ANNEX 29
VEGETATION RESTORATION PLAN

1 INTRODUCTION

As mentioned in the EIA (Section 6.4.1.5), the Project Owner will put in place a plan to restore vegetation in all non-forest areas (i.e., areas not included in the forest management plan) affected by the Project. The aim of the plan, which covers a total surface of 78 hectares, is to stabilize soils and restore pre-existing vegetation, to the extent possible, in order to control erosion, as a means of visual mitigation and to restore animal habitats. The areas where the forest was removed but can be recovered after construction are also considered, as well as the areas where Project intervention has generated the potential for erosion.

The vegetation restoration plan will be implemented throughout the Project area (muck disposal sites, road embankments, camps, etc.), except where vegetation cover is scarce, and where existing soil conditions fail to ensure the expected outcome of restoration efforts. The latter will be determined during micro-routing activities.

Vegetation restoration activities will be planned and developed based on the core principles of ecological succession, understood as the natural gradual change in the species structure and composition of an ecological community over time, and after a disturbance (Odum, 1981).

Ecological succession has at least two basic phases. The first phase is the colonization of an area by pioneer species, and the second is the establishment of late species that will eventually remain as dominant in the more mature stages of ecological succession. This stage of constant species composition is known as climax (Odum, 1981; Fuentes 1989).

In the case of the sclerophyllous scrubland, relevant studies indicate that dominant species in the communities lack the ability to colonize immediately after a disturbance. Therefore, pioneer species are the ones colonizing open areas (Armesto and Pickett, 1985). These pioneer species present the following characteristics:

- They usually form monospecific or low species diversity zones.
- They colonize big empty spaces.
- They tolerate the xeric conditions of open spaces.
- They produce a great quantity of seeds that are easily disseminated.

Once established, pioneer or colonizing species act as nurse plants for conversion to intermediate or late species. They also facilitate recruitment of species beneath their canopies. Appendix 1 makes reference to several studies on ecological succession, “nurse” effects, nursery production, and germination of certain species, all of which support the methodology to be used for vegetation restoration.

The vegetation restoration plan aims to accelerate and facilitate the natural ecological succession process after the disturbances caused by the Project’s construction works. These disturbances include, in some cases, the complete removal of vegetation. In order to achieve

the plan's objective, pioneer or colonizing species and late species are identified for the two environments affected by the Project, i.e. the Sub-Andean Sclerophyllous Scrub and Forest, and the Andean Scrub (see list of species for nursery production). Revegetation will take place in two phases: planting of pioneer species, and planting of late species.

Plant species will vary for each of the sites to be restored, depending on the species existing before the Project, and based on the list of species for nursery production included in this document.

The vegetation restoration plan is structured as follows:

1. Vegetation micro-routing.
2. Nursery production of species for restoration.
3. Revegetation of disposal sites, camps, embankments and tunnel access platforms.

The vegetation restoration plan contemplates setting up a nursery and recovery areas for transplanted plants. These areas will be appropriately supervised and receive an adequate supply of water for irrigation.

2. VEGETATION MICRO-ROUTING

As mentioned in the EIA, micro-routing and the subsequent submission of results to the Agricultural and Livestock Service (*Servicio Agrícola y Ganadero* - SAG) and the National Forest Corporation (*Corporación Nacional Forestal* – CONAF) will be undertaken to mitigate Project impact on the flora. Micro-routing involves a comprehensive field inspection of the sites that will be directly affected by the works. Once the area of intervention has been accurately determined, a visual inspection of conservation-dependent species and other individuals that can be rescued will be conducted.

During micro-routing, specialized staff will determine the areas where vegetation restoration can be successfully implemented, and those where the vegetation cover is scarce or non-existent, and where the existing soil properties do not guarantee the results expected to be achieved through restoration.

The micro-routing process comprises:

I. Demarcation of the area of intervention using chalk, stakes or pennants, in order to remove the minimum number of plants possible from the site.
II. Marking of plant species to be extracted, and subsequent development of an identification register, including the number of individuals affected, by species.
III. Consolidation of inspection and registration results in a Micro-Routing Report to be sent to the competent services for validation, before initiating earth-moving activities.
IV. Extraction of all plants likely to survive transplantation from the direct intervention area (previously demarked and inspected by specialized staff).
V. Removal of plants leaving enough soil to completely cover their roots, so that they are able to survive the period of time spent in the plant recovery areas.
VI. Soil that is not naturally moist, will be moistened prior to plant extraction, to avoid breaking the root ball and prevent plant dehydration.

3. NATIVE SPECIES NURSERY PRODUCTION PLAN

The production of native species will be supervised by a flora and native species reproduction expert. The aim of this plan is to reproduce the native species of the vegetation formations affected by the Project, focusing particularly on conservation-dependent species. These will be planted in a larger number than originally found in the area.

As already mentioned, the Project considers setting up a nursery. The nursery will have a storage room for supplies and materials, an area to prepare substrata, and a greenhouse to develop vegetative and seed reproduction programs. The nursery will be equipped with an irrigation system for the dry season. The SAG will be notified of the establishment of the nursery, which will also be used to conduct studies on the reproduction and development of conservation-dependent plant species.

The reproduction and plantation activities are summarized in Table 1 below, and the species to be reproduced in Table 2.

Table 1
Native Species Reproduction Plan

Activity	Timing	Methodology
Preparatory studies	Prior to construction works	Identification of the land occupancy map (*Cartografía de Ocupación de Tierras* – COT) units subject to intervention, and assessment of the dominant native species and species included in a conservation category.
Seed collection	Prior to construction works	Collection of seeds from all the native species existing in the unit, particularly dominant and conservation-dependent species. In lower areas, seeds are collected from November to March, depending on the species; and in upper areas, from January to April.
Nursery production	During works	- Production at the site agreed to by the Project Owner and competent authorities, which will begin operating during the autumn of seed collection. – The plants will remain in the nursery for at least 2 years in order to ensure a good survival rate.
Reproduction and development study	During nursery production	Development of a reproduction and development study on species included in conservation categories.
Planting	During and after works	Planting activities carried out by qualified company staff from April to July. The first plantation phase (pioneer species) will take place upon completion of the Project's construction phase, and the second phase (late species) two years after the first plantation.
Monitoring of replaced nursery plants for up to 5 years after completion of the Project's construction phase	After the construction phase	Monitoring of plants produced in the nursery and then transplanted for revegetation purposes for up to 5 years after completion of the Project's construction phase.

Table 2
List of Nursery-Grown Native Species

Species	Common Name	Type of Plant	Geographic Origin	Conservation Status	Type of Colonization
Acacia caven	Espino / Espino Caván	Tree	Native	Not threatened	Pioneer
Kageneckia angustifolia	Franjel	Tree	Endemic	**Vulnerable***	Late
Kageneckia oblonga	Bollén	Tree	Endemic	Not threatened	Late
Lithrea caustica	Litre	Tree	Endemic	Not threatened	Late
Porlieria chilensis	Guayacán	Tree	Endemic	**Vulnerable**	Late
Quillaja saponaria	Quillay (Soapbark)	Tree	Endemic	Not threatened	Late
Schinus polygama	Huingán	Tree	Native	Not threatened	Late
Trevoa quinquinervia	Tralhuén	Tree	Endemic	Not threatened	Pioneer
Adesmia confusa	Espinillo	Shrub	Endemic	Not threatened	Pioneer
Baccharis linearis	Romerillo	Shrub	Native	Not threatened	Pioneer
Baccharis rhomboidalis	Gaultro	Shrub	Endemic	Not threatened	Pioneer
Berberis empetrifolia	Monte Negro (Crown Barberry)	Shrub	Native	Not threatened	Pioneer
Chuquiraga oppositifolia	Yerba Blanca	Shrub	Native	Not threatened	Pioneer
Colletia hystrix	Crucero	Shrub	Native	Not threatened	Pioneer
Colliguaja integerrima	Colliguay	Shrub	Native	Not threatened	Late
Colliguaja odorifera	Colliguay	Shrub	Endemic	Not threatened	Late
Ephedra chilensis	Pingo Pingo	Shrub	Native	Not threatened	Late
Gochnatia foliolosa	Mira-mira	Shrub	Endemic	Not threatened	Pioneer
Guindilia trinervis	Guindillo	Shrub	Native	Not threatened	Pioneer
Gymnophyton isatidicarpon	Bio Bio	Shrub	Endemic	Not threatened	Pioneer
Haplopappus anthylloides		Shrub	Native	Not threatened	Late
Laretia acaulis	Llareta	Shrub	Native	**Vulnerable**	Late
Muehlenbeckia hastulata	Quilo (Wirevine)	Shrub	Native	Not threatened	Pioneer
Proustia cuneifolia	Huañil	Shrub	Native	Not threatened	Pioneer
Tetraglochin alatum	Horizonte	Shrub	Native	Not threatened	Pioneer
Viviania marifolia	Te de Burro	Shrub	Native	Not threatened	Pioneer
Astragalus cruckshanksii	Yerba Loca	Annual	Native	Not assessed	Pioneer
Bromus berterianus		Annual	Native	Not assessed	Pioneer
Clarkia tenella	Huasita	Annual	Endemic	Not assessed	Pioneer
Gnaphalium philippi	Vira vira	Annual	Endemic	Not assessed	Pioneer

Species	Common Name	Type of Plant	Geographic Origin	Conservation Status	Type of Colonization
Helenium aromaticum	Póquil	Annual	Endemic	Not assessed	Pioneer
Phacelia secunda		Annual	Endemic	Not assessed	Pioneer
Acaena splendens	Clonqui	Perennial	Native	Not assessed	Pioneer
Alstroemeria exerens	Liuto (Inca Lily)	Perennial	Native	**Little known**	Late
Gamochaeta stachydifolia		Perennial	Native	Not assessed	Pioneer
Gnaphalium gayanum	Vira Vira	Perennial	Endemic	Not assessed	Pioneer
Hordeum comosum	Cebadilla	Perennial	Native	Not assessed	Pioneer
Echinopsis chilensis	Quisco	Succulent	Endemic	Not threatened	Late
Eriosyce curvispina	Quisquito	Succulent	Endemic	**Vulnerable**	Late
Puya berteroniana	Chagual (Blue Puya)	Succulent	Endemic	**Vulnerable**	Late

4. REVEGETATION PLANS

The implementation of the revegetation plans for muck disposal sites (Table 3), and for temporary facilities, camps, embankments and tunnel access platforms (Table 4) will be supervised by a flora and vegetation restoration expert. Both plans are based on the same principles.

The aim of the plans is to stabilize slopes and embankments after construction, and restore, to the extent possible, the vegetation that existed before the Project. This serves erosion control, visual mitigation and animal habitat restoration purposes. The species used for revegetation will vary depending on the location of the disposal sites; however, the basis will be the COT plant formations, and the lists of species found in camp, embankment and tunnel access platforms (see Table 2).

As already mentioned, the areas where the restoration measures can be implemented will be determined on the basis of the micro-routing activities.

Table 3
Muck Disposal Site Revegetation Plan

Activity	Timing	Method and Tasks
Plant extraction	Before waste disposal	-Extraction of all plants likely to survive transplantation from the site that will be covered with waste material and the access road. -Includes geophyte and succulent plants, shrubs of up to 0.5m and trees of up to 1m. -Plants will be removed leaving enough soil to completely cover their roots, so that they are able to survive the period of time spent in the plant recovery areas. -Plants will be extracted and taken to the plant recovery areas from April to July, in the case of woody and succulent plants, and from November to March, in the case of perennials. Soil that is not naturally moist, will be moistened prior to plant extraction, to avoid breaking the root ball and prevent plant dehydration.
Collection of extracted plants	Before waste disposal	-Once extracted, plants will be placed in the collection and recovery area. -The plant recovery area is a shaded site equipped with a water supply system for irrigation. The area will be under continuous technical supervision, and will remain functional until the plants are replaced.
Extraction of non-transplantable organic material	Before waste disposal	-Cutting of all plants that cannot be extracted from the site and transplanted. -Tree trunks and larger twigs will be given to the local community for use as firewood. -Plant debris will be chipped on-site and spread on the surface of the dump site.
Soil extraction	Before waste disposal	-Extraction of the largest amount of soil (in terms of depth) possible, together with the organic material that was chipped and placed on the ground. -Soil will be extracted in layers so that after it is replaced, the layer with the largest amount of organic material is on top.
Disposal site management	During waste disposal	-Moistening of the external surfaces of the dump sites, especially the areas near public roads.
Soil restoration	After waste disposal	-Covering of the disposal site with the previously-extracted soil. The cover layer should be of at least 30cm, but in some areas a thicker layer is expected.
Improvement of the sowing and planting surface	After waste disposal	-Addition of polymers (5 – 10%) to the last layer of soil in order to improve its water retention capacity.
Seeding	After waste disposal	-Where slopes are highly unstable, hydro seeding of native species will be used to help with erosion control and quick planting. This will provide a good substratum for final planting. Hydro seeding will take place at the end of winter.
Planting	After waste disposal	Planting on embankments will take place after hydro seeding (when used), at the end of autumn, in order to ensure germination of the planted individuals, which will have spent at least 2 years in the nursery. Additionally, irrigation will be provided during the first 2 years of the first and second planting phases. The first planting phase

Activity	Timing	Method and Tasks
		(pioneer species) will take place immediately after the Project's construction phase, together with the hydro seeding (when used). The plants from the collection and recovery areas will also be transplanted during this first planting phase. The second planting phase (late species) will take place 2 years later.
Monitoring	After planting	Monitoring activities will take place every spring during the 5 years following the end of the above-mentioned planting phase. The aim is to monitor plant development, and control erosion. Any eventual potential for erosion found during spring monitoring activities, will be addressed before the winter of the same year.

Table 4
Revegetation Plan for Temporary Facilities, Camps, Embankments and Tunnel Access Platforms

Activity	Timing	Methodology
Plant extraction	Prior to preparatory activities and construction of temporary facilities	-Extraction from the corresponding sites of all plants likely to survive transplantation. -This includes geophyte and succulent plants, shrubs of up to 0.5m and trees of up to 1m. -Plants will be removed leaving enough soil to completely cover their roots, so that they are able to survive the period of time spent in the plant collection and recovery areas. -Plants will be extracted and taken to the plant recovery areas from April to July, in the case of woody and succulent plants, and from November to March, in the case of perennials. Soil that is not naturally moist, will be moistened prior to plant extraction, to avoid breaking the root ball and prevent plant dehydration.
Collection of extracted plants	Prior to preparatory activities and construction of temporary facilities	-Once extracted, plants will be placed in the collection and recovery area. -The plant recovery area is a shaded site equipped with a water supply system for irrigation. The area will be under continuous technical supervision, and will remain functional until the plants are replaced.
Extraction of non-transplantable organic material	Prior to construction activities	-Cutting of all plants that cannot be extracted from the areas of intervention. -Tree trunks and larger twigs will be given to the local community for use as firewood. -Plant debris will be chipped on-site and spread on the surface.
Revegetation in areas with no earth-moving activities	After abandonment of camps	-After the camps and tunnel access terraces are abandoned, the areas where no earth-moving activities have taken place, and soil conditions remain the same, will be revegetated. Only the soil conditions of the planting holes will be improved before transplanting. Transplanted plants will have remained in the nursery for at least 2 years.

Activity	Timing	Methodology
Revegetation in areas with earth-moving activities	After abandonment of camps	-Where earth-moving activities did take place, the largest amount of soil (in terms of depth) possible will be extracted, together with the organic material remaining after transplanting and firewood removal.
Stockpiling of extracted soil mixed with organic material	During Project construction works	-Soil will be extracted and stockpiled in layers so that after it is replaced, the layer with the largest amount of organic material is on top.
Soil stockpiling management	During Project construction works	-Moistening of the external surfaces of the stockpiling sites, especially the areas near public roads.
Soil restoration and improvement	After abandonment of Project construction works	-After road construction sites, camps and tunnel access terraces have been abandoned, soils will be stabilized, in areas where slopes exceed 45º, and decompacted, where necessary.
Seeding	After abandonment of Project construction works	-In areas where earth-moving activities have taken place and slopes are highly unstable, herbaceous plants will be used for revegetation purposes, via hydro seeding. This will help stabilize the areas quickly and provide a good substratum for planting the definitive species. Hydro seeding will be done in early spring.
Planting	After abandonment of Project construction works	Planting on embankments will take place after hydro seeding (when used), at the end of autumn, in order to ensure germination of the planted individuals, which will have spent at least 2 years in the nursery. Additionally, irrigation will be provided during the first 2 years of the first and second planting phases. The first planting phase (pioneer species) will take place immediately after the Project's construction phase, together with the hydro seeding (when used). The plants from the collection and recovery areas will also be transplanted during this first planting phase. The second planting phase (late species) will take place 2 years later.
Monitoring	After revegetation	Monitoring activities will take in spring to monitor plant development, and control erosion. Any eventual potential for erosion will be addressed before winter.

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APPENDIX 1
BIBLIOGRAPHIC COMPILATION OF ANTECEDENTS AND PAPERS CONCERNING VEGETATION RESTORATION

The following studies were mostly carried out by Chilean scientists during the past 10 years; they provide tools for ecologic restoration based on plants behavior in nature, and identify some key natural occurring processes that must be taken into account to carry out a successful restoration.

Some of these key processes are water intake and the nurse effect, which have been studied for species in the conservation category present in the PHAM area. *Kageneckia angustifolia* (franjel) and *Laretia acaulis* (llareta).

These data are the most up to date information as to tools for ecologic restoration and are part of the support of the methods that the PHAM will use to restore the affected areas.

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APÉNDICE 1
RECOPILACIÓN BIBLIOGRÁFICA DE ANTECEDENTES Y ESTUDIOS SOBRE RESTAURACIÓN DE LA VEGETACIÓN

A continuación se enumeran algunos estudios, realizados en su mayoría por científicos chilenos durante los últimos 10 años, que entregan herramientas para la restauración ecológica, basadas en el comportamiento de las plantas en la naturaleza, identificando ciertos procesos claves de ocurrencia natural, que deben ser considerados para lograr una restauración exitosa.

Algunos de estos procesos claves son el levantamiento hidráulico, la germinación de semillas y el efecto nodriza, este último estudiado incluso para especies en categoría de conservación existentes en el área del PHAM: *Kageneckia angustifolia* (franjel) y *Laretia acaulis* (llareta).

Estos antecedentes constituyen la información más reciente en términos de herramientas para la restauración ecológica, y son parte el sustento de la metodología que el PHAM utilizará para restaurar las áreas afectadas.

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