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BTB Group
ENRON Corporation

BOLIVIA-BRAZIL GAS PIPELINE PROJECT

ENVIRONMENTAL ASSESSMENT

EXECUTIVE SUMMARY

November, 1996

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November, 1996

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TABLE OF CONTENTS

ATTACHMENTS

Table 1 - Summary of Environmental Impacts and Mitigation Measures

Logistics Map of Project Area

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EXECUTIVE SUMMARY

1.0 Introduction

The purpose of the proposed Bolivia-Brazil pipeline project is to transport natural gas produced in central Bolivia to major industrial centers in Brazil, opening a new and important market for existing Bolivian reserves of natural gas and bringing an additional source of power to the Brazilian energy matrix. The project is being developed by Yacimientos Petroliferos Fiscales Bolivianos (YPFB) and Petrobrás, together with participating partners Enron Corporation and the BTB Group. The BTB Group represents a consortium comprised of Broken Hill Proprietary Company Limited (BHP), Tenneco Energy, and British Gas.

In 1988 the presidents of Bolivia and Brazil signed a "Treaty for Integration of Energy" in which Brazil committed to purchase electric power produced with Bolivian natural gas in a thermal plant to be erected on the border between the two countries. This Treaty was later followed by additional negotions and agreements for the transportation and sale of gas to the main industrial centers of Brazil, delivered through the proposed gas pipeline.

In 1990 YPFB commissioned an Environmental Impact Study to be completed for construction of the Santa Cruz - Puerto Suarez gas pipeline and a thermoelectric power plant in Puerto Suarez. Environmental missions from the Inter-American Development Bank and the World Bank visited Bolivia in 1991 and submitted comments and recommendations to the government of Bolivia and YPFB upon completion of their missions. The Bolivian government gave its approval to the project in 1991 by signing the *Declaratoria de Impacto Ambiental* and *Resolución Ministerial #269/91.* In the intervening period since 1991, the scope of the project changed substantially. The Puerto Suarez power plant is no longer part of the project, and the pipeline has been extended to include the Brazilian segment. Due to these changes and new environmental regulations, additional environmental studies were required in Bolivia and a complete EIA was required in Brazil.

Beginning in 1992, Petrobrás commissioned a Brazilian consultant to produce an Environmental Impact Assessment (EIA) and Risk Analysis (RA) for the Brazilian sector of the project. The studies were completed in two phases, the first segment being from Corumbá to Curitiba and the second from Curitiba to Porto Alegre. In 1996 the studies were revised, consolidated, updated and completed, when necessary, to comply with the requirements set out by the World Bank's Guidelines.

Since 1992, the EIA, Risk Analysis and numerous supplemental environmental reports have been submitted to Brazil's federal environmental office and the environmental agencies in the five affected states, and the licensing process is underway. The Previous License is anticipated in December, 1996, and the Installation License in the first quarter of 1997.

In January, 1996, work commenced on an Environmental Impact Study for the Bolivian sector to reflect the current project scope and environmental conditions. The EIS was based upon a comprehensive review of existing information, field work, and community consultation to evaluate the biophysical and socioeconomic environments in the area of influence of the project. The report was completed and presented to Bolivia's Ministry of Sustainable Development and Environment in November, 1996, and an amendment to the environmental license is expected to be issued at the end of January, 1997.

2.0 Regulatory Framework

Project sponsors have diligently reviewed all environmental laws and regulations applicable to the project in Bolivia and Brazil. The project will be constructed and operated in accordance with the legal requirements in each country, as well as internationally accepted environmental practices, policies and standards.

Bolivia

Bolivia's Environmental Law No. 1333, enacted in 1992, established procedures for environmental management and regulatory compliance for activities potentially impacting the environment. Article 62 of the Environmental Law provided that indigenous populations, together with public and private nonprofit institutions, social entities and traditional communities may participate in the administration of Protected Areas. The Ministry of Sustainable Development and the Environment (Ministerio de Desarrollo Sostenible y Medio Ambiente - MDSMA), created in 1993, has recently enacted six environmental regulations associated with Law No. 1333, addressing the following issues:

- Environmental Management (Reglamento General de Gestión Ambiental)
- Environmental Prevention and Control (Reglamento de Prevención y Control Ambiental)
- Atmospheric Contamination (Reglamento de Contaminación Atmosférica)
- Water Contamination (Reglamento de Contaminación Hídrica)
- Hazardous Substance (Reglamento para Actividades con Sustancias Peligrosas)
- Solid Waste (Reglamento de Gestión de Residuos Sólidos).

The Subsecretariat of the Environment (Subsecretaria del Medio Ambiente) was created to monitor compliance with the new regulations and environmental legislation.

Hydrocarbon Law No. 1689, was signed in May, 1996. At the time of this writing, environmental regulations necessary to enforce this new law have been proposed, but have not yet been promulgated. The law provides that an administrative concession must be

granted prior to construction and operation of a pipeline. The law also defines tariff requirements and responsibility for supervising and inspecting concessionaires. Transportation of hydrocarbons by pipelines is governed by the principle of free access.

Public Participation Law No. 1551 and its associated regulations were passed in 1994. The Law and its regulations established procedures for encouraging and involving the indigenous, peasant, and urban communities in the judicial, political and economic processes of the country. Law No. 1551 transferred some levels of authority from the central government to municipal governments and provided for distribution of a portion of tax revenues collected from the central government to the municipalities.

In September, 1995, Supreme Decree No. 24122 gave protection status to over 3.4 million hectares of land and established the Gran Chaco National Park and its Integrated Management Areas. The Decree defined the Bolivia-Brazil gas pipeline right-of-way as the boundary line between the park and the Integrated Management Area.

Bolivia's regulations related to archaeological heritage declare that all artifacts are property of the State and require authorization from the Ministry of Education and Culture prior to excavation activities. The regulations also establish penalties for destruction, damage, removal, or exploitation of cultural resources.

There are a number of proposed laws which have not yet been passed, including laws on indigenous settlements, biological diversity, and environmental norms for the hydrocarbon sector. Progress of these proposed laws will be monitored by Project Sponsors to ensure compliance and identify any potential areas of concern for the project.

Brazil

In the Brazilian Constitution (Carta Magna Brasileira) which was rewritten 1988, Chapter, No. VI, Article 225, was devoted to the environment, which confirmed the growing importance of this matter in Brazil. The Constitution also allocated authority to legislate on environmental issues between Federal and State levels.

The National Policy for the Environment (PNMA) was established under Article 2 of Federal Law No. 6.938 dated August 31, 1981. The purpose of the Law was the preservation, improvement and recovery of environmental quality, to ensure conditions for socioeconomic development, in compliance with the interest of national security and for protection of the dignity of human life. In 1990, Decree No. 99.274 created the National Environmental System (SISNAMA) as an organization with responsibility for promulgating rules and regulations to enforce the National Environmental Policy.

The following bodies and agencies make up the SISNAMA organization:

- Upper Body: the Council of the Government.
- Consultant and Deliberative Body: the National Council for the Environment (CONAMA). CONAMA has responsibility for advising on the establishment of

Federal environmental policies and issuing regulations to implement the National Environmental Policy.

- Central Body: Ministry for the environment, for Hydrological Resources and for the Legal Amazon.
- Executive Body: the Brazilian Institute for the Environment and Renewable Natural Resources (IBAMA). IBAMA is the Federal agency responsible for administering environmental legislation and regulations, and issuing certain licenses.
- Sectional Bodies: bodies or entities of the Federal or State public administration with activities associated with protection of the environment or responsible for such activities.
- Local Bodies: municipal bodies or entities.

From the array of directives consolidated into the PNMA stem the main guidelines related to environmental protection, through regulatory decrees, ordinances and resolutions enacted by the bodies and agencies that integrate the National System for the Environment

CONAMA's first and one of the most important resolution was 01/86, which imposed the requirement for an environmental impact study for projects which have the potential to impact the physical, chemical or biological environment. These studies are a fundamental part of the licensing process. Decree No. 99.274 established environmental licensing as a three-stage process, including a Previous License, Installation License, and Operating License.

CONAMA Resolution 06/86 provides that the request for environmental licenses must be published in the Official State Newspaper and in all major local newspapers in the project area. Resolution 09/87 requires that public audiences be held to review the environmental aspects of major projects. In accordance with these CONAMA resolutions and various state resolutions, notice of the Bolivia-Brazil project was published in the official federal journal and in the major regional or local newspapers in each state. The notices advised the public where the RIMA (environmental impact summary) for the project was available for review, normally in the local library. Public audiences were held in each state to provide local citizens an opportunity to understand and evaluate the project.

3.0 Project Description

Route

The Bolivia-Brazil Gas Pipeline will extend approximately 3100 kilometers from a point near the city of Santa Cruz de la Sierra, Bolivia, and terminating near the city of Porto Alegre in Brazil. The transmission system will originate at the Yacimientos Petroliferos Fiscales Bolivianos (YPFB) Río Grande Natural Gas Plant located approximately 40 kilometers southeast of Santa Cruz and extend approximately 560 kilometers in an easterly direction to the town of El Carmen de la Frontera on the Bolivia-Brazil border. The Brazilian segment extends approximately 2500 km through the states of Mato Grosso do Sul, São Paulo, Paraná, Santa Catarina and Rio Grande do Sul.

The Bolivian sector of the project will traverse the Bañados de Izozog, then cross the predominantly flat tropical dry forest of the Bolivian Chaco region within the Department of Santa Cruz. East of the Otuquis river, the pipeline will cross the northern portion of the Otuquis and Tacuaral marshes. In Bolivia the route crosses the Rio Grande, San Miguel and Otuquis rivers.

From the border, the route continues southeast crossing the Paraguay River and the Pantanal marshland, running parallel to Highway BR-262. In the 700 kilometer segment through the state of Mato Grosso do Sul, the pipeline crosses the Miranda, Pardo and Verde rivers. The pipeline then crosses the Paraná river into the state of São Paulo, continuing southeast, and crossing the Tiete river to the Petrobras REPLAN refinery at Campinas. From the refinery, the route turns south through Capão Bonito where it crosses the Paranapiacaba mountain range, then reaches the Itapirapuã river which separates the states of São Paulo and Paraná. The route crosses the Ribeira river and follows the right-of-way for existing oil pipelines into the state of Santa Catarina, then east of Curitiba and across the Tijucas Mountain Range and the Tijucas river. From this point, the route follows a new right-of-way, passing west of Florianópolis and terminating at the Alberto Pasqualini Refinery near Porto Alegre.

Environmental considerations played a key role in defining the route for the Bolivia-Brazil Gas Pipeline in both countries. After the primary objective of transporting natural gas from supply sources to market demand, the route was laid out based upon environmental sensitivity mapping. The route was further refined based upon environmental conditions identified through field reconnaissance.

Ecologically sensitive areas and areas of high population density were avoided to the extent possible. For example, in Bolivia the route was relocated to avoid the Cañon de la Victoria area due to its ecological importance. The Cañon de la Victoria is a hydrologic and biological connection between the wetland systems of the Bañados de Otuquis, in Bolivia, and the Pantanal, in Brazil. The route was modified to avoid crossing in this area which would impact a large natural wetland and might affect the hydrologic connection between the systems.

In Brazil, many deviations were made to the route to reduce impacts in environmentally sensitive areas. One notable example is in the Pantanal area. The original route in the Pantanal passed 40 km to the north of BR-262. In order to avoid crossing in this ecologically sensitive area of the Pantanal, the route was deviated to the south following the highway through previously impacted ranching and agricultural areas. Although this resulted in a considerable increase in cost, it was considered prudent in view of the environmental considerations.

Engineering Design

The pipeline system will have an initial contract demand of 8.0 million standard cubic meters per day with a maximum capacity of 30.0 million. Pipe will be manufactured in accordance with API-5L, X-70 and X-65 standards and will range from a maximum of 32 inches in diameter at the Rio Grande Gas Plant in Bolivia, progressively decreasing to 16

inches at Porto Alegre. Wall thickness will range from 0.406-0.650, depending upon the design factor. The pipeline will be designed for a maximum allowable operating pressure of 1420 psi with a minimum delivery pressure of 450 psi. In order to increase its transportation efficiency level, the pipe will be internally coated. Corrosion protection for the pipeline will be provided using external anti-corrosive coating and a cathodic protection system. Automatic reduced pressure shutdown valves will be installed to ensure safety of the line. Locations of these valves will be determined during the detail design phase of the project. Pig launchers and receivers will be installed for the purpose of internal inspection and cleaning of the pipe

There will be two meter stations in Bolivia and five in Brazil. It is anticipated that thirty city gates will be installed by State concessionaires along the gas pipeline in Brazil. Four compressor stations are included in the system design for the Bolivian sector and twelve for the Brazilian sector. Compressor station locations were selected based upon hydraulic studies and finalized taking environmental considerations into account. The stations will be constructed as required during the life of the project to increase delivery volumes and maintain acceptable pipeline pressure. In the initial stage of the project only one station will be constructed in Bolivia and four in Brazil. Compressor station sites will be restricted to a maximum 300 x 300 meter area in Brazil, with Bolivia requiring a smaller area, as the natural forest will mitigate noise from the compression equipment.

Meter stations and compressor stations will be automated for remote monitoring and control. A Supervisory Control and Data Acquisition (SCADA) system will serve to monitor and control all pipeline facilities from two Gas Control Centers, located in Santa Cruz, Bolivia and Guarulhos, Sao Paulo, Brazil. Each compressor station and meter station, as well as some valves and other remote facilities will be provided with electronic communication equipment for process control and data transmission to relay information to a host computer via the telecommunication system.

Logistics

Pipeline construction has been segregated into thirteen spreads - two in Bolivia and eleven in Brazil. Each spread will have one permanent camp and smaller camps which will move as construction progresses along the right-of-way. Camp site locations in Bolivia have been identified using the following criteria:

- Minimize disturbance of virgin ground
- Maximize use of readily available access roads
- Minimize number of camps and the size of the areas, primarily by 1) using areas for multiple purposes such as camp and storage and 2) using one camp location for two construction spreads at different times
- Minimize distance to storage yards

Location of camps in Brazil will be determined by the construction contractors, with the approval of the Project Sponsors' environmental team. The camp site locations must also have approval from the municipal governments and the local environmental authorities.

Camps will be located away from small towns, and will not be permitted in sensitive vegetation areas.

Extensive logistics studies have been conducted to determine methods for transportation of pipe and materials to the work sites. Seven possible sea ports have been identified for use in the project - four in Brazil, two in Argentina, and one in Chile. Internal ports on the Paraguay river near the Bolivia-Brazil border will also be utilized for offloading. Pipe imported through ports in Argentina may be transported by river to the Bolivia-Brazil border, then by train or roadway to designated storage yards in Bolivia and Brazil. Materials may also be transported from Argentina via the Belgrano Railway to Santa Cruz, then to storage sites by rail.

Pipe received through the four Brazilian coastal ports will be transported to storage areas by truck. Pipe received through the port in Arica, Chile, will be transported by truck to Santa Cruz, then to storage yards by railway.

There will be two primary storage areas in Bolivia and four in Brazil. From the storage yards, pipe will be transported by truck to the right-of-way for stringing.

No new access roads are proposed for the project; however, in some cases existing access roads will be upgraded. The majority of the required rework consists of drainage improvements and reshaping of existing roadways.

Construction

The construction right-of-way will be a maximum of 30 meters in Bolivia and 20 meters in Brazil. The additional width is required in Bolivia to provide free movement of construction equipment in this area of limited infrastructure. The permanent right-of-way will be reduced to 17 meters in Bolivia following construction. The pipeline will be installed approximately one meter below grade, or deeper in agricultural areas if required.

The pipeline construction will consist of several distinct phases, including clearing, grading, ditching, lowering-in, backfilling, hydrostatic testing and restoration. Highway crossings, river crossings and other unique topographic features may require the use of specialized construction techniques to mitigate and minimize environmental impacts.

An Environmental Construction Plan describing basic environmental construction techniques to be used for the project has been developed. The plan includes impact minimization techniques that will be employed during and after construction. These procedures have been designed to protect the environment and to minimize any potential effects of pipeline construction. Topics covered in the plan include:

- Preconstruction planning and standard environmental construction methods
- Erosion and sedimentation control practices, restoration and revegetation
- Specialized construction methods including waterbody and wetland crossing procedures and site-specific construction methods for environmentally sensitive areas
- Measures to prevent, contain, and control spills

During the detail design phase of the project, the application of these procedures will be defined on a site-specific basis for the entire pipeline alignment.

Gas Pipeline project implementation will be completed within a 36-month period, beginning in January, 1997. The construction is scheduled to take place in two stages. The first stage will commence with mobilization of the work force in May, 1997, and completion scheduled for August, 1998. The second stage will commence in April 1998, with completion in June, 1999.

4.0 Environmental Baseline Conditions

The study area in Bolivia was defined as an area located 10 km to the north of the Santa Cruz to Puerto Suarez railroad and 10 km to the south of the proposed pipeline alignment. This study area incorporates both the proposed pipeline route and the main route alternative considered for the project.

For the purpose of physical and biological baseline studies, the indirect influence area in Brazil comprises a 20 km wide strip, which was established based upon technical and economic considerations. Various routing alternatives were analyzed within this area to identify the optimum route from an environmental, technical, and risk perspective. The direct influence area is a 1,000 meter area on each side of the center line of the proposed pipeline.

For socioeconomic baseline information, the study area in Brazil includes the entire area of all the municipalities crossed by the pipeline which have their administrative seats in the 20 km strip. The data was taken from official data sources, qualified when necessary by primary data collected during field research. Archeological data was collected from all the municipalities crossed by the gas pipeline, not just those with administrative seats within the 20 km indirect influence area.

4.1 Physical Environment

Climate, Air Quality and Noise

The entire area of influence of the project in Bolivia is within the Steppe Climate zone according to the Koppen classification system. In general, this climate is characterized by warm dry winters, with mean temperatures over 23 degrees Centigrade. The distribution of average annual rainfall varies from about 700 mm/yr in the southwestern portion of the study area to more than 1000 mm/yr in the east.

The gas pipeline in the Brazilian sector will run through two very distinctive climatic units. The first unit is the region between Corumbá in the state of Mato Grosso do Sul, and Campinas, in the State of São Paulo, where the climate is tropical with a wet summer and a dry winter. In the Pantanal region there is a one to three month rainy season and a dry period which extends from 90 to 270 days. In the second climatic unit from Campinas to

Porto Alegre the climate is classified as wet subtropical, controlled by tropical air masses with local changes due to steep hills.

The majority of the gas pipeline route extends through undeveloped or agricultural and pasture land with minimal or no human activity. Consequently, the air quality and noise levels along the pipeline right-of-way are, in general, associated with the natural environment and correspond to low levels of air pollution and noise. The proposed storage yards and compressor stations are to be located within or in the vicinity of small, non-industrial urban areas. Air quality is good in these areas, and noise levels are in the low to medium range.

Geology, Geomorphology and Soils

The Llanura physiographic province in Bolivia is a broad, northwest-southeast trending trough which is bounded on the northeast and southwest by relatively elevated portions of the Brazilian Shield and the Faja Subandina, respectively. The surface of the Llanura is characterized by a nearly complete cover of quaternary aged sediments. These consist of varying thicknesses of generally fine grained sediments (clay, silt, and fine sand with lesser amounts of medium to coarse sand and gravel), which were deposited by alluvial, fluvio-lacustrine, coluvial and eolian processes.

Lands surveyed in the Brazilian sector range from pre-cambrian to quaternary times. Approximately 75% of the route is through sedimentary and volcanic rock of the Paraná Sedimentary Basin of the Paleozoic and Mesozoic ages. There are three environmentally sensitive areas from a geological perspective, 1) the section between Corumbá and Aquidauana, in the State of Mato Grosso do Sul in the Pantanal complex, 2) the region of Planalto de Paranapiacaba, next to the border of the States of São Paulo and Paraná, where there is the greatest density of areas with high physical fragility, and 3) the uphill portion of the foothills of Serra Geral, where there is a steep escarpment and the presence of rocks and deposits of talus which subject the hillsides to extreme instability.

The entire study area has a low degree of seismic activity which is confined to shallow surface layers, with a small probably of earthquakes due to the geotectonic configuration of the region. Coal deposits are present in some sections of the study area in Brazil, principally in the State of Santa Catarina.

Hydrology and Water Resources

The study area in Bolivia lies on the drainage divide between the Amazon basin to the north and La Plata basin to the south. The proposed pipeline route lies within the Llanura Chaqueña, which is generally flat with very little relief, except where the plain is cut by occasional small streams and creeks. The most significant rivers which cut the Llanura Chaqueña in Bolivia include the Río Grande and the Río Parapeti, which drain the western portion of the region and flow northward to the Amazon Basin; the southward flowing Río San Miguel, which drains the central portion of the region; and the eastward flowing Ríos San Rafael/Aguas Calientes, Tucavaca, and Otuquis, which drain the Sierras

Chiquitanas in the eastern portion of the region, draining south and east to the Río Paraguay.

Rivers, streams, and creeks in the Llanura Chaqueña generally lack well-defined channels, and are often characterized by broad meandering floodplains, frequent bank erosion and channel shifts during periods of high flows. Large areas of the Llanura Chaqueña are subject to periodic flooding.

The proposed pipeline route in Bolivia also traverses two large wetland regions; the Bañados de Izozog, associated with the Río Parapetí and the Bañados de Otuquis, associated with the Río Otuquis and the Pantanal area. The Cañon de la Victoria is an intermittent connection between two distinct wetland systems, the Bañados de Otuquis in Bolivia and the Pantanal system in Brazil.

In Brazil the project will pass through the hydrographic basins of the Paraguay river, the Paraná river and the South Atlantic. The Paraguay river basin drains an area of approximately 500,000 square kilometers. The Paraguay River is the main drainage vector of the Pantanal Complex which belongs to the Pantanal Depression geomorphologic unit. The extreme flatness of the area, with reduced hydraulic gradients is responsible for its very low drainage flow velocities. The Paraguay River is characterized by unstable banks and a meandering bed. The Miranda river is a tributary of the Paraguay river within this basin.

The Paraná hydrographic basin has a total area of 2,600,000 square kilometers and includes the Southeast region of Brazil, Paraguay, Eastern Bolivia, and Northern Argentina. Its vast network of rivers include the Pardo, Verde, Paraná, and Tiete. The rivers are typical highlands rivers with flow directions following the topographic gradient of the region.

The hydrographic basins of the South Atlantic are small, comprised of numerous small rivers that run predominantly in a Southwest/Northeast direction in a course that is parallel to the coastline. These rivers have origins in the backlands of the Serra do Mar, and upon reaching lower lands, have meandering courses over sedimentary fluvial and marine deposits. The Itajaí Acu river basin has been impacted by high organic and chemical discharges from the textile, metallurgical, and food industries located along the Blumenau/Brusque axis.

4.2 Biological Environment

Flora

Various types of vegetation cover are present throughout the study area in Bolivia, particularly since the area is a transition zone between the biogeographic regions of the Cerrado and the Amazon to the north, the Chaqueña region to the south and the Andes to the west. The three main vegetation types are:

Dry Forest - The area between the Río Grande and Río San Miguel is predominantly dry forest. The vegetation formations in this area are characterized by dense low shrub species and low altitude trees. Scattered emergent trees, approximately 20 meters in height are embedded in a matrix of smaller trees with a relatively open understory. The ground cover stratum is dominated by shrubby vegetation, and dense thickets of terrestrial bromeliads are scattered throughout the forest.

Riparian Forest and Marshland - Riparian forests, characteristic of the Bañados de Izozog region, grow along the Río Parapetí. These tall, dense semi-deciduous forests remain flooded the majority of the time. In addition to the arboreal stratum, the area is characterized by an abundant shrub stratum, vines and ferns. The understory is dominated by tree saplings. Many palm species are also associated with the riparian forests and other inundated areas such as the Tacuaral and Bañados Otuquis.

Savannah - Forested Savannah is present in broad areas east and southeast of the serranías de San José de Chiquitos. In general, these areas are dominated by grasses and sedges, with patches of dense shrub with heights ranging from 1 to 3 meters and small isolated trees. Scattered palms are in evidence in the eastern wet portion of this forested Savannah area.

In Brazil, the majority of the area crossed by the pipeline route has already been impacted by human activities. Much of the area is characterized by pasture, agriculture and cultivated forest. Only small areas of primary vegetation remain. The main vegetation types identified in the area of influence are represented as the following Ecological Zones: Pantanal, Cerrado, Seasonal Forest, Atlantic Forest, Araucária Forest, and Campo Limpo. Each one of these types is directly influenced by its physical and/or socioeconomic condition.

Pantanal Complex - The Pantanal is a complex mosaic of landscapes characterized by at least six vegetation types, including Cerrado, Grassy Timbered Cerrado, Cerrado Park, Cerradão, Semideciduous Seasonal Forest, and Deciduous Seasonal Forest. In spite of being decharacterized by human intervention, the Cerrado still maintains its dense arboreal character, constituted of elements of low and medium height, with about 50% of the species comprised of trees and thorny shrubs. The Grassy Timbered Cerrado is characterized by periodic inundations with a predominantly creeping vegetation, mixed with rare shrubs. The Cerrado Park is characterized small trees sparsely interjected over a continuous mat vegetation and tufts of arboreal Cerrado vegetation. The Cerradão formation has an average height of about 10 meters, occurring predominantly in isolated areas of the Pantanal Matogrossense plains. The upper canopy of the deciduous seasonal forest has an average height of about 20 meters, and is found in the area between the Paraguay and Miranda rivers.

Cerrado - The Cerrado is characterized by the following vegetation types: Cerradão, Cerrado Gramíneo-Lenhoso or Campo Cerrado and Campo, the latter

being the result of intervention by human activity in the area. The Campo Cerrado in this formation is extremely degraded, as a result of the burning for creation of pastures.

Seasonal Forest - This type of forest usually occurs in regions under the influence of two distinct seasons, a rainy season and a dry season, causing partial deciduality of its arboreal species, primarily the ones which occupy the upper canopy of the forest. This vegetation type is found only in scattered areas of the State of São Paulo and small areas of Rio Grande do Sul, although in the latter area it has been largely replaced by agriculture and pastures.

Atlantic Forest - The Atlantic Forest is a dense pluvial tropical forest located along the Brazilian coast line near the Paraná State border and parts of the State of São Paulo. Its dense vegetation with an upper layer of trees approximately 25 meters in height is characteristic of wet tropical areas, which do not have a biologically dry period.

Araucária Forest - The Araucária Forest occupies areas of high altitude, primarily in the Serra do Mar slopes. Its main characteristic is the large occurrence of Paraná pine, which is the dominant species of the upper canopy.

Campo Limpo - Within the study area, the Campo Limpo formation occurs almost exclusively in the State of Rio Grande do Sul. It is characterized by a variety of grass species growing in shallow soil layers.

Fauna

The composition and diversity of fauna present in the study area varies according to the life zone and level of disturbance of the natural habitat. The temperate dry forest area of the Chaco region has one of the highest mammalian species diversities on the continent. The majority of the mammals present in this area have extensive distributions in this part of the continent; however, this area also represents the southern limit of dispersion of some of the large Amazonian mammals like the capibara, jaguar, puma, and some primate species. The Pantanal Complex has a great biodiversity system, with great areas of flooded vegetation, which are habitat for some of Brazil's richest fauna. However, the process of environmental modification that the area has experienced has significantly reduced the populations of some species. The extensive use of land in Brazil for ranching and agriculture has contributed to the declining populations in much of the study area.

The avifauna exhibits Amazonian influences from the north and Andean-Patagonian influences from the south and southwest. In the western portion of the Bolivian study area the most common bird species include parrots, toucans and wading birds. In the dry and humid forest areas among the most common species are the charata, torcaza, toucan, cardinal, American ostrich, and vulture. In the Pantanal and the Bañados de Izozog area and in Isla Verde, large concentrations of ciconides and herons are present. Within the study area are also a great number of migratory birds.

The herpetofauna are also rich, with the occurrence of diverse species of amphibians and reptiles, and a great number of turtles. The Pantanal area also harbors several caiman species and lizards.

The many rivers in the Project area of influence harbor a high ictofauna species diversity, being surpassed in the neotropics only by the total existing in the Amazonian basin.

Species of Concern

The most pursued and threatened mammalian species include large mammals such as deer, wild pigs, and large cats which are hunted for their meat and skin. The felines are hunted indiscriminately because they are considered a threat to cattle which occupy a broad area of the woodland. Among the species which require protection are *Tayassu tajacu* (Pecarí), *T. albirostris* (Tropero), *Catagonus wagneri* (Chancho rosillo), *Alouatta caraya* (Mono Araña), *Mazama americana* (Urina), *Tapirus terrestris* (Anta), *Dasypus novemcinctus* (Tatú), *Priodontes maximus* (Tatú carreta), *Tolypeutes tricinctus*, *Panthera onca* (Jaguar), *Felis concolor* (puma or lion), *Blastocerus dichotomus* (Pantanal deer), *Hydrochaeris* (Capivara), *Chrysocyon brachiurus* (lobo-guará), and *Ozotocerus bezoarticus* (campeiro). The Chacoan peccary, blind armadillo, and the Chaco race of the guanaco are endemic to the Chaco and are not adequately protected in any other conservation area.

There are also a great number of avifaunal species which are threatened with extinction or that have a declining population, including *Amazonetta brasiliensis*, *Anodorhychus hyacinthinus*, *Amazona xanthrops*, *Columbina cyanopis*, *Alecturus risoria*, *Ara ararauna*, *Culcivora caudacuta*, *Nothura minor*, and *Falco deiroleucus*, among others. A great number of migratory birds, like the macaricos and the swallow are also in the process of reducing their populations.

The reptile species which is most threatened due to intense hunting is the caiman. In Bolivia, the *Caiman yacare* is intensively pursued, although there are laws to protect these reptiles. In Brazil the *Eunectes notatus*, *Dracaena notatus* and a great number of turtles are also endangered.

Threatened plant species in the Chaco area include *Bulnesia sarmientoi* and several species of orchids. There are also many ecologically critical vegetation species found in Brazil, such as *Aspidosperma*, *Bromeria*, *Cereus*, *Mimosa*, *Curatella americana*, and *Agonandra brasiliensis*. A complete list is included in Chapter 4 of the Environmental Impact Study for the Brazilian sector of the project.

Protected Areas and Areas of Environmental Sensitivity

In Bolivia the most ecologically sensitive area impacted by the project is the Gran Chaco National Park and Integrated Management Area, instituted in 1995 to protect the largest tract of subtropical dry forest in the Americas. The other protected area in Bolivia potentially impacted by the project is the Historical National Park of Santa Cruz La Vieja. National parks in Bolivia are areas of ecological or historical significance which are set

aside and protected, to allow natural evolution and development of existing ecosystems with minimal human intervention. Integrated Management Areas are areas which have a management plan for the controlled use and development of renewable natural resources. The management plan is designed to maintain a balanced interface between man and the ecological environment. The Gran Chaco and the adjacent Bañados de Izozog are rich in biodiversity and high in floral endemism. The Chaco is the largest protected area in South America and contains one of the highest mammalian species diversites on the continent.

In Brazil there are three primary areas of environmental sensitivity - the Pantanal Complex, Mata Atlantica, and Aparados da Serra. A 70 km stretch of the pipeline from the Verde River to a point just south of Miranda in the state of Mato Grosso do Sul will traverse the Pantanal, which is the world's largest fresh water swamp. The Pantanal is a unique ecosystem which is habitat for many of the world's threatened and endangered species. The Mata Atlantica is an ecologically sensitive forest which has been officially designated as a protected area. The cutting of vegetation in this area is forbidden by federal decree, unless specifically approved by IBAMA. The pipeline will cross 70-100 km of Mata Atlantica in the state of Santa Catarina, approximately 62 hectares of forest. The Mata Atlantica is notable because of its diversified fauna and flora, primarily smaller mammalian species and avifauna. The forest area is somewhat fragmented, however, due to farming, ranching and silviculture. The Aparados da Serra which is located on the boundary of the states of Santa Catarina and Rio Grande do Sul is a legally protected area. The area is particularly sensitive to erosion and is characterized by patches of Mata Atlantica, steep topography and associated talus deposits. There is significant rainfall associated with this topographic variation which accelerates the erosion process.

The following Legally Protected areas are located close to the Project Influence Area in Brazil:

- Pantanal Arenoso Biological Reserve;
- Pantanal Matogrossense Environmental Protection Area;
- Corumbataí Environmental Protection Area;
- Ibitinga Environmental Protection Area;
- Ipanema National Forest;
- Aparados da Serra National Park;
- Serra Geral National Park;
- Mata Atlântica Biosphere Reserve; and
- Permanent Preservation Areas (ciliary woods, marshes, areas of high slope)

4.3 Socioeconomic Environment

Land Use

Most of the study area in Bolivia is under natural vegetation cover. Low precipitation and relatively poor soils limit the capacity of the land to sustain intensive cattle ranching or agricultural activities. Human concentrations are scattered. The most prevalent land use type is lowland deciduous forest, which has been developed only to a small extent by the

logging industry, apparently due to the lack of moisture, which limits the development of commercially valuable timber resources. The second most prevalent land use type is the lowland pasture and/or shrubland, which is used for low density grazing and limited agriculture, and found primarily in the central portion of the study area. The floodplains of the Parapetí River in the west and the Otuquis River in the east which are characterized by abundant surface water, as well as shallow groundwater, support limited agricultural development, primarily rice. The most significant areas of cultivation occur in the western portion of the study area, mainly to the west of the Río Grande. Principal crops grown in this area include soybeans, sunflowers, barley, and corn.

In Brazil the predominant land use in the study area is pasture, which occupies approximately 60% of the total area. Natural vegetation cover occupies 15%, and agricultures occupies less than 10%. The distribution of these land uses varies among the states.

Two thirds of the land in the state of Mato Grosso do Sul is utilized for ranching, due to the native grasses which constitute the basic feed support for cattle. A small amount of the land is used for crops, principally soybean, rice and wheat. In São Paulo, the primary land use is agriculture, principally sugar cane. Remnants of the Mata Atlantica (Atlantic Forest) are also found within this state, near the Paraná border. The forest in this area has been greatly altered by agricultural and ranching activities. In Paraná, 40% of the land is agricultural, and 20% is used for cattle grazing. Natural forests and vegetation occupy approximately 15% of the area, and 8% of the land is used for commercial tree farms. In Santa Catarina, the primary land use is agriculture, with a large number of annual crops such as banana, rice, pineapple, sugar cane, tabacco, and manioc. The principal land use in Rio Grande do Sul is ranching (65%), followed by natural forests (22%). Annual crops occupy a small percentage of the study area.

Population

The sparsely populated study area in Bolivia is concentrated in six urban settlements, with a combined population of less than 50,000 inhabitants - Pailón, San José de Chiquitos, Roboré, El Carmen, Puerto Suarez, and Puerto Quijarro. There are three indigenous groups located within the study area: the Ayoreos, Chiquitanos, and the Izozeño Guaranís. The Ayoreos have a semi-nomadic culture and inhabit the areas located along the Santa Cruz-Puerto Suarez railroad. The Chiquitanos reside primarily in areas located in the vicinity of San José de Chiquitos. The Izozeños live along the Parapetí River in the area of the Bañados de Izozog. The twenty-two communities in Izozeño Guaraní group, with a total of 7500 people, are well organized and constitute the *Capitanía del Alto y Bajo Izozog* (CABI). It is not anticipated that there will be any resettlement in the Bolivian sector due to the pipeline project.

In Brazil, the population in the indirect influence area of the pipeline is approximately seven million, with over 90% being concentrated in urban areas. The demographic density is approximately 50 inhabitants per square kilometer. There are four indigenous groups in the pipeline area, three located in the states of Mato Grosso do Sul and one in Santa Catarina. The indigenous lands of Mato Grosso do Sul are a territory of the Terena

Indians, with a population of approximately 3500. These indigenous people have had many years of contact with other groups of Brazilian society and have integrated into the regional life as agricultural and urban workers. The Guarani Nandeva Indians in the state of Santa Catarina have historically lived a semi-nomadic life, existing upon hunting, fishing and subsistence agriculture. This social organization is changing, and the few remaining Indians are concentrated in one family unit living in the area of Palhoca.

Economy

The Bolivian macroeconomy faced a deep crisis in the mid-80's. Inflation rose to 24,000 percent in 1985. However, since 1985, Bolivia's economy has stabilized, and the country has maintained the lowest comparable inflation rate in South America.

The main sources of income for the population in the Bolivian study area are agriculture, ranching, various government institutions, and trade. The area around Pailón has fairly fertile soil, and the majority of the population is employed by large scale agroindustrial farms. In San José de Chiquitos and Roboré, the majority of the urban population is employed by the government, the railroad, or various commercial establishments. Ranching also contributes to these local economies. El Carmen has a 60% unemployment rate. Employment is available primarily through the logging concessions in the area and cattle ranching. Due to their proximities to the Brazilian border, the economies of Puerto Quijarro and Puerto Suarez are based almost exclusively on activities involving border trade.

Brazil also faced a severe economic crisis during the 1980s, but since July, 1994 the economy has stabilized. In the Brazilian study area there is great economic diversity, with some municipalities being typically agricultural or pasture land and others very industrialized. In Mato Grosso do Sul ranching is the predominant economic activity, followed by annual crops like soybeans and wheat. Border trade also contributes to the local economy in Corumbá. São Paulo is the most industrialized state in Brazil, with a concentration of industrial activity in the Arauquaria/ Paulínia/Campinas area. Production of sugar cane and citrus crops are also important sources of revenue in this state. The economies of Paraná, Santa Catarina and Rio Grande do Sul are primarily based upon industry, services, and agriculture.

Education

Basic education in the Bolivian study area region consists of a limited number of pre-schools, primary schools, and high schools. The Mennonite colonies, primarily in the western portion of the study area, have implemented their own educational systems based mainly on their cultural and religious beliefs. Because the area is rural, there are a limited number of technical schools, and due to the lack of universities, the majority of the population does not have access to higher education.

In Brazil the educational infrastructure is reasonably proficient because the pipeline route crosses some of the most developed states in Brazil. There are many universities,

concentrated in the larger cities. The better universities are owned by the state, although there are many private institutions. There are fewer schools in the rural areas which are typically owned by the State, and they have a larger student-teacher ratio. The best primary and secondary schools are typically privately owned.

Health and Safety

The medical facilities in the villages in Bolivia are comprised of small, minimally-equipped hospitals and first aid posts. The medical work force is limited, with often only one physician and one or two nurses, supported by several midwives located throughout the region. The most common diseases are dysentery, malaria, lung infections, parasites, bronchopneumonia, measles, and tuberculosis. There is a high rate of infant mortality as a result of poor living conditions, deficient health care and education services, and diseases such as dysentery and malaria.

Medical facilities in most of the project area in Brazil are fairly well equipped, and the medical staff is generally well trained. The most common diseases are hepatitis, dengue fever and parasitic diseases. In Mato Grosso do Sul there is also an incidence of malaria, yellow fever and rabies.

Cultural and Archeological Resources

The "Ethnic, Territorial, and Archeological Map of Bolivia" does not indicate any cultural or archeological resources in the study area. However, literature research has identified a limited number of sites in the general area, none of which are in the immediate vicinity of the pipeline route. The most important historical sites in the region are the Jesuits Cathedral and the Santa Cruz la Vieja National Historic Park, both of which are located in San José de Chiquitos.

In Brazil, much of the project area of influence has a high archeological potential due to its historical occupation by indigenous people. There are 615 known archaeological sites in the municipalities located within the five states traversed by the pipeline, most of which are outside the direct influence area of the pipeline. In Mato Grosso do Sul, one sees a predominance of earthen archaeological sites. In São Paulo, most of the sites are stone, while in Paraná 96% of the archaeological sites are ceramic. In the State of Santa Catarina and Rio Grande do Sul, there is a predominance of sambaquis and ceramic sites. The most significant buildings of historical interest are generally located in the main towns. The majority of these churches, homes, monuments and squares are protected on a state and municipal level.

5.0 Analysis of Alternatives

Various siting and construction alternatives have been evaluated for both the Bolivian and Brazilian sectors of the project. The final route was determined to best balance overall impacts to the human, biological, and physical environment while achieving its overall purpose, which is to transport natural gas from the petroleum fields near Santa Cruz to

markets in southern Brazil through an environmentally acceptable and economically viable pipeline route. Major alternatives considered are summarized in the following paragraphs.

Bolivia

Two alternate routes for the Bolivian sector were evaluated by CUMAT in a study performed in 1990. The first alternative was a route running parallel to an existing railroad between Pailón and Puerto Suárez. Under this alternative, the pipeline would run adjacent to or through the populated centers of Pailón, San José de Chiquitos, Roboré, El Carmen, and Puerto Suárez. The second alternative followed a relatively straight route from the Río Grande Gas Plant to Puerto Suárez, across the Bolivian Chaco region. The second alternative was preferred from an environmental perspective, mainly because it traverses relatively homogeneous terrain and avoids areas of slope instability along the southern foothills of the Sierras Chiqutanas. This alternative is shorter in distance and impacts less area of undisturbed forest and marshland. During the Environmental Impact Study performed in 1996 this route was further evaluated and modified to minimize potential environmental impacts, especially in areas of high environmental sensitivity such as the Cañon de la Victoria which is a key element of the hydrolic balance between the Pantanal in Brazil and the Bañados de Otuquis.

Brazil

Numerous alternatives have been considered in finalizing the pipeline route in Brazil, due to technical, economic and most importantly environmental considerations. In defining the route, the goal has been to minimize potential environmental impacts by avoiding steep slopes, areas of primary and secondary vegetation, protected areas, and urban areas. A notable example of how alternative routing was selected to minimize environmental impacts is in the Pantanal. The original route was 40 km North of BR-262, in a sensitive area of the Pantanal. The route was moved South into a previously impacted area parallel to the highway to reduce impacts. In the State of Santa Catarina, the original route passed within 50 meters of mines in coal exploitation areas. After evaluation of alternatives, the route was deviated to avoid these mining areas. Satellite imagery and aerial photography have been carefully evaluated to fine-tune the route and avoid forested areas and other areas of primary vegetation.

No Project

The "no project" alternative was also evaluated. If the project is not implemented, potential adverse impacts on the human, biological and physical environments as a result of the proposed project would not occur. However, there would be no potential positive impacts realized as a result of project implementation such as improved air quality due to use of clean burning natural gas in Brazil, increased employment opportunities, improved area infrastructure, and especially the generation of public revenues that can be used for health and education in Bolivia.

6.0 Environmental Impacts and Mitigation Measures

Impacts in the Bolivian sector were analyzed using a combination of matrices, modeling, and map overlays developed in a Geographic Information System (GIS). An impact identification matrix was used to determine associations between the project activities and the environmental parameters, based on predicted modifications to the existing environmental conditions as a result of construction and operation of the project. For each possible combination of activity and environmental parameter, an assessment was made as to whether the baseline condition of a given environmental parameter is likely to be modified by the project activity. The GIS-based map overlays were used in the quantification of the impacts on individual environmental parameters such as soils and vegetation.

A total of 25 impacts were identified in the Brazilian sector, based upon field studies, research, and evaluation of satellite imagery and maps. To mitigate these impacts and ensure regulatory compliance, ten environmental programs have been proposed. These programs and their costs are described in the annex tables included in the 1996 Environmental Impact Study prepared by PETROBRÁS. The impacts were classified in accordance with standard evaluation criteria. A composite summary of impacts and mitigation measures for the overall project are summarized in Table 1 of this Executive Summary.

6.1 Physical Environment

Air Quality and Noise

The potential air quality impacts identified are associated with the following activities or conditions in the study area:

- Dust associated with site grading, road and building construction activities.
- Pollutants related to construction equipment exhaust and welding activities.
- Emissions associated with the operation of the proposed compressor stations.
- Availability of natural gas as a fuel and energy source in Brazil

Impacts to air quality during the construction phase will be temporary and localized. An air screen model of the four proposed compressor stations in Bolivia was run using the SCREEN3 simulator program. The model predicted the project in-stack emissions rates for PM_{10}, SO_2, and No_x will be well below the World Bank Emission Guidelines for gas turbine sources and Bolivian air emission standards. No exceedances of the World Bank Guidelines for ambient air quality were predicted for any of the pollutants modeled. However, the model did predict a minor exceedance of the Bolivian 1-hour and 24-hour national ambient air quality standards for No_x. Identical equipment will be used for the compressor stations in Brazil.

To prevent or minimize potential air quality impacts, the following measures will be applied. Where available, water will be used to wet construction areas for dust control.

All engines will be properly maintained to minimize emissions of contaminants. Detail design will consider modifications to stack height and other parameters related to the operation of the compressor stations to ensure compliance with applicable regulations.

The noise from camps and construction activities along the pipeline alignment and the compressor station sites could affect wildlife and human settlements. This impact will be minimal and temporary. Compressor stations have been sited to avoid heavily populated and sensitive wildlife areas, which will minimize noise impacts during operations. Workers will be exposed to noise generated by compressor station equipment which will be mitigated by utilizing hearing protection devices.

Due to the substitution of clean-burning natural gas in Brazil other less attractive fossil fuels such as medium and heavy fuel oils with some sulfur content, there will be a reduction in the levels of atmospheric pollution, particularly in the metropolitan and industrial areas. Unlike oil and coal, natural gas contains little sulfur, which produces sulfur dioxide emissions upon combustion. Nitrogen oxides and carbon dioxide emissions and particulates emitted from the burning of natural gas are also lower compared to coal and oil. The increased availability of natural gas in Brazil will result in an improvement in air quality through replacement of alternative fuels which are more polluting sources of energy.

Geology, Geomorphology and Soils

The potential impacts identified related to geology, soils, and seismicity are associated with the following activities or conditions in the study area:

- Ground disturbance resulting in wind and water erosion
- Localized ground disturbance from blasting
- Damage to project facilities from geohazards and differential settlement
- Interference with mining activities in Brazil

The primary impact of the project on soils is an increase in erosion potential in areas where soil becomes exposed by vegetation removal and areas where soils are physically disturbed by trenching, spoil piling, and backfilling. Because the majority of the pipeline in Bolivia will traverse relatively flat areas with natural vegetation cover and low precipitation, it is anticipated that the potential for erosion will be low. The erosion potential is somewhat higher in some areas of Brazil, due to topographical features. Highly limited areas, from a construction point of view, such as hill slopes greater than 30 degrees, and terrains subject to erosion will be avoided where possible. To control erosion, appropriate erosion prevention and control techniques will be employed during construction, as described in the Environmental Construction Plan developed for this project.

Some areas will be replanted with natural vegetation to inhibit erosion. However, due to the limited rainfall in much of the Bolivian project area, the recovery of native vegetation and restabilization of disturbed areas will be a slow process. Vegetation recovery will be rapid in areas of higher precipitation. In some areas, the adjacent vegetation will serve as a barrier against wind and as a source of seeds for natural revegetation to occur. Overall,

the erosion potential is considered minimal as the right-of-way will disturb only a very narrow strip of soil.

Cambrian outcrops in the Puerto Suárez area, mountainous areas principally in the State of Paraná, and the rocky plateau in the Aparados da Serra may necessitate blasting, but this should not have a significant effect on the geomorphology with the implementation of managed blasting procedures. Soil compaction will be minimized through application of soil restoration techniques during final grading. Due to low levels of seismic activity and the absence of known, active faults in the study area, the potential for damage to project facilities resulting from a seismic event is negligible.

The final alignment of the pipeline route in Brazil was delineated to avoid the numerous mining sites. In cooperation with the National Department of Mineral Production (DNPM), attempts will be made to place restrictions on mining licenses granted in the future to avoid interference with the pipeline. Project sponsors will work with IBAMA and the DNPM to develop a Minerals Investigation Program to precisely identify the location of valuable mineral deposits.

Hydrology and Water Resources

The potential impacts related to hydrology, hydrogeology, and water quality are associated with the following activities or conditions in the study area:

- Increased sediment loads
- Disruption to local hydrology due to wetland and water body crossing activities
- Groundwater and surface water withdrawal to support both construction and operation activities
- Reduction in groundwater or surface water quality

For each significant river crossing, detailed studies of its hydrological conditions have been conducted to determine the best crossing method. To minimize sedimentation in water bodies and disturbance to wetland areas, controlled procedures for wetland and water body crossings will be implemented. Most of the river and stream crossings will be constructed using open-cut methods which could suspend sediment in the streams. However, many of the rivers to be crossed are shallow and carry heavy sediment loads, and the additional load is expected to be temporary and localized. Clearing of vegetation, trenching and storage of topsoil in the study area may also result in increased soil erosion and sediment load carried by surface runoff from the disturbed areas. The Paraguay and Itajaí-Acu rivers have very active beds and will be crossed by directional drilling which will eliminate the potential for sedimentation.

During the peak construction period, more than 1,600 persons will be on the project in Bolivia in various locations. Potable water for these workers will be withdrawn from wells at multiple locations installed at depths ranging from 100m to 200 m. The groundwater resources of these aquifers are recharged mainly by infiltration of rainwater, and the expected annual recharge is relatively high. Therefore, impacts from groundwater withdrawal to meet the domestic water requirements of the project are considered less

than significant. Aquifer mixing will be prevented by properly casing the wells. In Brazil it will not be necessary to drill water wells for potable water.

The majority of the water used for hydrotesting the pipeline is expected to be withdrawn from surface waters. To mitigate impacts to aquatic life, volumes of water for hydrotesting will be limited. The pipeline will be tested in 20-30 km segments, requiring withdrawal of approximately 15,000 m^3 per test segment. Thus, the impact of withdrawals from surface waters in considered less than significant.

Groundwater and surface water quality will be protected through the implementation of appropriate spill prevention and control measures. Potential impacts will be avoided or minimized by applying proper techniques to manage and dispose of hazardous materials. Domestic and sanitary wastewater generated at work camps and pipe storage yards will be treated prior to disposal. Extended aeration package plants or conventional septic system drains will be constructed to provide treatment. Impacts are not expected to be significant due to the short construction period and relatively small volume of discharge anticipated.

6.2 Biological Environment

Flora

Throughout most of the proposed pipeline corridor in Bolivia, a five meter wide strip of vegetation was cleared in 1993 in preparation for route survey and project implementation. Additional impacts will result from expansion of the cleared area to a width of 30 meters for pipeline construction. In most areas of the pipeline corridor, native herbaceous and shrubby species are expected to revegetate naturally following completion of pipeline construction. Due to the nature of the soils and dry climatic conditions, revegetation of the pipeline corridor in the Chaco may require more time than the remainder of the corridor. The Aeolic Plain will be replanted to expedite revegetation in this area. There will be a permanent loss of forested canopy in the 17-meter wide permanent corridor, but the canopy will return to the portion of the right-of-way which is not required for maintenance of the pipeline.

In Brazil 85% of the area crossed by the gas pipeline has been previously impacted by human activity. Remnants of original vegetation affected by the project are found in only 15% of the area, and only 7% of these areas will not readily regenerate. Where appropriate, areas will be replanted with native species collected from surrounding areas. This will be done in the Pantanal Matogrossence in areas of Chaquena vegetation, in the Araucarias Plateau and the Aluvial Pioner Formation. Workers involved in the project will be instructed about the importance of preserving natural vegetation, and construction activities will be monitored to ensure this is done.

Fauna

Potential impacts affecting animal populations include the following:

- Permanent loss or fragmentation of wildlife habitat.

- Disturbance to important habitat elements such as breeding, foraging, and cover areas.
- Displacement of individual animals during construction or maintenance.
- Temporary disruption of movement patterns of animals across the right-of-way.
- Direct loss of wildlife from construction activities or increased hunting pressure

The most substantial wildlife impact associated with the project will be the conversion of habitat in the permanent maintenance corridor. However, along portions of the right-of-way which were previously cleared for route survey, additional impacts will be minimal, due to the fact that impacts to faunal species have already occurred. Clearing of vegetative cover in the right-of-way will affect the nesting and foraging habitat for some wildlife species, but this impact will be minimized by restricting the permanent right-of-way strip to a narrow corridor.

Additional impacts on wildlife include disturbance, displacement, and mortality during construction. These impacts will be minimized by training the work force regarding protection of natural resources, including wildlife. Construction activities will be carried out as quickly as possible to diminish exposure time. The construction area will be monitored, and animals which may fall into the pipeline trench will be rescued.

Aquatic species in the area of the Pantanal, floodplains and major river systems are expected to be adversely impacted by high turbidity generated by construction activities. However, impacts are expected to be short-term. Fish species and mobile reptilian and mammalian species will likely move out of the area temporarily, but should return following completion of construction activities. Non-mobile species including benthic invertebrates and any bivalves will be eliminated in the construction corridor, but are expected to recolonize impacted areas quickly from surrounding areas.

To minimize loss of wildlife during construction, hunting and fishing by construction crews will be strictly forbidden. Intruders will be prohibited from entering wildlife areas during construction. Although the pipeline corridor will open access to previously undeveloped areas which might increase hunting activities, this will be controlled in the operations phase through the use of signs, fences and barricades.

Species of Concern

Impacts to terrestrial and wetland/aquatic plant and animal species identified as species of special concern are expected to be minimal and temporary. Temporary displacement of some species from the construction area will occur, and for some species movement across the right-of-way will be hampered during construction activities. After completion of construction, however, the right-of-way will be allowed to naturally revegetate as much as possible, and affected species of special concern are expected to return. To mitigate impacts to the wildlife populations, hunting will be strictly prohibited for anyone associated with pipeline construction and maintenance operations. Impacts to the population of protected floral species are expected to be insignificant.

Protected Areas and Areas of Environmental Sensitivity

Project activities will be conducted in the vicinity of two protected areas in Bolivia: the Integrated Management Area of the Gran Chaco National Park and the Historical National Park Santa Cruz La Vieja. Direct impacts in the Gran Chaco will be limited to clearing of the right-of-way. Secondary impacts may include the risk of colonization of areas in and around the park due to the establishment and maintenance of the right-of-way; however, this potential is deemed low. Indirectly, the possibility of increased hunting pressure within the park boundaries exists, and specific measures will be implemented to prevent it.

The access road from San José de Chiquitos to the right-of-way traverses the Santa Cruz La Vieja park. The park will be affected by road improvement work and increased traffic in the area. To mitigate any potential adverse impacts, the area will be closely monitored, and access to the park will be controlled. The work force will be educated in the significance of the park to Bolivia's national heritage and the necessity to protect this historic site.

The project sponsors propose to make a contribution to Bolivia's National Endowment Fund as an offset mitigation for direct and potential indirect impacts of the project. Revenues from the contribution will be earmarked for the management of parks in the Department of Santa Cruz funded through this program, primarily the Gran Chaco National Park. Administration of the funds will be managed by Bolivia's National Secretary of Natural Resources and the Environment.

To develop a plan to minimize potential environmental impacts in the Pantanal, extensive environmental studies have been completed. The route was finalized in this area based upon technical analysis and environmental considerations. For the most part, the pipeline will run parallel to an existing highway, which is a previously impacted area. Seasonal considerations and implementation of specialized environmental construction techniques and will further mitigate any adverse impacts.

The Mata Atlantica is a fragmented region in which areas of high ecological significance are interspersed with areas of low sensitivity. The route through this area was carefully selected to avoid environmentally significant areas to the extent possible, and additional impacts are expected to be minimal. Where environmentally sensitive areas cannot be avoided, they will be compensated.

After a comprehensive evaluation, it was recommended that potential impacts of soil erosion in the Aparados da Serra be mitigated by utilization of specialized construction techniques.

6.3 Impacts on the Socioeconomic Environment

Land Use

Some changes in land use are expected to occur as a result of project implementation. However, the Project Sponsors plan to restore land as much as possible to its pre-project condition. Conversion of land from existing uses such as farming and grazing has the greatest potential to create adverse social and economic impacts to rural households. Temporary conversion of land to support pipeline and facility construction may result in the loss of one to two years' use for crops and grazing. Landowners will be compensated for their losses. Little of the land along the pipeline route, storage yard or camp locations is currently under human use, so this impact is expected to be minimal. Project facilities have been sited to avoid areas of socioeconomic value as much as possible.

The project will create an increase in vehicular traffic, primarily during the construction phase. This impact will be mitigated by upgrading the access roads to work sites, camps and storage areas. Signs will be posted on access roads, and communities will be informed about traffic conditions.

The possibility exists for indirect land use impacts due to utilization of portions of the right-of-way as a trail or road, which may promote illegal trade, increase mobilization and colonization pressure. However, the project does not intend that the right-of-way be used as an access road and will provide measures to prevent such use. Signs, barriers and gates will be installed, and the area will be monitored on a regular basis.

Population

The study area will experience a small and temporary increase in population during the construction phase due to the influx of workers. Impacts to the local populations will be minimized by siting camps away from smaller towns and utilizing local labor as much as possible. While workers will be housed in camps along the right-of-way, it is expected that they will visit the main population centers in search of relaxation and entertainment during work breaks. One of the primary areas expected to be impacted is El Carmen in Bolivia, where an 800-person camp will be located. The presence of the working crew will be continuous, adding to the demand for services in this town. El Carmen should experience an overall positive impact due to the necessity to improve the water and electrical supply to support camp activities.

The project will increase the risk of accidents to the population due to the transportation and distribution of gas. This risk will primarily affect the population living in the immediate vicinity of the pipeline. The pipeline will include design factors to mitigate safety risk. Risk Management and Emergency Response plans will be developed and implemented to respond to unexpected events.

The project could potentially impact the indigenous people in Bolivia by opening up previously inaccessible areas of forest, which would reduce the forest areas available for indigenous use. However, since the right-of-way was partially cleared in 1993, no evidence of colonization has been detected. Therefore, this impact is considered insignificant.

Impacts to indigenous groups have been further mitigated by the establishment of the Gran Chaco National Park, which gives legal protection to the core territory of these groups. Through a contribution to Bolivia's National Endowment Fund, interest earnings will be designated to benefit the management of the Gran Chaco National Park by subsidizing park rangers and the construction of ranger stations.

To mitigate adverse impacts to the population, the project will maintain a Community Relations program to promote good relations with the communities in the influence area of the project, as well as providing environmental education and information. Preference will be given to local hiring. Impacts on local populations are considered to be minimal and temporary. No displacement of households is anticipated for the project.

Economy

The project will provide substantial direct financial revenues to Bolivia and Brazil through the sale and purchase of natural gas. Additional revenues will be generated through taxes on local goods and services. This economic impact will benefit both countries on a national, regional and municipal level throughout the life of the project.

The project will employ several thousand Bolivian and Brazilian nationals during peak construction of the pipeline, some of whom will be retained as operations and maintenance personnel. This increased employment will improve the local economy, primarily on a short-term basis during construction.

Urban areas will experience some increase in the demand for goods and services from pipeline construction and operations personnel, which will be a positive impact of the project. The potential exists for inflationary prices, which would have a negative impact on local residents, but this potential is not considered to be significant.

Education

National and expatriate project personnel will receive education and training in safety, environmental protection, and basic work practices. Comprehensive training will be provided to craftsmen to develop entry level and mid-level construction workers, and technical training will be administered to employees as required to prepare them for their assignments. This education and training would be considered a beneficial impact of the project on the national work forces. There is not expected to be any impact on the local education systems.

Health and Safety

Medical facilities in the urban areas will be upgraded to provide adequate medical care for personnel involved in the pipeline construction. This will have a positive impact on the available health care for local populations. With the temporary influx of people during construction, there may be an increase in contagious diseases, particularly sexually transmitted diseases. This adverse impact will be mitigated through education programs,

periodic health examinations and prophylactic health care. The increased risk of parasitic diseases such as malaria will be mitigated by chemoprophylaxis programs.

A Construction Safety Plan has been prepared to provide explicit instructions for accident prevention, occupational health, and construction safety procedures. The manual will apply to all contractor and subcontractor personnel as well as project personnel.

Archeology

No potentially significant impacts to cultural, archeological, or historical resources have been identified in the area of direct influence of the gas pipeline. However, an Accidental Discovery Plan has been developed to provide guidance in the event such resources are encountered during construction. An archeologist will be present during construction in areas with a high potential for archeological or cultural resources. Any artifacts discovered will be reported and/or salvaged in accordance with applicable governmental requirements and the Project Archeological Plan.

7.0 Public Consultation Program

In accordance with Bolivian and Brazilian regulations, public consultation programs were conducted during the preparation of the Environmental Impact Studies for the Bolivia-Brazil Gas Pipeline project in each country. In addition, project sponsors have been involved in numerous informal sessions to discuss project issues with the people.

In Bolivia project sponsors held a series of public meetings and visitations with government authorities, nongovernmental organizations, organizations of indigenous peoples, and affected communities. Sponsor representatives participated in the program, which was attended by approximately 850-900 people. The meetings in six affected municipalities followed an interactive approach to identify and discuss environmental issues associated with the project. This consultation assisted with identification of possible project impacts, reconciliation of opposing views about the project, discussion of licensing requirements, and promotion of understanding of the nature and extent of any social or environmental impacts.

The primary concerns of the Bolivian people were employment and basic needs such as water and electricity. These concerns are being taken into account in project planning. Preference will be given to utilizing local labor in the project. To the extent possible, water wells drilled for the project will be left for use of the people, and consideration is being given to donating electrical generators to some of the communities upon completion of construction. Additional information on this subject is included in chapter 8 of the Bolivian Environmental Impact Study.

In Brazil, numerous meetings have been held with municipal, state and federal government bodies, the scientific community and the concerned population to discuss the project. Interviews have been conducted with community leaders, and extensive research has been done in museums, universities, and various institutions. Videos have been presented,

brochures have been distributed, and presentations made in an attempt to inform the population about the project and resolve any concerns.

As prescribed in Brazilian regulations, a Summary of the Environmental Impact Assessment (RIMA) must be available for public review for at least forty-five days. For the Brazilian sector of the Bolivia-Brazil Gas Pipeline Project, this announcement of the availability of the RIMA was published in the official State journal and in the major regional and local newspapers in each affected State. Public audiences were held in each State to provide local citizens an opportunity to evaluate the project's environmental aspects and resolve public concerns. Project sponsors will continue involvement with the local populations to further demonstrate a commitment to the health and welfare of the people and the environment.

8.0 Environmental Management

A comprehensive Environmental Management Plan (EMP) is being developed, to serve as a master planning and management tool for the project. The plan establishes guidelines and procedures to manage the environmental aspects of the project. Included in the plan are environmental construction procedures, spill prevention and control, waste and hazardous materials management, air quality protection and noise control, vegetation and wildlife protection, and cultural resources management. Community relations, training, inspection, monitoring, impact mitigation and compensation are also addressed.

The main objectives of the Environmental Management Plan are 1) to avoid, minimize, control, or mitigate potential impacts from the project construction and operation on the physical, biological, and socioeconomic environments, and 2) to ensure continued project compliance with applicable environmental regulations.

To implement the Plan, an environmental organization and budget will be established within the Project Management organization. Under the direction of an Environmental Manager, a technical and field staff will be responsible for inspecting, monitoring and controlling Contractor compliance with the procedures described in the Environmental Management Plan. The Environmental Manager will have authority to halt activity in the event of non-compliance with the EMP which might have serious environmental impacts. The construction Contractor will be responsible for direct implementation, quality assurance and quality control of the Plan. The project sponsors' environmental committee will provide administrative support and oversight to the Environmental Manager.

Environmental training will be provided to all employees prior to commencement of work. New workers brought to the project after the initiation of project activities will receive training as soon as practicable following their arrival.

During construction, monitoring will be part of the inspection program. Environmental monitoring may include, but not be limited to erosion control, water quality, indigenous and protected wildlife species, cultural resources, water resources, vegetation, and protected areas.

As part of the management of the project, the sponsors will maintain a community relations program aimed at promoting good relations with the communities in the area of influence of the project, as well as providing environmental education and increasing awareness about the project and the environment.

The Environmental Construction Plan outlines basic environmental construction procedures that will be used to construct the pipeline and describes impact minimization techniques that will be employed during and after construction. These procedures are designed to protect the environment and to minimize potential effects of the pipeline construction. The Plan includes standard construction procedures and specialized techniques designed for use only as required under specific circumstances.

Environmental impacts of the project will be further mitigated through following procedures established in plans for "Spill Prevention and Control" and "Waste and Hazardous Materials Management". Specific procedures will be established to minimize direct and indirect impacts to vegetation and wildlife. A plan has also been developed to provide guidance in the event of an accidental discovery of cultural resources or human remains.

9.0 Conclusions

The majority of the pipeline route in Bolivia is in an area of low environmental sensitivity, and the probability of significant adverse environmental impacts is expected to be minimal. In Brazil 85% of the area of influence has already been impacted by human activity. Additional impacts of the project are expected to be minimal, and most negative impacts will be mitigated.

- The most significant impacts identified will occur during the construction stage, most of them being temporary and reversible.

- Throughout most of the study area, the physical and biological environment appears to be resilient to the type and magnitude of impacts anticipated from this project. The primary direct impact in most of the route will result from clearing the right-of-way. In Bolivia this impact will be reduced as a 5-meter wide swath has already been cleared for surveying.

- The most environmentally sensitive areas within the project study area are 1) the Gran Chaco Park in Bolivia, due to its protected status, large biological resources, indigenous populations, and biogeographic status, 2) the Pantanal Complex in Brazil, due to its species diversity, 3) the Atlantic Forest in Brazil, due to its primary vegetation and protected status, and 4) the Aparados da Serra in Brazil, due to its high erosion potential. Measures will be taken to mitigate or compensate for any adverse impacts to these areas.

- The population in the study area of the Bolivian sector is small, and throughout much of the area land use is sparse, partly due to limited land use capability associated with poor soil quality, low precipitation, and a lack of readily available surface and groundwater. Native, undisturbed vegetation is prevalent throughout much of the study area. Socioeconomic impacts of the project are not expected to be significant.

- The proposed pipeline alignment was selected to avoid areas of slope instability, populated areas, and environmentally sensitive or protected areas. The route was determined to best balance the overall impacts to the human, biological, and physical environment while achieving the project's overall purpose, which is to transport natural gas from production fields in Bolivia to markets in Brazil through an environmentally acceptable and economically viable transportation system. As a result of the Environmental Assessments, the route was further refined to avoid areas of potential environmental sensitivity.

- The principal positive impacts anticipated in the project area of influence are 1) an improvement in air quality in Brazil's industrial and metropolitan areas, 2) an increase in revenues for Bolivia from the sale of gas to Brazil, 3) redistribution of tax revenues back into the area of influence of the project, 4) a temporary increase in employment within the study area, 5) an increase in the demand for goods and services in the study area, and 6) an increase in funds allocated for management of protected park areas.

- The principal negative impacts anticipated in the project area of influence are 1) the removal of vegetation and wildlife habitat along the right-of-way, 2) an increase in the potential for erosion, sedimentation, and hydrology disruption due to project construction activities, 3) the potential for increased hunting pressure on species of special concern, 4) the potential for promoting colonization of undisturbed areas, and 5) the potential disruption of the hydrologic patterns in the rivers and Bañados.

- During the detail design phase of the project, procedures and design parameters will be refined to respond fully to concerns identified in the Environmental Impact Assessments. Project sponsors will continue participation in public consultation to evaluate public concerns as they relate to the final design and execution of the project.

- An Environmental Management Plan and Environmental Programs will be implemented to provide appropriate mitigation of unavoidable impacts and lower the significance of negative impacts to acceptable levels.

- The project is environmentally achievable, as its negative impacts may be satisfactorily mitigated, in order to reach a balance between economic growth and ecological preservation, in accordance with the goals of sustainable development. However, there will be a need for continued monitoring throughout the project life to ensure these objectives are maintained.

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Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Climate	No impacts on climate are expected.	N/A	N/A	N/A
Air Quality/Noise	Long-term Improvement in air quality in Brazil	•Increased availability of natural gas •Replacement of more polluting energy sources with cleaner burning natural gas	Benefits will be primarily in industrial and metropolitan areas.	N/A
	Increase in dust and particulates	•Construction of access roads, right-of-way, and camps •Increased traffic •Trench excavation •Installation of meter and compressor stations	Effects are expected to be largely avoidable. Actual emissions will likely be minimal and localized.	•If available, water should be used to wet construction areas.
	Increase in air emissions	•Engines and other construction equipment	Actual emissions will be minimal, localized and temporary	•Proper engine and equipment maintenance and minimization of operation time.
	Decrease in ambient air quality	•Turbines at compressor stations	Screen modeling suggests that Bolivian national ambient air quality standards could be exceeded.	•Final design will incorporate measures to ensure compliance with applicable regulations.
Geology	Alteration of surface rock structure	•Blasting due to rock outcroppings	There are few outcrops along the pipeline route which will require blasting.	•If blasting is required, best management techniques for blasting will be employed.
	Interruption in pipeline operation and safety risk	•Earthquakes and other seismic activity	Historical seismic records suggest minimal probability of earthquakes.	•System design will provide for pipeline safety protection
	Interference with mining activities	•Purchase/expropriation of land •Construction of access roads •Crossing water bodies	The project does not impact mining areas in Bolivia. To the extent possible, mining areas in Brazil have been avoided.	•Assess mineral potential of affected areas •Adjust final pipeline routing to avoid mineral deposits

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Geomorphology	Changes in local topography	•Cut and fill, grading, and road improvement activities	Changes in land forms will be negligible.	•Restore original grade.
	Increased erosion potential	•Vegetation clearance •Trench excavation and spoil piling •Access road construction and road improvements •Other construction activities • •	Much of the area of influence is flat, with low precipitation and natural vegetation cover, which reduces the potential for erosion.	•Application of erosion prevention and control techniques and revegetation where indicated.
	Potential scouring and bank erosion	•River and stream crossing activities	Many water courses along the route, particularly in Bolivia, tend to have shallow cross-section, with gently sloping banks and low scouring	Application of wetland and stream crossing techniques
	Destabilization of hill slopes	•Construction of access roads and clearance of right-of-way •Excavation of the trench	Width of construction corridors and roadways will be minimized in areas of rugged topography.	Utilization of special construction methods such as the two tone (bi-level) approach.
Soils	Soil compaction	•Heavy traffic on the right-of-way	Much of the right-of-way traverses areas of Quaternary deposits which are prone to compaction.	Soil restoration techniques during final grading.
	Mixing of soil layers, nutrient leaching, loss of organic layer.	•Access road construction •ROW clearance •Trench excavation •Spoil piling	Effects are more likely to be significant in wetland areas where an organic layer exists. Minimal impact where soils are sandy, with poor horizon development and little or no organic layer.	Application of appropriate construction techniques in final grading.
	Sudden erosion	•Discharge of hydrotest water.	Line will be tested in short segments. Hydrotest water will be discharged in upland areas.	Application of measures to minimize the potential for erosion, such as energy dissipation devices.

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Groundwater	Potential mixing of aquifers	•Drilling of water wells for use during construction	Groundwater resources in most areas have relatively high annual recharge.	Wells will be properly cased to avoid aquifer interaction.
	Potential lowering of the water table	•Withdrawal of water for camps	Construction timeframe is limited. Many camps will be mobile, moving frequently along the right-of-way.	Groundwater resources will be evaluated before well establishment.
	Potential groundwater contamination	•Accidental spills of fuel and chemicals	Fuels, lubricants and chemicals will be present in limited quantities.	Spill prevention and control measures will be applied.
Surface Water	Potential increase in sediment loads	•Construction activities in water courses and wetland areas.	Many rivers to be crossed are shallow and carry significant sediment loads. The additional load is likely to be insignificant.	Application of erosion and sedimentation control measures for river and stream crossings.
	Temporary disruption to local drainage patterns	•Wetland and water body crossing activities	Many water crossings will be on shallow, slow-flowing waters, thus reducing the magnitude of potential effects on local drainage patterns. Similarly, low rainfall reduces the risk of drainage impacts.	•Application of special wetland and water body construction techniques.
	Permanent modification of local drainage patterns	•Placement of fill and impervious surface for project facilities such as compressor stations.	To the extent possible compressor stations have been sited to minimize this possibility. In many areas there is low rainfall, generally flat terrain, and limited placement of fill and impervious surfaces will be required.	•Proper design of stormwater management systems and cross drains where necessary.
	Potential reduction in surface water availability	•Withdrawal of water for hydrostatic testing	The main sources of hydrotest water will be the major rivers. Volumes withdrawn will be limited to protect aquatic life, and preserve water for other downstream uses.	•Impact can be minimized with proper calculation of surface flow and withdrawal rate and volume.
	Potential contamination of surface waters	•Accidental spills	Project activities will require the utilization of hazardous materials such as gasoline, oil, and paints, but in small quantities and in localized areas.	•This impact can be largely avoided by applying proper techniques to manage and dispose hazardous materials.

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Surface Water (cont)		•Untreated discharges of domestic wastewater	Domestic wastewater will be generated mainly at the workers camps.	•Proper treatment and discharge of domestic wastewater.
		•Improper solid waste disposal	Solid and domestic wastes will be produced in all construction and camp areas.	•Waste management will include minimization, separation, recycling, and proper disposal procedures.
Vegetation	Alteration or elimination of vegetation and forest canopy	•Clearing right-of-way •Opening access roads •Construction of campsites •Construction of meter and compressor stations	A 5-meter wide swath was cut for route survey. Route has been selected to avoid forested areas as much as possible. Cutting of vegetation is prohibited by law in sensitive areas.	•Deforestation will be limited and regrowth will be allowed except in the permanent ROW. •Native species will be replanted in some areas.
	Removal of species of special concern	•Clearing right-of-way •Opening access roads •Construction of camps & facilities	Endemic species are present in a number of protected areas.	•Clearing will be restricted to the right-of-way and designated construction sites.
Fauna	Loss of individuals, including species of special concern	•Construction activities	Slow moving and/or small terrestrial animals, such as tortoises are most likely to be affected.	•Training will be provided to work force regarding protection of fauna.
	Increase in predatory hunting and fishing	•Mobilization of workforce •Opening of access roads and right-of-way •Crossing water bodies	There is an abundance of wildlife and species of special concern.	•Hunting and fishing will be strictly forbidden. •Access to wildlife areas will be controlled. •Warning signs will be displayed and work force will be educated about the hunting and fishing policy.
	Potential entrapment of fish	•Hydrostatic testing of pipeline prior to commissioning	This impact is largely avoidable if proper procedures are followed.	•Intake will be screened to prevent fish from entering pipe.

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Fauna (cont.)	Alteration or loss of habitat	•Clearing the right-of-way •Opening of access roads •Installation of camps •Construction of meter and compressor stations	Insects and small animals will be most affected. Most animals will return to the area upon completion of construction. A cut line has already been established throughout most of the route.	•Clearing for the pipeline will be contained within the right-of-way. •Size of camp sites and compressor stations will be minimized. •Construction. will be expedited. •Access by personnel to areas outside the work area will be controlled.
Protected Areas	Encroachment into Parks and other protected areas	•Clearing the right-of-way •Opening access roads	Camp sites and compressor stations will not be located in protected areas. Route has been selected to avoid protected areas to the extent possible.	•Work force will be educated on preservation of protected areas. •Impacts will be compensated.
Population	Increase in the population of the study area.	•Mobilization of the work force	This effect should be temporary, as it is unlikely that pipeline workers will settle permanently in the study area.	•Accommodations will be provided. •Priority will be given to local hiring. • Camps will be located away from small villages if feasible.
	Potential for cultural and social tension due to the interaction between residents and incoming workers	•Mobilization of work force	Cultural and social differences may arise.	•Measures will be applied to promote positive interaction and a productive cultural exchange between residents and incoming workers.

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Population (Cont.)	Exposure to risk of accidents	•Transportation of natural gas	Gas pipelines have an excellent safety record.	•Emergency Action Plans will be prepared for construction and operation and operation of the pipeline. •Communities will be informed about the pipeline. • Activities will be monitored and controlled to avoid accidents.
	Health problems and an increase in the incidence of contagious diseases, including sexually transmitted diseases.	•Mobilization of work force •Interaction between work force and local residents	Workers will visit nearby communities for supplies, relaxation and entertainment.	•Priority for hiring local labor •Medical examination for work force on admission and periodically thereafter •Medical and sanitation education •Proper treatment of water, solid and liquid waste from worksites and accommodations.
	Pressures on local health facilities	•Installation of construction camps •Construction activities •Operations of compressor and meter stations	Improvements will be made to local medical facilities to accommodate the needs the project.	•Hiring of local labor •Admission and periodic examination of labor •Medical and hygiene education for work force. Accident prevention campaign

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Economy	Potential for a temporary increase in the demand for goods and services.	•Mobilization of work force •Installation of camps and work sites	Workers are expected to depend upon local facilities for non-essential supplies and recreation, which will have a positive impact on local economies.	•Hiring of local labor •Location of work sites close to large urban centers as much as possible.
	Increase in employment opportunities for local labor force.	•Mobilization of construction work force •Use of local labor for maintenance operations	Significant opportunities will exist for nationals, particularly in non-skilled labor.	•Utilize fair hiring and compensation practices
	Long-term positive impacts to economies in Bolivia and Brazil will be realized.	•Promotion of industrial development in Brazil due to increased energy source	Industrial development will provide indirect benefits to economies in other countries.	N/A
	Improvements to local roadways	•Opening of access roads to the right-of-way •Installation of camps	Project will temporarily place heavy demands on the transportation systems in Bolivia and Brazil.	•Improve existing roadways • Construct new roadways if required.
		•Installation of compressor stations and meter stations		•Install road signs. •Inform communities of construction activities.
	Loss of farm and forest production	•Opening of pipeline right-of-way •Construction of access roads •Clearing for camps, pipe storage yards and extra work space •Installation of meter and compressor stations	Much of the right-of-way has already been cleared for surveying. Camps, storage yards, compressor and meter stations have been sited to avoid agricultural and forestry areas as much as possible.	•Landowners will be compensated for loss of production •Areas will be restored to pre-project conditions to the extent possible
	Increase in municipal revenues	•Taxes on transportation and distribution of natural gas •Contribution to Bolivia's national endowment fund	Through project taxes, improvements will be made to local municipalities.	N/A

Table 1. Summary of Impacts and Mitigation Measures

ENVIRONMENTAL PARAMETER	ENVIRONMENTAL IMPACT	CAUSE OF IMPACT	COMMENTS	MITIGATION MEASURES
Land Use	Alteration in land use	•Purchase/expropriation of land •Opening of right-of-way •Construction of access roads •Clearing for camps and extra work space •Installation of meter and compressor stations	Change in land use will be limited to the pipeline corridor, compressor and meter station locations, and new access roads.	•Segregation of topsoil in agricultural areas •Coordination of work schedule with harvest season where feasible •Revegetation with native species
Indigenous Populations	Encroachment into the historical range of indigenous groups	•Construction of access roads •Opening the right-of-way •Construction of compressor and meter stations •Operation of camp sites	Some indigenous territories are protected areas. Most indigenous areas have already been impacted. Project will not impact indigenous population in Brazil.	•Hunting and fishing by project personnel will be forbidden. •Any access roads not required for maintenance of the pipeline will not be retained.
Cultural, Archaeological, and Historical Resources	Potential disturbance to sites of special concern.	•Opening of right-of-way •Excavation of the pipeline trench •Construction of access roads •Installation of camps •Installation of compressor and meter stations	No historical or archeological sites have been identified in the area of direct influence of the pipeline. However, It is highly probable that such sites exist in the Brazilian sector.	•Development and implementation of a contingency plan for accidental discovery. •Enlist presence of an archeologist during clearing of any potential areas of archeological significance. • Salvage artifacts in accordance with the Archeological Salvage Plan.

BOLIVIA BRAZIL GAS PIPELINE - Logistics Map (Ports/ Waterways/Highways)