ANNEX 42

VEGETATION STUDY OF LA ENGORDA SUMMER GRAZING AREA

1. Introduction

The present study aims to characterize the vegetation in summer grazing areas and determine the effect intended by the works of the project, particularly in La Engorda sectors. This area is susceptible to alteration due to the change in the surface runoff regime in some canals.

This study includes the background collected in different prospective campaigns conducted in different seasons between 2005 and 2007, and that have generated important insights on vegetation in such area.

2. Objectives

The objectives of this study are:

— Characterize the composition (species) and abundance (coverage) of meadows in La Engorda area.

— Predict potential impacts from the project on these areas.

— Cartographically represent sectors that could be affected

3. General Background

In general, zoning in altitude layers of vegetation in the Andean foothills of Maipo River has been studied by many authors and if you do a summary of the proposals it would be: between 1500 and 2000 m, the floor of the Sub-Andean Scrubland; between 2000 and 2600 m, the Andean Scrubland; between 2700 and 3300 on the High Andean Steppe and above 3300 m the High Andean Desert. Regarding coverage of vegetation in altitudinal gradient, Cavieres *et al* (1999) and Muñoz *et al* (2000) indicate that it decreases as altitude increases; however, this reduction depends on the region. The same authors note that there are differences in the demarcation of the altitude range of floors and is very unlikely to distinguish limits applicable to the entire Andes of Santiago, because floors have local variations. However, the study cited above suggests the existence of consistent patterns of species distribution, depending on altitude, suggesting the influence of climatic factors on a regional level.

According to Gajardo (1994), the study area is located in the region of the High Andean Steppe, Mediterranean sub-region of the Andes, where the formation of meadows likely to be found corresponds to that of clandestine-Juncus balticus (meadow thatch- juncus), which often will be found impoverished by overgrazing.

Meadow units correspond to formations that are set in an edaphic environment, mainly organic, a condition characterized by permanent water saturation. Thus, they correspond to

an azonal biological ecosystem, with characteristic vegetation that develops due to high and permanent edaphic moisture content (by the existence of water sources or shallow underground aquifers). In general, its appearance is a dense to very dense herbaceous stratum (vegetation covers over 50%), low to medium height (5-100 cm), usually on a flat surface or with a very small micro relief. Water courses, when available, are restricted to small size furrows, fully vegetated, or to only one of large size.

A. History of previous campaigns

Generally the sectors studied in the Andean highlands have a nival and glacier hydrological regime. The runoff is of surface and subsurface type, as evidenced by the extensive network of smaller runoff associated with major streams, and small upwelling of water that appear in the vegetation. The geological material in this area is characterized by the presence of alluvial-torrential deposits formed by thick accumulations in the form of fans or semi cones constituted by thick deposits. This surface would allow the formation of a ground water aquifer of the semi confined type (see section 5.3 of the EIA).

Below are some results and conclusions of previous campaigns.

i) Fall 2005 Campaign

A. Flora

The explored area is small and is limited by close elevations between them, which explain the low wealth found (32 species). However, the time of the visit to the field contributes to the low wealth. In late autumn many species already have been completely dry or browsed by livestock that is abundant in the place. In relation to species in conservation categories, *Laretia acauli,* which apparently is quite common in the area searched, was found in the three vegetation units described. Also, *Alstroemeria exerens* was found. The appearance of the vegetation is low scrub and grasslands similar to those described for the study area. The feral foreign percentage is low, a similar trend in the area.

B. Vegetation

The units found are related to the Andean Scrubland floor, with dominance of shrubs less than 50 cm in height, where the dominant species are *Chuquiraga oppositifolia* and *Ephedra chilensis* (Muñoz *et al,* 2000). According to Pisano (1965) vegetation would be included in Andean Xeromorphic formation and finally, regarding Gajardo (1994), vegetation units are related to the formation of High Andean Steppe of the Andes of Santiago of the proposed associations, it would correspond to the: *Mulinum spinosum-Chuquiraga oppositifolia*, widespread regionally.

In conclusion, from the point of view of flora and vegetation, the greater problems detected are the possible impact of water draining on streams and meadows that grow around them, and the presence of *Laretia acaulis* , species in **vulnerable** category that could be affected by the project works.

ii) Spring 2006 Campaign

A. Flora

Species richness

The study conducted accounts for the presence of 258 species in the area of PHAM influence. This species number may seem low, if it is related to the diversity of environments visited. However, it is also relatively small areas and a large part of them are located on the floor where there is a lower richness.

Specifically, species richness reaches 97 in La Engorda area.

Growth forms

About 2,000 m ASL trees disappear and growth form that predominates in the appearance is low shrubs of no more than 50 cm in height, interspersed with grass turfs, with tough leaves. This pattern is somewhat different in meadows, dominated by perennial grasses without counterweight, although spatially very restricted to the immediate vicinity of water courses in the area of PHAM influence.

Geographic origin

In general in the area native species dominate, with feral foreign presence mainly on sites already altered by human activities, particularly under 2000 m altitude.

The pattern of species endemic in Chile is that they decrease with altitude, reaching the highest values in the area of sclerophyllous forest formations (43%) to decrease in the higher parts (15% in El Yeso and La Engorda). The values are to be expected given its direct phytogeographic relationship with the eastern side flora of the Andes

Endangered species

In the three high Andean sectors that will be intervened by the Project two species were found:

- *Laretia acaulis*, Balsam bog (Bolax gummifera) of Santiago: In the area of La Engorda is common and dominant in one of the formations.

- *Alstroemeria exerens,* Andean Inca lily is a perennial herb, provided of underground organ that is part of the Andean low scrubland. It is common in some areas of La Engorda.

B. Vegetation

Andean Sectors

The units of the towns located on the Andean floor according with Gajardo (1994) proposal correspond to the formation of the High Andean Steppe of the Andes of Santiago, whose distribution area covers ranges above 2000 m between the regions of Coquimbo and O'Higgins. The units recorded in the project area, according to the composition and dominant species, may framed mainly in association with *Chuquiraga oppositifolia-Mulinum spinosum*, widely distributed in the area of formation.

In connection with Luebert & Pliscoff (2006) proposal, the vegetation of the area is in what they see as the Andean Mediterranean Low Scrubland of *Chuquiraga oppositifolia* and *Nardophyllum lanatum*. The floor is distributed in the Andes, between the regions of Coquimbo and O'Higgins, between 2000 and 2600 m altitude.

Conservation issues

In relation to threatened species that are most sensitive given their condition, for the Andean is the following:

- *Laretia acaulis,* in El Yeso and Lo Encañado areas, because there this plant is scarce and is probably at the lower limit of its distribution in the area. In La Engorda the species can reach high densities.

Formations

Regarding vegetation formations of conservation concern in the Andean zone, it is concluded that:

- Andean scrubland: Andean formations according to the results of the study are widely distributed both in the country and in the project area.

- Wetlands are highly plant productive sites and azonal distribution. In the Andean some formations were found for this type of vegetation in Lo Encañado, in the basin of El Yeso and La Engorda.

4 Methodology

Information about the composition and abundance of species was gathered in the Spring 2007.

In La Engorda sector 16 parcels of 4x4 m were gathered, where abundance estimate was made visually (Picture 1). It is worth noting that in this sector information was gathered in meadow areas between Colina and La Engorda streams, and the surrounding of Las Placas stream, which had patches of wet meadow formations that had not been detected in previous campaigns, because coverage of the valley in late summer and autumn decreases significantly, probably due to decreased water availability and overgrazing.

Parcels were ordered by their degree of similarity using appropriate software (Statistica 6.0), obtaining similarity cladograms.

Picture 1: Parcel in vegetation formations in La Engorda.

5. Results

Results show the presence of two kinds of very different vegetation units (Figure 1 Picture 2). A group of units corresponds to azonal vegetation of meadows and the other to scrubland *Chuquiraga oppositifolia.* The composition and average coverage values for both communities are shown in Tables 1-4. The distribution of these in the area is shown in Picture 1 below.

Picture 2: La Engorda summer grazing area. Meadow unit (green) and scrubland unit (brown) are clearly distinguished.

Figure 1

La Engorda area: Cladogram of Parcel Use Planning

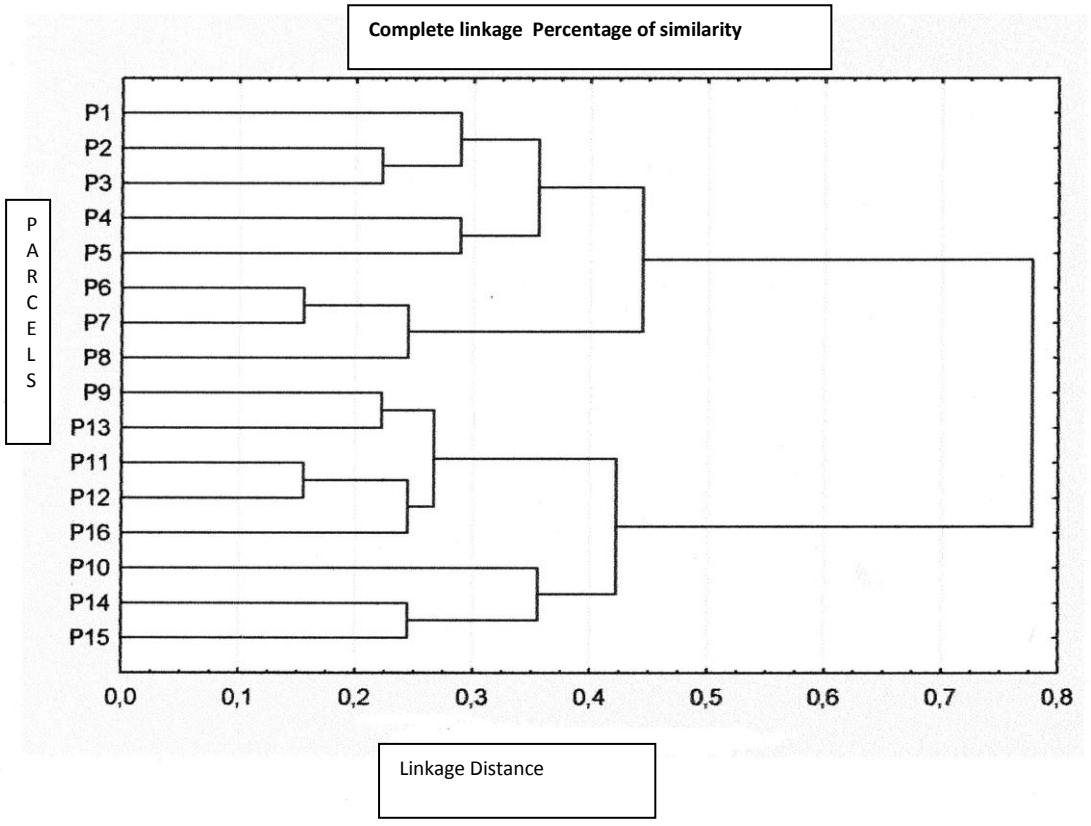


Figure 2: Study area and location of sampling parcels.

a. Meadow Unit

Species and their abundances are shown in Table 1. It is observed that the total coverage in the unit reaches an average of 80%. The unit, by the dominance of perennial herbs, has an appearance of continuous grassland. The dominant species are: *Carex gayana, Phylloscirpus acaulis, Eleocharis albibracteata* and *Taraxacum officinale.* The unit although it has a high coverage, due to overgrazing it has a minimum height. The presence of feral foreign species, *Taraxacum officinale* and *Plantago lanceolata* reflect the degree of alteration of the Unit. Regarding seasonality, species sprout in early summer, then grow, tend to dry in the fall, however, due to overstocking of cattle they tend to dry out and lose a lot of coverage in summer (Pictures 3 and 4).

Because sampling was conducted in spring, when regrowth of plants was just starting, it is possible that the number of species present in this unit is greater. It occupies a flooded area located near the confluence area of La Engorda and Colina streams, and a sector adjacent to Las Placas Stream.

The type of vegetation and species are widely distributed in the Andes Mediterranean ecological region (Andes between Region IV and VIII), there are no local endemisms and they are at national level.

In the last campaign (November 2007), meadows associated to floodplains in parts where the slope decreases were found. These meadows probably have a more seasonal character, since late summer and fall they tend to diminish significantly their vegetation cover, probably by a decrease in the availability of water and / or overgrazing. These meadows were not detected in the campaign in April 2005.

Waterways of La Colina and La Engorda streams are 2 to 3 m below the level found in the surrounding meadows to these courses, therefore it is likely that these have inflows and they are maintained from surface or sub-surface runoff forming the floodplain, and also feed the streams.

Pictures 3 and 4. Left: Meadow at the banks of Las Placas Stream. Right: Meadow adjacent to La Engorda stream (waterway of the stream is the rocky margin seen in the background, which is 2-3 m below the level of the land occupied by meadows); the meadow has a high cover of *Taraxacum officinalis* (yellow flowers).

Table 1

La Engorda: Meadow Unit

Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average (%)**	**Standard Deviation (%)**
Carex gayana	7	50	20	1	5	20	50	7	20,0	19,7
Phylloscirpus acaulis	1	1	7	70	30	0	0	50	19,9	27,2
Eleocharis albibracteata	1	1	60	1	30	5	1	10	13,6	21,2
Taraxacum officinalis	7	5	10	2	1	20	10	1	7,0	6,4
Juncus articus	2	1	1	2	0	20	5	10	5,1	6,8
Trifolium repens	7	3	1	1	5	0	3	10	3,8	3,4
Berberis empetrifolia	1	4	0	0	0	4	10	0	2,4	3,5
Lobelia olygophylla	1	2	4	2	4	1	1	1	2,0	1,3
Anagallis alternifolia	0	0	0	0	0	0	0	10	1,3	3,5
Hordeum chilense	1	0	1	1	5	0	0	1	1,1	1,6
Calceolaria filicaulis subsp. *Luxurians*	0	2	0	0	0	5	1	0	1,0	1,8
Acaena pinnatifida	3	1	0	0	0	1	2	0	0,9	1,1
Acaena magellanica	0	0	0	0	0	1	2	1	0,5	0,8
Senecio sp.	0	0	1	0	0	1	1	1	0,5	0,5
Poa pratensis	0	2	0	0	0	0	0	1	0,4	0,7
Chaetanthera chiliensis	0	0	0	0	0	1	1	0	0,3	0,5
Gamochaeta sp.	0	1	1	0	0	0	0	0	0,3	0,5
Geranium sessiliflorum	0	1	0	0	0	1	0	0	0,3	0,5
Werneria pygmea	1	0	0	0	1	0	0	0	0,3	0,5
Arenaria serpens	0	1	0	0	0	0	0	0	0,1	0,4
Laretia acaulis	0	0	0	0	0	1	0	0	0,1	0,4
Plantago lanceolada	0	1	0	0	0	0	0	0	0,1	0,4
Total Cover	**32**	**76**	**106**	**80**	**81**	**81**	**87**	**103**	**80,8**	**22,6**

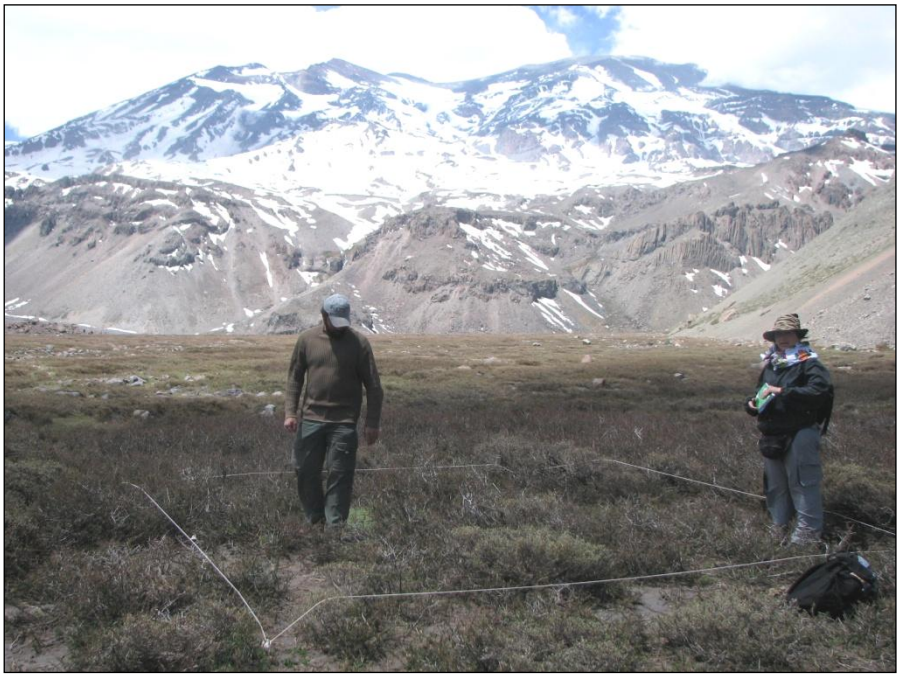
2. Scrubland Unit of *Chuquiraga oppositifolia*

Table 2 shows the species composition and abundance in the Unit. The vegetation cover in this unit reaches an average of 79.5%. The unit is dominated by shrubby species, which gives it an appearance of a scrubland up to about 100 cm in height; between the bushes grow perennial herbs that fail to generate a continuous coverage.

The dominant species are *Chuquiraga oppositifolia, Berberis* and *Laretia empetrifolia acaulis.* The unit is of zonal type, i.e. a unit that depends mainly on precipitation (snow and rain), locally, however, given the high coverage, it may be using moisture from any more or less superficial aquifer.

From the point of view of regional representation, the unit has an affinity with the association of *Mulinum spinosum* and *Chuquiraga oppositifolia*, a typical community for High Andean Steppe formation of the Andes of Santiago. The distribution of the formation is from the Choapa basin of the Teno. It is important the presence of *Laretia acaulis*, an endangered species, considered "vulnerable" nationally.

Because sampling was conducted in spring, when regrowth of plants was just starting, it is possible that the number of species present in this unit is greater. It occupies the non-flooded area of the canyon (Picture 6).



Picture 6. Scrubland of *Chuquiraga oppositifolia* near La Engorda Stream.

Table 2

La Engorda: Scrubland Unit with *Chuquiraga oppositifolia*

Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**Average (%)**	**Standard Deviation (%)**
Chuquiraga oppositifolia	75	40	20	10	20	40	50	30	35,6	20,6
Berberis empetrifolia	0	0	0	2	0	30	40	50	15,3	21,2
Laretia acaulis	4	30	7	0	20	0	0	7	8,5	10,9
Acaena pinnatifida	3	2	2	3	3	5	5	3	3,3	1,2
Hordeum chilense	3	7	5	1	3	0	0	3	2,8	2,4
Festuca kurtziana	0	3	3	1	1	5	1	0	1,8	1,8
Rytidosperma sp.	1	5	2	3	1	0	0	0	1,5	1,8
Perezia carthamoides	1	2	2	2	2	0	0	0	1,1	1,0
Ephedra chilensis	0	0	0	5	3	0	0	0	1,0	1,9
Senecio polygaloides	0	0	0	4	1	1	1	1	1,0	1,3
Zoellnerallium andinum	1	1	1	1	1	1	1	1	1,0	0,0
Chaetanthera chilensis	1	1	1	1	1	0	0	0	0,6	0,5
Olsynium junceum	0	2	1	1	1	0	0	0	0,6	0,7
Phacelia secunda	1	1	1	1	1	0	0	0	0,6	0,5
Plantago grandiflora	0	0	1	1	1	1	1	0	0,6	0,5
Ribes cucullatum	0	0	0	0	0	0	0	5	0,6	1,8
Stipa chrysophylla	2	0	0	0	1	0	2	0	0,6	0,9
Bromus sp.	0	0	0	0	0	2	1	1	0,5	0,8
Sisyrinchium adenostemon	1	0	0	0	1	0	1	1	0,5	0,5
Adesmia sp.	0	1	0	1	1	0	0	0	0,4	0,5
Calandrinia sp.	0	1	0	0	1	0	1	0	0,4	0,5

Species	1	2	3	4	5	6	7	8	Average (%)	Standard Deviation (%)
Haplopappus anthylloides	0	0	0	0	3	0	0	0	0,4	1,1
Cynanchum mucronatum	0	0	0	1	1	0	0	0	0,3	0,5
Chloraea alpina	0	0	0	1	0	0	0	0	0,1	0,4
Conyza sp.	0	0	0	0	0	0	0	1	0,1	0,4
Draba gilliesii	0	1	0	0	0	0	0	0	0,1	0,4
Micrasteris gracilis	0	0	1	0	0	0	0	0	0,1	0,4
Sanicula graveolens	0	0	0	0	1	0	0	0	0,1	0,4
Total Cover	**93**	**97**	**47**	**39**	**68**	**85**	**104**	**103**	**79,5**	**25,4**

8. CONCLUSIONS

In La Engorda area two very different units associated with different water requirements are included. The unit more dependent on water resources is the meadow, which in this case is characterized by the dominant presence of cyperaceae and grasses. This unit may benefit from the subsurface aquifer that occupies La Engorda area.

Scrubland of *Chuquiraga oppositifolia*, although is classified as zonal and would not be dependent on local water resources (surface runoff), apparently due to the high coverage, it also benefits from the aquifer to which roots could access up to 200 cm in depth.

If changes occur in the availability of water from aquifers, the outcome would be a gradual replacement of the association of meadow by scrubland, as meadows have in their composition elements typical of Andean scrubland formation, although in low proportion, *Berberis empetrifolia* and *Acaena pinnatifida* stand out, which have a seasonal nature, with less water availability in the summer. Reduction of runoff therefore would produce a gradual replacement process which will favor the location of species with lower water requirements, mainly species constituting the Andean scrubland adjacent to the meadows areas.

From the point of view of meadow conservation, in the absence of a control or regulation by the owners of the premises or the appropriate Authorities of the current form and intensity, meadows will deteriorate, losing more palatable species, and also excessive trampling will compress the soil causing changes in the distribution and abundance of species. Also, trampling can fragment the ground opening spaces for colonization with exotic feral species as *Taraxacum officinale* and *Plantago lanceolata*, which are already present, although not among the dominant.

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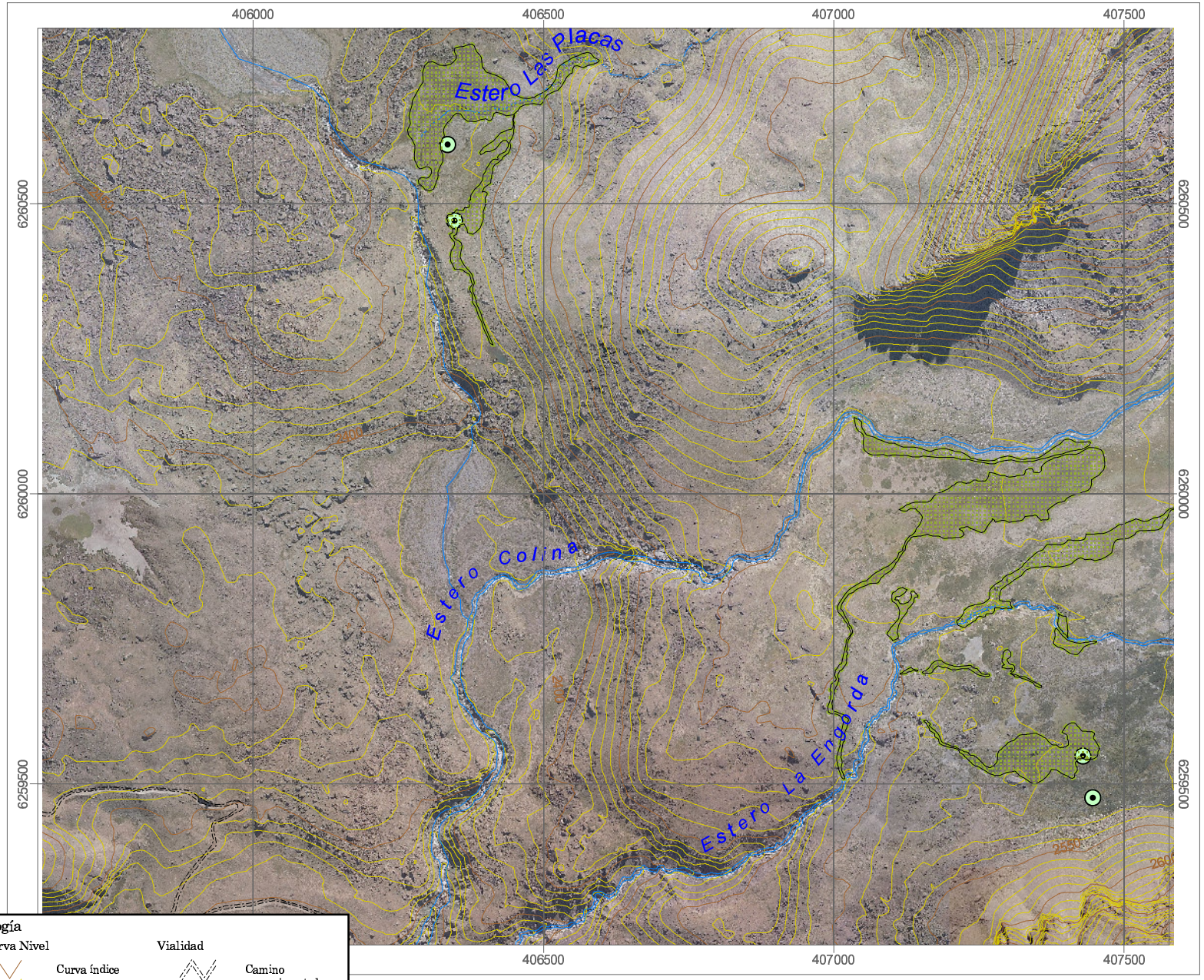

Simbología

Curva Nivel
- Curva índice
- Curva secundaria

Hidrografía
- Quebrada
- Estero

Vialidad
- Camino no pavimentado

Muestra Parcelas
- Parcela muestra
- Vegas

100 0 100 200 300 400 mt

Escala 1:10.000
Coordeandas UTM en Metros
Datum PSAD 56 - Huso 192
Elipsoide Internacional de 1924

ESTUDIO DE IMPACTO AMBIENTAL
PROYECTO HIDROELÉCTRICO ALTO MAIPO

TÍTULO: **ÁREA DE ESTUDIO Y LOCALIZACIÓN DE LAS PARCELAS DE MUESTREO - SECTOR EL VOLCÁN**

ESCALA:	FECHA:	LÁMINA:	REV:
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PREPARADO POR: ARCADIS GEOTECNICA

PREPARADO PARA: Gener

FUENTE MAPA BASE: Levantamiento Aerofotogrametrico Laser, Geoexploraciones S.A. Escala 1:5.000, Marzo - Abril 2006
FUENTE VEGETACIÓN: Levantamiento de Campo, Arcadis Geotécnica, 2006

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