ENVIRONMENTAL IMPACT STUDY
ALTO MAIPO HYDROELECTRIC PROJECT (PHAM)

CHAPTER 2 – DESCRIPTION OF THE PROJECT

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CHAPTER 2
DESCRIPTION OF THE PROJECT

2.1 GENERAL BACKGROUND

We now describe the Alto Maipo Hydroelectric Project, with an emphasis on those aspects related to its potential environmental implications. For the purposes of submission to the Environmental Impact Assessment System (SEIA), this description complies with the contents indicated in DS 95 SEIA Regulations and other requirements of information that are relevant to the environmental assessment process.

It must be indicated that the current definition of the Project is the result of extensive studies conducted by AES Gener in the last decade, in the upper Maipo River basin, which included the study of the area's geology, the analysis of the hydric resources and the geological risk, and the existing infrastructure. The technical-economic feasibility study that defined the current characteristics of the project included a preliminary assessment of the possible impacts on the environment, associated with the works and activities of the project, which allowed the works to be adapted to minimize their effects on the environment. Later, during the environmental assessment process that the project was submitted to previously, the Titular made a series of modifications and/or specifications in relation to the design, location and timeliness in which the works will be carried out, in order to guarantee their environmental sustainability. In this process, the validation or advance consultation of sensitive environmental aspects that the Titular made to some Public Services was important, as well as the community participation process that GENER has developed as part of its Policy to interest the Project in the community.

On the other hand, although the great potential of the run-of-the-river hydroelectric projects in the country is recognized, and as a consequence their environmental sustainability, this type of project faces barriers that disincentivize, affect and/or limit their development in a certain way, such as: uncertainty regarding the capacity of generation derived from dependence on hydric cycles, the construction of underground tunnels, with the consequent technical complexity, among others.

Due to the above, with the income that can be received from the sale of carbon credits, derived from the implementation of this project under the Clean Development Mechanism, (MDL), it is proposed to in part collaborate economically with overcoming the above-mentioned barriers, to permit the execution of the Alto Maipo Hydroelectric Project.

The additionality of the project is justified initially when analyzing the technological barriers which the project is facing, such as:

- The project is innovative in Chile, since it consists of a hydroelectric complex comprised of two run-of-the-river Plants that will operate in series, together generating a maximum power of 531 MW, to be provided to the Central Interconnected System (SIC) through a transmission system.

- The plants will be developed through underground works with cutting-edge construction technology and with a minimum of intervention on the surface, optimizing the use of the river basin's hydric resources by collecting the water without flooding, with the consequent decrease in negative impacts that the construction of a dam could have on the environment, with problems of alteration of river flows, erosion, effects on populations, loss of fertile soils, etc.

- Since the land is steep, the water cannot be transported by canals, so the project includes a total of 70 km of unlined high pressure tunnels, of which approximately 60 km correspond to the hydraulic tunnels of both plants and the rest is comprised of the windows (tunnels) of access to the main tunnels.

- Given the characteristics of the tunnels and the composition of the rock, the construction method to be used is a combination of "drill and blast", an advancing boring method with mechanical borers and controlled blasting and the mechanized excavation of complete sections with the use of a TBM (full face tunnel boring machine).

- Associated to the above, underground excavation implies considerable uncertainties, such as sectors with high internal tensions of the rock mass, and the geotechnical quality of the land among others, situations that can be controlled thanks to recent technological developments on the design and construction of underground works.

- Lastly, the power grid of the Central Interconnected System (SIC) corresponds mostly to Hydroelectric Plants with Dams and Thermoelectric Plants, with the Run-of-the-river Hydroelectric Plants being those with the least presence in this power grid.

In accordance with the above, the definitive configuration of the hydroelectrical system and its associated component works ensure its sustainability in time, without affecting the ecological systems in which it is inserted.

A. Name of the Project and the Project's Titular

The Project that is submitted to the SEIA is referred to as the "Alto Maipo Hydroelectric Project", hereinafter PHAM. Its location is shown in Figure 2.1.1 "General Location of the Project".

The titular of the PHAM is the company AES Gener, (hereinafter Gener), Tax I.D. number: 94.272.000-9, telephone 686 8900, fax 686 8991, domiciled at 310 Mariano Sánchez Fontecilla, 3rd floor, Las Condes, Santiago.

For these effects, the legal representative of AES Gener is Mr. Luis Felipe Cerón Cerón, national I.D. number: 6.375.799-3 with legal domicile at 310 Mariano Sánchez Fontecilla, 3rd floor, Las Condes, Santiago. His telephone and fax numbers are 686 8900 and 686 8991, respectively.

B. Objective and Justification of the Project

The objective of the Project is the generation of electricity through the construction and operation of two run-of-the-river plants in hydraulic series, the Alfalfal II and Las Lajas plants, which together will generate a maximum power of 530 MW, to deliver it to the Central Interconnected System (SIC) through a transmission system, connected to a substation. The transmission system does not form part of this EIA.

The project is justified by the progressive increase in the demand for electricity, of 6% per year in the last decade, which requires the incorporation of new plants into the existing generators used at a rhythm of approximately 400 MW annually.

The project, which will incorporate an average of 2350 Gwh per year into the system, has the advantage of being located in the center with the highest consumption of the SIC, through plants that are developed mainly through underground works with a minimum intervention on the surface, optimizing the use of the hydric resources of the river basin by capturing the water without flooding, to generate with in turbines that will be located in caverns inside the mountain, and then return the water to the river bed to be used for other purposes.

As will be seen further below, the flows collected have been calculated on the basis of hydrological studies of each flow that consider the respective ecological flows.

C. Location of the Project

The PHAM will be located to the south-southeast of the city of Santiago, in the county of San José de Maipo, Province of Cordillera, Metropolitan Region, specifically in the upper basin of the Maipo River (see Figure 2.1.1 “General Location of the Project”).

Both plants, Alfalfal II and Las Lajas, will be located in the Colorado river basin, downstream from the current Alfalfal I Hydroelectric Plant, owned by the titular. The Alfalfal II Plant will mainly use the water from the high zone of the Volcán River and the Yeso River, while the Las Lajas Plant will make use of the water generated in the Alfalfal II plant and the existing Alfalfal I plant, plus water from collection in the intermediate basin of the Colorado River. For the above, the project includes the construction of a total of 70 km of tunnels of which approximately 60 km correspond to the hydraulic tunnels of both plants and the rest are comprised of the windows (tunnels) of access to the main tunnels and the access tunnels to the machine caverns.

Both plants will be operated from the existing control building of the Alfalfal Plant.

Despite the fact that the project is developed in an extensive geographical area, its characteristic of being a fundamentally underground project whose works will be done at great depth (on average at over 800 m), translates into the areas of direct surface intervention being circumscribed to 4 main zones: the high basin of the Volcán River, the area of the Yeso River downstream from the dam, the Colorado river basin between the discharge of the Alfalfal Plant and the El Sauce Stream, and the Maipo River in the zone of the discharge of the project in the sector of Las Lajas. Annex 11 includes the list and location, with coordinates, of all the project works.

Insert Figure 2.1.1 “General Location of the Project”

Insert Figure 2.1.2 “Layout of the PHAM works”

D. Surface Area of the Project and Land requirements

The PHAM land requirements correspond to the surface area occupied mainly by the surface intakes and pipes, camps and the worksite setup, access roads, muck storage sites, and the electrical substation of the complex. It must be indicated that both plants will use the Alfalfal I Plant control building.

The underground works, such as tunnels and the machines cavern, do not require the use of surface land except for the access halls to the tunnels.

The total surface area required for the project is indicated in the following table.

Table 2.1.1
Total Surface Areas Required by the PHAM

Works	Surface area in Ha.
Surface civil engineering works	20
Setting up new access roads	31
Muck storage sites	34
Camps, worksite facilities and work fronts	20
Total	**105**

In accordance with the above table, the total land requirements of the PHAM are **105** ha. Of this surface area, only that corresponding to surface civil engineering works, roads and muck storage sites will be permanently occupied by the project. The sectors of camps, worksite facilities and work fronts, used during the construction stage, will be recovered or restored once the works are finished.

Detailed information on the surface area used by each one of the project works is included in Annex 11.

E. Access to the Project Area

Access to the different work fronts will be done through the use and improvement of existing roads, and the construction of new roads in accordance with that indicated in section 2.3.2.5. The new roads are located close to the existing road networks in the basin of the Volcán, Yeso and Colorado Rivers, that begin at Highway G-25, which connects the city of Santiago with the county of San José de Maipo.

Table 2.1.2
Roads that approach the PHAM Work Fronts and Camps

Road	Sector	Construction works
G-25	Parallel to the Maipo River	Works in the area o discharge into the Maipo River
G – 345	Parallel to the Colorado River	Works Alfalfal II- Las Lajas
G – 455	Connects highway G-25 with the sector of El Yeso	Works – El Yeso
Volcán	Connects highway G-25 with the project zone (private road Puente Colina-Bocatomas).	Works El Volcán

The project includes the construction of new roads from these roads, to connect the different work fronts with the camps and muck storage sites.

Regarding the improvements and maintenance of the existing public roads in the PHAM area, whose detail is attached in Annex 19 “Roads improvement program”, the respective projects will be presented to the Regional Road Authorities prior to beginning the works.

F. Estimated Investment and Useful Life and Timeline of the Project

The estimated amount of investment will be approximately MMUS $ 700.

This sum includes the total cost of the works, including the costs of construction of the civil engineering works (consumables and labor), supply and assembly of principal and auxiliary equipment.

The construction stage is approximately 5 years long, in accordance with the timeline indicated in the following table:

Table 2.1.3
General Project Timeline *

Works	Commencement date	End date
Preliminary Works	December 2008	Mayo 2009
Works in the El Volcán sector	June 2009	August 2013
Works in the El Yeso sector	June 2009	November 2012
Works in the Aucayes-Alfalfal II sector	March 2009	September 2013
Works in the Las Lajas sector	June 2009	December 2012

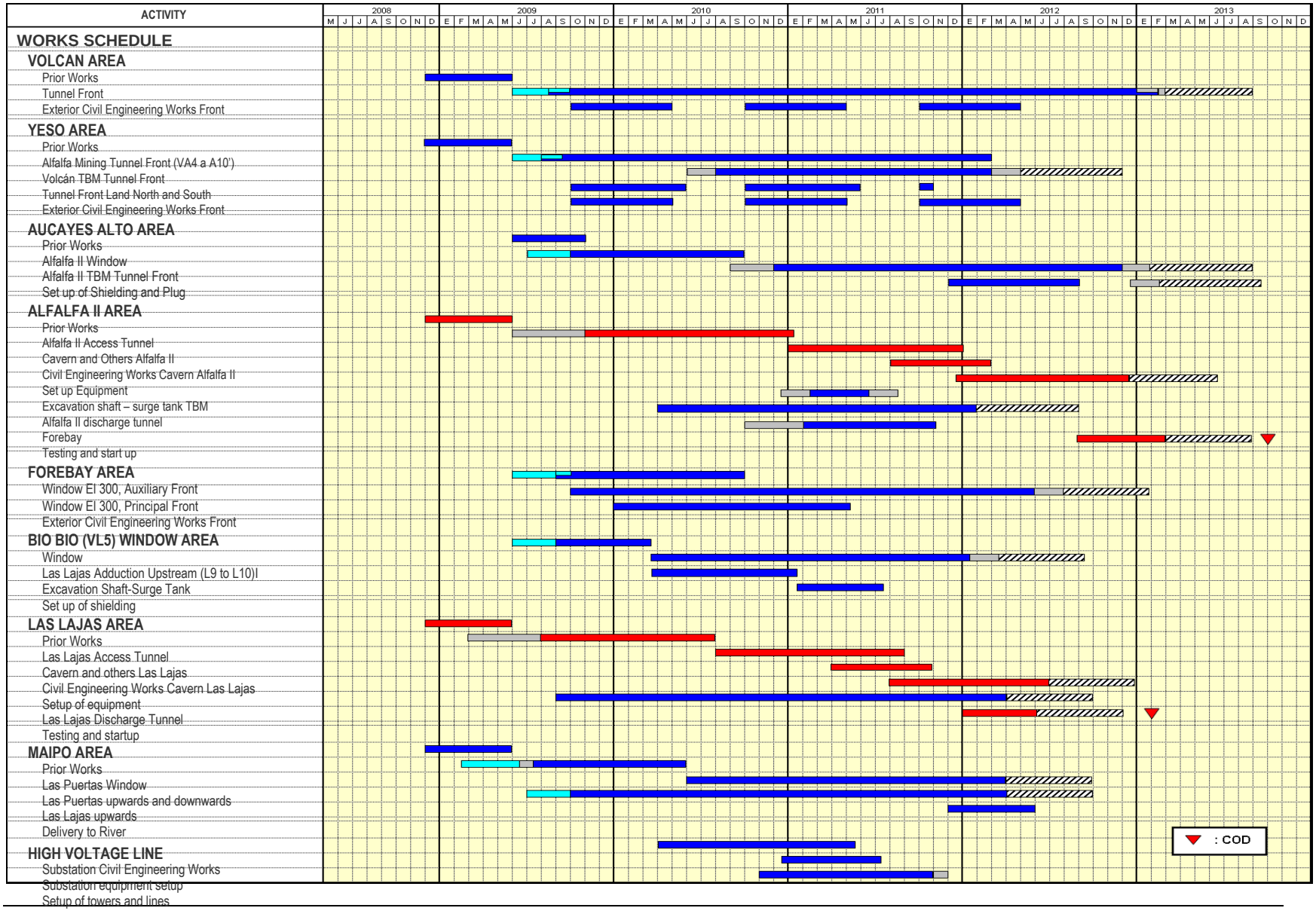
* Estimated dates that will be adjusted in accordance with obtaining a favorable RCA and authorizations, concessions and permits that are required from other authorities and third parties.

The preliminary works refer to the construction of service roads, worksite lines and the access portales to the Alfalfal II and Las Lajas cavernas.

We now present the PHAM General Construction Program. Annex 2 includes a detail of the Sequence of the Project activities.

Lastly, a decommissioning stage of the Project is not included, with it being possible to extend its useful life beyond a period of 50 years, through the conservation and modernization of equipment.

Table 2.1.4
General Construction Schedule



G. Labor

The labor requirement for the construction phase of the PHAM is estimated at 2,000 workers on average, reaching 2,500 at the peak of hiring.

Preliminarily, a total of 5 camps is foreseen which include the worksite facilities, each one with an approximate staff of 300 to 400 workers, including professional and technical personnel and workers, drivers and personnel associated with the dining hall, maintenance of the camp and health auxiliaries. The personnel that work on the construction will be transported by bus to the work fronts. The camps will have a permanent staff of 10 to 20 people, who will provide services of surveillance and general maintenance of the facilities. The work shifts during the underground works construction stage will be those necessary to work continuously every day 24 hours a day.

For the operations stage a total staff is considered of 50 people, required for the tasks of maintenance and operation of both hydroelectric plants.

2.2 MAIN WORKS OR COMPONENTS OF THE PROJECT

2.2.1 General Description of the PHAM

The Alto Maipo hydroelectric development project includes two plants located in series in the high sector of the Maipo river: Alfalfal II and Las Lajas. The project includes the use of the water from the high zone of the Volcán river, the Yeso river, the waters turbined by the Alfalfal plant and of the intermediate river basin of the Colorado River.

Alfalfal II Plant

The Alfalfal II plant, designed for a flow of 27 m^3/s, receives the water collected from streams located in the upper part of the Volcán river, which is taken to the Yeso River valley through the El Volcán tunnel. In the high sector of the Volcán River, up to a maximum of 12.8 m^3/s is collected through 4 intakes that intercept the different branches of streams that confluyen and form the north branch of the Volcán River, which in turn discharges into the Maipo River. The flow collected is taken to the El Volcán tunnel by an underground aqueduct. The flows collected are taken through gravel chambers at the sites of the intakes and de-silted together, before entering the Volcán tunnel. The Volcán tunnel collects the water collected in the high zone of the Volcán River and takes it to the Yeso river valley, where it receives the contribution of the latter through a buried duct that is located between the intake located in the Yeso river and an intake well located at the exit of the Volcán tunnel that joins both flows.

From the intake well, the flow is taken to the Alfalfal II tunnel through a penstock, to the adduction tunnel of the Alfalfal II plant, which is 13,600 m. long, until reaching the upper end of the pressure shaft. The surge tank and the forebay of this plant are located Slightly upstream from the beginning of the shaft. The gross head height is estimated at 1,146 m.

The machines house is installed in a cavern excavated in the rock mass in a sector located towards the east of the Aucayes stream, in the Colorado river valley. The generating equipment has two four –nozzle Pelton turbines, 500 rpm, for a maximum capacity of 2 x 136 MW.

The discharge tunnel of the Alfalfal II plant is approximately 2.5 Km long and delivers its flow to the Las Lajas plant adduction tunnel. The flow generated by the Alfalfal II plant can be directed to the machines house of the Las Lajas plant, or towards its forebay, located on the right edge of the Colorado river, in both cases via the tunnel mentioned above.

Las Lajas Plant

The Las Lajas Plant, designed for a flow of 65 m^3/s, receives the water generated from the Alfalfal and Alfalfal II plants, as well as contributions from the intermediate river basin of the Colorado river located between the intakes of the Alfalfal plant (Colorado and Olivares) and the current intake of the Maitenes plant. The contribution of the Aucayes ravine is added to this.

The Las Lajas Plant includes a forebay, which also works as headstock tank of the Alfalfal II plant. The water from the Alfalfal plant flows to this tank, located on the right bank of the Colorado river, which is done through pipes joining it to its discharge canal.

The water derived from Canal 1 (existing) of the Maitenes Plant, is taken by a canal and is de-silted in a pipe located on the left bank of the Colorado river. The crossing to the Las Lajas forebay is done through a siphon under the river.

The adduction of the Las Lajas plant begins in the forebay with the same name through a concrete pressure duct. This conduit crosses the Colorado River, through a siphon, and joins the Las Lajas tunnel, which has runoff pressure. The Las Lajas tunnel receives the contribution from the discharge tunnel of the Alfalfal II plant; furthermore, this tunnel, which receives the contribution from the Aucayes stream, has a surge tank and ends in a pressure shaft that feeds the turbines.

The machine house is located on the left bank of the Colorado River in a cavern excavated in the rock mass. The generating equipment has two 6-nozzle Pelton turbines, velocity 300 rpm, with a nominal flow of 32.5 m^3/s each unit and a gross head of 485 m.

The discharge tunnel of the Las Lajas plant discharges its water directly into the Maipo River. It has a length of 13.3 km and a horseshoe section of 35 m^2, with free runoff.

Figure 2.2.1 shows a simplified diagram of the use of the Alfalfal II – Las Lajas hydroelectric system.

Subsequently, section 2.2.2 describes the works and components that integrate the hydroelectrical system described above, which are relevant from the point of view of the environmental assessment. This description will be done by grouping the works into underground and surface works. On the other hand, the location of these components, facilities and works annexed to the project are illustrated in Figures 2.2.2 to 2.2.10.

Figure 2.2.1
Simplified Alfalfal II – Las Lajas System

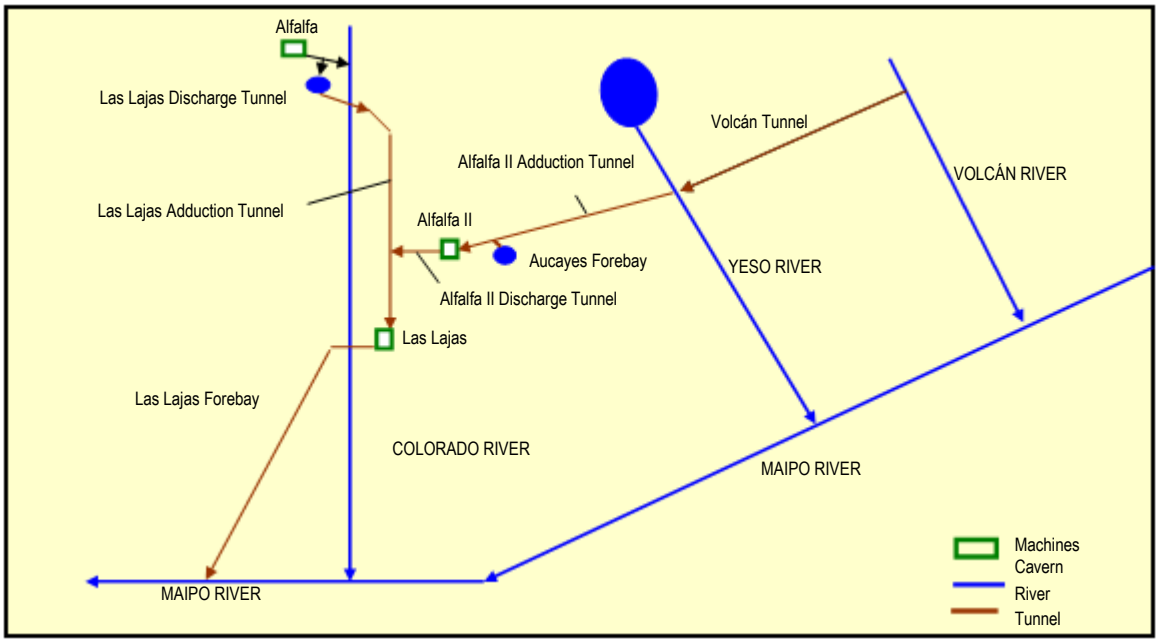


Figure 2.2.2:
"Location of the PHAM works and components. Upper Volcán river basin sector"

Figure 2.2.3
"Location of the PHAM works and components, upper Yeso River sector".

Figure 2.2.4
"Location of the PHAM works and components, Lo Encañado Lagoon sector"

Figure 2.2.5 “Location of the PHAM works and components, Aucayes sector”

Figure 2.2.6 “Location of the PHAM works and components, Alfalfal II Plant access tunnel sector”

Figure 2.2.7 “Location of the PHAM works and components, Alfalfal Sector”

Figure 2.2.8 “Location of the PHAM works and components, Las Puertas sector”

Figure 2.2.9 “Location of the PHAM works and components, Maipo River Discharge sector”

2.2.2 Surface Works

The surface works included in the project correspond to intakes, ducts, forebays, siphons and bridges.

We now set out a general description of these works. Their location is illustrated in Figures 2.2.2 to 2.2.9.

A. Collection systems

The Alto Maipo Hydroelectric Project considers the collection of resources at eight different points of the upper Maipo River basin. In each one of these points there are non-consumptive water rights for this project and, in the majority of them there are also ecological flows established by the Waters Authority for the concession of these rights.

Regarding these flows, the following table indicates the corresponding river basin, sub-basin and sub-sub-basin, in accordance with the classification used by the National Waters Bank of the DGA:

Table 2.2.1
Classification of Sub-basins according to the National Waters Authority

Course	Basin	Sub-basin	Sub-sub-basin	Code BNA
Colina Stream	Maipo River	Upper Maipo River	Volcán River	05702
La Engorda Stream	Maipo River	Upper Maipo River	Volcán River	05702
Las Placas Ravine	Maipo River	Upper Maipo River	Volcán River	05702
Cajón Del Morado	Maipo River	Upper Maipo River	Volcán River	05702
Yeso River	Maipo River	Upper Maipo River	Yeso River	05703
Colorado River	Maipo River	Upper Maipo River	Colorado River between Olivares River and Maipo River	05707
Aucayes Stream	Maipo River	Upper Maipo River	Colorado River between Olivares River and Maipo River	05707

The design flows of the Plants must be contributed for the total or partial sum of the design flows of each one of its intakes.

The collection points of the flows are the following:

- Alfalfal II Plant:
  - Cajón Del Morado
  - Cajón La Engorda
  - Colina Stream
  - Las Placas Ravine
  - Yeso River
- Las Lajas Plant:
  - Alfalfal discharge canal
  - Colorado River at the Maitenes Intake
  - Canal 2 of the Maitenes Plant

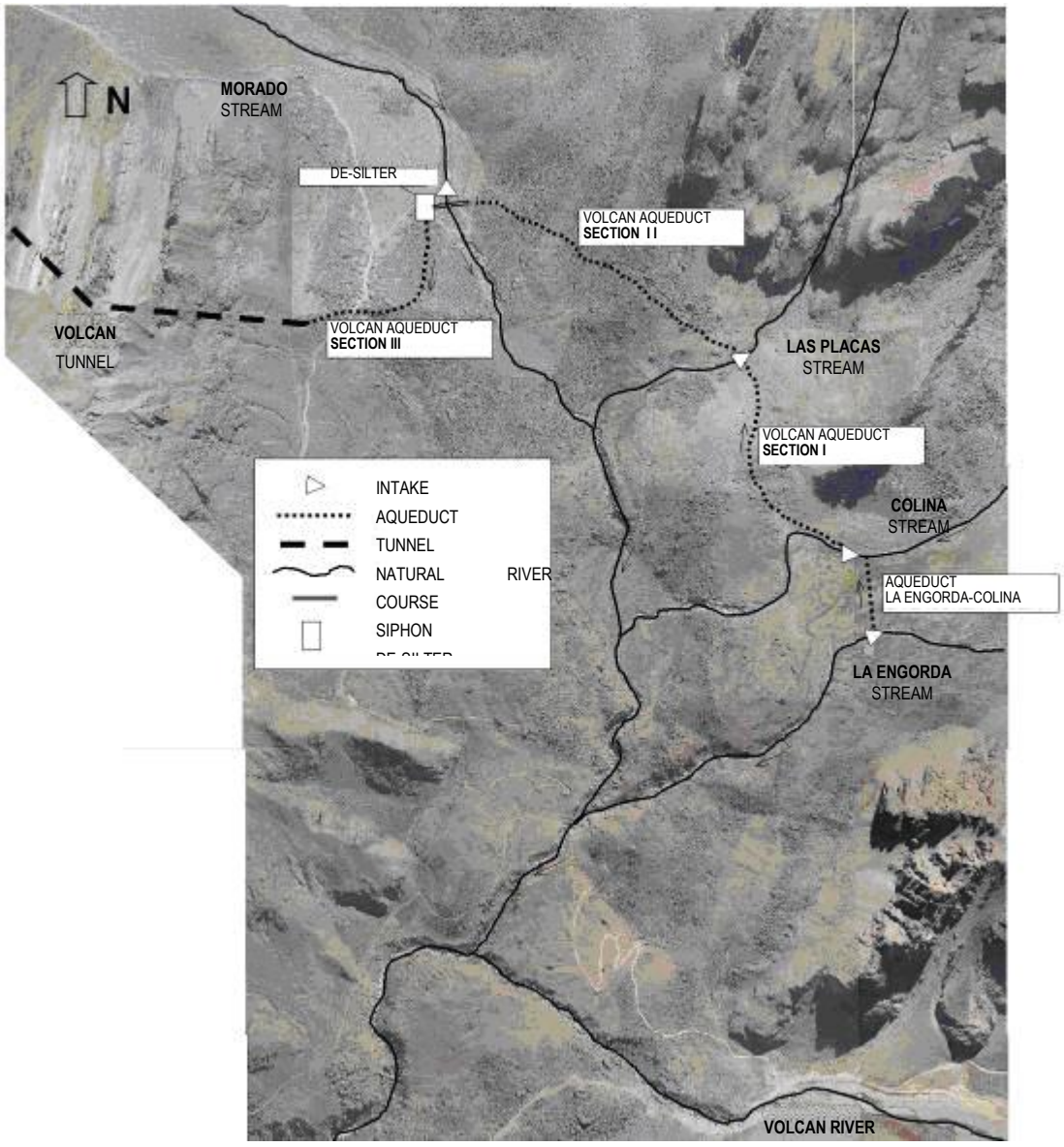
The design flows for the intakes of the Alfalfal II Plant and the Las Lajas Plant are presented in Table 2.2.2

Despite the above, only five points of collection require the construction of new intakes, those located in the valleys of the Volcán and Yeso rivers. In the Colorado River valley (Las Lajas Plant) all the collection is done from existing works.

- **Upper Volcán River Basin**:

As indicated previously, the Alto Volcán system of the Alfalfal II plant includes a set of 4 intakes used to collect water from the upper Volcán River basin, in particular, from the La Engorda, Colina, Las Placas and El Morado streams. The waters collected by the intakes are taken along aqueducts. The first section takes the water from La Engorda to the Colina stream, and the second takes the water collected from the La Engorda and Colina streams, to which is added the water collected from the Las Placas stream. After crossing the El Morado stream by a siphon, the water of the stream with the same name is added to it, and discharges in a common de-silter. The de-silted water is finally taken to the El Volcán tunnel. Annex 1 includes the general plans of the project and Annex 8 includes more detailed plans of the intakes.

Figure 2.2.10
Location of the Works Upper Volcán River Sector



La Engorda Intake

The La Engorda intake corresponds to a high mountain (or zip-line) type collection, located at 2,520 m.a.s.l. in the stream with the same name and designed to collect a flow of 2,1 m^3/s.

The intake consist of a water collector (or grid chamber) 3.2 m wide and 1.6 m long in the direction of the runoff located in the bed of the stream in such a way that the water is collected along the bottom of the flow. The water collector discharges the water collected to a duct 1.4 m wide which in turn takes it to a gravel chamber designed to remove particles with a diameter greater than 0.3 mm.

There will be a control section immediately downstream from the water collector, which narrows to 0.7 m wide and 0.97 m height, in order to impede that flows greater than the design value enter the intake during rises in the river water level.

The gravel chamber consists of a trapezoid structure, 1.4 m base width and 2.6 m surface width, with a length of 30 m. The gravel chamber delivers the water through a lateral spillway 2 m long located in the downstream end of the structure, from where it is taken to the Colina stream.

Sediment is removed through the operation of a large front hatch of the radial type that is 1.4 m wide, which discharges into a concrete duct that returns it to the stream. The longitudinal slope of the duct is 2% to ensure that the sediment deposited during the use of the hatch is washed away.

The passage of the ecological flow in the La Engorda stream, which has been set at 200 l/s, is done through the intake grid, in a canal prior to the derivation channel. In this way, when the river flow is less than the ecological flow, the entire flow passes to the stream through a hole designed for this purpose. For larger flows, the canal overflows to the intake from the derivation without altering the passage of the ecological flow.

Colina Intake

The intake in the Colina stream corresponds to a lateral type collection that includes the construction of a frontal barrier for runoff 15 m wide and approximately 2.5 m high regarding the stream bed, and whose base is located at 2,516 m.a.s.l. in the stream with the same name. The barrier will be of reinforced concrete. Two gravel chamber hatches of the radial type are considered with openings of 2 x 2 m adjacent to the lateral intake.

The lateral intake consists of a grid panel 3.8 m wide, which discharges the water collected to a transition canal that ends in a concrete duct that takes it to the gravel chamber.

The gravel chamber consists of a trapezoid structure, 2.0 m base width, and 5 m surface width, with a length of 36 m. The desripiador delivers the water to the El Volcán pipes, through a lateral spillway 4 m. long located at the downstream end of the structure.

The removal of sediment is done through the operation of a front hatch of the radial type, 2 m wide, which discharges into a concrete duct that returns it to the stream. The longitudinal slope of the duct is 2% to ensure that the sediment deposited during the use of the hatch is washed away.

The passage of the ecological flow, which has been set at 300 l/s, is done through a hole in the deviation barrier. In the lateral type intakes, it will be located in the same gravel chamber hatch, discharging directly into the river's discharge canal.

Las Placas Intake

The Las Placas intake corresponds to a high mountain type (or zip-line) collection located at 2,513 m.a.s.l. in the stream with the same name, and designed to collect a flow of 1 m^3/s.

The work consists of a water collector located in the bed of the stream, 2.8 m wide and 1 m long regarding the direction of the runoff. The water collector discharges the water collected to a canal 1 m wide which in turn discharges into a gravel chamber designed to remove particles with a diameter greater than 0.3 mm.

There will be control section immediately downstream from the water collector, which narrows to 0.5 m width and 0.74 m height, in order to impede that flows higher than the design value enter the intake during rises in water the stream water levels.

The gravel chamber consists of a trapezoid structure, 1.25 m base width and 1.75 m surface width, with a length of 14 m. The gravel chamber delivers the water through a lateral spillway 2 m long located in the downstream end of the structure, from which it is taken to the El Morado stream pipes.

The removal of sediment is done through the operation of a front hatch of the radial type, 1.25 m wide, which discharges into a concrete duct that returns it to the stream. The longitudinal slope of the duct is 2% to ensure that the sediment deposited during the use of the hatch is washed away.

The passage of the ecological flow in the La Engorda stream, which has been set at 140 l/s, is done through the intake grid, in a canal prior to the derivation channel. In this way, when the river flow is less than the ecological flow, the entire flow passes to the stream through a hole designed for this purpose. For greater flows, the canal overflows to the shunt intake without altering the passage of the ecological flow.

El Morado Intake

The intake in the El Morado stream corresponds to a lateral type collection, which considers the construction of a frontal barrier to runoff 12 m wide and approximately 2.5 m high with respect to the stream bed, and whose base is located at 2,511 m.a.s.l. in the cauce with the same name. The barrier will be made of reinforced concrete. Two gravel chamber hatches of the radial type with openings of 2 x 2 m are considered adjacent to the lateral intake.

The lateral intake consists of a grid panel 3.8 m wide which discharges the water collected to a transition canal that ends in a concrete duct that takes it to the gravel chamber.

The gravel chamber consists of a trapezoid structure 2.0 m base width and 3 surface width, with a length of 39 m. The gravel chamber delivers the water to the El Volcán pipes through a lateral spillway 4 m long located in the downstream end of the structure.

The removal of sediment is done through the operation of a front hatch of the radial type, 3.3 m wide, which discharges into a concrete duct that returns to the stream. The longitudinal slope of the duct is 2% to ensure that the sediment deposited during the use of the hatch is washed away.

The passage of the ecological flow, which has been set at 240 l/s, will be done through a hole in the deviation barrier. In the lateral type intake, the hole will be located in the same gravel chamber hatch, discharging directly into the discharge channel to the river.

- **Yeso River Valley**:

El Yeso Intake

The intake is located some 700 m downstream from the El Yeso dam, and its objective is to collect the contribution of the Yeso River to take it to the Alfalfal II Plant system.

The intake in the Yeso River corresponds to a lateral type collection, which considers the construction of a frontal barrier to runoff 17 m long and approximately 2.5 m high regarding the stream bed, and whose base is located at approximately 2,500 m.a.s.l. in the flow with the same name. The barriers will be made of reinforced concrete. There will be two desrip canals adjacent to the lateral intake, each equipped with remote controlled gravel chamber hatches of the radial type with openings of 3 x 3 m.

The conception of the gravel chamber system used is based on the design of the Olivares intake of the Alfalfal plant, which has presented a satisfactory functioning. It must be indicated that the design flows of this intake, of the intake as well as of rises in river water levels, are very similar to the Yeso River collection.

More details of the intake, designed for a maximum flow of 15 m^3/s, are presented in Annex 8, attached to this EIA.

- **Colorado River Valley**:

The Maitenes Plant Intake

The name of this intake comes from the Maitenes hydroelectric plant, since it corresponds to the intake of this plant in the Colorado river. The intake was built in 1923 and rebuilt in 1989, after the flash floods in 1987.

Photograph 2.2.1: Colorado Intake, Maitenes Plant

This existing intake consists of a fixed barrier that is transversal to the flow of the Colorado River and is located immediately downstream from the Alfalfal discharge. The intake as such is lateral with seven mobile openings and two gravel hatches which feed the Maitenes Canal 1 along the left bank of the Colorado River. Since the nominal capacity of the intake and the Maintenes canal exceed 10 m^3/s, both structures will be used by the Alto Maipo project to feed the forebay of the Las Lajas plant through the deviation of10 m3/s from Canal 1.

The use of the intake and piping works of the Maitenes Plant will be done by a deviation pipe that includes a de-silter and a siphon under the Colorado River. To absorb the increase in the level that originates in the forebay as the consequence of a rejection of load in the Las Lajas Plant, the edges of the Maitenes canal must be raised between the exit hall of the tunnel and the new de-silter.

Connection to the Alfalfal discharge canal

Consists of an extension of the evacuation canal of the Alfalfal plant, with a design flow of 30 m³/s. The works are connected by the right parament of the drainage channel (height of concrete base 1,321.82 m.a.s.l.) in the area which faces the siphon that crosses the Colorado River, and that currently delivers part of the water from Alfalfal to the Maitenes Plant canal.

The canal will have a slope of 0.36% and a square section of 4 x 4 m which ends in the forebay at 1,318.00 m.a.s.l. A lateral safety spillway has been projected at the end of the canal, which allows surplus to be emptied into the Colorado River; this spillway discharges to a quick toe wall, which dissipates the energy of the water before it reaches the water course.

Maitenes Plant Canal 2:

This canal currently takes up to 2 m^3/s of the water from the Aucayes stream from the existing intake to the forebay of the Maitenes Plant. The use of this water will be done by connecting this canal with the Las Lajas adduction tunnel through a vertical shaft some 150 m deep.

Table 2.2.2
Characteristics and Description of the Collection Pipes

Intake	Manner of captación	Design flow m^3/s	Ecological flow m^3/s	Location	
Engorda	High mountain intake	2.1	0.2	6.259.798	407.256
Colina	Lateral intake	6.0	0.3	6.260.082	407.156
Las Placas	High mountain intake	1.0	0.14	6.260.714	406.642
El Morado	Lateral intake	3.7	0.24	6.261.259	405.759
El Yeso	Lateral intake	15	0.20	6.274.117	399.669
Maitenes	Existing Canal 1	10	0.30	6.292.504	389.069
Alfalfal	Existing discharge canal	30	0.00	6.292.675	389.107
Aucayes	Existing Canal 2	2.0	0,.00	6.287.958	384.009

B. Piping

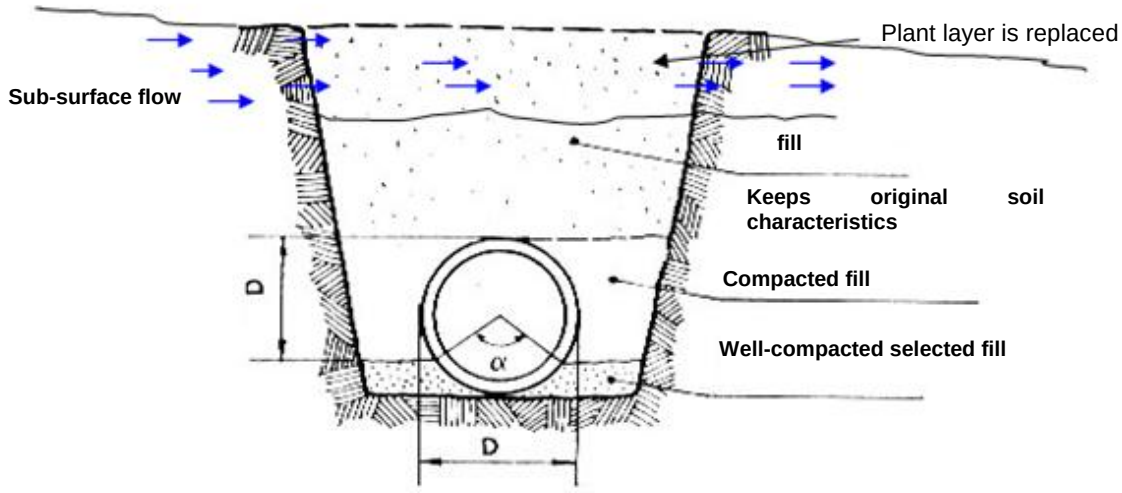
The PHAM includes the construction of several pipes that will connect the collection pipes with the tunnels. In general these are concrete ducts and steel pipes that will be buried occupying platforms whose maximum width will be 10 m excavated in natural land. The detail of these pipes is the following:

- **Engorda-Colina Aqueduct**

The water collected in the La Engorda intake will be taken by a circular duct of reinforced concrete 1,4 m in diameter and 400 m length to the Colina intake, to connect with the El Volcán aqueduct that begins at this intake.

This aqueduct will be buried in a ditch that will then be filled with granular material so that the ground and subsurface runoff that feeds the summer pastures of this sector is not interrupted, and finally replacing the layer of plant soil removed prior to the construction of the ditch that will house the aqueduct, so restoring its condition of wet meadow. The diagram below shows the characteristics of this pipe.

Figure 2.2.11
Characteristics and Description of the collection pipes



The following photograph shows the characteristics of the sector.

Photograph 2.2.2 Water course of the La Engorda stream

- **El Volcán Aqueduct**

– Section I: Consists of a circular reinforced concrete duct 2.4 m in diameter and 1,760 m long that takes the contribution from the La Engorda and Colina intakes to section II of the aqueduct that begins at the Las Placas intake (see Figure 2.2.10).

– Section II: Consists of a circular reinforced concrete duct 2,4 m in diameter and 1,060 m long that takes the contribution from the La Engorda, Colina and Las Placas intakes to section III of the aqueduct that begins at the El Morado intake (see Figure 2.2.10).

– Section III: Consists of a concrete box 2.6 x 2.6 m and 646 m long that takes the contribution of all the system's intakes to the El Volcán tunnel (see Figure 2.2.10).

- **Yeso River Pipes**

Consists of a reinforced concrete box 2.8 x 2.8 m and 1,350 m long that takes the water collected by the Yeso River intake to the intake well located immediately downstream from the exit hall of the El Volcán tunnel.

From the intake well to the entrance of the Alfalfal II tunnel the pipe is steel, D = 3.1 m, thickness = 12 mm. The pipe runs for a length of 4,700 m in the western direction, crossing under the Yeso River.

- **Feed of the forebay**

Consists of an extension of the Alfalfal plant drainage channel, with a design flow of 30 m³/s. the pipe connects by the right parament of the drainage channel (height of concrete base 1,321.82 m.a.s.l.), in the area facing the siphon that crosses the Colorado River, and that currently delivers part of the water from Alfalfal to the Maitenes Plant canal.

The canal has a slope of 0.36% and a vaulted cross- section of 4 X 4 m and ends at the forebay (height 1,318.00 m.a.s.l.).

- **Derivation from Canal 1 of the Maitenes Plant**

The derivation pipe is located approximately 400 m downstream from the Maitenes intake, it crosses the road from the Alfalfal Plant and feeds a de-silter comprised of two parallel buildings, to continue to cross the Colorado River through a siphon to the Las Lajas forebay.

- **Las Lajas Plant Adduction**

Consists of a concrete duct 3.2 x 3.2 m and 1,000 m long between the Las Lajas Plant forebay and the entrance hall to the adduction tunnel of this plant, crossing under the Colorado River through a siphon.

Table 2.2.3
General Characteristics of the Pipes

Pipe	Cross-section (m^2)	Length (km)
Engorda-Colina Aqueduct	1.5	0.40
El Volcán Aqueduct – Section I	4.5	1.76
El Volcán Aqueduct – Section II	4.5	1.06
El Volcán Aqueduct – Section III	6.8	0.65
Yeso River Pipe	7.8/7.5	1.35/4.2
Feed of Las Lajas forebay	16	0.40
Derivation from the Maitenes canal	4	0.25
Las Lajas Plant adduction	10	1.0

C. Forebays

- **Las Lajas Plant**

The Las Lajas plant forebay gives stability to this plant's hydraulic system and in addition acts as a headstock well, restoring the natural system of the Maipo/Colorado River when the Alfalfal II plant operates at its peak. The water is collected from this forebay through a concrete duct that takes the water to the adduction tunnel of the Las Lajas plant (Colorado siphon).

It is located next to the north bank of the Colorado River, in part excavated and in part developed with earth walls. The useable volume of the tank is 300,000 m³, developed on a surface area of 75,000 m^2. The installation of a waterproofing membrane has been considered for the entire surface of the tank, a concrete floor on the bottom as well as pipes for emptying and safety.

The forebay has a rectangular shape some 300 m long and some 250 m wide. The edge will be at approximately 1,325 m.a.s.l. and the average bottom at 1,316 m.a.s.l.

Immediately upstream from the feed canal discharge, a bypass has been projected that allows the maximum flow of 40 m^3/s from Alfalfal and the Maitenes canal to be maintained when the Forebay is out of service. This obra consists of a reinforced concrete duct with a square cross-section of 3.6 x 3.6 m situated below the tank, connected to the Las Lajas Plant adduction.

Plan 020-CI-PLA-044 review D, attached to Annex 8 illustrates the diagram of the cross-sections and details of the Las Lajas forebay.

- **Alfalfal II Plant**

The Forebay of the Alfalfal II Plant gives stability to the plant's hydraulic system and constitutes the surge tank expansion chamber, as can be seen in plan 020-CI-PLA-057 in Annex 1. It is located in the Alto Aucayes sector, some 2 km to the east of this stream, at 2450 m.a.s.l.

The forebay, whose total volume is 48,100 m^3, will be completely excavated in rock as can be seen in plan 020-CI-PLA-057 in Annex 1.

The feed of the forebay will be done through the connection to the Alfalfal II tunnel that will take the water from the Yeso River collection and the Volcán II tunnel.

D. Electricity Substation (S/E)

The Alto Maipo substation includes an approximate area of 0.5 ha and will be mainly comprised of electrical equipment and protection and control equipment, used to raise the output voltage of the generators of the Alfalfal II and Las Lajas Plants. It will be located on the east edge of the Colorado River, at coordinates N: 6.287.130 E: 380.170 (Datum WGS 1984).

The substation will be of the "GIS" type, with a nominal voltage of 22,000 volts and will have nine high voltage line terminations, namely:

- Two line terminations to connect the generators of the Alfalfal 2 plant
- Two line terminations to connect the generators of the Las Lajas plant
- Two line terminations to connect the two circuits of the high voltage line that will connect with the SIC Central Interconnected System
- One line termination to connect a simple circuit line that will connect with the Alfalfal plant substation

- One busbar coupling termination since the substation will have a double internal connection system (double busbar) to facilitate operation and maintenance, and
- One auxiliary measuring termination and grounding of busbars

E. Bridges and Minor Crossing Works

The PHAM includes the construction of bridges in the Colorado and Yeso Rivers and in the Manzanito and Aucayes streams, all on private roads. These bridges will comply with the standards of Chapter 3.100 of the MOP Highways Manual, and with the technical general Specifications of the Bridges Department of the same entity. They will essentially consist of a slab of reinforced concrete on metal beams, which will be supported on abutments on both sides of the river.

During construction, the intervention in the river course will be minimal, since the execution of the abutments will be programmed in the low flow season to then continue to place the beams, which is done from outside the flow of the river. For an adequate protection of the bridge against rises in water levels and subsidence, a rockfill will be placed against the abutments, which will constitute the only direct intervention made to the river, without deviations or constrictions.

- For the crossing of lesser water, solutions of the road drainage type will be used, for which pipes of corrugated steel will be used, with the diameter and number determined in accordance with the flow. These pipes will be covered by stabilizing material which will constitute the pebble layer.

F. Siphons

The PHAM includes the construction of 4 siphons that will cross the El Morado stream and the Yeso and Colorado Rivers. The general characteristics of these siphons are indicated in the following table:

Table 2.2.4
General Characteristics of the Siphons

Sector	Description	Cross-section (m^2)	Total length (m)
El Morado Stream	Steel piping	4.5	70
Yeso River	Steel piping	7.5	130
Colorado River	Concrete duct	4	105
Colorado River	Concrete duct	9	170

These siphons will be built under the bed of the water course, for which it will be necessary to temporarily detour it. Once the siphon is built, the original bed will be reinstated and protected with rockfill consolidated with concrete. The depth of the crossing under the river bed will take into account the depth of subsidence for the flow of the design increase in water level. In the case of the El Yeso siphon, this flow will be limited to the maximum discharge from the dam.

G. Discharge Pipes

In normal operations, the Alfalfal II plant will discharge its water into the Las Lajas tunnel through the discharge tunnel whose characteristics are indicated further below. In situations of emergency or interruption of operations of the Las Lajas Plant, the water can be discharged into the Colorado River through the Forebay of the Las Lajas Plant through a pipe provided with energy dissipation and protection elements that are appropriate to the riverbed and banks.

The Las Lajas plant will discharge directly into the Maipo River, through a discharge pipe projected through a canal excavated in rock.

For the situation of transient operation, a discharge pipe has been provided in the Yeso River, which will allow water to be discharged from the El Volcán tunnel to the Yeso River in the case of a rejection of load by the Alfalfal II Plant.

Discharge pipe into the Colorado River

The discharge pipe into the Colorado River is materialized through discharge pipes of reinforced concrete which include hydraulic energy dissipaters designed in such a way that the delivery of the water to the flow of the river is done without producing hydraulic alterations. In the discharges, the presence of blocks and rock is seen, which constitute a natural protection.

Discharge pipe into the Yeso River

A discharge pipe into the Yeso River is included, located 400 m downstream from the collection and designed to drain the flow of the El Volcán tunnel as well as the El Yeso collection.

The discharge into the Yeso River incldes a hydraulic energy dissipator of the toe wall drop type that ends in the flow of the Yeso River, designed in such a way that the delivery of the water to the river flow is done without producing erosion.

The pipe consists of a derivation chamber 3.6 m wide and 5 m long, where steel piping 2,5 m diameter is located, which serves as support to two remotely controlled butterfly type valves located in series. From the point of derivation to the discharge of the river, the pipe is 60 m long. The discharge is done at 2,472.5 m.a.s.l. in the Yeso River.

Discharge Pipes into the Maipo River

The final discharge of the flows generated by the Las Lajas Plant into the Maipo River is located downstream from the confluence of this river with the El Manzano stream, in the sector referred to as Las Lajas. The discharge is projected as a canal excavated in rock, with a base width of 7.0 m.

In this area there is a rock mass of excellent quality that goes upstream as well as downstream from the discharge. To avoid destabilizing the riverbanks, the discharge has

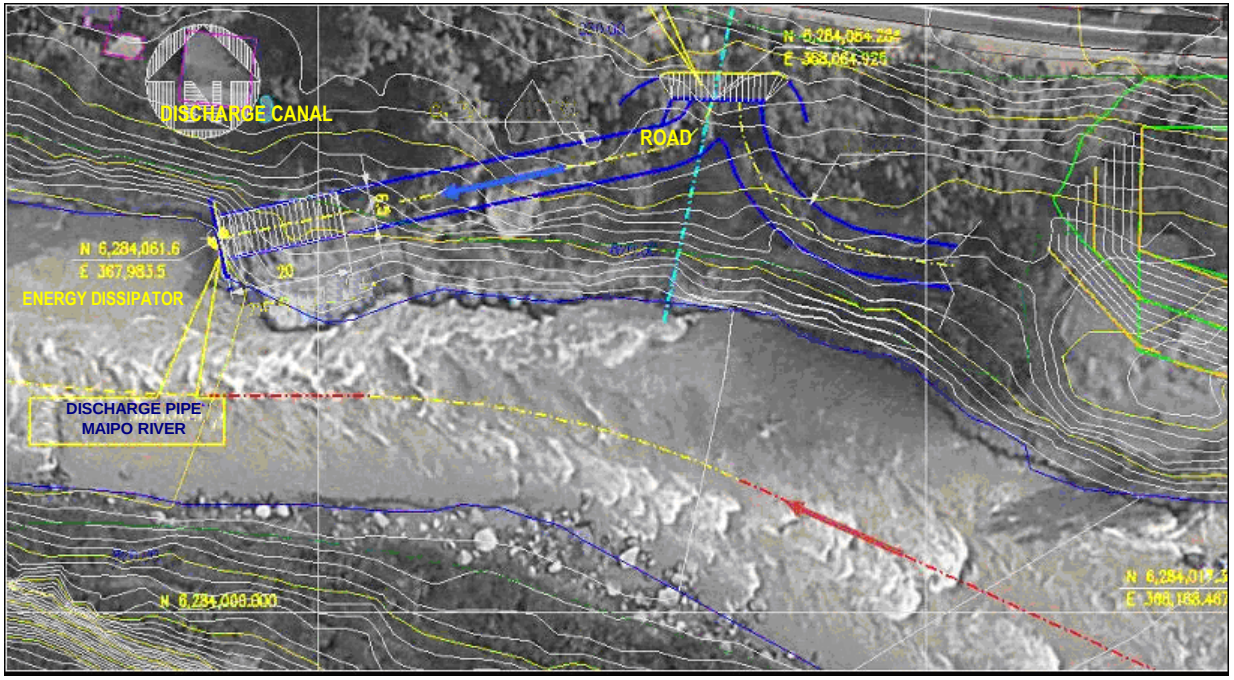
been projected parallel to the flow, as seen in Figure 2.2.14, for which there is no possibility of erosion in the opposite bank.

Protection rockfills will be installed immediately upstream from the discharge, using the muck removed from the excavation of the Las Lajas discharge tunnel.

The protection works use an existing concrete wall on the right bank of the Maipo river which will be reinforced with the installation of gabions on it. Another sector includes the installation of a double layer rockfill, with rocks of W_{min} 1.000 Kg. placed on a slope 2:1 (H:V) on a geomembrane of gr./m² .

We now show the area of discharge in the following photographs.

Figure 2.2.12
Diagram of the discharge of the Las Lajas Plant into the Maipo River



Photograph 2.2.3: Right hillside Maipo River in the area of the Las Lajas Plant Discharge

Photograph 2.2.4: Discharge Point seen from Downstream

Photograph 2.2.5: Close-up of the right hillside of the Maipo River in the area of the Las Lajas Plant discharge

Photograph 2.2.6: Old wall seen from the right bank of the Maipo River that forms part of the protections indicated in the discharge plan

2.2.3 Underground Works

The underground works of the PHAM are comprised of the tunnels, shafts, surge tanks and caverns. In this respect, we now present a general description of these underground works:

A. Tunnels

The project includes the construction of 70 km of tunnels, of which approximately 60 km correspond to the hydraulic tunnels, and the rest are comprised of the access windows to the main tunnels, the access tunnels to the machines caverns and the respective discharge tunnels of both plants.

- Adduction, access and discharge tunnels

  — The El Volcán tunnel, which has pressure runoff, will take water from the Engorda, Las Placas, Colina and El Morado streams. This tunnel, 14 km long, begins at an approximate height of 2,500 m.a.s.l. and ends at the connection point with the intake pozo at height 2,480 m.a.s.l. in the El Yeso sector.

  — The Alfalfal II adduction tunnel, 15 km long, will take water en presión from the Volcán and Yeso Rivers. It begins at a point situated some 1,100 m south of the Lo Encañado lagoon at a height close to 2,432 m.a.s.l. and ends at the beginning of the plant's drip shaft.

  — The Las Lajas adduction tunnel, approximately 9.6 km long, begins at the connection pipe with the Colorado River siphon and takes the water from the discharge of the Alfalfal Plant and from the Maitenes intake to the pressure shaft of the Las Lajas Plant. Along its path, it receives water from the discharge of the Alfalfal II plant.

  — Reinforced pressure shafts: The drop shaft of the Alfalfal II plant is 850 m long and occurs between heights 1,950 m.a.s.l. and 1,340 m.a.s.l., corresponding to the end of the Alfalfal II tunnel and the machines cavern respectively. The steel piping that along with the tunnel form the denominated reinforced pressure shaft will be installed inside this tunnel. There will also be a reinforced pressure shaft between the adduction tunnel and the machines cavern of the Las Lajas plant, which will be 162 m long. As in the Alfalfal II plant, this tunnel will be lined with steel piping.

  — Access tunnel to the Alfalfal II plant: this tunnel will developed between the access hall located in the valley of the Aucayes stream, at height 1,506 m.a.s.l., to the machines cavern that will house the plant's generating equipment. It is 2.4 km long and has a cross-section of 38 m2

— Access tunnel to the Las Lajas Plant: this tunnel is developed between the access hall located in the Colorado River valley, at height 1,025 m.a.s.l. to the machines cavern that will house the plant's generating equipment. It is 2.0 km long and has a cross-section of 38 m2

— Alfalfal discharge tunnel: 3.4 km long and has a cross-section of 21 m^2, discharges the water generated by the Alfalfal II plant to the adduction tunnel of the Las Lajas Plant

— Las Lajas Discharge tunnel: this plant's discharge tunnel has a cross-section of 33 m2 and is 13.54 km long, and takes the water generated by the Las Lajas plant by free flow and discharges it into the Maipo River.

The general characteristics of the tunnels are summarized in Table 2.2.5.

Table 2.2.5
General Characteristics of the Tunnels

Tunnel	Type of cross-section	Area (m^2)	Length (Km.)	No. of windows
El Volcán	Half point/circular	12/13	14	0
Alfalfal II	Circular/half point	16	15	1
Las Lajas	Half point	21/30	9,6	2
Alfalfal II Discharge	Half point	21	3,4	0
Las Lajas Discharge	Half point	33	13,4	1
Alfalfal II Access	Half point	38	2,4	0
las Lajas Access	Half point	38	1,9	0

The intermediate access windows have the objective of generating other work fronts (additional to the halls at each end) and muck discharge circuits.

B. Surge Tanks

The surge tanks are needed to absorb the transient phenomena of the operation of the plants (intakes and rejections of load).

Both plants will have surge tanks, whose specific characteristics will be defined in the detail engineering stage. In general they are vertical shafts with an expansion area in their upper part, which are connected to the respective adduction tunnels.

- Alfalfal II Surge Tank

The Alfalfal II surge tank is located at coordinates E: 385.550 N: 6.284.325 and is comprised of a shaft inclined over 500 m long with a circular cross-section and a diameter of 3.4 m, which connects to the adduction tunnel. The above can be seen in plan 020-TU-PLA-007 of Annex 1.

The surge tank will be excavated in rock. In the zones where the rock is good quality, this will not be lined and in the areas in which the rock is bad quality, it will be lined with 15 cm of shotcrete. It is estimated that 50% of the areas of these units will need shotcrete lining.

Finally, in the upper part, the shaft will widen to constitute the plant's forebay, whose characteristics are described in section 2.2.2 of the Surface Works.

- Las Lajas surge tank

The Las Lajas surge tank is located at coordinates E: 380.380 N: 6.286.850 and will be comprised of a communication shaft between the land and the body of the surge tank, which will be 5 m in diameter and 152.7 m high. The body of the surge tank will be a cylindrical cross-section 10 m in diameter with a height of 48.8 m, and the communication shaft between the surge tank and the Las Lajas tunnel will be 295.25 m high.

The body of the surge tank and the shafts will be excavated in rock. In the zones where the rock is good quality they will not be lined and in the areas in which the rock is bad quality they will be lined with 15 cm of shotcrete. It is estimated that 50% of the areas of these units will need shotcrete lining.

Finally, for safety purposes, the plant at ground level will install barriers at the shaft in order to prevent the entry of foreign bodies into the system. This pipe corresponds to an extension of the shaft, for which it will be 5 m in diameter, and will extend 3 m on the natural land. It will have a protection slab in its upper part, which will allow air to enter and exit.

Figure 2.2.13
Diagram of Alfalfal II surge tank

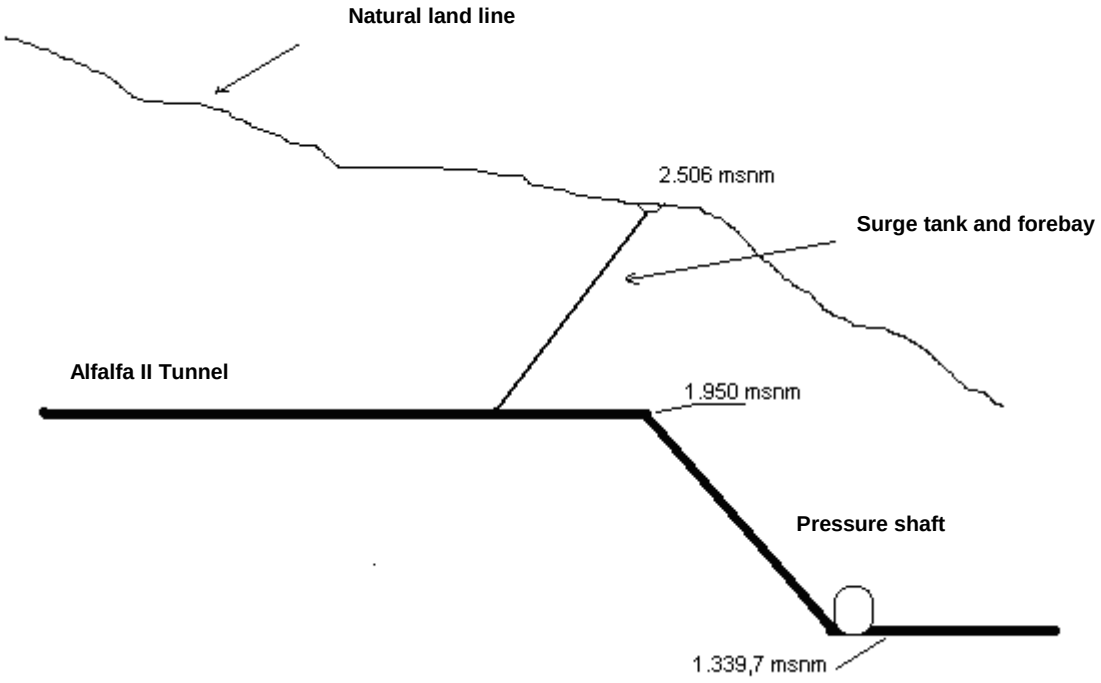
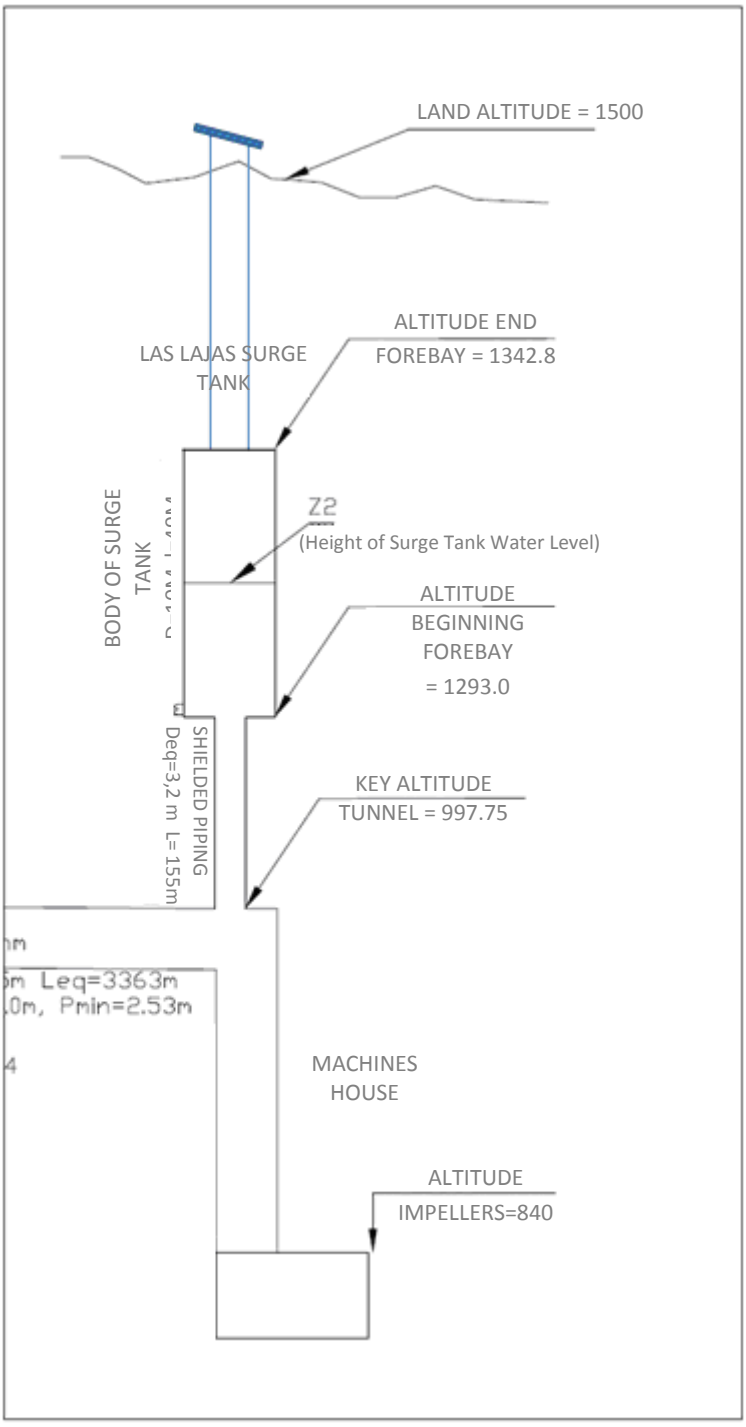


Figure 2.2.14
Diagram of Las Lajas surge tank



C. Machine Caverns

The machine houses will be installed in caverns excavated in the rock mass, using a total surface of 1500 m^2 for the Alfalfal II plant and 1700 m^2 for Las Lajas.

The structure of the machines house will be of reinforced concrete and its accesses will be through the respective tunnels described previously.

The electomechanical equipment will be housed inside the machines caverns, comprised of Pelton type turbines whose characteristics are indicated in Table 2.2.6 and synchronic type generators with a nominal power of 145 MVA for the Alfalfal II plant and 148 MVA for Las Lajas. It will also house the auxiliary services and the cooling systems.

Table 2.2.6
Turbine characteristics and equipment

Characteristics	Alfalfal II	Las Lajas	Unit
Number of units	2	2	[No.]
Nominal flow	13,5	32,5	[m^3/s]
Net nominal head	1.137	468	[m]
Nominal power	136	135	[MW]

2.3 DESCRIPTION OF THE STAGES OF THE PROJECT

2.3.1 Stage of collection of information

The titular of the project has carried out the technical, economic and environmental feasibility studies for the project, whose results have been included in the definition of the works. In particular, in the environmental issues, from the stage of feasibility the studies carried out allow the project to be sensitized in those aspects that could be addressed from the design of the works. This is the case of the reduction or concentration of the surface requirements of the project, the criteria for the location of temporary facilities and the layout of service roads, among others.

2.3.2 Construction Stage

The programming of the construction works indicated below include a series of measures of the environmental and safety type, which are incorporated from the engineering design to the execution of the project. In this regard, chapters 6, 7 and 8 indicate the control, compensation and environmental follow-up measures respectively.

2.3.2.1 Construction of the Surface Works

The most important activities for the preparation of land correspond to the cleaning and clearing of the land required for the construction and setting up of the works. These correspond to the removal of the plant layer and other similar materials that impede the on-site works. The plant layer will be removed in those areas where it is strictly necessary and mainly in the sites of worksite facilities and camps, setting up of muck stockpiling sites, surface civil engineering works and the construction and improvement of access roads to the work fronts.

Approximately 675,000 m^3 will be excavated and part of the common excavation material will be re-used in the fill of the excavations, construction of embankments and improvement of roads, among others. The works include different construction activities that include excavations and fills, which will be designed in such a way so as to compensate the cuts with the fills, depositing the surplus material in the stockpiles provided by the project in accordance with that indicated in Annex 6, “Muck stockpiling Site Management Plan”.

The 105 ha area intervened that will be occupied by the different project works, permanent and temporary, such as the civil engineering works, stockpiling sites, camps and work fronts, correspond to small interventions on the surface, specific or lineal in nature, that will provide the necessary culverts to channel and drain the rain water to so avoid altering the aquifer refilling mechanisms in the improbable case that these exist in the zones used by the project (see Annex 25).

A. Collection works

The collection works will be built in accordance with that indicated in the plans and specifications of the project in each one of the streams and will have a fixed barrier, to raise the level of the water and allow its entry into the adduction canal, and hatches that permit cleaning the gravel and sand that accumulate in the entrance of the adduction canals. The construction of these works begins with the temporary deviation of the respective water flow and the excavation of the support platform of the structures. Subsequently, the works of rebar and concrete will be done and finally the execution of the structural fills and protection rockfill. Finally, the hydromechanical equipment will be mounted.

B. Forebay

- Las Lajas

The works will begin by clearing the land to remove the plant layer. Then the earth will be moved using the excavation material in the embankments that will comprise the perimeter walls of the tank. Once the excavations have been carried out and prior to the construction of the embankments, all the annexed works will be built of reinforced concrete (discharge, emptying, cleaning). Finally, the waterproof layer will be installed.

For the specific case of the playing field (owned by the Ministry of National Assets and resources) used by the community of El Alfalfal and located in the area projected for the forebay, the Titular will replace this infrastructure by another with similar conditions, built on land owned by AES Gener S.A., which borders the ex-Maitenes camp. The above was agreed in meetings held with the management of the Alfalfal - Maitenes Sports Club and the Colorado River Neighborhood Residents' Committee.

- Alfalfal II

The forebay of the Alfalfal II Plant will be excavated completely in rock from the inside of the tunnel. The material of the excavation will be transported along the tunnel and will be deposited in the stockpile located in the Aucayes Alto sector.

C. Electrical Substation (S/E)

The construction of the S/E will begin with clearing the area and the construction of the exterior security fencing and another inside the property. Subsequently, the movements of earth will be carried out and the construction of the foundations, and supports of structures (metal and of equipment). Then the yard structures and electrical equipment will be assembled, and the protection and safety systems installed.

D. Pipes

The construction of the pipes begins with the excavation of variable ditches between 3 and 4 m width depending on the dimensions of the ducts. The depth of the ditch will be in accordance with the dimensions of the pipe.

In general, the excavations will be done in the direction of the slope to allow draining the rainwater and others that may eventually be in the ditches. In those cases in which the

conditions of the land make it necessary, the slopes of the ditch will be shored up.

If water is accumulated in the ditch due to rain or another cause, it will be drained by gravity or by mechanical means (pumping), to allow the construction work to be carried out appropriately. In those sectors which cross streams or ravines, piping will be installed which will be reinforced with concrete blocks.

Once the concrete structure has been built or the piping installed, as applicable, the fills will be done in accordance with that indicated in the plans and specifications of the project's detail engineering.

E. Siphons

The construction of siphons (crossing of the Colorado and Yeso rivers and the El Morado stream), begins with the temporary detour of the flow, to then carry out the work in accordance with the project's plans and specifications.

The layout of the detour will be done in the same water course, and will minimize the intervention of the river banks. For the Yeso and Colorado Rivers, the detour can have a maximum length of 40 m. The duration of the intervention in the Yeso and Colorado rivers for the execution of the works will be 1 year.

Once the siphon is built, the original riverbed is reinstated and is protected with rockfill consolidated with concrete. The depth of the crossing under the riverbed will take into account the depth of subsidence for the flow of the design rises in water levels. The dimensions of the riverbed allow a deviation of the flow of the river in the low-water season excavated in the water course, which is reinstated once the siphon is built.

In the case of the El Yeso siphon, this flow will be limited to the maximum discharge from the dam. A pipe will be installed to deviate the water during construction, and will be removed as soon as the works end.

2.3.2.2 Construction of Underground Works

A. Volumes of Excavation

It is foreseen that the construction of tunnels will generate a total of approximately 1.7 M m^3, of rock material, which will be transported to the muck stockpiling sites in accordance with that described in the Muck Stockpiling Sites Management Plan, attached in Annex 6 to this EIA. This material will be transported in carts on rails and/or on conveyor belts to the muck stockpiling sites, except for some works in the Colorado sector (Las Lajas plant) where it will be transported in hopper trucks, in accordance with the construction sequence of the works.

Table 2.3.1 indicates the approximate volume of rock materials removed in the different excavation fronts.

Table 2.3.1
Volume of Excavation in Rock

Stockpiling site	Quantity of rock material (M3)
1	89804
2	99261
3	0
4	125481
5	277349
6	0
7	101167
8	43333
9	335329
10	56667
11	49417
13	175000
14	15833
12	287500
Total (M3)[1]	1716141

In general terms, the 1.7 Mm^3 of rock material, added to the natural increase in volume of the rock and the fill material removed from the construction of roads and escarpes (675,000 m^3), gives a total of 2.7 Mm^3 of material to dispose of in the muck stockpiling sites (see Annex 6).

B. Construction Method and Drilling System

The construction of the tunnels is a sequential and progressive activity, which allows the possibility of working on simultaneous work fronts. Given the characteristics of the tunnels and the composition of the rock, the construction method used will be the “drill and blast” method, a progressive boring method with controlled blasting. The drilling diagrams will depend on the type of rock found.

As a supplement, the use of TBM (Tunnel Boring Machines) is included, that drill the rock through a tunneling machine.

On the other hand, and for reasons of constructability and optimization of the time periods for execution, the following work fronts will be used, distributed in the halls as well as in the windows:

- El Volcán Tunnel: Two (2) work fronts; at the entrance hall at the Volcán River valley and exit in the Yeso River valley.

- Alfalfal Tunnel: Three (3) work fronts: one front by window 1 and 2 fronts through window 2, located to the west of the Aucayes stream in the Colorado River valley.

- Alfalfal II discharge tunnel: 1 work front from the access tunnel to the plant.

- Access tunnel to the Alfalfal II machines cavern: 1 work front from the entry portal located towards the Aucayes stream flow.
- Las Lajas Tunnel: Seven (7) work fronts; 2 fronts in each window (3) plus 1 front along the tunnel entrance hall, all in the Colorado River valley
- Las Lajas Discharge Tunnel: 1 work front from the exit hall in the Maipo River
- Access tunnel to the Las Lajas machines cavern: 2 work fronts from the entry hall in the Colorado River valley.
- El Yeso Tunnel: One (1) work front, from the entry hall.

Presence of water during the excavations

It must be indicated that the project does not include using these possible leaks to increase the production of power. The design principles that regulate the project are oriented towards limiting the presence of leaks during construction, in order to establish efficient conditions in the excavation works.

So, in normal practices during the excavation of permeable zones, they are treated to make them as weatherproof as possible which helps their long-term stability and avoids subsequent repairs that make it necessary to stop these same tunnels functioning. More details on the treatment of leaks and in general the hydrology of the underground works and are attached in Annex 45.

C. Loading and Transport of Excavation material

In general the transport of muck from inside the tunnels to the stockpiling sites is on rails or conveyor belts; this is possible due to the location of the muck stockpiles close to the tunnel halls. This transport method minimizes the emission of dust resuspended by the vehicular flow.

In the cases where the above is not possible, hopper trucks with 12 to 15 m^3 capacity will be used for transport. The detail of the type of transport used is indicated in Annex 28. Trucks will be used for the construction works in the access tunnels.

2.3.2.3 Setup of Equipment, Testing and Entry into Operations

The activity that follows the execution of the surface and underground civil engineering works is the assembly of the hydro and electornmechanical equipment of the project. This equipment will be manufactured in accordance with design specifications and will be supplied through contracts with international companies.

The equipment will be transported from the port of arrival to the worksite, using a site especially set up for its storage.

2.3.2.4 Setup of Camps and Worksite Facilities

The construction of the PHAM involves the setup of 5 camps and 7 worksite facilities. The location of each one is illustrated in Figure 1 “Layout of the Project” attached in Annex 1 to the EIA.

Regarding the camps, each will have a staff of approximately 200 workers in the smallest and 400 in the biggest, including professional personnel, technicians, workers, drivers and operators associated with the kitchen, maintenance of the camp and health auxiliaries. Also, the camps are setup for the housing of personnel who will work on the construction sites; each area will be provided with hygienic services, potable water, first aid rooms, dining hall and recreation areas. These facilities will be built with materials in accordance with high mountain weather.

On the other hand, each one of these camps will house a contingent of workers that will remain in each sector for some days, moving in general short distances between the work fronts and the camp. For this reason, the camps will have the resources, commodities and safety conditions so that workers can overnight in the area and have at least two weeks’ autonomy given their high mountain nature.

The worksite facilities will have spaces for the contractors’ offices, machinery needed, warehouses, storage sheds, maintenance workshops, potable water services and hygienic services, parking for vehicles, areas for the transitory stockpiling of materials (waste management yards), etc. They will be built on the basis of prefabricated panels and metal structure industrial sheds.

With the objective of complying with the responsibility for good working practices in the camps and worksite facilities by the contractors and subcontractors, the Titular has prepared a document that contains the General Rules of Operation of Camps and Work Fronts, attached in Annex 33 to this EIA. This document sets of the general aspects of the management of construction works contracts that Gener will implement for the development of the PHAM, particularly in that referring to the Conduct and Behavior of contractor and subcontractor workers.

On the other hand, supported on the environmental pre-feasibility studies and the basic studies that form part of this EIA, the location and conditions of camp management have considered the environmental variable to prevent effects on the biotic resources, soils, surface water and landscape. The above is shown in the following environmental management aspects:

A. Placement Criteria

- The land defined for the placement of the camps do not correspond to land with agricultural use. In the high areas, the camps will be located outside the areas of summer grazing use and high mountain vegetation in ravines or in zones with constant irrigation.

- Particularly in the Colorado River sub-basin, the cutting and wear to native bush or herbaceous vegetation formations that constitute forest will be minimized.

- The camps will be placed in sectors without the risk of avalanche and as far as possible from points of observation from public roads or scenic points.

- Finally, and in accordance with the Baseline Studies, the land defined for the installation of worksites and camps has been prospected by specialists, and the presence of findings or sites with archaeological or historical value or belonging to cultural heritage, or species of plants that are in some conversation category has been ruled out in a preliminary manner.

B. General Characteristics of the Camps and worksite facilities

The camps as well as the worksite facilities will have internal roads for the free circulation of the vehicles and works personnel, which will be lined with stabilizing material. These roads will be connected with the roads that go to the work fronts.

In general, the project includes:

i) Potable Water

In all the camp sites, a potable water system will be set up, which will extract the water from nearby ravines or streams after authorization from their owners. If there is insufficient water available for the requirements of the camps, the Titular will present applications for the respective consumptive use water rights. The potable water system will include a filtration and disinfection treatment, a system of impulsion to the storage tank and to the distribution network to the bathroom fixtures. These potable water systems will comply with that provided in DFL 1/90 of the MINSAL. Prior to the operation of the system, physical-chemical analyses will be done of the potabilized water in accordance with the parameters established in NCh 409/84 “Water Quality for Potable Use ".

The potable water will be distributed to the work fronts from the camps and will be stored in ad-hoc tanks.

A priori a conservative estimate is made of an approximate total demand of 80 m^3/day in each camp for the concept of human consumption, considering an average minimum supply of 200 liters per day per worker (400 workers).

ii) Hygienic Services

A sequential sedimentation system will be set up at all the camps. Chemical toilets will be set up at all the work fronts. Each one of the installations (camps, worksite facilities and work fronts) will have a number of bathroom fixtures (toilets, showers, washbasins, etc.) in accordance with that established in D.S. 594/99 of MINSAL, especially in that regarding quantity and distance to the work post.

Gener will ensure that the contractor keeps these services well-maintained and functioning.

iii) Solid waste

In the Project construction stage, solid waste will be generated corresponding to surplus excavation materials and cuts for the construction of tunnels, roads and machines caverns.

This waste will be transported to the muck stockpiling sites, in accordance with that indicated in section 2.3.2.2, letter C.

Regarding the waste from construction, a minimum generation of this is foreseen, given the use of pre-assembled materials and their re-use or sale. Without prejudice to this, temporary areas will be set up in the camps for the storage of this waste, referred to as waste management yards, in which will be disposed basically remains of wood, rebar, formwork, some solvents, oils and lubricants, the latter from minor maintenance activities on machinery and vehicles. This property will be fenced, will have a waterproof floor and will have a spill gutter in its design. It will also have fire extinguishers and be correctly signposted.

Solid household waste or similar will be accumulated temporarily in containers with lids and removed from the camps as well as from the worksite facilities. The collection of this waste will be done by the contractor who will have trucks or pick-up trucks enabled to transport this waste to an authorized dump.

iv) Fuel

The storage of fuels (diesel, gasoline, gas, etc.) as well as the oils, lubricants, solvents and others that are necessary to carry out the works at the worksites, will be done through tanks and or storage drums, used in closed areas especially set up for this, which will have containment parapets against possible spills, signposting that indicates the presence of flammable products and the prohibition to smoke inside and around the property, sand or sawdust to control spills and a dry chemical dust extinguisher. The tanks and/or drums will be hermetic and resistant to pressure and blows and will be stored tidily, in accordance with the provisions of D.S. 379 of the Ministry of Economy, Development and Reconstruction of 1985, which establishes the minimum safety requirements for the storage and handling of liquid fuel derived from petroleum.

On the other hand, Gener will ensure that the works contractor complies with the rules regarding transport, storage and handling. For this the Titular has developed a Waste Management Plan for work fronts, works and camps that is attached in Annex 18. This management plan describes the procedures and equipment necessary for the management and disposal in an efficient, safe and responsible manner, of the waste generated in the project's construction phase. This document details the responsibilities that the implementation of the plan will delegate, and what records and reports will be required for the purposes of control and supervision. The fuel will be supplied by tanker trucks owned by distributor companies to the work and camp sectors, from the stations established in the Metropolitan Region.

Regarding the management and storage of explosive material used in the rock excavation works, the contractor will have the respective authorization in accordance with that established in DS 400/78, Min. of Defense and it will be stored in authorized arsenals.

C. Closure stage

For the temporary facilities, AES Gener will have a complete and thorough program of closure and withdrawal from the areas and facilities and the subsequent cleaning and/or

restoration of the sites occupied temporarily.

The facilities that will be used in the construction phase that will be removed or dismantled will be camps, worksite facilities and the work front platforms used for the access and placement of other small facilities.

The camps and worksite facilities can be restored in the totality of the area that was occupied, while the platform must remain permanently as an access road to the tunnel and a small work space (400 m^2 approximately) for minor auxiliary facilities.

The main activities provided for the total or partial removal (in the case of some platforms) of the facilities and the restoration of the areas intervened are the following:

- Dismantling and total removal of the worksite facilities and camps, which include the offices of the contractors, personnel and workers' rooms, machinery needed, warehouses, storerooms, maintenance workshops, potable water services and hygienic services, parking for vehicles and transitory material stockpiling areas, etc. The potable water installations will be removed, including piping and storage tanks, as will the sanitary installations, consisting of modular chambers of the treatment plant per camp plus the sewage network and chemical toilets.

- Removal of the electrical installations, a procedure realized by specialized personnel, including the posts and wiring placed by the project in some sectors, except those that will supply the works with electricity during the project operation. Also, the generating equipment installed in each camp will be removed.

- The solid waste from the construction, stockpiled in temporary areas, will be removed completely, as well as others that may be spread out in the camps, work sites and neighboring sectors.

- After the removal of all the mobile elements, the fencing, anchoring and other minor elements will be removed, as well as remains of concrete due to the preparation of mixes, decantation pools, etc.

— The soil will also be cleaned if there are spills of liquids or substances used for the execution of the works that are foreign to the soil. The soil will be cleaned, with the entire surface layer affected being removed and transported to a site authorized for its treatment and final disposal.

— Once the area is free of all type of installations, elements or substances that are foreign to the environment, the soil will be decompacted in the areas where it has been compacted (Constructions, internal roads, etc.).

— The upper soil layers that have been stockpiled for these effects will be used (See Annex 29 “Plant restoration plan”).

— The preexisting vegetation will be replaced as far as possible, in order to control erosion, visual mitigation and the restoration of the fauna habitat (see Annex 29 “Plant vegetation plan”).

— The plantations will be monitored for the first 5 years from when the planting is done. This monitoring will be done in the spring in order to monitor the development of the species, and the possible appearance of points of erosion will be controlled prior to the following winter (see Annex 29 “Vegetation recovery plan”).

The activities of closure and restoration of the areas used temporarily will be contractually required from the Contractors.

2.3.2.5 Construction and Improvement of Access Roads to the Work Fronts

- **New Service Roads**

Given the conditions of inaccessibility of a large part of the project area, approx. 31 km of roads will be built, which will be used for the transport of the muck and movements of land in general, the transport of personnel, machinery, equipment and supplies and consumables that the contractor requires in the camps, worksite facilities and work fronts. Also, some of these roads will be used during the operations stage for the transport of personnel that carry out the task of maintenance and monitoring of the permanent facilities.

Table 2.3.2
Construction of Roads

Sector	Width of strip (m)	Length (km)
Aucayes Ravine	10	18.7
Yeso	10	4.2
Colorado	10	0.7
Volcán	10	7.1
Total		30.7

The layout of these roads is shown in Figures 2.2.2 to 2.2.10.

A plan is attached in Annex 9 at a legible scale, with the roads that the Project will build, linking the location tourism interest, archaeological and landscape sites spatially in these areas, to verify that there are no interferences due mainly to the following:

- The work fronts are in general very isolated.
- The PHAM contractor or titular will not cut off transit or access to visitors or tourists.
- The environmental management of the PHAM will guarantee the safeguarding the archeological resources and will prevent any risk of interference with tourist or recreational activities.

The road use analysis conducted (see Annex 14) confirms that no significant effects are expected on the existing road use and where sites with tourism, archaeological and landscape interest are accessed.

Without prejudice to the above, it is important to indicate that given the geographical and landscape characteristics of the area in which the project work is carried out, no specific landscape attractions are identified, but rather elements with a high landscape value stand out that are repeated along the entire length of the area (see section 5.9 of the EIA), such as the presence of seasonal snow, existence of summer grazing, rocky slopes, seasonal lagoons and reservoirs of potable water such as the Lo Encañado lagoon and the El Yeso dam, sites whose access is currently restricted.

It must be highlighted that the project's design and engineering has included the following measures that optimize the construction of the new roads:

- The length of the roads has been minimized, due to the location of camps and sites of muck stockpiling in the areas near the windows of the tunnels and other work fronts.

- The layout of these service roads has considered minimizing the intervention of ravines and hillsides that present tree or brush vegetation. In this way, the use of pre-existing tracks has been given priority.

On the other hand, and in relation to the construction of new roads, the design of the layout and embankments, slope and maximum velocities, will be done in accordance with that indicated in the Highways Manual. Also the geotechnical studies associated with the type of rock and soil existing in the road layout sector will be carried out.

The construction itself of roads begins with the preparation of the land, mainly with the clearing of the area (rocks and plant materials). The slope cuts are then done, which are necessary in accordance with the layouts defined. Given that most of the works will be done on rocky material, in narrow topographical conditions, a cut will be made in the rock, through the use of controlled blasting with pre-cutting. Prior to the use of explosives, the Works Contractor will process the corresponding permits before the pertinent entities.

In those sectors that present risks given their topographical characteristics, the risk prevention measures indicated in Chapter 8 “Risk prevention measures in roads” will be taken.

Once the layout of the roads has been materialized, the surfaces will be stabilized through granular and/or bischofite layers. This later material is used as a dust suppressor on earth or gravel granular roads, keeping the surface of the road damp, impeding the suspension and resuspension of particulate material. The works contractor will keep the roads in a good state of repair at all times during the PHAM construction stage.

Once the construction of the roads has ended, signposting will be installed and the restoration and replacement of those areas occupied temporarily for the placement of the machinery will be carried out.

The works on the roads will form an integral part of the Project and will have the approval of the MOP Roads Authority.

Finally, during the execution of the works, if the contractor redefines new layouts or uses other existing roads, it will notify the authorities and comply with the environmental and/or sectorial legislation applicable to it.

- **Improvements to Existing Roads**

With relation to the improvements and the maintenance of the public roads existing in the PHAM execution area, the Titular includes the improvement of Highway G-25 (El Volcán sector) and Highway G-455 to the El Yeso dam, this due to the fact that both roads are currently in a bad state of repair. The road to the El Yeso dam has a standard upper layer of gravel, with precarious cleaning, and highway G-25 in the above-mentioned sector has an upper layer of granular material with a treatment apparently of salt only in the populated sectors to avoid dust rising due to the passage of vehicles.

The detail of the current condition of each of these roads and the measures of improvement of roads are indicated in section 5.6 of Chapter 5 and in Annex 19 “Road Maintenance Program”, both attached to this EIA respectively.

Finally, and prior to the beginning of the road improvement activities, the projects will be approved by the Regional Roads Authority of the Metropolitan Region of Santiago.

- **Maintenance of Roads**

This activity will be carried out to maintain operational the service roads set up by Gener, and the existing public or private roads, during the entire period of the construction of the works.

Table 2.3.3
Machinery used in the maintenance of the roads

Equipment	Number	Frequency	Total days per year
Tanker truck	1	Daily	151
Grader	1	Monthly (1)	84
Compacting roller	1	Monthly (2)	42
Hopper truck	1	Twice-yearly (3)	14

Notes: (1) One week per month; (2) Once week every two months; (3) One week twice a year

Regarding the use of the tanker truck, this is justified during the summer season, given the emission of particulate material generated during the activities of movement of land and the constant transit of vehicles. On the other hand, and as indicated previously, the construction of new roads will include the application of a Bischofite type dust suppressor, impeding the suspension and resuspension of particulate material in a more effective manner than continual wetting by the tanker truck.

Regarding this scenario, the Project Titular includes the use of the tanker truck in the following way:

- During the first year of construction of the project, and limited to the construction and improvement of roads. Its use will be daily in the areas where this work will be carried out, that is in the El Volcán, El Yeso and Aucayes sectors. Once the construction and improvement of roads has ended, the transit of the truck will no longer be necessary, since both directions of the roads will have agglomerates in their surface to mitigate the emission of dust. The characteristics of the improvement and construction of roads is detailed in Annex 19.

- In the work fronts of the surface works and the fronts located in the halls of the tunnels. In addition, the use of this wetting vehicle will be used in the muck stockpiling sites, allowing atmospheric emissions to be mitigated while unloading the material. Its use will be extended throughout the entire construction stage of the works (see Gantt chart, attached in Annex 2), with a daily frequency.

Regarding the number of trucks, it is foreseen that there will be one truck per work area (El Volcán, El Yeso, Alfalfal, Aucayes and Las Lajas).

The above added to the other atmospheric emissions mitigation measures described in chapter 6 of the EIA and those indicated in the Emissions Study, attached in Annex 5, will allow the effective control of all activities with a higher generation of particulate material.

2.3.2.6 Muck stockpiling sites

The PHAM includes setting up 14 muck stockpiling sites for the tunnels and a smaller volume of remains of inert material from the opening of roads and construction of canals. The plans of the stockpiles, as well as their Management Plan, are included in Annex 6. It is estimated that the total volume at these sites, including volume of rock (expansion) and soil, will reach a total of around 2.75 M m^3.

For the selection of the sites of location of the muck stockpiling, their design and management rules have been considered, as well as technical, environmental and safety criteria.

A. Location

The location of these muck stockpiling sites is illustrated in Figures 2.2.2 to 2.2.10.

From a technical and safety point of view, the muck stockpiling sites have been located as close as possible to the windows of tunnels and other surface work fronts, in areas without the risk of avalanches or landslide areas.

Regarding the environmental criteria of location, the following has been considered:

- They have been located far from any type of population or houses used for permanent or temporary housing.
- The location of these sites has prioritized those zones with low visual impact, that is, as far as possible form points of observation, whether from public roads or elevated areas.
- In the high section of the Project area, the fill sites have been located in a form attached to natural elevations, so that the fill terraces give continuity to the general morphology of the zone.
- In general, these are sectors with little soil value (land with V, VI and VII use capacities), where altering the original morphology of the land and the interruption of surface water courses has been avoided.
- In these sectors, the existence of findings or sites with archaeological value has been ruled out, according to the results of prospective surface studies.

B. Setting up of Muck stockpiling sites

- The public roads that will be used to access the muck stockpiling sites will be set up with the road and signposting solutions proposed by the study of the road capacity in the PHAM area.

— It will be a priority that the height of the muck material and its final morphology at closure complies with the relief characteristics where it is located.

— While the muck stockpiling sites are under construction, there will be controlled access to the deposit area. For the sites located in sectors with easy visibility, wood and wire fences will be installed. The use of green barriers with species existing in the surroundings will be evaluated, especially for the case of the stockpiling sites on the banks of the Maipo and Colorado Rivers.

— The corresponding signposting will be installed in order to protect the safety of workers and visitors.

C. Operation of the mucks stockpiling sites.

The manner in which the surplus of the excavation will be deposited is the following:

— First the vegetation layer will be removed until it has the proposed gradient, then 1.5 m height of tunnel excavation materials will be deposited, then it will be compacted with heavy machinery and so on. The material will be deposited in the form of terraces.

— The muck stockpiles will be done in an ordered manner, forming even and safe platforms, with natural slopes formed of the same material, ensuring their stability. Finally, it will be covered with 20 cm of fine materials, to then place on this surface the vegetation cover from the materials removed previously from the first sites, which will be removed and stockpiled temporarily, to then be placed at the site during the closure works of the respective stockpile, in the low areas of the project, until it has the gradient proposed by the Works Contractor and approved by GENER. In addition, a soil reclamation will be carried out from the areas of locations of roads, pipes and tanks, which will be used to restore the stockpiling sites and other surfaces used temporarily. It is feasible to remove a surface layer of soil from the total area to be intervened, for the subsequent restoration of the vegetation, from the muck stockpiles and from the soil from the clearing for the surface works of the project. These volumes will be available for the restoration of the vegetation.

— It does not include obtaining organic soil from other areas not related to the Project.

— The area surrounding the muck stockpile site and its access roads will be kept free from excavation material and will be in perfect conditions for transit.

— The transit of machinery and vehicles will only be done along the authorized accesses and roads and defined for the project works. The Contractor will clearly outline the areas of circulation and parking for vehicles and machinery linked to the activity, absolutely restricting the use of areas not authorized by the works inspection.

— The internal roads of the stockpiling site will be stabilized in accordance with that described in section 2.3.2.5.

— Organic remains, junk, wood or paper, mud or other materials will not be placed in the project's muck stockpiling sites.

D. Decommissioning

— As indicated previously, the format for of each deposit will be in accordance with the topography of the place. Each terrace at the site will be leveled until it has a flat surface, and the slopes from the piling and compacting of materials will be profiled until they reach the natural slope of the materials, avoiding landslides, detachment or erosion of material by rainwater.

— All types of temporary structures or areas of the Contractor will be removed from the sites. Signposting will also be removed.

— Sterile material will be lined with scarified soils from clearing or, if this is insufficient, with other natural engraftment soils in the area. This lining will have a minimum thickness of 20 cm.

— The plan for the restoration of vegetation will allow the natural ecological succession process to be accelerated and encouraged, after the perturbation of the project works. For this, pioneer or colonizing species will be used and late-developing species. The colonizer species, once established, act as tanks for the intermediate or late-developing species, also favoring the recruitment of the latter.

All the measures indicated above will be implemented by the Works Contractor. GENER will carry out an environmental follow-up plan for the management and use of sites, which will include on-site inspections and periodic controls of the records of entry to the site, among other actions.

2.3.2.7 Extraction, Use and Handling of Borrow Pits

The project does not include special areas for the extraction of borrow pit materials or of aggregates.

In the El Volcán and El Yeso works sectors, the requirements for these materials will be covered with the surplus from the excavations of the works existing in the project's river flows. Namely, intakes, siphons, abutments of bridges and protection rockfills. The material from the excavations for the foundations of these works will be reused to obtain the aggregates required for the construction of the Project. The sites to use will be left as shown in the respective plans. Annex 1 contains the Project's works plans.

The aggregates for the works located in the Colorado River basin will be supplied by authorized third parties located in the Works sector.

The quantification of the requirements for aggregates is indicated in Table 2.3.13 of section 2.4 of this Chapter.

2.3.3 Operations Stage

The operation of the Alfalfal II – Las Lajas hydroelectric plants, set out in hydraulic series, will together generate a power of 531 MW. The operation begins in the intakes where the water is collected that will be taken to the machines cavern to be transformed into electricity.

2.3.3.1 Flows that Contribute to PHAM

The project will generate water from the Volcán, Yeso and Colorado Rivers, whose non-consumptive use rights are owned by the titular. These rights were granted in accordance with the hydrology of each one of the flows, establishing an ecological flow for them (Engorda, Colina, las Placas and Morado streams) that the project must respect.

Table 2.3.4 below gives a detail of the non-consumptive water rights use that are permanent and possible as well as of continuous and discontinuous exercise that AES Gener S.A. will use for the Alto Maipo Hydroelectric Project. The corresponding alveus is set out in each one; the flows granted; the background on its collection points and restoration; the resolutions through which they were constituted and their inscription in the respective Property Registry.

In order to adapt the rights of AES Gener S.A to the needs of the Alto Maipo Hydroelectric Project, to this date, several applications for the transfer of non-consumptive water use rights are being processed before the General Waters Authority (DGA), as shown in files VT-1302-226; VT-1302-227 VT-1302-228; VT-1302-229; VT-1302-230 and VT-1302-s/n°, corresponding to the flows of Las Placas; Cajón del Morado; La Engorda Stream; Colina Stream; Yeso River and Colorado River respectively.

Table 2.3.4
Background on Water Rights

Water flow	Sub-basin	Exercise of the right	Flow (m3/S)		Location Collection and Restitution Point (UTM Coordinates, km)				Difference in level between collection and restitution	Registration in the C.B.R.				No. date of Resolution granting or modifying the right		
					Collection		Restitution			Folio	No.	Year	City	No.	Date	
					North	East	North	East	(m)							
Cajón Del Morado	Volcán River	See table 1			6.262,0	404,75	6.258,7	405,8	410	232 overleaf	448	2004	Puente Alto	282	20/07/2004	
Las Placas Ravine	Volcán River	See table 2			6.260,95	406,95	6.258,7	405,8	410	232 overleaf	448	2004	Puente Alto	282	20/07/2004	
Colina Stream	Volcán River	See table 3			6.260,35	408,4	6.258,7	405,8	410	232 overleaf	448	2004	Puente Alto	282	20/07/2004	
La Engorda Stream	Volcán River	See table 4			6.259,6	408,50	6.258,7	405,8	410	232 overleaf	448	2004	Puente Alto	282	20/07/2004	
Yeso River	Yeso River	Permanent	Continuous	15	See note				1.100	183	218	1986	Puente Alto	107	25/04/1983	The water will be collected in the Yeso River, downstream from the wall of the dam with the same name, at altitude 2500 m.a.s.l. The restitution will be done in the same river, before the confluence with the Maipo River, at altitude 1400 m.a.s.l.
Colorado River	Colorado River	permanent	Continuous	25	See note				335	141	253	2007	Puente Alto	393	14/09/1982	The water will be collected along the right bank of the Colorado River, approximately 650 m downstream from the discharge of the Los Maitenes Hydroelectric Plant, and will be restored to the Maipo River, immediately upstream from the intake of the La Sirena Canal.
Colorado River	Colorado River	permanent	Continuous	5	See note				189,6	481	546	1982	Puente Alto	15	14/01/1980	The water will be collected in the Colorado River at altitude 1321.1 m.a.s.l. and will be restored to the river at altitude 1132 m.a.s.l.
Colorado River	Colorado River	permanent	Continuous	14	See note					190	236	1983	Puente Alto	Contribution (DFL 29 of 1931)		The water will be collected in the intake of the Maitenes Plant and restored to the Colorado River through the discharge canal of the referred-to plant
Quempo Stream	Colorado River	permanent	continuous	1	See note				900 or 713	171 overleaf	196	1988	Puente Alto	85	15/03/1988	The water will be collected in the Quempo stream at altitude 2032 m.a.s.l. The restitution will be done in the Colorado River, 200 m downstream from the Maitenes Plant machines house, or alternatively 180 m downstream from the intake of the same Plant.
Chacayes Stream	Colorado River	See table 5			6.298,760	405,683	See note		1002 or 815	124	232	2006	Puente Alto	285	24/02/2006	The restitution will be done in the Colorado River, 200 m downstream from the Maitenes Plant machines house, or alternatively, 180 m downstream from the intake of the same Plant.

Notes:
1.- UTM coordinates refer to South American Provisional Datum of 1956, Zone 19.
2.- Variable flows constituted [m3/s]:

Table 1

Cauce	Exercise	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Average Q
Cajón del Morado	Permanent and continuous	0,59	0,5	0,49	0,44	0,44	0,47	0,66	1,28	1,91	1,66	1,34	0,92	0,89
	Possible and continuous	0,81	0,57	0,48	0,58	0,43	0,52	0,83	1,48	1,79	2,04	2,11	1,39	1,09
	Total	1,4	1,07	0,97	1,02	0,87	0,99	1,49	2,76	3,7	3,7	3,45	2,31	1,98

Table 2

Water flow	Exercise	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Average Q
Las Placas Ravine	Permanent and continuous	0,36	0,3	0,29	0,27	0,26	0,28	0,4	0,76	1	0,99	0,8	0,55	0,52
	Possible and discontinuous	0,48	0,34	0,28	0,3	0,2	0,31	0,5	0,24	0	0,01	0,2	0,45	0,28
	Total	0,84	0,64	0,57	0,57	0,46	0,59	0,9	1	1	1	1	1	0,80

Table 3

Water flow	Exercise	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Average Q
Colina Stream	Permanent and continuous	0,72	0,61	0,59	0,54	0,53	0,56	0,8	1,55	2,33	2,03	1,63	1,12	1,08
	Possible and continuous	0,99	0,7	0,58	0,7	0,53	0,64	1,02	1,81	3,21	3,97	2,58	1,7	1,54
	Total	1,71	1,31	1,17	1,24	1,06	1,2	1,82	3,36	5,5	4 6	4,21	2,82	2,62

Table 4

Water flow	Exercise	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Average Q
La Engorda Stream	Permanent and continuous	0,5	0,43	0,41	0,38	0,37	0,39	0,56	1,08	1,62	1,41	1,13	0,78	0,76
	Possible and continuous	0,68	0,48	0,4	0,49	0,36	0,44	0,7	1,02	0,48	0,69	0,97	1, 18	0,66
	Total	1,18	0,91	0,81	0,87	0,73	0,83	1,26	2,1	2,1	2,1	2,1	1,96	1,41

It must be kept in mind in all cases that the processes for granting changes of source and transfer of water use rights are not subject to the prior processing and approval of the project in the SEIA. What is related to these aspects is processed and resolved exclusively in accordance with the procedure indicated for these effects in the Water Code and in the Procedures Manual of the General Waters Authority. The above in virtue of the fact that the administrative act that grants water use rights as well as the administrative permits indicated above, do not constitute sectorial environment permits.

On the other hand, the design flow of the plants must be provided for the total or partial sum of the design flows of each one of the intakes. These flows have been defined for the Gener Alto Maipo Hydroelectric Project in accordance with the available hydrological information that considers the study of the river basins involved, calculating the series of flows of each one of the rivers and ravines that the project uses, for a period of 50 years. These studies were done on the basis of previous studies, fluviometric records in effect at the time at the General Waters Authority (DGA) and at AES GENER, among others (see Annex 10).

The points of interest for the hydrological evaluations are defined by the collection points in the Colina, La Engorda, Las Placas and Morado streams, in the upper sub-basin of the Volcán River, the Yeso River downstream from the dam, the Aucayes dam and the Colorado river (discharge from the Alfalfal plant and the intake of the Maitenes Plant). Figures 2.2.2 to 2.2.10 indicate the positions of the collection points with respect to the other components of the PHAM and Table 2.3.5 items denominated in accordance with the National Waters Bank nomenclature.

Table 2.3.5
Classification of sub-basins in accordance with the National Waters Bank

Flow	River basin	Sub-basin	Sub-sub-basin	BNA code
Colina Stream	Maipo River	Upper Maipo River	Volcán River	05702
La Engorda Stream	Maipo River	Upper Maipo River	Volcán River	05702
Las Placas Ravine	Maipo River	Upper Maipo River	Volcán River	05702
Cajón Del Morado	Maipo River	Upper Maipo River	Volcán River	05702
Yeso River	Maipo River	Upper Maipo River	Yeso River	05703
Colorado River	Maipo River	Upper Maipo River	Colorado River between Olivares River and Maipo River	05707
Aucayes Stream	Maipo River	Upper Maipo River	Colorado River between Olivares River and Maipo River	05707

The maximum flow generated by the plants corresponds to their design flow. In the case of Alfalfal II this is 27 m^3/s and in the case of Las Lajas 65 m^3/s. This means that, with the full opening of the turbines' injectors, the maximum possible flow passing will be the respective

design flow. Having hydraulically calculated the system of flows indicated above, if the sum of flows available at the intakes exceeds the value of the design flow (typical situation in the summer), the surplus water is automatically returned to the flow through the discharges of the respective collection works.

Table 2.3.6 shows the design flows of the intakes and Table 2.3.7 shows the maximum, average and minimum flows for each section of the project's pipes

Table 2.3.6
Pipes PHAM Adduction System

Point	Maximum derived design flow m^3/s
Colina Stream	6
Las Placas Stream	1
El Morado Stream	3.7
La Engorda Stream	2.1
Yeso River	15
Aucayes Stream	2
Colorado River Alfalfal	30
Colorado River Maitenes	10

Table 2.3.7
Flows per section of the pipes

Section	Flow (m^3/s)		
	Maximum	Average	Minimum
Aqueduct connection Engorda- Colina	2,10	0,72	0,00
Aqueduct Colina-Las Placas	8,10	3,01	0,31
Aqueduct Las Placas- Morado	9,10	3,32	0,31
Aqueduct Morado-Tunnel Volcán	12,80	4,65	0,43
Tunnel Volcán	12,80	4,65	0,43
Aqueduct El Yeso –Pozo de Toma	15,00	7,52	0,00
Piping Pozo de Toma _Tunnel Alfalfal II	27,00	12,50	4,8
Tunnel Alfalfal II	27,00	12,50	4,8
Pressure duct forebay LL-Tunnel las Lajas	39,88	21,90	6,40
Canal Aucayes-Tunnel Las Lajas	2,00	0,67	0,06
Tunnel las Lajas	65,00	35,17	10,51

In the specific case of the water in the Yeso River, the calculation of the average and minimum flows has been done considering the historical statistic (1968-2005) of delivery of water of the El Yeso dam, supplied by Aguas Andinas.

Finally, and in terms of effects on third parties, it is important to highlight that the main irrigation canals that are supplied by the Maipo River in the project's area of influence, that is the First Section, have their intakes located beginning with the pipe corresponding to the La Sirena canal, located approximately 4.5 km downstream from the denominated Independiente Intake of the company Aguas Andinas located in the sector of Las Vertientes. Keeping the above in mind and considering that the point of delivery of the Project's water (Las Lajas Plant) is located upstream from the La Sirena canal intake, it can be affirmed that the PHAM will not affect the availability of the hydric resource used for irrigation.

However, two canals have been identified - Maurino and El Manzano - whose intakes are located in the Colorado River flow and downstream from the collection obras of the Las Lajas

plant. The PHAM, in the exercise of its legally constituted rights, will not affect the intake of these canals, so the exercise of the rights of the users of the referred-to canals will not be infringed.

Regarding decreases in the flow of the river, in accordance with that observed and studied, it is considered that there will not be problems for both canals to collect their resources with the system currently used, since it will only be necessary to continue with the work related to the construction of small "Goats' feet" parapets, or in general any system that allows the river water to be deviated from the intake area.

For more detail regarding the intakes, canals and/or other collection works in the project's area of influence, please refer to section 5.6 of the EIA.

A. Ecological flows

The power generated by the project is obtained from the hydric resources contributed by the Engorda, Colina, Las Placas and El Morado Streams, all of these tributaries of the Volcán Colorado River and its tributary the Aucayes stream. The extraction of these resources affects the rivers mentioned in hydric terms as well as in terms of water life. Due to the above, the Titular has carried out a complete study of the remaining flows in each one of the river flows mentioned and their ecological flows, whose analysis and methodology is described in detail in Annex 10 "Analysis of the Ecological Flow and Flow Requirements". This hydrological analysis of the Qe has used a wide statistical heritage, using records of flow data of over 50 years, and adjustments on the basis of conventional statistical analysis methods. Also, criteria other than hydrology have been assumed, linked to the preservation of the natural habitats and the environmental functions of the water resources, especially since the PHAM is inserted in an area that presents significant singularities from an environmental point of view as well as regarding anthropic intervention.

In this regard and in accordance with the conclusions of the mentioned study, there are the following considerations associated with the ecological flow for each of the flows that will be collected for the execution of the project:

- For the Yeso River, a Qe has been estimated of 2.6 m3/s in the section with the highest sensitivity. This Qe considers the habitat conditions necessary to maintain aquatic life; this is maintaining the depths of run-off and the flow velocities. Even when it is not necessary to let an ecological flow pass the intake from the point of view of the habitat, given the conditions of variation of flow generated by the operation of the El Yeso dam, Genera will let a flow of 200 lt/s pass from its intake, which added to the contributions from the intermediate basin, will allow the preservation of the natural habitat downstream from the collection.

- In the Colorado River, the Qe has been estimated at 0.6 m3/s. As with the Yeso River, this flow will allow the habitat conditions necessary for the maintenance of life in this river flow to be maintained. In this regard, to comply with aquatic habitat quality conditions, the PHAM proposes ensuring a minimum flow of 0.7 m3/s in the zone defined as the ecological flow. To comply with this, the PHAM includes in one part not

collecting the resources of the Quempo stream which originally had been included within the project works, whose annual average flow is 0.72 m3/s, and if necessary, will let a flow of 0.3 m3/s pass in the Maitenes Plant intake.

- Regarding the La Engorda, Colina, Las Placas and Cajón El Morado Streams, the variations in flow do not significantly alter the runoff conditions, due mainly to its elevated slope (torrent type runoff). These conditions greatly limit the development of aquatic organisms, since the cutting stress generated by this runoff avoids the establishment of aquatic flora and fauna. In addition, the high load of sediments generates a low quality environment for the aquatic biota. Also, due to the morphological characteristics of these flows, the aquatic habitat quality conditions for the fish life is not met naturally since the presence of fish has not been detected (see C. 5 Baseline and Annex 10). Based on this, the Qe incorporates the large seasonal variation shown by the flows in these water courses, for which it is proposed to maintain a flow of 10% of the average monthly flow, controlled in an integrated manner at their confluence.

- For the case of the Aucayes stream, it must be indicated that the Alto Maipo project will use the totality of the resources currently generated by the Maitenes Plant, with this plant being out of service most of the time. However, with surplus in the river, once the requirements finally made are complied with regarding the flows remaining in the river, the Maitenes plant will be able to operate in summer. This situation has motivated the decision to not intervene in the current intake of the Aucayes stream, despite these resources being used by the new project, which will be materialized by deviating the flows currently taken by the canal to the adduction tunnel of the Las Lajas Plant through a shaft that will connect both aqueducts. Since it does not intervene in the intake, ecological flows are not considered in this stream.

B. Transport of sediment

AES Gener has developed a sediment study of the Maipo river in the section intervened by the project works, that is, between the union with the Volcán River and the Independiente Intake in the Las Vertientes sector. The conclusions of this study, as well as the methodology, procedure, data and parameters used are included in Annex 20.

It is concluded that in this section, the Maipo River decreases its rate of washing away slightly without generating situations of degradation of the riverbed. Downstream from the Independiente Intake, the export of sediment with the project is still higher than the extraction of aggregate that is currently realized in the river. This latter has reached critical levels that do not make increasing its extraction possible.

The study also makes some considerations regarding the general situation of the river up to its mouth. Howeber, it must be kept in mind that the complexity and dynamics of the behavior of the wear of the bottom and in suspension require wider studies that incorporate all the players of the river.

The Titular offers to support the global studies that the pertinent authority determines necessary for an integral management of the sedimentological resources of the Maipo River and its erosion-sedimentation balance.

C. Process of Generation of Energy

The design flow of a hydroelectric plant is the result of the technical-economic study that defines the optimal point between the size of the plant, the costs and the income associated due to the sale of energy and power. In this way, the optimal design point is such that for a marginal increase in size, the increase in costs is the same as the increase in the income in terms of present value. The result of the economic optimization in general shows plant factors in the range of 0.50-0.60 for a typical run-of-the-river plant. This plant factor is the same as the ratio between the average flow generated and the design flow of the plant (maximum flow).

For the Alto Maipo Hydroelectric Project the following design flows have been obtained:

- Alfalfal II Plant : 27 m^3/s, Plant factor: 0.49[2]
- Las Lajas Plant : 65 m^3/s, Plant factor: 0.54

The process of generating electricity in the plants that comprise the PHAM consists of the functioning of a hydraulic turbine that converts the potential energy of the water into mechanical energy of rotation. This mechanical energy is transformed into electricity through a generator that is physically coupled to the same shaft as the turbine, inside the machines cavern.

As indicated previously, for their process of generation the Alfalfal II and Las Lajas hydroelectric plants will use a maximum flow of 27 and 65 m^3/s respectively, allowing the generation of approximately 2350 Gwh/year.

The calculation of the generation of energy of the project considered the availability of flows according to statistical records of the past 50 years, the losses of load of the hydraulic system and the global efficiency of the generating equipment.

A. Maintenance of the Facilities

— Civil Engineering Works :

The maintenance referring to Civil Engineering Works can be separated into:

- Intakes and Hydraulic Pipes
- Roads
- Infrastructure (Buildings)

[2] The plant factor of 0.49 of the Alfalfal II Plant is explained by the high head and the low flows of this plant, whose pipes are set by minimum construction sizes.

For Intakes and Hydraulic pipes, they are works to be done in the periods in which the adduction tunnels are emptied, which can be every 6 to 8 years. It basically consists of technical inspections, cleaning, clearing and minor repairs. The maintenance of mechanical equipment in the Intakes is done at least once a year, where seals in the hatches are changed, leaks in hydraulic circuits are eliminated, lighting, etc.

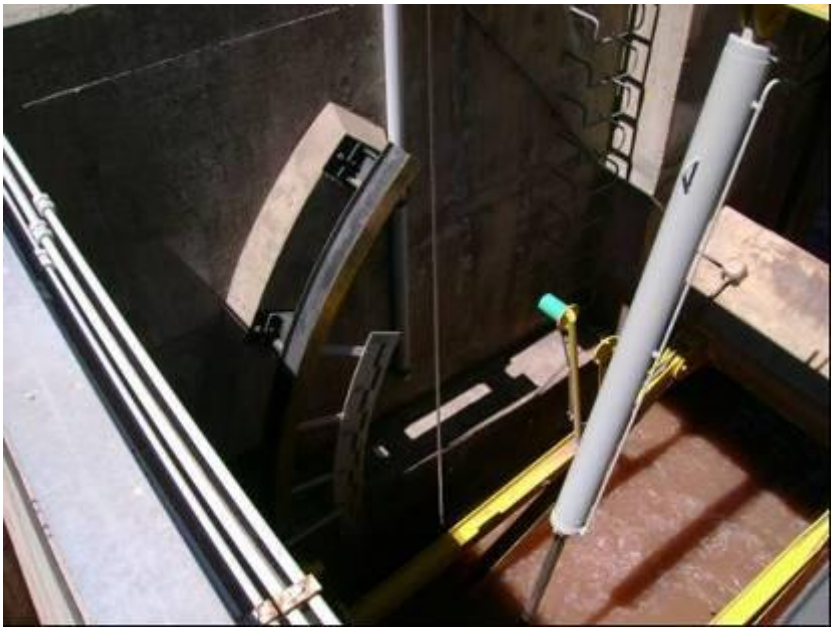
AES Gener in its Alfalfal Plant that is currently operating in the Colorado River valley, has two lateral type intakes, Olivares and El Colorado, located in the rivers with the same names.

Both intakes, designed for 12 and 18 m^3/s respectively, have electrical energy, through which the gravel chamber hatches located in the barrier installed in the course of the river can be operated remotely.

The hatches are of the radial type with a hydraulic opening system that is operated with electricity from the centralized control room located in the Plant's control building. The intake has a remote inspection system by television, with which the condition of the grates and the hatches can be observed.

During the winter, the intake is inaccessible by land and is constantly monitored remotely, to full satisfaction in its 17 years of operation. In the low-water season it has constant land access, which allow the hatches to be operated opportunely. Below are photographs of the AES Gener Olivares and Colorado intakes.

Photograph 2.3.1: Intake grate, control meters and hatch for cleaning the bottom – Olivares Intake



Photograph 2.3.2: Radial hatch of the gravel chamber discharge to the river – Olivares Intake

Photograph 2.3.3: View upstream of the total closure hatches - Colorado Intake

Photograph 2.3.4: Radial hatch in the discharge of the Colorado intake, detail of the paving stones of the bottom in perfect condition – Colorado Intake

For roads and road infrastructure, there will be a work crew to carry out work clearing, cleaning, and maintaining signposting and culverts along the entire network of roads of the project. The frequency and intensity of this work will depend on the period of the year. The clearing will be intensified during the winter period, to eliminate snowballs as well as of materials, and in the period prior to the winter the culverts must be adapted to withstand the rain. The rest of the year, it corresponds to minor clearing and maintenance of signposting.

In Infrastructure the work to be done is sporadic and less in amount (paint, plumbing, roofing, cleaning, small modifications, etc.)

— **Electrical Equipment**

- Equipment in high Voltage Yards

Preventive maintenance work will be done on disconnectors, switches, cleaning of insulators, as well as the verification of the tightness of screws in all existing structures. The preventive maintenance work includes the review through the analysis of thermovision for the detection of hot points due to bad connections. All the activities mentioned previously have a frequency of at least once a year.

— **Electromechanical Equipment:**

Corresponds to the maintenance of the equipment inside the Machines Cavern which are classified into:

- Principal Equipment
- Auxiliary Equipment.

Principal Equipment, Turbine, Generator, Principal Transformers, Spherical Valves, etc. Maintenance will be done to all this equipment once a year during a period not greater than 25 days and fundamentally in the winter period, that is in the period of scant flow in the rivers when a unit can be placed on standby. Major maintenance of this equipment will be done every 6 to 8 years, which will coincide with the tunnel inspection process. This could last between 30 to 35 days. All the work will be done inside the Machines Cavern.

Auxiliary Equipment, referring to cooling water pumps, compressors, auxiliary transformers, ventilators, air conditioning equipment, banks of batteries, fire extinguishing systems, etc. All this equipment will be incorporated within a Preventive Maintenance Plan, with different frequencies of execution but that do not exceed two years. They can be taken out of service at any time without affecting generation, since the majority of them are duplicated. All the work will be done inside the Machines Cavern.

Table 2.3.10 indicates the general technical specifications of the turbines, generators, principal transformers included for the Alfalfal II and Las Lajas Plants.

Regarding the consumption of consumables, cooling oil is only used in the principal transformers and in general no leaks are detected in this equipment. Other oils are those used to lubricate the rests. During normal operation of the plant, there is no variation in the oil level and in general a volume of 20 lt can be estimated every 4 years, which is recovered in steam extractors and is then re-used. Leaks due to breakdowns go to drainage chambers, where water/oil separators are installed.

Table 2.3.10
Characterization of Generating Equipment

Facilities	Descriptor	Un.	Alfalfal II Plant	Las Lajas Plant
Plants	Nominal power	MW	272	270
	Type of plant		in cavern	in cavern
	Number of units	c/u	2	2
	Design flow	m^3/s	27	65
Turbines	Type	-	Pelton	Pelton
	Placement of shaft	-	vertical	vertical
	Direction of rotation	-	clockwise	counterclockwise
	Net head height with full load	M	1.120	468
	Design flow	m^3/s	13,5	32,5
	Nominal power	MW	136	135
	Velocity	Rpm	500	300
	Number of injectors	c/u	4	6
	Diameter of wheel	M	2,7	2,9
Generator	Type		Synchronic	Synchronic
	Phases		Three-phase	Three-phase
	Frequency	Hz	50	50
	Nominal power	MVA	145	148
	Generation voltage	kV	12	12
	Connection		Star	Star
	Excitation system		Static	Static
	Cooling system		Closed circuit of forced air and water/air coolers	Closed circuit of forced air and water/air coolers
	Potency factor	0/1	0,9	0,9
	Number de poles	c/u	12	20
Transformer	Type		Three-phase	Three-phase
	Maximum Power	MVA	170	170
	Voltage	kV	220/12	220/12
	Connection		YNd11	YNd11
	Cooling		FOW	FOW
	Assembly		in cavern	in cavern

B. Maintenance of Roads

This activity will be executed to maintain operational the service roads set up by Gener, and for existing public or private roads, during the period of annual maintenance of intakes and adduction canals, in accordance with that described in section 2.3.2.5 of the EIA.

2.4 REQUIREMENTS OF CONSUMABLES, MACHINERY AND SERVICES

2.4.1 Construction Stage

A. Power supply

During the construction stage, the electricity will be supplied through works lines of 12 and 23 KVA, from power generation sources belonging to GENER existing in the area. In this regard, the El Volcán, El Yeso and Lo Encañado sectors will be supplied by the networks from the Queltehues plant. The works of the El Colorado sector will be supplied through a connection to the Alfalfal I and Maitenes plants. The distribution of this electricity supply will be done through posts adjacent to the roads.

In addition, there will be a backup diesel power generator in each camp, which will have all the sectorial authorizations.

B. Fuel

The fuel to be used during this stage corresponds to diesel oil and gasoline, used for the functioning of the vehicles and motorized equipment. The supply of this fuel will be done through tanker trucks of distributor companies, from the stations established in the Metropolitan Region to the worksite and camp sectors. The transport will be done in accordance with that provided in DS N°298 “Transport of Hazardous Substances on Highways”, specifically in that relating to fuel substances. It is estimated that during the construction stage, the consumption per month will reach 0.5 m^3 gasoline and 1 m^3 diesel oil per camp.

Eventually, the Contractors will opt to set up temporary tanks for the storage of fuel at their worksite facilities. Their installation and subsequent use will comply with current regulations and will have all the corresponding sectorial permits processed by the Contractors and required contractually by Gener, and they will be managed in accordance with that indicated in section 2.3.2.4.

C. Supply of Water and Sanitary Facilities

For the supply of potable water to camps and other facilities, the workers will use the water from the ravines existing in the estates where this property is located, after authorization by the owners. If there is insufficient water available for the PHAM requirements, the Titular will present the respective consumptive use water rights applications.

These supply alternatives will be presented to the General Waters Authority for their consideration.

In general terms, the potable water system will include a filtering and disinfection treatment, a system of impulsion to the storage tank and to the distribution network of sanitary fixtures. These systems of potable water will comply with that provided in DFL 1/90 of the MINSAL. Prior to the operation of the system, the physiochemical analyses will be done of the potabilized water in accordance with the parameters established in NCh 409/84 “Water Quality for Potable Use ".

The potable water will be distributed to the work fronts from the camps and will be stored in ad-hoc tanks.

A priori, a total approximate demand is estimated in a conservative manner of 80 m^3/day in each camp, for the concept of human consumption, considering an average minimum supply of 200 liters per day per worker (400 workers).

A requirement of water is also included for the construction activities used in the manufacture of concrete and irrigation, among others. Part of this water will correspond to that treated in the treatment plants located in each one of the camps and will be distributed through tanker trucks to the different work fronts.

Regarding the sanitary installations, in each camp an individual sewage network will be set up connected to the sequential sedimentation systems located in the project’s camps, which will have the approval of the respective sanitary authority. During the winter period, this treated water will be discharged into the closest surface water courses, complying with the maximum limits established by D.S. Nº 90/2001 in its Table 1, which sets “maximum limits allowed for the discharge of liquid waste into fluvial water bodies”. In the dry season, the treated water will be reused to wet surfaces (see Annex 18).

Regarding the hygienic services, they will be adapted to that established in DS 594/99 of MINSAL, especially in that regarding the quantity and other specifications (hot water, showers, etc.). The Contractor will ensure the correct maintenance and functioning of these services.

In work fronts with a temporary presence of workers, chemical toilets will be set up, which will be managed by a company authorized by the Sanitary Authority, and the waste from these units will be disposed of in accordance with current regulations. This same company will be in charge of the sludge removed from each treatment plant.

D. Supplies and Requirements of Machinery and Equipment

The following table presents a detail of the principal requirements and supplies necessary for the construction of the Project and the relationship to their transport (number of trucks).

Table 2.3.11
Supply requirements

		Maipo	El Sauce	Pta. Aux	Aucayes	C. Carga	Yeso	Volcán	Total
Steel and anchoring bolts	ton	300	600	600	300	1.000	1.000	1.000	4.800
Cement	ton	12.000	16.000	16.000	10.000	8.000	12.000	12.000	86.000
Supplementary aggregates	ton	60.000	20.000	20.000	5.000	0	0	0	105.000
Wood	ton	50	200	200	50	700	700	300	2.200
Fuel	ton	200	600	800	200	400	400	400	3.000
Steel pipes	ton	0	1.200	3.000	0	0	1.600	200	6.000
Concrete pipes	ton	0	0	0	0	0	0	5.000	5.000
Other Cargo various	ton	1.000	1.750	2.000	1.000	1.000	1.500	1.750	10.000
Total	ton	73.550	40.350	42.600	16.550	11.100	17.200	20.650	222.000

Regarding the machinery required to carry out the construction work, this is set out in the following table:

Table 2.3.12
Principal Machinery and Equipment to be Used in the Construction of the PHAM

Equipment / Machinery	Nº
Bulldozer	17
Backhoes	7
Front loader	20
Hopper trucks	18
Cement mixer trucks	16
Jumbo	12
Track drill	3
Manual drills	32
Diesel compressors	32
Injection pumps	6
Concrete base	9
Cars on rails	85
Road graders	2
Compacting rollers	2
Tanker trucks	2
Tunneling machines	3

E. Road traffic contributed by the Project

The road traffic contributed by the project to each one of the areas will be depend on the size of the works inserted in each of them, that is, each work front will have specific requirements according to the number of windows, length of the tunnel and annexed works (intakes, pipes, etc.).

In general terms, the road traffic flow contributed by the project refers to:

- Transport of materials and supplies: used for the construction of the project will come from suppliers within the county or from other points of the Metropolitan Region, for which public roads as well as service roads will be used. In particular for the case of the transport of concrete, only service roads will be used, since it is considered that the Contractor will have its own modular plants at the worksite facilities.

  Aggregates will also be transported from the Works sector to the Colorado River facilities.

- Solid waste: generated at the worksite facilities, which will be transported to authorized stockpiling sites (detail Annex 18).

- Transport of personnel: regarding the transport of personnel, it is considered that the works will have shifts of 7 to 10, 24 days per month, with 8-hour days. The continuous shift system, with overnighting at camp, will reduce the number of trips to the metropolitan area. The movement of personnel will use the public roads and service roads generated by the Project. The public roads will be used with a low frequency, exclusively in the shift changes.

The detail of transport requirements, as well as of cargo (trucks), as well as of people in buses and light vehicles, to each one of the work fronts, is presented in detail in Annex 14 “Road Assessment”, attached in Annex 14 of this EIA. For the estimate we have considered the vehicles necessary to satisfy the totality of the works, that is, all the activities developed within approximately 5 years programmed for the construction stage of the project (see Sequence of the project activities, Annex 2) and the most unfavorable conditions for execution of the project. Also, this calculation includes the trucks considered for the transport of aggregates from the extraction well located in the locality of La Obra and the vehicular flows due to the transport of concrete.

In absolute terms, the total flow of trucks that will be used by the project will be 3 trucks/hour, 2 buses/hour and one light vehicle per hour. In addition there will be a lower flow on highway G-345 in a section of approximately 2 kilometers for the concept of transport of the muck. This transit will be done from the work front for the construction of the Access Portal to the Las Lajas Tunnel (VL2) to the muck stockpiling site 14. The quantity of material to be transported is approximately 159,000 Ton/ year, in a period of 15 months, which is the most unfavorable scenario, with a flow of 2 trucks per hour.

2.4.2 Operations Stage

A. Power Supply

The operations of the Alfalfal II and Las Lajas plants will be managed from the current Alfalfal I plant.

B. Fuel

The permanent storage of diesel or other fuel will not be required.

C. Supply of Water and Sanitary Installations

New facilities will not be required, since those existing at the Alfalfal Plant will be used.

D. Supplies and Requirements of Machinery and Equipment

During the operations stage only minor equipment will be required associated with the tasks of maintenance of the PHAM works. These refer to instruments, support equipment and motor vehicles to access the works sector.

2.5 DESCRIPTION OF THE EMISSIONS, EFFLUENTS AND WASTE GENERATED BY THE PROJECT

2.5.1 Solid Waste

In general, the production of waste will occur during the project's construction stage. For AES Gener the appropriate management of the waste and residue of the project has special importance, for which programs have been designed for the handling, management, compilation, stockpiling, transport, final disposal, reuse or sale of the different waste generated in the camps and worksite facilities, as well as on the work fronts (see Annex 18). Along with this, Gener will establish strict contractual requirements from the Contractors to ensure appropriate management and final disposal of the solid waste.

The principal waste or residue and the management considerations are set out below:

- Muck and excavation surplus: will correspond mainly to inert material comprised of damp crushed rock that is removed from the tunnels. The total volume of the muck that will be generated during the entire construction stage of the project corresponds to 1.7 Mm^3, which added to the natural expansion of the rock and the fill material removed from the construction of roads and slopes (675,000 m^3), gives a total of 2.7 Mm^3. In addition, surplus rock and common material from the construction of surface works will be generated. The final disposal of this material will be in 14 muck stockpiling sites of the Project. The detail of the muck stockpiling sites and the quantity generated per activity is indicated in Annex 6.

- Construction waste: will consist of wood, ends of pipes, debris, wires, remains of packaging, metals and empty paint cans. A production volume is estimated of around 30 to 40 m^3/month. This low rate of generation is due to the re-use or sale of materials that have commercial value and use at the worksite of pre-assembled components.

- Hazardous waste: will be generated in a lower proportion and will correspond to waste from the maintenance of machinery in the workshops, storehouses and work fronts, such as the remains of oils, solvents, batteries, oil filters and lubricating grease. From the environmental point of view, the waste indicated is considered hazardous, even though some of them do not have reagent, flammable, radioactive, corrosive and/or toxic characteristics, according to the definitions in DS 148/03 of the MINSAL. In accordance with this, GENER will adopt procedures of documentation and labeling, as well as the storage, handling and disposal of this material in a safe way in accordance with current legislation.

  As a waste minimization step, the reuse of this material will be prioritized at the same work fronts and/or sale to third parties. The waste that cannot be reused or sold will be stockpiled in a temporary manner in the waste management yards especially set up in each one of the camps or worksite facilities, to then be removed and disposed of at authorized dumps by companies authorized for the transport of this type of waste.

Regarding the quantity, this is considered to be around 200 l/month per worksite facility.

— Household waste or similar: this material will be generated in the camps and worksite facilities. This type of waste will basically correspond to remains of food from the dining halls, containers, paper, cardboard, etc. A conservative estimate is made of a global quantity of generation of around 2,500 kg/day during the construction stage, in accordance with a rate of generation of 1 kg/inhab/day and considering that the maximum contingent of 2,500 workers will constantly have 25% of workers off-shift.

Household waste or similar will be disposed of in polyethylene bags and differentiated in containers according to the type of material with recycling potential at each point of generation. This waste material will be sent directly to an authorized sanitary landfill operated by third parties.

The non-organic waste similar to household waste and some construction waste such as metal, cans, etc., which have recycling or re-use potential will be transported to the waste management yard. The re-use of these materials will be prioritized on the same work fronts and/or sale to third parties. The waste that cannot be re-used, recycled or sold will be disposed of in a sanitary landfill in accordance with the detail indicated in Annex 18, attached to this EIA.

The estimates of movements of waste and residue by sector have been included in the global analysis of project flows (see Annex 14).

— Plant remains: This type of material will basically consist of remains of shrubs, weeds, and in a lower proportion, trees removed from the works sites. Given the characteristics of the plant cover in the area, a lower volume of generation is estimated, which will be produced particularly during the works of opening roads and pipes on the surface and the removal of plants from tunnel windows, forebay and installations of other minor obras.

There is no a priori estimate of the waste comprised of plant remains from the cleaning of the land for the execution of works, however, a low volume of generation is estimated.

Plant matter being sent to sanitary landfills will be avoided. This type of material can be used in the revegetation programs (restitution of soil) or be placed in non-intervened adjacent areas, to operate as safeguard sites for fauna displaced by the works (restitution of habitat conditions), at the same time serving as material that lessens the effect of the wind, and retains atmospheric humidity. Under no circumstances will this waste be burned.

2.5.2 Liquid Waste

A. Wastewater

During the construction phase, wastewater will be generated from the baths, showers, dining halls and other activities inside the camps, worksite facilities and work fronts. The generation of this waste will be on average 68 m^3/day per camp, considering, in a conservative manner, a maximum contingent of 400 workers, an average consumption of 200 l/day/worker, considering the totality of the work fronts.

The wastewater will be purified through a primary and secondary treatment in modular treatment plants of the activated sludge type installed in each one of the camps. The wastewater generated at the work fronts (chemical toilets) will be transported by the contractor through septic tank cleaning trucks to the camps for their subsequent treatment. During the operations stage, the project will use the existing Alfalfal and Maitenes plant facilities.

During the winter period, the treated water will be discharged to surface water courses in strict compliance with maximum limits established by D.S 90/2001 in its Table 1, which establishes “Maximum limits permitted for the discharge of liquid waste into the body of fluvial water”. The points of discharge will be located in the proximities of the sites provided for setting up camps, which are presented in Annex 15. The Titular will monitor the water treated prior to its discharge at these points. In the dry season, the treated water will be reused, after sanitary authorization, to wet surfaces as a measure to control the resuspension of dust, complying voluntarily with the parameters established by NCh 1.333 “Water quality requirements for different uses” (see Annex 18).

The sludge generated in the treatment of water will be removed weekly by the works contractor, and will be transported and disposed of at authorized sites. The sludge will be removed by septic tank cleaning trucks and in accordance with the volume of sludge generated, it is estimated that between 2 and 3 septic tank cleaning trucks with 6 m^3 capacity will be required per camp per week during the entire construction stage. The Contractor will keep a control log of the volume of sludge removed. These documents will be at the disposal of the authorities when they wish to see them.

B. Liquid industrial waste

Parallel to the generation of wastewater at the camps and work fronts, liquid industrial waste will be generated from construction activities, such as the preparation of concrete, washing and preparation of aggregates, washing of the chassis and trailers of trucks, machines, tools and lastly in the construction of tunnels that will generate water from inside.

In accordance with the above, the generation of this type of liquid waste will be limited only to the worksite facilities. In the camps, wastewater will not be generated, since the activities carried out in these areas are limited to the permanence of personnel.

The wastewater will be treated by a decantation pool, which will allow the separation of the liquid industrial waste into clear water and sedimentable sludge (see Annex 18).

During the winter period, these treated waters will be discharged into the courses of the closest surface waters, complying with the maximum limits established by D.S. 90/2001 in its Table 1 which establishes the “Maximum limits permitted for the discharge of liquid waste into the body of fluvial waters”. The points of discharge will be located in the proximities of the sites provided for the setup of worksite facilities, indicated in section 3.3.2 and represented in Annex 15; in these points, the Titular will monitor the treated water prior to its discharge. In the dry season, the treated water will be reused mostly for processing concrete or for the activities involved in construction (see Annex 18).

2.5.3 Atmospheric Emissions

During the construction phase, the main emissions into the atmosphere will correspond to the particulate material or resuspended dust due to the movement of land associated with excavations, loading and unloading, and transport of inert materials with different granulometry. Furthermore, emissions will be generated from the transit of trucks, small vehicles and the functioning of machinery at work fronts on the surface.

In accordance with the results of the study of emissions (Annex 4), the rate of emission of PM10 attributable to the construction of PHAM indicates that the maximum PM10 emissions will be generated during year 3, and correspond to 277 tons/year.

Regarding the PM10 emissions, it is observed that in the year with most emissions, the project activities exceed the limit of emissions permitted by the PPDA by over 150 tons. Based on this, it has been necessary to implement an Emissions Compensation Plan (PCE), which establishes the actions to be carried out to compensate the 150% of the emissions generated by the project. Since in the worst case, the PM10 emissions of the project reach 277 ton/year, the compensation of emissions must be around 415 tons. For this the Titular has developed an Emissions Compensation Plan, which details the measures adopted to ensure that the final emissions of the Project will remain below the levels established by article 51 of the Atmospheric Prevention and Decontamination Plan (PPDA). The detail of this Plan is presented in Annex 5, appended to this EIA.

Without prejudice to the above, it is important to highlight that the area where the project is located presents good ventilation conditions that allow the dispersion and displacement of the contaminants. Also, most of the work fronts are located distant from populated centers, for which there are no direct receptors.

We now present a summary of the measures taken by the Titular of the project during the construction of the PHAM that form part of the general construction management of the project:

- The new roads established will be stabilized on the surface through granular layers of leveled slides plus watering with magnesium chloride (bishofite). This latter material is used as a dust suppressor in earth or gravel roads, maintaining the contact surface damp, and impeding the resuspension of particulate material (see Annexes 4 and 5).

- The good conditions of the roads will be maintained at all times during the PHAM construction stage, in order to facilitate the transit of vehicles.

- The trucks with material that move outside the work fronts will be covered with canvas to avoid the detachment of material. This when it deals with the transport of inert material to the stockpiling sites, transport of supplies to work fronts or camps, which could come from or go through populated areas.

- An adequate mechanical maintenance of equipment, machinery and vehicles will be carried out, under the concept of operational efficiency and the minimization of atmospheric emissions.

- Wet the interior surfaces of the camps and maintain all types of stockpiling of material of fine granulometry covered with plastic or textile canvas, or in closed containers, especially in those sectors close to public roads.

- In each camp, the brining of waste and combustible materials will be prohibited (wood, plant matter, paper, leaves or waste of any type).

No atmospheric emissions will be produced during the Project's operations stage.

2.5.4 Noise

In the construction stage, the main sources of generation of noise can be classified into two types: fixed sources and mobile sources.

The fixed sources correspond to the work fronts and the worksite facilities. The work fronts have on-site facilities where all the construction work is done on the surface as well as the underground works. The worksite facilities will function as the base of operations of the work fronts, where the areas for warehouses, parking, care of personnel and administration in general will be installed.

The main activities that generate noise at the work fronts will correspond to movements of vehicles and machinery, the functioning of the concrete plant and the power generators, worksite movements of land, loading and unloading of material, and construction works in general. In the case of worksite facilities, the main activities that generate noise will correspond to the internal circulation of trucks, the functioning of the power generators and the activities of the workers in the fuel and machinery storage areas, offices, gatehouse, sanitary services, dining halls, etc.

For mobile sources, they will correspond to the flow of cargo trucks and buses along public roads.

In general terms, and for the emission of noise from fixed sources, the works area has a high degree of isolation regarding potential receptors and most of the work fronts will be underground.

Without prejudice to this, there will be some works close to the population in the Alfalfal works. Particularly for the control of noise generated and in order to minimize the impact of the noise emissions on this sector, acoustic barriers will be installed with which it is expected to decrease from 11 to 15 dB (A) (see section 6.4.1.2 and Annex 30).

In addition, specific control measures will be implemented that are required contractually from the Contractors and consist of:

- Generating semi-enclosures specific to the noisiest machinery, such as cranes, power generators, etc.

- Prioritize the works on the surface being done during the daytime (8:00 – 21:00 hrs.).

- The machinery used will be reviewed and tested by the contractor company in order to detect mechanical problems that could alter the established noise levels. This will be established in the employment contracts.

On the other hand, and in relation to the generation of emissions from mobile sources, there are zones considered to be sensitive by the Project (see Annex 30) that are located close to roads where there is population or houses. For these cases, prior to the beginning of the works, a “Works execution Work Program” will be presented in order to reduce the impacts and minimize the inconvenience that the project activities could cause the community. This will be integrated into the development of the Project, communicating the occurrence of sporadic sources of noise.

The complete detail of the identification of sensitive receptors, the evaluation of acoustic impact and the environmental management measures, are presented in Annex 30, appended to this Addendum.

Lastly, to verify the effectiveness of the mitigating measures, noise will be monitored at the 8 sensitive points in accordance with the procedure established by DS Nº 146/97 of the MINSEGPRES, in order to verify compliance with the maximum limits permitted of the sound pressure level (see detail in section 8.2.2 of Chapter 8).