



# EL MOLINO AND SAN MATIAS HYDROELECTRIC PROJECTS

## ENVIRONMENTAL IMPACT STUDY VOLUME I OF VI CHAPTER 1

**DOCUMENT 2148-12-EV-ST-010-01**

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## 1 GENERAL INFORMATION

### 1.1 INTRODUCTION

By the climatic and topographical conditions of the Andean region of Colombia, which is characterized by its high rainfall and steeped topography, this zone has a high potential for the development of hydroelectric projects.

In the last century, the constructive efforts were focused toward the large hydroelectric projects which have a long period of construction and a long-term investment recovery

From laws 142 and 143 of 1994, the Government initiated a process of linking the private investment in the provision of public services and in the provision of infrastructure, policy that has been supported by the subsequent governments. In the case of electric energy, changes were made in the energy market conditions which favor the economic income of the so-called minor plants and allow the construction of the same and the consequent interest of private investors who require a good profitability. These modifications in the system changed the look toward the small hydroelectric power stations which also generate lower environmental impacts.

HMV Engineers Ltda identified early this opportunity and began promoting this type of projects with the recognition of such sites for the development of these small plants, and their consequent development. As a result of this work, it was built the minor plant La Cascada, of 2.3 MW in the municipality of San Roque, which operates since July of 2007, and was a pioneer in the country now that it was certified as a clean project and worthy of bonds by reduction of carbon emissions in the United Nations programs, CDM projects (Clean Development Mechanism). Also began operation the central Guanaquitas and Caruquiade 9.7 MW each, in the municipality of Santa Rosa, and HMV Engineers also has under construction a central of 20.5 MW in the municipality of Salgar and another of 20 MW in the municipality of Cocorná, which should start operation in the middle of 2012 and second half of 2013; these plants have also begun the process of certification as CDM projects

In addition HMV ENGINEERS identified in the Calderas River the hydroelectric project San Miguel, of 42 MW, which was licensed by CORANARE through Resolution 112-5075 in August 31 of 2010 and were assigned obligations of firm energy for the period between 1 December of 2015 and 30 November of 2035 by means of the energy auction organized by the CREG on 28 December of 2011.

Within the inventory of potential uses identified by HMV Engineers Ltda is the hydroelectric development of the San Matias River, that takes advantage of the waters of the same river which is also intended to be registered as CDM project; located in the middle of the Antioquia department, about 95 km from the city of Medellin, in the jurisdiction of the municipalities of Cocorná and Granada.

In this way HMV engineers requested to the Corporación Autónoma Regional Rionegro Nare-CORNARE-, their ruling on the need to present Environmental Diagnostic of alternatives -DAA- for the hydroelectric development of the San Matias River, to which CORNARE replied affirmatively, process that ended with the selection of projects that should go to the stage of the Environmental Impact Study, according to resolution 112-0306 23 of August 2010.

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The Environmental Impact Studies of the two selected projects (El Molino I and El Molino II that from now on will be called El Molino and San Matias), were carried out jointly since a portion of their influence areas are overlapping, so that a portion of the information from the surveys is equal.

For the preparation of the Environmental Impact Study was conducted a work between September 2011 and March of 2012, adjusted to the extent set forth in the Terms of Reference set by CORNARE.

The environmental impact study for the San Matías Hydroelectric Project consists of 11 chapters:

- **CHAPTER 1 General Information.** This chapter describes the general characteristics of the project, such as the background, objectives, scope and working methodologies.
- **CHAPTER 2 Description of the project.** Describes the technical characteristics of the project at the level of feasibility in the stages of construction and operation; presenting the designs of the different facilities.
- **CHAPTER 3 Characterization of the influence area.** This chapter defines the influence areas for the project development and it is identified, and described the current state of the elements and components of the environment (physical, biological and social), carrying out a comprehensive analysis of these components, in order to identify its environmental sensitivity.
- **CHAPTER 4 Demand of natural resources.** In this chapter are identified and quantified the natural resources that can be affected by the development of the project, including those that require permits, concessions or authorizations.
- **CHAPTER 5 Identification and assessment of environmental impacts.** There is an identification and evaluation of the main environmental impacts generated by the development of the project, carrying out an analysis of two development scenarios which covers trends without project and with project. In addition, it presents an analysis of the evaluation of the potential cumulative impacts that can be generated and economic evaluation of impacts.
- **CHAPTER 6 Zone of environmental management** this chapter is a synthesis of the vulnerability of the identified environmental units leading to the classification of the exclusion areas and intervention with restrictions.
- **CHAPTER 7 Environmental Management Plan** This chapter presents the programs that specify the different measures of environmental management necessary to prevent, mitigate, correct and compensate for the impacts generated by the development of the project during the stages of construction and operation.
- **CHAPTER 8 Plan for monitoring and follow-up:** This chapter sets out the key measures that will allow carrying out the monitoring and follow-up of prevention, mitigation, remediation, and compensation rose in the Environmental Management Plan for the physical components, biotic and social.
- **CHAPTER 9 Contingency Plans.** This chapter introduces the risk analysis of the project, as well as the attention measures of emergencies and contingencies in the constructive phase of the project and the guidelines for the operation.

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- **CHAPTER 10 Plan of abandonment and final restoration.** It is proposed the different activities to be developed in the intervened areas and infrastructure by the project, in order to restore the initial conditions of the environment to a possible extent.
- **CHAPTER 11 Investment Plan of 1 %.** The proposal is presented to the technico-economical and economic for the implementation of the investment of 1 %, in accordance with the procedures laid down in the current regulations, Decree 1900 of 2006.

## 1.2 OBJECTIVES

The objectives of this Environmental Impact Study are:

- Characterize components and elements of the environment in the influence area of the hydroelectric project San Matias.
- Estimating the demand, use of natural resources that will be used or affected during the execution stages of construction and operation of the project.
- Determine the potential fragility and environmental sensitivity in the study area in order to identify the areas where the project can be built, and those areas that should be excluded or handled in a special way.
- Identify and assess the cumulative impacts that the hydroelectric project will generate, in its phases of construction and operation.
- Make the economic assessment of the most important identified impacts.
- Design measures of environmental management necessary to prevent, mitigate, correct and compensate the impacts generated by the project during the stages of construction and operation.
- Design indicators to follow up the changes in the environment by the construction of the project and the implementation of the designed management measures.
- Define the program for follow up the and monitoring, to assess the efficiency and effectiveness of the measures of environmental management.
- Carry out a risk analysis of the project and define the measures to attend emergencies and contingencies for the stages of construction and operation of the project.

## 1.3 BACKGROUND

Since 2006, HMV ENGINEERS LTDA began studies on the possibility of developing some type of hydroelectric project in the basins of the San Matias, Tafetanes, Cocorná and Calderas rivers.

By means of Communication HMV 39692 from February 9 of 2007, HMV Engineers Ltda. requested to the (Corporación Autónoma Regional RionegroNare-CORNARE) permission of studies to determine the feasibility of project facilities for the future development of hydraulic force in the water basin from San Matias River and Tafetanes, through the construction of hydroelectric energy plants.

By Resolution No. 112-4112 August 23 of 2007, the Corporation granted permission for the study of natural resources to project works for future development of the hydraulic force of the

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water basin from rivers San Matias and Tafetanes, in jurisdiction of the municipalities of Cocorná, El Santuario and Granada.

As a result of this activity, HMV identified the feasibility of a possible use of the San Matias River waters between the altitude 1280 MASL and confluence with the Cocorná River, for the generation of electrical energy by means of two alternatives. The first alternative consisted in the development of two hydroelectric projects in chain called El Molino I and El Molino II, and the second alternative in the development of a single project, which integrates them, called El Molino.

Given that there were two alternatives, CORNARE in response to the request made by HMV, by means of the Auto 112-0739 from July 4 of 2008, provides that the hydroelectric development of the San Matias River between the altitude 1280 MASL and the confluence with the Cocorná River, requires the submission of an environmental assessment of alternatives -DAA- and sets out the terms of reference for this purpose.

The document of DAA was developed from the reference terms and was sent to CORNARE on September 11 of 2009. There were two alternatives: Alternative 1, which consists of two hydroelectric projects in chain, to take advantage of the benefits conferred by the regulation of the electric sector, called El Molino I and El Molino II of 21 MW installed capacity each; and alternative 2, a project called El Molino of 34 MW installed capacity.

By means of the Auto 112-0306 from August 23 of 2010, CORNARE selects option 1 for the preparation of the Environmental Impact Study of two hydroelectric projects in chain, called El Molino I and El Molino II, and issued the terms of reference for this purpose.

This document presents the Environmental Impact Study of El Molino hydroelectric project II, which will be hereinafter referred to as " Hydroelectric Project San Matias", according to the Terms of Reference " *I-TER-1-01 - Construction and operation of generating hydroelectric power stations* ", to continue with the processing of the environmental licensing according to the provisions of the competent environmental authority framed in the existing norms.

Complementing the work, which includes the Environmental Impact Study, consultations were held on the presence of ethnic minorities in the area of potential hydro developments in the San Matias River, with the following results.

- Through communication with the Ministry of the Interior number EXTMI11-0015660 from November 4 of 2011, HMV ENGINEERS LTDA., requesting certification on the presence of ethnic groups, to which the Ministry through Resolution 556 of November 28 of 2011, replied that " *there is no record of reservoirs constituted, communities outside of the reservoir, election of community councils, or identifies presence of other ethnic groups* ", as can be seen in Annex 1.
- Through communication with INCODER 2011113281 of the November 15 of 2011, HMV ENGINEERS LTDA., requesting certification on the existence of indigenous reservations and collective territories and reservoirs of black communities, to which the INCODER replied that the defined polygon by the coordinates handed over by HMV, there are no certified indigenous reservations or in certification process, or with collective titles in black communities, as can be seen in Annex 2.

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## 1.4 SCOPE

As mentioned in the Terms of Reference, *"The environmental impact study is the tool for making decisions about the project, which defines the measures of prevention, correction, compensation and mitigation of environmental impacts that the project will generate"*<sup>1</sup>

In this regard, the scope involves:

- Characterize the physical aspects, biotic and social, in such way that will generate information that would allow the recognition and analysis of the current state of the natural and cultural resources.
- Optimize the use of natural and cultural resources, minimizing the generation of negative impacts and booster the positive.
- Bring up primary information for the formation of the environmental baseline, to complement and update the information of the alternatives Environmental Assessment.
- Delimit the influence area the project, taking into account vulnerable communities and sensitive or critic areas to the project identified impacts.
- Identify and assess the impacts generated by the hydroelectric project implementation, and determine the levels of uncertainty that may exist. Proper methodologies should be used to ensure less subjectivity and interdisciplinary nature.
- Involvement of affected communities, developing information processes. Annex 3 presents the information process carried out in the development of this study.

## 1.5 METHODOLOGY

Below is a list of the different methodologies used for upbringing, processing, and analysis information on each element of the physical, social and biotic environments.

### 1.5.1 Physical Environment

#### 1.5.1.1 Geology and geomorphology

The information presented in this study, was extracted from the Environmental Assessment of alternatives of the study "hydroelectric development of the San Matias River - El Molino".

For the work of the facilities, aerial photographs were taken by (Aeroestudios), shown in Table 1-1.

**Table 1-1 Index of aerial photographs of the influence area**

Strip	Photos
03s	942-950
04	935-941
10	729-731

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1 ENVIRONMENT MINISTRY OF HOUSING AND TERRITORIAL DEVELOPMENT H-B-1-01- Construction and operation of hydroelectric power generators,. Bogotá, 2006

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Strip	Photos
11	722-724
12	717-719
14	726-728

From the field observations and secondary information, it is described and mapped the main features of the geological units, geomorphologic and morphodynamic characteristics.

### 1.5.1.2 Soils and potential uses

For the characterization of soils and potential uses was used the information raised in the "General Study of soils and land zoning of the department of Antioquia", developed by the Geography Institute Agustin Codazzi and the Government of Antioquia in the year 2007.

### 1.5.1.3 Hydrology

The information on the hydrology was extracted from the Environmental Assessment Alternatives of hydroelectric development of the San Matias River - El Molino.

For the estimation of flow rates are identified 34 rainfall stations belonging to the IDEAM, EPM and CHEC, located in the basins of the Cocorná, San Matias, Tafetanes, Calderas, and Santo Domingo rivers; and four stations of flows on the Cocorná, San Matias, Calderas and Santo Domingo rivers, the first three belonging to the Public Companies of Medellin and the last to the IDEAM. Out of these, only the one from IDEAM was used (Pailania), because of internal policy Public Enterprises of Medellin did not supply the series of flows.

### 1.5.1.4 Water Quality

To complement the field information collected for the Environmental Assessment Alternatives of the hydroelectric development of the San Matias River - El Molino monitoring was conducted in the same three stages of the first study, in September of 2011 which covers the influence areas of El Molino and San Matias hydroelectric projects.

- **Physical - Chemical Quality**

For the sampling to establish the physical and chemical quality of the water, complying with the procedure laid down in the guide monitoring of effluents, surface water and groundwater of the IDEAM.

There were measures *in situ*, the air temperature at the beginning of the assessment in each sampling site and the water temperature at 15 centimeters below the current surface, electrical conductivity, dissolved oxygen, Oxygen Saturation Percentage and potential of hydrogen ions (pH).

Water samples were taken to analyze the variables, DBO<sub>5</sub>, DQO, orthophosphates (PO<sub>4</sub><sup>3-</sup>), total phosphorus (P), nitrates (N-NO<sub>3</sub>), Ammoniac nitrogen (N-NH<sub>3</sub>), total nitrogen (NTK), sulfates (OS<sub>4</sub>), total hardness (CO<sub>3</sub>), total iron (Fe), total solids, total suspended solids, sedimentary solids, turbidity, fat and oils, total coliforms and fecal.

- **Benthic Micro algae**

To collect the field samples, it was carried out a perifiton material removal adhered to rocky substrates, immersed or exposed to the current flow, using brushes and plastic knife. As an

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area unit is used 234 cm<sup>2</sup> per section (six replicas of 39 cm<sup>2</sup>). The samples were fixed with a Lugol's solution of 10% (0.5 ml per 100 ml sample) and transported to the laboratory in opaque plastic containers properly labeled.

For the observation of the micro algae samples, it was used an inverted microscope and montage of the sample was made in a count camera of Uthermöl of 1.0 ml capacity. To make valid comparisons between the quantitative analysis, it was taken into consideration the volume of the samples, which for the initial phase of observation and counting was stirred in a plastic container 40 times in order to homogenize the sample and to count through the provision sample of 1.0 ml in the observation camera.

To make the count 30 observation fields were selected, according to a random sampling system, and getting the density of algae per volume unit (ind/ml), which was also related to the referred sampling area (234 cm<sup>2</sup>) (Uehlinger 1964). The counting was done with 400X magnification.

The taxonomic determination was based on the work of Kramer & Lange-Bertalot (1991 A. and B), Cox (1996), Komarek & Anagnostidis (1999), Wehret *al.* (2002), Komarek & Anagnostidis (2005).

- **Aquatic Macro invertebrates**

For obtaining the samples of aquatic macro-invertebrates in each section of interest, benthic samples were taken with triangular net over rocky surfaces and hedges of macrophytes, and manually, by lifting stones, sticks and submersed leaves for the capture of these organisms. The effort of collection by stretch was 30 minutes in total, and the samples were placed in plastic bags, preserved with alcohol at 70 %, and transported to the laboratory for taxonomic determination.

The biological material collected in the field is separated from other accompanying materials (organic and inorganic) and the specimen is stored in separate plastic vials with alcohol at 70 %. Through stereoscope Nikon SMZ1000 was made the determination of the maximum possible taxonomic level using the taxonomic keys from Pennak (1978), McCafferty & Provonsha (1981), Lopretto & Tell (1995), Merrit and Cummins (1996), Wiggins (1998), Fernandez & Dominguez (2001) and Heckman (2006).

#### **1.5.1.5 Uses of water**

To establish the water uses in the influence area of the project, to supplement the information delivered by CORNARE in regard to the existing legal concessions in the influence area of the project, a visit was made in the detailed area, identifying the uses of the existing flows

#### **1.5.1.6 Atmosphere**

- **Climate**

To complement the information that appears in the Environmental Assessment Alternatives of the hydroelectric development of the San Matias River - El Molino, from the weather station, registries were used, installed during the sampling done in the period from September 27 until October 13 of 2011.

- **Air Quality**

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For the characterization of the air, the firm K2 Engineering conducted monitoring in four points of the influence area, between September 26 and October 14 of 2011.

In addition it restarted the monitoring results carried out for the hydroelectric project El Popal, which share some of the influence area which was carried out by the company Environmental Monitoring High Technology Ltda (MAHT), between April 30 and May 18 of 2011

- **Noise**

For the characterization of noise, monitoring is carried out in four points of the influence area during September 29 and 30, October 2 and 9 of 2011. Sampling was conducted by the firm K2 Engineering.

We also considered monitoring results done by MAHT, for the hydroelectric project El Popal.

### 1.5.1.7 Landscape

The landscape information was extracted from the Environmental Assessment Alternatives of the hydroelectric development of the San Matias River - El Molino, which was based on the concepts issued by Etter, (1990), and the methodology proposed by Villota (1992) to the physiographic classification, which considers the geomorphologic environment (highlight and rocks), the parent material, weather and climate as formation factors of the landscapes and associated soils.

## 1.5.2 Biotic Environment

### 1.5.2.1 Flora

For the characterization of flora in the study area first defined a land map cover in the influence area of the project based on aerial photography to scale 1:20 in the year 2008, complemented with the coverage reported in the EOT of the municipality of Granada (2002) and the regional system of protected areas to the southeast of Antioquia (Sanchez, 2003) and its subsequent corroboration in the field. The coverage was interpreted following the methodology *CorineLandCover*, taken from the study adapted to Colombia by IDEAM, 2010.

For the direct influence area it was defined the areas where the facilities will be, which overlapped with the map of land cover scale 1:10, built on the basis of aerial photographs of the area and corroboration in the field. From this information it was performed a forest inventory at random, with a sampling error of less than 15 %.

For this purpose parcels were placed based on the methodology used by Gentry (1982), called RAP ( *Rapid Assessment Plot* ) and subsequently amended by the Convention ISA-JAUM (2004) .This method consists in the establishment of blocks of 0.1 ha (50 m x 20 m), which are divided into five rectangular plots of 50 m x 4 m (200 m<sup>2</sup> ), inside of which are plotted subplots, one of 5 m x 4 m (20 m<sup>2</sup> ) and a 25 m x 4 m (100 m<sup>2</sup> ), located at the beginning of each plot.

In total 100 plots were established in 200 m<sup>2</sup>, 100 subplots of 20 m<sup>2</sup> and 100 subplots of 100 m<sup>2</sup>. Within the plots of 200 m<sup>2</sup> were counted and measured all the woody plants whose stem had a diameter at breast height (DBH measured at 1.3 m from the surface of the ground) ≥ 10 cm (stem). In the parcels of 100 m<sup>2</sup>, were counted and measured the individuals

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within the range of  $5 \text{ cm} \leq \text{DBH} < 10 \text{ cm}$  (age stages) and in the subplots of  $20 \text{ m}^2$  recorded the presence and abundance of plants with  $< 5 \text{ cm}$  DBH saplings).

The registered plants in each parcel, for the category of stem, were marked with asphaltic paint where it is specify the number of the plot and the row of the tree. For each species was collected a botany sample for later identification in the Herbarium of the National University. The botanical samples collected in the field, were pressed on sheets of news paper previously labeled, and were subsequently alcoholized with alcohol at 70 %, to prevent detachment from the leaves and the attack of insects or organisms.

The plant material previously fortified was taken to the workshop of the Herbarium of the National University, where it was ready to be dissected and where process for taxonomic identification is performed.

For the taxonomic determination of the species were followed systems of classification APG (2009), for which aid was used in specialized literature, such as keys and species descriptions, with the comparison with the morphological specimens deposited in the Herbarium of the National University (MEDEL), the database of the *Missouri Botanical Garden* ([www.mobot.org](http://www.mobot.org)) and with the collaboration of specialists in some groups or botanical families.

#### **1.5.2.2 Terrestrial Fauna**

- **Mammals**

For the inventory of mammals, tours were conducted by the edge and the inside of the coverage of secondary vegetation and forests, seeking to explore the edges of creeks and the San Matias River, these being the best preserved sectors.

In the different sampling sites were conducted indirect records: auditive evidence, prints, and marks in the bark of the trees, trails, paths, rooting, diggings feces, food waste, dens and caves. There were also direct recordings as: sightings, installed mist nets to capture bats, and traps Sherman type collapsible for the capture of small alive terrestrial mammals such as rodents and marsupials.

The sampling of bats was performed with two mist nets type (mist-nets), with mesh eye of  $3 \times 3 \text{ cm}$  and  $4 \times 3 \text{ cm}$ . The net facilities were placed in foraging and activity areas as edges and clear forest vegetation with florid or fructified and areas with water bodies. The net facilities were deployed in the afternoon (5:00 pm) and were left open until the following day (Muñoz, 2001, Voss et al., 1996, Wilson et al, 1996). The determination and taxonomic classification of the species that have been based on Cuartas-Calle and Munoz, 2003a, b; Muñoz et al. , 2003; Cuartas-Calle et al, 2001; Muñoz, 2001; Alberico et al. , 2000; Emmons and FEER, 1999; Wilson and Reeder, 1992; Eisenberg, 1990.

For the capture of small non-flying mammals (PMNV), Sherman traps of  $9 \times 9 \times 28 \text{ cm}$  and  $25 \times 25 \times 45 \text{ cm}$  were installed. In total 10 traps were installed, located at strategic sites and micro habitats, as fallen logs, base of trees, branches of trees, base and foliage of palms, cavities formed by the roots, burrows, in edges of stones and in paths (Wilson et al, (1996) and Aranda-Sanchez (1981)).

All the traps were examined daily in the morning hours, to verify the presence of catches and change lures. For traps it was used as bait a mixture of oats in flakes, corn, bananas,

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peanuts, essences of vanilla and banana. The determination and taxonomic classification of the species were based on Cuartas-Calle , 2005; Morales-Jimenez et al. , 2004; Cuartas-Calle and Munoz, 2003a, b; Defler, 2003; Alberico et al. , 2000; Emmons and FEER, 1999; Wilson and Reeder, 1992; Eisenberg, 1990.

There were also diurnal walks to obtain records of mammals of greater, middle and small size, which were obtained by direct observation or indirect evidence. In addition, photographic records were obtained when the observation conditions were allowed; there were also used surveys and reports to the inhabitants of the area about the presence of mammals in the area.

In addition, it was installed a capture camera Cudde digital back type; mark Capture IR that has a photo receiver that is triggered by the body heat of near animals. The camera was left at night near supporting beams, for the nocturnal animal's registration. It is worth noting that it is very helpful, since it allows photographing several nocturnal animals, now that in daytime the recording is difficult.

- **Birds**

For the characterization of the birds, direct observations were carried out, using binoculars 10x40 and capture of specimens with three mist nets (mist-nets), at an approximate distance of 40 m between them and during an average of eight hours a day, for five days. These net facilities were placed in strategic places such as along roadsides, inside the forest, debris, pastures and along the riverbanks, attempting to ensure the transit of the birds. Those once captured, were placed in cloth bags, then taken the respective pictures and released afterwards, since it was not carried out a collection of specimens.

The bird count was also carried out, taking into account the number of individuals per species, both the captured as those observed. Another parameter was the cumulative number of different species that were observed daily.

Sampling was carried out between 10 and 14 of October 2011. Bird observation was carried out between 7:30 am until 5:30 PM. For their capture the mist nets remained on place roughly nine hours each, for a total of twenty-seven hours of the day for the three net facilities, for a total of 135 hours for the 5 days.

- **Herpetofauna**

The methodology used was the method of Visual encounters (VES), which consists in walking through an area or habitat for a predetermined time. The species is sought through detailed tours, by lifting the rocks and fragments of vegetation, removing the dead leaves and carefully examining the caves and roots, trying to include the greatest possible number of micro habitats (bodies of water, forests and open areas, among others).

The captured animals were collected directly by hand, they were later placed in plastic or cloth bags, with wet leaves to avoid dehydration. To make the catch, the sightings or to listen to the vocalizations, data was recorded on the location where the individuals were captured, such as: municipality, Vereda, coordinates, date and time of sampling; in addition, characteristics of the micro habitat that the individuals inhabited when they were detected, and finally information was recorded on the number of individuals per species.

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Also auditory samplings were carried out, which consists in trying to hear the songs of male individuals or in chorus, and then follow each different singing to identify the source which allowed in some occasions to recognize the species.

In addition, the encountered individuals were captured, photographed and later released on the same site in which they were found.

### **1.5.2.3 Aquatic Fauna**

The field work was done following the lines of the "General Methodology for the presentation of Environmental Studies" (Resolution 1503 of 2010, Ministry of Environment, Housing and Territorial Development - MAVDT), which establishes that the copies of each section are collected through the method of electro-fishing along transects of 100 m and with nets (with mesh size of 1 cm and 2 m in diameter), maintaining a constant fishing effort (30 hauls of nets), in order to allow comparisons between the stages and sampling.

The electric fishing method is very suitable for the conditions that the bodies of Andean water have (stony flowing bottoms) (Maldonado et al. 2005). The sampling tranches were chosen trying to assess the greatest amount of meso - habitats (pools, rapids, pools) present in the sector). The samplings were punctual and in diurnal, done during a rainy season, the days 12 and 13 of September 2011.

The individuals collected were measured, weighed, taxonomically determined in field, photographed and returned to the natural flow. The taxonomic determination was supported by the key proposals by Dahl (1971), Maldonado et al. (2005a) y Nelson (1994).

### **1.5.3 Socio-economic environment**

To complement the information contained in the Environmental Assessment Alternatives of Hydroelectric development for the San Matias River - El Molino, the methodology used includes techniques implemented in social research, for the primary recollection of information, such as:

- Direct observation is a simple and effective method for obtaining information. This was done visiting the urban areas of the municipalities in the indirect influence area and the Vereda of the project direct influence. Accompanied by the respective photographic record.
- The field notes allowed describing events or situations of interest for the study.
- The open interview allowed identifying, in general terms, the most important problematic situations in the area, for its further deepening. It was given by direct communication, through spontaneous conversation, with some people from the municipal center and leaders from the Veredas.
- The semi structured interview. A questionnaire with inquires was handed to the presidents of Boards of Communal Action from the Veredas of direct influence, to common people of the municipal headers and veredal leaders.
- Then, likewise, a collection of information from the different dependencies of the municipal administrations units, such as the secretariats of Planning and Community Development and the Sisben offices.

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#### 1.5.4 Identification and assessment of impacts

The identification of the of the impacts was carried out by means of a matrix of double entry, where the components of the environment (arranged in columns) come across with the activities of the project that may potentially cause impacts (arranged in rows).

With the interaction are identified the impacts that are generated, evaluated qualitatively by the use of a methodology developed by Grove, which was developed by the Planning Unit of Natural Resources of the Public Enterprises of Medellin in the year 1986, with the purpose of evaluating its hydraulic utilization projects, and which is based on the parameters Presence (P), Evolution (E), magnitude (M) and duration (D), using these to calculate the environmental rating (Ca), which represents the seriousness or importance of the effect that this is causing, whose mathematical expression is:

$$Ca = C (P [7 \times E \times M+3 \times D])$$

And the estimated value is classified in accordance with the following ranges:

- $\leq 2,5$ : Little significant or irrelevant
- $>2,5$  and  $\leq 5,0$  Moderately significant or moderate
- $>5,0$  and  $\leq 7,5$  Significant or relevant
- $>7,5$ : Very significant or serious

#### 1.1.1 Preparation of thematic maps

For the preparation of thematic maps of the influence area of the project, it was used the *ArcGIS Desktop software* (version 10.0), which processed the collected cartographic information.

In addition tools from the *ArcGIS platform* were used to generate the digital terrain model (DTM), starting from the detailed topographic databases, specific to the project.

To generate the coverage map, aerial photographs were used, with a first phase of work office of photointerpretation, subsequently verified in the field.

There were also used tools from GIS, such as the algebra of maps, allowing the use of mathematical operators (addition, multiplication, subtraction or division), to obtain a new map based on the values of each of the input layers with their respective weighting, to build the Zoning Environmental Blueprints.

The coordinate system used for the construction of the plans is located with origins Bogota of Datum Magna - SIRGAS.

#### 1.6 WORKING GROUP

Table 1-2 presents the staff list of the participating professionals in the Environmental Assessment of Alternatives.

**Table 1-2 Professional who participated in the Environmental Impact Study**

Name:	Profession	Charge
Elvira Aguilar Amaya	Agronomy engineer Master's Degree in forest	Director of the EIA

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<b>Name:</b>	<b>Profession</b>	<b>Charge</b>
	and environmental conservation	
Alejandro Aguilar Amaya	Geological Engineer specializing in environmental management	Advisor
Sandra Montoya Arboleda	Economist	Coordinator social environment
Rodrigo Velez Otalvaro	Civil Engineer Master's Degree in water resources utilization	Coordinator of the physical environment
Paula Gomez Lopez	Forest Engineer Candidate for Master's Degree in forest and environmental conservation	Coordinator of the biotic environment
Catalina Berdugo Villegas	Environmental Engineer - Specialist in project management	Physical factors
Marta Isabel Matute	Anthropologist -	Demographics, cultural, economic and development trends
Nicolas Diaz Granados	Anthropologist -	Spatial aspects and political
Dany Conrado Palaces Agudelo	Forest Engineer	Aspects biotic - Flora
Sebastian Ramirez Echeverry	Forest Engineer	Aspects biotic - Flora
Marcela Montoya Jimenez	Biologist	Aspects biotic - Flora
Emerson Suarez Gaviria	Forest Technician	Aspects biotic - Flora

**Table 1-2 Professional who participated in the Environmental Impact Study  
(Continued)**

<b>Name:</b>	<b>Profession</b>	<b>Charge</b>
Ercilia González Giraldo	Forest Technician	Aspects biotic - Flora
Carlos Cuartas Calle	Biologist	Aspects biotic - Wildlife
Manuel Peña Restrepo	Biologist	Aspects biotic -Fauna
Sandra Gallo Delgado	Biologist	Aspects biotic - Wildlife
William Cano Zapata	Biologist M. Sc in Biology	Aspects biotic - Limnology
Monica Tatiana Lopez	Biologist M. Sc in Biology	Aspects biotic - bentos
José Andrés Posada G	Biologist M. Sc in Biology	Aspects biotic - macro invertebrates
Juan Guillermo Ospina P	Biologist	Aspects biotic - Ichthyology
Ariel Bermudez Cortez	Biologist	Aspects biotic - Ichthyology
David Peña G.	Sanitary Engineer	Physical Aspects - water quality
Edwin Siegert Echeverri	Civil Engineer	Director technical studies
Sandra Aguilar Jimenez	Civil Engineer	Technical Coordination of the study. Hydraulic Studies and hydraulic facilities
Fabio Villegas Gutierrez	Civil Engineer M. Sc. Hydraulic	Hydraulic facilities Adviser, hydrology and geotechnics
Mauricio Velez Restrepo	Geological Engineer Specialist in geomorphology and soil	Geological and geomorphological studies

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<b>Name:</b>	<b>Profession</b>	<b>Charge</b>
	Specialist in image interpretation of remote sensing applied to the geology	
Gloria Mejia Sierra	Civil Engineer M. Sc. Utilization of Water Resources	Hydraulic Studies and hydraulic facilities
Wilhen Deyver Salazar	Civil Engineer Specialist in economics	Hydrological Studies, of power and energy, and financial. Hydraulic Facilities
Beatriz Romero Turizo	Civil Engineer. Specialist in project management	Hydraulic Studies and hydraulic facilities
Alvaro Villamizar Restrepo	Civil Engineer Specialist in finance, evaluation and preparation of projects	Budget, construction timetables and financial evaluation
Juan Pablo Sandoval	Civil Engineer Specialist in finance, evaluation and preparation of projects	Geotechnical studies and areas of deposits
Elizabeth Vargas Rodriguez	Civil Engineer Specialist in energy markets	Hydrological and climate studies
Andres Hurtado Montoya	Civil Engineer Candidate to M. Sc. Utilization of water resources	Hydraulic Studies

**Table 1-2 Professional who participated in the Environmental Impact Study  
(Continued)**

<b>Name:</b>	<b>Profession</b>	<b>Charge</b>
Federico Ortiz Cárdenas	Environmental Engineer	Areas of lending and deposits
Claudia González Martínez	Sanitation engineer specialist in environmental management	Waters
Jaime Mejia Cordoba	electromechanical engineering Technologist	drawer (artist)
Diana Aranda Agudelo	Technologist of architecture	drawer (artist)
Juan Diego Ramirez Maya	Technologist of architecture	drawer (artist)
Duber Ruiz Restrepo	Technologist of architecture	drawer (artist)
Teresita Builes	Technologist of architecture	drawer (artist)

## 1.7 REGULATORY FRAMEWORK

Table 1-3 addresses some of the laws, decrees and resolutions codes that were considered in this study of environmental impact.

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**Table 1-3 Environmental legislation applicable to the project**

<b>Norm Type</b>	<b>Norm</b>	<b>Description</b>
General Application	National Constitution	Mechanisms and instruments of national compliance. As primary objectives of the national economy, the search for a balanced development looking for a healthy environment, through the planning and the incorporation of the environmental dimension in environmental accounting and development plans. It recognizes and reclaims the cultural and biological diversity of the country. It is expressly established the social and ecological functions of the corporate business.
	Lew 56 de 1956	States rules on public works for power generation, power transmission, aqueducts, irrigation system, among other and regulates the explorations and easements of property affected by such facilities.
	Decree 2811 of 1974.	Mentions the factors that damage the environment, air pollution, water, soil or other renewable resources, understood by contamination the alteration of the environment by human activity.
	Decree 919 of 1989.	Organizes the National System for Prevention and attention of Disasters.
	Decree 2591 of 1991.	Regulation of the guardianship.
	Law 99 de 1993	Framework Law on environmental issues, created by the Ministry of the environment among others.
	Law 357 de 1997	Subscribes to the Ramsar Convention on Wetlands of International Importance especially as Waterfowl Habitat, signed in Ramsar in 1971.
	Decree 1449 of 1977.	Provisions on conservation and protection of waters, forests, terrestrial and aquatic flora.
	Decree 1974 of 1989.	Regulates the article 310 of the Decree 2811 of 1974 on districts of integrated management of renewable natural resources and the Law 23 of 1973.
	Resolution 584 of June 2002	Through which the Ministry of Environment, Housing and Territorial Development, stated the wild species that are endangered in the national territory, on the basis of the information contained in the series "red books of endangered species in Colombia".
	Signaling Manual of 2005	Devices for transit regulation .
	RAS - 2000 or Resolution 1096 of 17 of November 2000	By means of which it is adopted the technical regulation for the drinking water and basic sanitation.
	Decree 2820 of 2010.	By means of regulates Title VIII of the Act 99 of 1993 on environmental licenses.

**Table 1-3 Environmental legislation applicable to the project. (Continued)**

<b>Norm Type</b>	<b>Norm</b>	<b>Description</b>
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<b>Norm Type</b>	<b>Norm</b>	<b>Description</b>
	Decree 02 of 1982.	Establishes among others, the air quality standards and their methods of measurement and the special rules of particle emissions for some fixed artificial sources.
	Decree 948 of 1995.	Rules on the emission of pollutants produced by mobile sources, environmental criteria of fuel quality for use in internal combustion engines in motor vehicles.
	Resolution 627 of 2006	To establish the national standard for noise emission and ambient noise.
	Resolution 601 of 2006	To establish the standard of air quality or admission levels, for the entire national territory in reference conditions.
	Decree 979 of 2006.	Amending articles 7, 10, 93, 34 and 108 of the decree 948 of 1995
	Resolution 909 of 2008	By establishing the norms and admissible standards of contaminants to the atmosphere by fixed sources and other provisions are dictated.
	Resolution 610 of 2010	By amending the resolution 601 of 2006. Modifies the articles 1, 4, 5, 6, 8 and 10 of resolution 601 of 2006.
	Resolution 650 of 2010	By means of the adoption of the protocol for monitoring and follow-up of air quality.
	Resolution 2154 of 2010	By means of adjusting the protocol for monitoring and follow-up to the air quality taken through resolution 650 of 2010 and adopting other provisions
	Resolution 760 of 2010	Through the adoption of the protocol for the control and monitoring of the air pollution generated by stationary sources
	Resolution 2153 of 2010	By means of adjusting the Protocol for the Control and Monitoring of the air pollution generated by Stationary Sources, taken through the Resolution 760 of 2010 and adopting other provisions"
Water	Decree 1541 of 1978.	Establishes the procedures to be able to use the hydric resources
	Decree 2857 of 1981.	Accounts for the management of river basins.
	Decree 1594 of 1984.	Establishes water quality criteria according to the pollutants and also the rules for discharge of wastewater into a water body.
	Decree 1729 of 2002.	By means of which regulates part XIII, title 2, Chapter III of Decree 2811 of 1974 on watershed, partially paragraph 12 of article 5 of Law 99 of 1993.
	Decree 1575 of 2007.	Sets the system for the Protection and Control of water quality for human consumption
	Decree 3930 of 2010.	By means of is partially regulating Title I of the Act 9 of 1979, as well as the Chapter 11of the Title VI-Part 111 - Book 11of the Law Decree 2811 of 1974 in regard to uses of water and liquid waste and other provisions.

**Table 1-3 Environmental legislation applicable to the project. (Continued)**

<b>Norm Type</b>	<b>Norm</b>	<b>Description</b>
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Norm Type	Norm	Description
Soil	Law 09 de 1989	The regulation of land use is the identification of the aptitude of uses and the environmental degradation of the area.
	Law 388 de 1997	Land Use: in compliance with this law, the Colombian municipalities developed the plans or diagrams of order, as the basic tool to develop the management process of the municipal territory.
Solid Waste	Resolution No 541 of 1994	Concerning upload, download, transport, storage and disposal of rubble, materials, concrete, aggregates loose construction, organic layer, soil and subsoil of the excavation.
	Decree 1713 of 2002.	To regulate Law 142 of 1994, the Law 632 of 2000 and the Law 689 of 2001, in relation to the provision of sanitation public service the Law 2811 of 1974 and Law 99 of 1993 in relation to the Integrated Solid Waste Management.
	Decree 1505 of 2003.	Partly Modify the Decree 1713 of 2002, in connection with the plans of integrated solid waste management.
	Decree 1140 of 2003.	Amending partially the Decree 1713 of 2002 in relation to the topic of storage units and other provisions.
	Decree 838 of 2005.	Whereby establishing new rules for the final disposal of waste
Hazardous Waste	Resolution 2309 of 1986	It lays down rules for the compliance of the contents of Title III of Part 4 of Book 1 of the Decree-Law number 2811 of 1974 and of the Titles I, III and XI of the Act 9 of 1979, in regard to special waste.
	Law 430 de 1998	Dictates prohibitive rules in environmental matters, relating to hazardous waste.
	Decree 2676 of 2000.	States the regulation of the integral management of hospital waste and similar.
	Decree 1609 of 2002.	establishes the requirements for the transport of dangerous substances
	Decree 1446 of 2005.	Handling of fuels.
Fauna	Decree 1681 of 1978, Act 13 of 1990 and Decree 2256 of 1991	Contained the regulation of marine resources, which covers, among others, the protection and promotion of marine resources.
	Decree 1608 of 1978.	Regulates the Code on Natural Resources Renewable and Environmental Protection in the field of wildlife
	Law 84 de 1989	National Statutes for the protection of animals, among its provisions is to develop effective measures for the preservation of wildlife.

**Table 1-3 Environmental legislation applicable to the project. (Continued)**

Norm Type	Norm	Description
Fauna	Law 165 de 1994	Ratifies the Convention on Biological Diversity and incorporates it into national law.
	Law 611 de 2000	It lays down rules for the species management of wild and aquatic fauna.
	Act 13 of 1990 or general statute for fishing	Establishes that the Institute of Fishing and Aquaculture (INPA) enters to coordinate the functions of the INDERENA in the management of aquatic areas in regard to the exploitation of marine resources.

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<b>Norm Type</b>	<b>Norm</b>	<b>Description</b>
Flora	Decree 1383 of 1940.	Takes measures for the defense and development of forests.
	Law 2 de 1959	On forest economy of the Nation Conservation and Renewable Natural Resources.
	Decree 877 of 1976.	Uses of the forest resource. Areas of forest reserves.
	Decree 622 of 1977.	Regulates the System of National Parks.
	Law 79 de 1986	Declares the areas of protective forest reserve for the conservation and preservation of the water.
	Decree 1791 of 1996.	Through establishing the regime of forest development.
	Resolution 283 of 2010	By means of which are declared wild species that are endangered in the national territory and take other determinations.
Social	Law 163 of 1959	By means of dictates action on defense and conservation of the historical, artistic and public monuments of the nation.
	Decree 264 of 1963.	This regulates the Law 163 of 1959 and will increase the inventory of items that are considered.
	Decree 1715 of 1978.	Regulates the decree-law No. 2811 of 1974, Law 23 of 1973 and the Decree Law 154 of 1976, in regard to the protection of the landscape.
	Law 45 of 1983	Subscribes to the Convention for the protection of world cultural and natural heritage.
	Law 121 of 1991	Indigenous Territories
	Law 21 of 1991	Ratifies convention No. 169 of the OIT concerning indigenous and tribal peoples.
	Law 70 of 1993	Rights of the black minorities
	Decree 2159 of 1993.	Sets out the functions of the Colombian Institute of Anthropology (ICAN).
	Law 134 of 1994	Protection and enforcement of rights "mechanisms for citizen participation".
	Law 143 of 1994	Regime for the generation, interconnection, transmission, distribution and marketing of electricity.
	Law 397 of 1997	General Law of the culture. Archaeological protection area in the environmental license.
	Resolution 282 of 1997	Creation of the National Committee of Preventive Archeology (CONAP) and other provisions.
Law 472 of 1998	Popular Actions	

**Table 1-3 Environmental legislation applicable to the project. (Continued)**

<b>Norm Type</b>	<b>Norm</b>	<b>Description</b>
Social	Decree 833 of 2002.	Partially regulating Act No. 397 of 1997 in terms of the national archaeological heritage.
	Law 743 of 2002	By means of develops the article 38 of the Political Constitution of Colombia, for the agencies of communal action.



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