settler, with an incorporated grease trap. Subsequently, the water will be driven toward the rain collectors and then driven to a point in creek number one in the coordinates and 884,036 and 1,159,119 N. Sludge and sands deposited and the resulting oils shall be disposed in accordance with the requirements of the project Environmental Management Plan for these type of elements.

2.3.7 Construction and assembly of the pressure and relief pipe line

Initially the bench for the pipe line will be constructed, through procedures and conventional excavation equipment already mentioned. Then the anchors and filling are constructed according to the design requirements.

Finally it will be installed the pressure or relief pipe line in accordance with the Cartography, and poured, if required the secondary concrete anchors or the fillings in the tranches with buried pipe line.

2.3.8 Collection Construction

The adduction starts in the settling tank located after the power house of the project El Molino. The purpose of this structure is to regulate the amount of water that the turbines need the for power generation and establish the required hydraulic submergence for the entrance to the conduction tunnel of the Hydroelectric Project San Matias. This tank will be built by El Molino hydroelectric project, during the construction of the power house of this project.

2.3.9 Construction of power house

The adequacy of the area where the power house will be built, using the equipment mentioned above as bulldozer, backhoe, and dump trucks. It is possible the use of dynamite to perform some blasting in areas with good rock or moderately fractured.

Then filters and drainage systems will be installed and will begin the casts of the concrete, using a small dosing mixture plant. The concrete will be mobilized to the sites of draining through a tower crane, which also will be the means of transport of irons, aggregates and other construction materials.

For mounting the equipment such as turbine and generator, will be used 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.

2.3.10 Equipment Requirements

2.3.10.1 Cement Mixers

For the construction of the El Molino hydroelectric project, the cement mixers of two bags each, with a useful mixing capacity of 255 l, and it will be placed in the collection area, portal of the access tunnel and power house. Its technical specifications are presented in Table 2-5.

Table 2-5 Technical specifications of the cement mixer

Three-bladed Internal System
Chassis made of structural steel and motor carrier in foil and 18 caliber gouge door l to prevent accidents at work
Pedal type brake 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

2.3.10.2 Grinder

They will be placed two grinding plants, one in the area of entrance to the conduction tunnel and in one at exit area of the tunnel. Each floor will consist of two grinders, a primary and secondary one. The primary, whose technical specifications are presented in Table 2-6, will be composed of a hopper for receiving materials and a jaw crusher that works on stones and rocks.

After passing through the primary grinder, 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, whose specifications are presented in

Table 2-7, is used in order to sort and filter the material that has already been crushed.

Finally, the aggregates after being classified, go to a grinding cone that adapts to grind various types of rocks. Its technical specifications are presented in Table 2-8.

The areas of benefit for the grinding plants will be 3,000 m^2 for the entrance area of the conduction tunnel and 2,500 m^2 in the exit area of the tunnel.

2.4 BUDGETS AND PROJECT SCHEDULE

2.4.1 Construction Schedule

In accordance with the characteristics of the project, it is estimated that the construction will be done in 28 months, by entering the first unit to the system in the 26th month, and the second in the 28th month. The duration of the activities was estimated based on yields of similar undertaken work or are currently under construction, taking into account the interrelationship that the activities have among themselves. Figure 2-1 shows the construction schedule for the project.

Table 2-6 Technical specifications of primary grinder plant

1. Vibratory Bar 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 chassis of two axis, with output conveyor, below the primary crusher, feed hopper
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 • Conveyor two ply • Rolls of the charging stations in 4" • Motor Pulley with rubber cover • Pulley of queue, type spider pillow blocks with 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 to 35 degrees and rolls of impact of rubber, with the following specifications: • Engine of 10 HP, Dodge reducer type • Three-ply conveyor belt • Rolls of the charging stations in 4" • Motor Pulley with rubber cover • Pulley of queue, type spider pillow blocks with type "adjustable" or take up (sieve and return to primary)
5. Soft Starter SIEMENS for engine of 100 HP for use in primary crusher

Table 2-7 Technical specifications of sieve

Chaffer Sorter Trio of 3 floors of 6' X 20'
Size 6' x 20' 3 floors
For heavy duty bearings
Electric Motor 40HP
Security Guards
Power supply box in steel anti-wear type AR-400
Discharge lips of 6" in each floor
Conveyor for fine sieve under 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. Discharged 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. Discharged by the rear of the plant.

Table 2-8 Technical specifications of the grinding cone

MRA Symons cone 4' STD
Electric motor for 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

PROYECTO HIDROELÉCTRICO SAN MATÍAS
CRONOGRAMA DE CONSTRUCCIÓN

Id	Task Name	Duración	Comienzo	Fin	Predecesoras
1	**PROYECTO HIDROELECTRICO SAN MATIAS**	**607 d**	**lun 01/01/01**	**mié 30/04/03**	
2	**ORDEN DE INICIO**	0 d	lun 01/01/01	lun 01/01/01	
3	**GESTIÓN AMBIENTAL**	819 dt	lun 01/01/01	lun 31/03/03	2
4	**MOVILIZACIÓN E INSTALACIÓN**	89 dt	lun 01/01/01	sáb 31/03/01	2
5	**ADQUISICION DE PREDIOS**	180 dt	lun 01/01/01	sáb 30/06/01	4CC
6	**VIAS DE ACCESO**	**85 d**	**jue 01/02/01**	**jue 31/05/01**	
7	Portal de salida del túnel	119 dt	jue 01/02/01	jue 31/05/01	4CC+31 dt
8	**ENERGÍA PARA CONSTRUCCIÓN**	**65 d**	**lun 01/01/01**	**sáb 31/03/01**	
9	Energía para construcción	89 dt	lun 01/01/01	sáb 31/03/01	2
10	**OBRAS DE CAPTACIÓN**	**151 d**	**sáb 16/03/02**	**mar 15/10/02**	
11	Captación	120 dt	lun 17/06/02	mar 15/10/02	27FF
12	**Equipos captación**	**151 d**	**sáb 16/03/02**	**mar 15/10/02**	
13	Fabricación y transporte compuerta captación	153 dt	sáb 16/03/02	vie 16/08/02	14CF
14	Montaje compuerta capatción	60 dt	vie 16/08/02	mar 15/10/02	27FF
15	**TÚNEL Y TUBERÍA DE CONDUCCIÓN**	**521 d**	**jue 01/02/01**	**vie 31/01/03**	
16	**Excavaciones**	**312 d**	**jue 01/02/01**	**lun 15/04/02**	
17	Portan entrada	58 dt	jue 01/02/01	sáb 31/03/01	4CC+31 dt
18	Excavación túnel desde portal de entrada	380 dt	sáb 31/03/01	lun 15/04/02	17
19	Plazoleta y portal de salida	91 dt	jue 01/03/01	jue 31/05/01	7CC+28 dt
20	Excavación túnel desde portal de salida	319 dt	jue 31/05/01	lun 15/04/02	19
21	**Concretos**	**110 d**	**lun 14/01/02**	**sáb 15/06/02**	
22	Concretos túnel desde portal de entrada	122 dt	mié 13/02/02	sáb 15/06/02	18FF+61 dt
23	Concretos túnel desde portal de salida	121 dt	lun 14/01/02	mié 15/05/02	20FF+30 dt
24	**Inyeciones, Revestimiento y blindaje**	**109 d**	**mié 15/05/02**	**mar 15/10/02**	
25	Inyecciones	92 dt	mié 15/05/02	jue 15/08/02	23
26	Revestimiento en concreto	60 dt	dom 16/06/02	jue 15/08/02	25CC+32 dt
27	Blindaje	61 dt	jue 15/08/02	mar 15/10/02	25;26
28	**Almenara y tuberia**	**108 d**	**jue 16/05/02**	**mar 15/10/02**	
29	Almenara	91 dt	mar 16/07/02	mar 15/10/02	27FF
30	Tubería superficial	152 dt	jue 16/05/02	mar 15/10/02	27FF
31	**Llenado conducción**	31 dt	mar 31/12/02	vie 31/01/03	27;48
32	**CASA DE MÁQUINAS**	**498 d**	**jue 01/02/01**	**mar 31/12/02**	
33	Excavación de la plazoleta	58 dt	jue 01/02/01	sáb 31/03/01	4CC+31 dt
34	Excavación subestructura y fundación	91 dt	jue 01/03/01	jue 31/05/01	33CC+28 dt
35	Concretos primarios subestructura	91 dt	mar 01/05/01	mar 31/07/01	34CC+61 dt
36	Concretos superestructura	91 dt	dom 01/07/01	dom 30/09/01	35CC+61 dt
37	Concretos secundarios subestructura	273 dt	dom 30/09/01	dom 30/06/02	36
38	Mampostería	182 dt	dom 30/09/01	dom 31/03/02	36
39	Acabados	274 dt	lun 01/04/02	mar 31/12/02	55FF
40	Obras de descarga	273 dt	jue 31/05/01	jue 28/02/02	34
41	**EQUIPOS ELECTROMECÁNICOS**	**607 d**	**lun 01/01/01**	**mié 30/04/03**	
42	**Puente grua**	**241 d**	**jue 01/03/01**	**vie 01/02/02**	
43	Fabricación y transporte	275 dt	jue 01/03/01	sáb 01/12/01	2;44CF
44	Motaje y pruebas	62 dt	sáb 01/12/01	vie 01/02/02	36;47CF
45	**Turbinas, válvulas, reguladores, otros**	**521 d**	**lun 01/01/01**	**mar 31/12/02**	
46	Fabricación y transporte	545 dt	lun 01/01/01	dom 30/06/02	2CC
47	Turbina No. 1	241 dt	vie 01/02/02	lun 30/09/02	46FC-149 dt
48	Turbina No. 2	244 dt	mié 01/05/02	mar 31/12/02	47CC+89 dt
49	**Equipos auxiliares mecánicos**	**327 d**	**lun 01/10/01**	**mié 01/01/03**	
50	Fabricación y transporte	273 dt	lun 01/10/01	lun 01/07/02	51CF
51	Motaje y pruebas	184 dt	lun 01/07/02	mié 01/01/03	69CF
52	**Generadores**	**456 d**	**dom 01/04/01**	**mar 31/12/02**	
53	Fabricación y transporte	456 dt	dom 01/04/01	lun 01/07/02	55CF
54	Montaje generador No. 1	182 dt	lun 01/04/02	lun 30/09/02	47FF
55	Montaje generador No. 2	183 dt	lun 01/07/02	mar 31/12/02	48FF
56	**Transformadores**	**370 d**	**mié 01/08/01**	**mié 01/01/03**	
57	Fabricación y transporte	365 dt	mié 01/08/01	jue 01/08/02	58CF
58	Motaje y pruebas	153 dt	jue 01/08/02	mié 01/01/03	69CF
59	**Equipos eléctricos auxiliares**	**261 d**	**mar 01/01/02**	**mié 01/01/03**	
60	Fabricación y transporte	181 dt	mar 01/01/02	lun 01/07/02	61CF
61	Motaje y pruebas	184 dt	lun 01/07/02	mié 01/01/03	69CF
62	**Equipos de control, comunicación y protección**	**236 d**	**vie 01/02/02**	**mié 01/01/03**	
63	Fabricación y transporte	181 dt	vie 01/02/02	jue 01/08/02	64CF
64	Motaje y pruebas	153 dt	jue 01/08/02	mié 01/01/03	69CF
65	**Equipos subestación de conexión**	**197 d**	**lun 01/04/02**	**mié 01/01/03**	
66	Fabricación y transporte	153 dt	lun 01/04/02	dom 01/09/02	67CF
67	Motaje y pruebas	122 dt	dom 01/09/02	mié 01/01/03	69CF
68	**Pruebas finales**	**85 d**	**mié 01/01/03**	**mié 30/04/03**	
69	Pruebas unidad No. 1	58 dt	mié 01/01/03	vie 28/02/03	31FC-30 dt;54
70	Operación comercial unidad No. 1	0 d	vie 28/02/03	vie 28/02/03	69
71	Pruebas unidad No. 2	61 dt	vie 28/02/03	mié 30/04/03	69;55
72	Operación comercial unidad No. 2	0 d	mié 30/04/03	mié 30/04/03	71

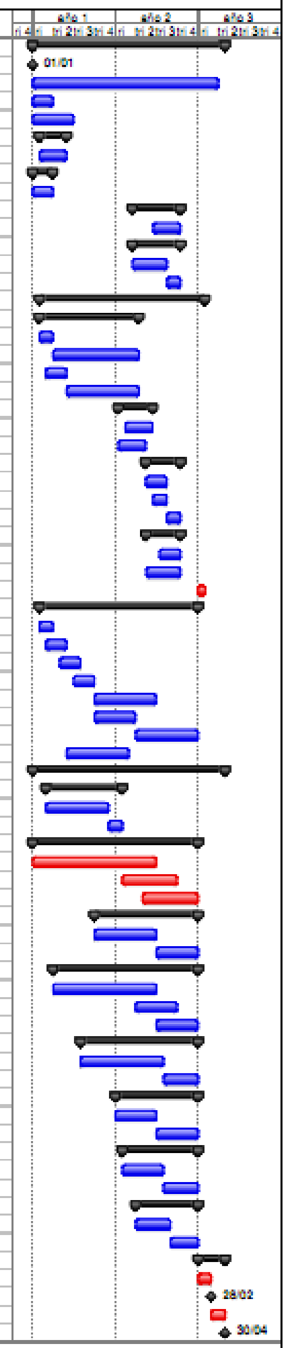

Figure 2-1 Construction Schedule

2.4.2 Budget of the Project

- **Quantities of the facilities**

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

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.

- **Project Budget**

The total project cost is estimated at **USD 36,425,203** , distributed to each of the items as presented in Table 2-9.

Table 2-9 Costs of the Project

Item	Cost (USD)
Previous studies (identification, pre-engineering course and environmental licenses)	404,942
Lands and easements	314,607
Archaeological Management Plan	1,724,150
Investment of 1% (Law 99/1993 - Article 43)	185,208
Civil Facilities;	18,206,228
Electromechanical equipment	14,189,098
Engineering, supervising and Management	1,400,969
Total	**36,425,203**

The cost of the project for the investment of 1% in the basin, in accordance with the Law 99 of 1993 and its regulatory Decree 1900 of 2006 is US$ 185,208, which corresponds to the investment in land acquisition, creation of easements, civil facilities, acquisition and rental of machinery and equipment used in the civil facilities.

2.5 SUBSTATION OPERATION AND MAINTENANCE.

2.5.1 Operation

The operation of the hydroelectric power station San Matias, as part of a wholesale energy market established in Colombia, and connected to a national transmission system (STN), must comply with certain conditions of a technical nature imposed by the national dispatch center (CND) and the Commission for Regulating Energy and Gas (CREG), as stipulated in the Act 143 of 1994.

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

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 operators (intake cleaners) who shall follow the instructions of the shift operator with respect to the cleaning of screens and tanks, in addition to the opening and closing of the gates.

2.5.2 Maintenance

The maintenance to be carried out in the plant is characterized by the search for tasks that allows removing or minimizing the occurrence of failures, and in turn reduces the consequences, considering all the risk factors. The maintenance seeks to ensure the continuous service of the central , taking advantage of efficient water resources.

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

All maintenance activities will be coordinated with the head of operation and maintenance and will be scheduled in its due course. For these activities will be provided the total availability of staff working in the Central Plant.

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 operation technical characteristics.

2.5.3.1 Camps, offices, warehouses and workshops required during operation

At the stage of operation in the power house, it will host 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 river Cocorná. The handling of domestic solid waste shall comply with the established in the Management Plan for this study.

The warehouse and workshop are to be placed in the left margin of the river Cocorná, on the right side of the road projected by the project El Popal. The workshop will feature a collection site for oils, greases, batteries, and perimeter channels for spill control. The liquid waste that is harvested in the perimeter channels, will be stored temporarily and subsequently delivered to an authorized operator.

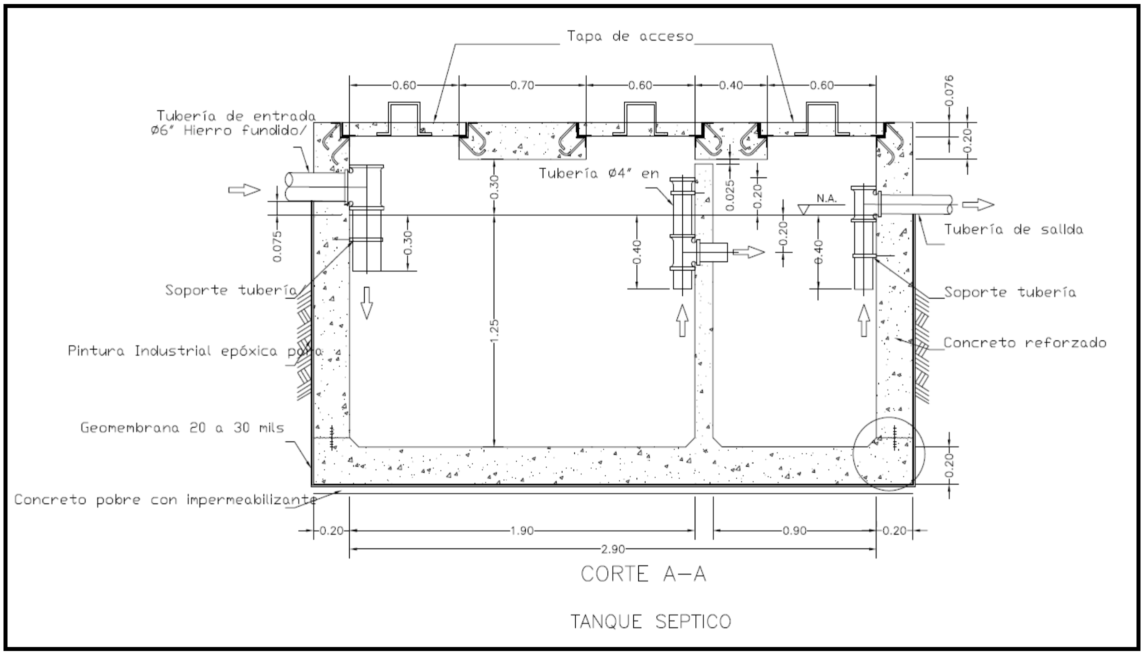

Figure 2-2 Septic tank section

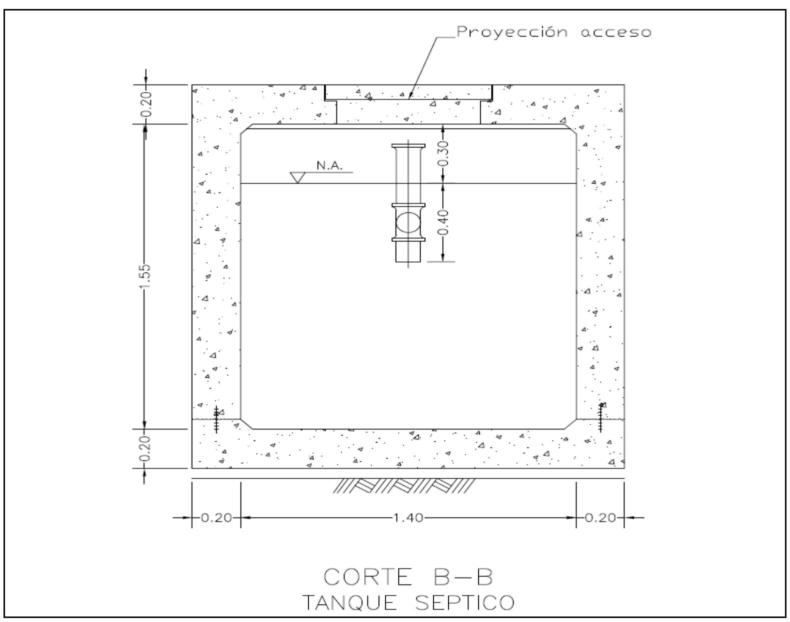

Figure 2-3 Septic tank section

2.5.3.2 Water Intake

As already mentioned, the water required for the generation of hydroelectric power from the Project San Matias, corresponds to the turbined water that comes from project El Molino. The nominal flow for generation is of 10 m^3/s.

The generation system will be controlled through sensors arranged in the settling tank located in the power house of the El Molino hydroelectric project, which restrict the levels of operation and will determine the correspondence between the flows provided by the El Molino hydroelectric project and for turbinate by the San Matias hydroelectric project. The variations levels will be monitored by the control system, allowing the flow to adjust according to the contributions of the river, and at the same time maintaining the levels in the estimated ranges for the operation.

If the turbinate flow of the El Molino hydroelectric project exceeds the generation of San Matias hydroelectric project, these waters will be discharged to the San Matias River.

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

2.5.3.3 Power Generation

During its operation, the hydroelectric plant in San Matias will be 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 group, which consists of a turbine and a generator coupled by the same shaft; this group generator is located in the power house.

In this case, the Francis type turbine of horizontal axis (reaction turbine of mixed flow total intake and radial). This turbine has three basic elements that are the distributor (directs and regulates the water toward the impeller), diffuser (fluid outlet, it takes the shape of the suction tube) and the impeller vanes (composed of mobile parts).

The turbine receives the high-pressure water flow toward its vanes through the charge pipe line and takes advantage of the kinetic energy and water potential 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 forwarded 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 the same amount. This process is performed with the objective to be able to transmit energy over long distances.

2.5.3.4 Discharge of waters to the San Matias River

The turbined water that comes out of the power house of the hydroelectric power station San Matias, which correspond to the nominal flow provided by El Molino hydroelectric project is (10 m^3/s), will be delivered to the San Matias River by means of the discharge channel, whose path has been prepared to lead the water into the river with the slowest possible speed, which is reduced through the implementation of structures of energy dissipation to achieve to deliver the waters to the river with a minimum speed, avoiding undermining at the shores and bed of the river, product of the energy and speed accumulated by the gap that exists between the power house and the river in the discharge point.

The sediment load of this water is expected to be minimal, since these will be retained in the sand remover of the El Molino hydroelectric project; in addition, the industrial use in the generation of energy no additional contaminants are pored into the water.

2.5.3.5 Water for operation

The water required during the stage of operation shall be obtained as follows:

It is planned to use during the operation the aqueducts built in the areas of home of engines of the projects El Molino and El Popal, the first for the area of collection and the second for the machines zone, where the water would be necessary both in construction and operation

2.5.3.6 Maintenance of access roads

The maintenance of access roads during the operation phase ensures the proper transport of the operational staff, materials and equipment for the system maintenance 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 disposal.

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

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

2.5.3.8 Verification status of the house of valves and control valve

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

2.5.3.9 Status check of the house of engines

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 of the equipment and electrical systems, hydraulic systems and drains, among others.

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

This activity consists in the review remote or manual, carried out by the manager of the plant with the help of the operation and maintenance staff, the values supplied in panels and systems of measurement and control, and detected by the Logic Control Programming (PLC) of the plant computerized system. It will be confirmed at site, possible leaks of fluids in the primary system and the operating mechanisms of the turbo generator, complementary and auxiliary devices, among others.

2.5.3.11 Check the status of the turbo generator equipment in the power house.

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

2.5.3.12 Verification of the electrical substation

For the proper functioning of the electrical transmission system and distribution, it will be identified the general condition of the electrical substation in visual form, checking the devices of control and measure, to detect anomalies produced in the system in response to the recommendations of the equipment manufacturers. When damage occurs caused by line breaks and voltage surges or lightning on the system, the electrical engineers will carry out visual verification and maintenance.

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

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

2.5.3.14 Labor required

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

2.5.3.15 Annual cost of operation

The costs of administration, operation and maintenance are taken as a value proportional to the rated power, given that the size of the equipment is the most important factor for their influence in the maintenance cost. In the central will be installed equipment for hydroelectric generation of 21 MW, so that the estimated annual administration cost for operation and maintenance is around US$700,000 .