Sustainable Energy Development in Chilean Patagonia: A Comprehensive Critique of the August 2008 HidroAysén Environmental Impact Assessment

Graham Scholars Program
Winter 2009
CEE 490: Sustainable Energy Development in South America

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Preface

This report represents a course project prepared by a group of 17 undergraduate students and 1 graduate student at the University of Michigan enrolled in the course CEE 490 – *Sustainable Energy Development in South America* during the winter semester of 2009. In addition to studies of relevant documents, the students visited the Aysén region in February 2009 including some of the areas that would be impacted by the proposed projects, and participated in discussions and presentations with a number of stakeholders. The course was sponsored by the Graham Environmental Sustainability Institute; the views expressed in this report do not represent an official position of the University of Michigan or the Graham Environmental Sustainability Institute. Most of the students participating in the course were not fluent in Spanish and the review of lengthy documents in that language posed significant difficulties in ensuring accurate interpretation of the fundamental information that was analyzed in this report. There have been considerable efforts made to ensure the accuracy of the contents of this report but it is possible that relevant information was not located within the documents or was incorrectly translated.

Contents

Executive Summary

This report summarizes the collective work of eighteen students enrolled in the winter 2009 course *Sustainable Energy Development in South America* supported by the Graham Environmental Sustainability Institute at the University of Michigan at Ann Arbor. The goal of the course was to study international sustainability issues utilizing the perspective of a case study. The specific focus was a hydropower project proposed by the company HidroAysén on the Baker and Pascua Rivers in the Patagonia area of Chile. The overall project involves a total of five dams that would generate electricity to be exported to the Central Interconnected System grid further north through a long distance transmission line approximately 2,000 km in length. The class incorporated a travel component to the Aysén Region in Patagonia and to Concepción, in the central part of the country, allowing students to interact with stakeholders and academics engaged with the project. A major course activity involved a review of the environmental impact assessment (EIA) submitted in August 2008 for this project. The focus of this report was to analyze the information presented in the EIA based on its completeness, relevance of information, and validity.

The report contains a background review of the Chilean economy and how it contributes to current patterns of energy (particularly electrical energy) consumption. Details of the proposed projects are included in this background as well as a description of the environmental impact assessment process in Chile, especially as it relates to the projects.

The students had access to the lengthy environmental impact assessment, supporting reports that were developed by various organizations as part of the baseline study, comments to the assessment that were submitted as part of the EIA review process, and various other documents. Students performed an analysis of the EIA focusing on six topics: hydrology, sedimentation, aquatic ecosystems, terrestrial ecosystems, community impacts, and tourism. These topics cover the majority of individual impacts that were identified and evaluated within the EIA. Students sought to identify information relevant to sustainability and the potential impacts of the various components of the project and to evaluate the level of completeness with which such information was addressed. For each category, this report includes a summary of the information contained within the EIA and other relevant documents as applicable, comments presented to the regulatory body, CONAMA, during the review period, a critique of the information developed, and recommendations for a more complete impact assessment.

During the course of the EIA evaluation, it became clear that several weaknesses of the assessment were related to the regulatory framework of the process itself. A critique of these deficiencies is included in the report. This section is followed by a list of category specific recommendations prepared by the participants of this course to suggest approaches to improving the environmental impact assessment.

The report concludes with a series of general observations regarding the EIA as follows:

One of the key limitations of the EIA was the failure to approach the analysis of impacts from an ecosystems perspective. The EIA was subdivided into a number of individual sections where impacts were analyzed sequentially. Although some of the proposed mitigation schemes were devised to address more than one of these impacts, the connections between the various impacts were generally unexplored. In addition, the ranking system employed to determine severity of impacts appeared to be somewhat arbitrary both in terms of its emphasis and application.

There is insufficient information presented in the EIA on many topics. The baseline study was conducted over a relatively short period of time with little opportunity to gather information on system variability. The relative lack of pre-existing information on Patagonian ecosystems makes this deficiency more problematic. In addition to incomplete studies, several important issues appear not to have been considered at all.

Details are lacking in the area of mitigation, reparation and compensation strategies. One activity that consistently appears in the description of compensation actions is the promise to perform various studies and to report the results. This approach does not appear to match the definition of compensation as required by the impact assessment process.

The environmental impact assessment process for the HidroAysén projects was conducted independently of a similar analysis of the long distance transmission lines that will be required to carry the energy from Aysén to the Santiago area. Given the mutual dependence of these two systems, it is inappropriate to separate the regulatory consideration of them.

Introduction

Due to increasing energy demand in the nation of Chile and unreliable supplies of imported fuels, there has been a push for alternatives to conventional fossil fuels, with particular emphasis on hydropower production in Patagonia. A major development has been proposed by the company HidroAysén consisting of a five-dam project in the Aysén region in southern Chile. The proposed projects have generated considerable controversy with recent public opinion polls indicating that a majority of the Chilean population oppose project implementation[1]. HidroAysén presented the Environmental Impact Assessment (EIA) for these five hydropower projects in August 2008. The EIA is a lengthy document (roughly 10,500 pages in the body and appendices of the EIA and approximately another 5,000 pages in supporting study reports) summarizing the project details, applicable regulations, the results of baseline studies characterizing the natural and human environments surrounding the project areas, the anticipated impacts of the project implementation, mitigation measures for impacts deemed significant, and proposed monitoring activities. This report is the product of a 2009 University of Michigan course sponsored by the Graham Environmental Sustainability Institute under their Graham Scholars Program. One of the course objectives was to analyze the proposed projects, and specifically the environmental impact assessment from the perspective of environmental sustainability. Consequently, the objective of this report is to present a critique of various aspects of the proposed hydropower projects and the associated environmental impact assessment. The EIA is analyzed in terms of its completeness and accuracy, with specific focus on environmental sustainability issues. This report is a collective effort of all student participants in the course. Six project teams were formed with the objective for each to analyze a specific topic presented in the EIA. The class size did not allow for the entire document to be considered, but the topics were selected so that a large majority of the impacts presented and discussed in the EIA were analyzed. The 2009 Graham Scholars examined the EIA in the context of six general categories; hydrology, sedimentation, aquatic ecosystems, terrestrial ecosystems, community impacts and tourism. Issues addressed in these various categories include:

Hydrology: The effects that the hydropower projects would have on the flow regimes of the Baker and Pascua rivers, and how the characteristics of these rivers influence the proposed hydropower projects. Topics include the electrical power generation potential of individual projects, changes in river flow regimes due to planned project operation, potential climate change effects including the effects of glacial lake outburst floods (GLOFs), and potential limitations to the statistical analyses of the river flows.

Sedimentation: Geological studies, and volcanic activity and their influence on sustainability of the proposed dam projects over their lifetime are reviewed. Reduction in reservoir storage capacity due to sedimentation and reduction in downstream nutrient transport associated with

[1] *Poll: Opposition to Chile Dam Project on the Rise*. Santiago Times, April 21, 2009.

the sediments is addressed. The bases for estimates of sediment transport and reservoir sedimentation are questioned.

Aquatic Ecosystems: The effects of construction and general operation of the proposed dam projects on aquatic flora and fauna are analyzed. Project implementation would require expansion of two port facilities with projected impacts on both the marine and freshwater flora and fauna in Mitchell Fjord and the Baker and Pascua Rivers. Proposed mitigation strategies are also reviewed.

Terrestrial Ecosystems: The adequacy of a baseline study designed to determine the species found in the area of influence of the proposed project are analyzed, with a focus on species with conservation concerns or which are endemic to the Patagonia region. Also included is evaluation and analysis of the projected impacts of the projects and proposed mitigation strategies for terrestrial flora and fauna.

Community Impacts: Effects of the projects on regional communities now and in the future is addressed. This section analyzes proposed resettlement and compensation plans, as well as the effect of the proposed projects on existing community structures.

Tourism: Effects on the tourism industry that is presently based on an image of a pristine natural environment are reviewed. There is special emphasis on the influence of the projects on economic development, infrastructure, and regional planning within the context of tourism.

Other documents in addition to the EIA were analyzed in the preparation of the report. These included background documents providing information on the projects, the Patagonia region or Chile in general, and providing perspectives on various technical, economic, and cultural issues. Additionally, during the trip to Patagonia in February 2009, students participated in various discussions and presentations on related topics. A compilation of the various baseline study reports from Chilean universities and organizations was acquired. Comments made by various government agencies, municipalities and private citizens were accessed through the government website related to the project. The group also compared several dam projects implemented throughout the world and reported as case studies in the World Commission on Dams report[2] to draw parallels to the proposed hydropower projects in Aysén. Based on a synthesis of this information, recommendations are suggested to improve the EIA and to develop a more comprehensive analysis of the projects.

[2] *Dams and Development: A New Framework for Decision-Making*. London: Earthscan Publications Ltd., 2001.

Background Information

The Chilean Economy

Chile has one of the leading economies in Latin America with regard to economic growth. This economy is largely based on its abundant mineral resources, agriculture, forest products, and fishing[3]. Chile is the world's largest producer of copper and mineral resources account for over half of its exports[4]. Chile's major industries include processing raw materials and manufacturing of consumer goods[5]. These products include copper and other minerals, processed food, fishmeal, iron and steel, wood and wood products, transportation equipment, and textiles[6, 7]. Santiago is the national capital and the dominant population and economic hub with nearly half the population living in the Metropolitan Region surrounding Santiago[8].

One of Chile's main economic drivers is the fluctuations in copper prices and other minerals including iron and nitrates. Profits depend largely on demand and prices in the world market; thus, the monetary value of Chile's mineral resources relies largely on fluctuating worldwide economic conditions. Chile's economic model encourages foreign investment and many key economic sectors are dominated by international companies. Chile's Gross Domestic Product (GDP) is expected to grow at an average 4.9% per year between 2002 and 2030 (In 2008 GDP increased 5.1% from the previous year)[9]. Strong growth rates in the economy generally coincide with corresponding increases in energy demand. The mining industry is particularly energy intensive. Chile's total primary energy consumption grew 1.8% annually from 2001 to 2004 with electricity consumption increasing by 5.1% over the same period[10]. Projections for electrical energy consumption suggest an even larger increase (5.0 %) than GDP growth over the 2002 to 2030 time horizon[11]. This expansion is coupled to a projected expansion in mining sectors. Not only are mining and refining very energy intensive, but the demand for consumer goods has increased with generally rising incomes. This has increased oil consumption by 25% through higher vehicle ownership and increasing economic activity[12].

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[3] Central Intelligence Agency, "Chile: Economy," CIA World Factbook, https://www.cia.gov/library/publications/the-world-factbook/geos/CI.html
[4] Ibid.
[5] Ibid.
[6] Infoplease. "Chile – Economy," Family Education Network http://www.infoplease.com/ce6/world/A0857288.html, Accessed on April 20, 2009
[7] Economy. (2006). Retrieved on April 21, 2009 from http://www.ddg.com/LIS/aurelia/chieco.htmhttp://www.ddg.com/LIS/aurelia/chieco.htm
[8] Revista de Urbanismo, "Urban Form at the Fringe of Metropolitan Santiago, A Result of a Normative or Profitability Plan?" Universidad de Chile, http://revistaurbanismo.uchile.cl/n1/13.html, accessed April 21, 2009
[9] Export Council for Energy Efficiency, "Energy and Electricity in Chile, http://www.ecee.org/pubs/assess/chile/Chile3.htm, accessed on April 24, 2009
[10] Asia Pacific Energy Research Center, "Energy Demand and Supply Outlook 2006: Chile," http://www.ieej.or.jp/aperc/2006pdf/Outlook2006//ER_Chile.pdf, p. 16
[11] APEC Energy Demand and Supply Outlook 2006: Chile
[12] Ibid.

Chile's Electricity Grid

Chile's energy sector is largely privatized and has unbundled the generation, transmission, and distribution systems of its electricity sector. There are four independent and disconnected electric grids (partly a result of the country's unique geography) in Chile that serve 97% of the population. They are: the Interconnected System of the Great North, Central Interconnected System (SIC), System Aysén and System Magallanes[13]. The National Energy Commission (NCE) is the regulatory committee for the electricity sector in Chile that develops policy and rules for proper functioning, proposes strategies, and serves as an advisory board to the government. The NCE helps determine base electricity rates, and allows private companies to negotiate electricity prices with customers. Empresa Nacional de Electricidad, (ENDESA), is Chile's largest energy producer, producing over 50% of the country's power with an energy portfolio composed of 76% hydropower and 24% thermal[14]. ENDESA, which formed as a national electric utility in 1943, was privatized in 1988 during the Pinochet regime. While the company was solely Chilean, ENDESA acquired about 80% of the water rights in Chile, including 96% of the water rights in the Aysén region, primarily for non-consumptive water use in hydropower generation[15]. In 1997, ENDESA-España bought 32% of ENDESA-Chile and by 1999 the Spanish company owned more than 50% of the ENDESA-Chile company shares. Ownership of the company has changed relatively recently in 2009 with 92% ownership currently held by an Italian company, Enel[16]. For this reason, ownership of water rights for non-consumptive use for the majority of potential hydropower sites in Chile is held by foreign business interests.

HidroAysén, the company proposing the PHA (Proyecto HidroAysén), is a joint venture between ENDESA-Chile and Colbún (a Chilean electric utility company) formed in 2006. ENDESA-Chile holds 51% of the total company shares, while Colbún owns 49% of the company[17]. The PHA has been proposed for the Baker and Pascua Rivers in the Aysén region. Despite the infrastructure needed to cover the long distance between the Aysén region and the SIC central grid system, these two rivers present relatively low flow variability and very high electricity production potential, making them attractive for hydroelectric development. This would prove favorable for ENDESA because the power generation from annual variable flows of the central rivers

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[13] Global Energy Network Institute, "National Energy Grid of Chile," GENI Inititative – Global Electricity Grid Linking Renewable Energy Resources Around the World,

[14] United States Department of Energy, "An Energy Overview of Chile," http://www.geni.org/globalenergy/library/national_energy_grid/chile/EnergyOverviewofChile.shtml, Accessed on April 19, 2009

[15] Orrego, Juan Pablo. "CPP Investment Board urged to abandon controversial Chilean transmission scheme | Probe International." Probe International | Rethinking foreign aid, restoring accountability, reinvigorating economies. http://www.probeinternational.org/chilean-patagonia/cpp-investment-board-urged-abandon-controversial-chilean-transmission-scheme, accessed July 2, 2009.

[16] "Enel Takes Over Endesa" United Press International, February 23, 2009, http://www.upi.com/Energy_Resources/2009/02/23/Enel-takes-over-Endesa/UPI-69561235423493, accessed July 2, 2009.

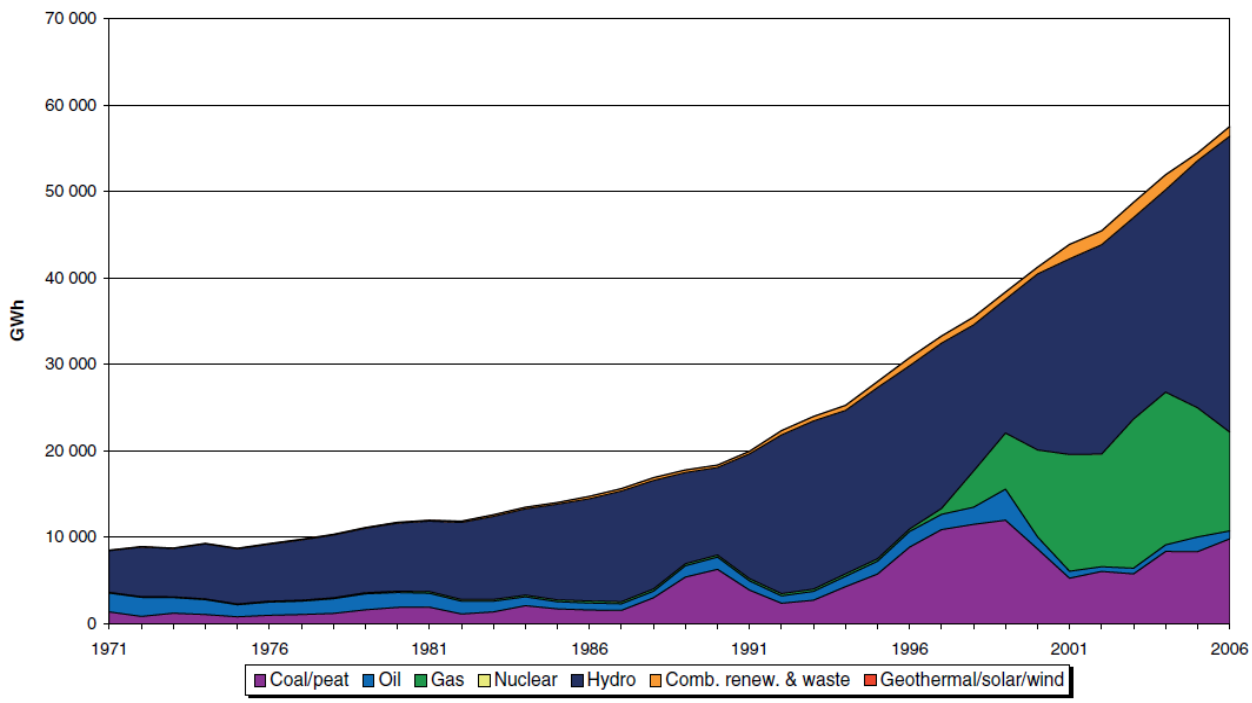
[17] "Environment." 2007. HidroAysén. 1 April 2008. http://www.HydroAysén.cl/eng/medio_ambiente.html.http://www.HydroAysén.cl/eng/medio_ambiente.html.

would be supplemented by generation of these more consistent southern rivers[18]. Due to the more consistent flow patterns in these rivers, the national power generation variability is projected to decrease from 23% to 9% if the PHA is installed[19].

Chile's Energy Portfolio

The energy portfolio of Chile is dominated by hydropower, natural gas, and coal, followed by small portions of oil and combined renewable and waste energy. Figure 1 shows the contributions to electrical energy production from various sources and a clear steep upward climb in energy consumption. Chile's growth in electrical energy demand is expected to increase 5% per year from 2002 to 2030, which basically mirrors their projected growth in GDP, which is expected to grow at 4.9% per year during the same period[20].

Figure 1- Electricity generation by power source.



Source: International Energy Agency [F]

[18] Proyecto Hidroeléctrico Aysén. "Fundamentos Y Presentación Resumida." EULAChile, Concepción, Chile. 13 Dec. 2007. <www.eula.cl/contenido/Diciembre2007/EULA%20Presentacion%20de%20proyecto%2013%20Dic%202007.pdf>

[19] Proyecto Hidroeléctrico Aysén. "Fundamentos Y Presentación Resumida." EULAChile, Concepción, Chile. 13 Dec. 2007. www.eula.cl/contenido/Diciembre2007/EULA%20Presentacion%20de%20proyecto%2013%20Dic%202007.pdf, Slide 28

[20] Export Council for Energy Efficiency, "Energy and Electricity in Chile," http://www.ecee.org/pubs/assess/chile/Chile3.htm, Accessed on April 24, 2009

Hydroelectric
Chile's installed capacity of hydropower is approximately 5,000 MW[21] (roughly 34,000 GWh per year of production) and accounts for about 50% of the country's electricity generation.

Coal & Oil
Chile has two major coal mines, which produced 0.4 million short tons in 2006, while the country as a whole consumed 5.4 million short tons in the same year[22]. Coal is used primarily for power generation as a complement to hydropower, and thus its use tends to fluctuate.

Chile had only 150 million barrels of proven oil reserves in 2006, which limited their production to approximately 15,000 barrels/day[23]. Consumption at that time was 238,000 barrels/day, and Chile imported the difference between demand and supply primarily from Argentina, followed by Brazil, Angola and Nigeria.

Natural Gas
Natural gas is used to generate around 38% of the electricity. Although Chile has its own natural gas reserves,[24] they are insufficient to meet demand. Currently, Chile's major source of imported natural gas is neighboring Argentina, but this trade relationship is complicated due to a history of political strife with Bolivia. Bolivia is a large producer and exporter of natural gas, but the country will not trade directly with Chile, nor will they allow Argentina to re-export Bolivian natural gas. Instead, Argentina exports its own natural gas supply to Chile, and consumes the gas that it imports from Bolivia. However, when Bolivia fails to meet the natural gas demands of Argentina, this indirectly affects Chile; if Argentina cannot meet its own energetic needs, it exports less to Chile. This has happened often since 2004 such that it has been called an energy "crisis" and Argentina has cut supplies by 20-50%[25] at these times, subsequently causing blackouts in Chile. Chile has tried to alleviate their dependence on Argentina for natural gas by converting some natural gas-fired plants to run on other fuels such as diesel or coal. Rising diesel and coal costs make these options expensive and may only be a short-term solution. This situation clearly emphasizes the need in Chile for energy autonomy.

With the exception of hydropower, Chile has limited energy resources and thus relies on imports to sustain its growth. For example, the country is expected to import 100% of its oil by

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[21] International Energy Agency, "Chile – Statistics," http://www.iea.org/Textbase/stats/graphresults.asp?COUNTRY_CODE=CL, Accessed on April 27, 2009
[22] The Encyclopedia of the Earth, "Energy Profile of Chile," http://www.eoearth.org/article/Energy_profile_of_Chile, Accessed on April 27, 2009
[23] Ibid
[24] International Energy Agency, "Chile – Statistics," http://www.iea.org/Textbase/stats/graphresults.asp?COUNTRY_CODE=CL, Accessed on April 27, 2009
[25] The Encyclopedia of the Earth, "Energy Profile of Chile," http://www.eoearth.org/article/Energy_profile_of_Chile, Accessed on April 27, 2009

2030[26]. If energy consumption forecasts prove to be accurate, significant efforts must be made to maintain the supply of electricity consistent with increasing future demand.

Proposed Solutions

Chile's current Minister of Energy, Marcelo Tokman, has defined three pillars for energy policy: security, efficiency, and sustainability.[27] Chile's energy crisis affects all three pillars as the country's current energy portfolio cannot meet demand at all times. Hydropower, which supplies about half of the country's power, is limited by the variability of water cycles in the central regions of the country. While this is a fairly sustainable power generation method, fluctuations in available power due to weather variations can affect its security. Natural gas is a very insecure energy source since it is heavily imported from Argentina as described above. Currently, the alternatives to hydropower and natural gas are imported coal and petroleum; fossil fuels that are expensive and not sustainable over the long term. Several options have been considered for diversifying Chile's energy portfolio to make it more resilient to weather fluctuations, imports, and other factors.

Expanding Hydropower

The proposed PHA would add 2,750 MW to Chile's existing hydroelectric capacity. Although the locations of these projects are very far from Santiago and the Central Interconnected System, they present favorable trade-offs for power generation capacity relative to reservoir inundation area. The PHA projects are currently under environmental review. Other large-scale projects have been proposed for areas closer to population centers including projects on the Biobío River in Region VIII[28]. Small-scale micro-hydropower projects with capacities under 20 MW are covered under the 2008 Renewable Energy Law (discussed in more detail below) and are provided with financial incentives for their development. However, the size of these projects indicates that a large number of individual projects would be required to substantially impact the national energy supply.

Liquid Natural Gas

One option for Chile is to diversify with liquid natural gas (LNG). It has appeared as one of the more attractive options since LNG can use the existing natural gas electricity generating infrastructure. A few mining companies have announced their intent to build a port facility in the northern grid region to replace and expand thermo-electric facilities that currently rely on coal and petroleum[29]. LNG does have disadvantages, however, in that it is an imported commodity and is subject to international production, prices, and supply/demand.

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[26] Ibid

[27] Latin Business Chronicle, "Chile's Energy Crisis: No Magic Solution,"

[28] Witte, Benjamin. "Another major dam planned for Chile's BioBio." The Santiago Times, October 8, 2008

[29] "Chile's mining minister eyes start of LNG terminal." *Reuters*. June 15, 2009.. http://www.reuters.com/article/rbssIndustryMaterialsUtilitiesNews/idUSN1524227720090616 (accessed July 3, 2009).

Natural Gas

The Magallanes Basin in the most southern region of Chile is believed to have extensive reserves of natural gas and the Chilean government has initiated bidding for the extraction of the natural gas resources there.[30] The exact amount and potential are still undetermined, and the distance from the source to the large population centers of Chile will be a significant obstacle to overcome.

Nuclear

Chile does not currently have nuclear power facilities. In 2006, however, Chile committed to an open debate on the issue [31]. Government officials have visited nuclear sites in France and Russia, and have resolved to make a decision on the issue by 2010[32]. Argentina and Brazil produce nuclear power and could provide important insights if Chile were to pursue this alternative.

Renewable Energy

Chile enacted law 20.257 in March, 2008 that set specific targets for Non-Conventional Renewable Energy (NCRE)[33]. Specifically the law mandates that NCRE comprise 5% of Chile's energy supply by 2010 and 10% by 2024[34]. Financial incentives are also provided for this energy development under the law. NCRE involves such options as wind and solar energy, biogas and forestry biomass, geothermal, and small-scale hydropower (projects under 20 MW installed capacity). Although the NCRE targets are relatively modest in comparison to similar mandates in other countries, this effort represents a significant step for Chile, which has found little application of these technologies in the past. Several of these approaches have long term potential, particularly geothermal with generating potential in the range of 1235-3350 MW having been estimated in preliminary studies[35]. Wind energy has also been the subject of considerable interest with 3000-5000 MW of new generation capacity considered to be feasible in the next 10-15 years[36]. However, in order to meet the 2010 NCRE target, micro-hydroelectric development will likely receive a majority of energy investment due to current acceptance of the technology. These micro-hydropower projects consist primarily of run-of-the river installations in rivers and irrigation canals. There are currently over 300 such potential projects

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[30] Latin Business Chronicle, "Chile's Energy Crisis: No Magic Solution, http://www.latinbusinesschronicle.com/app/article.aspx?id=1721, Accessed on April 24, 2009

[31] International Energy Agency, "Chile – Statistics," http://www.iea.org/Textbase/stats/graphresults.asp?COUNTRY_CODE=CL, Accessed on April 27, 2009

[32] Latin Business Chronicle, "Chile's Energy Crisis: No Magic Solution, http://www.latinbusinesschronicle.com/app/article.aspx?id=1721, Accessed on April 24, 2009

[33] "Renewable energy law signed into effect in Chile," *Reuters*. March 20, 2008. http://uk.reuters.com/article/idUKN2040461920080320 accessed July 3, 2009

[34] Ibid.

[35] Speiser, R.M. "Energy Security and Chile Policy Options for Sustainable Growth" U.S. Assessment of Energy Economics, Report USAEE WR08-006, January 2008.

[36] Malinowski, M. "Wind Energy Catches on in Chile." Santiago Times, August 20, 2007.

identified with a total generation capacity of over 900 MW[37]. However, compared to the HidroAysén projects, with a total capacity of 2750 MW (which doesn't qualify under the renewable energy classification), it is clear that many such projects would be required to meet the same production level.

A study conducted by the University of Chile and the Technical University Federico Santa Maria estimated that between 39,800 and 56,500 GWh per year could be generated by a combination of wind, solar, and geothermal energy in Chile, but the authors indicate that a significant change in national energy policy will be required to meet these targets[38].

Energy Efficiency

Another area the Chilean government is working on is public awareness of personal energy use. Similar to the Energy Star program in the United States, the government and ministry of economy are developing appliance and building energy performance standards for Chile. Their goal is to reduce electricity consumption by 15 percent over the next 10 years[39].

Description of the Aysén Hydroelectric Project

The Aysén Hydroelectric Project (referred to as PHA in this report and the EIA) consists of five dams in Chile's Region XI, commonly referred to as Aysén or Patagonia. Two of the dams are on the Baker River, Baker 1 and Baker 2, with the other three on the Pascua River, Pascua 1, Pascua 2.1, and Pascua 2.2. There is a sixth project, the Del Salto project, with a much smaller generating capacity (to be used to generate power for the larger projects), that is not considered in detail in this report. The Baker and Pascua Rivers are the first and third largest rivers in Chile, respectively, based on average annual discharge at the river mouth. Both rivers originate as outflow from large lakes, General Carrera (through Lake Bertrand) in the case of the Baker and O'Higgins Lake for the Pascua. River flow is derived from a combination of rain at lower latitudes and snow and glacial melt during the summer months, with stable average flow hydrographs (See Figure 6 for the two Baker River project sites compared to similar data for a site on the Biobío River located in Region VIII). The Pascua River is 62 km long with no major tributaries and thus has a relatively constant flow spatially while the Baker has several significant tributaries, causing discharge to increase significantly along the river's 170 km length[40]. Figure 2 is an inset map of the Patagonia region, and Figure 3 indicates the locations of the five projects; these figures are taken from the environmental impact assessment.

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[37] Promoting Renewable Energy in Chile and its impact on Copper Production, www.leonardo-energy.org/copper/wp-content/uploads/2008/07/new-renewable-energy-law-in-chile.doc

[38] Julie Sutor, "Renewables Could Meet Half of Chile's Electrical Needs," *The Patagonia Times,* August 10, 2008

[39] Export Council for Energy Efficiency, "Energy and Electricity in Chile," http://www.ecee.org/pubs/assess/chile/Chile3.htm, Accessed on April 24, 2009

[40] "Basic Facts: Baker & Pascua Rivers, Proposed Dams and Transmission Lines | International Rivers," Home | International Rivers, http://internationalrivers.org/en/node/2139, accessed April 5, 2009

Figure 2. Map of Aysén Region with locations of Baker and Pascua Rivers.

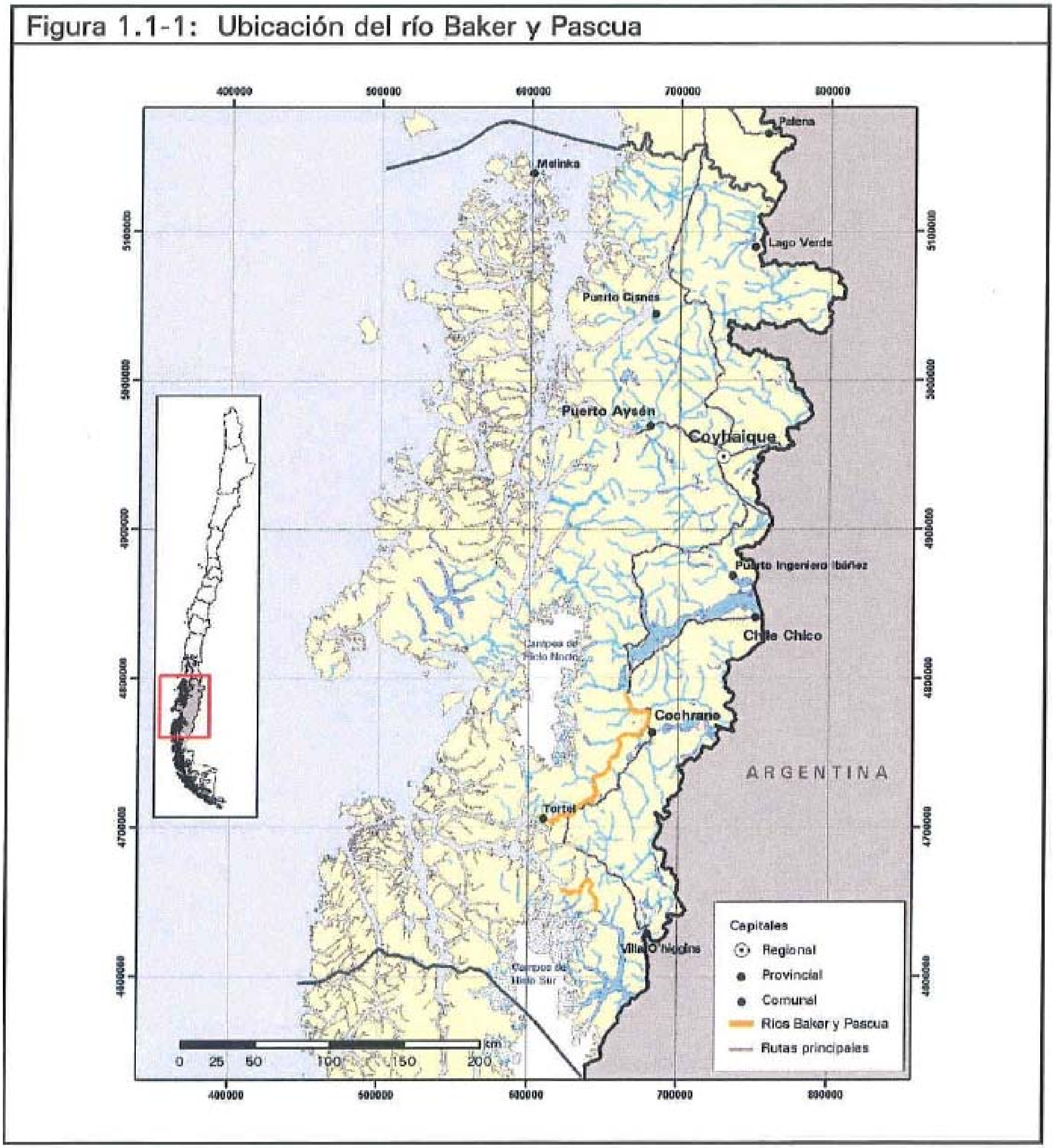
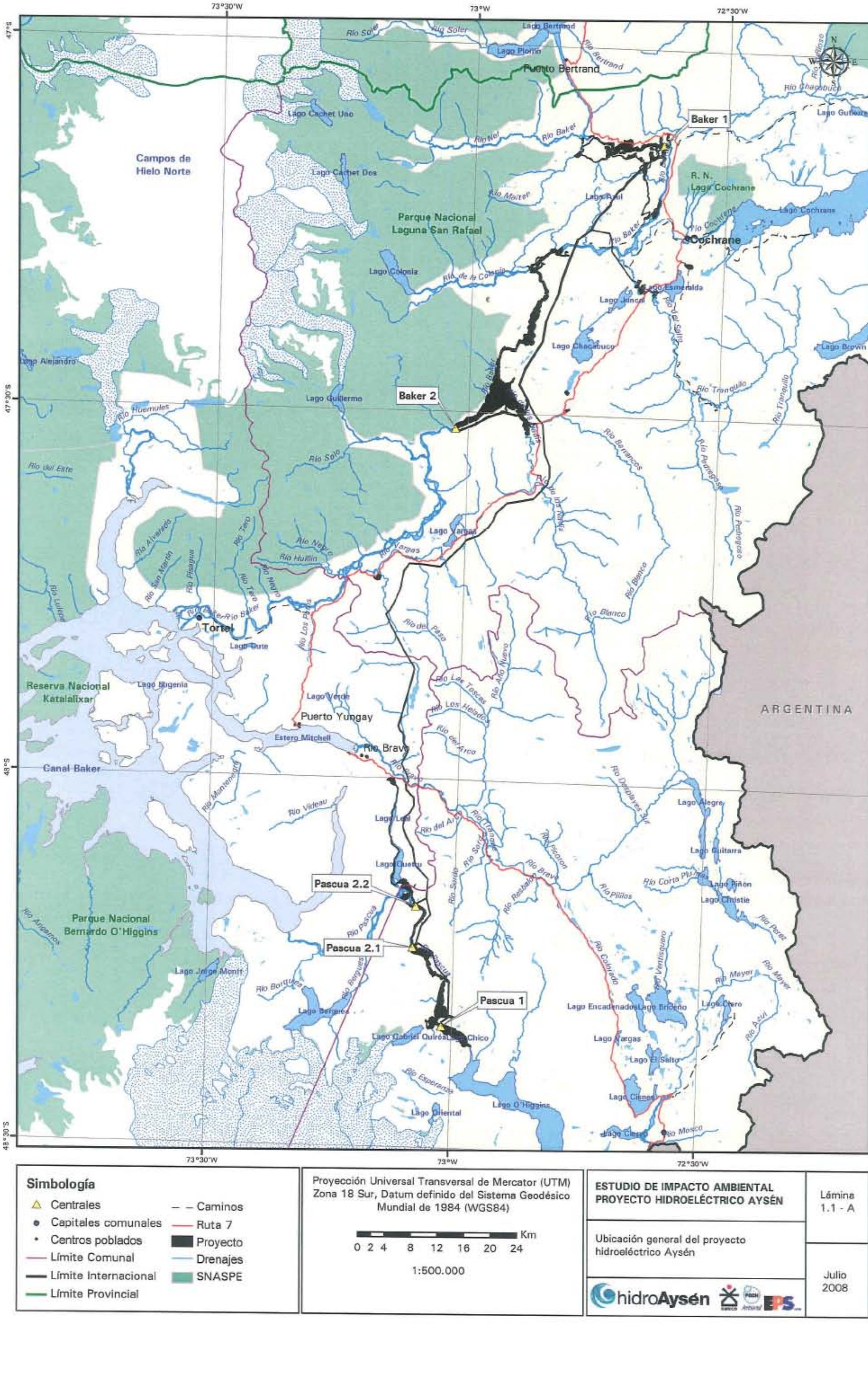


Figure 3. Local map with project locations.



The power stations are projected to have a combined installed generating capacity of 2,750 MW of power with an average annual generation of 18,430 GWh. These projects are projected to add about 30% of current power production to the SIC grid. Since the power produced is to be exported from the region, about 179 km of local 500kV transmission lines will deliver the power from the individual projects to a station near the Baker 1 site that will convert the electricity to direct current and deliver it through an approximately 2000 km long transmission line to the Santiago area where it will then be converted back into alternating current and fed into the SIC grid[41]. The environmental impact assessment only considers the effects of the local transmission lines (including the del Salto project) which are referred to as the link system and not the longer transmission line that spans across multiple regions; the long distance transmission line project requires a separate environmental impact assessment.

A summary of the key aspects of the five hydroelectric projects are included in Table 1. This information is taken from various sections of the environmental impact assessment. The presented information includes some hydrological characteristics of the rivers, characteristics of the impoundments behind the dams, and projected average power generation characteristics. The spillway capacities for the individual projects have been designed to pass the estimated 1000-year flood discharge. The hydraulic residence time for each reservoir (defined as the maximum reservoir volume divided by the mean annual discharge) is less than five days. This lack of storage dictates that the projects will be operated in run-of river mode. The reservoirs are intended to be operated within a three meter elevation range; the volume of water in storage within that 3 m range allows less than one day of flow at the design discharge so long term control of variations in river discharge will not be possible. However, the use of the projects for hydro-peaking is planned. During low flow conditions, the projects would be operated at the proposed minimum flow during off-peak hours and at the design discharge during peak flow hours[42]. Detailed operation rules are not provided in the EIA.

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[41] HidroAysén, Environmental Impact Assessment, Chapter One, p. 56
[42] HidroAysén, Environmental Impact Assessment, Chapter Five p. 203-210.

Table 1: Main characteristics of PHA power stations							
Station	Units	Baker 1	Baker 2	Pascua 1	Pascua 2.1	Pascua 2.2	Total
Average Annual Discharge	m^3/s	642	948	622	689	692	-
Estimated 100 Year Flood	m^3/s	2520	4540	1380	1960	1960	
Estimated 1000 Year Flood	m^3/s	3370	6080	1600	2310	2310	
Probable Maximum Flood	m^3/s	5500	10,000	2200	3300	3300	
Project Design Discharge	m^3/s	927	1,275	880	980	980	
Minimum Ecological Flow	m^3/s	260	380	230	280	280	
Inundation area	ha	710	3,600	500	990	110	5,910
Maximum Reservoir Volume	10^6 m^3	173	380	192	200	25	
Installed Generating Capacity	MW	660	360	460	770	500	2,750
Annual average Energy production	GWh	4,420	2,530	3,020	5,110	3,350	18,430
Residence Time (at mean flow)	hours	75	111	86	81	10	
Residence Time for 3 m elevation change (at design flow)	hours	6.4	23.5	4.7	8.4	0.9	

World Commission on Dams Report

The period from the 1930s through the 1970s involved the construction of many large dams worldwide. These dams had a wide variety of objectives such as providing flood control, hydroelectric power and water storage for irrigation. As these projects were operated over the years, a consensus developed that a large number did not fulfill their original objectives and that undesirable and unanticipated side effects often accompanied the project implementation. In response to growing controversy over the impacts of large dams, the World Bank established the World Commission on Dams (WCD) in 1997 to review the economic development effectiveness of large dams and to develop general criteria for planning, operation, monitoring, etc. of large dam projects. Efforts of the Commission included detailed case studies of 8 specific dam projects and a cross check survey involving a lower level of analysis for 125 large dams to establish larger patterns. The Commission released a report in 2000 entitled *Dams and Development: A New Framework for Decision Makin*g.[43]

Independent study groups were established to prepare case studies for the eight following projects:

- Grand Coulee Dam in the United States
- Pak Mun Dam in Thailand
- Aslantas Dam in Turkey
- Glomma projects in Norway
- Tucurui Dam in Brazil
- Kariba Dam, joint project between Zambia and Zimbabwe
- Tarbela Dam in Pakistan
- Gariep and Vanderkloof Dams in South Africa

Nearly all of these projects were implemented without the requirement for an environmental impact assessment; a notable exception being the Pak Mun project. Although Thailand did not have legislation or regulations requiring an assessment, it was required at the time of project planning as prerequisite for obtaining World Bank funding.

General conclusions from the World Commission on Dams report include the following observations:

- Most impacts on rivers, watersheds and aquatic ecosystems have been negative and efforts to mitigate these negative impacts have been met with limited success;
- In many cases, project implementation was followed by irreversible loss of species and ecosystems;
- Most adverse environmental impacts were unanticipated;
- Effects in the rivers downstream from the dams were not well anticipated;
- It is difficult to account for environmental and social costs, making an accurate determination of the true project economics difficult;
- Costs and benefits associated with the projects were generally not borne by the same groups of stakeholders.

[43] The World Commission on Dams, *Dams and Development: A New Framework for Decision Making,* (London UK: Earthscan Publications, 2001)

The Environmental Impact Assessment

EIA Process and Timeline
Chile adopted the current Environmental Framework Law in March, 1994,[44] that generally established the country's environmental policy. This law established a procedure, called the Environmental Impact Assessment System, by which the environmental impacts of certain projects are assessed. The National Environmental Commission (CONAMA) uses this procedure to decide whether the environmental impacts of proposed projects are acceptable under Chilean Law[45].

Projects that fall under the scope of the Environmental Impact Assessment System are required to submit an Environmental Impact Statement, also known as an Environmental Impact Assessment (EIA), to CONAMA. If the project only affects a single region of the country, then the EIA is submitted to the regional branch of CONAMA, which is referred to as COREMA. The law requires that the EIA include the following specific information:

- a description of the project,
- a plan for compliance with applicable laws,
- a baseline study of environmental elements that will be affected,
- a prediction and evaluation of the environmental impacts,
- a plan of mitigation, reparation and compensation efforts to reduce negative effects,
- a plan for continued monitoring of environmental impacts,

as well as other information outside the scope of this report.

Once CONAMA receives the EIA, it has five business days to rule whether the EIA "complies with the formal requirements and is therefore acceptable in form." If the EIA is acceptable, CONAMA must, within three business days, send copies of the EIA to public agencies and local governments deemed to have a stake in the project. These entities have forty business days to issue a response to the EIA, stating whether or not the project complies with applicable environmental laws. The EIA is also made available for public comment. These reports and public comments are compiled by CONAMA into a Final Technical Report to which the entity submitting the EIA must respond. The Political Committee of CONAMA must then consider the EIA, the Final Technical Report, and public comment and issue a resolution regarding whether the project is environmentally acceptable. This resolution must be issued within 120 days of the

[44] National Law Center for Inter-American Free Trade, "Chile," http://www.natlaw.com/interam/ch/en/sp/spchen1.htm, Accessed on May 28, 2009
[45] Ibid

date when the EIA is initially submitted; but can be extended if the public agencies or CONAMA requires clarification, rectification, or more information with respect to the EIA[46].

Background on the HidroAysén Environmental Impact Assessment
The proposed HidroAysén project falls under the scope of the Environmental Impact Assessment System. On 14 August, 2008, HidroAysén submitted the Environmental Impact Assessment for the proposed hydroelectric projects, beginning the review process. The document is over 10,000 pages long, "cost twelve million dollars and took the Chilean firms Poch and EPS, as well as Sweco, a Swedish company, three years to complete[47]." HidroAysén contracted with a number of Chilean universities and other organizations to conduct many of the studies that form the basis for the baseline study. These include the following components:

- Research on Vegetation and Terrestrial Flora- Universidad Austral.
- Research on Terrestrial Fauna- Universidad de Concepción.
- Research on Aquatic Flora and Fauna, Water Quality and Ecologic Flow- Centro de Ecologia Aplicada.
- Research on Land, Climate, Meteorology, Hydrology, Hydrogeology, Geology and Geomorphology- Universidad de Chile.
- Research on Oceanography, Marine and Estuarine Flora and Fauna- Universidad de Valparaiso.
- Research on Landscape, Territorial Planning and Protected Areas- Universidad Central.
- Research on Hazardous Areas- Universidad de Chile
- Research on Population, Socioeconomic Aspects, Quality of Life and Touristic Activities- Pontificia Universidad Católica de Chile.
- Research on Land's Holding, Equipment and Infrastructure- Pontificia Universidad Católica de Chile.
- Research on Cultural Heritage (Historical, Archaeological, Anthropo-Archaeological, Religious, National Monuments) - Universidad Bolivariana.

Reports providing the results of these studies have been combined into a single document released in December of 2007 entitled *Proyecto Hidroelectrico Aysén, Informes de Caracterization de Componentes Ambientales Sectores Rio Baker y Pascua, Region Aysén.* The EIA considers information from this roughly 5000 page document as background knowledge to the projects and therefore does not always reference it directly.

CONAMA accepted the submitted EIA as complying with formal requirements, and made it available to environmental authorities (municipalities and provincial governments, ministries of agriculture, fisheries, energy, health, water, ports, airports, etc.) and the public for comment.

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[46] National Law Center for Inter-American Free Trade, "Chile," http://www.natlaw.com/interam/ch/en/sp/spchen1.htm, Accessed on May 28, 2009
[47] Inter Press Service, "Environment Chile: Patagonia Dams On Hold," http://ipsnews.net/news.asp?idnews=44791, Accessed on May 28, 2009

Thirty-two environmental authorities issued over 3,000 observations and requests for clarifications, rectifications or more information, which the Aysén regional branch of CONAMA combined into a consolidated report known as ICSARA. On 13 November 2008, COREMA Aysén notified HidroAysén that it had five business days, until 20 November 2008, to reply to the ICSARA report. On 19 November 2008, HidroAysén requested that the review process be suspended. HidroAysén has indicated that they plan to re-open the review process, most likely in August 2009.[48] Documentation regarding the EIA is presented on the CONAMA website

https://www.eseia.cl/expediente/expedientes.php?modo=ficha&id_expediente=3103211&idExpediente=3103211#-1.

This website includes the environmental impact assessment documents, communications between CONAMA and HidroAysén, and with various municipalities and government agencies. Agency and public comments on the EIA are posted on the site as well and as of June 1, 2009, almost 10,000 public comments had been posted.

Organization of the HidroAysén Environmental Impact Assessment

The August 2008 EIA is organized as follows:

- Chapter 1: Description of project;
- Chapter 2: Plan of compliance with applicable environmental law;
- Chapter 3: Description of environmental conditions that require an EIA be presented for the project;
- Chapter 4: Environmental baseline study;
- Chapter 5: Prediction and evaluation of environmental impacts;
- Chapter 6: Plan of mitigation, reparation, and compensation measures;
- Chapter 7: Follow-up plan to ensure compliance with environmental protection measures;
- Chapter 8: Description of measures taken to involve citizens in project planning;
- Chapter 9: Compilation of reports, studies, people involved in preparation of EIA, etc.

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[48] "Environment Chile: Patagonia Dams On Hold," Inter Press Service, http://ipsnews.net/news.asp?idnews=44791, Accessed on May 28, 2009

It is important to note that the EIA submitted to CONAMA includes no evaluation of the impacts of the 2,000 km long transmission lines required by the PHA. These are necessary to deliver the energy from the direct current conversion station near the Baker 1 project site to the location near Santiago where it will be converted back to alternating current and fed into the central (SIC) electrical grid. This observation is important in evaluating the overall effects of the PHA and will be discussed in detail below.

Chapter 4 describes the environmental baseline, or the current state of the environment in Aysén for each of the five proposed sites for the PHA. This information is organized according to environmental component, including water quality, aquatic ecosystems, terrestrial ecosystems, tourism, areas of archeological and historical heritage, and socioeconomic systems. This report does not address each category listed in the baseline but considers those categories that incorporate the majority of the anticipated negative impacts.

Chapter 5 describes how each of the five proposed projects is expected to affect the environmental base line for each identified environmental component. The EIA describes 111 impacts. In order to determine the magnitude of each impact, the EIA employs a modified version of the Leopold Matrix, a common method of environmental impact assessment developed by the U.S. Geological Survey in 1971, that assigns values between +100 and -100, with positive numbers indicating positive impacts, zero indicating no impact, and negative numbers indicating negative impacts.[49,50] In the EIA implementation, total impact (IT) of a dam component on the surrounding environment is calculated by assigning numerical values to the characterization of the impact (C), the magnitude of the impact (M), and the environmental value (EV) and then evaluating the product of the three numbers.[51] The characterization is described as either positive (+1) or negative (-1), while the magnitude and environmental values range between 0 and 10, resulting in possible IT values ranging between +100 and -100.[52] A more detailed explanation can be found in the EIA section 5.1.2.1.3. A summary of this method follows:

Impact Scoring System
Total Impact (IT) = Character of the Impact (C) * Magnitude of the Impact (M) * Environmental Value (EV)

Where:
C = either a positive or a negative 1 based on a perceived positive or negative impact.
M = P(E + I + D + R)
P = probability that the project under study has the given effect on the environment (ranges from 0-1)

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[49] Scientific Committee on Problems of the Environment, "SCOPE 5 – Environmental Impact Assesment," http://www.icsu-scope.org/downloadpubs/scope5/chapter04.html#fig4.4, accessed on April 10, 2009
[50] HidroAysén, Environmental Impact Assessment, Chapter Five pages 5-17
[51] Ibid, p. 5-17
[52] Ibid, p. 5-17

E = The extent, or the area influenced by the project (from 0 to 3)
I = The intensity, or the degree of alteration of the environmental component (0 – 3)
D = The duration of the impact (0 -2)
R = The reversibility, or whether or not the component can recover its baseline value (0 to 2)

For Environmental Value (EV):
1) Components that have a low base line quality, are not relevant to other components or are relatively abundant receive scores from 1 to 3.
2) Components that have a high quality base line but are not relevant to other components or are relatively abundant receive scores from 4 to 5.
3) Components that have a low quality base line but are relevant to other components or are relatively rare receive scores from 6 to 7.
4) Components that have a high quality base line, are relevant to other components and are relatively rare receive scores from 8 to 10.

For the probability (P):
1) When there is little expectation that the impact will be manifest during the lifetime of the project, it receives a score of less than 0.1.
2) When a small expectation that the effects of an impact will occur, it receives scores from 0.1 to 0.29.
3) When there is an intermediate expectation that effects of the impact will occur, it receives scores from 0.3 to 0.59.
4) When there is a high expectation that effects of the impact will occur, it receives scores from 0.6 to 0.89.
5) When there are very high expectations that effects of the impact will occur, it receives scores from 0.9 to 1

For extent (E):
1) Impacts that can only be seen in the area where they are located and have a source that is spatially very limited receive a score of 0.
2) Impacts that are manifested in the wider environment including municipal areas receive a score of 1.
3) Impacts that extend over a provincial area receive a score of 2.
4) Impacts that extend over a regional area receive a score of 3.

For intensity (I):
1) Impacts where the degree of alteration is deemed small and that the baseline remains receive a score of 0.
2) Impacts where the degree of alteration involves noticeable changes but not significant with regard to the baseline receive a score of 1.
3) Impacts where the degree of alteration involves significant changes in the basal condition but within an acceptable range receive a score of 2.
4) Impacts where the degree of alteration with respect to the baseline condition is significant and unacceptable receive a score of 3.

For duration (D):

1) Impacts that occur only during the action that causes them and impacts of short duration receive a score of 0.
2) Impacts that range two to five years receive a score of 1.
3) Impacts that last longer than five years receive a score of 2.

For reversibility (R):

1) Impacts that are reversible in a natural way receive a score of 0.
2) Impacts that are not reversible in a natural way but can be reversed at least partially through corrective action receive a score of 1.
3) Impacts that are not reversible in a natural way and cannot be reversed by corrective action receive a score of 2.

The EIA rates and ranks all total impacts based on the distribution of scores as follows:

0 - 20 – Not significant
21 - 40 – Slightly significant
41 – 61 – Moderately significant
61 – 100 – Significant

For example, table 5.4.4-4 in the EIA describes the effect on biotic communities (freshwater ecosystems during the construction phase of the projects) due to increases in suspended solids from each of the dams. The Baker 1 dam receives the following scores.

C = -1
P = 0.8
E = 1
I = 1
D = 0
R = 0
M = 1.6
EV = 10

TI = C * M * EV
TI = -1 * 1.6 * 10
TI = -16 = Not significant

The EIA ranks all impacts from most significant to least significant and focuses primarily on those impacts that receive scores greater than 61 and are therefore considered significant. These are the impacts for which serious discussion is provided of the potential to harm the local environment, requiring mitigation and/or compensation[53]. Because the EIA contains little discussion of less significant impacts, this report is primarily a critique of those impacts deemed “significant” by HidroAysén in the EIA. However, it is the opinion of the authors that the EIA commits a serious oversight in de-emphasizing “not significant” impacts and addressing each “significant” impact separately as it is the cumulative effect of all the impacts that will, ultimately, determine the environmental consequences of constructing and operating the PHA.

[53]HidroAysén, Environmental Impact Assessment, Chapter Five, pages 5-17

Hydrology

Introduction

Hydrology is the term used to describe the movement and distribution of water in a geographical area on the earth's surface. Hydrology influences biotic ecosystems within the riverine environment prior to and following the installation of a dam and also controls the design of a dam from the standpoint of power generation; ultimately influencing the economics of a project. A dam alters the river's hydrology in many ways, including alterations of flow regime (the nature of flow variation over multiple time scales) that affect river ecology, nutrient flow, and other physical and chemical characteristics of the water. A key consideration is the magnitude and variation of the volumetric flow rate. Unless otherwise stated, in this section the terms "flow" and "flow rate" refer to volumetric flow rates.

This section reviews comments made in the EIA related to hydrology. A physical characterization of the river system is necessary to inform other parts of the EIA that address topics such as sedimentation in the river and aquatic ecosystems. A key issue is the availability of data from which projections are made of future flow trends that will influence the project operation. The EIA should provide compelling evidence that its predictions of river flow are reliable, thus validating the basis on which the projects have been proposed.

Information Provided By the EIA

Hydrology and Dam Operation

The EIA provides information regarding flow variability, mainly at monthly and longer time scales. These analyses are performed on relatively short (less than 50 years) time series of flows monitored on the two rivers. The data collected at stream gauging locations is extrapolated to the proposed dam sites and subjected to a variety of statistical analyses. This data analysis affects the size of dam facilities such as spillways and also influences the estimates of power that can be generated from the projects.

Hydro-peaking is the operational practice where more power is produced by a hydroelectric dam during peak electricity demand periods of the day than off-peak times. This is accomplished by releasing more water from the reservoir and through the turbines during daily peak demand hours. Since the average flows during months with high river discharge are close to the capacity of the two turbines proposed to be installed at each dam site, both turbines will basically operate continuously during high flow conditions. However during low flow months, the projects will be used in hydro-peaking mode with significant flow variation over the course of a day. The discussion of impact MF-HID-OPE-02[54] explains the hydro-peaking operating procedures that are analyzed for impacts of intra-daily flow variations downstream from the Baker 1, Baker 2, and Pascua 2.2 projects. Analysis is not provided for the Pascua 1 and 2.1 projects since the reservoir from the next downstream dam basically extends to the toe of these dams and any flow fluctuations are adsorbed in the reservoir. The effects of hydro-peaking on both residence time and variation in water level both upstream and downstream of the dam are discussed. Oscillations in water level can affect shoreline erosion, and will also have an impact on the behavior of flora and fauna in both terrestrial and aquatic ecosystems. Residence time can affect the temperature gradients, tendency for sedimentation and other water quality responses in the reservoirs.

Minimum flows at each of the projects are discussed in the EIA as well as the basis for their determination[55]. Relevant regulations are discussed and minimum in-stream or "ecological" flows are established at levels higher than dictated by regulations. Each of the five projects would be constructed with two turbines[56] and it appears that the minimum flows are selected as the lowest flow rate that can efficiently generate electricity with a single turbine in operation. Table 1 in the Background section provides a summary of relevant flow rates including minimum flows. One other stipulated operational constraint is that the water level fluctuation in any reservoir will not vary by more than three meters with a specified maximum and minimum reservoir water surface elevation.

The Baker 1 project is considered as an example, where the maximum water surface elevation is specified as 200 m above mean sea level while the minimum elevation is 197 m[57]. In the Baker 1 reservoir, the water level may vary as much as three meters over a period of six hours due to electrical generation operations[58]. Extensive analysis is performed on the hydrologic impacts of flow regulation at a representative low flow condition, namely the 85% exceedance probability flow (that is, the flow rate that 15% of days annually fall below on average). At this low flow condition, the operational plan will be to release water at the minimum flow rate (260 m^3/s) for most of the day and then to ramp up the flow relatively quickly to the design flow rate of 927 m^3/s during the hydro-peaking period. This change in flow (667 m^3/s) is significantly greater than the natural average daily flow at the 85% exceedance flow (453 m^3/s).[59] This increase in flow rate will create a flow wave downstream of the dam that diminishes in magnitude with downstream distance. Extensive modeling analysis is presented to predict the details of the flow wave[60]. One issue that is significant with respect to these flow waves is the effect on downstream aquatic ecosystems. Natural systems will have evolved to the natural hydrological variations of a river system. Since these are quite low in the Baker and Pascua

[54] HidroAysén, Environmental Impact Assessment, Chapter Five p. 203-210.
[55] Ibid. p. 203
[56] HidroAysén, Environmental Impact Assessment, Chapter One p. 47
[57] Ibid. p. 46
[58] HidroAysén, Environmental Impact Assessment, Chapter Five p. 203
[59] Ibid, p. 203-204
[60] Ibid, p. 249-253

Rivers, the effects of hydro-peaking operations can be expected to exert a significant and negative influence on the aquatic ecosystem; this is not discussed in detail in the EIA. The EIA generally emphasizes the importance of maintaining statistical averages for daily, monthly and yearly flow rates. However, when balancing a delicate aquatic or terrestrial ecosystem, it is important to consider the transient effects of fluctuating flow, which would sometimes vary by as much as the annual average flow, over the course of several hours due to the proposed hydro-peaking operation.

The EIA also presents consideration of water level variations due to a 10,000-year flood in the rivers, and concludes in each case that the variation takes place over a long enough period of time that the event is not important[61]. It is unclear what the significance of this flow rate is since water level variations associated with an event that occurs on average once in 10,000 years will be of relatively minimal ecological significance and the dams will have little influence on the river flow since there is little storage available in the reservoirs.

Retention time in Pascua 1 would be decreased by approximately two hours (about 10% lower) due to hydro-peaking, which the EIA does not consider to be a significant impact for aquatic ecosystems. The effect of hydro-peaking on flow waves downstream of the Pascua 1 is considered negligible, as the variations in height would be attenuated in the Pascua 2.1 reservoir[62].

The EIA emphasizes the actions of tributaries to attenuate flow variation, although many of the tributaries provide minor contributions to the overall river flow. For example, the average flow rate for the Pascua River is estimated to increase by only 11 percent from the upstream project to the most downstream one (Table 1).

Documentation of Hydraulic Characteristics

Adequate knowledge of the hydraulic characteristics of the rivers is important in predicting changes to geomorphology and aquatic ecosystem behavior both upstream and downstream of the dam sites. In EIA chapter 4, "Environmental Baseline," HidroAysén has broadly characterized the hydraulic river flow into three types[63]:

- Waterfalls, at 13.5 km, 15.0 km, 26.0 km, 100 km and 101 km downstream of the Baker 1 dam.
- Regions with series of rapids and pools (mainly located downstream from the confluence of the rivers Baker and Chacabuco, and at "some intermediate sites." These regions fail to produce whitewater or cascades--attributed to the relation between the height of runoff, the relative roughness of the bed and the character of sediments.
- Braided channels in large regions of the Baker and its tributaries. These "twisted sections" cause changes in the pattern and path of the river over the course of the

[61] Ibid, p. 207-208
[62] Ibid, p. 206
[63] HidroAysén, Environmental Impact Assessment, Chapter Four p. 222

season. These regions are attributed to decrease in land slope, which causes the river to wind and erode at the shore.

Magnitude and annual variation in power generation potential

The capacity factor (CF) of a hydroelectric generating facility is the ratio of the actual energy produced in a year divided by the total possible energy produced if all turbines were continuously operating (rated power times total hours in one year):

$$CF = \frac{Actual\ Annual\ Output\ \left(\frac{kWh}{yr}\right)}{Rated\ Power\ (kW) * 8760\ \frac{hr}{yr}} \qquad \text{Eq. 1}$$

The EIA does not present estimates of capacity factor but does provide estimates of average annual energy generation and the rated capacities of each individual project (Table 1). The amount of energy produced annually depends on whether the combination of river flow and reservoir storage allows a dam to be operated at its maximum rate of power production, and whether the operational scheme involves a base load or peaking plan. The EIA does not report how its projected average annual energy generation numbers have been calculated, thus the following is an independent calculation based on the available monthly average river flow data in order to determine if the reported power and energy production are feasible.

To determine the capacity factor for the Baker river flow data presented in the EIA[64], it is assumed that the power output is directly proportional to the flow. Based on the monthly average flows at the Baker 1 and Baker 2 sites, a midpoint Riemann sum is used to estimate the total volume flowing through the dam in an average year.

For Baker 1, the monthly average flow does not exceed the design flow and does not fall below the minimum flow required to operate the dam. The capacity factor is computed by dividing the total area under the monthly average flow curve by the area under the design flow curve as indicated in Figure 4 to determine a capacity factor of 68%. For Baker 2, the monthly average flow rate does exceed the design flow rate during the months of December, January, and February (Figure 5). This suggests that the spillways may be used to bypass any flow exceeding the design rate of 1275 m^3/s, thus the monthly flow is maximized at 1275 m^3/s.   The energy generation potentials for the two projects are reasonably consistent with the information presented in Table 1; deviations are probably due to minor differences in assumptions. Based on this analysis of the Baker dams, it appears that reasonable estimates regarding average energy production have been made.

[64] Ibid. p. 233

Figure 4- Baker 1 Dam Flow Rates

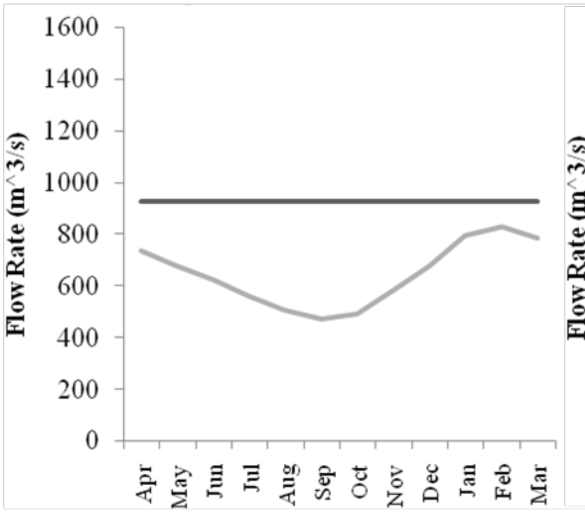
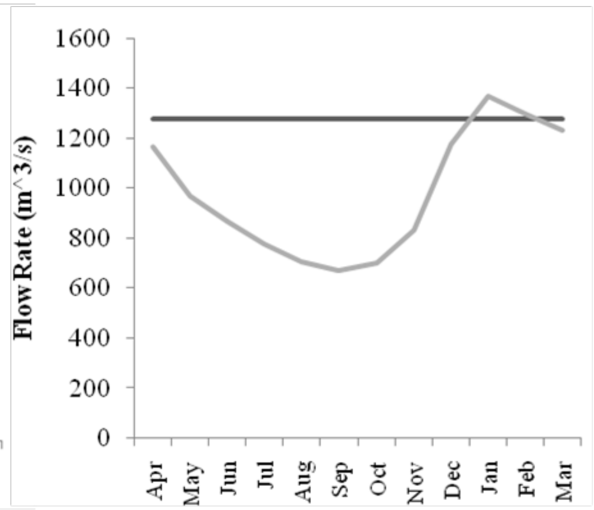


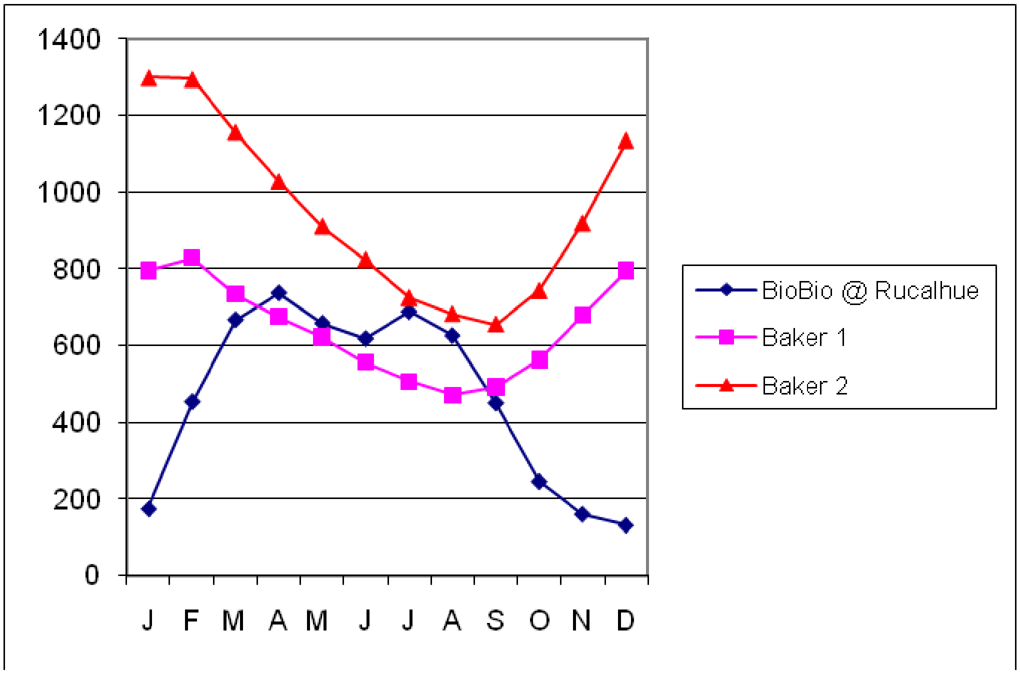
Figure 5- Baker 2 Dam Flow Rates



The executive summary of the EIA asserts that the flows of the rivers in the project are complementary to those already used to generate electricity for the SIC grid elsewhere in the country[65]. Flows in the Biobío River at Rucalhue[66], are compared to the flows of Baker 1 and Baker 2 in Figure 6 in terms of average monthly discharge computed from about a 45 year record in all cases. The glacial melt during the summer months yields the highest monthly average flows in the Baker but the greater winter precipitation in the Biobío basin yields higher river flows in that river during winter months. This effect is even more pronounced in the larger rivers further north of the Biobío. The results in Figure 6 thus demonstrate that if the PHA is implemented there will be reduced seasonal variability in hydro-electrical power generation. In addition, the ratio of the maximum to minimum monthly flows for the Biobío is 5.54 and only 1.75 for the Baker 1 location, re-iterating earlier comments regarding the uniformity of the annual hydrograph for the Baker and Pascua Rivers.

[65] HidroAysén, Environmental Impact Assessment, Executive Summary p. 1
[66] UCLA School of Engineering and Applied Science, http://www.engineer.ucla.edu/, accessed on May 20, 2009

Figure 6. Flow of Baker is complementary to flow of other Chilean rivers used for hydroelectric power generation.



Effect of daily flow variation on river level

The EIA claims to have analyzed flow patterns during each of 15%, 50% and 85% exceedance probability flow rate scenarios[67], but presents projected operations only for the 85% exceedance probability daily flows, presumably since this would involve the more significant flow variations. The EIA terms change in the daily oscillation of flow rate and thus downstream water level "wave-flooding."

The EIA considers impacts due to wave flooding for Baker 1, Baker 2, and Pascua 2.2, because Pascua 1 and 2.1 are in series such that potential fluctuations from the upstream dam would be mitigated in reservoirs further downstream (Pascua 2.2 in the case of Pascua 2.1 for example; the Baker 2 site is sufficiently far downstream that free flow conditions are established between the Baker 1 dam and the Baker 2 reservoir). It addresses effects of wave-flooding in three regions for each dam, for a total of eight regions (one region is considered directly under the influence of both Baker 2 and Pascua 2.2). The regions are defined by confluences and geographic landmarks downstream of the dams[68].

When analyzing plant operations in the case of the 85% exceedance probability flow, there is generally a large increase in river level over relatively short periods of time (for example, a 0.5

[67] HidroAysén, Environmental Impact Assessment, Chapter Five p. 245
[68] Ibid, p. 247

m rise over the course of two hours, in the case of the closest region downstream of the Baker 1 dam). Predicted water level fluctuations are even more significant for the Pascua 2.2 site [69]. Following the increased flow rate during the hydro-peaking operation, the river would experience lower flow rates and dip about 20 cm below the level expected with the average discharge associated with the 85% exceedance probability daily flow.

EIA Impact Ratings

Although the EIA provides detailed graphs of height variations downstream in the eight areas of impact, the EIA provides little insight into its assignment of scores for the ranking system. The probability of occurrence for impact OPE-MF-HID-06, which concerns operating practices and fluctuation of daily flow rate, is given as 0.8[70]—which implies that there is a probability of 0.2 that such daily fluctuations will not occur. It is unclear what is implied by this probability value since the hydro-peaking scheme, if implemented, will certainly cause the flow fluctuations at least certain times of the year.

The EIA defines the intensity of impact on a scale of 0-2. With regards to flow variation over Baker 1, the intensity was considered low (value of 1), since the effects, "…are not significant on those sections where it is possible to identify any human activity or utility of the river."[71] This suggests that the EIA scoring system merely evaluates the human impact of the dam; however, many of the rivers' important aquatic and terrestrial flora and fauna may rely upon sections below the dam that are unused for human utility.

With regards to flow variation over Baker 2 and Pascua 2.2, the intensity was considered low (value of 1) because, "…while the downstream oscillation involves change in baseline condition, this is not significant."[72] The EIA provides no basis on which to claim that changes to baseline condition would not be significant to terrestrial and aquatic ecosystems or to the geomorphology of the river shoreline and beds downstream of the dams.

Impact MF-HID-OPE-05 investigates the potential erosion of banks due to flow variation[73]. Regardless of flow into the reservoirs, there is a requirement that some percentage of flow drain in order to maintain river ecosystems downstream of the dams. According to the EIA, this results in significant hourly flow variations for 85% exceedance probability days, which are analyzed within the EIA.

[69] Ibid, p. 251
[70] Ibid, p. 254
[71] Ibid, p. 255-256
[72] Ibid, p. 256
[73] Ibid, p. 232-245

Comments on the EIA

Comments on the hydraulic baseline

The EULA report (Informe 3, Informe de Análisis Tecnico de Línea Base Proyecto HidroAysén, University of Concepción, Sept. 2008) takes issue with several components of the hydraulic baseline. This primarily descriptive section fails to adequately describe the nature of the riverbed in many of these areas. For example, it does not identify which flows are alluvial, i.e. flow rates above which the bed material becomes mobile. As the EULA report states[74], "This information is useful to be able determine the impacts from the proposed works and their operation on the morphology of the river system."

The description implies that braided channels are directly induced by and indicative of lower slopes, which is not necessarily true. The characterization also does not consider the potential effects of the dams on hydraulic regimes, or even suggest what may cause the present conditions, such that potential effects on geomorphology might be estimated.

Hydraulic studies were carried out through, "interpretation of aerial photographs and field work, which included flyovers along the river Baker".[75] No mention is made of attempts to characterize the cross-sectional flow of the river or examine the riverbed and geomorphology of the river system. Such investigations are important to understanding the true nature of the rivers' flow patterns. Cross sectional information is presented at various portions of the EIA, including the analysis of the effects of mining riverbed deposits[76], but the extent of river section measurements is not clearly defined.

The hydraulic nature of the Pascua River at each dam site is ostensibly characterized in Table 4.3.5-16 in several values that are unclearly defined, if at all. Flow characteristics for the intermediate areas, as well as areas downstream of the dams, are not considered except in qualitative terms later in the section[77].

The EIA defines the downstream area of influence of both the Baker and Pascua rivers as stretching to the nearest tributary, emphasizing the role tributaries will play in restoring altered flow and sedimentation characteristics of the rivers[78]. However, flow of the tributaries is often orders of magnitude smaller than that of the main river. Furthermore, tributaries are highly variable and do not necessarily contribute standard flow patterns or sediment inputs[79]. Thus, there is no sound technical justification to extending an area of influence to only one tributary.

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[74] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 24 #23
[75] HidroAysén, Environmental Impact Assessment, Chapter Four p. 222
[76] HidroAysén, Environmental Impact Assessment, Anexo B, Apéndice 2, pp. 128-134
[77] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 16 #48
[78] HidroAysén, Environmental Impact Assessment, Chapter Four p. 210
[79] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 2 #10

The area of influence downstream of the Baker 1 project is given as 35 km[80], but no justification is given for this length. The downstream areas of influence for the other dam sites are given by hydrologically significant points (areas of confluence, etc.) unless, as in the case of Pascua 1, the next dam's impoundment begins directly at its foot. As mentioned in the preceding paragraph, this definition itself is questionable.

Pascua River Flow Estimation

River flow data is a key piece of information in the analysis of water hydrology and power. The analysis of the Pascua River flow rate was not obtained directly from river measurements at the projected dam sites. Instead, river flow information was collected from three different locations and that data was used to estimate the flow of the Pascua River at the dam locations. According to Table 4.3.5-3 of the EIA, the three locations of the flow history for the Pascua River were made at the Lake O'Higgins drainage point into the Pascua River, at the Pascua River before it flows into Lake Quetru, and at Santa Cruz at Charles Fuhr[81].

The Santa Cruz at Charles Fuhr gauging station is located substantially to the southwest of the Pascua River, on the opposite side of the Andes Mountains, in Argentina. The data collected from the Santa Cruz station was used to fill in river flow data for times in which the flow data on the Pascua River was unavailable. The data from the Santa Cruz station was modified in order for it to be used to extend the Pascua River flow data back to 1960 because there is no data for the Pascua prior to 1962 (and only that long for the Lake O'Higgins gauging station; Lake Quetru data only goes back to 1978). A correction method was developed using data in which there was an overlap of information for both the Pascua River and at the Santa Cruz site. This was done in order to estimate missing values of the Pascua River flow in order to extend the flow record back to 1960.

Comments to the EIA have raised questions regarding the method of river flow estimation that HidroAysén used in the data analysis. There are many comments in the EULA report that question the reliability of the estimated river flow values for the Pascua. A major comment raises the issue that the Santa Cruz River is located on a river that drains into the Atlantic Ocean, on the opposite side of the Andes Mountains, and thus represents a completely different watershed area than that of the Pascua River in terms of geographical details such as slope. More importantly, the flow data is from a completely different climatic zone. The comment goes on to recommend using data collected from a source in the same watershed area as the proposed dams in order to estimate the river flow data for the Pascua River[82], although this is practically not possible due to the unavailability of such data. Additional comments from the EULA report[83] question the accuracy and precision of the estimated river flow values of the Pascua River.

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[80] Ibid. p. 6, #203
[81] HidroAysén, Environmental Impact Assessment, Chapter Four p. 214
[82] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 2 #13
[83] Centro de Ciencias Ambientales (EULA), "Anexos Informes," #'s 44, 46, 52, 60, 62, 63, 64

Change in Flow Rate Patterns
The EIA notes that since the 1970's, the region has received more rain, and thus become more dependent on rainfall, as evidenced by "increased sensitivity to periods of greater or lower rainfall."[84] The EIA states, "There is a noticeable increase in variance of the average annual flow. For example, at the Baker's Bertrand Lake gauging station, the variance during the period 1960-1974 is 59 m^3/s, and during the period 1975-2004 is 83 m^3/s."[85] Given this information, it may be logical to analyze these two periods as distinct regimes (up to 1974 and then since 1975), or to use only data since 1975 in making estimations[86]. Furthermore, the potential source of this statistical shift is not mentioned in this section, much less taken into account or utilized as a predictor for future behavior, which may be particularly useful given concerns with long-term regional and global climate change. Given the El Niño trends discussed below, there may be some connection with this phenomenon as well.

The EIA claims that a slight decline in annual flow averages over the sampling period is characteristic of global flow behavior, with citations from several studies[87]. The EULA cites at least one example of a study showing the opposite trend (increase in average monthly flow rates due to climate change). In addition, the EULA report notes that the EIA fails to provide any detailed data or statistical support for its claim of cyclical data with a 7 ± 3 year period[88].

Critique of EIA Accuracy and Omissions

Depth of analysis
The EIA analysis of potential shoreline erosion should draw from knowledge of the morphology and physical characteristics of the riverbed and shoreline, as documented in Chapter 4. However, these characteristics have been only documented in broad scope. It is unclear how the EIA reconciles its classification of geomorphologic behavior with the lack of detailed information regarding the geomorphology and riverbed characteristics in either the Baker or the Pascua.

Presentation and emphasis of data
The flow rate data are often presented in relative terms, comparing daily flow ranges with either annual average flow or 85% exceedance probability daily flow averages. Mixing the choices of flows to use as a basis for comparison confuses the interpretation of the data as well as predictions. No explanation is given regarding the choice of 85% exceedance probability as a basis for comparison. Data is not clearly presented or organized for any of the reservoirs.

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[84] HidroAysén, Environmental Impact Assessment, Chapter Four p. 241
[85] Ibid, p.242
[86] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 14 #39
[87] HidroAysén, Environmental Impact Assessment, Chapter Four p. 228
[88] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 12 #30

Significance of change in water level due to operating practices

The EIA acknowledges the operating practices as potential sources of intra-daily oscillation, but because the operating practices never cause the river downstream of the dams to exceed or fall below maximum or minimum observed natural flow rates, it dismisses the variations as trivial because the statistical daily and monthly average flows do not change. While wave-flooding may not result in statistically significant variations, the increased frequency of oscillation of river flow rate and large intra-daily fluctuations may affect both shoreline erosion and the health of both aquatic and terrestrial ecosystems due to rapid variations in water level and velocity.

Impact of Weather and Climate Change on Hydrology

Various aspects of hydropower projects are controlled by flow variability in the river system. For example, monthly average flow variability must be considered to design the operational characteristics of the generating equipment. Similarly, spillway capacities are generally sized to carry a flood with a defined recurrence interval (1000 year return period in the current projects). Ability to compute these various statistics depends on having an adequate database from which to estimate the various flow metrics. While it is possible to argue about the particular statistical procedures to estimate specific variables, the circumstances surrounding these projects suggest a number of more important concerns. One problem is that flow data for the Baker and Pascua Rivers only extend back to about 1960, providing roughly 45 years of flow data with which to perform the statistical analysis. While there is an obvious problem with using such a short time record to estimate a 1000 year flood, for example, there are more serious concerns about the particular circumstances. Regardless of the statistical methods used to perform an analysis, a fundamental assumption is required that the flow time series is *stationary*. A stationary data set implies that if one had a very long time record, any subset of the flow data would yield essentially the same statistical results with no long term trends in the record. There are reasons to believe that a number of factors may be contributing to trends in flow data for the Pascua and Baker that violate the assumption of a stationary data set. Lack of validity of this assumption renders conclusions drawn from the data analysis questionable at best. The lack of stationary hydrologic data has been indicated to be a significant issue worldwide[89]. While the issue is addressed to a minor extent in the EIA, some of the key factors were not addressed. The following sections identify major issues that should be addressed to inspire confidence in the statistical analyses.

Flow Variability

The EIA attributes a decrease in annual standard deviation of flow rates to the presence of lakes in the region[90]. These lakes are not newly occurring, and have had a constant presence since the collection of data began. Thus, any change in statistical flow must be due to other effects, which have not been adequately explored.

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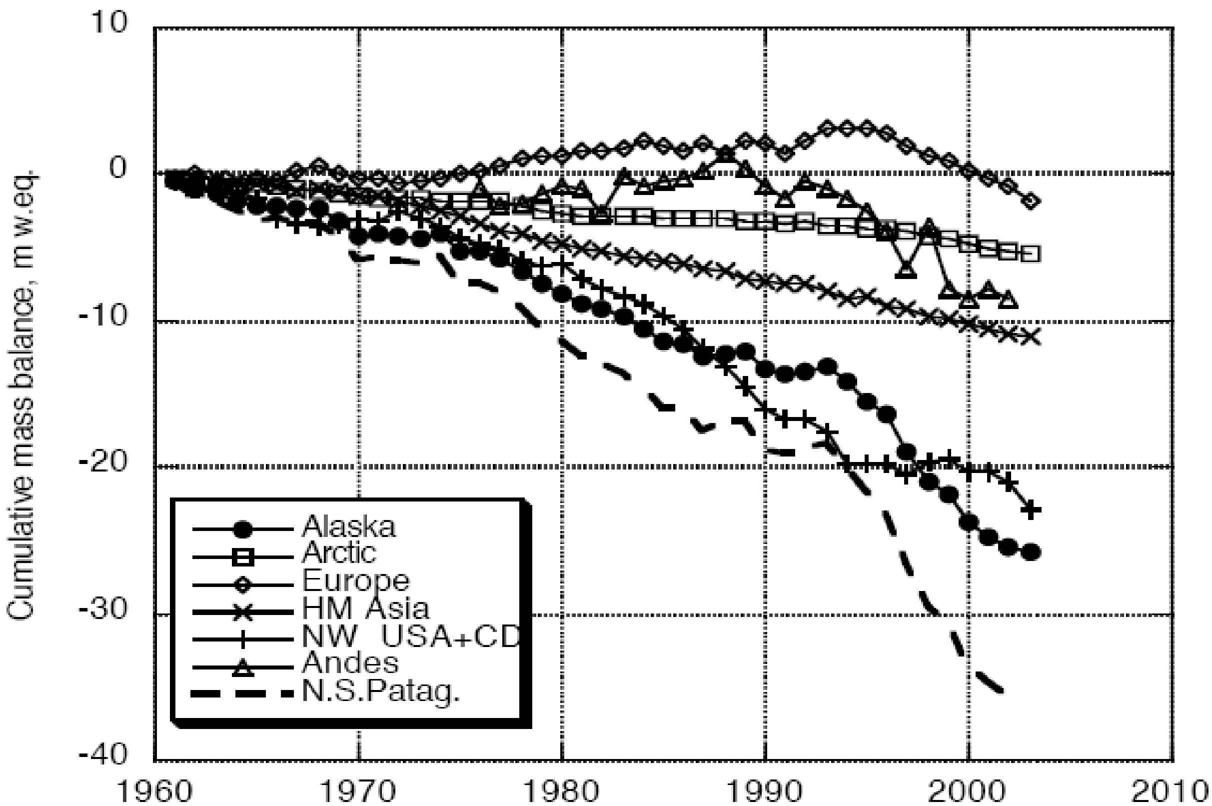
[89] "Stationarity is Dead: Whither Water Management," P.C.D. Milly, et al, Science, vol. 319, 5863, 573-574

[90] HidroAysén, Environmental Impact Assessment, Chapter Four p. 269

Increase in Ice Melt
The direct source of water for the two rivers is lakes. Lake General Carrera through Lake Bertrand for the Baker River, while the Pascua is mainly fed by Lake O'Higgins. A major inflow source to these lakes, and thus the secondary source of the rivers is glacial melt. Many of the major tributaries such as the Nef and Colonia Rivers in the Baker system are also fed by glacial melt. Since glacial melt is a major contributor to the flow of the rivers, a change in glacial melt rate is of relevance when it comes to analysis of the projects. The EIA does not address the effect of climate change on the change in rate of glacial melt, and thus potential changes in river flow rate, both in terms of the existing data records and with respect to future flow conditions. The ice mass in the Patagonia Region has been decreasing over the last few decades according to Figure 7[91].

Figure 7: Ice Mass Balance over Large Geographical Regions of the Earth,



This figure indicates a decrease in ice mass for the combined Northern and Southern Patagonia Glacial fields. In addition to the decrease of over 35% cumulative ice mass, the figure also

[91] "Glaciers and the Changing Earth System: A 2004 Snapshot." Mark B. Dyurgerov and Mark F. Meier, INSTAAR, University of Colorado at Boulder.

suggests that the rate of ice melt is increasing with time, and thus more water is flowing into the river system than would have been the case in an equilibrium climatic state and that this effect is variable over time. These trends imply that the measurements that were collected for the rivers were during a time of non-stationary hydrology, and thus may not be a good representation of the rivers' behavior in the future.

El Niño in Statistical Analysis

The EIA attributes some anomalous flow patterns to the presence of El Niño: "Importantly, the Pascua River in the record shows a period between 1978-79 and 1985-85 which show the largest deviations between the annual values, which could be explained in light of increased amount of liquid and solid precipitation. This could be influenced by the presence of El Niño, August 76 through March 77, July 77 through January 78, October 79 through April 80 and April 82 through July 83."[92] There is no further consideration into the possible cause as El Niño is not mentioned again in Chapter 4, nor is its impact accounted for in any other statistical analysis.

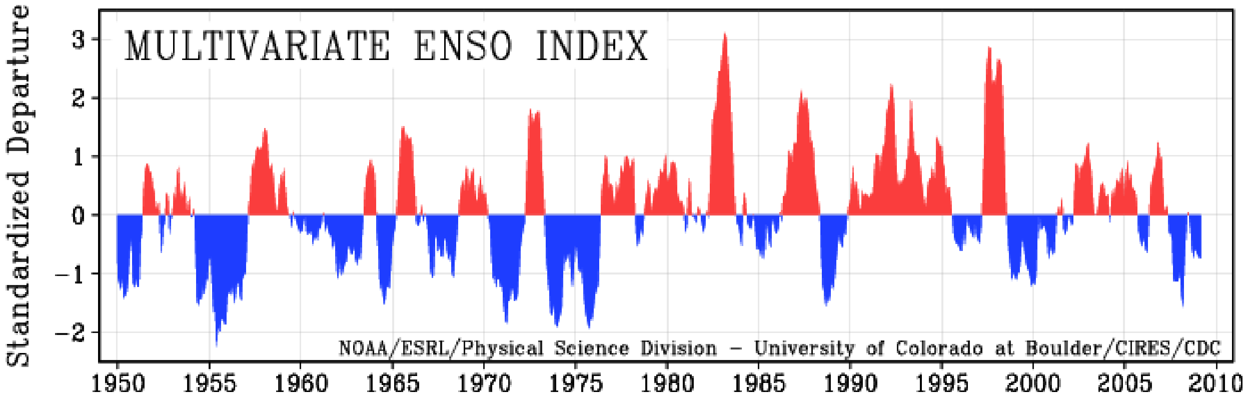
If, as suggested, El Niño has caused notable shift in flow rate patterns, the question is raised whether data from this period provides a suitable foundation for a baseline study. The number of El Niño events was unusually high during the period over which the data was gathered[93]. Figure 8a indicates variations in the Multivariate El Niño /Southern Oscillation Index (ENSO Index is a measure of the strength of El Niño/La Niña events with large positive values indicating strong El Niño activity) over roughly the period of flow record, suggesting that the period from the late 1970s to about 1995 was a period of anomalous El Niño activity. A longer term plot of the Southern Oscillation Index is included in Figure 8b and also indicates a strong anomaly over the same general time period (negative values of the Southern Oscillation Index indicate El Niño activity). Since El Niño is characterized by a flux of warm air and water to the Patagonia region, the effects of El Niño could provide insight into potential climatic effects. No such connection is made or even alluded to in this section of the EIA. Again, the issue of non-stationary hydrological data related to the prevalence of El Niño conditions within the short time series poses potential limitations to interpreting the results of statistical analyses

[92] HidroAysén, Environmental Impact Assessment, Chapter Four p. 316-317

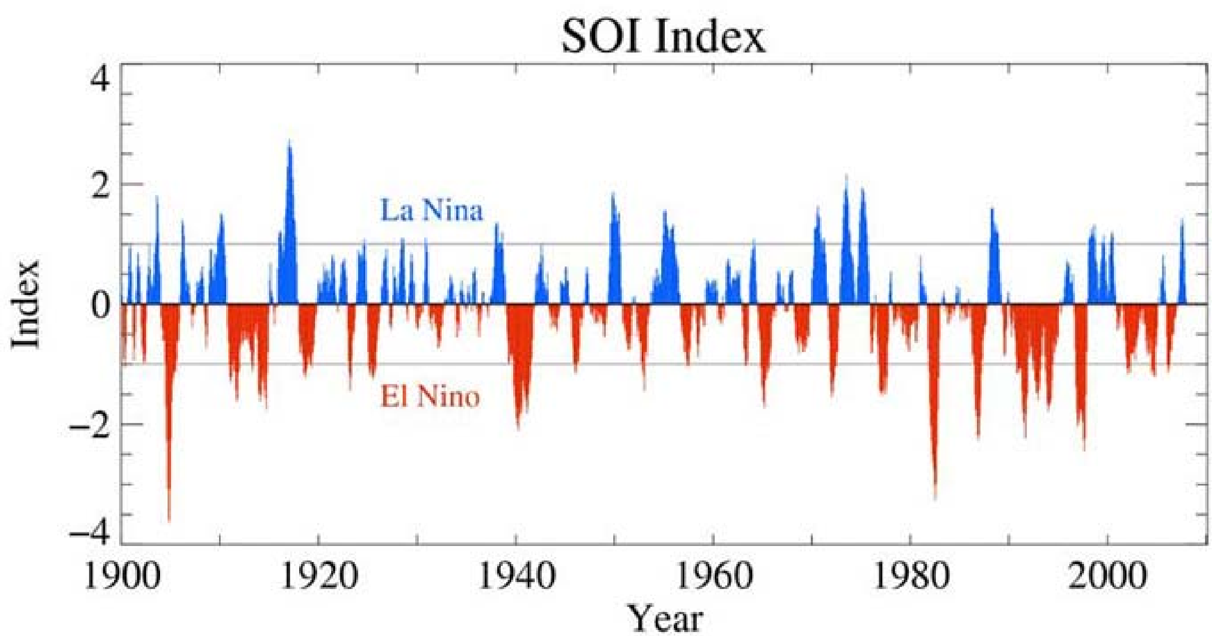
[93] [NOAA/ESRL/Physical Science Division – University of Colorado at Boulder/CIRES/CDC].

Figure 8.

a.) **Multivariate El Nino/Southern Oscillation Index from 1950 to present (Source:** http://www.cdc.noaa.gov/people/klaus.wolter/MEI/)**.**



b.) **Southern Oscillation Index from 1900 to present (Source:** http://www.niwa.co.nz/our-science/climate/information-and-resources/clivar/elnino).



Glacial Lake Outburst Flood Concerns

The EIA does not consider the effect of glacial lake outburst floods on the PHA project[94,95,96]. A glacial lake outburst flood (GLOF) is a phenomenon where a lake dammed by ice walls suddenly drains through the wall of ice. Since April 2008, there have been four GLOF events (through March, 2009) originating from Lake Cachet 2 into the Colonia River, a tributary that enters the Baker River between the proposed Baker 1 and 2 dams. Prior to April 2008, the most recent GLOF event was in 1963, over fifty years earlier.

The GLOFs from Lake Cachet 2 have significantly increased the flow of the Baker River at least up to six times the flow at the time of the event, such as during the December 21-22, 2008 GLOF where the flow rapidly increased from 573 m^3/s to 3008 m^3/s[97]. Other studies have estimated the flow from the recent events to have peak flows from 3500-4500 m^3/s. These flows can be compared to the typical monthly averaged flows in the Baker River, which remain under 1000 m^3/s most of the year, as indicated in Figure 5.

There is also potential for a flood to occur simultaneously with a GLOF event. During mid-February 2009, Patagonia experienced significant precipitation that was 58% above average[98]. This caused an increase in the flow of the Baker River from 1100 to 2763 m^3/s, a net increase of 1663 m^3/s. A flood combined with a GLOF from Lake Cachet 2 could feasibly increase the river flow to over 6100 m^3/s.

Although the EIA has not included any consideration for GLOF events, the design of Baker 2 dam has a maximum capacity rating of 7355 m^3/s, with 1275 m^3/s flowing through the turbines and 6080 m^3/s flowing over the spillway, as seen in Table 2 below. This design is sufficient to handle the GLOF and flood events that have occurred in recent times. However, there is also geological evidence suggesting paleo-floods related to GLOFs from Arco Lake in the Colonia valley with flows ranging from 7,500 – 16,000 m^3/s during the 1950s[99] at the Baker 2 section of the river. The conditions in Table 2 should only be considered to be relevant to the conditions in Lake Cachet 2 and do not reflect the possibility of GLOF events from other lakes that drain into the Baker River. Note that the estimates of discharge from Arco Lake exceed the capacity of Baker 2 to pass water in a controlled fashion, but the higher end of these estimated flows substantially exceed the probable maximum flood for the project (Table 1), again raising doubts regarding the basis for the hydrological analyses.

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[94] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 13 #37
[95] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 23 #85
[96] HidroAysén, Environmental Impact Assessment, Chapter Four p. 237 &317
[97] Jonathon Leidich, GLOF 8.10.2008 Glaciar Colonia, Lago Cachet dos, Inundación del Rio Colonia, Rio Baker, Valle Grande, Comunidad Cochrane, Provincia Capitán Prat. Also see http://glaciologia.cl/colonia.html/
[98] Jonathon Ledich. Las Crecidas del Rio Baker, Provincia Capitán Prat, XI Región de Aysén Chile, February 24, 2009, http://www.ecosistemas.cl/1776/articles-85339_recurso_1.pdf
[99] Tanaka, K. (1961): Geographical Contribution to a Periglacial Study of the Hielo Patagónico Norte with Special Reference to the Glacial Outburst Originated from Glacier-Dammed Lago Arco, Chilean Patagonia. Faculty of Economics, Kobe University. Japan. p. 109

Table 2- Flows for PHA Baker 2 and Recent GLOF Events.

	Baker 2
Design discharge (m^3/s)	1275
Spillway discharge (m^3/s)	6080
Total Dam discharge (m^3/s)	7355
River flow with GLOF	4500

The sudden increase in frequency of GLOFs from Lake Cachet Dos also strongly suggests a link to climate change in the Patagonia region, which is another topic the EIA has failed to explore.

Comparison to WCD Case Studies

As demonstrated by hydropower projects examined in the World Commission on Dams report, project operations do not always meet expectations if hydrological influences are not properly considered. For instance, along the Mun River upstream from the confluence with the Mekong River in Thailand, the Pak Mun Dam was constructed as an alternative to a new natural gas generation facility. However, it does not accomplish its intended design to operate as a peaking plant.

Power production at the Pak Mun dam peaks during the wet season when it is least needed in the power system and is lowest in the dry season when it is most needed. During wet months Pak Mun cannot pass the total daily inflow through the turbines during the 4-hour peak demand period and must generate power during off-peak hours as well. Also, when the Mekong River's water level is high it increases the tail water elevation at the dam, reducing the station head and causing the generators to be shut down.

Pak Mun dam was designed as a 136 MW, run-of-the-river project, to serve peaking needs, but can only use 15% of its capacity as reliable 4-hour peak capacity. The actual dependable capacity, calculated from daily power output from 1995-98, assuming all available power is assigned to a 4-hour peak demand period, is 20.8 MW[100]. Thus the Pak Mun dam can be considered to offset only that amount of gas turbine production. However, the value of alternative generating capacity adopted for comparative purposes by the Electricity Generating Authority of Thailand (EGAT) and sanctioned by the World Bank was much higher at 150 MW. The actual operation of Pak Mun is often very different from what was assumed in the planning studies. This type of operation may be beneficial from an ancillary services point of view (such as frequency and voltage regulation, Var control etc.), but the energy benefits are much less

[100] Amornsakchai, Sakchai, Philippe Annez, Wanpen Wirojanagud, Ek Watana, Suphat Vongvisessomjai, Sansanee Choowaew, Prasit Kunurat, Jaruwan Nippanon, Roel Schouten, Pradit Sripapatrprasite, Chayan Vaddhanaphuti, and Chavalit Vidthayanon. *Pak Mun Dam, Mekong River Basin, Thailand*. Cape Town: World Commission on Dams, 2000, p. 26

than planned[101]. Thus, inadequate consideration of the system's hydrology allowed a dam to be constructed that did not meet the specified objectives.

The Kariba Dam in Zimbabwe also performed differently than expected. The construction time was much longer than expected and the installed turbines were different than originally designed. The change in plan led to an increase in maximum capacity of the project from 1200 MW to 1320 MW and a 10% higher design flow. However, the actual average output from the project was about 6400 GWh per year when 6,720 GWh/year was anticipated. This discrepancy indicates that the dam is often operated at lower heads than expected, and thus also with lower efficiency[102].

Conclusions

The EIA is characterized by a lack of depth in its analysis of several hydrologic considerations. This section of the report has attempted to corroborate, where possible, claims that have been made. While some claims are reasonable, particularly regarding the capacity factor and the seasonality of the flow as complementary to other hydroelectric sources of power, there is a lack of supporting evidence in the EIA itself.

The EIA fails to adequately address concerns about the long-term flow patterns of the rivers. The scope of the data is limited, particularly for the Pascua, and the methods of data gathering and extrapolation are questionable. The EIA fails to justify the use of the data as a statistical baseline for projecting future behavior of the rivers. In particular, the presumption of a stationary hydrologic data record appears to be questionable for a number of reasons as discussed above. Anomalous events have been inadequately explored, and explanations have been given without the depth necessitated by this type of document.

Finally, the physical characterization of the river system is insufficient to inform other parts of the EIA, which address topics such as sedimentation in the reservoirs behind the dams and impacts on aquatic ecosystems. The lack of consideration of some of the basic issues described in this system does not lend confidence to the results presented.

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[101] Ibid, p. 87

[102] *Kariba Dam Case Study*. Cape Town: Soils Incorporated (Pty) Ltd and Chalo Environmental and Sustainable Development Consultants, 2000. p. 40

Sedimentation

Introduction

As a part of the project review process, HidroAysén is required by law to submit an Environmental Impact Assessment (EIA) before proceeding with construction.[103] But in addition to being a legally required document, the EIA is a valuable resource for considering the wider scope of the project. A well-performed Environmental Impact Assessment should conform to three major criteria, as given in the Asian Development Bank's book *Environmental Impact Assessment for Developing Countries in Asia*.[104] First, it should be complete and conform to terms of review for the appropriate government agency or agencies. Second, it should present accurate and truthful scientific data as well as use acceptable methods of data assessment. Third, it should provide a clear description of environmental impacts, recommended mitigation strategies, and monitoring and management plans. The EIA is reviewed and analyzed in this section as to its ability to meet these criteria with respect to sedimentation issues.

Information Provided By the EIA

Baseline Information
The EIA does not have a separate section that deals with sedimentation issues. Sediment transport related issues are discussed within the water quality sections while the sections that present information on geomorphology tend to concentrate on qualitative descriptions of surface soils and land processes as opposed to riverine processes. For example, there is a description of the geomorphology of the area that will be impacted by road improvements[105] and the transmission lines[106], while the more commonly accepted concept of geomorphology is restricted to processes in river corridors. This section will concentrate on sedimentation aspects of the EIA analysis.

The University of Chile was contracted to perform the baseline study related to water quality. Basic water quality data was collected at a total of 58 sample stations established along the Baker and Pascua River systems, 50 in the Baker River Basin and 18 in the Pascua Basin.[107] On the Baker, 28 are classified as main stem stations, 19 are located on a tributary, 2 were in wetlands and one was located in the Mitchell Fjord.[108] In the Pascua, 12 stations were located

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[103] HidroAysén, Environmental Impact Assessment, Presentacion Initial p. 3
[104] Lohani, B. et al, *Environmental Impact Assessment for Developing Countries in Asia*, Vol. 1 (Asian Development Bank, 1997) Ch 12
[105] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 160
[106] Ibid. p. 158
[107] Ibid. p. 327
[108] Ibid. p. 328

on the main river, 4 were located on tributaries and 2 were in the estuary at the mouth of the river.[109] Maps of station locations are presented in the document.[110] A total of five sampling campaigns were conducted between August, 2006 and November, 2007 with the intention to acquire data for at least one sample campaign during each season.[111] Water quality samples were collected at each station and these were quantified for total suspended solids from which the suspended sediment transport rate was estimated by multiplying by the river discharge. A related sediment transport quantity was the bed load discharge; it was determined from a separate measurement with a bed load sampler and the measured river width. Results in the analysis are presented for suspended sediment discharge and bed load discharge; these are variously reported in m^3/day or tonnes/day.

In addition to the baseline study measurements, additional measurements at a gauging station on each river have been preformed intermittently over the years. These include a total suspended solids sample, that combined with the measured river discharge, was used to compute suspended sediment transport rates; many more measurements and over a wider range of flow rates are available compared to the five sample campaigns, but the measurement locations are more limited. These results are presented in the appendices to the EIA.[112] [113] Bed load measurements were not obtained during these sample events.

Projected Project Impacts

The Environmental Impact Assessment identifies a number of specific impacts that relate to issues associated with sedimentation. These are included under the categories of Water Quality, Hydrology, Aquatic Flora and Fauna and Marine Flora and Fauna. If one includes land surface erosion as a contribution to sediment in rivers, additional categories would be included in the list. The following discussion concentrates on the issues described in the four listed categories. Specific identified impacts include (along with the phase of project implementation and their determined level of significance):

Water Quality

- Water quality changes related to the increase of the sedimentation in the dam area, operation phase, moderately significant impact;
- Deterioration of water quality due to the mining of aggregate deposits, construction phase, low significance impact

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[109] Ibid. p. 331
[110] Ibid. p. 500
[111] Ibid. p. 327
[112] HidroAysén, Environmental Impact Assessment, Anexo B, Apendice 2, p. 40
[113] Ibid. p. 147

Hydrology

- Modification of the sediment transport pattern downstream from the dam structure, operation phase, moderately significant impact
- Increase in the sedimentation in the reservoir area, operation phase, low significance

Freshwater Flora and Fauna

- Alteration of the biotic communities due to the increase of solids in suspension, construction phase, not significant impact
- Alterations of biotic communities due to changes in the amount of nutrients and sediments downstream from the dams. operation phase, low significance impact

Marine Flora and Fauna

- Changes in the amount of nutrients and sediments to the estuaries, operation phase, not significant impact

These impacts can be classified into two categories: temporary impacts associated with the construction phase resulting in increased sediment inputs creating impacts downstream of the dams and impacts associated with the interruption of sediment due to the dams and reservoirs. Due to the assessment of impact level, only the latter influence is considered to rank as high as a moderate impact suggesting that sedimentation issues are considered to be relatively unimportant in the EIA. This assessment is consistent with the HidroAysén presentation to the University of Michigan contingent. On Friday, February 27th, 2008, at the Centro de Investigación en Ecosistemas de la Patagonia, located in Coyhaique, HidroAysén engineer Daniel Roth Metcalfe stated, “Specific solutions [to the issue of sedimentation] can be determined as you get more data and based on what the problem is.” This statement is consistent with the relatively low significance associated with sedimentation impacts in the EIA. The following discussion raises some concerns not addressed in the EIA suggesting that the significance of several of these impacts should be elevated.

Proposed Mitigation and Monitoring Actions

One proposed mitigation action, but comprised of several different actions, was listed in the EIA to deal with sedimentation impacts. This action is described as “management of areas of deposition and erosion, to maintain the bed level and the resource quality downstream of the projects.[114] There are also components of the mitigation plans under this category that relate more specifically to water quality such as partial removal of vegetation below the minimum reservoir elevation which has the objective to prevent oxygen depletion due to vegetation decay.[115]

[114] HidroAysén, Environmental Impact Assessment, Chapter Six, p. 52
[115] Ibid. p. 53

The mitigation actions that relate specifically to sedimentation issues are re-vegetating disturbed sections downstream from the dams, maintaining vegetation in the arid upland areas to prevent soil erosion, and to encourage the growth of reeds in the shallow areas of the Baker River reservoirs to filter out suspended sediments.[116] Monitoring plans include the following elements:[117]

- Monitor shoreline erosion in the reservoirs
- Measure bed levels in the reservoirs to estimate rates of sediment deposition and take samples of the deposits to characterize the sediment quality (organic content, etc.)
- As part of the required water quality sampling, measured suspended sediments to ensure that the concentrations remain within admissible ranges
- Keep track of features such as sand bars and islands in the reaches downstream of the dams as indicators of sediment processes.

Comments on the EIA

Other organizations within Chile have expressed concern about the results of the analysis provided in the EIA. One organization is the Center for Environmental Sciences, EULA at the University of Concepción. EULA responded to the HidroAysén EIA with more than two hundred pages worth of notes and comments on selected portions of the EIA. Some of the concerns that relate to sedimentation include:

- The lack of information regarding sediment sampling.[118]
- The short duration of onsite investigation work for the EIA, which does not seem to match the scope of the project.[119]
- The characterization of the geomorphologic section as "merely descriptive" and possesses "conceptual errors".[120]
- Insufficient cross sectional data for the sediment transport model.[121]
- The choice to dynamically model only the main stems of the river and impose the tributaries as point sources at the boundaries. This approach prevents understanding the effect of tributaries on the sediment transport capacities of the main channel sections.[122]
- Misapplication of the Ackers & White equation to a gravel bed river.[123]

[116] Ibid. p. 54
[117] Ibid. p. 55
[118] Ibid, p. 9
[119] Ibid,p. 9
[120] Ibid,p. 10
[121] Ibid,p. 33
[122] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 34
[123] Ibid,p. 35

- Averaging the outputs of the three sediment transport equations applied (Meyer-Peter and Mueller, Ackers & White and Wilcock & Crowe) does not necessarily give a more correct result, especially when Ackers & White is intended for sand bed rivers.[124]
- The failure to identify an area of indirect influence with respect to hydrology, when it is known that the disruption of flow regimes, sediment transport and other ecologically significant processes can extend for many kilometers downstream of the actual dam structure itself.[125]
- Lack of background information provided about the measurements conducted (including time, date and location, instruments used and sampling frequency) as well as the raw data and all but the barest description of the analyses performed.[126]

La Comisión Nacional del Medio Ambiente (CONAMA) is Chile's environmental regulatory agency, which ultimately will decide whether or not the proposed Baker and Pascua river projects will be implemented. One of CONAMA's functions in the EIA process is to summarize the comments made by the various participants (including the EULA comments listed above which were submitted through the DGA, *Dirección General de Aguas*) in the review process and provide a list of issues that the applicant is required to provide responses to. The agency has published over 400 pages of comments, questions, and clarification requests, all of which HidroAysén must respond to before the projects can move forward. Some of the most significant issues raised in the CONAMA document with regard to sedimentation include:

- Failure to adequately include an analysis of the potential to create landslides as a result of construction and operation of the dams.[127]
- The EIA states that the dams will not cause a significant impact on the amount or type of terrigenous sediment entering estuarine ecosystems and states that if this were to become an issue, HidroAysén will provide means of compensation. HidroAysén is requested to describe said compensation and to give background information as to why this was not rated as a "significant impact."[128]
- Failure to address the potential impact of GLOFs on the projects.[129]
- Failure to analyze a large enough catchment area with regard to sediment being transported through the fluvial systems. [130]
- Failure to recognize the diversity in size of sediment being added to the main channels by various tributaries, the different timing of flooding events in various tributaries and

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[124] Ibid,p. 36
[125] Centro de Ciencias Ambientales (EULA), "Informe de Análisis Tecnico de Línea Base Proyecto HidroAysén," p. 43
[126] Ibid, p. 45
[127] Comisión Nacional del Medio Ambiente (CONAMA), "Informe Consolidado Nº 1 de Solicitud de Aclaraciones, Rectificaciones y/o Ampliaciones a el Estudio de Impacto Ambiental del Proyecto: Proyecto Hidroeléctrico Aysén," p. 22 #105
[128] Ibid p. 128, #168
[129] Ibid p. 21, #102
[130] Ibid p. 161, #293

the corresponding amounts of sediment being transported at flood stage, and again, asks HidroAysén to extend the area of influence. [131]

- The EIA does not include glacial ice fields, the ultimate source of the water that will power the five proposed projects, in the area of influence of the project, indicating that there is no future potential change with regard to glacial inflows to the Baker and Pascua Rivers. With no previous study of this issue, HidroAysén is requested to conduct a study and include glacial ice fields in the area of influence for the projects.[132]
- Requests HidroAysén to complete a sampling of suspended sediment in the Baker River and in various tributaries of the Pascua River.[133]

Additionally, CONAMA, on several occasions, asks HidroAysén to clarify the reasoning behind rating some potential impacts as "not significant," when previous knowledge may indicate otherwise. For example, a translation of comment 171 follows:

"171. Regarding the impact on the hydrology, the EIA indicates that during the construction phase, an alteration of a stretch of the main channel is expected, which does not have a total value of impact as significant. During the operation, the PHA will change the flow regime, cause a change in the sediment transport regime downstream of the dams, increase sedimentation in the reservoir area, introduce landslides on the banks derived from the operation of the plants and changes in intra-daily oscillations in the flow due to the wave-flooding during plant operation . . . the only thing considered as a significant impact is changes in runoff regime. In this regard, the developer will expand by providing background information and objectives to validate its conclusion because it is not reasonable that there are no significant impacts. Moreover, the holder shall raise mitigation, reparation and compensation commensurate with the impacts it generates, i.e., a plan cannot be considered compensation, since, as stated in Article 60 of the DS 95/01 MINSEGPRES, compensation measures are intended to produce or generate a positive alternative and equivalent to a significant adverse effect."[134]

These questions regarding the EIA's method of determining the value of an impact are important for policymakers and the general public to understand, as impacts receiving a rating of “significant” are given more analysis and mitigation plans are required. For example, the EIA gives the impact ratings for changes in the composition and quantity of nutrients entering the Baker and Pascua river estuaries. In this table, each of the PHA receives a total impact score of "not significant."[135] Additionally, the EIA rates the extent for each of the PHA, as 0, where 0 is defined as local, or when the impact can be seen in the area where it is located, the source and

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[131] Comisión Nacional del Medio Ambiente (CONAMA), “Informe Consolidado Nº 1 de Solicitud de Aclaraciones, Rectificaciones y/o Ampliaciones a el Estudio de Impacto Ambiental del Proyecto: Proyecto Hidroeléctrico Aysén,” p. 162 #299
[132] Ibid, p. 163, #302
[133] Ibid, p. 165, #309
[134] Ibid, p. 129, # 171
[135] HidroAysén, Environmental Impact Assessment, Chapter Five p. 889

its immediate environment, and when the source is point or small.[136] However, as Vargas points out, rivers are one of the most important sources of nutrients for marine environments.[137] The EIA claims that alteration of nutrient input will only affect the immediate area surrounding the mouth of the rivers and that local marine biota will adapt over time to the changes, yet fails to address the effects on the greater marine ecosystem.[138] This issue is important because Chile's extensive salmon farming industry depends on the health of these fjord and inland sea ecosystems.[139] In this way, changes in the nutrient input to the Patagonian seas have the potential to not only affect aquatic ecosystems, but also a thriving sector of the Patagonian economy.

Critique of the EIA

A few definitions and words of clarification are needed in order to preface this discussion. Sediment transport is usually sub-divided into two components, bed load and suspended load. Bed load is considered to be transported by sliding or bouncing along the river bottom while suspended load is carried much higher in the water column with only occasional bottom contact; while the distinction between the two components seems relatively clear, there is a gradual transition between the two components when there is a gradation of sediment size with the smaller material being carried in suspension and coarser material transported as bed load. Different measurement techniques are required to sample the two components and measured data are differentiated according to the bed load and suspended load definitions which are ultimately defined by the measurement technique. Sediment transport models may be intended to predict one or the other of these two components or may be considered to be total load models which lump the two components together into a predicted total transport rate. The relative contributions of each of the two components can be assessed by the ratio of the sediment settling velocity, w_s, to the shear velocity, u_*, of the flow. When the value of the ratio is less than about 0.4, suspended sediment load is considered to be the dominant mode of sediment transport while for values greater than about 2, bed load is considered to be dominant (in between, both components are important).[140] In order to apply a sediment transport model, information is required regarding the flow characteristics (depth, velocity, etc.) For the field sampling events, the measured flow characteristics were generally employed, while the results of a flow model, HEC-RAS, were used to provide model predictions for more general forecasts. In a reservoir behind a dam, for example, reduced flow velocity in water encountering the impoundment will result in a decreased capability for that water to transport sediment, creating deposition in the reservoir. After the water passes through the impoundment, its velocity increases, resulting in an increased sediment transport capacity compared to water in the reservoir. This increase in flow velocity causes erosion in the

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[136] Ibid. p. 10
[137] Vargas, Christian A., "Sustainability of Fjord Ecosystems in Chilean Patagonia: An Ecological/Biogeochemical Perspective," Universidad de Concepción
[138] HidroAysén, Environmental Impact Assessment, Chapter Five p. 890-892
[139] Vargas, Christian A., "The Aquatic Environment in Patagonia Ecosystems," Universidad de Concepción
[140] Raudkivi, A. J. (1998). *Loose Boundary Hydraulics*, A. A. Balkema, Rotterdam

downstream riverbed as the water re-establishes its original sediment transport capacity, which was diminished as the flow entered the reservoir.

Regardless of the specific model implemented, the premise for the formulation is that the flow is spatially uniform (constant velocity, depth and sediment transport rate) and that the sediment transport is in equilibrium with the bed itself, i.e. there could be exchange with the bed material so that the sediment being transported can be deposited onto the bed with an equal amount of equivalent material being picked up from the bed. Although flow is rarely spatially uniform, deviations from that condition are often sufficiently minor so that this assumption is not critical in analyses; the assumption of equilibrium between the bed and transported sediment is more questionable in the Baker and Pascua River systems.

Sediment transport is addressed in the EIA by two approaches; field measurements and mathematical modeling. Multiple field samplings provide estimated sediment transport rates at select locations and conditions on the two rivers while models are employed to develop estimates over a wider range of flow conditions. Four different specific sediment transport models have been utilized in the presentation of predictive results in the EIA. These models are the Meyer, Peter and Mueller model, the Ackers and White model, the Parker model and the Wilcock and Crowe model. The Parker model is not employed in all applications, and the models provide predictions that only generally match each other. All of these models were originally developed utilizing a calibration process by comparisons to a limited set of (usually) laboratory data that are not the same among the various model formulations. Separate data and model predictions appear in two references, the EIA itself and the 2007 University of Chile study (provided in the combined report Proyecto Hidroelectrico Aysén, Informes de Caracterizacion de Componentes Ambientales, Sectores Rio Baker y Pascua, December, 2007) that was performed under contract with HidroAysén. Interestingly, predictions in the two sources vary considerably, apparently due to differences in application methodology. Since the data are presented in more detail in the University of Chile study, much of the following discussion relies on the presentation in that document.

There were a total of 16 sediment sampling stations located along the length of the Baker River[141] (Figure 4.3.5-40). For purposes of the following analysis, we will use the data from the station B-6 which is located about halfway between the confluence with the Nef River and the Baker 1 site as generally representative of the other sample stations. It is located a fair distance from any major tributary contributing sediment input and therefore is more likely to represent a local equilibrium condition compared to a station just downstream from a major tributary. The University of Chile study includes data for a number of key parameters at the B-6 from three sampling events, conducted in August, 2006, November, 2006 and January, 2007 (Table 3) .

[141] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 276

Table 3. Key flow and sediment transport parameters for Station B-6 from University of Chile Study (Anexo 5, Tablas de Resultados, Estudio de Transporte y Composición de Sedimento, various tables)

Sampling Date	August, 2006	November, 2006	January, 2007
Discharge (m^3/s)	500	489	758
Shear Velocity (cm/s)	9.23	5.56	9.0
Bed Load Rate (kg/d)	5,273	167	3,409
Suspended Load (kg/d)	309,000	976,000	404,000
Bed Load d_{50} (mm)	2.1	2	1.4
Bed d_{50} (mm)*	470	470	470
Suspended Load % Organic	23	11	20

*Not provided exactly at Station B-6, taken from Table 6.2.1.9 from closest reported site.

The EIA suggests that the suspended load transport is about 100 times greater than the bed load transport rate. Although there is considerable variability in the results from the various samples at Station B-6 and other sites, this seems a reasonable estimate. Considering the median grain size d_{50} of the bed load material at this site is about 2 mm, the fall velocity for sediment in this size range is about 20 cm/s, yielding a ratio for w_s/u_* ranging from about 2.2-4.6 for the various sampling dates. This suggests that bed load should be the dominant mode for sediment transport, according to the criteria by Raudkivi[142], whereas the actual data indicate the opposite trend. A second observation is that the median size of the bed material is about 250 times larger than the median size of the bed load material, suggesting that the sediment transport is not controlled by a local exchange process with the bed. One way to interpret these discrepancies is to consider that sediment input from the tributaries is an important aspect of the sediment transport process, violating the spatially uniform assumption in the development of the various sediment transport models. Additional evidence presented below tends to confirm this conclusion. This condition makes any sediment transport analysis applied to any one of the four transport models questionable. This issue is not addressed in the EIA.

An additional question related to the application of the sediment transport models is the range of their applicability. A number of specific concerns can be identified. For example, the Ackers and White formulation is based on sediment between about 0.04 – 4 mm in diameter with a fair amount of scatter for data in the largest size range.[143] This formula is therefore being applied outside the range for which it was developed. The other three formulations were developed for gravel bed load transport; for example, the Meyer Peter Mueller formula was developed from flume data for gravel between 3.1 and 28.6 mm[144] and therefore is not applicable to applications with a significant suspended load contribution. Therefore, although

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[142] Raudkivi, A. J. (1998). *Loose Boundary Hydraulics*, A. A. Balkema, Rotterdam

[143] Ackers, Peter and William White, "Sediment Transport: New Approach and Analysis," *Journal of the Hydraulics Division, ASCE,* 99 (1973): 2041-2060

[144] V.A. Vanoni. Sedimentation Engineering, ASCE Manual of Practice 54, 1977

the various sediment transport formulae can be applied, there should be no confidence that the predictions have any level of accuracy since many fundamental conditions associated with the model development are not satisfied. In addition to this problem, there are inconsistencies in the application among the two references. For example the University of Chile study provides a table 6.2.1.11 that predicts the bed load transport rates for the four formulae at various flow rates. The predicted sediment transport rates for a discharge of 490 m^3/s are Meyer, Peter and Mueller (73,300 tonnes/day), Ackers and White (0 tonnes/day), Parker (31,700 tonnes/day) and Wilcock and Crowe (38,200 tonnes/day). These numbers compare to a bed load of 5.2 tonnes/day and a total sediment load of 314 tonnes/day (combining the suspended sediment transport rate and the bed load rate) for the August, 2006 sampling event which is at that discharge. The EIA has much lower predicted sediment transport rates for the same flow rates with the same formulae although a similar table to provide a comparison is not presented. This appears to be due to a different method of characterizing the sediment size, but details are insufficient to be able to deduce the exact analysis procedures employed. Certainly the above comparison does not inspire confidence in the ability to predict sediment transport rates. There may also be issues with how the “measured” sediment transport rates were estimated (apparently from local measurements at a single location within the flow cross-section and at a wade-able depth).

The measurement of suspended sediment discharge versus river flow rate is supposed to be a unique relationship, although, data tend to exhibit a reasonable amount of scatter due to measurement errors and variations in some incidental parameters such as water temperature. Figures 9 and 10 are taken from the EIA for gauging stations on the Baker and Pascua Rivers. It can be seen from Figure 9 that at some intermediate flow rates, the sediment transport rate varies over approximately three orders of magnitude for a particular flow rate. This suggests that more factors are important than measurement errors and other incidental factors, again indicating that tributary inputs may be controlling the observed sediment transport as opposed to the main river discharge. Credence is lent to this hypothesis by the fact that the Pascua River, with many small tributary inflows, exhibits much less variation (about 1.5 orders of magnitude) as indicated in Figure 10. Clearly, this level of variability, in particular for the Baker River, makes the extrapolation of predictions, either from highly variable data or mathematical models of limited applicability, highly questionable. Without much more investigation, it is not possible to even suggest all the implications of this uncertainty.

Figure 9. Baker 2 Rating curve of suspended sediment discharge versus river discharge (EIA, Anexo B, Apendice 2, p. 40)

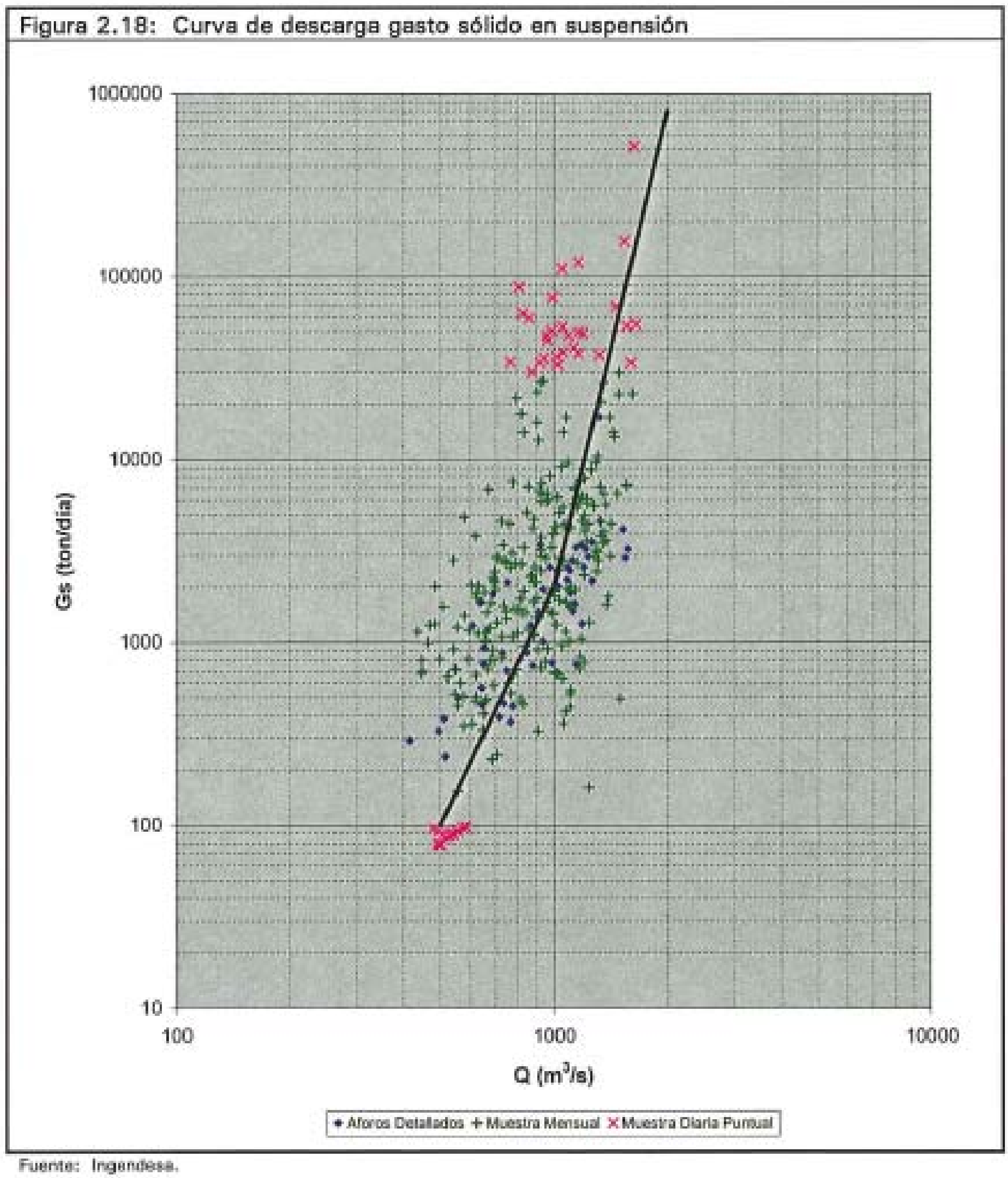
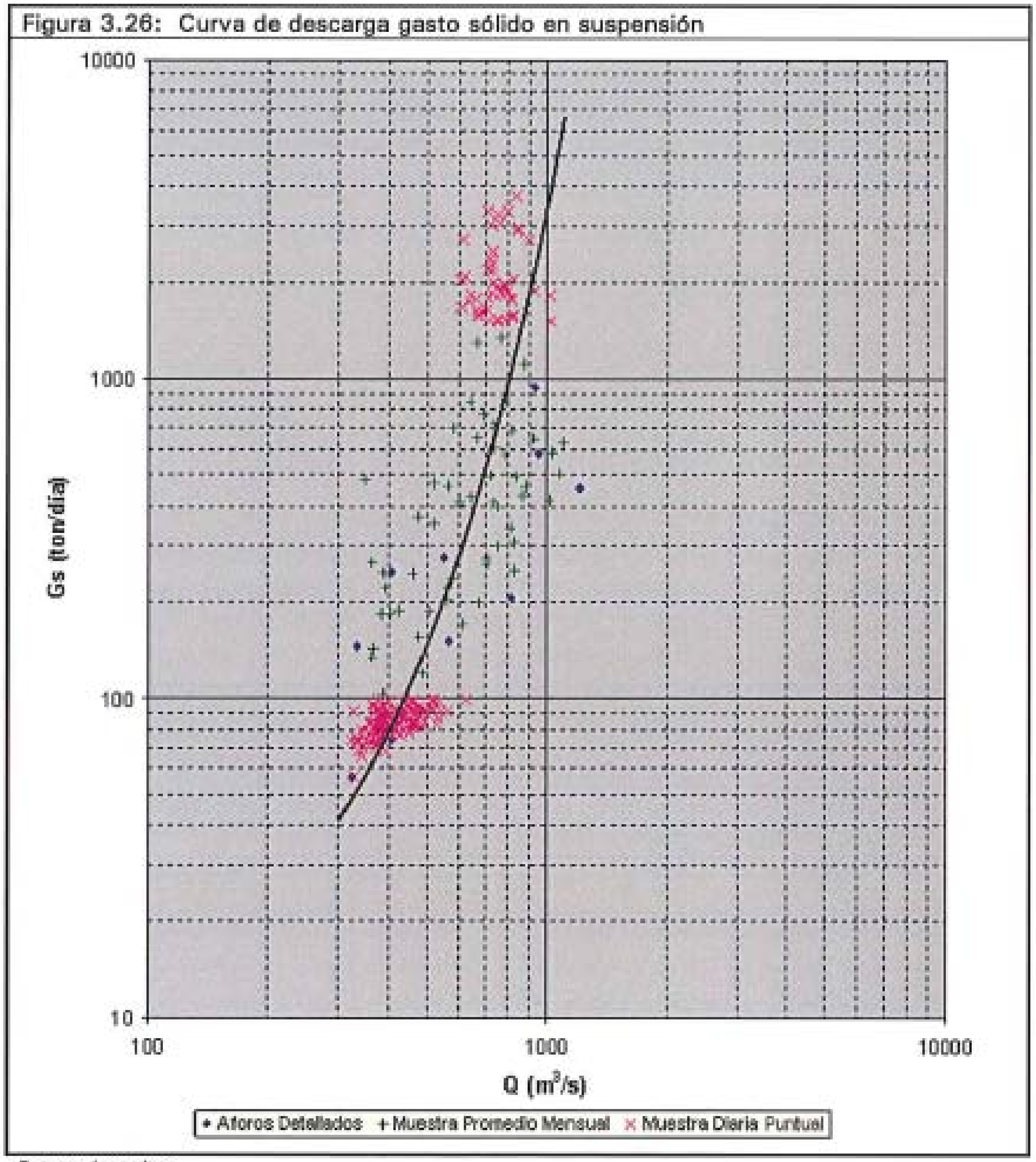


Figure 10. Pascua 2.2 Rating curve of suspended sediment discharge versus river discharge (EIA, Anexo B, Apendice 2, p. 147)



Fuente: Ingendesa.

In addition to the high level of uncertainty, a number of other implications are raised by examination of the data presented in Figures 9 and 10. From Figure 9 and 10, a smooth curve of the form $Qs = A\ Q^b$ could be fitted to the data, and this is a common approach. From the figures, a rough estimate of the exponent b is 3.5-4.0. Note that the Baker River discharge data does not extend above a rate of about 1500 m^3/s. If the discharge was doubled, the sediment discharge rate would increase by about one order of magnitude. By implication, even a short duration glacial lake outburst flood could contribute significantly to sediment transport compared to sediment transport over a longer time period at more typical flows. It is possible, therefore, that these infrequent events could have a significant effect on reservoir sedimentation.

Finally, Table 3 indicates that a significant fraction (about 20 percent) of the suspended sediment load is organic in composition. This suggests that high nutrient loads may be carried in suspension in these river flows. Therefore, suspended sediment inputs into the fjords may be considered to generate a potentially large nutrient input and therefore exert a strong controlling influence on fjord productivity, especially given the fact that the Baker and Pascua Rivers contribute such large water inputs into the fjords. The effect of interrupting the sediment inputs is not considered in the EIA to be a significant impact, which shows a lack of understanding about the possible interactions between fjord productivity and river inputs.

Another potentially significant issue that the EIA disregards is the possible effects of sedimentation on project construction and operation. The report states that accumulations of sediment are "reversible in the medium to long term . . . nevertheless, it is not possible to determine their magnitudes exactly." Where the EIA does discuss areas of possible sediment buildup, such as behind the cofferdams and at the discharges of diversion tunnels, these possible problems are dismissed as "not relevant".[145] This comment and others like it suggest that sedimentation is a problem that will take care of itself, therefore rendering estimates of the rate of reservoir sedimentation a non-issue. Ignoring sedimentation that other dams around the world have faced, including, but not limited to Pakistan's Tarbela dam, as described in the World Commission on Dams case study of this project[146] is poor judgment at best.

Mitigation of sedimentation is not adequately addressed in the EIA, and where it is presented, the issues are mostly discussed with regard to its occurrence during the construction phase of the projects. For instance, in section 6.3.1.6.2 of chapter six of the EIA, which discusses water quality monitoring during the construction phase, HidroAysén outlines an extensive plan for preventing excessive erosion during that period, including: limiting construction to dry periods, maintain access roads for the type of vehicular traffic required by the projects, employ sediment fences and methods of stabilizing slopes, standardized procedures for the handling of fuels, chemicals, and biohazards, and monitor the status of total suspended solid transport.[147] With regard to water quality management during the operation of the dams, as outlined in section 6.3.1.6.3 of the EIA, HidroAysén states it will: remove large quantities of biomass from the reservoirs before filling so as to prevent declining dissolved oxygen levels as the organic matter decays; maintain riparian vegetation in arid regions surrounding the reservoirs to prevent excessive erosion; encourage the spread of reeds both in the reservoirs and

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[145] HidroAysén, Environmental Impact Assessment, Chapter Five p. 175-176
[146] Asianics Agro-Dev. International (Pvt) Ltd., "Tarbela Dam and related aspects of the Indus River Basin, Pakistan, A WCD case study prepared as an input to the World Commission on Dams" http://www.dams.org/kbase/studies/pk/ Accessed on April 5, 2009
[147] HidroAysén, Environmental Impact Assessment, Chapter Six p. 45-55

downstream from the dams to act as sediment traps as well as to take up excess quantities of phosphorous and nitrogen; monitor accumulations of biomass along the edges of reservoirs to prevent declining dissolved oxygen levels due to decomposition; and the company pledges to maintain measurements of suspended total solids because HidroAysén is, interested in learning the rates of sedimentation and composition of the Total Suspended Solids.[148] This last section raises questions, as rates of sedimentation and the composition of total suspended solids should be matters of concern with regard to baseline environmental quality and rates of sediment transport, not a subject of study after completion of the projects. Additionally, while the EIA gives an ambitious plan to monitor water quality and sediment transport after the projects are completed, it does not mention in what way, who will provide the labor, where monetary support will come from, and the scientific basis for their conclusions that the mitigation measures will, in fact, protect water quality for the duration of the projects.

Finally, the EIA does not discuss the idea that settling of sediment in the reservoir will lead to increased erosion rates downstream of the dams. This phenomenon has many names, including "hungry water", based on the idea that a river has an equilibrium amount of sediment that it prefers to carry determined by qualities such as flow, channel shape, available sediment and other factors. Concluding that the high velocity water being released from the impoundments will not cause increased erosion below these dams is an oversight, and this phenomenon should be investigated.

Sustainability and Sedimentation

Project Planning Horizon

The EIA indicates 50 years of use for the proposed projects although many projects have longer operational lives. Given the current limitations of construction methods, technology, and the inability to forecast the future, any hydro-electric project with this life of greater than 50 years can be considered a successful project. However, it is important to note that, on most rivers, there are a limited number of potential dam sites. If a dam site is lost to sedimentation, that site is no longer available for the purposes of dam operation. Therefore, while the water powering a dam's turbines can be regarded as a renewable resource, the location of the dam must be viewed as a finite resource.[149]

If adequate sites for dam development are to be viewed as a finite resource and hydroelectric power is to be viewed as a sustainable source of energy, then it is relevant to evaluate the sustainability of developing a dam with a long project design life such as the HidroAysén projects. Hydroelectric power is unique in that once a dam goes into operation, assuming a constant flow of water, demand for electricity, and excluding maintenance costs, the project

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[148] Ibid, p. 45-55

[149] Fan, Jiahua and Gregory L. Morris, *Reservoir Sedimentation Handbook, (*New York: McGraw-Hill Professional, 1997) p. 2.21

can be expected to generate almost pure profit over its lifetime for the project's developer. Therefore, it can be inferred that it is in the best interest for the developer to operate the project as long as is safely deemed possible, or, as long as the benefit of operating the dam outweighs the cost of operation. In the case of the HidroAysén projects, while each dam is specified to have a life of 50 years, this choice is typically for economic planning purposes only, and it can be expected that the projects can be safely operated beyond 100 years, and that HidroAysén will continue their operation beyond the specified 50 years. While there are many factors contributing to the lifetime of a dam project, one of the most important that can limit operation is sedimentation of the reservoir. Globally, it is estimated that 1% of the global reservoir storage capacity is removed each year due to sedimentation.[150] This implies that several new dams would need to be constructed worldwide each year in order to consider hydropower as a sustainable energy resource. As Morris and Fan (1997) point out, a dam's ability to generate power can be severely compromised after only a small percentage of the reservoir's total volume becomes filled with sediment. According to the EIA, the predicted volume of sediment retained in the Baker 2 reservoir after forty years of operation is on the order of 20, 38, or 115 million m^3 depending on the specific assumptions.[151] These predicted volumes correspond to 5.3%, 10%, and 30.3% of reservoir's total volume respectively (Table 1), which is significant. Therefore, HidroAysén's Environmental Impact Assessment should include a scenario for dealing with sedimentation for the PHA, if not for sustainability reasons, then for ensuring the longevity of the economic return the company can expect from the projects.

Mitigating Reservoir Sedimentation

The EIA does discuss measurements of both bed load and suspended sediment transport in the Pascua and Baker rivers and uses these measurements to predict the amount of sediment being transported by each river at given flow rates.[152] However, the EIA does not discuss methods of mitigating sedimentation should it become a problem in any of the five reservoirs. A brief discussion of the three most commonly employed sediment removal methods, sediment dredging, flushing and routing, follows.

Dredging a reservoir entails physically removing sediment that has been deposited over time by the fluvial system. Sediment can be removed by either hydraulic dredging via machinery operated from a system of barges or by dry excavation, whereby the reservoir is drained and sediment is excavated from the bottom of the reservoir.[153] Because the volume of material that needs to be removed is often large and because it is often difficult to find a waste site in close proximity to the reservoir, dredging of reservoirs can be extremely expensive.[154] For example,

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[150] McCully, P. , *Silenced Rivers: The Ecology and Politics of Large Dams,* Zed Books, London, 1996.
[151] HidroAysén, Environmental Impact Assessment, Chapter Five p. 228
[152] HidroAysén, Environmental Impact Assessment, Annex Six, Tables 6.2.1.3; 6.2.1.4; 6.2.1.10
[153] Fan, Jiahua and Gregory L. Morris, *Reservoir Sedimentation Handbook, (*New York: McGraw-Hill Professional, 1997) p. 16.1
[154] Ibid, p. 16.1

the approximate cost of dredging a reservoir in the United States currently is around $2.50 per cubic meter of sediment. Additionally, this cost increases as a function of pumping distances, digging depths, and distance from the disposal site.[155] With such high costs, dredging is often used as a point source mitigation measure in large reservoirs, most often being employed to clean hydropower intakes, navigational channels, and recreational areas.[156] A reservoir that requires dredging once can be expected to require the service multiple times over the project's lifetime and can continue only as long as adequate sites for disposal exist.

Flushing entails emptying a reservoir by opening a low-level outlet, temporarily restoring river-like flow, scouring a channel through deposited sediments, and discharging those eroded sediments through the outlet to the river below the dam wall.[157] After an initial flushing event, subsequent flushes maintain the original channel scoured from the reservoir floor, only removing sediment from the established channel.[158] Flushing, when carefully planned, can be effective in restoring a reservoir's capacity, being most effective in reservoirs having a capacity to annual inflow volume ratio less than 0.3.[159] Additionally, after a channel has been established via the initial flushing event, secondary channels can be dredged or constructed laterally along a reservoir in order to effectively flush sediment from the entire width of a reservoir.[160] On rivers with multiple dams, such as the proposed projects for the Baker and Pascua Rivers, flushing events need to be carried out concurrently, or sediment flushed from the upstream reservoir will simply become deposited in the downstream reservoir. While flushing can be an effective means for extending the life of a reservoir, similar to dredging, it too must be performed as long as the reservoir is being used. Flushing can have significant effects on aquatic habitats. Increases in suspended solids, turbidity, and decreases in dissolved oxygen levels can result in:

1) The blockage of fish gills inducing suffocation
2) Washouts of nests and fry
3) Modification of the benthos due to deposition
4) Modification of the aquatic food chain
5) Introduction of toxins into aquatic food chains if deposited sediment contains harmful chemicals or compounds.[161]

In a single flushing event on the 1 MW, run-of-the-river Spencer Dam on the Niobrara River in Nebraska, 22,471 fish mortalities were recorded as water quality along the entire 64 km stretch

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[155] Ibid, p 2.21
[156] Ibid, p. 16.1
[157] Ibid, p. 15.1
[158] Ibid, p.15.1
[159] Ibid, p. 15.3
[160] Ibid, p. 15.25
[161] Fan, Jiahua and Gregory L. Morris, *Reservoir Sedimentation Handbook, (*New York: McGraw-Hill Professional, 1997) p.18.21

of river below the dam was impaired by the event.[162] Any time flushing is used to remove sediment from a reservoir, careful planning and study of the possible impacts is essential to ensuring that the environmental costs of the procedure do not outweigh the benefits of increased reservoir storage capacity.

Sediment routing encompasses any method manipulating the hydraulics or geometry of a reservoir, allowing sediment to pass through or around a dam, minimizing deposition.[163] An example of sediment routing would be significantly lowering reservoir volume during a river's flood season so as to allow near normal flow rates, therefore passing a majority of the flood sediment through the dam. Routing differs from flushing in that routing attempts to pass sediment before it has been deposited, whereas flushing addresses the issue after sediment has already been deposited. Sediment routing is generally considered the most environmentally friendly method of sedimentation management, as it partially preserves the natural flow of sediment through a fluvial system.[164] In the case of the HidroAysén projects, the described type of sediment routing would not be possible since the reservoir elevations will be controlled within a narrow range and the low reservoir storage volumes would not permit significant manipulation of flows.

Recommendations

This EIA does not seem to meet the second and third standards given in the Asian Development Bank document cited in the introduction to this section, namely, the need to present accurate and truthful scientific data as well as use acceptable methods of data assessment and to provide a clear description of environmental impacts, recommended mitigation strategies, and monitoring and management plan. There seems to be widespread disagreement as to the accuracy and methodology of the results presented in this document. It also suffers from a lack of clarity with regards to methods of analysis, interpretation of results and long term management and monitoring strategies.

Recommendations for improving this document are as follows: First, make available all cited reports so that data used to create sedimentation models and the hydrologic series are available for review. Second, publish addendums describing in more depth the methods of analysis used in the models and more details on their projected levels of precision and accuracy. Third, perform additional measurements of sediment transport in the rivers (both suspended and bed load quantities) and use this information to improve calculations of sediment transport and the model(s) used to predict them. Fourth, develop and publish a clear, long-term sediment monitoring plan, as well as a plan for sediment management.

[162] Ibid, p. 18.27
[163] Ibid, p. 13.1
[164] Ibid, p. 13.2

This list contains the main suggestions for concrete things to do to respond to specific criticisms of the EIA science and long-term management plan. However, more difficult to change will be the EIA's perspective on the dam sites and their surrounding areas. Overall, the thinking behind this document reveals three major flaws: first, that the EIA discusses only the effects that the project will have on the environment and not the effects that the environment can have on the project; second, a perspective on the effects of the project that limits the discussion to local areas and does not consider larger scale issues; and third, a failure to see the environment surrounding these project sites as unique and having value.

Conclusions

The EIA's perspective on sedimentation is an example of how the environmental impact assessment views only a one-way relationship between the project and its surroundings. Sediment transport by rivers is a naturally occurring event that can have a profound effect on the construction and operation of these dams. Failure to recognize this takes a very short-term view of projects that must be properly managed in order to reach their planned design lives. A more long-term view of environmental risks and a plan for mitigating and monitoring them would be much more beneficial than one which is designed for the short term only. Also, the idea of areas of indirect impact must be expanded to consider effects of the dam that range beyond the local scale and include those at the regional level as well. For example, many processes in the fjord ecosystem at the mouth of the Baker likely depend on sediments and nutrients that are transported from upstream. Impoundments have also led to temperature stratification in the rivers as well as changes in the oxygen content of the water which can prove lethal to fishes and other aquatic species.[165] A more wide ranging approach to the effect of dams will again prepare the company better for issues that may arise during construction or operation.

Aquatic Ecosystems

Introduction

The Environmental Impact Assessment sub-divides aquatic ecosystems into marine (and delta estuarine) and freshwater ecosystems and treats each component separately. The EIA also divides impacts into those that occur during the construction phase and the operation phase with the majority of impacts determined to be limited to the construction phase. Within these, the impacts of each of the five proposed dams are analyzed individually in terms of how each will affect either ecosystem.

Information Provided By the EIA

Marine Flora and Fauna

The baseline report states that the hydroelectric projects would directly affect the Mitchell estuary and the surrounding waters; and that only the construction of the ports and the subsequent navigation would have a direct impact on the marine biology of this area.[166] The areas of indirect impact include the northern portion of Barrios Island and the estuarine zones of the Baker and Pascua Rivers.[167] The EIA recognizes that these estuarine zones are important because of their high levels of productivity and because of the particular dynamic that is created by the mixing of fresh and saline waters.[168]

The areas that are presumed to be affected by the projects were sampled in August 2006 and January 2007; these time periods are considered to be representative of winter and summer conditions, respectively.[169] There were four sampling stations located in the Mitchell Estuary, and five located in the Motalvo Channel, which is opposite of the mouth of the Baker River.[170] The report describes the specific locations and sampling methodologies used for phytoplankton, zooplankton, benthic organisms, fishes, birds, amphibians, mammals, aquatic vegetation, and other species of interest.

The data suggest that there are marked seasonal differences in the abundance of aquatic organisms. For phytoplankton in the Mitchell Estuary, the density of organisms in the winter was much higher than in the summer[171]; possibly related to the fact that the volume of flow of the rivers is less in the winter because glacial melt is decreased. A similar pattern was also

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[166] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 1065
[167] Ibid, p. 1066
[168] Ibid, p. 1088
[169] Ibid, p. 1070
[170] Ibid.
[171] Ibid, p. 1128

found for zooplankton and subtidal benthic organisms (such as crustaceans).[172] Since productivity is typically greater during the summer as compared to the winter, this difference between seasons suggests that density of aquatic invertebrates may be sensitive to changes in the flow volume of the rivers.

In addition to the section devoted to the sampling, the report explains the importance of estuarine areas that make up the majority of the area affected by the projects. Estuaries, transition zones between terrestrial drainage systems (rivers) and large receiving waters (typically the ocean), are highly productive areas and are therefore important for both marine and freshwater species. These ecosystems are influenced by the mixing of different water densities and the tides. Estuaries are complex ecosystems, as they are affected by ocean conditions, weather conditions, the quality and quantity of the freshwater flows, and variances related to annual precipitation. These systems are particularly susceptible to human impacts, the consequences of which are often difficult to predict.

This section of the report concludes by stating that it is important to consider how changes upstream from the estuaries will affect the productivity of these delicate systems.[173] The productivity of estuarine zones can be seen as an indicator of the health of the waters in the area. Changes in the upstream hydrological regime can alter the dynamics of pelagic communities (phytoplankton and zooplankton), which underpin the productivity of these systems as they are the primary base levels in energy transfer in aquatic environments. Overall, because there are no species in this area that are included in the Red List of Threatened Species of the IUCN (International Union for Conservation of Nature), nor are there any taxa protected under national legislation[174], the EIA indicates that the impacts on the estuaries from the projects would be minimal. Thus, as in the case of terrestrial ecosystems discussed in the next section, environmental impacts in the EIA are primarily considered in the context, not of the impact of this ecosystem, but on whether environmentally significant (endemic, endangered, etc.) species are affected.

Freshwater Flora and Fauna

In the baseline report, the EIA analyzes the freshwater flora and fauna located in the area influenced by the Aysén Hydroelectric Project (PHA).[175] This area is defined as the basins of the Baker and Pascua Rivers. The description of the aquatic biota in this area is focused on fishes and their primary source of food (macrozoobenthos); the *Ley General de Pesca y Acuicultura* (General Law of Fish and Aquaculture), which was enacted in 1991 to regulate the development of the fishing industry in Chile, has established requirements to protect both.[176] The Law defines an environmental impact as an "alteration of the environment that is affected directly or indirectly by a project or activity in a determined area." The Law does not distinguish

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[172] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 1128-1129
[173] Ibid, p. 1129
[174] Ibid, p. 1131
[175] Ibid, p. 965
[176] Ibid.

between native and introduced species, and the EIA claims that introduced species should also be considered in the analysis because of their economic importance to the tourism and fishing industry of the Aysén region.[177]

To conduct the research that is included in this baseline report, the Baker and Pascua River basins were each sampled six times over two years. During the first stage, each river was sampled in May, August, and November of 2006 and January of 2007. During the second stage, each river was sampled in September and November of 2007. In the Baker River basin, samples were taken at 39 stations; 19 stations were located in the river, while 20 were located in the main tributaries.[178] In the Pascua River basin, samples were taken at 10 stations; eight stations in the river, while two were located in the main tributaries.[179] The taxonomic groups sampled were phytobenthos, phytoplankton, zoobenthos, zooplankton, fishes, and vegetation.

In accordance with the *Ley General de Pesca y Acuicultura*, it was also necessary to assess the impacts on migratory fishes within the rivers that would be dammed. The Law, however, does not define what qualifies a fish species as migratory. The EIA characterizes a migratory fish as any fish that travels a great distance and migrates for reproductive reasons.[180] In general, knowledge about the natural movements of native fish species is limited and fragmented and the EIA states that the detection of the presence of a fish species in a course of water is not sufficient to establish the existence of its migration.[181] Despite the lack of specific information, the EIA recognizes that physical barriers to fish migration would be created by the proposed projects and that migratory fish species wouldl experience by interrupted genetic flow. The EIA also defines sections of the aquatic environment which are considered an Area of Environmental Value (AVA).[182] Such areas include, but are not limited to:

- Sections of the river of significant width
- Sections of the riverbank with developed beaches and deposits of sand
- Sections of the river that contain islands
- Sections of the river that present favorable conditions for growth of phytobenthos and zoobenthos

Within the whole Chilean territory, approximately 44 species of native fishes have been identified, nine of which have been found in the Aysén region.[183] A recurring phenomenon in the rivers of the Aysén region, as well as throughout the rest of Chile, is the high abundance of introduced species, namely trout and salmon. The preliminary sampling presented in the EIA found only nine native fish species and thus supports the conclusion that both the biodiversity

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[177] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 966
[178] Ibid, p. 969
[179] Ibid, p. 974
[180] Ibid, p. 979
[181] Ibid, p. 981
[182] Ibid, p. 983
[183] Ibid, p. 985

and abundance of native freshwater fish species of Chile are less than that of other latitudes and in neighboring countries.[184] This phenomenon in Chile could be explained by tectonic activity, changes in ocean levels, the presence of the Atacama Desert to the north, the Andes Mountains to the east, as well as the presence of short rivers with considerable slope and prevalent rapids.[185]

Project Impacts

Effects of Port Construction on Marine Ecosystems
The EIA identified two negative environmental impacts to marine ecosystems that would be associated with the port construction[186].

- Alteration of intertidal and marine habitats
- Alteration of ecologically connected coastal and marine communities

The first stage of project construction would be the modification of two ports in the Mitchell Fjord on the marine Pacific Coast of Chile. Both the Pascua and the Baker Rivers drain into the Mitchell Fjord and this is where supplies would be delivered for portage upriver to the construction sites of the five proposed dams. According to the EIA, the Rio Bravo Port will be a temporary structure, and the Yungay Port already in existence[187]would only require a temporary expansion. Alteration of habitats scored low negative impacts (-6 for each port), despite having high probability and medium to high intensity values[188]. This is because the EIA deems the alterations of these habitats as having low magnitude and low extension because less than 10 hectares of surface area in the Mitchell Fjord would be impacted[189]. Also, the EIA gives the port construction phase a low reversibility rating because it assumes the habitats would revert back to their natural state after the construction time period, and thus the communities would re-colonize[190]. The low overall negative impact can also be attributed to the low environmental value rating because the EIA does not find any bird, mammal, or plankton species of relevance (endangered, endemics or of special conservation concern) in the baseline assessment sampling[191].

Similarly, the alteration of ecologically connected coastal and submarine communities scored low negative impacts. The EIA claims that these communities "should assimilate and equilibrate" to any changes from sediment re-suspension and eventual deposition. To reach this post-construction equilibrium, the EIA states that affected communities will follow a series

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[184] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 985
[185] Ibid, p. 985
[186] Ibid, p. 873
[187] Ibid.
[188] Ibid, p. 877
[189] Ibid, p. 878
[190] Ibid, p. 879
[191] Ibid.

of ecological processes, including possibly alternation of the dominant species, followed by changes to the other species in the ecosystem. This is deemed "partially reversible" by the EIA, even if the systems cannot return fully to their original states, because new species and/or the same may be observed in the future once the ecosystems have equilibrated[192].

Effect of Dam Construction on Marine Ecosystems

The EIA indicates that the construction of the hydroelectric power plants would require a series of steps that would directly and/or indirectly change the habitats, and thus the communities, of the downstream estuarine flora and fauna of the dammed rivers. [193]

- Clearing the sites
- Diverting the river flows into tunnels
- Building cofferdams
- Constructing the dam itself
- Harvesting the trees in the area that would be flooded
- Filling the reservoir, with deforestation at the borders

Effect of Dams on Freshwater Ecosystems

The EIA identified five negative environmental impacts to freshwater ecosystems that would be associated with the construction phase of the PHA[194].

- Loss of river habitats
- Alteration of river habitats by mining the river-bed aggregate deposits
- Alteration of the biotic communities because of increased suspended solids
- Alteration of river habitats by filling the reservoir
- Loss of individuals from native fish populations

Addressing the first impact of the dam construction phase, loss of river habitats, the EIA claims that the specific sections of the river that will have interventions are considered unfavorable for the aquatic biota because they are zones with high rapids[195]. The Pascua 1 and 2.1 all scored -21, while the Baker 1 and 2, and Pascua 2.2 all scored -35[196]. The probability was high for each case, however the extension was considered local because each dam occupies an amount of the river surface area that is considered "proportional" to the flow[197]. The intensity rating of each dam had high expected impact because the changes from river systems to lake systems will be "radical"[198]. The duration rating was high because the dams are expected to have 50-year life-spans, and as such, the changes associated with each project are ranked as

[192] Ibid, p. 880
[193] Ibid, p. 875
[194] Ibid, p. 776-7
[195] Ibid, p. 777
[196] Ibid, p. 778
[197] Ibid, p. 783
[198] Ibid.

irreversible[199]. The environmental value of the section of river surrounding each dam did not have particularly high values, because the EIA claims that the dams will be placed in areas that include rapids, waterfalls, and/or current velocities of at least 3 m/s (thus, these areas do not present characteristics typical of fish habitats)[200]. Despite many of the ratings being high, the final environmental impact values of the PHA are quite low because of the assigned low environmental and extension values.

As stated previously, the construction phase of the dams would utilize materials portaged up-river from the two marine ports, but also materials would be mined from the river-bed to be used as construction aggregate. The second negative impact of construction of the PHA is the alteration of the river habitats by exploiting these river bed deposits[201]. However, all of the projects are classified as low extension and partially reversible because the EIA states that the habitats should "recover" after the mining[202]. The environmental relevance of each sector scored moderate to high, depending on the abundance of native fish species, because the areas selected for mining river-bed rock deposits correspond to sectors of slower current velocities where these fish species tend to live and spawn[203].

The habitats in fluvial ecosystems are characterized by a combination of factors such as aquatic vegetation, the form and texture of the sediment, the flow regime, and the depth of the water. The loss of riparian vegetation would directly affect the river-dwelling fauna and indirectly affect the dynamic of nutrients, water temperature, and aquatic communities. The extraction and processing of the river-bed rock deposits could eliminate refuge areas and alter fish-spawning habitats, thereby diminishing the density and diversity of the biomass communities. Diminishing the heterogeneity of the aquatic vegetation could decrease the diversity of habitats and drive a reduction in the capacity of the wildlife to establish itself[204].

The third impact of dam construction, alteration of biotic communities by increasing the suspended solids in the rivers,[205] depends on physical disturbances to the terrestrial and aquatic environments. Construction work for provisional roads and access roads, as well as the repositioning of Route 7 would create erosion which along with the disruption of the river-bed due to physical intervention could produce an increase in the suspended solids content of the rivers. This could eventually affect the organisms at the lowest trophic levels that are the food source for fish. The excess turbidity of the water from portaging barges could also interfere with the feeding and respiration processes of zooplankton, benthos and fish species, thereby limiting their viability. [206]

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[199] Ibid, p. 783
[200] Ibid.
[201] Ibid, p. 784
[202] Ibid, p. 788-9
[203] Ibid, p. 789-790
[204] Ibid, p. 784, 790
[205] Ibid, p. 790
[206] Ibid, p. 790-1

Due to their glacial origins, the Baker and Pascua Rivers normally carry a high sediment load in the summer. However, although the baseline measurements indicate high suspended solid levels, the affected areas still have high diversity and abundance of species. [207] Ultimately, the intensity ratings were rated low because the EIA claims that the affected areas would not suffer radical changes, but rather those within "acceptable ranges", because the rivers of the region have naturally high sediment loads, especially in the summer months. [208] The duration rating is low, classified as "seasonal" interventions. [209] The probability of each river being impacted by an increase in suspended solids depends upon their position in relation to the roads. [210] All of the dams receive fully reversible ratings because the EIA states that the increase in suspended solids due to erosion would return to natural levels after the road construction period ends. [211]

Alteration of river habitats by filling the reservoirs during the installation phase of the dam construction is the fourth environmental impact of the operation phase that the EIA surveyed[212]. This scores quite high for the Baker 1 and 2 projects (-40 and -63, respectively), with lower negative impact scores for the Pascua projects (-32, -24, -16 for 1, 2.1, and 2.2, respectively)[213]. The extension rating is again analyzed by impoundment surface area, with the Baker 1, Pascua 2.2, 2,1, and 1? all having large impacted areas (100-1000 hectares) and the Baker 2 with a very large impacted area (greater than 1000 hectares)[214]. Despite the extremely high probability rating that each river would experience drastically changed flow rates, the intensity values remain moderately low because the EIA states that residence times are still significantly less than lentic environments, thus the new reservoirs would remain more like rivers than lakes[215]. The duration of all individual projects is high with an irreversible rating because the dam life is projected to be 50 years[216].

The environmental value of each dam once again depends upon the fish species present and their abundance; Baker 1 is classified as moderate because there were two AVA ??sectors with low abundance of species (introduced: *O. mykiss* and *Salmo trutta*, native: *Galaxias platei, Hatcheria macraei,* and *Percichthys trucha*). The Baker 2 receives a high environmental value due to the presence of 5 AVA sectors with relatively low abundance of species (again, predominantly introduced *O.mykiss, S. trutta*, and fewer native *G. platei*). The Pascua projects all score low environmental significance because there are not many sections classified as AVAs. The EIA states "with sufficient certainty" that this is because the rapids in this part of the river are too fast and that the morphology of the rapids limits the presence of fish species in

[207] Ibid, p. 793
[208] Ibid.
[209] Ibid.
[210] Ibid, p. 794
[211] Ibid, p. 795
[212] Ibid, p. 796
[213] Ibid, p. 797
[214] Ibid, p. 802
[215] Ibid, p. 801
[216] Ibid, p. 802

and around these sections (Pascua 1 only presenting two introduced species: *O. mykiss* and *S. trutta*)[217]. The large variance in negative environmental impact assessments (-16 to -63) shown are due to the different extensions of the affected areas, as well as the different environmental values that depend on the presence of native fish species[218].

The fifth environmental impact during the construction phase of the PHA deals with the loss of individual fish from native populations[219]. During the construction phase, the rivers would be passed through diversions tunnels at the construction sites, thereby producing strong turbulence and increased hydrostatic pressure, which could kill the fish passing through these tunnels. The risk of this occurrence is assessed by the abundance of fish in the zones where the tunnels would be created. The evaluation only takes into account the native fish species and the negative effects on the biodiversity of the region. The probability of each section to experience a loss of native fish species depends upon the abundance of native species in that area, as well as whether or not the fish would find the diversion tunnels[220]. Because there is only one registered native fish species found in the Pascua River (*Galaxias maculatus* is classified as "Fuera de Peligro: Not endangered ", and exists only above the Pascua 1 section), the Pasuca 1, 2.1, and 2.2 receive negligibly low overall negative scores (-1, -1, -3, respectively). Similarly the EIA rated the Baker Projects as low significance (Baker 2: -21, Baker 1: -10), despite the baseline study citing four different native fish species ("Vulnerable": *Galaxias platei* and *Percichthys trucha*, "Rare": *Diplomystes viedmensis* and *Hatcheria macraei* making up 14.3% of 801 samples taken near the Baker 2 site and *Galaxis platei* and *Hatcheria macraei* making up 3.8% of the total 238 captured fish species near Baker 1)[221]. The impact is deemed partially reversible with medium duration because the diversion tunnels would only be used for 2-4 years (depending on the length of construction for each dam) [222]. However, the intensity is high because if significant numbers of individual fish die, this would greatly alter the populations and dynamics of these ecosystems[223].

Operation Effects on Marine Ecosystems: **Ports**
During the 12-year span that the ports would be used, there would be barge traffic that could create environments unsuitable for aquatic life, such as high vorticity regions with circulation of sediment[224].

Operation Effects on Marine Ecosystems: **Dams**
Despite the consideration that the dams cannot impound water for more than 24 hours, they would alter the natural conditions and residence times of the rivers. In particular, the hydro-

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[217] Ibid, p. 803
[218] Ibid.
[219] Ibid, p. 804
[220] Ibid, p. 806
[221] Ibid, p. 807
[222] Ibid.
[223] Ibid, p. 806
[224] Ibid, p. 883

peaking operations would modify the natural flow regime at lower flow rates, thereby changing the transport and concentrations of nutrients. This change in nutrient flow to estuaries could impact the community connection in coastal and marine ecosystems. [225] The five dams would require three actions during the operation stage. [226]

- Maintenance of the dam and the flooded region
- Accumulation and release of large volumes of water
- Regulation of flows.

The EIA recognizes that there is a synergistic relationship between the aquatic chemistry and quality of the water and the change in the transport of sediments to the marine systems from the inevitable change in flow and composition of the rivers due to the operation of the proposed projects[227]. When evaluating the magnitude of the negative environmental impacts of the PHA on the nutrient and sediment transport in these fluvial systems, the EIA uses the term "tampon effect"[228]. This means that the downstream dams each act more-or-less to absorb effects from upstream dams, and thus in terms of the Baker River, the Baker 1 would have lesser negative environmental impacts than the Baker 2 project because it is located upstream on the river. Similarly, the construction effects of the Pascua 1 and 2.1 are less intensive than the Pascua 2.2 since the Pascua 2.2 discharges into a riverine environment as opposed to a reservoir[229].

The EIA states that physical and chemical changes to the aquatic systems caused by the PHA could also lead to changes to the biological composition of these ecosystems[230]. In these systems, the fjords and interior channels are connected to the sea and thus the hydrochemical regimes of the sea depend not only upon the oceanographic conditions, but also on the exchanges of flow in the fjords[231]. Of particular relevance to the sediments and nutrients in the fjord system is the transport of phosphorous and nitrogen, important elements that determine the abundance of aquatic flora. If the dams result in an excess of nitrogen and phosphorous, these waterways could experience eutrophication, thereby causing asphyxiation of the aquatic fauna[232].

The alteration in the transport of nutrients and sediments to the marine and estuarine ecosystems for the three upper-most dam projects (Baker 1, Pascua 1, Pascua 2.1) all score slightly lower (-14) than those of the lower-most regions of the rivers (Baker 2, Pascua 2.2) (-18) due to the "tampon" effect[233]. These values are quite low despite their high probability and

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[225] Ibid, p. 884
[226] Ibid.
[227] Ibid, p. 883
[228] Ibid, p. 886, 894
[229] Ibid, p. 886
[230] Ibid.
[231] Ibid, p. 887
[232] Ibid, p. 888
[233] Ibid, p. 891

high environmental value. The EIA states that although they did not find species of relevance, the estuaries contain fish species native to the region *(Aplochiton zebra)*. All projects had low extension values because the EIA assumed that only local and immediate estuaries would be impacted by the changes in sediment and nutrient transport[234]. Although duration was high since the life of the dam is estimated at 50 years, the projects were classified as "partially reversible" because the EIA estimates that the inter-marine and submarine habitats would "modify and adapt permanently to the generated conditions". The low overall negative impact can be attributed to low intensity and extension, despite high probability of occurrence and high environmental value of the region[235].

Similarly, the alteration of connected coastal and submarine ecosystems due to the changes in the transport of sedimentation and nutrients score as relatively low negative impacts[236]. Although the EIA states that the flora and fauna of the area are of "major susceptibility"[237] in terms of the ability to sustain productivity due to transport changes, the three upper-most dam projects (Baker 1, Pascua 1, Pascua 2.1) scored -17 while the lower-most projects (Baker 2, Pascua 2.2) scored -25[238]. The extension is medium because the effects would be seen in a broader environment, associated with the estuaries of each river and the probability is high because altering sediment to the fjords would most assuredly have consequent changes in the communities of the coastal ecosystems[239]. Once again, the overall negative impact was deemed "not significant", despite high duration, high environmental value, and "partial" reversibility of the 50-year dam systems.

Operation Effects on Freshwater Ecosystems: Dams

The EIA identifies five environmental impacts to freshwater ecosystems that would be associated with the operation phase of the PHA[240]:

- Generation of new habitats by the presence of reservoirs; this alteration was considered a positive impact while all others were considered as negative impacts
- Alteration of biotic communities by the change in the flow regime downstream of the dams
- Alteration of biotic communities by the changes in the transport of nutrients and sediments downstream of the dams
- Alteration of fish communities by the barrier effect of the dam and the reservoir
- Loss of individuals from native fish populations.

Addressing the first and only declared positive impact of the dam operation phase, the EIA claims that the filling of the reservoirs could generate new lentic habitats in zones which were

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[234] Ibid, p. 890
[235] Ibid.
[236] Ibid, p. 893
[237] Ibid, p. 892
[238] Ibid, p. 893
[239] Ibid, p. 894
[240] Ibid, p. 809

previously riverine with less than 2 meters of depth[241]. The EIA claims that these new environments with large surface area will be good for establishing communities of benthic organisms, which would serve as a food source for fish species[242], primarily the introduced species of rainbow and brown trout. These trout species tend to dominate the highest trophic levels in an ecosystem and could colonize the new lentic environments; rainbow trout in particular have a high capacity for establishing local populations and migrate between river and lake habitats. However, referencing a study by the Universidad de Concepción, the EIA claims that it is not possible to estimate how the new lentic environments will alter the dominance of the introduced species.[243].

All of the dams receive positive impacts for generating new habitats because the EIA states this could offer an increase in the heterogeneity of the environment[244]. Probabilities for each of the projects are high despite the consideration that the boundaries of the reservoir do not guarantee that there will be 100% adequacy for the biota[245]. This is especially the case for Pascua 2.1 and 2.2 (scoring overall +24 and +16 respectively), because these regions currently have unfavorable fast-current habitats. The extension of each dam is again determined by the impoundment surface area that would be affected (greater than 100 hectares), thus all had high values[246]. These impacts were deemed irreversible due to the 50-year duration of the PHA, as did the intensity of each impact because the flow currents would be substantially less after filling the reservoirs[247]. The environmental value depends upon the fish species contained in the area[248].

The second impact of dam operation, alteration of biotic communities by the change in the flow regimes below the dams, depends upon the depth and flow velocity of each river[249]. Baker 1, 2, and Pascua 2.2 all score very high negative impacts (-50 “moderate”, -65 and -65 “significant” respectively), while Pascua 1 and 2.1 score negligibly (-4 for both projects)[250] since these latter dams would basically discharge directly into the reservoir of the next downstream dam. In all cases, the residence times would increase because the proposed hydro-peaking schemes for generation of electricity demands a minimum flow of operation during off-peak hours, and this altered flow regime could ultimately affect the benthic and fish communities below each dam[251]. Variations in flow between peak and off-peak power generation periods could cause oscillation of covered and uncovered riverbeds, introducing “sterile zones”, which would inevitably lead to a loss of habitat for aquatic biota. The EIA claims that this oscillation occurs

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[241] Ibid, p. 809
[242] Ibid, p. 810
[243] Ibid.
[244] Ibid, p. 813
[245] Ibid.
[246] Ibid.
[247] Ibid, p. 813-14
[248] Ibid, p. 814
[249] Ibid.
[250] Ibid, p. 818
[251] Ibid, p. 815

naturally between seasons, where the water level would be highest in the summer. However, the EIA claims that these oscillations would permit a recuperation of the affected habitats of the benthic colonies such as currently occurs naturally during the glacial-fed summer flows[252]. This conclusion is suspect since it seems highly unlikely that there are any connections between seasonal water level fluctuations and intra-daily ones. The EIA also concludes that slower flows are better for fish species[253].

A minimum ecological flow for each dam was determined from the CEA study that determined flows less than the minimum flows actually proposed for each project (Table 1 in the Background section.) Since these minimum flows are less than the estimated minimum flows for each dam location under current conditions[254], it is presumed that this will result in loss of aquatic habitat. The EIA states that there could be many ways in which a loss of habitat could occur, however, erosion of the reservoir perimeter is not included in this determination. The probability, extension, and intensity all score low for Pascua 1 and 2.1, due to the presence of reservoirs immediately downstream from the flow through the dam [255]. The other three Baker projects all score relatively high for these three categories, and all the dams have high duration and irreversible values. Once again, the scores for environmental value depend upon the abundance of native species[256].

The third impact on freshwater communities, alteration of biotic communities by the change in the transport of nutrients and sediments below the dams, depends greatly on how much sediment is already in each river[257]. As has been described, the reservoirs will act as barriers for the macronutrients and sediments due to reduced velocity in the reservoirs[258], thus altering the organic content of the rivers. This could eventually affect the benthic communities present in the lower waters, which in turn would affect the fish communities at higher trophic levels. To evaluate the impact, the EIA first estimates the presence and transport of those micronutrients and macronutrients that would be retained in the reservoirs[259].

The EIA states that diminishment of suspended solids could result in benefits for the biotic communities of the rivers, and that the effect of settling would be limited since the retention time for each of the five reservoirs does not exceed two weeks[260]. Once again, the most down-river dams score the highest negative environmental impacts (-27 for both the Baker 2 and Pascua 2.2) due to the “tampon” effect”[261]. The probability of each occurring depends upon the residence time for each reservoir, which would affect the possibility for settling (6-12 days

[252] Ibid, p. 815
[253] Ibid, p. 816
[254] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 235, 264
[255] Ibid, p. 819
[256] Ibid, p. 820
[257] Ibid, p. 821
[258] Ibid.
[259] Ibid.
[260] Ibid.
[261] Ibid, p. 822

retention time scores “moderate”). Extensions for all were low and are related to the presence of relevant downstream tributaries with the ability to contribute nutrients and sediments. If there are many tributaries, the extension is low[262]. The intensity also scores low for all the projects because the EIA states that the settling would not significantly alter the base conditions of the water systems[263]. Again, the duration scores high and is classified as irreversible. The environmental value rating is based upon both the AVAs and the abundance of native species.

The fourth impact of dam operation, alteration of fish communities due to the barrier effect of the dam and the reservoir, recognizes that the longitudinal and latitudinal movements of fish would be limited and thus would modify populations[264]. This section analyzes both the native and the introduced fish species in riparian zones with flow velocities less than 6m/s, with discharges between 471 and 828m^3/s, and temperatures 3.5-16.7◦C[265]. The EIA claims that high-speed rapids are natural barriers themselves, and also that temperature effects will not be significant in such areas with high velocities[266]. For example, salmon, which are migratory fish, appear in relative abundance on the Baker River, but do not appear in the Pascua River, which has greater velocities. Thus, both Baker projects score much higher (-18 for each) than the Pascua projects (-7 for 2.2, and -2 for 1 and 2.1)[267].

Finally, the loss of individual fish of native species during operation of the dams all score relatively low (Baker 1, -8, Baker 2, -16, Pascua 1 -2 and Pascua 2.1, -2, and Pascua 2.2, -3)[268]. As in the construction phase, the probability and environmental value depend on the abundance of native fish species in the area above each dam[269]. The extension and intensity is high in all cases, assuming that the turbines would most certainly kill any fish that swim through[270]. The duration and reversibility are again high, based on the assumed 50-year dam life[271].

[262] Ibid, p. 824
[263] Ibid.
[264] Ibid, p. 825
[265] Ibid, p. 833
[266] Ibid, p. 826
[267] Ibid, p. 828
[268] Ibid, p. 838
[269] Ibid, p. 839-40
[270] Ibid, p. 840
[271] Ibid, p. 839

Mitigation, Reparation, and Compensation

Mitigation Strategies

The EIA discusses plans to mitigate and compensate negative impacts that the PHA may inflict, as well as methods to avoid environmental accidents. It mentions that HidroAysén is conscious of its responsibility to ensure suitable environmental management of the project and that the firm is also aware of its role in combining efficient development of hydroelectric resources in the region with the economic activities of the Aysén region and protection of the environment[272]. The sections include plans for mitigating the negative impacts on the flora and fauna of both aquatic and marine ecosystems. Despite the diversity of impacts, the EIA offers only four means of mitigation and compensation. The projects will environmentally manage the mining of the riverbed, study the ecology of the rivers and their estuaries and zones of adjacent ocean, create an area of conservation, and rescue benthic fauna.

Mining Riverbed Deposits

During the construction process, HidroAysén plans to mine the riverbed to obtain aggregate for construction purposes[273]. Mining these riverbeds can directly and/or indirectly affect river ecosystems that depend closely on the dynamics of the water, including temperature and nutrient flow. All impacts would be mitigated through "proper environmental management of the exploitation of deposits"[274]. The mission of this management plan would be to diminish the effects on the aquatic biota caused by the intervention of the channels and bordering zones and facilitate the recovery of habitat after the operation. There would be a specific environmental management plan for each deposit, relying on the technical information from the engineering design, administrative plans for process and personnel, and engineering specifications that will be considered at each stage of the projects. These reports will lay out plans to control increased turbidity and water temperature as well as the protection and recovery of the flora and fauna[275].

Creation of a Conservation Area

The fish populations of these ecosystems would be greatly affected by the proposed inundations due to changes in habitats and nutrient/sediment flows. Especially affected would be the joint communities in the sub-tidal and inter-tidal areas. The EIA plans to compensate and mitigate for the negative impacts of riverbed mining as well as the loss of individual fish and communities through the creation of a conservation area. This conservation area would encompass 5,772 hectares of land and would include a diverse array of habitats and biodiversity of species.[276] The intent is to allow for the preservation of ecosystems and the development of scientific studies through environmental education. To ensure the adequate

[272] HidroAysén, Environmental Impact Assessment, Chapter Six, p. 2
[273] Ibid. p. 344
[274] Ibid. p. 105
[275] Ibid. p. 345
[276] Ibid. p. 371

representation of flora and fauna, the EIA suggests that the location of the conservation areas would be based on the community concept; a concept that relies on the interaction of plants and animals with processes of population dynamics and succession. The EIA claims that the area of conservation must have structural heterogeneity and contain sections adjacent to coastal marine areas. It is unclear whether the location of the conservation area has been identified or what the specific details of such an area will be. In the terrestrial ecosystems section of the EIA, reference is also made to the creation of a conservation area which will also occupy 5800 hectares. It is suspected that the two conservation areas may be one and the same, in which case, the aquatic habitat would not occupy anything close to 5800 hectares. Also, since the aquatic portion of the conservation area apparently must comprise both freshwater and marine components, the specific ecosystems in the conservation area may not closely resemble those in the reservoir areas of the projects. More details of the proposed conservation area(s) are required to understand the implications of this mitigation alternative.

Study of the Ecology of the Pascua and Baker Rivers, Including Estuaries and Adjacent Marine Zones

The EIA acknowledges that the construction of the dams, filling of the reservoirs, and the eventual operation of the power stations would alter the existing conditions of the Pascua and Baker Rivers, their estuaries and adjacent marinas[277]. Thus, the EIA offers a compensation for the potential impacts that the projects would generate by supporting the development of systematic investigations of these river ecosystems. These studies would contribute information for the evaluation of future projects of this type and would concentrate on understanding the fluvial dynamics of the rivers, their estuaries, and tributaries as well as the coastal and marine areas. Additional focus will be placed on the protection of the native fish populations through conservation measures.

The study would be intended to develop knowledge of the ecology of the rivers, and intra/interspecific relationships between the native species. The plan also hopes to appoint regional authorities to develop strategies for the conservation of the rivers. The EIA proposes that this preliminary research commence at the beginning of the construction stage and continue for 20 years of the operation stage. Follow-up would include a report of their findings every three years. The mission of this report would be to develop a strategy for proper conservation of the biodiversity in rivers with proposed hydroelectric plants[278].

As stated in the sedimentation section, however, it is the opinion of these authors that such study information is pertinent to understanding the true effects the PHA could have on aquatic flora and fauna and ultimately making an informed decision as to whether or not the PHA should be built. Pursing such knowledge post-construction is irresponsible and will not contribute to the sustainable development of Patagonia’s resources.

[277] Ibid. p. 106
[278] Ibid. p. 376

Rescue of Benthic Fauna
Additionally, part of the mitigation plan proposed by the EIA includes rescuing benthic fauna prior to construction. To collect benthic fauna, transects would be walked three times per day for a week prior to construction. These species would be relocated to areas of similar habitat[279]. It is unclear that areas to be populated currently contain a deficit of the species to be relocated.

Comparison to WCD Case Studies

Aslantas Dam (Turkey)
This case study concludes that fish passages or ladders should be considered in future dam projects. Although fish species and their population in the vicinity of the Aslantas and upstream dams have apparently not been negatively affected, the dam does not allow passage for eel. For this reason, eel species no longer exist in the reservoir and upstream of the dam; and thus eel fisheries have been adversely impacted[280].

Pak Mun Dam (Thailand)
An issue in this case, as in many of the cases, is that aquatic ecosystems are quite complex, and sufficient studies must be performed prior to the construction of a project to avoid negatively impacting these delicate habitats. The absence of a comprehensive pre-project assessment and insufficient consideration of the project's impact on fish and fisheries was a critical lapse in judgment. There have been 256 fish species identified in the Mun River, 77 of them migratory. Following dam completion, only 96 species have been identified upstream from the dam[281]. One of the projected benefits associated with the dam construction was the development of a significant reservoir fishery with projections of increased productivity to 100 kg/ha/yr in the reservoir without stocking or 200 kg/ha/yr with stocking[282]. However, these estimates were unrealistically high for run-of-the river reservoirs[283]. In reality, estimates indicate that fish productivity has declined to 40 percent of the pre-project catch levels[284]. The outcome of fish populations in the waters upstream of the Pak Mun Dam suggest that optimism for projected benefits is not a suitable replacement for careful pre-construction planning, analysis, and study of the waters involved.

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[279] Ibid. p. 110
[280] Agrin Co. Ltd.. 2000. *Aslantas Dam and related aspects of the Ceyhan River Basin, Turkey*, A WCD case study prepared as an input to the World Commission on Dams, Cape Town, www.dams.org
[281] Amornsakchai, Sakchai, Philippe Annez, Wanpen Wirojanagud, Ek Watana, Suphat Vongvisessomjai, Sansanee Choowaew, Prasit Kunurat, Jaruwan Nippanon, Roel Schouten, Pradit Sripapatrprasite, Chayan Vaddhanaphuti, and Chavalit Vidthayanon. *Pak Mun Dam, Mekong River Basin, Thailand*. Cape Town: World Commission on Dams, 2000, p. 41.
[282] Ibid, p. 37
[283] Ibid. p. 39

Tucuri Dam (Brazil)

This report, again, stressed the importance of adequate baseline studies. A combination of waterfall inundation, submerged plant decomposition, and slow currents decreased the livability of the reservoir as aquatic life suffered due to a drop in dissolved oxygen levels[285]. As a result, fish diversity decreased in the reservoir and downstream of the dam. Fisheries downstream were especially disrupted as productivity declined by 70 percent. New species continue to be discovered in the area, and questions have been raised as to how many undiscovered endemic species were never recorded and have been lost due to dam construction and operation.

Grand Coulee Dam (USA)

Because of over fifty years of other extractive processes such as logging, canneries, and smaller dams that were well established in the Columbia River system prior to construction, it was difficult to establish pre-dam ecological conditions upstream of the Grand Coulee Dam. Similar to the Patagonian PHA, fisheries management plans for the dam included accommodations for fish transport, rearing and transplanting[286]. These strategies have experienced varying degrees of success with hatchery and transport exhibiting fair success at best. Even with these outcomes, the case study assessment is positive with a "stable salmonid population with some degree of genetic diversity." This observation may be over-optimistic, however, given that in recent years several salmonid species in the Columbia River Basin have been placed under the protection of the Endangered Species Act.[287]

Glomma River Dams (Norway)

In the case of the dams in the Glomma river system, the dams were built on a smaller scale and the effects have been hard to measure. The initial 1947 predictions suggested few negative and even some positive impacts. Although spawning sites would be obstructed and this would require artificial hatcheries to support recreational fishing and ecosystem productivity, it was not believed that water productivity would be negatively impacted by the dams. In actuality, the brown trout population was eliminated in this ecosystem due to changes in the food web[288]. Fish ladders in these water systems have found varying degrees of effectiveness and stocking has also experienced variable levels of success.

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[285] *Tucurui Dam and Amazon.Tocantins River Basin,* The World Commission on Dams, Cape Town, 2000, www.dams.org

[286] Ortolano, L., Kao Cushing, K., and Contributing Authors. 2000. *Grand Coulee Dam and the Columbia Basin Project, USA*, case study report prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

[287] Federal Caucus, Conservation of Columbia Basin Fish, Final Basinwide Salmon Recovery Strategy, Vol 1. December 2000. p 17, http://permanent.access.gpo.gov/lps57088/d3/Final_Strategy_Vol_1.pdf

[288] Norwegian Institute for Nature Research and Eastern Norway Research Institute, 2000. The Glomma and Laagen Basin, Norway, case study prepared as an input to the World Commission on Dams, Cape Town, www.dams.org

Conclusions

Although there are several instances in which the EIA admits that the construction and operation of the PHA would change the temperature and nutrient flows of marine and freshwater aquatic systems, many attempts are made within the document to minimize the importance of negative impacts. Preliminary theories and conjectures are made using insufficient data and it is clear that not enough is known about these ecosystems to effectively analyze the impacts of the PHA on water quality, flora, and fauna. Confusing and misleading language is used throughout to justify the variables and equation used to numerically evaluate the environmental impacts of the projects (see section entitled "The Environmental Impact Assessment" in Background Information).

From analysis of the EIA baseline study, it is clear that species sampling is incomplete and there is the risk that many incorrect assumptions are made when there is limited information available from which to hypothesize. For example, the Marine Flora and Fauna sampling consisted of only nine sampling stations (four in the Mitchell Estuary and five in the Motalvo Channel) over two sampling times (August 2006 and January 2007, representing winter and summer seasons respectfully). Freshwater systems had slightly more comprehensive sampling techniques including 39 stations and six sampling times over two years. However only one of these sampling times overlapped for comparison to the previous year (May, August, November 2006, and January, September, November 2007). Sampling was only conducted using two types of gear (electro-fishing and set lines with #6 hooks[289]) and was not stratified by microhabitat. Lakes were only included during the last field trip when gill nets were used, which gives incomplete data on the types of species that can survive in the reservoirs resulting from the dams. Equally appalling is that each sampling effort was approximately 15 minutes per site over the span of 51 days (including travel), suggesting little effort at gathering a complete picture of biodiversity at each site[290].

An example that highlights the necessary research that should be undertaken to construct sound management is a study of the San Pedro Dam (also in Chile) and its microendemic *Diplomystes*[291].   Colbún, owner of the San Pedro project and a stakeholder in the proposed PHA, initially asserted that because of the project's preservation of flow rate with the operation of the dam in a run-of-the-river mode, the impact would be minimal to *Diplomystes.* Without any previous knowledge on the biology of the organism, this assertion was difficult to support. After studying the organism, it was discovered that it was not found in lacustrine habitats along the same ecosystem, a potential issue with the creation of the dam reservoir. Additionally, it was found that while the species does not migrate for reproduction, it is mobile along the length of the river. This case illustrates that the complexity of ecosystems cannot, and should

[289] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 978
[290] Centro de Ciencias Ambientales (EULA), "Anexos Informes," p. 68 #5
[291] Habit, E., "Biological impacts of hydropower development in Patagonia: Issues and EIA analysis," A presentation on March 1, 2009, EULA, University of Concepción

not, be glossed over. To preserve the ecological heritage of these two Patagonian ecosystems, living fossils like the *Diplomystes* warrant adequate study before implementing projects that may have significant negative impacts on populations.

The analysis of the impacts uses an incomprehensible rating system and obscure language to justify the development of the PHA, with no rating exceeding 70 out of 100 possible. For example, in the freshwater section analyzing the alteration of biotic communities with respect to change in flow regimes below the dams, a rating of –50 is deemed “moderate”. Many problems arise in this faulty scoring system. It is often observed that when only one or two of the variables has a low rating and four to five variables are high, these are given low overall negative environmental impact values because of the way that the equation weighs individual factors (see overall recommendations at the end of this document for further discussion).

In addition, more often than not, variables are incorrectly assigned low values due to the parameters included in the designation schemes. Often times, those impacts with high environmental, probability, irreversibility, and intensity values somehow are assigned low negative overall environmental impact values because they have low extension and duration values, or some similar combination of these six variables. For example, low extension values are attributed to small surface areas to be affected (e.g. less than 10 hectares), which isn’t always the case; in terms of the impacts of port construction on the Marine Ecosystems, the EIA states that the extension value is low because it only takes into account the small bays where the ports will be constructed, thus ignoring effects on the greater glacially fed oceanic areas. The extension values with respect to filling reservoirs was also evaluated in terms of surface area, and since the EIA claims that reservoirs are more like rivers than lakes, this impact also received a low intensity rating. For example, a retention time of six to 12 days is described as “moderate”.

Similarly, port construction was given a low reversibility rating because the EIA deemed that these ecosystems would revert and re-colonize post-construction. Likewise, reversibility and duration ratings were low for the mining of river-bed aggregates in the freshwater systems, despite high environmental value of these areas where fish spawn. In terms of loss of native fish species to the dams due to a lack of fish ladders, the Baker River received a “low” rating, despite there being four of the nine native species of fish in the area. These types of assumptions occur several times throughout the entire document within assessments of the other impacts; the reversibility and duration analyses thus disregards the fact that if species are decimated during the two to twelve year construction period, it will hinder their viability post-construction. The few instances when the EIA does acknowledge this fact, it asserts that possibly altering the dominant species in an ecosystem could be a positive impact on the ecosystem, as it could increase the biodiversity of these regions.

Other controversial language used includes “within an acceptable range,” “not radical,” “moderate,” “natural”, and “seasonal”. For example, the EIA states that the increase in sediment due to the turbidity of barges and the erosion of riverbanks during the construction phase is a “seasonal” problem that is “reversible”, and already occurs “naturally” due to the glacial nature of the river systems. However, once much of the sediment has settled and the dams are in place, the probability of the area needing to be dredged is quite high, and the EIA does not make any mention of this fact (see similar discussion in the Sedimentation section).

Overall, the mitigation and management plans of the EIA are quite flawed. As has been explained, more research is needed to expand the knowledge base for effective management of the aquatic ecosystem. Among other issues, the HidroAysén EIA study does not adequately address genetic diversity of the fish species (only one gene flow study was completed), nor does it address the swimming capacity or migration behaviors of these species. It is only with this information that proper mitigation strategies can be implemented.

The four mitigation and management proposals do not appear to be sufficient to mitigate and compensate the negative impacts inflicted. There is little explanation about how these measures will positively impact or mitigate the problem. For example, no explanation is given on the definition of managing the exploitation of deposits. It is also unclear how the study of a modified river is an adequate compensation scheme. Finally, the description of the conservation area is vague with regard to detail and concept.

Ultimately, the aquatic section of the EIA recognizes the importance of estuarine areas, such as those that make up the majority of the affected marine area, and the delicate balance of these complex ecosystems. These systems are particularly susceptible to human impacts, and as has been shown in the comparison to the case studies in the World Commission on Dams report, the consequences of altering these ecosystems are often difficult to predict. Because there are no species protected under national legislation or registered on the IUCN Threatened Species list in this area, the EIA states that the impacts would be minimal, disregarding how individual species in differing trophic levels interact and depend upon one another. When it is convenient, the EIA states that there is not enough information to make projections into the future, while in other areas of the report it concludes that sufficient research and baseline studies have been performed. The EIA also mentions in multiple sections that while there are many factors impacting these habitats, "there exists a built-in framework of feedback and interdependence that will respond and adapt to these changes."[292] However, little is known about the feedback mechanisms in these ecosystems or their ability to recover over time. The reality of ecosystems being able to "fix themselves" is not one that should be relied on without adequate studies, which cannot be surmised by two years of baseline research. In sum, while the EIA recognizes negative impacts, it undermines these impacts by using ambiguous language and overlooking the scope of these impacts with mitigation plans that are vague and don't directly address the issues.

[292] Ibid. p. 107

Terrestrial Ecosystems

Introduction

In the Environmental Impact Assessment, HidroAysén presents information regarding the terrestrial ecosystems including baseline studies, prediction and analysis of impacts, and mitigation, reparation, and compensation plans. In this section, we examine the EIA as presented by HidroAysén, discuss comments on the document provided by stakeholders, and key issues that were overlooked.

Baseline Studies

Baseline Studies of Terrestrial Flora

The terrestrial ecosystems of the Aysén Region have a unique and complex structure that is determined by its geographical attributes, including elevation, relief, and latitudinal and longitudinal coordinates. In order to assess the impacts that the proposed hydropower projects would have on the physical environment, a baseline study was conducted to describe the flora in the area of influence of the projects in the Baker and Pascua River basins. The EIA notes that the study area was approximately 180,000 hectares and research took place from April 2006-March 2007 with four sample campaigns to account for seasonal variations of the vegetation.[293] The process of the study can be broken down in two main parts: (1) characterization of the terrestrial flora and vegetation in the area of influence in terms of its biodiversity, level of endemism in Chile, and conservation status and (2) identification of plant species in ecosystems affected by the project and defining their location, distribution, and abundance with emphasis on species that fall under any conservation category.[294]

The EIA defines an area of direct influence as all areas involving the loss or disturbance of the existing flora and vegetation as a result of the installation of temporary and permanent components of the project. This area includes the hydroelectric power plants (including reservoir areas), the electrical transmission system, and the infrastructure required for the construction of the project, including roads, facilities in Cochrane, landfill, weigh stations, and power lines.[295] The 500 kV transmission lines would be approximately 70m off the ground and extend for about 179 km in the regions near the Baker and Pascua projects[296]. Observations of the flora and vegetation within the entire study area were characterized at different levels, from a regional view in Aysén, the basin area of the Baker and Pascua Rivers, and the land directly affected by the PHA.

The study concludes that the total area of influence for flora and vegetation is 7,085 hectares,

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[293] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 771.
[294] Ibid, p. 768.
[295] Ibid. p. 769
[296] HidroAysén, Environmental Impact Assessment, Chapter One p. 56

about 82.3% of the total project area. Approximately 3,809 hectares of this area were described as areas of environmental value (AVA), determined by the presence of species of conservation concern. Within the AVAs, 16 communities/plant associations were described and recognized by the following ecological criteria: state of successional vegetation, floristic uniqueness, and representation of the regional vegetation of forest and scrub structures.[297] Overall, in the area of influence, 299 vascular plant species were found, belonging to 78 families, three endemic to Chile and 12 of conservation concern. Of these species, 71 have restricted distribution to Regions XI and XII and comprise plant communities classified as forest, bush, meadow, wetland, or steppe.[298] The proposed Baker 1 and 2 site areas have a higher diversity of vegetation, primarily grasslands and shrubs, whereas the Pascua River area consists of more forest vegetation and wetlands. In general, the species richness of the Aysén Region decreases from north to south due to the presence of ice fields. The study area reflects this, as does the project areas. The Baker River contains the greatest variety of plant communities, with many introduced species and a greater degree of human intervention. Conversely, the Pascua River has a lower overall diversity of vegetation with little to no signs of human disturbance.

Baseline Studies of Terrestrial Fauna

The wildlife habitat of the Aysén Region is dependent upon the type of vegetation in the area. Therefore, the baseline study to determine the fauna found in this region is similar to the flora and vegetation baseline study. The objectives were (1) to characterize the terrestrial fauna of the area influenced by the PHA in terms of its richness, endemism, and conservation status and (2) to identify species of animals in different habitats within the PHA's area of influence, defining their location and distribution with emphasis on those under a conservation category.[299] The baseline study for the terrestrial fauna included an area of indirect influence, unlike in the study of flora and vegetation. The area of direct influence is where the physical activities of the PHA will directly impact the fauna including the hydroelectric power transmission system and infrastructure construction necessary for the completion of the projects. The area of indirect influence is where the activities or construction of the project could have some influence on the fauna, particularly less mobile species—small mammals, for example.[300] This area of indirect influence is defined as a buffer of 120 meters surrounding the outer edge of the area of direct influence as a reasonable distance to provide safety for small mammals.[301]

Within the areas of influence there are areas of environmental value that have been identified

[297] Ibid, p. 842-843
[298] Ibid, p. 843
[299] Ibid, p. 868
[300] Ibid, p. 869
[301] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 869

according to the following criteria:[302]

- Species richness—the total number of vertebrate species in an aquatic habitat or vegetation association
- Presence of species of conservation concern
- Presence of endemic species
- Presence of species with low tolerance to displacement—small fauna
- Presence of rare species—specific habitat requirements

These areas have been characterized regionally and according to the particular area of the proposed hydropower sites.

Within the areas of direct and indirect influence, the study enumerated the following species counts:[303]

Table 4- Species Counts Presented in the EIA

Site Location	Total Vertebrate Species	Amphibians	Birds	Mammals
Baker 1	120	5	102	13
Baker 2	122	6	103	13
Pascua 1	98	9	75	14
Pascua 2.1 & 2.2	112	9	89	14
Transmission System	128	10	103	15

In the basin areas, there is a high abundance of waterfowl that depends on submerged vegetation and mud for habitat, reproduction, and food. This is an example of the relationship the fauna have with the physical environment demonstrating how alterations to the riparian habitat could significantly impact the waterfowl. According to the research conducted, the

[302] Ibid, p. 887-888
[303] Ibid, p. 929-937

entire study area includes 50 species classified as of conservation concern. Of these 50 species, 29 are found in the Baker River and Pascua River basin areas where four are listed as endangered, nine vulnerable, two rare and six inadequately known.[304] These species consist of mammals, birds, and amphibians.

Project Impacts

Impact Evaluations
Identification, distribution and assessment of potential environmental impacts on the terrestrial flora and fauna are evaluated by HidroAysén based upon the results of the baseline study. The potential impacts could occur either during the construction phase and/or operation phase of the project. The construction phase includes the assembly of support facilities, infrastructure, central hydropower and the link electrical transmission systems in the regions near the Baker and Pascua projects. The evaluation of the PHA construction was associated with impacts on the flora and fauna, which in turn were assessed by their intensity, probability of occurrence, duration and reversibility. Floristic uniqueness and diversity of species were used for assessing the significance of environmental impacts. The floristic uniqueness index was determined by: conservation status, phyto-geographical source, and distribution in the regions of Chile for the vascular plant species. Ecological value is given to species of conservation concern, endemism to Chile, and native with distribution restricted to Regions XI and XII, all of which are used to determine the species diversity index. Environmental value areas include aquatic and terrestrial habitats that represent unique attributes of biodiversity and were used to assess the PHA's impacts. These areas are determined by the total number of species in various conservation categories along with the number of endemic, low mobility and rare species.

Flora and Vegetation Impacts
From the baseline study, there are 132 different plant communities in the PHA's area of influence, and 16 within areas of environmental value. Two levels of impact have been considered for the flora and vegetation: the loss or alteration of entire plant communities and the loss or alteration of individual plant species.[305] Impacts that have been estimated to involve the loss or alteration of two or more plant communities are considered to have the highest environmental significance. Overall, plant communities will be affected during both the construction phase and operational phase, but with varying severity.

Construction Phase
The loss of plant communities, resulting in the loss of ecosystem services and the loss of wildlife habitat would be the primary impacts during the construction stage. This involves the modification of resources and conditions necessary for the survival of present fauna, also

[304] HidroAysén, Environmental Impact Assessment, Chapter Four p. 942
[305] HidroAysén, Environmental Impact Assessment, Chapter Five p. 487

affecting future organisms that depend on these resources. Other services impacted by the disruption of the plant communities are the control of soil erosion and regulation of the hydrological cycle. The total area of vegetation loss due to the construction of the PHA is 3,240 hectares in environmental value areas.[306] 81.4% represent a permanent loss due to the construction of the dams, infrastructure and transmission lines. The other 18.6% of this area is a temporary loss associated with the construction of support facilities for which restoration is contemplated.

The overall nature of the PHA impact is negative because it involves the loss of plant communities in areas with and without environmental value. The probability of occurrence of these impacts is very high, with an extreme value of one, because the loss of vegetation is necessary and inevitable for the construction sites. Intensity is rated high because all aspects of the project involve a total loss of vegetation, due to the clearing of brush and vegetation indicated in the project description and implementation of the forest management plan. The total loss of plants implies a long-term duration of impact, which may or may not be reversible. Within the Baker River basin area, reversibility is more likely because it involves forests and shrub ecosystems that can be regenerated. However, impacts are irreversible in portions of the Pascua River basin area occupied by bogs and wetlands. Due to the fragile ecology and limited knowledge of these wetland ecosystems, there are no known regeneration techniques. Furthermore, the permanent upgrading and replacement of roads involve irreversible impacts that may affect 12 different plant communities.

Impairment of plant communities would also occur along the transmission line routes, due to the disruption of selective vegetation that is necessary for line construction. Construction operations involve cutting adult individuals that reach heights in excess of four meters.[307] These actions do not result in the total loss of the vegetation, but alters the plant in terms of structure and composition. This results in the alteration of biological relationships between the vegetation components. Overall, the construction of the transmission lines has a negative impact, high probability of occurrence, long-term duration of impact and is irreversible. However, intensity is described as low to moderate because it does not result in the total loss of the vegetation, just the alteration.

Operation Phase

After construction is complete, it is expected that the flora and vegetation would be impacted due to ongoing maintenance of the electrical transmission system. Existing plant communities would be permanently altered within the 65 m right of way for the 500 kV transmission lines of the link system[308]. Natural recovery of the vegetation is likely, but depends on the degree of intervention by pruning. Re-growth of the plants would not be allowed within a minimum safety separation of six meters between the foliage and the towers and electrical wiring.[309] The

[306] HidroAysén, Environmental Impact Assessment, Chapter Five p. 508
[307] HidroAysén, Environmental Impact Assessment, Chapter Five p. 541
[308] HidroAysén, Environmental Impact Assessment, Chapter One, p. 63
[309] HidroAysén, Environmental Impact Assessment, Chapter Five p. 569

maintenance activities would be performed frequently; therefore the probability of impact occurrence is extreme and long-term.

In general, the largest percentage of vegetation loss is projected to be associated with the reservoir areas created behind the dams. The PHA would not only impact the vegetation, but cause indirect effects such as loss of habitat for wildlife and decreased soil protection. Habitat loss is significant because it is one of the main causes of extinction and can also result in decreased genetic variability, which lowers the overall biodiversity of an area.

Fauna Impacts

Fauna affected during the construction and operation stages include: mammals, amphibians, land birds and waterfowl. The EIA does not consider reptiles in the impact evaluation because there were no individuals of this taxon found in the baseline study.[310] The fauna in the PHA's area of influence are assumed to be mainly affected by the loss of vegetation, which disrupts habitat. Habitat loss as a whole could result in the displacement and/or mortality of the wildlife. The construction phase results in habitat fragmentation and the presence of humans, while the operation phase is hazardous primarily due to transmission lines.

As a result of the construction and operation of the PHA, impacts on the fauna would occur over 4,496 hectares.[311] The most significant impact would be associated with habitat loss that could cause a change in community structure and ecosystems, resulting in a loss of biodiversity at the genetic and population levels. A loss in canopy habitat for birds should also be taken in consideration affecting over 1,066 hectares due to the maintenance of the transmission lines' right-of way. The terrestrial fauna would be impacted in multiple ways, directly through mortality and loss of habitat or indirectly through noise and human presence and changes in the plant communities or ecosystems.

Construction Phase

Several activities carried out during this stage would disturb habitats and individual animal species. The temporary and permanent measures of the PHA construction are expected to impact the fauna through habitat fragmentation by clearing the land in areas to be used, generation of noise by the use of machinery and explosives, human presence in places that had low population density prior to the construction, flooding of the reservoir areas, vehicular traffic- especially heavy machinery, and displacement from the power lines.[312] The effect of the construction on the fauna can be broken down into six categories, only one of which is positive:

<u>Impact by the components and facilities of the PHA</u>

The nature of this impact is considered negative due to the abundance of habitat loss. The probability of occurrence is extreme in all aspects of construction because the loss of terrestrial

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[310] Ibid, p. 601
[311] Ibid, p. 604
[312] Ibid, p. 602

habitats by clearing vegetation and flooding is a necessary condition for the construction process. It would have a high intensity resulting from a radical change in the surface vegetation. However, the intensity of impact for the construction of the transmission lines is deemed moderate because it is assumed to affect only the survival and reproductive rate of birds. Impacts from the construction of support facilities would last five years, but the impacts from the loss of habitat would be long-term. Referring to the permanent components of the project, impacts would be irreversible, but may be partly reversible at the locations of the temporary support facilities. It is also noted that some vegetation communities could be regenerated through reforestation to restore habitats. However, in the Pascua River area, the construction would affect wetland ecosystems and these results would be irreversible.[313]

Death and displacement of individuals

Direct mortality of individuals would result from the clearing of the land using heavy machinery, drowning when flooding the reservoirs, and constructing new roads.[314] These types of impacts have high significance especially if it affects species of conservation concern and endemism or species with low population sizes and low reproductive rates. These instances are viewed as negative due to the death of native fauna. There is an extreme probability of occurrence because mortality is inevitable during construction. In areas that include animals of low mobility with a lower chance of escaping, the intensity of impact is high, resulting in a long-term effect. Because mortality is inevitable, the impact is irreversible.

Behavioral disturbances of native fauna

The main focus is the effects from artificial lighting used during construction that will last 24 hours a day, noise of machinery from helicopters and explosives, plus the effect of human presence on wildlife. From previous research conducted by HidroAysén, it is found that noise can affect the physiology and behavior of animals and avoiding human presence can interfere with their useable energy spent on foraging and reproductive activities.[315] All of these activities can affect an animal's reproductive behavior. Thus, the impact made on the behavior of native fauna would be negative, but the probability of occurrence is moderate with a value of 0.5. The intensity of the impact is high due to the radical change from a calm and quiet environment to one with considerable noise and human presence. Duration of impact would be temporary depending on the length of construction within each sector. The impact is considered reversible; once the construction is complete, the environmental noise would return to its baseline.

Barrier effect on small mammals and amphibians

This impact could occur in all areas where the habitat would be fragmented. Constructing a barrier through a continuous environment impedes the mobility of organisms, which limits their ability for dispersal, migration and colonization. There would potentially be a reproductive loss

[313] HidroAysén, Environmental Impact Assessment, Chapter Five p. 612
[314] Ibid, p. 623-624
[315] Ibid, p. 640-641

and a modification in behavior of some species due to the avoidance of roads, people and other structures.[316] These barriers could also reduce the flow of individual genes and could create meta-populations that are subject to a higher probability of extinction. The impact has only been considered for small mammals and amphibians, because it is assumed that large bodied mammals or birds would move away from impacted sites. This impact would be negative due to the loss of gene flow and the probability of occurrence is high (value of 0.71), because interruption of habitat continuity is unavoidable. A high impact intensity is applied to species of low mobility with little ability to relocate. This impact would be a consequence of habitat loss, so the effect would be long-term.

Edge effect

This impact occurs when a habitat is fragmented and the biotic and abiotic conditions alter the surrounding areas. Edge effect would occur at the perimeter of the forest and scrub ecosystems adjacent to areas of vegetation loss associated with construction. The edge of these habitats would likely have higher temperatures, lower humidity, higher solar radiation and increased winds compared to the baseline, potentially modifying the abundance of species, changing the vegetation structure and lowering the food supply for wildlife.[317] The greatest effect would be on species living in the forests, reducing their reproductive success and increasing mortality by predation. Overall this impact is negative because the edge effect would likely lower the diversity of the region. The probability of occurrence would be high as a result of fragmentation of forests and scrubs which inevitably causes edge effect. Duration is expected as long-term and intensity would be moderate to high due to sensitivity changes in structural and microclimatic conditions. There is a possibility that these impacts would be reversible because the vegetation communities in some areas can be restored after abandonment.

Generation of new habitat for waterfowl

Among all the impacts presented affecting terrestrial fauna, waterfowl habitat generation is the only impact presented to have a positive nature. The reservoir areas of the Baker River and Pascua River sites would create new open water habitats. This presence of water resources can provide places for food, shelter and reproduction, mostly for waterfowl. The impact is considered as positive because the filling of the reservoirs involves the generation of new types of habitats and lake water for birds.[318] The probability of occurrence is high due to the fact that the generation of lake or reservoir habitats is a necessity for the PHA. Severity of impact would be high as a consequence of the significant increase in availability of aquatic habitats. These impacts would have a long-term duration as the dams are expected to operate for more than 50 years.

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[316] Ibid, p. 656
[317] Ibid, p. 664
[318] Ibid, p. 636-637

Operation Phase
Barrier and edge effects would also occur during the operation of the dams, due to habitat fragmentation associated with the construction phase. Impacts that may occur from the power lines are of more concern. Birds could collide with the lines or potentially be electrocuted, experiencing a greater impact during operation rather than during the construction period.[319] The impact of the power lines would be influenced by the following factors: biology of the birds and visibility of the cables in certain conditions. The biology incorporates age, social characteristics, migration characteristics, size/weight and distance of flights. Birds would be more vulnerable if they are young with little flying experience, social and fly in flocks, migratory, large with little maneuverability and/or take several short distance flights during the day. The visibility issue includes climate, time of day, and areas of habitat concentration. Most collisions would occur during dusk/dawn hours of the day and during the fall and winter due to precipitation, fog, and winds. Birds use the geomorphologic characteristics of the landscape as migration routes or corridors, and the towers may cause disorientation. Coastal and inland wetland areas would experience higher mortality rates because birds primarily inhabit in such areas.[320]

Mitigation, Reparation, and Compensation

HidroAysén identifies many impacts to the terrestrial ecosystems as a result of the Baker and Pascua projects. The most significant impacts would come during the construction phases of the individual projects.[321] Thus, they have proposed plans to offset the environmental effects of the project, which can be divided into mitigation, reparation, and compensation efforts.

Mitigation
Mitigation measures proposed were restriction on cutting vegetation, protection of the flora and fauna, rescue and relocation of animals, and prevention of collisions of birds with the transmission lines.[322] A detailed description of each follows, including a summary of the plan and the impacts to be mitigated.

Restriction on cutting vegetation
Restriction on cutting vegetation deals primarily with clearing vegetation near the transmission lines. HidroAysén plans to have a 6 meter boundary between any vegetation and the link power line structures, clearing an area for the towers but removing as little vegetation as possible.[323] This mitigation plan is cited for handling the following impacts:[324]

- loss of vegetation in areas of environmental value (AVA) that are in the area of direct

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[319] HidroAysén, Environmental Impact Assessment, Chapter Five p. 672
[320] Ibid, p. 689-693
[321] HidroAysén, Environmental Impact Assessment, Chapter Six p. 1
[322] Ibid, p. 75-76
[323] HidroAysén, Environmental Impact Assessment, Chapter Six p. 338
[324] Ibid, p. 75-76

influence of PHA
- loss of vegetation *not* in areas of environmental value (AVA) that are in the area of direct influence of PHA
- alteration of vegetation during construction of power lines
- alteration of vegetation during maintenance of power lines

Compliance to these measures will be documented by annual reports describing the vegetation affected prior to and after construction, as well as during maintenance of the power lines.

Protection of Flora and Fauna
The second measure, protection of flora and fauna, is much broader and is referenced widely throughout the EIA. HidroAysén would work with the Internal Regulation for Environment Protection (NIPA) in Chile to negotiate contracts for all activities performed during the construction phase of the project. These contracts would limit and regulate activities such as camping, fishing, and using material deposits found in the catchment area.[325] This plan would restrict removal of flora and/or fauna from the area, and forbid introduction of exotic, non-native species. Hunting of animals in the region would also be forbidden. HidroAysén plans to implement a training program on environmental education for workers that would teach the value of the environment and encourage conservation, protection, and discourage disturbing the wild areas where workers would be present.[326] A lecture series was proposed as well, with topics ranging from environmentally-friendly conduct, identification of rare flora species, and the negative impacts of non-natives species and human interference.[327] Lastly, the plan includes an activity for installing signage on the temporary roads to notify drivers that they are entering an "environmentally sensitive" area and should watch out for wildlife. This is aimed to lessen the expected mortality associated with low mobility species as they cross the roads.[328]

This measure is cited as a mitigation plan for every impact detailed in the terrestrial ecosystem section of the EIA.[329] The full list can be reviewed in the Project Impacts section. The compliance indicators for this plan include registering workers who have completed the environmental education training, and reporting on the implementation of signage on roads.[330]

Rescue and Relocation of Animals
The purpose for the rescue and relocation of animals is to minimize the loss of wildlife with low mobility, but would also include species that are endemic to Chile and those on the conservation list.[331] The effort would start prior to the start of construction in some areas designated as having "high biodiversity" such as bogs, prairies, forests and two areas in the

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[325] Ibid, p. 340
[326] Ibid, p. 341
[327] Ibid, p. 341
[328] Ibid, p. 342
[329] Ibid, p. 92-94
[330] HidroAysén, Environmental Impact Assessment, Chapter Six p. 343-44
[331] Ibid, p. 97

areas of the Baker 1 & 2 reservoirs where islands are forecasted to form in the inundation area (14 and 33 ha, respectively).[332] Several species of frogs, mice and other micro-mammals were identified from the baseline study for rescue/relocation.[333] The relocation sites would be selected based on proximity to fishing grounds, type of vegetation, sun exposure, etc. that most represent the area where the individuals were found. Animals rescued/relocated would be tagged with transponder tags and tracked monthly and seasonally as part of compliance with this mitigation activity.[334] This information would be recorded in an annual report.[335]

This mitigation plan is in response to the following impacts: loss of native vertebrates inside the AVAs, and loss of native vertebrates outside the AVAs.[336]

Prevention of collisions of birds and transmission lines

The 500 kV transmission lines would be approximately 70m off the ground and extend for about 179 km in the regions near the Baker and Pascua projects[337]. Birds flying in these areas could collide with the power lines, resulting in injury or death. The goal is to implement measures to decrease the likelihood of a collision between birds and the transmission lines. This can be accomplished by making the lines more visible with balls, buoys, fins, coils, etc. [338] These modifications would be made in areas of large bird populations within the area of direct influence of PHA.[339] The compliance measures for this plan include the generation of a specific study to determine sites for installation and reports on implementation measures.[340]

Reparation

The only reparation plan discussed in the EIA is with regards to the temporary restoration works required for the areas affected by PHA. Essentially, all the landforms, soils, flora/fauna, habitats, etc. must be restored to their original form after the temporary structures are disassembled once construction is completed.[341] The management techniques for restoring these natural areas are suggested as the following: removal and storage of soil, preparing the ground, re-vegetation techniques, and management of the vegetation.[342] Removal of the soil includes preparation measures like removing vegetation and collecting seeds; storage involves piling the soil to avoid compaction to retain its original characteristics.[343] Preparing the ground calls for leveling and remodeling the landscape to its original grade and improving drainage.[344]

[332] Ibid, p. 101
[333] Ibid, p. 99
[334] Ibid, p. 102
[335] Ibid, p. 102
[336] Ibid, p. 93
[337] HidroAysén, Environmental Impact Assessment, Chapter One p. 56
[338] Ibid, p. 104
[339] Ibid, p. 103
[340] Ibid, p. 104
[341] Ibid, p. 352
[342] HidroAysén, Environmental Impact Assessment, Chapter Six p. 353-54
[343] Ibid, p. 354-55
[344] Ibid, p. 357

The re-vegetation techniques mentioned in the EIA call for replanting select species found in studies to inhabit the region.[345] Such species would be replanted randomly in rows and groups at a density of 1667-2500 plants/hectare.[346] Management of the vegetation calls for protecting the recently planted flora from fire, grazing livestock, pests, and weeds.[347]

Compliance to these action plans would be monitored by an annual report to detail the following: percentage of soil restored, vegetation recovered, and presence of native flora and natural colonization in an area.[348]

Compensation

Incorporation of ecological criteria in the reforestation stage of the Forest Management Plan

The Forest Management Plan calls for reforesting approximately 4,500 ha of forest affected by the project to re-create the areas as close as possible to those cut down.[349] The goal will be to incorporate ecological criteria to match the original forest structure. Species of trees already identified for reforestation are lengas, cypress, evergreens, and *Coihue Magellan*, as they are all native species and will quickly regenerate.[350] "Micro-sites" for planting would be selected based on features that provide natural protection for new saplings. The new plants would also be protected from fire, grazing by livestock and wild animals, pests and diseases, and competition from weeds. The encroachment of alien species would also be monitored. Trees would be planted in groups to replicate natural growth, and organic matter may be added to the soil.[351] The proposal would be monitored by an annual report on its progress.[352] This strategy for compensation is cited for lessening the impacts for the loss of vegetation inside and outside the AVAs in the area of direct influence of PHA).[353]

Creation of a Conservation Area

A conservation area is proposed for the rescued and relocated species of flora and fauna should the PHA be constructed. The size of this conservation area would be approximately 5,800 ha, which is about the size of the AVAs, and would reflect the diversity of flora and fauna in areas affected by the project.[354] It was also stated that this area could serve a dual purpose and serve as a natural laboratory for scientific studies and investigations. As seen with the relocation of animal species in the Kariba Dam project in Zambia/Zimbabwe, the conservation area could also serve as a tourist destination[355]. In conjunction with creating the conservation area, a

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[345] Ibid, p. 365-67
[346] Ibid, p. 368
[347] Ibid, p. 370
[348] Ibid, p. 371
[349] Ibid, p. 77
[350] Ibid, p. 79
[351] Ibid, p. 80
[352] Ibid, p. 81
[353] Ibid, p. 76
[354] HidroAysén, Environmental Impact Assessment, Chapter Six p. 371
[355] *Kariba Dam Case Study*. Cape Town: Soils Incorporated (Pty) Ltd and Chalo Environmental and SustainableDevelopment Consultants, 2000. p. 66

Management Manual would be devised to define and regulate all actions and developments inside the area and would be publicized and sent to environmental authorities in Chile.[356]

The conservation area aims to offset any loss in vegetation and loss of habitat for native vertebrates in the areas inside and outside of the AVAs.[357]

Saving Germoplasms of Unique Species

Species that are endemic to Chile or have restricted habitats throughout Regions XI and XII are intended for preservation in this compensation plan.[358] The seeds of these species would be conserved and replanted in a reserved site that is representative of the natural environment where they were found. The extraction of these germoplasms would be performed in the spring and summer so that the plants would be easy to identify with care given to avoid damaging the saplings.[359] This process would be monitored via an annual report on the progress of the rescue and relocation of unique flora species.[360] This measure would be applied to reduce the impacts of the loss of species of unique flora that are and are not located in AVAs in the area of direct influence of PHA.[361]

Conservation and Sustainable Management of Cypress Trees

Though little is known of its ecology, Guaitecas Cypress trees (*Pilgerodendron uviferum*) are a popular building material in the region and are used frequently, which suggests that their use should be regulated.[362] The initial studies call for understanding the natural regeneration, growth, productivity, and habitat of Cypress trees.[363] This would be accomplished by monitoring three separate plots of 1,000 m^2 representative of their habitat[364] and by consulting experts to develop a forest management plan for the trees. Once significant knowledge is gained, it would be disseminated through lectures, workshops, and field visits.[365] There would also be a publication on the sustainable management of Cypress trees.[366] Similar to saving germoplasms, this measure would be applied to lessen the impacts of the loss of individual species of unique flora that are and are not located in AVAs in the area of direct influence of PHA.[367]

Study of the deer in the area of PHA

There are two main species of deer in Chile, the Huemul and the Pudu. Both are listed as

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356 Ibid, p. 376
357 Ibid, p. 93-94
358 Ibid, p. 81
359 Ibid, p. 85
360 Ibid, p. 87-88
361 Ibid, p. 76
362 Ibid, p. 88
363 Ibid, p. 89
364 Ibid, p. 90
365 HidroAysén, Environmental Impact Assessment, Chapter Six p. 91
366 Ibid, p. 91
367 Ibid, p. 76

endangered species due to disease, loss of habitat, and poaching.[368] By studying these deer, HidroAysén hopes to contribute to the general knowledge of the species and encourage their conservation. The company would implement a monitoring system to study their population trends and habitat use in the catchment areas of the project.[369] Compliance for this plan would occur through an annual report with distributed materials detailing the knowledge of deer populations and habitat use.[370] This mitigation plan was cited for the following impacts: Loss of habitat for native vertebrate fauna inside and outside the AVAs.[371]

Analysis of the EIA

There are several issues that have been raised with regard to the 2008 environmental impact assessment. The following is a summary of comments and criticisms of the EIA from various sources and compiled by CONAMA. Additional comments from this review are presented in the following discussion.

Baseline Study

The biggest issue with the baseline study presented in the EIA is that the accuracy of the baseline study is unknown. When conducting the baseline studies, rigorous scientific methods were not employed. In assessing the flora of the area, only 54 plots were used to survey an area of 180,000 ha. (This statement comes from the comments consolidated by CONAMA and published as the document *Informe Consolidado Nº 1 de Solicitud de Aclaraciones, Rectificaciones y/o Ampliaciones a el Estudio de Impacto Ambiental del Proyecto "Proyecto Hidroeléctrico Aysén"***.** The actual comment occurs in section 8 of the document presenting the comments from Dirección Regional de SAG Region de Aysén or the Regional Bureau of Agriculture and Livestock Service. The comment appears to have originated from a series of unclear comments within the EIA. Reference to 54 plots occurs twice in Chapter 4.[372, 373] The 54 plots actually refer to the number of stations investigated for the enumeration of mosses, lichens and fungi[374] and there were numerous other study sites investigated as part of the baseline study. However, the discussion in the EIA does not provide any details related to number or types of other sampling stations; this can only be clarified by reference to the original reports.) Similarly, only 23 days of fieldwork were performed to tabulate the fauna found in the area. Thus, it is difficult to assess whether the findings of the baseline studies are accurate.

There is not enough relevant information to evaluate the project; not all topics of importance

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[368] Ibid, p. 96
[369] Ibid, p. 96
[370] Ibid, p. 97
[371] Ibid, p. 76
[372] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 774
[373] Ibid, p. 812
[374] Universidad Austral, Determinación de la Línea Base de vegetación y flora terrestre para Proyecto Hidroeléctrico Aysén, July 2007, p. 143

are covered. Specifically, there is no description of the whole terrestrial ecosystem of the area of influence of PHA. This issue is a result of a lack of information and data gathering and a lack of analysis of the system from an ecosystem perspective. The interactions between flora and fauna of the area were not studied. According to comments compiled by CONAMA, "...the study does not provide detailed description from the ecosystem perspective, nor has it defined the Areas of Environmental Value from this perspective. These omissions are not only due to the lack of information on the flora and fauna, but also to the absence of a critical analysis from said perspective, which would permit the recognition and environmental evaluation of protected wilderness and other ecologically co-dependent areas." [375]

Impacts

There are also several issues with respect to the impacts discussed in the EIA. First, it is unknown whether native plants will be able to re-vegetate areas where soils have been moved, compacted, polluted, or otherwise disturbed during the construction phase. Second, the "barrier effect" of roads are only discussed in the context of the Pascua 2.2 project; but completely ignored for the other projects. Even narrow roads can provide a significant challenge for lower mobility fauna to cross; reduced mobility can cause higher difficulty in finding food and escaping predators. Finally, high mobility species, such as large mammals and birds, are almost entirely ignored when considering the impacts of the projects because it is assumed that they can move easily to another area. However, many of the species considered to have high mobility do, at some stage of their lifecycle, have low mobility. For example, eggs, hatchlings, and newly born mammals all could be adversely affected by the projects.

During the construction and operation phases, HidroAysén has declared areas that would directly and indirectly influence the fauna of the region. However, the description of the area of indirect influence is unclear. It is apparently intended to protect species with low mobility, such as small mammals and amphibians or reptiles. HidroAysén does not consider birds and larger mammals for indirect impacts since they believe these animals have the ability to escape the construction and other activities of the PHA. Consequently, the area of indirect influence is considered to be a buffer zone of 120 meters from the outer edge of the work for PHA. HidroAysén considers this delineation a reasonable distance for the safety of low mobility animals because some species range of movement is within an area of 63x63 square meters[376] (120 meters representing a factor of safety by approximately doubling the 63 m dimension). There is no reference for their calculation of the buffer zone and this space is likely inadequate because not all species exhibit the same mobility patterns. It is also unclear where this buffer would be placed and whether or not it would be a continuous area. In addition, the purpose and function of the buffer zone is not clearly identified.

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[375] Informe Consolidado Nº 1 de Solicitud de Aclaraciones, Rectificaciones y/o Ampliaciones a el Estudio de Impacto Ambiental del Proyecto "Proyecto Hidroeléctrico Aysén, Comments from SERNAGEOMIN (National Service of Geology and Mining) in comments on Chapter 4 - Linea Base, B - Areas Protegidas

[376] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 869

Mitigation, Reparation, and Compensation
The mitigation plans appear thorough and incorporate compliance indicators. Several reports would be created as a way to study the area and the effects of construction. However, as was mentioned in the sedimentation and aquatic ecosystems sections of this report, it is the opinion of the authors that HidroAysén's plan to implement the PHA and then commit to studying the effects on the local environment is irresponsible and not in the best interests of informing a sound decision on these projects. The purpose of an EIA is to give an overview of the current state of the environment and how the proposed projects will affect the status of that environment. While committing now to an investigation of ecosystem function is an appropriate gesture on HidroAysén's part, studies of this nature should be included in the environmental baseline study of the EIA, not a project for post construction.

Offering environmental education lectures[377] (to protect flora and fauna) appears to be a positive way to inform the workers about the value of preserving the environment and minimizing their presence. The efficacy of posting signs along roads through "environmentally sensitive" regions[378] to protect flora and fauna is debatable. HidroAysén anticipates the inevitable increase in animal mortality from vehicle traffic but provides a weak mitigation plan. In the mitigation plans for rescuing and relocating animals[379], only low-mobility animals (amphibians and micro-mammals) were mentioned[380], indicative of the assumption that animals of higher mobility will independently leave the area as construction starts. Though this is likely true to an extent, the high-mobility animals will not be tagged and tracked to investigate possible negative impacts.

The reparation plans seem appropriate for returning the lands to their natural state after the temporary buildings and structures are removed. Replanting these areas with native species found in the region[381] is a logical and necessary step to restoring the land. The plans mention protecting the newly planted flora from fire, grazing, weeds, etc.[382] which is necessary to establish roots and thrive in their new environment, but seems like a major commitment of manual labor. The plan calls for manual weeding to reduce competition for nutrients, and monitoring performed a couple times per year.

One of the key omissions of the terrestrial ecosystems analysis relates to the plans for restoration of soils in areas disturbed by construction activities. Although measures to store and remove soils are mentioned in the reparation plans[383], there isn't an analysis from the environmental perspective on what could happen to them during the construction phase. Soils

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[377] HidroAysén, Environmental Impact Assessment, Chapter Six, p. 341
[378] Ibid. p. 341
[379] Ibid. p. 96
[380] Ibid. p. 98-99
[381] Ibid. p. 77
[382] Ibid. p. 80
[383] Ibid. p. 17

are a vital part of the terrestrial ecosystem and help determine what will grow and flourish.

The creation of the conservation area[384] and saving germoplasms[385] of unique flora are important compensation measures. The conservation area is a good plan to help protect the relocated flora and fauna. This action is also mentioned as a compensation for aquatic ecosystems (with the same area of 5800 ha mentioned[386]), but the exact breakdown of terrestrial/aquatic space distribution is not mentioned, so it is unclear if this conservation area is the same for both of the ecosystems. An area of 4,500 ha was mentioned for reforesting trees specifically[387], but no link was made between this and the conservation area. As for saving germoplasms, this seems like the easiest way to preserve a species without up-rooting and transplanting the vegetation. Planting from seeds will take more time and care to establish in a new area. Compensation plans involving Cypress trees[388] and deer[389] will add to the general knowledge of each species, which both lack.

The EIA presents no concrete plan to protect areas where the existence of rare or endangered species is likely. For example, nesting sites for birds can be sensitive to human activity. There is no mention of these sites in the EIA. Finally, disruption of existing wildlife by relocated wildlife is not considered. A significant increase of certain predatory animals, in a small area, can have a negative impact on the equilibrium of the ecosystem. Relocation areas are not specified; thus, it is impossible to know whether relocation will have a significant effect on the existing ecosystem.

Conclusions

Overall, we believe that the assessment of environmental impacts of the dam projects on terrestrial ecosystems, as presented by HidroAysén in the EIA, is informative but substantially lacking in key areas. In some areas, such as animal rescue efforts and germoplasm conservation efforts, the EIA is very detailed and contains useful information. However, some broader issues are more questionable. The accuracy of the baseline studies is questionable due to somewhat unreliable methods of data collection, which makes analysis difficult. As the EIA did not take a wide "ecosystemic" perspective when analyzing different effects, localized effects on flora and fauna could have larger consequences than anticipated. Unfortunately, there is not enough data or understanding within HidroAysén's reporting on terrestrial ecosystems to anticipate these consequences.

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[384] Ibid. p. 76
[385] Ibid. p. 81
[386] Ibid. p. 260
[387] Ibid. p. 77
[388] Ibid. p. 88
[389] Ibid. p. 95

Community Impacts

Introduction

According to the Rules of the System of Environmental Impact Assessment (SEIA), "the human group is: a group of people who share a territory in which they interact constantly, giving rise to a system. Life consists of social, economic and cultural rights, which eventually tend to tradition, community and feelings of attachment."[390] An assessment of the EIA with respect to human and community impacts must evaluate the success of efforts to provide a complete baseline study, determination of potential project impacts, and a thorough, thoughtful approach towards mitigation. This section will first provide an evaluation of the EIA based on the discussion of four major human impacts within the EIA; social disruption, impact on local economy, resettlement, and transportation. An overall assessment of the quality of the EIA will follow. A brief overview of relevant case studies will provide insight on the potential impacts of the PHA installation. It will close with a discussion of the cumulative impacts of the PHA and its relation to sustainability.

Information Provided by the EIA

The Aysén region has a population of 91,492[391] with an average of 0.8 inhabitants/km^2.[392] Nearly 65% of the population in the region is between ages 15-64 representing a large sector of economically active individuals. The economy is "linked to the use of natural resources such as aquaculture, livestock, forestry and mining,"[393] with an emphasis on livestock and silvoagropecuaria (stewardship and wise use of natural resources). The scale of these practices at present is commensurate with the size of the population in the region. The human activity within the Aysén region creates an intentional microcosm of individuals living a more spartan lifestyle and there is great pride among constituents in the "Patagonian way of life."

Social Disruption

The incidence of social disruption due to the installation of PHA would begin with the influx of workers during the project; The influx of 5,000 workers (at peak capacity) to the campsites would affect nearby residents of Cochrane, population 2,867[394], by altering access to municipal goods and services as well as introducing a potential for social unruliness. The EIA states that a separate set of infrastructure and services (i.e. health, dental) would be privately provided to workers to avoid interference with resident access to goods and services currently provided.[395] The EIA also claims that construction camps would be self-sufficient entities such that workers would not enter communities and cause social disruption. A proposed mitigation is the

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[390] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 1137
[391] Ibid. p. 1221
[392] Ibid. p. 1160.
[393] Ibid, p. 1327.
[394] Ibid, p. 1218.
[395] HidroAysén, Environmental Impact Assessment, Chapter Six, p. 136

inclusion of a "program to control the residence and behavior codes for the PHA workers in the area of the project's influence"[396] to include confined camps with onsite entertainment, regulation of worker transit and behavior, efforts to avoid permanent worker settlement, sanctions to contractors whose workers fail to abide by codes, motorized vehicle control, social monitoring/register of problems, and educational campaigns to discourage poor behavior.

Impact on the Local Economy

The EIA defines a set of five impacts on the local economy, four of which are determined to be positive in nature and one negative impact. All of these would be confined to the construction phase of the project and all are judged to be of low or no significance. Positive impacts would be:

- Increase of local commercial activity including provision of services.[397] The presence of additional population in the region is expected to promote business activities in the nearby towns.
- Generation of direct employment.[398] Statistics on the expected number of workers required during the project construction are provided, broken down into classifications of skilled, semi-skilled, and non-skilled workers.[399] The issue of whether skilled workers are available in the region is not addressed but it is stated "the work force will come, with a high degree of probability, from Coyhaique and the towns of Chile Chico, Cochrane, O'Higgins, Tortel, and Rio Ibanez in proportion to their populations. "[400]
- Generation of indirect employment.[401] This is associated with the provision of support services for the increased population; no estimates of the additional employment to be gained are provided.
- Increase of municipal income.[402] This increase would come from increases in motor vehicle fees, driver's licenses, building permits, etc. due to the increased population in the region.

The one negative impact was assessed to be an increase in the price of firewood[403] but this was judged to be of low significance. Since firewood is the dominant source of heating in the region, this impact was reasoned on the basis of supply/demand economics and no further analysis was developed to provide more than the conceptual reasoning.

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[396] Ibid. p. 133
[397] HidroAysén, Environmental Impact Assessment, Chapter Five, p. 955
[398] Ibid. p. 958
[399] Ibid. p. 960
[400] Ibid. p. 960
[401] Ibid. p. 963
[402] Ibid. p. 970
[403] Ibid. p. 966

Resettlement
The PHA would require 14 families to be permanently resettled and 15 families to be relocated within the same property.[404] HidroAysén states its intention to provide the affected families with housing that is equal to or better in quality than their current housing. There is a detailed description of the type the homes they will offer: they will be $70m^2$ (larger than the typical existing home sizes), contain three bedrooms, a kitchen, and an interior bathroom, and possess a woodstove and other necessities. They ensure that sanitary services, water and electricity would be accessible at the new locations.

Additionally, the EIA presents a plan to mitigate the economic and psychological impacts of resettlement. In their Program for Economic Support, HidroAysén says that they would provide both a food and a "productive" allowance for the first 24 months after resettlement, which they consider to be enough time for the families to re-establish normal economic activities.[405] The allowance is greater than the amount of similar government subsidies and higher than the average cost of living for rural people in the country. Resettled families would have access to a team of PHA representatives who will work with families to resolve inconveniences and settle disagreements.

Transportation
Route 7 is currently the only road connecting Coyhaique in the north and Cochrane, Villa O'Higgins, and Caleta Tortel in the south. The road is paved from Coyhaique to the town of Cerro Castillo, and then continues as a gravel road.[406] The region's port and airport infrastructure are similarly underdeveloped. In order to build the dams, HidroAysén would need use this public transportation network to bring in large quantities of materials, goods and equipment. Route 7 would also be used for the frequent transport of personnel between worksites and the airport in Balmaceda. For these reasons, HidroAysén plans to build new roads and to improve the quality of some existing roads and bridges, including paving certain sections. These new and improved roads would then be available to the general public.

Analysis of the EIA

Social Disruption
The range of proposed mitigation measures is broad but there is insufficient depth in the descriptions to provide confidence in its efficacy or the seriousness with which HidroAysén intends to address the issue. There is insufficient information to assess the provision of municipal services to the camps, as pointed out by SEREMI de Vivienda y Urbanismo (Regional Ministry of Housing and Urban Development), Región de Aysén, "There are no specific plans for setting up the camps…vehicle access, drinking water, sewage treatment system etc. for Camp

[404] HidroAysén, Environmental Impact Assessment, Chapter Five, p. 195
[405] Ibid, p. 202-203.
[406] HidroAysén, Environmental Impact Assessment, Chapter Six, p. 124

del Salto area is not indicated."[407] They additionally point out that although there are plans to isolate construction workers in camps, there would be an influx of professionals working on the project who would move to Cochrane with their families. These individuals would increase demand for municipal services within the town (education, health, safety, transportation, etc.) The nondescript explanation of plans to address social behavior by workers is insufficient to prevent negative impacts that would occur with even the best implemented plans. Significant health implications would accompany the influx of a predominantly young male workforce; SEREMI de Salud (Regional Ministry of Health) lists among these; more alcohol consumption, drug addiction, violence, increases in youth pregnancy, and increases in sexual transmission of HIV/AIDS.[408] The most grievous omission is consideration of the long-term, irreversible changes the PHA would have on the way of life for the Patagonian people by opening up the region to unchecked development. Realistically, if the project is implemented the social structure would reach some new equilibrium, but it will likely be unstable, unsustainable, and unrecognizable from the unique social structure that exists at present.

Impact on the Local Economy

Mitigation plans for local economic impacts are sparse. The main economic concern addressed in the EIA is firewood prices. Because firewood is relatively cheap and widely available in the region, it is by far the most widely used source of fuel. To avoid causing price fluctuations, HidroAysén plans to import to the region all of the wood that they use (so as not to affect local demand) and offer firewood free of charge to elderly and poor families.[409] This plan, as it is presented in the EIA, seems poorly considered. They do not outline any specific parameters for who would receive firewood, and have not studied the local market well enough to know how much firewood they should distribute to avoid price fluctuations. An arbitrary distribution of firewood could cause prices to fall, thereby harming those whose livelihood depends on its sale. Conversely, any rise in firewood prices would create a significant financial strain for the local population, especially in the winter when large quantities of fuel are necessary for survival.

Additionally, the EIA's list of economic impacts is too narrow in scope. Besides firewood, there are a number of other goods whose prices would be impacted by the project implementation. The Regional Ministry of Housing and Urban Development (SEREMI de Vivienda y Urbanismo, Región de Aysén) comments that the EIA does not sufficiently address fluctuations in prices for housing, land, and food. Many citizens have pointed out that land and housing prices are already beginning to rise in response to HidroAysén's property acquisition. They worry that this might eventually lead to a situation where prices become too

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[407] Señor Alexis Lorenzo Saavedra Naranjo, *Oficio Nº 449 Solicitud de Evaluación del Estudio de Impacto Ambiental del Proyecto "Proyecto Hidroeléctrico Aysén*. SEREMI de Vivienda y Urbanismo, Región de Aysén (Coyhaique: SEREMI, 7 October 2008) 1 h.

[408] Señora Marcia Osses Báez. *Oficio Nº 449 Solicitud de Evaluación del Estudio de Impacto Ambiental del Proyecto "Proyecto Hidroeléctrico Aysén."* SEREMI Secretaria Ministerial de Salud, Región de Aysén. Aysén: SEREMI, 7 October 2008.

[409] HidroAysén, Environmental Impact Assessment, Chapter Six, p. 130.

high for the local population to afford, or where the region's inhabitants are tempted to sell their land and migrate to cities. The Santiago Times reports that land prices are already beginning to rise due to HidroAysén's land acquisition in anticipation of project approval. The purchase of nearly 7,000 acres at around US$1,000 per acre (a major inflation from the previous market price between US$250-US$430) has already caused an increase in land values and excluded lower income families from entrance into the housing market.[410]

The EIA also fails to address the demand for goods and services that the workers will generate. As noted by the Housing and Urban Development ministry, the camps would need to provide food, clothing and other goods to their workers. From the EIA, it is not clear if they plan to import these items, or if they would buy them locally. Local acquisition would benefit vendors, but might also lead to inflation. Overall, the EIA does not address the cumulative rise in the cost of living that would result from the project's construction.

Finally, the EIA gives only cursory attention to the project's impact on local employment markets. Because unemployment in the region is currently very low, it is likely that the project's high-paying jobs will draw workers who are already employed away from their current occupations. This could lead to a vacuum of labor in other sectors of the economy. Furthermore, the regional ministry of health notes that workers who migrate to the region for the project may choose to remain after its completion, thereby saturating local employment markets and creating a much higher level of unemployment.

Resettlement

Although HidroAysén outlines a "Program of Communication and Information"[411] to inform families of the resettlement process, the Health Ministry has criticized the EIA for not providing sufficient information about the location of the new properties. In particular, the report does not address the productive resources that would be available at the new sites. Thus it is not clear that the displaced individuals would be able to find work at the new locations and be able to maintain their old way of life. This calls into question the assertion that they will be able to retain the same standard of living after resettlement, especially after conclusion of the 24-month financial support period.

Another concern is that the prices assigned to homes, equipment, infrastructure and animals to compensate for their loss were arbitrarily determined. Several of the citizens who commented on the report called for an independent assessment of the value of the property that would be destroyed or lost, rather than allowing HidroAysén to be the sole judge.

In Chapter 5, the report also describes numerous family cemeteries and historical sites that would be inundated if the projects are completed. To address these impacts, they have proposed to exhume the bodies currently buried in several cemeteries, and to move them to a

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[410] *Chile: HidroAysén Pushing Prices Up in Cochrane.* The Santiago Times. 19 February 2009.
[411] HidroAysén, Environmental Impact Assessment, Chapter Seven, p. 86

location specified by their living relatives. Additionally, they plan to build a “Cultural Diffusion Center”[412] in Cochrane, where they would display photographs and documentation about historical sites that were flooded, and to build commemorative plaques for the cemeteries and other sites that were lost. Some citizens, along with the Health Ministry, criticized these plans as insufficient, since the loss of a sacred or historical site is irreversible and cannot be compensated.

There are also concerns about the disruption of organizational and social networks for the resettled people, and the psychological impact of being uprooted. Several of the citizens who commented on the report pointed out that they have been living on their properties since the 1940s, and that they have carried on traditions associated with the “Patagonian Way of Life” of their ancestors, the region’s original colonists. The plan for resettlement does not take into account the loss of social, economic and cultural relations caused by displacement, and it does not guarantee that they will continue to have access to communal infrastructure.

Furthermore, many of the citizens and agencies argue that the EIA does not accurately identify all of the people that would be displaced or affected by the inundation. Some of the citizens, particularly those who live directly upstream of the projects, were concerned that HidroAysén may have miscalculated the reservoir’s boundaries and that their land, too, would be flooded. Also, several people pointed out that they had family cemeteries within the reservoirs’ boundaries, which were unaccounted for in the EIA.

Additionally, the Health Ministry noted that many more people might be obliged to leave their homes during and after the project’s construction than the number of families who are initially displaced. Additional displacement could be caused by environmental disruption (due to noise pollution, increased traffic, or increases in suspended dust near the roads), or due to economic or social disruptions caused by the dams.

Transportation

The increase of traffic flow on Route 7 would have numerous impacts on the local community, and many of these are not considered in the EIA. The Regional Ministry of Transportation and Telecommunications (SEREMI de Transportes y Telecomunicaciones) has commented that travel along Route 7 and other roads would become more difficult and dangerous. Many of the citizen commentators have also pointed out that it is common for farmers and ranchers to transport their livestock along the road. With increased traffic flows, the risk for accidents would be much higher for the animals, their owners, and the drivers.

Additionally, the agency and citizen commentators found that the EIA lacks detailed analysis of this change in traffic flow. The EIA references a “system to control transit of vehicles,”[413] but it is vague in describing measures HidroAysén would take to mitigate the risk for congestion or

[412] HidroAysén, Environmental Impact Assessment, Chapter Five, p. 147.
[413] Ibid, p. 137

accidents. In particular, the company would need to transport roughly 500 passengers between the Balmaceda airport and the worksites every time there is a shift change, yet they have not detailed their plan for transporting such a large number of people.[414]

The EIA gives only cursory attention to the impact of increased traffic on the quality of life for people living near the roads. Some citizens expressed concern about the impact of suspended dust on the health of those who live near the road, particularly the elderly. The study acknowledges this impact and proposes to irrigate the roads, but it does not specify how, where, and how often this would be done. Furthermore, the transport of materials and people would create noise pollution for those living nearby. With the frequent circulation of trucks and heavy machinery, along with helicopters moving overhead, noise pollution could have a significant impact on quality of life in the area. As many citizens have commented, there is already a great deal of noise pollution related to the PHA, and HidroAysén has not taken any steps to address this. Although noise pollution is mentioned in the EIA, it appears that HidroAysén has no plans to mitigate the effect or compensate the local population.

Overall Assessment of EIA with Respect to Community Impacts

It is our opinion that the EIA does not properly address the implications of the project from a human perspective. This failure can be attributed to multiple factors, the first of which being that this type of document is not well suited to address subjective matters of human well being. A fair attempt was made at quantifying geographic, demographic, and economic data relevant to human affairs but this data is insufficient to illustrate the lifestyle and identity of people living within the PHA area of influence. Those affected would be better represented through a document prepared using community-based participatory research to create an equitable collaboration between community members and formally trained research partners. Including affected parties in the research process would ensure that important issues as defined by those impacted receive proper attention. Decision makers would benefit from this measure by receiving a more complete, less biased document that incorporates a discussion of the intangible effects of the project. The research process to prepare the baseline study did incorporate resident consultation through the use of a “snowball” method to identify a total of 164 key informants by “making contact with a limited number of people in the study area who provided contact with others…”[415] We find this method exclusive and insufficient to represent the entirety of the population.

The volume of the discussion of social impacts within the EIA was extensive but lacked detail with respect to significant impacts/mitigation measures. The size and layout of the document made it difficult to find and synthesize relevant information. Separating the document into

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[414] Señora Alejandra Aguilar. *Oficio Nº 449 Solicitud de Evaluación del Estudio de Impacto Ambiental del Proyecto "Proyecto Hidroeléctrico Aysén."* SEREMI de Transportes y Telecomunicaciones, Región de Aysén. Coyhaique: SEREMI, 7 October 2008.
[415] HidroAysén, Environmental Impact Assessment, Chapter Four, p. 1148

baseline, impact, and mitigation chapters impeded the ability to follow a single impact (i.e. price of firewood, social impacts of workers) from baseline to mitigation. For its overwhelming length, it is surprising that relevant information such as specific plans for worker camps and a resettlement budget are not included. We should acknowledge that information we believe to be omitted may be in the document but difficult to locate; this is a valid criticism of the document as well. The document is inaccessible for uneducated readers and lacks necessary clarity for decision makers to evaluate the impacts of PHA. We acknowledge the fact that EIAs are prepared with the intention of earning development permission but feel that there is dishonesty in failing to present material clearly, whether intentional or not.

A final criticism of the prepared EIA with respect to the human impacts is the fact that the document lacks force of law with respect to mitigation measures. HidroAysén does not voluntarily create any enforcement mechanism to ensure that mitigation measures are completed. Alternatively, the vagueness of mitigation measures places in doubt the commitment of HidroAysén to corporate social responsibility. If PHA is built, there will be significant social impacts that persist long after the project has turned a profit. Residents deserve a framework that allows a mode of potential recourse if HidroAysén does not adhere to mitigation plans. There are procedures in the United States that permit residents to pursue proper mitigation provision such as the use of a community benefits agreement (CBA), "a legally enforceable contract, signed by community groups and by a developer, setting forth a range of community benefits that the developer agrees to provide as part of a development project."[416] The challenge in implementing a similar process in this scenario (in addition to potential differences between legal systems) is that it is difficult to perform any kind of community organization due to the widely dispersed nature of the population. Efforts should be made to establish a mode of recourse for affected parties, regardless of the difficulty to achieve such a measure.

Comparison to WCD Case Studies

Pak Mun

The Pak Mun Dam was built on the Mun river in Thailand from 1991-1995 by the Electricity Generating Authority of Thailand (EGAT). With a total installed capacity of 136 MW, the Pak Mun project is significantly smaller in scale than the PHA which has an anticipated installed capacity of 2,750 MW. Despite the Pak Mun project's reduced scale relative to the proposed PHA, many significant social impacts have resulted from the project. The Pak Mun case demonstrated an underestimation of social impacts related to the dam installation. An environmental impact study (EIS) was prepared for the Pak Mun Dam project in 1982. A plan revision in 1989 altered the design and location of the dam presented in the 1982 EIS, but no revision or new study was completed. The new design reduced the expected extent of displacement from an estimated 20,000 persons in 4,000 households to 1,500 persons in 248

[416] The Partnership for Working Families, "Community Benefits Agreements (CBAs)," http://www.communitybenefits.org/article.php?list=type&type=39, accessed April 1, 2009

households. When the dam was installed it ultimately displaced 238 homes during construction and an additional 705 homes after impoundment. An additional 6,202 households permanently lost income from fisheries, an impact that was not anticipated by the EIS.[417]

The mitigation plan was insufficient in scope and manner, most likely because the baseline was incomplete. The estimated cost of compensation and resettlement in millions of US$ (1996) was 22.4 while the actual cost was 32.3.[418] Much of this additional cost was paid to individuals who suffered from damages to fisheries, a vital source of food and income. Failure to include all parties affected by the project was a serious omission in the baseline study. The loss of access to productive land/waters led to outsourcing of jobs and urbanization. A large part of the compensation effort was monetary (about 66%) and insufficient to address the needs of displaced individuals and those who lost their livelihoods. As the case study authors note, "it is well established that a one-time cash compensation cannot substitute a permanent and sustainable source of livelihood, which in this case is the fisheries."[419]

This case highlights the common error of severely underestimating the area of influence for a dam project which is costly to people in the area of impact in a physical and social sense as well as to the developer in a budgetary sense as they must devote more money to mitigation measures. This case further demonstrates the problems that result when the people directly impacted by the project are not given complete consideration or inclusion in project planning. According to the case study prepared for the World Commission on Dams, "The history of the Pak Mun project is the history of the struggle between the affected people and EGAT over the right to livelihood and the right to the environment upon which the affected people depend for their living, and not over fair compensation."[420]

Kariba

The Kariba Dam was a project constructed by Zimbabwe and Zambia on the Zambezi River from 1955-1959. The dam was constructed to provide hydropower to the two countries and have an installed capacity of 1,320 MW, about half as large as the proposed PHA. Project construction displaced approximately 57,000 Tonga people[421], an inconsequential part of the process according to developers due to the prevailing racist sentiment of the time. According to the authors of the WCD case study:

> "Generally, the losses experienced by displaced communities were all encompassing – economic (land), political (autonomy), social and psychological (the social fabric was

[417] Amornsakchai, Sakchai, Philippe Annez, Wanpen Wirojanagud, Ek Watana, Suphat Vongvisessomjai, Sansanee Choowaew, Prasit Kunurat, Jaruwan Nippanon, Roel Schouten, Pradit Sripapatrprasite, Chayan Vaddhanaphuti, and Chavalit Vidthayanon. *Pak Mun Dam, Mekong River Basin, Thailand*. Cape Town: World Commission on Dams, 2000 p. 14
[418] Ibid. p, 20
[419] Ibid. p. 113
[420] Ibid. p. 13
[421] World Commission on Dams, *Kariba Dam Case Study,* (Cape Town: World Commission on Dams, 2000) p. 25

> torn apart and people were separated from relatives on the Zambian side) and cultural (loss of shrines or cultural property in general). The benefits (schools, clinics, infrastructure, etc.) were by far outweighed by the losses indicated above. This was not a surprise, since the relocated communities were not meant to benefit from the project."[422]

Resettlement of displaced peoples was not given priority and mentioned only as an administrative expenditure. No environmental impact assessment was created for this project.

The Tonga people had longstanding strong ties to their surroundings including an economy based on, "riverine and upland farming, livestock rearing, hunting, fishing and manufacturing."[423] Many of these practices relied heavily on the flood patterns of the river system and the Tonga had to switch to monoculture production when displaced to areas with less productive soils. Those displaced were not consulted in the planning stages of the project and were forced to evacuate their land against their will in a haphazard manner such that they felt "treated like animals or things."[424]

This case highlights the importance of community involvement and consultation in project preparation. It also serves as a cautionary tale that when individuals living within the area of impact are not considered as beneficiaries of the project, they often end up as casualties of a development that serves to benefit others. This is a potential danger in the case of the PHA. The power generated by PHA will be sent to Chile's central grid (SIC) that does not service the region in which the project would be built. As the Kariba case study demonstrates, there is little incentive on behalf of the developers to act with social responsibility towards those who will bear the burden of project development. The historical inequity of cost/benefit distribution in large scale hydropower developments deserves consideration when evaluating the social impacts of the PHA.

Cumulative Impacts and Sustainability

For development to be sustainable, it is vital to consider the cumulative impacts of projects like the PHA over time. Accordingly, the EIA's narrow time frame is one of its most crucial shortcomings. By opening up the Aysén region to industry, the PHA would pave the way for other energy-intensive companies to set up operations in Aysén and throughout Patagonia. Over time, this domino effect could have a much more far-reaching impact on the local population than the PHA's immediate effects.

The case of the Grand Coulee Dam is illustrative of the potential for a dam to spur unchecked development. Grand Coulee rendered the Columbia River accessible for numerous other hydropower projects. Since Grand Coulee's construction, over-damming has had a number of

422 Ibid. p. 46
423 Ibid, p. 26
424 Ibid. p. 38

unanticipated and irreversible effects, not only on the ecosystem, but also on the region's culture and economy. For the local population, the dam's cumulative impact was the economic marginalization of the indigenous population, a transformation of local agriculture and fishing activities, and the loss of a pristine environment.[425]

In Aysén, there are already signs that the PHA could have a similar effect. Installation of a large energy generating project and its associated power transmission lines make the area attractive for development by other small power companies and industries. Of the water rights held in the Aysén region 96% are for con-consumptive uses and 99.4% of those are for hydropower production.[426] Companies like ENDESA have been developing plans to build dams along many of the region's untapped rivers. Another hydroelectric project, the Cuervo Project[427] is essentially a resurrection of the former Alumysa project that was shelved in 2003 and may still be used for supporting an aluminum reduction plant. Such unchecked growth is unsustainable within a region that does not have sufficient natural resources or social infrastructure to support the accompanying growth in population that increased development would bring.

Conclusions

From HidroAysén's perspective, it is understandable that they would not choose to assess the cumulative impact of their proposal. Additionally, the World Commission on Dams report demonstrates that it is difficult to anticipate a dam's indirect consequences. However, it is vital that decision-makers who are concerned with sustainability consider projects' cumulative impacts. Only by taking into account the potential long-term consequences can an accurate estimate of the PHA's costs and benefits be obtained. For the local communities of the Aysén region, the PHA could be the first step in a profound and irreversible transformation of their economy, society and culture, and these long-term costs must be incorporated into any assessment of the project at large.

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[425] World Commission on Dams. *Grand Coulee Dam and the Columbia Basin Project USA*. Capetown, South Africa: Secretariat of the World Commission on Dams, 2000, xiv, xv, 169.
[426] Segura, Patricio, Coalición Ciudadana por Aysén, Reserva de Vida. *Represas en Aysén, Reserva de Vida*. Presentation in Coyhaique, March 2009.
[427] Witte, Benjamin. "XSTRATA inks deals with Transelec for Chile power line." *The Santiago Times*, July 9, 2008

Tourism

Introduction

The tourism industry in Aysén, Chile is still in its early stages of development. This section of the paper will review the current state of tourism in the Aysén region, estimates of how the proposed hydroelectric dams would affect the tourism industry during the construction phase, and how tourism would be affected in the post-construction/operation stage of the hydrological projects. This analysis is structured in four key areas: economic, regional tourism planning initiatives, infrastructure, and the intrinsic value of nature. It also includes a section of criticisms or information missing from the EIA for both the construction and operational phase of the projects. Information was primarily drawn from various studies of the region, the baseline study, as well as the Environmental Impact Assessment (EIA).

Information Provided by the EIA and Other Sources

The EIA identifies six impacts to the tourism industry[428]. The negative impacts include:

- Significant: Loss of three tourist facilities (two to be inundated by the Baker 2 project and one by the Pascua 2.2 project).
- Medium Significance: Decline in the image of touristic products in the Capitán Prat province.
- Medium Significance: Loss of tourist attractions and associated activities due to the construction.
- Low Significance: Alteration of tourist attractions and associated activities due to the construction.
- Low Significance: Reduction in the availability of touristic infrastructure (hotels, restaurants, etc.) in Cochrane due to the arrival of people directly and indirectly related to the project.

The one positive impact that the EIA identifies in relation to the tourism industry is:

- Low significance: Increase in the commercial activity related to the tourism industry due to the arrival of people directly and indirectly related to the project.

Current State of Tourism Industry in Aysén

Economic

The EIA recognizes that due to the high quality of nature in Aysén, ecotourism is a growing industry with great potential in the Aysén region.[429] The economic health of the tourism

[428] HidroAysén, Environmental Impact Assessment, Executive Summary, p. 23
[429] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1745

industry is defined by four key metrics: sales figures, number of jobs/companies involved in the tourism industry, the number of visitors to the region, and the annual growth figures of these areas.

Sales
Sales and revenue figures are not presented in the EIA. These data, instead, were collected by SERNATUR (Servicio Nacional de Turismo or National Tourism Service) which estimates that revenue for the tourism industry in Aysén was US $66.8 million in 2007[430]. These sales figures drawn from SERNATUR were based on the assumption that foreign tourists would spend US $74 and Chilean tourists would spend US $54 per day. These figures were compared to the estimated number of tourists and multiplied by 6.6, the average number of days that a tourist spends in the region. Other studies provide similar results. The University of Chile's 2008 study estimated that Chileans spent US $59 per day and foreigners spent US $96 per day. [431]

Jobs/Companies
The tourism industry provides a significant number of jobs for the Aysén region. The EIA does not assess the number of jobs provided by the tourism industry. The 2008 study by the University of Chile[432] estimated that 5,600 livelihoods are directly dependent on tourism. These jobs accounted for $US 58.5 million in income for 2008. SERNATUR (using data from the National Institute of Statistics) estimates that there were 1,400 jobs in hotels and commerce in 2006. If one was to include restaurants, transportation, stores, communications, and personal activities sectors that number increases to 37,450 jobs. SERNATUR also estimates that 633 companies provided these jobs. According to CIEP, the number of jobs directly related to tourism is expected to increase by 5.58% annually in the period 2005 - 2015.

While the EIA does not address the number of companies that are engaged in the tourism industry, it does provide information on hotels and restaurants in the area. The EIA indicates 4,234 beds in ten communities in the region with an average seven rooms in each hotel available to tourists.[433] The study goes on to analyze the type of accommodations available such as lodges, hostels and hotels. In the following section, the EIA finds that there are 102 restaurants in the region, offering 4,408 seats for customers. [434]

Visitors
It is important to distinguish that the number of visitors to the region consists of only about half of the number of "passengers" into the region. Therefore, for purposes of analysis, SERNATUR

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[430] SERNATUR study summarized in Bourlon, Fabien, "Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén," A presentation on February 27th, 2009, CIEP
[431] Sapiains, Rodolfo, Fernando Salamanca, Ernesto Castillo and Andres Jaramillo. *Impacto de los Proyecto de Represas en Aysén en el Desarrollo del Turismo de la Región*. University of Chile, Department of Psychology, June 2008. p. 20
[432] Ibid.
[433] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1748
[434] Ibid. p. 1751

assumes that 50% of all travelers into the region were tourists.[435] Furthermore, it is noted in the EIA that 40.1% and 37.6% of tourists came by air and automobile, respectively; the other 22.3% were assumed to come via the ports.[436]

The number of visitors into the region was based on statistics from INE (Instituto Nacional de Estadisticas de Chile or National Institute of Statistics) from 2000-2006. The data indicates that in the six years between 2000 and 2006, an annual average of 110,285 people visited the region[437]. There are some differences in the estimates for the number of visitors to the region. SERNATUR estimates that for 2006, 129,720 visitors came to the Aysén region while CIEP estimates that number to be as high as 152,254.[438].

Aysén is a popular destination for both national and international visitors. SERNATUR estimated that 67% and 33% of visitors in 2001 were Chilean and foreign, respectively. Data from the 2007 University of Chile study indicates a similar trend, with 62.1% and 37.9% of visitors Chilean and foreigners, respectively[439].

Annual Growth
Combining all of these statistics, it appears that tourism in the Aysén region is growing at a steady pace. Average growth for the region from 2001 to 2006 was 5.35% while Chile as a whole experienced a 6.69% increase in foreign visitors[440]. The EIA does not address a cumulative growth rate for the tourism industry.

Regional Planning Initiatives
Between 1999 and 2008 there have been sixteen regional planning initiatives that were related to tourism. While these are regional projects, many contain partnerships with municipal and national governing structures as well.[441] While the EIA does not address all of the regional projects engaged in the development of the tourism sector, it does recognize nine regional programs that are directly involved in the development of tourism.[442]

SERNATUR has a national campaign called "Naturaleza que conmueve" (nature that moves you) that has positioned the Aysén region as a premier destination for eco-tourists. The Aysén region

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[435] Standard established by SERNATUR
[436] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1751
[437] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1752
[438] Fabien Bouron, "Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén," A presentation on February 27th, 2009, CIEP
[439] Sapiains, Rodolfo, Fernando Salamanca, Ernesto Castillo and Andres Jaramillo. *Impacto de los Proyecto de Represas en Aysén en el Desarrollo del Turismo de la Región*. University of Chile, Department of Psychology, June 2008. p. 19
[440] SERNATUR study summarized in Bourlon, Fabien, "Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén," A presentation on February 27th, 2009, CIEP
[441] Fabien Bouron, "Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén," A presentation on February 27th, 2009, CIEP
[442] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1739

created a Regional Land Management Plan (PROT) that outlined four specific goals: —the appreciation, observation, and experience of nature; small tourism groups that are organized by small, local businesses; to minimize the local impact on the cultural and natural environment; and protection of natural areas. There is a mandate for economic ventures to respect PROT.

The National Tourism Interest Zone (ZOIT) based around Lake General Carrera is one of the more unique programs.[443] Started in 1999, this program started a bi-national basin management plan for the lake. Within the ZOIT program, the "Chile Emprende" initiative was created in 2007 to specifically cover Lake General Carrerra and the Northern Ice Fields. A US $500 million "action plan" was carried out. Among other national funding programs over US $1 billion has been spent on regional initiatives that are directly related to tourism[444]. Most of these regional plans identify the development of more eco-tourism and agro-tourism services as a significant potential for economic growth for the region.

Infrastructure
A few key pieces of infrastructure are vital to the success of the tourism industry in Aysén, namely the Carretera Austral (Route 7), the ports, and the airport. The Austral highway system, is 1,240 kilometers (770 miles) long starting in Puerto Montt in the North and extending to Villa O'Higgins in southern Aysén. The EIA addresses the significance of the Carretera Austral to the tourism industry as it provides a number of attractions and landscapes on its route.[445] The ports of Puerto Yungay and Puerto Aysén are small and provide access to a limited number of tourist attractions.

Intrinsic Value of Nature
Tourism in the Aysén region is almost entirely dependent on the pristine, high quality of natural areas in the region. The EIA recognizes that the attraction of the region lies in its natural beauty: mountains, rivers, lakes and glaciers.[446]

Of the 208 attractions registered by SERNATUR in 2007, 85% are based on the natural environment, with the other 15% centered on cultural attractions.[447] There are nine national parks in the Aysén region. The most popular tourist activities rely on the health of the natural environment: sport fishing, horseback riding, hiking, observing the flora and fauna, sailing, kayaking, rafting, cycling, and mountaineering. The EIA specifically highlights the sport fishing industry as a well-established tourist activity for over ten years that has attracted foreign visitors, generated employment in the region, and positively enhanced the image of the region. Still, it mentions that of the 14 rivers in the region that have good conditions for sport fishing,

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[443] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1739
[444] Fabien Bourlon, "Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén," A presentation on February 27th, 2009, CIEP
[445] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1759
[446] Ibid. p. 1740
[447] Ibid.

the Simpson and Ñirehuao Rivers, which are located in the northern part of the region, have the best conditions.[448] The EIA also recognizes "scientific tourism," or scientists in the region to study the biodiversity and geographical features in the region. Furthermore, it recognizes agro-tourism as a potential area of growth within the tourism sector as it may pair the unique culture of Patagonia along with an even distribution throughout the region.[449]

The 2007 study performed by Robinson and Torres at the University of Chile found that 60% of the tourists they interviewed go to Aysén to enjoy the preserved nature and have high requirements in terms of the quality of the destination[450]. The 2008 University of Chile study found that major reasons for tourists to visit Aysén include the natural beauty (40%), the landscape (17.8%) and the low human intervention (6.1%)[451].

There is minimal atmospheric contamination, which is mostly from diesel gas, wood burning for fuel purposes, and vehicle emissions. Population in the region is also very small with only 0.8 residents per square kilometer.[452] This untouched feeling of nature is romanticized as the unique "Patagonian Way of Life," characterized by the gaucho and the rustic atmosphere.

Analysis of the EIA

The baseline study of the Aysén region is missing key information regarding the current state of the tourism industry in Aysén. In addition, there are a number of issues that the baseline study misrepresents.

There is no analysis of the total revenue and employment generated due to tourism in the region in the EIA. SERNATUR does provide relatively recent statistical data to evaluate these aspects of the tourism industry. By not including this information, the study does not fully address the importance of the tourism industry for the region. Furthermore, providing the number of beds in hotels and chairs in restaurants seems to be a misguided attempt to provide insight into the size of accommodations that are available. The EIA also documents the number and size of hotels and restaurants in the industry; however, revenue and employment figures may be more useful in determining the real impact of tourism for the local people of Aysén.[453]

The baseline study states that because of the wide distribution of national parks, rivers, and lakes, in different areas of the region, there is no concentration of tourist activities except for

[448] Ibid. p. 1739
[449] Ibid. p. 1745
[450] University of Chile 2007 study by. Robinson and Torres summarized in Bourlon, Fabien, "Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén," A presentation on February 27th, 2009, CIEP
[451] Sapiains, Rodolfo, Fernando Salamanca, Ernesto Castillo and Andres Jaramillo. *Impacto de los Proyecto de Represas en Aysén en el Desarrollo del Turismo de la Región*. University of Chile, Department of Psychology, June 2008. p. 63
[452] HidroAysén, Environmental Impact Assessment, Chapter Four p. 1160
[453] Ibid. p. 1748

around Coyhaique, the major urban area of the region.[454] Furthermore, it states that the national parks in the Aysén region, specifically those around Capitán Prat and Lake General Carrerra receive the least amount of visitors in relation to other protected areas in the country. However, the data they use for the number of visitors to this region are from 2004. SERNATUR estimates that in 2005 alone, the region as a whole experienced a 15.3% increase in the number of visitors and subsequently a 1.9% and 8.4% increase in 2006 and 2007[455], respectively. While the number of visitors to a national park is not directly comparable to the number of tourists to an entire region, using data from 2004 underestimates the more recent influx of visitors to the region.

The EIA claims that there is a homogenous distribution of attractions across the region.[456] They also state that 85% are natural attractions; while they may be "homogenously" distributed across the region, they are unique geological features that are not simply repeated across the region. Each of these attractions has its own conditions and appeal as a tourist destination. Furthermore, this section includes a system for ranking the attractions based upon their international, national, regional, and local appeal. The methodology and purpose of this ranking system is unclear.

The baseline study mentions other attractions in the Aysén region, including the "Sanctuary of Natural Marble Cathedrals" but does not include visitor information to these attractions[457]. While it easier to collect data on nationally run attractions such as national parks and protected areas, it is misleading to not include information for other tourist attractions.

Tourism during Project Construction

Economic

By all estimates, the tourism industry is expected to be negatively impacted by the construction of the hydropower projects.

Sales

CIEP estimates that $US 38.6 million of tourism revenue would be lost during the construction of the dams resulting in a reduction in revenue to only around $US 20.2 million.

Jobs

The number of jobs associated with tourism in the Aysén region is expected to decline significantly due to the construction of the hydropower projects. This job loss would not be offset by employment by HidroAysén during the project construction, because only a small percentage of those jobs would go to local people. This is primarily because the local residents do not have the skills or training they need for these specific construction jobs. The small percentage that would be employed would most likely be in unskilled or service jobs related to

[454] Ibid. p. 1748
[455] Ibid. p. 1752
[456] Ibid. p. 1740
[457] Ibid. p. 1745

the projects, such as working at the workers' residence camp.

Visitors

According to both the CIEP study and the 2008 University of Chile study, sharp declines in the number of visitors to Aysén are expected. The University of Chile study estimated that during the 2008-2016 period of dam construction, 71.5% of visitors would cancel their visits to Aysén.[458]

Regional Planning Initiatives

The EIA does not mention how it would work with regional planning initiatives to mitigate the effects dam construction would have on the tourism industry or the region as a whole.

Infrastructure

The tourism industry stands to benefit the most in the situation that the dams are built from infrastructure improvements during construction of the hydropower projects. The EIA outlines benefits to the road system in the region, highlighting the addition of 90 km of new roads, the renewal of 187 km of current roads, and the replacement of 10 km of existing roads[459]. The focus of the improvements would be Route 7 (the Carretera Austral) and X-906 where there would be higher traffic flow and higher access to both natural and cultural tourist attractions[460]. Roads are especially pertinent as so much of the projected tourism development is expected along much of the length of the Carretera Austral[461]. New roads would certainly be essential in continuing the growth of tourism in Aysén. With the primary road in Southern Aysén (the Carretera Austral) consisting of gravel and dirt and no pavement outside of the larger municipalities, the development of more attractive tourist areas depends partially on the comfort of transport offered by improved roads. Tourism infrastructure is also slated for improvement with the addition of eight scenic overlooks and 10 km of new footpaths[462].

Another marked improvement for the region would be development of dock facilities. These improvements would be focused primarily in the Puerto Yungay area[463] where there is also proposed development for tourism[464]. New ramps are to be placed in both Puerto Yungay and at Puerto Rio Bravo[465]. While these improvements would be made primarily for the supplies being brought in during construction, the benefits could be reaped into the future by the tourist

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[458] Sapiains, Rodolfo, Fernando Salamanca, Ernesto Castillo and Andres Jaramillo*. Impacto de los Proyecto de Represas en Aysén en el Desarrollo del Turismo de la Región*. University of Chile, Department of Psychology, June 2008. p. 40

[459] HidroAysén, Environmental Impact Assessment, Chapter One p. 83

[460] HidroAysén, Environmental Impact Assessment, Chapter Five p. 1195

[461] Ecosistemas, “Plan Regional de Ordenamiento Territorial – Región de Aysén,” http://www.ecosistemas.cl/1776/articles-71694_documento_pdf.pdf, accessed April 20, 2009

[462] HidroAysén, Environmental Impact Assessment, Chapter Six p. 185

[463] HidroAysén, Environmental Impact Assessment, Chapter One p. 78

[464] Ecosistemas, “Plan Regional de Ordenamiento Territorial – Región de Aysén,” http://www.ecosistemas.cl/1776/articles-71694_documento_pdf.pdf, accessed April 20, 2009

[465] HidroAysén, Environmental Impact Assessment, Chapter One p. 81

industry that develops in the area; however the EIA indicates that these ramps would be temporary for the duration of the construction. Additionally, the region would benefit from improved telecommunications and a landfill in the San Lorenzo area[466].

However, there are also some drawbacks to infrastructure development. For example, there would be the loss of the La Araucaria camp site as well as De los Nadis cabins/lodge and alternative camping as an effect of inundation by Baker 2[467]. This would destroy a portion of the limited tourism industry that already exists. Further, the Cochrane area could expect an increased competition for tourism infrastructure during construction due to the influx of workers and others associated with the projects.[468] The plan would be to develop infrastructure to a point where this potential kind of increase in tourism in the region could be accommodated, but at the time of construction, there is a very good chance that the existing infrastructure would be inadequate. Furthermore, the increased traffic on the main roads caused by construction vehicles and the transport of workers will cause wear in the roads that are already in disrepair at present.

Intrinsic Value of Nature
Construction of the hydropower projects would cause negative impacts to the current natural image associated with the region of Aysén. Air emissions in the forms of particulate matter and combustion gases would increase due to excavation, construction, and the use of heavy machinery to do these tasks. Additionally, there would be a significant increase in noise emissions in the region due to machinery, blasts, vehicle transit, functioning of generators, and the use of helicopters to construct the transmission lines.[469] These conditions could lead to a marked deviance from the high air quality and relative quiet of the region today. Furthermore, there is the expected loss of image of the region as a natural exception to a rapidly-developing world that will be severely influenced by the sights of construction vehicles, the construction project sites, and the transmission lines being erected in the region.

The EIA does, however, point out the benefits associated with the projected treatment of liquid waste. Both for domestic sewage as well as liquid industrial waste, there are plans to treat and dispose the liquid according to regulations.[470] However, this is a false positive because the amount of liquid waste that will be produced is greater than current levels, even if it is being disposed of properly.

Criticisms and Missing information
There are a number of omissions regarding the period of construction in the EIA. The primary criticism is that the EIA does not take a holistic approach to understanding the impacts of the

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[466] Ibid. p. 90
[467] HidroAysén, Environmental Impact Assessment, Chapter Five p. 1200
[468] Ibid. P. 1203
[469] HidroAysén, Environmental Impact Assessment, Executive Summary p. 12
[470] Ibid. p. 12

hydropower projects.[471] To try to understand one aspect in a vacuum with no regard for the way it influences or is influenced by other issues lends itself to overlooking unintended consequences. This is especially true in the context of tourism where the infrastructural positives cannot be seen without imposing environmental degradation, loss of natural image of the region, and alteration of social landscape in the area. Additionally, the EIA does not offer any kind of compensation for or replacement of the inundated areas mentioned above in *Infrastructure.* It also neglects the regional unity efforts in tourist activities in terms of clusters and zones that have been created in the efforts to develop tourism in Aysén today[472]. If HidroAysén is truly concerned with maintaining and continuing the growth of tourism in the region, it should make a concerted effort to work with programs already in place that have been created by local people, who best understand the region.

Tourism during Operational Phase of Projects

Post-construction, there would continue to be lasting effects of the HidroAysén hydropower projects in the Aysén region. There are different projections as to how exactly the tourism industry would be influenced, either with a leveling out of tourists in the years following[473] or a slight rise as tourists begin to return to the region.[474] In both of these scenarios, tourism is not projected to increase at the same rate currently experienced or near the rate that it is projected to grow if the hydropower projects were not to be built.

The EIA explicitly recognizes the impact of the projects on tourism as a diminishing of the image of the Patagonia region. However, this impact was assessed to be only moderately significant and only to extend through the construction phase.[475] This assessment is incompatible with the University of Chile survey that indicated that 71.5% of respondents indicated that they would not visit Aysén during the construction phase but 40% also indicated that they would never return to Aysén.[476] The EIA, on the other hand, does not recognize any negative impacts on tourism that would occur during the operations phase of the project. Clearly, there is a disconnect between the public perceptions of the projects and the anticipated impacts described in the EIA.

Economic

The EIA regards the economic impacts of the hydropower projects as beneficial to the Aysén region. It is mentioned that the projects would dynamize the economy to the end of social development in the surrounding area[477]. Most of the economic gain in the region would be an

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[471] Farmer, Ian. "Ficha de Observaciones Ciudadanas." Sistema de Evaluacion de Impacto Ambiental
[472] Ibid
[473] University of Chile 2008. Sapians, Salamanca, & et al. summarized in Bourlon, Fabien, “Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén,” A presentation on February 27th, 2009, CIEP
[474] Bourlon, Fabien, “Hydroelectric Projects, A Challenge for the Sustainable Development of Aysén,” A presentation on February 27th, 2009, CIEP
[475] HidroAysén, Environmental Impact Assessment, Chapter Five p. 1189
[476] Santiago Times, Study: Chile Dam Projects will Scare away Tourists. July 9, 2008
[477] HidroAysén, Environmental Impact Assessment, Chapter Five p. 955

effect of the improved infrastructure in the region.

Regional Planning Initiatives
Minimal to this point as most projections only reach until 2014, the heart of the construction phase.

Infrastructure
Most of the effects of the hydropower projects on the infrastructure in Aysén would be similar during operation as during construction [see above].

Intrinsic Value of Nature
In terms of the natural value enjoyed in the Aysén region today, there would be many negative effects associated with the dam projects. The region is expected to see an increase in air emissions in the forms of particulate material and combustion gases at inconsistent intervals when support power generating units are utilized.[478]

Not the hydropower projects specifically, but the associated transmission lines stand to detract a significant amount from the intrinsic value of nature that is essential for the tourism industry in Aysén. The transmission lines would present noise emissions caused by the "corona effect".[479] This phenomenon occurs through an electrical field ionizing the surrounding air.[480] The consequent buzzing would be heard along the length of the transmission lines that parallels the Carretera Austral in some locations.[481] Furthermore, the route along which the transmission lines are to be constructed will not only need to be partially cleared of vegetation during construction, but would need to be continually maintained throughout operation. This creates a situation where the proposed 70 m tall structures holding the lines would be coupled with severely pruned vegetation within the right-of-way, further detracting from the naturalness of the area. Although it is not possible to separate the effects of the transmission lines from other components of the infrastructure, the transmission lines would be one of the more visible aspects of the projects and the results of the University of Chile survey cited above can be interpreted to suggest negative impacts on tourism in the region. In light of the fact that the transmission line lifetime is considered by the EIA to be indefinite, there would be effects on the tourism industry well into the future. The effectiveness of the abandonment plan for the worker camps, etc. as proposed by the EIA may have significant influences on the image of Aysén for tourists coming into the region. The EIA mentions a plan to dismantle or destroy facilities to restore "intervened areas in the forms and conditions identified in the present EIA."

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[478] HidroAysén, Environmental Impact Assessment, Executive Summary, p. 12
[479] Ibid. p. 12
[480] PG&E Delta Distribution Planning Area Capacity Increase Substation Project. August 2005. <http://www.cpuc.ca.gov/environment/info/aspen/deltasub/pea/16_corona_and_induced_currents.pdf>.
[481] Ecosistemas, “Plan Regional de Ordenamiento Territorial – Región de Aysén,” http://www.ecosistemas.cl/1776/articles-71694_documento_pdf.pdf, accessed April 20, 2009

Criticisms and Missing Information
The primary omission from the Environmental Impact Assessment is the effect that the hydropower projects would have on the Patagonian image of pristine and natural wilderness. Without a doubt, tourists entering Chilean Patagonia would be confronted with a different image from the pristine nature that exists today. The EIA does not offer any steps to monitor or mitigate the alteration of the region's perception and without these programs, there is the distinct possibility of a change to the tourism industry that the region is ill-prepared for with potential devastating effects. The region would also perceivably need to be marketed in a different way to account for the deviance from pure nature especially in areas of proposed heavy tourism development.[482]

While the EIA does point out its intentions to restore the area to the present conditions in its worker camp abandonment plan, there is no comprehensive plan to actually perform this action. Without an integrated plan that incorporates restoration of all aspects of the ecosystem that is being destroyed for the construction of the worker camps, it can be expected to take a long time for the area to be returned to a condition that tourists can regard as natural.

Finally, there is a conspicuous lack of analysis on effects of the transmission lines in the EIA. Compared to other facets of this report, tourism stands to be influenced perhaps most heavily by the construction of these structures. The proposed route for the local transmission lines parallels the Carretera Austral for about 40 km just south of the proposed Baker 2 project[483], and would be visible in other areas. Another major factor is the long distance transmission line further to the north that would carry electricity to Santiago. As of today, there is no EIA regarding these lines and the potential effects they would have on any system in the region, including tourism. Although the EIA process dictates that the long distance transmission line is a separate project from the PHA, logically this is not the case, since the hydropower projects would not be viable without the transmission line and vice versa. It is only logical that the two projects should be considered simultaneously, even if the EIA process requires separate submissions.

Conclusions

In summary, there needs to be a significant addition to the amount of knowledge available presently to legitimately understand the effects that the HidroAysén hydropower projects would have on the tourism industry in Chilean Patagonia. Past projects have shown that without proper planning prior to construction, there can be numerous unintended consequences; many of them negative. For example, the tourism industry near the Pak Mun dam in Thailand, even after the project was relocated to preserve natural rapids from inundation, still experienced very slow growth after the dams were built. The construction of a park and the installation of sanitary facilities in the area surrounding the Kaeng Saphue rapids

[482] Farmer, Ian. "Ficha de Observaciones Ciudadanas." Sistema de Evaluacion de Impacto Ambiental
[483] HidroAysén, Environmental Impact Assessment, Chapter One, p. 61

(located upstream of the dam but the reservoir water level is lowered during the summer to expose the rapids) have been insufficient to compensate for the loss of natural image of the dam, in part due to increased sedimentation resulting from the dam projects. The decline of tourist numbers has been coupled with a decrease in the amount of time spent by those visitors near Kaeng Saphue.[484]

Of course, every hydropower project is different, but it would be irresponsible to disregard the history of the Pak Mun dam as entirely unrelated to the HidroAysén projects in Chile. The fact that there are efforts to manage the impacts to the region of the projects does not indicate that those identified impacts will be the only ones to arise through the course of construction and operation. While the present EIA does take note of a number of potential impacts of the dams, the next necessary step is to explore the measures to compensate for the negative impacts in a way that considers the many different aspects of tourism in the region.

[484] Amornsakchai, Sakchai, Philippe Annez, Wanpen Wirojanagud, Ek Watana, Suphat Vongvisessomjai, Sansanee Choowaew, Prasit Kunurat, Jaruwan Nippanon, Roel Schouten, Pradit Sripapatrprasite, Chayan Vaddhanaphuti, and Chavalit Vidthayanon. *Pak Mun Dam, Mekong River Basin, Thailand*. Cape Town: World Commission on Dams, 2000.http://www.dams.org, p. 36

Critique of the EIA Process

One of the issues that became clear as a result of the review of this environmental impact assessment was that there are overall deficiencies associated with the assessment process. Based on our understanding of the requirements for the EIA, it appears that the regulatory process requires the assessment to be performed following only a general format, and therefore it allows the omission of key considerations. This section lists a series of general concerns that the EIA has inadequately addressed.

- One of the significant issues discussed in the World Commission on Dams report is the issue of equity; there is often no connection between those who benefit from a project and those who are negatively impacted by its implementation. This theme is repeated in the HidroAysén proposal with the stark reality that all of the power generated will be exported from the region where it is produced. A key component of an impact assessment is to clearly delineate the costs and benefits to the Aysén Region and its people. Attempts to minimize this equity issue will generally rely on strategies such as denying the existence or minimizing the significance of negative impacts or providing some sort of financial remuneration to offset negative impacts that are acknowledged. The first approach appears to have been taken in the current EIA. A key question remaining is whether and how various stakeholders from the Aysén region will be able to participate in the decision making process and how their concerns will factor into the final decision as to whether the projects will be developed.
- The process appears to accept the premise of the project while attempting to address the question of whether undesirable environmental impacts are expected and if so, whether or not they can be successfully mitigated. This is a significant conceptual difference between the environmental impact assessment process in Chile as compared to the United States. The Chilean approach completely avoids a central question regarding whether or not there are better solutions to address a specific policy issue, in this case, how to manage an expectation of increased national demand for electricity. The environmental impact assessment process in the United States requires an evaluation of alternatives in order to demonstrate that the proposed solution is the best approach to meet the intended objectives[485]. The Chilean approach allows the development of project proposals that may primarily serve to fulfill the narrow objectives of a developer, with the subsequent requirement that environmental impacts can be acceptably managed. This is a questionable approach to the management of natural and human resources.
- The administrative process of separating the environmental impact assessments for the hydropower facilities and the long distance transmission lines that are required to deliver the electricity to the central grid is flawed. The two components are intimately linked since the hydroelectric projects as proposed cannot be implemented without the transmission line, nor is the transmission line required if the hydroelectric projects are

[485] “National Environmental Policy Act, Basic Information” http://www.epa.gov/oecaerth/basics/nepa.html#eis

not completed. This close coupling indicates that the two components should be considered either in parallel or as a combined project concept. The current process does not require such an analysis. The HidroAysén projects are being considered by the Aysén COREMA since the projects themselves are confined to one region while the transmission lines must be approved by the national CONAMA since they would span across multiple regions. There is considerable ambiguity regarding the details of the transmission line system. In February, 2007 a HidroAysén staff member told a group of University of Michigan and University of Concepción students that, with regard to the transmission lines, the intention is to only install the capacity necessary to transmit the amount of energy generated by the five proposed PHA projects. There is evidence to support this contention as witnessed by the recent announcement that the Swiss-based mining conglomerate XSTRATA has contracted with Transelec (the same entity that would construct the HidroAysén transmission lines) to construct a second transmission line to service the proposed Cuervo hydroelectric project under planning for the Cuervo and Blanco Rivers and Lago Condor[486]. Although not as large in aggregate as the HidroAysén projects, the 1,100 MW of generating capacity represent a significant infrastructure project. Although details of neither transmission line are available, it seems reasonable that the two would follow a similar route to the central part of the nation, essentially doubling the required transmission infrastructure. Questions of implementation of the transmission system are critical to understanding the longer term implications to the Aysén region as the provision of additional transmission capacity will surely encourage more hydropower development in Patagonia. While breaking these major projects into individual components may simplify the EIA approval process, it becomes more difficult to anticipate the overall environmental impacts as well as the implications to sustainability in Patagonia.

- The EIA's system of labeling individual impacts as "significant" or "not significant" is flawed in that it fails to recognize the relationships between impacts. The EIA describes 111 impacts, thirty of which are labeled "significant" (twenty-eight of those being negative impacts)[487] therefore including serious discussion of their effects on the local environment and possible mitigation strategies. While it is important to address the most severe impacts, none of the mentioned 111 impacts are exclusive. It is irresponsible to dismiss the eighty-three "not significant" impacts and focus on the twenty-eight significant negative impacts because in reality, it is likely that addressing any one impact will also influence other aspects of the system. In analyzing impacts individually, the EIA does not account for the overall impact the PHA would have on the local environment and the people of Aysén. Analyzing impacts in this way inherently works in HidroAysén's favor as it focuses critical analysis of the PHA on individual impacts rather than the overall effect on the local environment and its people. This is exemplified in the above individual analyses of the EIA, as well as the comments offered by EULA and government agencies within Chile. Each section and each

[486] "XSTRATA inks deals with Transelec for Chile power line, " Patagonia Times, 11 July, 2008
[487] HidroAysén, Environmental Impact Assessment, Executive Summary, p. 20

comment, analyzed separately, reveals very little about the PHA and may seem inconsequential. If the EIA is to be used as a tool to determine whether or not the PHA will be built, it should emphasize the overall effect the five proposed dams will have on the surrounding environment and its people, not individual impacts, as it is the overall impact that should ultimately determine whether or not the projects are built.

- Of the 28 negative impacts that were identified associated with the projects, 24 of them were indicated to be associated with the construction phase[488] while the other four are associated with the operations phase. While there is no way to assess the details regarding the identification of significant impacts, this outcome could be used to suggest that nearly all of the significant negative impacts will be only associated with the construction phase and therefore limited in terms of their temporal impact. It is not at all clear that this is a justifiable conclusion, especially given experience with other dam projects where many significant impacts are felt long after the completion of the project construction.
- It is our opinion that the limited number of significant impacts during the operational phase of the project is an indication of the failure of HidroAysén's rating system. Given the evidence of significant environmental harm caused by existing first and second generation dams (see WCD case studies), it is unreasonable to expect just four significant impacts to arise during the operation phase of a dam and we suggest that a better system of impact rating is required in order to fully determine the environmental impacts that would occur as a result of building the PHA.
- One manifestation of the implications of the approach employed in the EIA is that impacts to biota (aquatic and terrestrial) are judged at of high environmental value only if rare and endangered species are involved. This view of environmental value does not look at the system as a whole where it can rationally be argued that the Baker and Pascua River watersheds represent unique ecosystems due to the fact that they represent two of the three largest rivers in the nation and discharge into a significant fjord system where the sheer magnitude of their nutrient inputs is likely to be of significance, even if it is poorly understood. These conditions surely qualify as having high environmental value even in the absence of individual species that are used as the basis for defining this metric in the EIA.
- One issue that is not clear whether it is specific to this particular assessment or the overall process is the consistent use of proposals for studies to be completed after project implementation as compensation activities. According to Article 60 of the DS 95/01 MINSEGPRES, compensation measures are intended to produce or generate a positive alternative and equivalent to a significant adverse effect."[489] While performing studies to gain missing information regarding various ecosystem elements may be valuable, this activity does not appear to meet the definition as provided in the regulatory framework. Of course, it is unknown whether these proposals would be considered acceptable by CONAMA as legitimate compensation activities.

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[488] HidroAysén, Environmental Impact Assessment, Executive Summary, p. 20
[489] Ibid, p. 129, # 171

- Furthermore, topic-specific information was often fragmented and difficult to locate within the Environmental Impact Assessment (EIA). This issue is almost inevitable in a document of over 10,000 pages in length. However, analysis of a single issue such as sedimentation, for example, requires reading multiple sections (hydrology, water quality, geomorphology, etc.) in each of the baseline, impacts and mitigation chapters. This problem was partially created by the structure required for the preparation of an EIA, but extends beyond that issue. Appendices were not referenced properly within the text. We can expect that many criticisms of the EIA's content are undoubtedly the result of the poor organization of the report and the inability to review all relevant information on any one aspect of the project. The EIA is meant to aid in decision making regarding this project. If such a document is not well-organized, a good analysis is not possible even if all the presented information is accurate.

Overall Recommendations

The HidroAysén project is a "second-generation dam project," in the sense that the proposed projects follow the first wave of worldwide dam building that lasted from roughly 1930-1980. Given the subsequent awareness that has been created by the analyses of these earlier projects, it is appropriate to draw on these experiences in order to avoid repetition of the same types of mistakes seen in first generation dams. This is the result of the global community becoming more aware of the costs and benefits of hydroelectric power generation. We believe that a comprehensive analysis of environmental and human impacts is a necessary part of the determination of costs and benefits, requiring the commitment of resources and effort to develop an understanding of the implications of project implementation. The eventual costs of mitigating unforeseen impacts are often much greater than the costs of failing to recognize their existence in the first place. Therefore, we propose a number of improvements to the current assessment and include suggestions for implementing them. These are listed according to the categories covered in this report.

Hydrology

In any hydroelectric project, the power output achieved is intimately connected to the hydrology as is the design of key system components. For this reason, a solid understanding of the river flows are extremely important for design considerations, estimates of project profitability, and the safe construction, maintenance and operation of the dam. The following are a list of recommendations for improving this aspect of the EIA:

- Include an analysis of glacial lake outburst floods as extreme flood events, and develop a plan for dealing with them during construction and operation phases.
- Consider the impact of climate change on the hydrologic series. Discuss how changes in precipitation, glacial melt, and other natural phenomena might affect the basins in question.
- Improve the statistical analysis of the hydrologic series, including but not limited to: understanding El Niño events as short term anomalies that may influence statistics of

relatively short data records and using El Niño events to address possible effects of climate change.
- Include a more careful consideration of the effect of hydro-peaking operations on changes in flow regimes. The EIA implies that the natural flow regime would be maintained in the rivers due to small storage volumes in the reservoirs. While this is true at time scales greater than one day, the short term flow variations due to hydro-peaking will be quite significant and likely to exhibit a number of negative effects.

Sedimentation

The problem of sedimentation was not adequately dealt with in the HidroAysén EIA. The natural process of sediment transport in rivers becomes an issue to be managed in the operation and maintenance of many dams, and as such it should be recognized as an important issue in project planning, design and construction. The following are some recommendations for improving the project perspective on sedimentation:

- Make available all cited reports and all raw data used to construct the sediment transport model used in the EIA.
- Publish addendums to the current EIA which describe the methodology used in the sediment transport analysis and modeling in greater detail.
- Begin a sediment sampling regime in the Pascua and Baker River basins that directly measures both suspended sediment and bed load. The role of sediment inputs from the major tributaries is apparently an issue of critical importance and needs to be part of such a study. Use this information to improve the current sediment transport model or support a more experimentally based plan for sediment management.
- Develop and publish a clear plan for long-term sediment monitoring and management.

Aquatic Ecosystems

A major issue with the EIA's analysis of aquatic ecosystems is that no responsibility is taken for the general lack of knowledge about these systems. The argument seems to be that since few studies have been conducted regarding the flora and fauna in these areas, the species that are present are of little importance. However, lack of current understanding of a species does not imply that the taxon in question has no value. It is the responsibility of those who will affect these ecosystems to properly examine, understand, and protect what they may threaten. Additionally, the following are a list of recommendations for improving this aspect of the EIA.

- Dedicate more resources to evaluate the biodiversity at each site. Sampling effort was approximately 15 minutes for each site over the span of 51 days (including travel).
- Use appropriate sampling methodology. The baseline study for aquatic biota is flawed in its sampling methodology as sampling was conducted using only two types of gear and was not stratified by microhabitat.
- Conduct more research on aquatic fauna. There is insufficient evidence regarding the state of migratory fishes in the Baker and Pascua Rivers. There is also limited and fragmented information regarding their migration routes. Without this information, it will be impossible to avoid or mitigate negative impacts from the projects.

- Properly document genetic diversity of the fish species in the affected areas. If the projects were to be implemented before such a study takes place, this information could remain unknown indefinitely.
- Include more detailed information regarding mitigation strategies. The EIA discusses "proper management" in relation to protecting aquatic ecosystems. However, this phrase is not well defined and could be interpreted in a variety of ways. The proposed management strategy may help limit some of the negative impacts from the projects but its overall effectiveness at maintaining the health and integrity of the system as whole is unknown.
- Dedicate more resources to understand how the potentially affected ecosystems function. In order to mitigate some of the negative impacts from the projects, the EIA states that a conservation area would be created but provides little information with respect to details and expected efficacy of such an effort. Insufficient information is currently known about the affected ecosystems to create an effective conservation area that will offset the negative impacts.

Terrestrial Ecosystems

Overall, the EIA presents no description of terrestrial ecosystems as a whole. There was not only a lack of information, but there was also a lack of analysis from an ecosystem perspective. Because of this, there is insufficient consideration of species density, heterogeneity, and variability. Such considerations are imperative to evaluating the effects of the proposed projects on terrestrial ecosystems. Additionally, the following are a list of recommendations for improving this aspect of the EIA.

- Expand the sampling effort and support the design with appropriate data. A relatively small number of sample plots were used to survey over 180,000 hectares. This sampling effort is insufficient to study the entire area that may be impacted by the proposed projects.
- Consider high mobility species. They are largely ignored because there is the assumption that these species will be able to move away from the impacted areas. However, it is necessary to consider that these species may be unable to travel significant distances during certain life stages.
- Evaluate how relocated wildlife will impact the wildlife living in areas to which affected animals will be relocated. If relocated wildlife generates a negative impact on the animals in the areas to which they are relocated, the process of relocation needs to be re-evaluated.
- Consider the concept of endemism. Such a concept is important to consider in projects like this because certain species may be found only in the areas impacted by the projects. While they may not be particularly economically valuable to the local economy, their absence in other locations suggests that it is important to preserve these species where they naturally exist in order to prevent extinction.
- Devise a plan to protect areas with rare or endangered species. The necessity for such a plan is obvious.

- Consider how the projects will impact the health and integrity of the soils. The soil is important to consider because it has a tremendous impact on the flora that rely on its nutrients and the fauna that then consume these plants.

Community Impacts
An Environmental Impact Assessment is, by definition, an analysis of the possible and probable effects a development will have on the surrounding environment and is therefore ill suited for addressing qualitative measures such as human and social welfare. The EIA provides a broad analysis of possible human and social impacts, but does not adequately incorporate the views and opinions of the ultimate bearers of the projects' environmental costs, the people of Aysén. Additionally:

- The EIA should incorporate a longer-term view of the impacts associated with project implementation. These projects would open the region to further human development, making the area more attractive to outside business and industry. This has serious implications for the people of Aysén who pride themselves on a certain "Patagonian way of life," and these projects potentially jeopardize the future integrity of this lifestyle.
- The EIA should discuss the infrastructural requirements for workers camps. The EIA does not mention vehicle access, drinking water, wastewater treatment, and the provision of food, clothing, and other goods. Since most of the economic impacts associated with project development were asserted to be positive, it is important to understand the intended relationship between the worker camps and the local communities.
- While the EIA does address the effects on the local economy, its scope must be broadened to include effects on housing, land, and food prices as well as the potential for such phenomena as urban migration and inflation of goods other than firewood.
- A more comprehensive plan to control the behavior of workers needs to be included. The current plan is insufficient considering the potential impact of nearly doubling the local populations in the vicinity of the camps.
- The EIA needs to do a better job of incorporating the views of local people. The people of Aysén would be better represented in a document drafted using community participation in collaboration with trained researchers, rather than a third party appraisal of the possible effects and the degree of mitigation necessary.
- The EIA should be written so that it is more accessible to uneducated readers, as many of the people most likely to be affected are uneducated and of the working class.

Tourism
Both Aysén's blossoming tourism industry and HidroAysén's proposed dam projects rely on the region's natural resources to generate capital. However, because tourism depends upon the pristine quality of the local environment and because HidroAysén seeks to harness and modify that untapped potential, there is a clear conflict of interest between the two industries. While tourism stands to benefit and sustain the local economy long-term, the EIA fails to note that beyond the construction phase, the benefits and capital generated by the projects will contribute very little to the local community. Additionally:

- With tourism growing significantly each year (some years by as much as 15%), using data from as recently as 2004 may not accurately predict the total productivity of the tourism industry today. The EIA should use the most recent data available, or gather its own data to ensure accurate representation of the tourism industry.
- The EIA needs a more comprehensive analysis of total revenue and employment generated by the region's tourism industry.
- The projects are expected to cause a significant decrease in the rate of growth, employment, and revenue generated by tourism during the construction phase. Additionally, during the operation phase, tourism is not expected to recover to pre-construction rates of growth and this is not acknowledged in the EIA. An analysis of the opportunity costs of project implementation should be included; namely, would the growth and amount of capital generated by tourism without the dams be greater than the benefits to the Aysén community should the projects be constructed?
- The EIA fails to present a holistic analysis of the effects of the projects on the local tourism industry. For example, the document neglects regional planning initiatives concerning contemporary and future tourism development. The EIA should include a comprehensive plan to coordinate with said initiatives, where possible.
- The EIA should include an analysis of the impacts on tourism from the transmission lines required to transport electricity from the five dams to local collection system and those required to transport electricity from Aysén to the Central Interconnected System (SIC). The transmission lines will be the PHA's most visible component. This has significant implications for the intrinsic value of nature upon which tourism relies. The EIA needs temporal analysis, as tourism will be impacted by the projects indefinitely. Long term projections of the impacts on tourism must be evaluated when determining the total impact of the projects on local tourism.

Conclusions

The focus of this report was to analyze the EIA based on its completeness, relevance of information, and validity. We have determined that the EIA in its present form does not provide a comprehensive analysis of the impacts of the PHA project sufficient to inform decision makers.

One of the key limitations of the EIA as presented was the failure to approach the analysis of impacts from an ecosystems perspective. This was manifest in a variety of ways. The impact assessment was subdivided into a total of 111 individual impacts and these were analyzed sequentially. The implication of such an approach seems to be that so long as each of the individual impacts identified can be “managed”, nothing should prevent the project from moving ahead. Although some of the mitigation schemes were devised to address more than one of these impacts the connections between the various impacts were generally unexplored. In addition, the ranking system employed to determine severity of impacts appeared to be somewhat arbitrary, both in terms of its emphasis and its application.

There is insufficient information presented in the EIA on many topics. One important reason for this is the relatively short time allocated for collection of baseline information, especially on systems that may exhibit considerable variability. The relative lack of pre-existing information on Patagonian ecosystems makes this deficiency more problematic. In addition to incomplete studies, several other issues appear not to have been carefully considered or at all (effects of hydro-peaking operations, climate changes, etc.) A broader view of potential impacts is required.

Details are lacking in the area of mitigation, reparation and compensation strategies. For example, a conservation area is proposed for both aquatic and terrestrial flora and fauna, but the details are completely lacking and while it appears that one conservation area is intended to meet both objectives, there are conflicting descriptions of what the conservation area will accomplish in different areas of the text. One activity that consistently appears in the description of compensation activities is to perform various studies and to report the results. The basis for this approach being defined as a compensation activity is never discussed, but this does not appear to match the definition of compensation as required by the impact assessment process.

Finally, the environmental impact assessment process for the PHA was conducted independently of a similar analysis for the long distance transmission lines that will be required to carry the energy from Aysén to the Santiago area. Given the mutual dependence of these two systems, it is illogical to separate the regulatory consideration of them.

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APPENDIX 1

TRANSLATION OF THE EXECUTIVE SUMMARY OF THE HIDROAYSEN PROJECT ENVIRONMENTAL IMPACT ASSESSMENT

This document was originally translated at the University of Michigan by Cristina Reina-Neito in February, 2009 with subsequent modifications by Steven J. Wright

Executive Summary

2. Introduction

This document corresponds to the executive summary of “Environmental Impact Assessment” (EIA) by Aysén Hydroelectric Project (from now on, PHA) which the company Centrales Hidroelectricas de Aysén S.A. (from now on, HidroAysén) considers carrying out in the municipalities of Cochrane, Tortel and O’Higgins, in the province of Capitan Prat, in General Carlos Ibanez del Campo’s Aysén’s Region.

The PHA consists of the construction and operation of Hydroelectric Complex Aysén, fundamentally composed of five power stations, named Baker 1, Baker2, Pascua 1, Pascua 2.1 and Pascua 2.2, which will be located on the Baker and Pascua rivers, taking advantage of part of their energy potential. Aysén‘s Hydroelectric Complex, once operational, will have an installed capacity of 2,750 MW and will generate an annual average energy of 18,430 GWh, which will be incorporated to the Central Interconnected System (SIC), which supplies electricity to more than 93% of the Chilean population.

The resources available in the Baker and Pascua rivers are among the most important that the nation has to meet its electric supply needs. These resources have complementary hydrologic characteristics to the rivers in the central area of the country, specifically the ones that are used to generate electricity. Chile will be more independent and have energy security through the sustainable use of a resource that is theirs, clean, renewable and strategic, as water is, all this framed in the complex international situation with energy resources. Likewise, this development initiative, will dynamize the economy in an important way and will boost the conditions for the social development of the region of Aysén, improving the infrastructure associated with land transport, increasing employment and helping its inhabitants’ development.

PHA consists of, apart from the power stations, permanent facilities such as: an electric transmission system, infrastructure buildings in Cochrane, electric supply system for works, dock facilities, building of new roads (90 km), renewal (187 km) and replacement (10 km) of existing public roads, telecommunication systems and landfill, among others. Moreover, it is considering support facilities during the building stage, such as: camps, working facilities, medical center, deposits, aggregate plants, concrete plants, sites for stockpiling excavation material and transfer stations (facilities used in freight transport between the ports and facilities), all of them described in the EIA’s project description.

The current EIA is based on the environmental characterization that covered studies over approximately 300,000 hectares, an area several times larger than the project’s surface area for works and dams. For a long period of time, more than 2 years depending on the particular study, prestigious universities and research centers carried out several field campaigns, generating a great deal of new information about the region of Aysén. The research performed and the entities in charge are the following:

- Research on Vegetation and Terrestrial Flora- Universidad Austral.
- Research on Terrestrial Fauna- Universidad de Concepcion.
- Research on Acquatic Flora and Fauna, Water Quality and Ecologic Flow- Centro de Ecologia Aplicada.
- Research on Land, Climate, Meteorology, Hydrology, Hydrogeology, Geology and Geomorphology- Universidad de Chile.
- Research on Oceanography, Sea and Estuary Flora and Fauna- Universidad de Valparaiso.
- Research on Landscape, Territorial Planning and Protected Areas- Universidad Central.
- Research on Areas of Risk- Universidad de Chile
- Research on Population, Socioeconomic Aspects, Quality of Life and Touristic Activities- Pontificia Universidad Católica de Chile.
- Research on Land's Holding, Equipment and Infrastructure- Pontificia Universidad Católica de Chile.
- Research on Cultural Heritage (Historical, Archaeological, Anthropo-Archaeological, Religious, National Monuments) - Universidad Bolivariana.

The relationship between total reservoir area (5,910 hectares) and the capacity for energy generation (18,430 GWh per year) makes PHA one of the most efficient ones in the world, with a ratio far greater than other projects of similar technology. In fact, the power per reservoir hectare is 0.47 MW/ha and the annual generation per area unit is 3.12 GWh/ha.

The project's study stage uses an innovative approach in the different dimensions that it comprises. One of its main characteristics has been to establish a proactive early communication, open and transparent, from the beginning of the research, with the objective of informing the communities, opinion leaders and local, regional and national authorities properly about the evolution of the project and the environmental components studied. One year prior to the initiating the study for the EIA, the Region of Aysén and public opinion in general, were presented the main characteristics of the Aysén Hydroelectric Project. In this way, it has been innovative by informing about PHA's substantial components and the environmental components that have motivated the studies. PHA has responded to various requests for information and communication with the community through the creation of their offices in Coyhaique (since December 2005) and Cochrane (since April 2006), permanent and itinerant "Open Houses" (in HidroAysén offices), seminars and scientific panels, creation of documents for outreach, and information meetings, among others.

The objectives, by which HidroAysén has developed their actions, which have been incorporated early in PHA's design, include the following aspects:

- Respect for the local culture.
- Minimize relocations.
- Protection of native flora and fauna.
- Minimize reservoir surface areas.
- No impact on glaciers, since they are not affected by dam areas.

- Reduction on the impact on touristic and cattle farming areas.

3. Environmental criteria used in the project's design.

Once the need to conduct studies for PHA was understood, the Head of the Project, imposed the incorporation of design criteria that take into account, from an early stage, modern environmental concepts to carry out construction projects such as Aysén Hydroelectric Project. In fact, with the voluntary exposition and popularization of PHA to the different sectors of opinion and the community, both in a regional and national level, it was possible to gather different interests and concerns, that later were reflected in PHA's design phase. That is to say, PHA's engineering has been done from the point of view of identifying impacts and design to mitigate them, following the best standards currently at our disposition. This means that an important amount of the mitigation measures are a substantial part of PHA's engineering design.

Taking all this into account, some impacts have been minimized and resolved using the construction projects design and planning. For example, three relevant aspects can be mentioned: i) With the reduction of reservoir areas that was achieved as a result of the optimization of the engineering designs, it has been possible to diminish re-location to 14 families. The above mentioned, plus a design of self-sustained camps, near the working areas and with limited massive and permanent access to town centres, it allows to mitigate, due to the design and planning, impacts on human settlements; ii) Taking into account that one of the main modifications that PHA introduces is in the rivers that are used to produce energy, some designs have been developed that self-impose, for every of the power stations, rules and minimum flows of operation that ensure the minimal impacts in the intermediate basins and the river downstream from the power stations. These minimum flows of operation, established by HidroAysén, are above the limits imposed by current regulations as protective measures, and are created to ensure that the natural conditions of the rivers are maintained. The aforesaid, added to a working scheme that includes the return of water, either by generating units or through spillways, to the river's natural course at a point immediately downstream from the works of the same (a necessary component to the construction of the reservoir or dam works), they try to alleviate potential impacts that are normally found in this type of project. All this, makes it possible to guarantee that the daily maximum variation of PHA's reservoirs (decrease) will not be greater than 2 metres with respect to its maximum level in normal conditions of operation; iii) Taking into account the loss of sectors with scrubland vegetation, PHA's Forestry Management Plan (PMF) incorporates from the beginning the identification of sectors and specific lots where the compromised reforestation is intended to be done. This reforestation will be carried out with the native species identified in PMF, mainly intended for conservation in an effective area of 4,574 ha. It is important to mention that for all this to happen, an implementation model has been designed that ensures the existence of species meant to be protected, in sectors where they currently exist or existed in a natural way and are near to towns from Coyhaique to O'Higgins, and creating jobs additional to the PHA ones.

These are the main environmental criteria considered:

- Develop a project with the maximum efficiency, trying to reduce the dam areas and getting the maximum amount of energy.

- Minimize flow oscillations in rivers and dams, creating rules and minimum flows of operation that ensure the lowest impacts in the intermediate watersheds or downstream from the power stations. These minimum flows of operation, established by HidroAysén, are above the limits imposed by current regulations as protective measures, and are created to ensure that the natural conditions of the rivers are maintained.
- To establish water restitution to the river's natural course, either by generating units or through spillways, at a point immediately downstream from the works of the same. That is to say, it is not considered to dry up the current courses of the rivers, beyond the required construction areas.
- Do not intervene in the normal fluctuation of Bertrand and O'Higgins Lakes, located upstream from the source of Baker and Pascua rivers respectively.
- Maintain the elevations of the Baker River and the Nef River, such that the waterfall at their confluence is preserved, also in the Nef River valley, to maintain tourism activities at the confluence and upstream.
- Reduce the water level in the reservoir of Power Station Baker 2, so that the natural conditions in Valle Grande are maintained, a sector including the confluences of Baker River with Santa Teresa Stream and with Del Salto River, an area that incorporates livestock farming activities in the project's area of influence.
- To apply landscape considerations into the work's design. Underground designs (caverns for machinery and encapsulated substations) will be considered and the views of the route of the transmission lines will be minimized (link system). Design of exterior work with building architecture compatible with the surroundings.
- Design of self-sustained camps that allow the minimization of the use of basic services from nearby towns and combine the project with the cultural vocation of the influence area.

4. PROJECT DESCRIPTION

3.1 General background

3.1.1 Objective

PHA's objective is the construction and operation of Aysén Hidroelectric Complex that is fundamentally composed of five power stations. This power generation will be carried out through the rational and sustained use of part of the hydroelectric potential of Baker and Pascua Rivers, specifically in the sectors where HidroAysén owns non-consumptive water rights, and will be used to supply the SIC.

3.1.2 Justification and geographical location

For its national electric supply, Chile has different electrical grids, independent of each other. Within this context, the Central Interconnected System (SIC) supplies the electric needs of more or less 93% of the population and their economic activities, covering from Taltal, in the North, down to Chiloe Island in the South. SIC has different sources of generation, whether renewable or non-renewable. Among the first ones, they have thermoelectric power stations (natural gas, diesel and coal) and for the second ones hydroelectric power stations and other non-conventional technologies. In recent years due to both the situation with natural gas supply from Argentina and the international situation with energy resources that has increased the prices of all fossil fuels (which Chile does not have in the adequate quantity or quality to satisfy their minimum requirements), SIC has reduced their security parameters and has increased their price levels for electricity. It is in this context that HidroAysén has set out to develop PHA, trying to provide a solution that is required in an energy context and with direct connection to the nation's economic and social growth, makes it of the utmost urgency and importance. According to the projections that can be obtained from the system's growth information, it is possible to assume that when all the power stations are working, they will produce 21% of the energy used by the SIC.

The hydrological resources for the region of Aysén are strategic for Chile and, particularly the rivers Baker and Pascua, which have flows of high magnitude and of low variation within the year, compared to other rivers of the central area of the country. These unique conditions are due fundamentally to the climatic characteristics of the area and the regulation done by the lakes that are located upstream from the rivers mouths, the lakes General Carrera-Bertrand and O'Higgins, respectively. These conditions explain one of the main qualities of this project, that is to use in a sustained way an abundant resource with low seasonal variation, for which the hydrologic pattern is also complementary to other sources of hydroelectric energy generation and in this way to diminish the periods of shortage of the hydrologic resource in SIC's hydroelectric matrix, granting more independence and energy security to the country. Among other effects, we can point out that with the contribution of Aysén Hydroelectric Project, the variability in SIC's interannual hydroelectric generation will be diminished, with the consequent benefit for the electric supply of the System.

PHA will be located between parallel 47º and 49º South Latitude, in the rivers Baker and Pascua. The geographic coordinates (UTM) of the area of PHA's location (vertexes of the polygon that border the project areas) are summarized in the following table:

Table 3.1-1 Coordinates of PHA's area of location

Vertex	UTM Coordinates – Datum WGS84 (UTM zone 18)		UTM Coordinates – Datum WGS84 (UTM zone 18)	
	East	North	West	South
V1	634.500	4.783.000	73º 13' 40"	47º 05' 34"
V2	687.500	4.783.000	72º 31' 48"	47º 04' 48"
V3	669.200	4.639.700	72º 42' 55"	48º 22' 23"
V4	616.200	4.639.700	73º 25' 50"	48º 23' 06"

Baker 1 power station is located in the Chacabuco Narrows, around 1,000 m upstream from the confluence of the Baker and Chacabuco Rivers; Baker 2, in El Salton Narrows, around 2 km upstream from the junction of Baker and El Salton rivers all of them in the municipality of Cochrane, Province of Capitan Prat, Region XI of Aysén del General Carlos Ibañez del Campo, (from now referred to as the Aysen Region); Pascua 1 in Lago Chico Narrows, around 1,200 m upstream from the confluence of the Pascua River with the outlet of Gabriel Quiros; Pascua 2.1, in Pascua River Narrows, around 8 km upstream from San Vicente sector; and Pascua 2.2, in San Vicente Narrows, around 4 km upstream from the confluence of the Pascua River and the outlet of Lago Quetru, all of them in the municipality of O'Higgins, Province of Capitan Prat, Aysén Region.

3.1.3 Parts, actions and construction work

The following table summarizes the main characteristics of the hydroelectric power stations:

Table 3.1-2: Main characteristics of PHA power stations

Stations	Unit	Baker 1	Baker 2	Pascua 1	Pascua 2.1	Pascua 2.2	Total
Maximum elevation of operation*	m	200	93	266	200	101	-
Reservoir Area	ha	710	3,600	500	990	110	5,910
Design discharge	m^3/s	927	1,275	880	980	980	-
Station Power capacity	MW	660	360	460	770	500	2,750
Annual energy average	GWh	4,420	2,530	3,020	5,110	3,350	18,430

* The maximum elevation of operation is referred to Datum WGS-84. Topographic uplifting 2006

As far as it is concerned, PHA's link system of electric transmission is alternating current, and has the purpose of connecting the stations with an electric converter station (AC/DC). The direct current system is not part of PHA and will be presented to the Environmental Impact Evaluation System by the corresponding project holder. Part of the link system will involve a substation with an approximate area of 2 ha, named Los Ñadis, which will allow the connection between the double-circuit line of 500 kV from Baker 2 and a double-circuit line of 500 kV from Pascua, and from where a double-circuit line of 500 kV will connect the aforementioned substation with the converter station. As far as it is concerned, Baker 1 will be directly connected to the converter station through a short-length of double-circuit line of 500kV.

The following table will summarize PHA's characteristics of the electric transmission line:

Table 3.1-3: Main characteristics of PHA's Transmission Lines

Lines	Baker 1	Baker 2	Pascua River Power Stations
Voltage (kV)	500	500	500
Line's Power (MVA)	740	400	1,920
Circuits (c/u)	2	2	2
Length (km)	1.5	12	165
Right of Way area (ha)	10	78	1,073

PHA's works of infrastructure include Cochrane facilities (administrative offices and housing), the system for the electric supply to construction areas (power generators, Del Salto hydroelectric power station of 14 MW and line of 66kV), dock facilities (Puerto Yungay Harbor with new ramps and in Puerto Rio Bravo), building of new roads (90 km), renewal (187 km) and replacement (10 km) of existing public roads, telecommunications (VHF) and landfill in San Lorenzo area.

To carry out PHA's permanent works, including hydroelectric power stations, link lines and infrastructure works, it will be necessary to have supporting facilities (temporary works) that will only operate during PHA's construction stage. These facilities will be the following: a medical

center in Cochrane, working facilities (workshops, storage areas, fuel station and magazines), camps, provisional roads, deposits, aggregates plants, concrete plants, stock piles and transfer stations. In spite of their temporary character, it has been planned that these facilities should have a harmonious relation with the environment and their location. Also, in the closure or abandonment stage of these works, the correspondent restoration actions of the sectors involved are planned.
Designs have been developed for all PHA's works that incorporate aspects that consider the adequate place in the environment- not only taking into account landscape criteria, but also physic and biotic and human settlements- and that are considered safe both in the construction and in the operational stages. As an example, we can mention that for the dam and security works (spillways and bottom outlet according to the circumstances) of every power station it has been considered and verified, through tested engineering techniques, that they will function satisfactory under extreme hydrologic conditions that may take place in both rivers. Also, during PHA's construction and operational stages, HidroAysén will maintain an operational plan of community information and a coherent plan of action as stated in the applicable legislation on these effects and coherent with the audit requirements that this legislation confers to competent authorities.

3.1.4 Investment amount, area involved, schedule for the activities and lifespan of the project.

The estimated inversion to develop PHA is US$ 3,200 million and the total estimated area used by PHA is 8,722 ha, that mainly corresponds to reservoirs (5,910 ha, without excluding the current areas of the river courses located in the inundation areas that is 1,990 ha) and the link system for electric transmission as alternating current (1,379 ha).

PHA's construction will last for a period of 11.5 years, during which the construction of one or more power stations will take place. The building sequence will start with infrastructure works and Baker 1 power station, then Pascua 2.2, Pascua 2.1, Pascua 1, and finally, Baker 2. The power stations will begin to be operational in the years 5, 7, 9, 11 and 12, respectively.

According to the rest of PHA components, the link lines will be built in parallel with their power stations; they have to be finished before the power stations begin to be operational. The construction and outfitting of the support facilities will initiate the beginning of PHA's construction stage.

Taking into account the nature and technology of this type of project, the power stations and transmission system lifespan is considered as indefinite, because the works can function for long periods once the necessary periodic maintenances are carried out. The experience in other projects shows that in this type of installation, only the mechanical equipment is subject to obsolescence, a problem that is solved out through replacing them by new technology, as needed. Civil works, as far as they are concerned, do not present the same situation. The following table will present the schedule for PHA's activities:

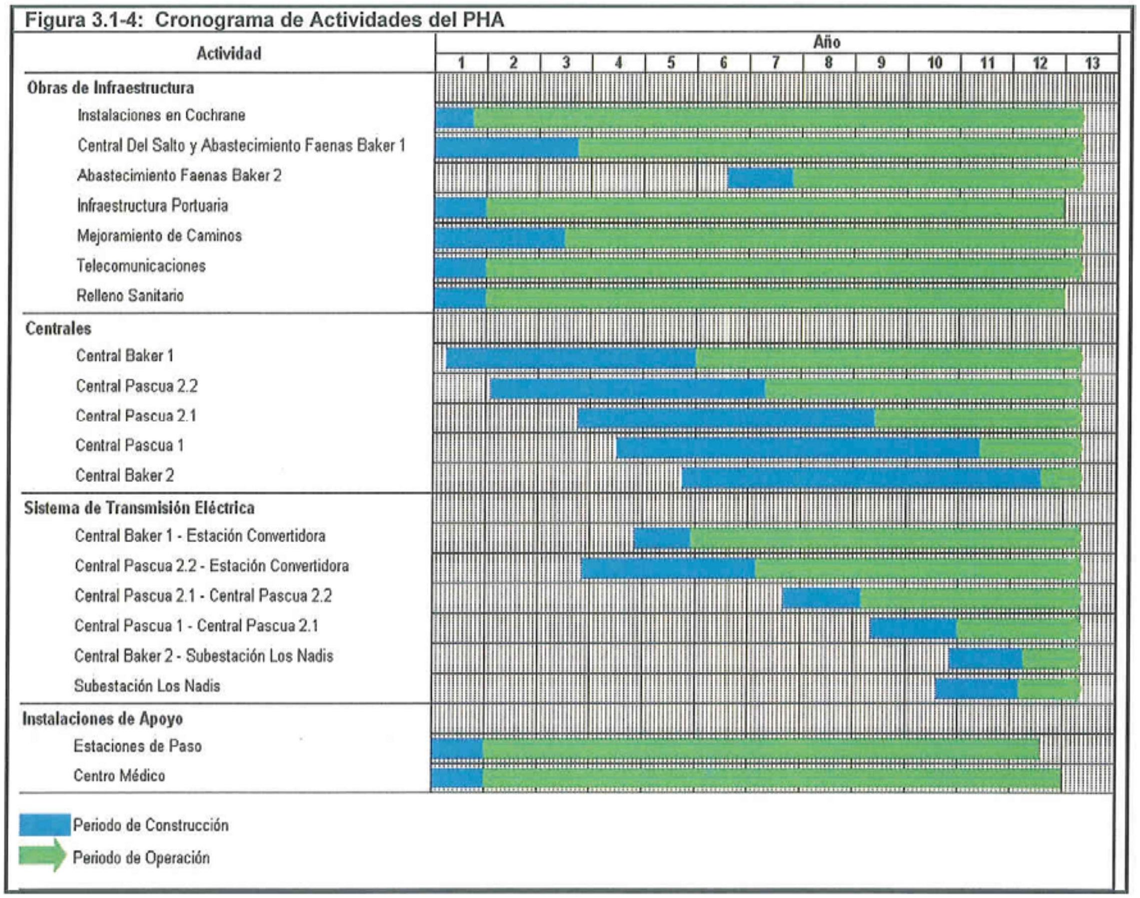

Figura 3.1-4: Cronograma de Actividades del PHA

- Blue: building stage
- Green: operation stage

3.1.5 Water use rights

PHA’s development requires water use rights to be put into effect, including the necessary ones for the working facilities, camps and industrial use. These rights, of consumptive use, will be opportunely obtained, through the appropriate mechanisms and according to the project’s work program.

On the other hand, for each of Aysén Hydroelectric Complex power stations it is required to have water use rights for non-consumptive use. HidroAysén posesses rights for PHA’s area and taking into account the important engineering optimization process that has been developed, and that permitted a significant reduction in the area of the reservoirs planned – while still maintaining a high energy contribution- it has been necessary to complement existing water rights by requesting additional non-consumptive rights for each of Aysén Hydroelectric Complex; these are currently in the application procedure before the competent authorities. The object of the previously said is to allow the efficient use of the resources available in both rivers. To implement PHA in an efficient way, the required rights should be owned.

3.2 Description of the building stage

3.2.1 Hydroelectric Power Stations

The construction of each PHA power station involves the following main activities:

- Clearing and cleaning: In the areas of the location of the works, accesses, working facilities, and support facilities of every power station, the clearing and cleaning of the vegetation, according to the type of work or activity, will be required.
- Building and renewal of access roads: Building roads will require both rock excavation and common material, and the fills to create embankments and of granular materials for pavement stratum.
- Construction of diversion works: It requires two diversion tunnels and two cofferdams, one located upstream from the dam and the other downstream from it, allowing the deviation of the watercourse while the dam is being built.
- Construction of the dam: Roller Compacted Concrete dams will be built for the Pascua River power stations (HRC in Spanish; RCC in English) with vertical face in the upstream section and batter in all downstream sections. Baker River power stations consider a conventional concrete dam (Baker 2) and a concrete face gravel dam for Baker 1.
- Construction of spillway, water intake and penstocks: The spillway construction process depends on its design, which can be on the dam (Pascua River power stations and Baker 2) or on one of its sides (Baker 1). Water intake works consist of concrete structures, in which service and emergency sluices are installed to control the flow that goes to the penstocks. The construction of the penstocks considers two alternative types: channel-charge chamber-tunnel or tunnel-chimney-tunnel.
- Construction of powerhouse: There is a priority to build a powerhouse for all power stations, consisting of underground works, except for Baker 2, for which, taking into account its structural characteristics, the design has considered an above ground powerhouse.
- Construction of exit works: It includes the construction of passages with lock-gates, exit tunnels and passing works.
- Construction of bottom outlet: This is a security work that will allow, in the commissioning stage, to control the dam filling speed, permitting the verification of the dam performance and of the reservoir slopes in the new hydraulic conditions.
- Assembly of electro mechanical equipment: That is to say, turbines, power generators and transformers located in the interior of the powerhouse or cavern.
- Construction of electrical panels: It includes activities such as earth-moving, metal support structures, wire netting construction, structure assembly, electric equipment assembly and equipment testing.
- Dam filling: Before initiating the power station operation, once construction is completed on the dam, spillway, water intakes, bottom outlets and removal of the cofferdams that are in the reservoir area, the reservoir will be filled. The filling period for Baker 1 and Baker 2 is 36 and 14 days respectively. The filling period for the stations in Pascua River is 20 days (Pascua 1), 45 days (Pascua 2.1) and 25 days (Pascua 2.2).

3.2.2 Electric Transmission System

Parallel to the construction of the power stations, the works of the link system will be carried out, to connect the stations to the line frame in the converter station AC/DC that will be located in the vicinity of Baker 1. The construction of the link line system will be carried out combined with the construction of the power stations. The main activities are the following:

- Removing of vegetation in the sectors where the towers and the substation will be located.
- Helicopters will support the construction of the transmission lines, reducing access tracks to the structures or towers.
- Construction of pillars, assembly of structures, conductors and insulation strings.
- Construction of Los Ñadis substation, in an approximate area of 2 ha, that considers earth-moving, building of foundations, substation and electric equipment metal support structures, construction of the substation control room, construction of ground network and wiring from the control room to the exterior electric equipment, assembly of the exterior structures, assembly of the exterior electric equipment and GIS switching substation, assembly of telecommunication equipment, protections, control and measurements in control room, assembly of battery chargers and battery banks, transformer and emergency back-up power unit in control room, with connection to the protection systems, controls and measurements located in the control room and equipment testing.

3.2.3 Infrastructure work

The construction program, considers starting with the building of the infrastructure work, including Cochrane installations (offices and housing), the system for the electric supply for the construction facilities (Del Salto hydroelectric power station and the 66 kV transmission line), dock infrastructures (Puerto Yungay Harbor and new ramps in Puerto Rio Bravo), building of new roads (90 km), renewal (187 km) and replacement (10 km) of existing public roads, telecommunication (VHF system) and landfill in San Lorenzo sector.

The supply of input, materials and equipment necessary for the first months of construction will be carried out through the current public ramp of Puerto Yungay, property of Ministry of Public Works (MOP), since the works in the future Puerto Yungay will be under construction.

In order to do this, it will be necessary to carry out some renewal actions that will guarantee their permanent working conditions, not only to maintain the continuity of Carrera Austral traffic, but also for PHA’s requirements. Taking all this into account, construction and renewal of the installations located in Puerto Yungay sector has been planned.

On the other hand, the electric supply during the construction stage will be done through an integral system, composed of power generators and Del Salto hydroelectric power station (including the transmission line of 66 kV) which construction will also be started in the first year of the project. Del Salto power station will be used in the electric supply of the power stations in

Baker River; nevertheless, between the beginning of Baker 1 construction and the commissioning of Del Salto power station, power generators will be used. A VHF system has been developed for the communication in all the area, among the different works, technique inspection offices and HidroAysén offices. This system will have radio stations, with capacity for voice channels and a channel for data to link GPS communications.

3.2.4 Support Installations

To build the power stations, the link system for the electric transmission and the infrastructure works, the following support installations will be constructed and equipped: a medical centre in Cochrane, working facilities (workshops, storage areas, fuel station and magazines), camps, provisional roads, deposits, aggregates plants, concrete plants, stock piles and transfer stations. All these works have an abandonment or closure plan, which includes the corresponding restoration actions of the sectors involved.

3.2.5 Inputs, equipment and machinery

These are the main inputs and equipment required for PHA's construction:

- Inputs: Aggregates and filling material, (both taken from local areas), cement, fuel, tyres, batteries, oil, framework, cores and explosives, water (for human use and construction), liquid gas and electricity. The main inputs used will be aggregates (7.9 million m^3 approx.), cement (406,000 ton approx.) and fuel (328,000 m^3 approx.)
- Equipment and machinery: Machinery such as bulldozer, front loaders, draglines, dump trucks, mixers, compacting machines, motor graders, water trucks, hydraulic cranes, drilling machines, track drills and trucks.

3.2.6 Labor

PHA's implementation will last 11.5 years, during this period an annual average of labour of 2,260 workers will be required. The maximum monthly number will be 5,100 people, distributed in different work fronts in PHA.

3.3 <u>Description of the operation stage</u>

3.3.1 Power Stations Operations

After each of Aysen Hydroelectric Complex power stations become operational, that is to say; Baker 1, Pascua 2.2, Pascua 2.1, Pascua 1 and Baker 2, the power equipment will be controlled by the operators, following the instructions from the load centre and the power station's rules of operation. In reservoir operaetions, the activities during the operation stage are related, mainly, to the control of reservoir levels in a permanent and automatic way. With all these measurements, it is possible to calculate the flow that comes to the dam, which is a fundamental parameter in the operation of each power station.

Since the objective of Aysen Hydroelectric Complex is to deliver energy to the SIC, the functioning of the power stations will be adapted to variations in this system's demands of CDEC-SIC (Load Economic Negotiate Centre). No power station will be able to regulate the rate flow to the dams seasonally or daily, they will only be able to regulate intra-daily, that will allow them a regular bounded control, so that they can work at their maximum level of operation some hours per day. The aforesaid, also permits to guarantee that the daily maximum variation of PHA's reservoirs (decrease) will not be greater than 2 meters with respect to its maximum level in normal conditions of operation.

Aysén Hydroelectric Complex has imposed, through the design, a rule on minimum flow rates of operation (evacuate through outlet works or through the each power station generating units), so that the effects are minimized, not only downstream from the every dam working area, but also the intermediate basins. These minimum flows of operation, established by HidroAysén, are above the limits imposed by current regulations as protective measures, and are created to ensure that the natural conditions of the rivers are maintained.

The following table shows the background of the design of PHA's power stations, detailed in the flow rate design (A), the exceeding probability (B) and the minimum flow rates of operation (C).

Table 3.3-1: Rate flow design of PHA's power stations

Power Station	A(1)	B(2)	C(3)
	m^3/s	%	m^3/s
Baker 1	927	5	260
Baker 2	1,275	14	380
Pascua 1	880	12	250
Pascua 2.1	980	11	280
Pascua 2.2	980	12	280

Note: (1) From the incoming flowing rate, the power station uses the design rate flow in generation, and the excess is evacuated through the outlet; (2) The exceeding probability means that in the mentioned % of the days, the water level in the dam does not fluctuate, remaining in the maximum, so that the evacuated flow rate is the same as the incoming one; (3) the minimum flow rates of operation corresponds to the minimum average flow rate in every power station return flow point throughout all PHA's operation stage.

3.3.2 Personnel

In an operation pattern, Aysén Hydroelectric Complex will require approximately 140 people for their operation and routine maintenance. The operation of the power stations will be carried out through two organizations, one organization for Baker 1, Baker 2 and Del Salto power stations, having their base in Cochrane and the other one for Pascua 1, Pascua 2.1 and Pascua 2.2, having their base in one portion of the construction camp for the Pascua River power stations that will be accordingly equipped for this purpose.

3.4 <u>Description of the closure or abandonment stage</u>

PHA's abandonment plan is restricted to support facilities (temporal) necessary to the construction and commission of the hydroelectric power stations and some infrastructure works. These facilities will be dismantled or demolished, as appropriate, restoring the intervened areas in the forms and conditions identified in the present EIA.

Hydroelectric power stations, the system for electric transmission and some infrastructure works (facilities in Cochrane, harbour infrastructure and renewal and road building) have got an indefinite lifespan, even though the electro mechanical equipment and the civil works that compose the different power stations will need to be maintained so that they function adequately.

3.5 Description of emissions and releases to the environment

3.5.1 Construction stage

In this stage the following emissions and releases to the environment will be generated:

- Atmospheric emissions: Includes emissions of particulate material and combustion gases, generated from the crushing and screening of the terrain, levelling, filling and compacting of the ground, handling of excavation surplus and use of vehicles and machinery (exhaust gas emissions), vehicle transit through roads or non-paved roads, power generating units (exhaust gas emissions from power generating units), etc.
- Noise emissions: Generated in stationary sources (facilities and works) and PHA's mobile ones, associated to equipment and machinery in working lines, blasts, machinery and vehicles transit, functioning of power generating units, etc.
- Domestic solid waste, sludge from water treatment plants, non-hazardous industrial solid waste, hazardous solid waste and hospital waste. All waste will be stored in areas authorized by health authorities. In particular, for the domestic solid waste, the San Lorenzo landill will be used, the environmental sector permit is applied in this EIA.
- Liquid waste, which is basically composed of domestic sewage and industrial liquid waste (RILES). All liquid waste will be treated and disposed according to regulations.

3.5.2 Operation Stage

In this stage the following emissions and releases to the environment will be generated:

- Atmospheric emission: Correspond to emissions of particulate material and combustion gases produced by the functioning of support power generating units that would be possibly used during the operation of the hydroelectric power stations.
- Noise emissions: Generated in electric lines and Los Ñadis substation, by the "corona effect".
- Solid waste, such as: domestic solid waste, sludge from water treatment plants, hazardous solid waste and hazardous waste. All waste will be contained in areas authorized by health authorities.
- Liquid waste, which is basically composed of domestic sewage and industrial liquid waste, all of them will follow the current environmental regulations.

3.5.3 Closure or abandonment stage

Which include the atmospheric emissions created by the dismantling of the temporal works. All these activities will follow the environmental current regulations.

4 Compliance Program of Environmental Applicable Law

4.1 General and Specific Regulations

EIA considers the Compliance Program of Environmental Applicable Law to PHA, the general regulations applicable to the project, the environmental regulations of special character directly associated to environmental protection, and the use and resource management control of natural and environmental issues cited.

To implement and enforce the valid environmental legislation, PHA considers all the legislation belonging to, according to the stated in the Environmental General Requirements Law (Law Nº19,300/94) and SEIA Regulations (D.S. Nº95/01 from MINSEGPRES). PHA will provide specific performance of the analyzed provisions. The analysis carried out, for order purposes, was structured in accordance with the provisions in the Art. 12, letter d), from the above mentioned Regulations.

It should be taken into account that since it is a work that involves hydroelectric power stations and an electric transmission system (lines 500 kV, 66 kV, and an electric substation of 500 kV), PHA is subject to the legal provisions of General Law of Electric Services (D.F.L. Nº4/20,018 of 2006 of Ministry of Economy, Public Works and Reconstruction) and its Regulations (D.S. Nº327/98 of Ministry of Mining), apart form other rules specific to this area.

According to the regulations referring to pollution, EIA carried out an analysis on their enforcement in relation to the solid waste generation, liquid waste, noise level, atmospheric emissions, and electromagnetic field generation. Finally, the competent authorities on management of the current regulations to PHA were identified.

4.2 Sectorial Environmental Licenses

According to the requirements in Title VII of SEIA Regulations, the sectorial environmental licenses applicable to PHA, needs to be granted and the technical and formal contents presented to give proof of their performance. Based in the previously stated, and as a result of a review of the stated in the referred title, we come to the conclusion that according to the location and nature of PHA, the sectorial environmental licenses (PAS) identified in the following table are required:

Table 4.2-1: Summary of the Main Sectorial Environmental Licenses (PAS) applicable to PHA		
Article of SEIA Regulations(*)	**Environmental Rules that Support the Environmental License**	**Description of the Sectorial Environmental License**
72	Article 117 of D.S. Nº1/92 Ministry of National Defense. Regulation for the control of aquatic pollution.	Permit to install and operate in a sea terminal and the conducting pipes for polluting substances or substances that can be polluting.
89	Article 11 of Law Nº11,402.	Permit to carry out excavations of gravel and sand from the river courses and estuaries in authorized areas by the General Direction of Public Works
90	Article 71 letter b) of D.F.L. 725/67, Ministry of Health. Health Code.	Permit to build, modify and expand any public or private work assigned to evacuation, handling or final disposal of industrial or mining waste.
91	Article 71 letter b) of D.F.L. 725/67, Health Code.	Permit to build, modify and expand any public or private work assigned to evacuation, handling or final disposal of drainage and sewage of any kind.
93	Article 79 and 89, D.F.L. 725/67, Health Code.	Permit to build, modify and expand any waste treatment plant of any type; or for the installation of a place allocated to stocking, selection, industrialization, commerce or disposal of final waste of any type.
94	Article 4.14.2, D.S. 47/92 Ministry of Housing and Town Planning. Town Planning and Constructions General Ordinance.	Qualification of the industrial undertakings and storage.
95	Title VII of Law 18,882, General Law of Fisheries and Agriculture, and D.S. 430/92 of Ministry of Economy, Public Works and Reconstruction.	Permit to fish with research purposes, necessary to the monitoring of the stocks conditions of the hydrologic species, in appliance of the Plan of Environmental Monitoring.
96	Paragraphs 3 and 4, Article 55, D.F.L. 458/75 of Ministry of Housing and Town Planning, General Law of Town Planning and Constructions.	Permit to subdivide and urbanize rural lands to complement any industrial activity with housing, providing equipment to any rural sector, or equip any health resort or tourist camp or for the industrial constructions, of equipment, tourist and populations, outside of the urban limits.
99	Article 9, Law 4,601. Law on Hunting.	Permit to hunting or capturing of animals of endangered species that are necessary to the development of the re-location Measures.
101	Article 294, D.F.L. 1,122/81 of Ministry of Justice, Code of Waters	Permit for the construction of the hydraulic works
102	Article 21, D.L. 701/74, Law on Forestry Development	Permit to cut or exploit the native forest, in any type of terrain or plantation located in areas of preferably forestry use.
106	Article 171, D.F.L. 1,122/81 of Ministry of Justice, Code of Waters	Permit for the works for the regulation and defence of the natural river courses.

(*)Articles according to Supreme Right Nº 95/01 of MINSEGPRES, SEIA Regulations

In PHA's EIA all the technical and formal background, required for the proceedings and acquisition of the mentioned sectorial environmental licenses, has been included.

5 RELEVANCE ANALYSIS OF THE RESEARCH ON ENVIRONMENTAL IMPACT

The Article 11 of Law Nº 19,300/94, states that if a project generates or presents one or more of the effects, characteristics or circumstances mentioned in it, the project or activity holder, should present a Research on Environmental Impact (EIA). The analysis carried out for PHA, indicates that it has to be sent to SEIA through a EIA because it presents or could generate the effects, characteristics or circumstances stated in letters b), c), d), e) and f) of the mentioned Article of Law Nº 19,300/94. In the section 7.2 of this executive summary a more detailed description of these effects, characteristics or circumstances can be found.

6 BASE LINE

6.1 Area of influence

In order to develop the Base Line, in PHA's area of influence, HidroAysén commissioned prestigious universities and research centres to conduct several field studies, that, over a long time (more than two years, depending on the particular study) generated a great deal of relevant and new information about Aysén Region. This environmental characterization included research in around 300,000 ha, an area several times larger than the one of the projects works and dams.

With the objective to characterize the base line, and consistent with the stated requirement in letter f) of SEIA Regulations, the project's area of influence was defined for every of the environmental components involved in the physical environment, biotic, human, use of the land, cultural heritage, landscape, contingency areas and tourism. In addition, in order to incorporate an ecosystem approach, the base line considered an integrated characterization of PHA's area of influence.

On the other hand, due to the magnitude of the project, that involves a great deal of works and facilities (including building and operation stages), in all media areas of particular environmental importance were analysed, configuring a concept of Area of Environmental Value (AVA). In this way, the AVAs are the result of the characterization of the different elements, in which it was possible to determine these areas which are considered sensitive by their basal condition or, that have or present a characteristic that constitutes them in an area with a unique value, differentiated from the rest.

6.2 Characterization of PHA's area of influence

In the following table, the main characteristics of the base line, for every environmental component considered in PHA, are summarized:

Table 6.2-1: Main Base Line Component Characteristics
Physical Environment – Climate and Meteorology
The pluvial pattern of the region of Aysén, contains one of the most rainy areas of the country, where the rainfall are over 3,000 mm a year, in the coastal stations (Isla San Pedro, 3,777 mm) and a reduced annual amount (pluvial gradient East-West). The thermal behaviour of the region of Aysén is characterized by average annual values that go from 6 to 9º C, with maximum thermal fluctuations between the periods December-January and June-July. These values are above 10º C in the areas located in the interior, away from the ocean influence and with a higher continental effect. According to the research, we can distinguish the following climates: Temperate-Cold Climate of west coast with a maximum winter rainfall (Cfb); Continental trans-Andean Climate with steppe degeneration (Cfc); Cold Climate of high altitude or ice (EFH) and Cold Steppe Climate (BSk).
Physical Environment - Geology
The geological formations that appear the most in the Baker River course correspond, basically to the eastern Andean metamorphic complex and Patagonic batholith and in a subordinate way, only in the northern part of the area, to the Ibañez Formation. In the Pascua River course and in the area of Yungay and Rio Bravo harbors, the geologic formations correspond to eastern Andean metamorphic complex, mainly represented by metasedimentary rocks of clastic source from the Paleozoic Age.
Physical Environment – Geomorphology
In the area of influence of Baker River the following geomorphologic units from a glacial-fluvial origin are distinguished: bars, flood plains, terraces, flats, alluvial fans, moraine, till. The area of influence of Pascua River shows two areas of characteristic relief, delimited by the east-west axis, composed by Mitchell Fjord and Bravo River. To the North of them, a relief with shallow and highly-sloped valleys can be observed, with a general variation of altitude between 500 and 2,000 m.s.n.m. In Pascua River surroundings, the relief is characterized by narrow and deep glacial-fluvial valleys (axis Leal Lake – Quetru Lake, Pascua River and Bravo River) with high-sloped hillsides, between 30º and 45 º.
Physical Environment – Edaphology
The capacity to use the soil of the Region of Aysén reveals a lack of terrain suitable for cultivation, it being less than 1% of the regional area. In a regional level, more than 63% of the territory is classified as Class VII, that is to say, with capacity to maintain wild life or to use as protection in gathering grounds. Class VII soil, of preferred forestry use, correspond to around 10% of the total regional, while Class VI soil (cattle-forestry) is less than 5%, and Class V less than 2%. Despite the reduced percentages, these areas represent the productive potential of the region. PHA's direct influence area in Baker River basin has got mainly Class V+VI and VIII, that is to say, its use is limited to wild life, recreation or watershed protection areas. Finally PHA's direct influence area on Pascua River basin, considers soil that belong mainly to Classes VI+VII, VII+VIII and VIII, that is to say, its use is limited to shepherding, forestry activities and activities of protection.
Physical Environment – Hydrology
The average monthly water flow in Baker River, in the places disposed for the location of PHA dams, have a typical behaviour of rivers that receive their waters from rain, snow and glaciers. The statistics that describe the historical series of the monthly average water flow indicate that with an exceeded probability of 50% are: 641.2 m^3/s, 947.1 m^3/s and 33.8 m^3/s, for sector Baker 1, Baker 2 and Del Salto. On the other hand, for Pascua River, the behaviour is similar to the one described for Baker River. The values with an exceeded probability of 50% are: 622.5 m^3/s, 686.8 m^3/s and 689.9 m^3/s for Pascua 1, Pascua 2.1 and Pascua 2.2 respectively.
Physical Environment – Water quality
Most of the parameters measured and analysed from Baker and Pascua Rivers and their tributaries, provided a result of Exceptional Class Water, as proposed by DGA (2003). Among the variety of 62 parameters measured, some of them, mainly metallic ones, are naturally in a higher concentration than for exceptional class waters. These materials are Al, B, Cu, S, Fe, Mn and Mo. Also, in this classification, are considered the Total Suspended Solid (STS). The previously said is in direct relation to the geological characteristics of the riverbed. From the parameter of average anthropomorphic origin, that is to say total coliforms and faecal ones, together with the biochemical demand of oxygen (BDO_5), the values were always extremely low in practically all measurement locations. A lot of the parameters included in the measures are close or below the minimum detectable concentrations with the analytical method used and below the minimum value established by the regulation (NCh 1333).
Physical Environment – Hydrogeology
Two separated hydrogeological units were identified for the area of Baker River. One of them, corresponding to unconsolidated sediments (A) and, the other, to units of cracked rock, with low permeability, with values lower than 10^{-2} cm/s (B). 20% of the area of interest, presents unconsolidated sediments, while the other 80% presents a unit of rock with a high fracture level, to which it is associated a low-medium permeability level is associated. For Pascua River, in a 1:50,000 scale, two separated hydrogeological units were identified: one corresponding to unconsolidated sediments (A) and the other to units of cracked rock, with low permeability, with values lower than 10^{-2} cm/s (B). The drilling carried out in the Baker River surroundings indicate the presence of groundwater in the rock, located at variable depth, between 1.6 and 30 m. According to the obtained background obtained from the drilling in the

surrounding areas of Pascua River, the groundwater depth is between 1.2 and 39 m from the surface.
Physical Environment – Oceanography
The oceanographic conditions of Mitchell Fjord indicate that the currents reflect the influence of the wind and run parallel to the coast. The highest speeds are associated to wind events (temporal ones) with an orientation, mainly, along the major axis of the fjord, having a low predominance of the west-east direction. Seasonally, the magnitudes increase in winter and summer, even though the average values are low (range of 16 knots). The storm events happen with registered durations of up to 12 days and the extreme winds of up to 46 knots. Oceanographically, Puerto Rio Bravo sector and Puerto Yungay sector share the general conditions of Mitchell marsh.
Physical Environment – Noise and Vibrations
On average, the noise level for all the research area fluctuates around the value of 40 dBA. This level is considered as low and representative of a rural area, where earth roads occasionally used by medium-size vehicles can be distinguished and natural noise mentioned before. With the exception of the town of Cochrane, and the presence of the touristic activity, the inhabitants of the evaluated sectors experience low noise levels, around 40-50 dBA in average, these values being stable in time. According to the mechanical vibrations, there are no noise and/or vibration sources of importance in the sector that allows establishing reference vibration levels in the ground.
Physical Environment – Air Quality
The main atmospheric contamination sources currently existing in the area of PHA's location and their origin is in the generation of electric energy from diesel gas (through stations or electric generator), combustion or wood burning (used at a residential or large consumer level), light vehicle traffic through non-paved roads and exhaust emissions coming from the vehicles that transit through PHA's influence area. Wood burning is possibly one of the main sources of atmospheric contamination in PHA's area of influence. According to the measures taken in the town of Cochrane, the most worrying variable is the particulate matter of breathable size (MP10), that even though in the monitoring period had an average of 47 $\mu g/m^3$ -24 h, on two punctual occasions the values were high (out of 57 measurements), one with exceeding concentrations (167 $\mu g/m^3$ -24 h) and another of latency (144 $\mu g/m^3$ -24 h) of daily rule (150 $\mu g/m^3$ -24 h according to D.S. Nº 59/98 of MINSEGPRES).
Biotic Environment – Terrestrial Flora and Vegetation
For the terrestrial flora and vegetation component, PHA's area of influence covered an area of 7,085.2 ha, which represents 82.3% of the total area of the project (8,614 ha). In this area, a total of 32 vegetal associations were identified, grouped in eight of woods; ten of scrubland; six of meadows, three of moors, three of swamp-meadows and two of steppes. In PHA's area of influence, a total of 299 species of vascular plants were determined, pertaining to 78 families, identifying three endemic species of Chile and 20 species with a restricted distribution to the regions XI and XII. In the project's area there was identified no species of plants officially declared under any conservation category, according to the classification system of CONAMA. Even though, according to the referential documents (Red Book and updates), in PHA's area 12 species of vascular plants with conservation concern were identified.
Biotic Environment – Terrestrial Fauna
In PHA's area of influence (direct or indirect), a total of 128 species of terrestrial vertebrates were registered. Out of them, 103 species correspond to birds, belonging to 32 families; 15 were mammals, belonging to six families; and 10 corresponded to amphibious, belonging to two families. No reptiles were detected in all the research area. In PHA's area of influence, four species in the category Endangered were registered, nine in the category Vulnerable, two were catalogued as Rare specie and six are classified as Inadequately Known. In PHA's area, it was registered (directly or indirectly) the presence of individuals of huemul in the project's area, specifically in the area of the rivers Baker (Barrancoso and sector Los Ñadis) and Pascua (Lago Quetru and Laguna Caiquenes). Regarding the pudú, its presence was only registered in the area of the Pascua River, specifically in the sector of Lago Quetru.
Biotic Environment – Aquatic Flora and Fauna
The rivers Baker and Pascua are rivers of high amount of sediments. On the whole, they present a relatively low diversity of fish species: ten species in Baker and seven in Pascua. The abundance and diversity of organisms in these rivers is highly variable, both spatial and temporal. Regarding fish species, we have to highlight the presence of a total of 11, out of them; eight correspond to native species and three to introduced ones. Taking into account the native species, three of them are in the category of Vulnerable, one is considered Rare, one Inadequately Known and one is considered non-defined for the region. Finally, we should highlight that two species are considered Out of Danger. In relation to the abundance of fish, Baker River and its tributaries is a system broadly dominated by the introduced species of Salmo trutta (brown trout) and Oncorhynchus mykiss (rainbow trout). There are particular sectors in which this situation is reversed, situation observed in Baker River at Cochrane and lakes Largo and Juncal level, where it can be observed the highest levels of abundance and riches of native species. On the other hand, Pascua River presents two sectors clearly differentiated: the superior, in which the abundances are scarce and is dominated by introduced species; and the low sector (starting in Quetru Lake), where the abundances are higher and is dominated by native species.
Biotic Environment – Sea Flora and Fauna
The sector of Mitchell marsh is characterized by a low presence of birds and sea mammals. In this last group, it was only detected the specie Otavia flavescens (common seal). Regarding the species over which conservation categories have been established – fish - none of the captured species in Winter or the included in the survey to fishermen, are

included in any category of conservation. In Summer, on the other hand, the peladilla (Aplochiton zebra) is the only one that has been declared as Vulnerable specie in the region of Aysen. On the other hand, both the pelagic communities and the taxa macrobenthos found in the studied sectors, are not considered in any conservation category.
Human Environment – Geographic Dimension
Issues include the distribution of the human groups in the territory, population density by municipalities and sectors, states size and land tenancy, singular resources and road network, travelling and connectivity. In general, the municipalities of PHA's area of influence have a small population and great area. The density in the province Capitan Prat is 0.097 inhabitants per km^2. Their urban centres are: Chile Chico and Cochrane (under the category of towns) and Villa O'Higgins and Tortel (with the definition of villages) and with a very low occupation in rural areas. The results obtained at a local level, in the studied sectors, show a clear pattern of property, in which the increase of the size of the properties is directly proportional to the increase of the latitude.
Human Environment – Demographic Dimension
Both in the region and in the municipalities of PHA´s influence, we can observe a high percentage of the population in the age range of 15-64 (around 65.0%), which means that the majority of their inhabitants constitute an economically active population. This condition is also an expression of the productive characteristics of the area, with a predominance of the primary sector. In the same way, a male predominance can be appreciated, a bit higher in the municipalities analyzed, and particularly in the age range corresponding to the military contingent present in the area (Pascua River sector), through the Military Working Camp (CMT), that is in charge of the opening of new sections of the Austral Highway. The previously mentioned reflects the high levels of male subjects. The analysed region has got the lowest population density of the country. The inhabitants are concentrated in its north, especially in the municipality of Coyhaique. To the South of this location, the population is more and more scarce. The urban population average in a regional level is 80.5%. The total population of the province Capitan Prat is 3,837 inhabitants, and in the region of Aysen is 91,492 inhabitants.
Human Environment – Anthropologic Dimension
The historical and cultural development of the region of Aysen constitutes a defined identity, expressed in "The Patagonian Way of Life". Since the process of colonization and the development of productive activities such as stockbreeding, an identity was created, not only in a regional, but also in a provincial level. An important part of the Patagonian identity is the stockbreeding and forest activity, described as the most important productive activities of the region.
Human Environment – Socioeconomic Dimension
Several economic activities In the region of Aysén are linked to the use of natural resources, such as aquaculture, stockbreeding, forestry and mining. This coincides with the economic activities developed in the area of direct influence (municipalities and rural sector), being more important the stockbreeding and forestry-agricultural production. There are locations in the region devoted to a tertiary activity, in the urban areas. The industry is very incipient and is located, mainly in the city of Coyhaique. In PHA's area there is not a significant industrial activity. The primary activity is, by far, the main type of activity, associated basically to stockbreeding (apart from the forest work in the sectors Vagabundo and Pascua), which is operated by their owners, generating essential income for the family, being highly dependent of properties.
Human Environment – Social welfare Dimension
At a regional level, particularly in the urban centres, there are several levels of basic services that ensure social welfare conditions (medium and medium-high). The services and equipment infrastructure at a provincial and municipal level is mainly located in the urban areas (power line distribution system, drinkable water and sewerage), while, in the rural sector the level of services is low. In a municipal level, they also have basic services such as potable water, electricity, sewage and telephone, but with less coverage. This municipal situation is compensated, in part, with aids and a strong public investment, being much higher than the national average.
Use of the Land, Territorial Planning and Protected Areas
In PHA's area of influence, the category of "scrubland" is the predominant, followed by the category of "native wood", ratifying the region land's vocation, in particular, the ones in PHA's area of influence, which are used for forestry-stockbreeding. In PHA's area of influence, the only current instrument for territorial planning, correspond to Regional Plan of Territorial Zoning and Plan for Coastal Border Zoning. Nevertheless, it has to be considered that today there are other instruments being dealt with, such as Inter-Municipal Regulator Plan of Lago General Carrera and the Regulator Plans of the municipalities of Chile Chico and Cochrane. On the other hand, it should be mentioned that in the area, there are the following protected areas: two national parks (Laguna San Rafael and Bernardo O'Higgins): one national reservation (Lago Cochrane); and Historical Monument (Isla de los Muertos); a Typical and Picturesque Area (Caleta Tortel); and an area of touristic interest (Lago General Carrera).
Cultural Heritage – National Monuments
We have to highlight the presence of a Typical Area (Caleta Tortel) and a National Historical Monument (Isla de los Muertos).
Cultural Heritage – Historical Heritage
The analysis of the results of the heritage component shows the historical riches of the area, mainly in the frame of

the processes of colonization and settlement from the end of XIX century. These riches are shown through historical routes, housing and family cemeteries. The historical routes have got an important symbolic value for the current population since they correspond to the original penetration roads that allowed the colonization of the territory.
Cultural Heritage – Archaeological Heritage
According to the presented results, only two archaeological sites were registered in PHA’s area of influence. The first of them corresponds to an eave and the second to a place where the presence of stings and bolleadoras. Both sites are located in the area of direct influence of this component.
Cultural Heritage – Anthrop-Archaeological Heritage
The Anthropo-archaeological heritage has got different aspects and dimensions, both material and immaterial, that has been developed in the sections Anthropologic Dimension, Historical Heritage and Religious Heritage.
Cultural Heritage – Paleontologic Heritage
The terrain’s visual inspection and the analysis of the samples led to the conclusion that, at least in the visited sectors for PHA’s area of study, there is no evidence of fossil deposits, apart from the new points highlighted in the bibliography. We have to mention that they are located outside of PHA’s area of influence.
Cultural Heritage – Religious Heritage
The roadside shrines and shrines constitute cult elements that are part of the religiosity of the catholic population of the nation, and potentially are places visited and venerated, which confers them a character of “active” heritage, a condition that consequently states that they present a religious value for the community.
Landscape
The analysis of quality, fragility and visibility applied to 67 visual basins was carried out mainly in places or sectors with a higher current concentration and potential of observers, that is to say, the road network of the area, recognising inside of it route 7 or Austral Highway and route X-906 Camino Ventisquero Montt. The results show that in PHA’s area, the landscape units, with a visual quality of high and medium-high, represent 81% of the identified units where the landscape elements or combination of them present outstanding features, while 1% (two units) present low quality.
Contingency Areas
The areas where contingencies on the population/and or environment could be generated where identified, when natural phenomena happened, the development of natural activities and the carrying out or modification of PHA and/or combination of both.
Tourism
The region of Aysen presents a low developed tourism, even though it has a high touristic development potential that is not currently exploited. Nevertheless, the sector has experienced development in recent years in the touristic demand and offerings. The main limits of the region tourism are fundamentally related to accessibility and climate factors that restrict the touristic season to the summer time. The attractive things and activities present in PHA’s area of influence are related fundamentally to special interests tourism, that is to say, sport fishing and adventure tourism, linked to Baker River.

7 EVALUATION OF ENVIRONMENTAL IMPACT

7.1 Methodology used

For the identification and classification of PHA´s environmental impacts, the following aspects were taken into account: the description of the works and facilities associated to this project; the current environmental legislation applicable and the environment (environmental base line) where PHA is located.

The methodology used covered the development of the following stages, in a sequential way:

- Stage 1: Verification checklists (work/activities lists and environmental components);
- Stage 2: Elaboration or environmental impact matrixes (crosschecking between works/activities and environmental components);
- Stage 3: Impact assessment;
- Stage 4: Impact hierarchy and establishment of significant impacts.

Stage one was carried out according to PHA's description (Chapter 1 of EIA) and of the results of base line (Chapter 4 of EIA); the stage 2 is the result of the crosschecking of the previous information. On the other hand, the impact assessment that comprises stage 3 was carried out using the following mathematical expression:

$$\boxed{\text{Total Impact (IT)} = C * M * VA}$$

Where "C" corresponds to the impact character (values +1 or -1); "M" is the magnitude of the impact (values from 0 to 10); and "VA" is the environmental value of the component (values from 0 to 10). At the same time, "M" corresponds to the arithmetic addition of: the impact extension, "E" (values from 0 to 3); impact intensity, "I" (values from 0 to 3); impact duration, "D" (values form 0 to 2); and reversibility of the impact, "R" (values from 0 to 2). According to the previously said, the Total Impact (IT) can fluctuate between -100 and +100.

Taking into account the classification and hierarchy of the impacts to which stage 4 pf the methodology refers to, the following values scale of impact was used:

Table 7.1-1: Values scale for PHA environmental impacts

Total Impact (IT)	Scale (Absolute value)
NS: Not significant	0 – 20
LS: Low Significant (LS)	21 – 40
MS: Medium Significant (MS)	41 – 60
SG: Significant (SG)	61 - 100

7.2 Identified and evaluated environmental impacts

The table 7.2-1 summarizes the number of environmental impacts identified for PHA, according to the previously described methodology. Also, in the table 7.2-2 and for each environmental component, PHA potential impacts are indicated, their associated stage of occurrence and the total value ascribed according to the scale in the previous Table 7.1-1.

Table 7.2-1: Number of PHA' potential environmental impacts

Total Impact	Number of Impacts				
	Construction		Operation		Total
	Positive (+)	Negative (-)	Positive (+)	Negative (-)	
NS: Not significant	1	8	2	5	16
LS: Low Significant (LS)	4	23	1	11	39
MS: Medium Significant (MS)	0	15	2	9	26
SG: Significant (SG)	2	24	0	4	30
Total	7	70	5	29	111

Table 7.2-2: PHA's Potential Environmental Impacts				
Environmental Component	**Impact Code**	**Potential Impact**	**Associated Stage**	**Total Impact**
Climate-Meteorology	MF-CYM-OPE-01	Modification of the Thermal Pattern due to the existence of dams	Operation	+NS
	MF-CYM-OPE-02	Changes in the humidity and evaporation due to the existence of dams	Operation	- LS
	MF-CYM-OPE-02	Changes in the days with frost and ice due to the existence of dams	Operation	+NS
Geology	No impacts on this component were identified			
Geomorphology	MF-GGF-CON-01	Alterations of stable hillsides due to the construction of temporary and permanent works	Construction	-MS
	MF-GGF-CON-02	Alteration of geographical features by the installation of stock piles and aggregate mining.	Construction	-MS
	MF-GGF-CON-03	Loss of formations with scientific interest (thin glacial deposits)	Construction	-SG
Pedology	MF-EDA-CON-01	Loss of the soil quality	Construction	-SG
	MF-EDA-CON-02	Alteration of the soil quality	Construction	-MS
	MF-EDA-CON-03	Alteration of the micro-topography and change in the drainage pattern	Construction	-LS
	MF-EDA-OPE-04	Generation of erosion processes	Operation	-LS
Hydrology	MF-HID-CON-01	Alteration of a river stretch in the main course due to the station building	Construction	-LS
	MF-HID-OPE-01	Changes in the superficial runoff pattern	Operation	-SG
	MF-HID-OPE-02	Alteration in the flow regime	Operation	-MS
	MF-HID- OPE -03	Modification of the sediment transport pattern downstream from the central dam	Operation	-MS
	MF-HID- OPE -04	Increase in the sedimentation in the reservoir area (increase of the level in the bed of reservoir area)	Operation	-LS
	MF-HID- OPE -05	Activation of mass removal processes in the river banks, derived from the operation of the stations	Operation	-MS
	MF-HID- OPE -06	Changes in the intra-daily oscillations of the flow due to plant operation (hydro-peaking)	Operation	-LS
Water Quality	MF-CAG-CON-01	Changes in water quality related to the construction of the stations and the related works	Construction	-LS
	MF-CAG-CON-02	Deterioration of water quality due to the exploitation of aggregate deposits	Construction	-LS
	MF-CAG-CON-03	Alteration in the water quality due to construction and renewal of roads	Construction	-NS
	MF-CAG-OPE-01	Water quality changes related to the increase of the sedimentation in the dam area	Operation	-MS
	MF-CAG-OPE-02	Changes in the quality of the water downstream from the station due to the stations' operation and the blocking effect of the dam	Operation	-MS
Hydrogeology	MF-HIG-OPE-01	Increase of the static level of the aquifer in the vicinity of the dam	Operation	-LS
Oceanography	MF-OCF-CON-01	Alteration of the dynamic and circulation patterns in the coastal area inside the influence area of the harbour works	Construction	-NS
	MF-OCF-OPE-01	Alteration of the surface extension of the	Operation	-NS

		mixing zone		
	MF-OCF-OPE-02	Alteration of the fluvial terrestrial sediment quantity arriving at the estuary’s mouth	Operation	-NS
Noises and vibrations	MF-RYV-CON-01	Increase of the basal noise levels due to heavy machinery use in the surface	Construction	-MS
	MF-RYV-CON-02	Increase of the basal noise levels due to blasts	Construction	-MS
	MF-RYV-CON-03	Increase of the basal noise levels due to heavy vehicles’ traffic	Construction	-LS
	MF-RYV-CON-04	Increase of the basal noise levels due to helicopter flights	Construction	-NS
	MF-RYV-CON-05	Increase of the vibration levels due to blasts	Construction	-NS
Air Quality	MF-CAI-CON-01	Increase of the concentrations of particulate material in the air	Construction	-LS
	MF-CAI-CON-02	Increase of the gas concentrations in the air	Construction	-LS
Terrestrial Flora and Vegetation	MB-FVT-CON-01	Loss of vegetal associations that constitute AVAs in PHA´s direct influence area	Construction	-SG
	MB-FVT-CON-02	Loss of vegetal associations that do not constitute AVAs in PHA´s direct influence area	Construction	-SG
	MB-FVT-CON-03	Alteration of vegetal associations due to the construction of the electric transmission lines	Construction	-SG
	MB-FVT-CON-04	Loss of individuals of singular flora species in AVAs of PHA´s direct influence area	Construction	-SG
	MB-FVT-CON-05	Loss of individuals of singular flora species in AVAs outside PHA´s direct influence area	Construction	-SG
	MB-FVT-OPE-01	Alteration of vegetal associations due to maintenance of the electrical transmission lines	Operation	-MS
Terrestrial Fauna	MB-FFT-CON-01	Loss of the habitat of the fauna of native terrestrial vertebrates inside AVAs	Construction	-SG
	MB-FFT-CON-02	Loss of the habitat of the fauna of native terrestrial vertebrates outside AVAs	Construction	-SG
	MB-FFT-CON-03	Loss of individuals of the fauna of native terrestrial vertebrates inside AVAs	Construction	-SG
	MB-FFT-CON-04	Loss of individuals of the fauna of native terrestrial vertebrates outside AVAs	Construction	-SG
	MB-FFT-CON-05	Generation of new habitats for the aquatic bird fauna	Construction	+SG
	MB-FT-CON-06	Alteration of behaviour of native fauna in AVAs	Construction	-LS
	MB-FFT-CON-07	Alteration of behaviour of native fauna outside AVAs	Construction	-LS
	MB-FFT-CON-08	Barrier effect for micro-mammals and amphibious in AVAs	Construction	-SG
	MB-FFT-CON-09	Barrier effect for micro-mammals and amphibious outside AVAs	Construction	-MS
	MB-FFT-CON-10	Edge effect inside AVAs	Construction	-SG
	MB-FFT-CON-11	Edge effect outside AVAs	Construction	-MS
	MB-FFT-OPE-01	Barrier effect for micro-mammals and amphibious in AVAs	Operation	-LS
	MB-FFT-OPE-02	Barrier effect for micro-mammals and amphibious outside AVAs	Operation	-LS
	MB-FFT-OPE-03	Edge effect in AVAs	Operation	-SG
	MB-FFT-OPE-04	Edge effect outside AVAs	Operation	-MS

	MB-FFT-OPE-05	Loss of individuals of the fauna of native terrestrial vertebrates inside AVAs	Operation	-MS
	MB-FFT-OPE-06	Loss of individuals of the fauna of native terrestrial vertebrates outside AVAs	Operation	-MS
Aquatic Flora and Fauna	MB-FFA-CON-01	Loss of lotic habitat due to the civil works of the dam	Construction	-LS
	MB-FFA-CON-02	Alteration of lotic habitat due to the mining of fluvial deposits	Construction	-MS
	MB-FFA-CON-03	Alteration of the biotic communities due to the increase of solids in suspension	Construction	-NS
	MB-FFA-CON-04	Alteration of lotic habitat due to the dam filling	Construction	-SG
	MB-FFA-CON-05	Loss of individuals of species of native fish population	Construction	-LS
	MB-FFA-OPE-01	Generation of new habitats due to the presence of the dam	Operation	+MS
	MB-FFA-OPE-02	Alterations of biotic communities due to changes in the flow rates downstream from the dams	Operation	-SG
	MB-FFA-OPE-03	Alterations of biotic communities due changes in the amount of nutrients and sediments downstream from the dams	Operation	-LS
	MB-FFA-OPE-04	Alteration of the fish communities due to the blocking effect of the dam and its reservoir	Operation	-NS
	MB-FFA-OPE-05	Loss of individuals of native fish population	Operation	-NS
Sea Flora and Fauna	MB-FFM-CON-01	Alteration of the intertidal and subtidal habitat	Construction	-NS
	MB-FFM-CON-02	Alteration of the community assemblies of the coastal and subtidal ecosystems	Construction	-NS
	MB-FFM-OPE-01	Changes in the amount of nutrients and sediments to the estuaries	Operation	-NS
	MB-FFM-OPE-02	Changes in the community assemblies of coastal and subtidal ecosystems	Operation	-LS
Geographic Dimension	MH-DGE-CON-01	Change in the housing location due to relocation caused by dams, works and PHA's activities	Construction	- SG
	MH-DGE-CON-02	Connectivity is affected due to the loss of infrastructure used by the inhabitants (footbridge, rope-ferries, change in the road routes, bridges or other infrastructure works) due to PHA's works	Construction	-LS
	MH-DGE-CON-03	Renewal of infrastructures associated to land transport (roads, provisional paths, bridges) due to PHA's works and its maintenance	Construction	+SG
	MH-DGE-CON-04	Increase of the amount of vehicles on route 7, due to PHA's works and activities	Construction	-SG
	MH-DGE-OPE-01	Alteration of navigation practices in Baker and Pascua rivers due to the variation of the river flow during the stations operation	Operation	-LS
Demographic Dimension	No impacts on this component were identified			
Anthropologic Dimension	MH-DAN-CON-01	Effects in the manifestation of practitioners of the immaterial culture due to PHA's works and activities	Construction	-MS
	MH-DAN-CON-02	The social and organization network of the local population is affected in sectors modified by dam areas	Construction	-LS
	MH-DAN-CON-03	Change in attachment to the land in re-	Construction	-LS

		located population		
	MH-DAN-OPE-01	Generation of concern in population downstream from the dam due to eventual accidents, phenomena or natural disasters	Operation	-LS
Socio-Economic Dimension	MH-DSE-CON-01	Increase of the commercial activity and the activity of services due to PHA's construction	Construction	+LS
	MH-DSE-CON-02	Generation of direct employment due to PHA's works	Construction	+LS
	MH-DSE-CON-03	Generation of indirect employment due to PHA's works	Construction	+NS
	MH-DSE-CON-04	Variation in firewood prices	Construction	-LS
	MH-DSE-CON-05	Increase of the municipal incomes due to works associated to PHA's construction	Construction	+LS
Basic Social Welfare Dimension	MH-DBS-CON-01	Increase of social problems due to the travel of workers to municipalities during free time while in shifts	Construction	-LS
	MH-DBS-CON-02	Increase of social problems due workers/families relocation to a direct influence area	Construction	-SG
	MH-DBS-CON-03	Change in the access to municipal and/or state services of Cochrane due to temporal increase of population	Construction	-MS
Use of land	US-USU-CON-01	Change in the use of land in sectors that are not areas of environmental value	Construction	-LS
	US-USU-CON-02	Change in the use of land in areas of environmental value	Construction	-MS
	US-USU-CON-03	Limit in the use of land in areas of location of electric transmission lines	Construction	-NS
Territorial Planning	No impacts on this component were identified			
Protected Areas	US-APR-CON-01	Alteration of 41.8 ha of Laguna San Rafael National Park due to the filling of Baker 2 dam	Construction	-LS
Declared National Monuments	No impacts on this component were identified			
Historical Heritage	PC-PHI-CON-01	Loss of historical heritage elements due to the project construction	Construction	-SG
	PC-PHI-CON-02	Historical heritage elements affected by proximity to construction activities	Construction	-LS
	PC-PHI-CON-03	Historical heritage elements affected by the alteration of the ground due to construction activities	Construction	-LS
Archaeological Heritage	PC-PAR-CON-01	Archaeological heritage elements affected by the project construction	Construction	-MS
Anthrop-Archaeological Heritage	No impacts on this component were identified			
Paleontologic Heritage	No impacts on this component were identified			
Landscape	PA-PAI-CON-01	Partial loss of original landscape, as a result of the establishment of the dam areas	Construction	-SG
	PA-PAI-CON-02	Alteration of the visual quality, due to the modification of the physical, biotic and anthropomorphic components of the landscape	Construction	-SG
	PA-PAI-CON-03	Alteration of the visual quality due to the introduction of elements of anthropomorphic origin in the landscape	Construction	-SG
	PA-PAI-CON-04	Increase of the landscape visual fragility due to the increase of the accessibility to	Construction	-SG

		the new areas		
	PA-PAI-CON-05	Alteration of the visual nature of the landscape due to the development of the project's works and activities	Construction	-LS
	PA-PAI-OPE-01	Permanent insertion of anthropomorphic elements in the landscape	Operation	-SG
	PA-PAI-OPE-02	Creation of new bodies of water in the landscape	Operation	+MS
Tourism	TU-TUR-CON-01	The image of the touristic products is affected in the province of Capitan Prat	Construction	-MS
Tourism	TU-TUR-CON-02	Alteration of tourist attraction and associated activities due to PHA's construction works	Construction	-LS
Tourism	TU-TUR-CON-03	Loss of tourist attraction and associated activities due to PHA's construction works	Construction	-MS
Tourism	TU-TUR-CON-04	Loss of touristic facilities due to PHA's construction works	Construction	-SG
Tourism	TU-TUR-CON-05	Reduction of availability in the touristic facilities of Cochrane due to the arrival of people directly and indirectly related to the project	Construction	-LS
Tourism	TU-TUR-CON-06	Increase in the commercial activity related to the touristic facilities due to the arrival of people directly and indirectly related to the project	Construction	+LS
Tourism	TU-TUR-OPE-01	Diversification of touristic products; incorporation of new attractions and potential routes in the road to Chico Lake through the Pascua Sector	Operation	+LS

8 PLAN OF MEASURES OF MITIGATION, RESTORATION, COMPENSATION, HAZARD PREVENTION AND ACCIDENTS CONTROL.

PHA has developed a Plan of Measures of Mitigation, Restoration, Compensation, Hazard Prevention and Accidents Control that corresponds to the established in Art. 12, letter h), of SEA's Regulations. Through this plan, the way in which HidroAysén will take care of the effects, characteristics and circumstances that PHA will present or generate, detailed in Art.11 of Law Nº 19,300/94.

There are measures included in this plan to avoid, eradicate or minimize the effects that the construction, operation of PHA and abandonment or temporal closure of the works may generate. It also includes measures for reparation and/or compensation, as appropriate. At the same time, the hazard prevention plan contains the operational measures and design criteria used to avoid or minimize hazardous situations with environmental risks. As far as it is concerned, the hazard prevention plan contains the operational measures to control and minimize the impacts in the event that unforeseen circumstances take place in the implementation of the hazard prevention plan.

8.1 Plan of Measures of Mitigation, Compensation and Impact Repairing

In Chapter 6 of EIA, there is an exhaustive description of the operation plans with the respective measures of mitigation, compensation and potential environmental impact reparation associated with the PHA's construction and operation stages and that address in an integral way the 99 negative impacts generated by the project. As an example, there will be indicated measures that have dealt with important aspects of the impact evaluation and their own description of compensation and reparation that HidroAysén will be responsible for implementing:

- The implementation of a Social Management Plan (PMS) is considered, so that it covers three areas or groups of measures: i) Human Environment Measures, that is applicable to specific segments of the population inside the area of influence of the project; ii) Attention to the Community and PHA's Residents Measures, oriented to inform, channel and solve eventual requirements or claims of the residents; iii) Measures related to the Re-location of people Directly Affected by PHA.

  According to the Relocation Plan (PDR), it is included the detailed measures to implement for the 14 family groups to be re-located, 15 family groups to re-settle and two family groups to be temporarily displaced, due to the project's works and activities. It is important to indicate that by re-location we assume the family group settling, both at an individual and community level, as appropriate, in a different sector or sectors to the ones where the family currently live and develop their immediate activities. At the same time, by re-settle we assume the family group settling inside their own property in a suitable sector to continue developing their activities and outside the range of PHA's works that originated their re-settlement. The implementation of a management and monitoring system of PDR is contemplated and also of an independent audit, to determine whether the expected results, and required by the authority, are obtained. The duration of the Plan will be 10 years from the beginning of the re-location and re-settlement, as appropriate.

  HidroAysen, will be responsible of the application and implementation of the measures that PMS establishes and the respective programs. Consequently, an evaluation of the results obtained in the Environmental Monitoring Plan (see Chapter 7 EIA) will be carried out. For the previously said effects, it will be provided with the corresponding functional and operative unit. According to the aspects related to the Social Welfare dimension, the specific measures are proposed, such as: Implementation of a program of housing control and PHA's workers behavioural politics in the area of influence of the project, management system for the vehicles associated with PHA traffic and specific programs of support for state and/or municipal services assistance.

- When considering aspects related to socioeconomic activities, which nowadays are developed in PHA´s area of influence, HidroAysén proposes to implement a group of measures that, on the whole and in an integrated way, will promote tourism activities in this area. In fact, they propose measures to protect and value heritage elements (historical, religious and archaeological), that added to the creation of a Center for the Cultural Diffusion in Cochrane or its neighborhood, will generate a diffusion channel for all the elements that compose the cultural heritage of PHA's area of influence and that today are not included in the economic activities related to the tourism in the area. Also, HidroAysén suggests the construction of an Area of Conservation, with a minimum area of 5,770 ha, that will contain the maximum quantity of environmental elements from the area, and so take care, in an integral way, of the different impacts in the physical and biotic environment and also in the landscape. This Area of Conservation, which will be used as a “natural laboratory”, will be integrated as a relevant factor to boost tourism in PHA’s area. All these proposals, will allow the developing of a good deal of the touristic potential of the area, incorporating aspects to this activity that are not developed today.

- In addition, HidroAysén suggests the development of several studies related to the affected components. As an example we can mention: research on deer in PHA’s area; ecologic research of Baker and Pascua River, their estuaries and sea areas nearby; and the study of touristic capacities associated to Puerto Bertrand, Cochrane, Caleta Tortel and Villa O’Higgins. These studies will allow the suggestion and development of actions that will improve the conservation and establish mechanisms to collaborate in the conservation of the environment.

The following table indicates, for each component, the mitigation, reparation and compensation measures that are proposed to implement:

Table 8.1-1: List of mitigation, reparation and compensation measures by environmental components
Geomorphology
• Stabilization of slopes and hillsides • Restoration of geoforms • Paleoclimatic research
Hydrology
• Delimitation of the area of station construction • Assurance of a flow no lower than the minimum flow of operation • Zoning of the river system • Mechanisms to mitigate the alteration of the navigation practices in Baker and Pascua Rivers due to the operation of the stations
Edaphology
• Demarcation of the working areas • Environmental considerations in the implementation of construction techniques • Stabilization of slopes and hillsides in unstable areas • Conservation of vegetal material and its use in the area near the towers • Re-vegetation of areas with damage to the soil (according to Restoration Plan in the provisional works) • Recovery of the area of sanitary landfill to reset the terrain in its environment • Final land processing in areas of temporal use (according to Restoration Plan in the provisional works) • Re-compostion of the stored soil (if it corresponds) • Restoration of micro-topography
Terrestrial Flora and Vegetation
• Incorporation of ecologic criteria in the reforestation stage in the Forestry Managemenet Plan • Conservation of germplasm of singular species of vascular flora • Conservation and sustainable management of Cypress from las Guaitecas
Sea Fauna
• Environmental management for the construction of harbour works
Geographic Dimension
• Maintenance of the connectivity associated to the loss of infrastructures used by the inhabitants in their journeys • Traffic management system for the vehicles associated to PHA
Anthropology
• Community information about accidents and/or natural disasters in the infrastructure works (dams)
Historical Heritage
• Construction of a commemorative landmark of family cemeteries

• Complete documented registry of the ruins of Quinto for its conservation in the historical context • Dis-inter and transport of tombs • Fence the perimeters and value enhancement of the cultural heritage • Fence the perimeters and archaeological supervision during the land movement in the sectors associated to cultural heritage elements
Archaeological Heritage
• Generation of an restricted and archaeological supervision area
Tourism
• Elaboration of Research on Touristic Potential: Puerto Bertrand, Cochrane, Caleta Tortel, Villa O'Higgins and connection axes, in the frame of a potential touristic local development in the area of influence of PHA • Creation of a Touristic Information Centre, located inside the Cultural Information Centre of the city of Cochrane • Implementation of eight viewpoints and 10 km of path. Sectors to be defined in the Research on touristic potentialities • Replacement of the lost touristic facilities, displaced by the PHA's construction • Training of human resources
Noise and vibrations
• Mitigation of the increase of the noise levels, due to construction activities in the surface, blasts and traffic of heavy vehicles • Mitigation of the increase of the noise levels due to air transport (helicopters)
Water Quality
• Conservation of the water quality in areas of construction of dams and associated works, including roads • Conservation of the water quality in areas of exploitation of aggregates deposits • Management of areas of deposition and erosion, to maintain the level of bed sediments and the quality of the resource, downstream from the stations
Air Quality
• Hydrate the vehicles and machinery traffic routes; and areas of land movement • Stabilization and compacting of the vehicles and machinery traffic routes • Covering of vehicles for the transport of materials • Covering and hydrating of the material stored • Speed control of the vehicles inside the working areas • Revision and inspection of all the vehicles and machinery used during PHA's construction
Terrestrial Fauna
• Research on the deer of PHA's area of influence • Rescue and relocation of terrestrial vertebrates • Prevention of bird collision with electric transmission lines
Protected Areas
• Increase area of Laguna San Rafael National Park
Social Welfare Dimension
• Program of housing and good behaviour control for PHA's workers in the area of influence of the project • Specific programs to support the provision of municipal and/or state services
Socioeconomy
• Mechanisms for the management of firewood for PHA's activities
Religious Heritage
• Removal and transport of commemorative elements. Relocation in the location selected by the family • Removal and transport of commemorative or cult elements. Relocation in the place of origin • Generation of a restricted area around the element
Landscape
• Program of general measures for the protection of the landscape • Program of mitigation of impacts on the landscape • Program of reparation of impacts on the landscape
Integrated Measures
• Relocation Plan

- Plan for the attention to PHA's residents
- Restriction in the vegetation cutting during the construction and maintenance of the electric transmission lines
- Protection of native flora and fauna
- Environmental management for the use of aggregate deposits
- Mechanism to mitigate the alteration of the navigation practices in Baker and Pascua Rivers, due to the operation of the stations
- Restoration in the temporal works
- Construction of a Conservation Area
- Ecologic Research in Baker and Pascua Rivers, their estuaries and adjacent sea areas
- Centre for the Cultural Diffusion in Cochrane

8.2 Plan for hazard prevention and control of accidents

The plan of hazards prevention is applicable to the construction and operation stages of PHA, which involves general security measures, contingency measures for the construction and operation, measures for the storing and transport of material, measures for hazardous materials spillages, plan for the control of the accidents and hazards to the community and environmental duties to carry out the works. Also, it includes the plan for the control of accidents in case events occur that are unforeseen in the plan for hazard prevention. In Chapter 6 of EIA can be found the exhaustive description of the plan for the hazard prevention and control of accidents of PHA, applicable to their stages of construction and operation.

9 PLAN FOR THE ENVIRONMENTAL MONITORING

9.1 Contents

The Plan for the Environmental Monitoring (PSA) has the object of establishing the monitoring of the relevant environmental variables that require the EIA of the PHA. The specific objectives of the plan are basically the following: to validate in practice the real effect caused by PHA's activities that have a greater anticipated impact, through measurements in the environmental components susceptible to being affected; verify the effectiveness of the mitigation and measurements related to prevention of environmental impacts suggested for the PHA; the performance of applicable environmental rules applicable to PHA; and to detect in an early stage any unforeseen or unwanted effect, in a way in which it is possible to be controlled following the appropriate measures and/or actions.

The functional structure that will be implemented by HidroAysén to carry out the environmental management of PHA consists of an Environmental Vice-Management, which will be created by three areas: environmental coordination, social coordination, and control and administrative aspects. Through this organization, directly linked to the construction of the Project HidroAysén will implement and maintain the PSA of PHA.

9.2 Proposed plan for the tracking or monitoring

The following table summarizes the environmental monitoring considered by PHA for each of the environmental components potentially affected by the construction or operation in the PHA.

Table 9.2-1: Environmental Tracking or monitoring by components	
Component	Monitoring
Climate and Meteorology	Monitoring and evaluation of the change that will be produced over the local climatic conditions in the immediate dam surroundings
Geomorphology	Stabilization of slopes and hillsides
	Restoration of geoforms
Edaphology	Loss and alteration of land resources
	Replacement of microtopography
	Control of erosion
	Replacement of the land resource and vegetal layer
Hydrology	Alteration of the main river stretch
	River flow pattern
	Superficial runoff pattern
Water quality	Changes in the water quality due to work construction
	Changes in the water quality due to mining of aggregate deposits
	Changes in the water quality due to the project's operation
Hydrogeology	Monitoring of the static level of the aquifer
Noise	Noise generation due to construction works
	Noise generation due to air operations
Air quality	Control of the particulate material
Terrestrial Flora and Vegetation	Incorporation of economic criteria in the reforestation stage of the forestry management plan
	Conservation of germplasm of the singular species of the vascular flora
	Conservation and sustainable management of the Cypress de las Guaitecas
Terrestrial Fauna	Research on deer inside PHA´s area
	Rescue and relocation of terrestrial vertebrates
	Prevention of bird collision with electric transmission lines
Sea Fauna	Monitoring of abiotical and biotical parameters of the estuaries in the rivers Baker and Pascua, adjacent sea areas and Yungay and Rio Bravo harbors
Geographical Dimension	Maintenance of the connectivity and new structure
	System of traffic management in route 7
	Mitigation of the modification of navigability
	Program for refurbishing receptor properties
	Program for the re-location of families
	Program for the productive development
	Program for purchase of properties affected by re-location
Anthropologic Dimension	Community information
	Program for the socio-cultural development
Socioeconomic Dimension	Mechanisms of firewood management for PHA´s activities
Social Welfare Dimension	Control of residency and behaviour policies
	Support services
Historic Heritage	Confirmation of performance of the registry of the ruins of Quinto
	Confirmation of the construction of a commemorative landmark or confirmation of the process of disinterment and transport of tombs (alternative measures)
	Confirmation of performance of the fencing of historic elements and installation of informative signage
Archaeological Heritage	Confirmation of the area of restriction and program of archaeological supervision

Religious Heritage	Confirmation of performance of the process of transport and reinstallation of Quinto landing
	Confirmation of performance of the process of transport and reinstallation in the place of origin of commemorative or cult elements
	Confirmation of performance of the fencing of the elements and restrictions of part of the works
Tourism	Monitoring of design, construction and fitting out of the proposed elements
	Monitoring the changes of touristic supply and demand in the Province of Capitan Prat
Integrated Measures	Program for the productive development
	Relocation plan
	Care plan for residents
	Restriction in the vegetation cutting during the construction and maintenance of the electric transmission lines
	Protection of native flora and fauna
	Environmental management for the use of aggregate deposits
	Restoration in the temporal works of the project
	Construction of a Conservation Area
	Ecologic Research in Baker and Pascua rivers, their estuaries and adjacent sea areas
	Confirmation of the running of the Cultural Diffusion Centre
	Program for information and communication

10 CIVIC PARTICIPATION

HidroAysén considered the execution of a process of PHA's Anticipated Civic Participation, additional to the formal process of Civic Participation that has to be developed according to Law Nº 19,300-94 and SEIA Regulations. During the year 2007, HidroAysén developed a voluntary dialogue with the community named "Conversemos" (Let's Talk) through the creation of physical places and itinerant ones called "Casas Abiertas" (Open Houses). In this process, that was implemented considerably before the time established in the current legislation, allowed to open a communication channel, both of submission of information about the project to the community and of reception of comments and concerns, being hence transformed in an activity perfectly aligned with the principles of participation and transparency established by the company.

The process of "Open Houses" consisted of presentations of the PHA through scale models, panels, informative material and expositions in a community physical place in the cities of Cochrane, Villa O'Higgins, Caleta Tortel, Chile Chico, Puerto Bertrand, Puerto Guadal, Puerto Tranquilo and Coyhaique, where more than 2,800 people participated and around 800 remarks were received, which constitute, without any doubt, fundamental consumables for the project development in different areas. It is worth noting that the participation of the inhabitants of the Province of Capitan Prat, added to the ones of the city of Puerto Bertrand, amounted to 44% of the total of their population. All the process was accompanied by live interviews in the radio stations of the cities visited.

After the process previously mentioned, HidroAysén implemented regular communication channels with the community through two Permanent Open Houses, located in the offices that the company maintains in Coyhaique and Cochrane, since the beginning of the research stage. In these places, with the support of scale models 1:30,000 of the project area and the audiovisual media available, community inquiries are met. Also, in November 2007 the Web page www.hidroaysen.cl was put into service.

In a voluntary and advanced way, there were presented other researches of “Environmental and Social Characterization in sectors of the rivers Baker and Pascua”, from which the baseline for the Environmental Impact Assessment was developed. These researches were also presented to the civil and scientific community, by the researchers that conducted the studies, in panels held in the cities of Coyhaique, Cochrane and Villa O’Higgins.

It is worth noting that an important part of PHA’s environmental assessment considered the early inclusion of mitigation, reparation and compensation measures, suitable to local sensitivities. That is the reason why, from the beginning of PHA’s design, HidroAysén incorporated planning mechanisms to inform the community about the different stages for the starting of the hydroelectric power stations. In this way, there were established methodologies of information delivery from house to house in the different communities of the area of influence.

Taking into account the process of formal Residents Participation, as part of the activities of this process, HidroAysén will publish in Diario Oficial and in a newspaper of national circulation or regional one (in the case or a regional newspaper, with circulation in the Region of Aysén del General Carlos Ibañez del Campo), an extract of EIA previously endorsed by CONAMA, containing a summary of PHA’s description and the main results of EIA. Chapter 8 of EIA describes the program of actions appointed to assure the informed participation of the community inside SEIA’s framework, and also during the building and operation stages of PHA.