

CHAPTER IV

ENVIRONMENTAL ASSESSMENT

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1.0 INTRODUCTION

The purpose of this environmental assessment section is to identify the potential environmental effects as a result of the construction and operation of the PLNG Export Project. The environmental management of those potential effects together with the economical benefits derived from the Project implementation will guarantee a sustainable development, environmentally and economically favorable to the country.

In general the objectives of the environmental assessment were the following:

- To identify the environmental and social-economic resources that could be potentially affected by the construction and operation of the Project.
- To assess temporary, residual, and accumulative impacts produced by the construction and operation of the Project. To assess the magnitude of the impacts identified both in a time and spatial contexts. The impacts identified are potential in nature with varying degrees of probability and are based in many cases on worst-case scenarios and assumed static environmental conditions, which in reality vary naturally and may actually heighten or lessen impacts.
- To analyze information obtained during the public consultation process of the EIA, including observations, suggestions and recommendations expressed by the affected public concerning the construction and operation of the Project.
- To rank the potential impacts identified for the project according to their importance with regard to the environmental setting in the Project area.

The environmental assessment has been performed through an interactive process between the owner (PERU LNG S.R.L.), the environmental consulting team conducting the EIA (Golder Associates) and the Front End Engineering Design (FEED) consultant (Kellogg Brown & Root). The interaction between the owner and consultants allowed the evaluation of design options and the planning of the Project in order to minimize the negative effects and to maximize the positive effects during the construction and operation phases of the Project. The Company provided additional data prepared by Monitorio Ambiental y Investigacion de Impactos S.A. and Inspectra S.A. for the marine EIA and Contingent Plans which are included as Appendices.

An analysis of the project design and activities required for the development of the Project was performed during the environmental assessment, by contrasting the proposed activities and their impacts with the environmental baseline limitations established during the EIA process.

During the environmental assessment, applicable environmental measures were evaluated to determine if the proposed environmental management systems to be implemented during the construction and operation activities are adequate.

A qualitative and quantitative identification and assessment of environmental impacts using modified Leopold cause-effect matrices was conducted by the environmental specialists based on information provided by baseline studies, identification of sensitive areas, and their interaction with project design and implementation activities. During the identification of impacts the following were considered: 1) the cause or promoting agent of a change for those activities of implementing the Project; and 2) the effect or changes that will be observed on the environmental or social component as a result of the implementation of those Project activities. The following sections explain the assessment process implemented.

The environmental impact assessment as described in this section provides a mechanism that balances the interests of PERU LNG S.R.L., the public and the government of Peru. This balance has been achieved by incorporating the project specific information from a variety of sources that have been involved in the development of this project, such as the environmental authorities, the affected public located in the area of influence of the Project and the various technical studies prepared by several firms during the EIA for this Project. Input from the affected public obtained during the consultation process carried out during the EIA development was also incorporated in this environmental assessment.

Finally, results from this chapter will be used in defining the management strategies for controlling, preventing and mitigating the impacts that are addressed in Chapter V “Environmental Management and Monitoring Plan”.

2.0 IDENTIFICATION OF IMPACTS

The possible environmental impacts were identified based on the activities related to the construction and operation of the Project. Also, the actions or agents that can lead to a change of an environmental factor, when the activity is carried out, were identified for each of the Project activities.

2.1 Project Activities

The following activities are anticipated during the construction phase of the Project:

- **Transportation and Mobilization**, includes all the activities related to the transportation of equipment, machinery, supplies and personnel to and from Melchorita during all of the construction phase. Transportation will be conducted by land and sea.
- **Site Preparation** includes all the activities related to earthwork (cut and fill) on the non marine portion of the site, required for the construction of the process areas, storage and support-building areas.
- **Construction of Infrastructure and Utilities** includes the construction of internal access roadways, installation of the temporary construction camp, administrative buildings, permanent residence buildings, power generation, seawater inlet facilities, desalination plant, firewater system, the effluent treatment system and other services.
- **Construction of Process and Storage Areas** includes the construction of foundations for process and the storage tank areas, the construction of metal-framed structures, the assembly of mechanical components (including process units and internal process pipes) and the construction of all mechanical and electrical components of all the processes, storage and loading units.
- **Construction of Marine Facilities** includes the construction and installations of all marine components of the project such as the trestle, the loading platform, ship mooring installations, the dredging of the navigation channel for the access and departure of LNG ships, and the breakwater to provide protection from wave actions during the LNG berthing and loading operations.
- **Systems and Equipment Testing** includes all non-destructive hydrostatic pressure and X-ray testing applied to all the mechanical systems such as tanks, pipelines, valves, and containers, as well as tests to the electrical and automated systems for controlling the processes, storage and loading.

The following activities are anticipated during the operation of the Project:

- ***Treatment and Liquefaction of Natural Gas*** consists of processing the natural gas entering the plant until its transformation into liquefied gas and its temporary storage before being exported.
- ***LNG Ship-Loading Operations*** includes all of the operations associated with the arrival, loading and departure of LNG ships and the operations of tugboats to guide and tow the LNG ships to the berth.
- ***Tug Boats and Utility Service Dock Operations*** includes all operations related to permanent berth of three tug boats at northern mooring dolphins and refueling, routine maintenance and tug supply provided at the small utility dock located on the south side of trestle.
- ***Maintenance of the Plant*** includes all the activities required for ensuring the proper mechanical, electrical and automatic operational systems of the plant.
- ***Maintenance of Marine Facilities*** includes the maintenance dredging of the navigation channel and the routine maintenance of all civil or mechanical systems required for the proper operation of structures such as the trestle, the loading platform and breakwater.
- ***Closure of Operations and Abandonment*** includes all the activities related to the closure of the plant and its installations at the end of the estimated useful life and the activities related to the proper abandonment of the installations and the rehabilitation of the site.

2.2 Environmental Components and Change Indicators

According to the information collected during the baseline studies for the different physical, biological, social-economic and cultural components represented in the Project influence area (see Chapter 3), change indicators (events that show the occurrence of an effect) have been identified based on the susceptibility of the component to exogenous agents. This analysis performed by the different specialists taking part in the environmental impact assessment is summarized in Table 1. A code has been assigned for each of the indicators identified in each environmental components analyzed, with the aim to facilitate the information management in the process of impact identification and its easy representation in the matrix of environmental impact assessment.

Table 1 Change Indicators

Environmental Component	Code	Change Indicators	Effects
Air	A-1	Alteration in the air quality	Refers to the environmental effects such as: dust and particulate generation (PM10), atmospheric emissions of mobile sources (combustion gases of vehicles and equipment) and atmospheric emissions (NO2, SO2 and CO) of stationary sources.
Noise	R-1	Increase of the noise levels	Considers the increase of environmental noise above baseline levels due to the temporary introduction of noise levels.
Water	H-1	Increase of the seawater turbidity	Refers to the direct increase in suspended particulate material in the seawater and the alteration of the aquatic habitat.
	H-2	Alteration of the physical-chemical quantity and quality of the seawater/river water	The water quantity refers to the water demand required for the project and the supply of the resource and competence for its use. The physical quality refers to changes in the water direction and water speed and their relation to the typical settlement patterns in the project site. Also, it refers to changes in the physical or chemical quality of the water that may be produced by accidental spills of hydrocarbons (such as combustibles, greases and oils) or other substances related to discharges that deteriorate the quality of the resource.
Soils and Landforms	SU-1	Alteration of the soil structure	Refers to effects such as soil mixing and the compacting of any surface soils that may exist.
	SU-2	Alteration of the physical-chemical quality	The physical quality refers to the surface erosion caused by aeolian or water-related transport of sediments, or the combination of both. The chemical quality refers to characteristics of the soil that may be affected by accidental hydrocarbon spills (such as combustible, greases and oils) or other substances related to discharges that deteriorate the quality of the resource.
	SU-3	Alteration of landforms	Refers to the alteration of landscape caused by cut and fill activities during the construction phase.

Environmental Component	Code	Change Indicators	Effects
	SU-4	Alteration of the beach morphology	Refers to the changes in the deposition of sediments patterns caused by the interaction with new fixed marine structures.
Terrestrial and Marine Flora and Fauna	FF-1	Loss of terrestrial vegetal cover	Refers to the removal of surficial vegetation Tillandsias (bromeliad), an endemic air plant that grows on the ground in sandy soils.
	FF-2	Alteration of the structure and composition of the marine communities	Refers to the direct disturbance of the marine substratum and the effects caused to the Planktonic and Benthic communities and habitats in the subtidal and intertidal zones.
	FF-3	Changes in the fish catch	Effects to the artisan fishing activity of the zone and the reduction or increase in fish catch due in combination with other effects caused by fluctuations in the benthic and planktonic communities and turbidity.
	FF-4	Reduction in the registries of marine fauna	Refers to the decrease of the number of sightings in the area or the direct eradication of species with conservation ranking that are directly related to accidental contacts with project elements or indirectly related due to the effects caused on the trophic chain elements or their habitats.
Social	S-1	Alteration in the demographic composition	Refers to the self-induced migration of the population seeking employment and the creation of substandard settlements.
	S-2	Alteration of the local customs	Refers to the alteration of the normal social relationships established in the population in the zone of influence by interacting with the workers coming from places other than those of the direct influence area.
	S-3	Nuisance to the population	Refers to the effects on the population living in the areas of influence near terrestrial or marine corridors used for transporting equipment, machinery, supplies and personnel required for the project and the increase of the vehicular traffic and the potential for accidents.

Environmental Component	Code	Change Indicators	Effects
	S-4	Interruption of road infrastructure	Refers to the effects on the transitability conditions and on structures such as roads and bridges that impede the normal vehicular flow on the roads.
	S-5	Restrictive access to fishing zone	Refers to the restrictive access to artisanal fishermen along the beach and offshore areas due to the plant construction and operation to provide for plant and fisherman safety.
Economical	E-1	Increase of the tax revenues	Refers to the increase in tax revenues that will be receive by the local, regional and national governments from the operation.
	E-2	Increase in the demand of goods and services	Refers to the increase in the purchase of supplies, goods and services directly related to the construction and operation of the plant, which will result in the increase of available quality and the supply of some goods and services at local, regional and national levels.
	E-3	Job Creation	Refers to the demand of workers (skilled and non-skilled) that the project will require throughout the construction and operation phases. The development of this project will produce two types of employment: direct employment, during the construction of the plant which will help alleviate the levels of unemployment in the area; and indirect employment created by the increase in the demand for local goods and services.
	E-4	Alteration of the income derived from artisan fishing	Refers to the reduction in fish catch due to restricted access to the artisanal fishing zone described in S5.
Cultural	AR-1	Alteration or destruction of the archaeological resources	Refers to archeological findings not found during the CIRA process and uncovered during the construction activities and the effects attributed to them.

2.3 Interaction of Project Activities and Environmental Components

After identifying the Project activities, the environmental components and their change indicators in the study area, an interaction matrix presented in Table 2 identifies the potential impacts from the development activities (by combining the information provided in section 2.2) during the construction and operation phases of the Project.

The definition of Environmental Impact used in this study refers to the product of the interaction of an activity causing a change on a given resource. The changes observed in this resource are the environmental effects, with importance determined through an assessment scheme to establish its significance for the development of the Project.

For identifying the environmental impacts that potentially will be observed in the study area as a consequence of the development of the construction and operation activities of the ExProject, the matrix presented in Table 2 has been prepared. See the list of codes assigned in Table 1 for the interpretation of this table.

Table 2 Matrix of Interaction of Environmental Components and Project Activities

ENVIRONM ENT	COMPONENT	PROJECT PHASES											
		Construction						Operation					
		<i>Transportation and Mobilization</i>	<i>Site preparation</i>	<i>Construction of Infrastructure and Services</i>	<i>Construction of Process and Storage Areas</i>	<i>Construction of Marine Facilities</i>	<i>Tests to Systems and Equipment</i>	<i>Treatment and Liquefaction of Natural Gas</i>	<i>LNG Ship- Loading Operations</i>	<i>Tug Boats and Utility Service Dock Operations</i>	<i>Maintenance of the Plant</i>	<i>Maintenance of the Marine Facilities</i>	<i>Closure of Operations and Abandonment</i>
PHYSICAL	Air	A-1	A-1	A-1	A-1	A-1		A-1	A-1	A-1	A-1	A-1	A-1
	Noise	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1	R-1
	Water	H-1				H-1			H-1	H-1		H-1	H-1
		H-2	H-2			H-2	H-2		H-2	H-2		H-2	H-2
	Soil		SU-1	SU-1	SU-1						SU-1		SU-1
			SU-2	SU-2	SU-2			SU-2			SU-2		SU-2
			SU-3	SU-3	SU-3	SU-3					SU-3	SU-3	SU-3
						SU-4			SU-4				
BIOTIC	Terrestrial and Marine Flora and Fauna		FF-1	FF-1	FF-1						FF-1		FF-1
						FF-2						FF-2	FF-2
						FF-3			FF-3	FF-3		FF-3	FF-3
		FF-4	FF-4	FF-4	FF-4	FF-4		FF-4	FF-4	FF-4		FF-4	FF-4
SOCIAL	Social		S-1	S-1	S-1			S-1					
			S-2	S-2	S-2	S-2							
			S-3	S-3	S-3	S-3			S-3	S-3		S-3	S-3
			S-4	S-4	S-4								
			S-5	S-5	S-5	S-5	S-5	S-5	S-5				
	Economical	E-1	E-1	E-1	E-1	E-1		E-1	E-1		E-1	E-1	E-1
		E-2	E-2	E-2	E-2	E-2	E-2	E-2	E-2	E-2	E-2	E-2	E-2
		E-3	E-3	E-3	E-3	E-3	E-3	E-3	E-3	E-3	E-3	E-3	E-3
			E-4	E-4	E-4	E-4		E-4	E-4				
	Cultural		AR-1	AR-1	AR-1								

3.0 EVALUATION OF IMPACTS

The evaluation of impacts consisted of defining the attributes to be assessed for each of the impacts analyzed and assigning a relative scale of values for each of these attributes. The process developed a ranking of each of the impacts generated by the Project activities during the construction and operation phases of the project as described as follows.

3.1 Evaluation Criteria

In the process of environmental impact assessment for the Project, the attributes and the scale of values were defined for the analysis of impacts. The attributes established for the environmental impacts were based on the characteristics and the spatial-time behavior produced by the interaction of the project activity and the environmental component affected.

The attributes defined for the evaluation of the potential impacts were the following:

- Type
- Geographic extent
- Length
- Magnitude
- Probability of occurrence
- Frequency
- Reversibility

The ranking of these attributes is represented in Table 3. The definition of these attributes is based on the behavior of typical impacts known, derived from the construction and operation of similar projects in the oil industry.

Table 3 Ranking Criteria

Attribute	Classification	Definition
Type	Positive	Net benefit for the resource
	Neutral	No net benefit or detriment for the resource
	Negative	Net detriment for the resource
Geographic Extent	Direct	Confined to the area directly affected by the project.
	Local	It goes beyond the areas directly affected but it is located within the boundaries of the assessment study area that will be specified for each discipline or indicator.
	Regional	It extends beyond the local or administrative boundaries specified for each discipline or indicator. It is considered as an indirect impact.
Length	Short-term	Less than a year
	Medium-term	Between 1 and 5 years
	Long-term	More than 5 years
Magnitude	None	No change is foreseen
	Low	It is predicted that the disturbance will be slightly greater than the existing typical conditions.
	Medium	It is predicted that the effects are much higher than the typical existing conditions but without exceeding the criteria established in the permissible limits or without causing changes in the economic, social, biological parameters within the ranks of natural variability or social tolerance.
	High	The predictable effects exceed the criteria established or the limits permitted related to potential adverse effect, or they cause a detectable change in social, economic and biological parameters beyond the natural variability or social tolerance.
Frequency	Permanent	It will occur continually
	Temporary	It is limited to a specific period (For example: during construction)
	Periodic / Occasional	It occurs intermittently but repeatedly either at equal time intervals or at irregular time intervals (occasional) (For example, during maintenance activities)
Occurrence Probability	Low	Little probability
	Medium	Possible or probable
	High	Occurrence
Reversibility	Short-Term	Effect could be reverted in a year or less
	Medium-Term	Effect could be reverted in more than a year but in less than ten years
	Irreversible	Permanent effect

3.2 Evaluation of Impacts

The evaluation of impacts performed by a multi-disciplinary team was carried out using a Leopold modified matrix, in which the environmental factors potentially affected and the Project activities that can lead to a potential impact were represented (see Sections 2.1 to 2.3).

The evaluation method used for the matrix consisted of assigning values, in a relative scale, to all the attributes of the impact analyzed for each of the interrelations of project activity to environmental effect.

Table 4 represents the relative scale of values established by the multi-disciplinary team for each of the attributes shown in Section 3.1.

Table 4. Scale of Values for Ranking of Impacts

Type (C)		Length (Du)	
Negative	-1	Long-Term	3
Positive	1	Medium-Term	2
Neutral	0	Short-Term	1
Magnitude (M)		Frequency (F)	
High	3	Permanent	3
Medium	2	Periodic	2
Low	1	Temporary	1
Probability of Occurrence (Po)		Reversibility (R)	
High	1	Irreversible	3
Medium	0,9-0,5	Reversible at medium-term	2
Low	0,4-0,1	Reversible at short-term	1
Geographic Extent (E)			
Regional			3
Local			2
Direct			1

The assignation of values to each of the interactions analyzed generated a multiple index according to the following mathematical equation, whose result represents the quantitative and qualitative characteristics of the impact:

$$Ca = C \times Po \times (M + E + Du + F + R)$$

For assigning values to each of the impacts, according to their attributes, each environmental specialist used the information obtained from the baseline studies as well as the observations, suggestions and recommendations from the public consultation process. Appendix 3 contains all of the assigned values and final score given to all potential changes (22 as shown at table 1) that may occur during environmental and social component interactions with project activities (a total of 12 for construction and operation as described in section 2.1).

With the aim to visualize these quantitative and qualitative characteristics of the impact analyzed in the matrix of interactions, a rank of values was established assigning a color code to each one. (see Table 5).

Table 5 Ranks of Values and Color Code

Ranks of Value				
			Predicted Effect	Color Code
15	A	+1	Positive	
0		0	Neutral	
-5	A	-1	Slightly negative	
-10	A	-5,1	Moderately negative	
-15	A	-10,1	Highly negative	

The results from this evaluation process are shown in the matrix of evaluation of impacts for the construction and operation phases presented in Tables 6 and 7, respectively.

Table 6. Matrix of Evaluation of Impacts – Construction Phase

ENVIRONMENT	COMPONENT	INDICATOR	PROJECT PHASE					
			Construction					
			<i>Transportation and Mobilization</i>	<i>Site Preparation</i>	<i>Construction of Infrastructure and Services</i>	<i>Construction of the Process and Storage Areas</i>	<i>Construction of the Marine Facilities</i>	<i>Tests to Systems and Equipment</i>
PHYSICAL	Air	A-1						
	Noise	R-1						
	Water	H-1						
		H-2						
	Soil	SU-1						
		SU-2						
		SU-3						
		SU-4						
BIOTIC	Terrestrial and marine flora and fauna	FF-1						
		FF-2						
		FF-3						
		FF-4						
SOCIAL	Social	S-1						
		S-2						
		S-3						
		S-4						
		S-5						
	Economical	E-1						
		E-2						
		E-3						
		E-4						
	Cultural	AR-1						

Table 7. Matrix of Evaluation of Impacts - Operation Phase

ENVIRONMENT	COMPONENT	INDICATOR	PROJECT PHASE					
			Operation					
			<i>Treatment and Liquefaction of Natural Gas</i>	<i>LNG Ship-Loading Operations</i>	<i>Tug Boats & Utility Service Dock Operations</i>	<i>Maintenance of the Plant</i>	<i>Maintenance of the Marine Facilities</i>	<i>Closure of operations and abandonment</i>
PHYSICAL	Air	A-1						
	Noise	R-1						
	Water	H-1						
		H-2						
	Soil	SU-1						
		SU-2						
		SU-3						
		SU-4						
BIOTIC	Terrestrial and marine flora and fauna	FF-1						
		FF-2						
		FF-3						
		FF-4						
SOCIAL	Social	S-1						
		S-2						
		S-3						
		S-4						
		S-5						
	Economical	E-1						
		E-2						
		E-3						
		E-4						
	Cultural	AR-1						

4.0 ANALYSIS OF IMPACTS

This section presents an analysis of the environmental impacts that potentially will occur during the project construction and operation phases, determined according to the process described above.

4.1 Physical Environment

4.1.1 Air Quality

Construction Phase

The Project site is located in an area that is uninhabited with no commercial or industrial land use activities. The existing air quality at the site is typical of a rural area with emissions being predominantly from vehicles as mobile sources on the eastern border along the Pan Americana Sur. The results of the baseline air quality data are described in Chapter III of the EIA.

The maximum air quality impacts during construction are anticipated to be temporary and intermittent from construction sources. These emissions will occur during the construction period when heavy equipment is engaged in the earthwork operations during the clearing, grading, and compaction of the site, as well as the installation of buildings and associated structures for the Project.

The air pollutant emissions due to these sources are primarily associated with potential dust or particulate matter (PM) associated with earthwork operations. Since the site has a rolling terrain with very little vegetation, the earthwork operations are expected to be of short duration compared to the duration of the construction of the Project. Air quality impacts during construction are considered to be a local impact, since the dispersion of dust will be less than 1 km from the site.

Construction equipment used to prepare the site will produce emissions to the atmosphere from the combustion of fuels such as diesel and gasoline. These gases include NO_x, hydrocarbons, CO, PM, and SO₂. These emissions are expected to be temporary and intermittent during the construction phase of the Project producing low air quality impacts.

The Project site is located in a rural area where the air quality is considered representative of arid areas with wind transported particulate matter where there are other major sources of air pollution than motor vehicles. Ambient air quality impacts associated with the construction phase are considered insignificant.

Operation Phase

The air quality modeling for the proposed Plant indicates that the Project's maximum air quality impacts are predicted to be significantly below the World Bank Ambient Air Quality Guidelines (World Bank, 1999). The maximum impacts are also low compared to the Peru Air Quality Standards and U.S. Ambient Air Quality Standards.

The following section provides descriptions of the methods and assumptions used in the air quality modeling analysis to predict the maximum impacts for the Project.

General Modeling Approach

Air quality impacts from the proposed Project were predicted using an air dispersion model and air modeling techniques approved by the U.S. Environmental Protection Agency (EPA) as presented in the Guideline on Air Quality Models (EPA, 2001). The World Bank, in its Pollution Prevention and Abatement Handbook (1999), generally recommends the use of EPA models in predicting impacts from emission sources. Golder has also used EPA models for similar projects in many countries throughout the world. The selection of the air dispersion model was based on its applicability to simulate impacts in different types of terrain. In the EPA modeling guidelines, simple terrain is considered to be areas where terrain features are all lower in elevation than the top of the stack(s) under evaluation. Complex terrain areas are considered to be those that are above the stack height elevation.

Based on the simple and complex terrain features surrounding the proposed Project site, the Industrial Source Complex Short-Term (ISCST3) air dispersion model (Version 02035) (EPA, 2002) was used to predict maximum air quality concentrations due to air emissions for the Project. This model can predict concentrations for a variety of sources and for all different types of terrain using two algorithms. The algorithms include the ISCST3 algorithm for performing refined modeling analyses

in simple terrain, and the COMPLEX I algorithm for providing screening-quality impacts in complex terrain. The ISCST3 model is a steady-state Gaussian plume model that can be used to assess the air quality impact of emissions from a wide variety of sources associated with industrial facilities. The model is maintained through the EPA Technology Transfer Network (TTN) Internet web site.

The ISCST3 model has rural and urban options, which affect the wind speed profile exponent law, dispersion rates, and mixing-height formulations used in calculating ground-level concentrations. The criteria used to determine when the rural or urban mode is appropriate are based on land use near the proposed plant's surroundings (Auer, 1978). If the land use is classified as heavy industrial, light-moderate industrial, commercial, or compact residential for more than 50 percent of the area within a 3-km radius circle centered on the proposed source, the urban option should be selected. Otherwise, the rural option is more appropriate. Major features of the ISCST3 model are presented in Table 8.

For modeling analyses that will undergo regulatory review in the United States, the following model features are recommended by EPA (1999a) and are referred to as the regulatory options in the ISCST3 model:

- Final plume rise at all receptor locations,
- Stack-tip downwash,
- Buoyancy-induced dispersion,
- Default wind speed profile coefficients for rural or urban option,
- Default vertical potential temperature gradients,
- Calm wind processing, and
- A decay half-life of 4 hours for SO₂ concentration calculated in urban areas.

In this analysis, the regulatory options were used to address maximum impacts from the proposed Project. Based on a review of the land use around the site, the rural mode was selected, as the majority of land use is not compact residential, industrial, or commercial within 3 km from the proposed Project site.

Table 8 Major Features of the ISCST3 Model, Version 01001

ISCST3 Model Features	
Polar or Cartesian coordinate systems for receptor locations	
Rural or one of three urban options which affect wind speed profile exponent, dispersion rates, and mixing height calculations	
Plume rise due to momentum and buoyancy as a function of downwind distance for stack emissions (Briggs, 1969, 1971, 1972, and 1975; Bowers, 1979)	
Procedures suggested by Huber and Snyder (1976); Huber (1977); and Schulman and Scire (1980) for evaluating building wake effects	
Procedures suggested by Briggs (1974) for evaluating stack-tip downwash	
Separation of multiple emission sources	
Consideration of the effects of gravitational settling and dry deposition on ambient particulate concentrations	
Capability of simulating point, line, volume, area, and open pit sources	
Capability to calculate dry and wet deposition, including both gaseous and particulate precipitation scavenging for wet deposition	
Variation of wind speed with height (wind speed-profile exponent law)	
Concentration estimates for 1-hour to annual average times	
Terrain-adjustment procedures for elevated terrain including a terrain truncation algorithm for ISCST3, and a built-in algorithm for predicting concentrations in complex terrain	
Consideration of time-dependent exponential decay of pollutants	
The method of Pasquill (1976) to account for buoyancy-induced dispersion	
A regulatory default option to set various model options and parameters to EPA recommended values (see text for regulatory options used)	
Procedure for calm-wind processing including setting wind speeds less than 1 m/s to 1 m/s	

Note: ISCST3 = Industrial Source Complex Short-Term.

Source: EPA, 1999.

The ISCST3 model is designed to calculate hour-by-hour concentrations (or depositions) for averaging time periods of 1, 2, 3, 4, 6, 8, 12, and 24 hours. If used with 1 year of sequential hourly meteorological data, the ISCST3 model can also calculate annual concentration (deposition) values. The ISCST3 model can input polar and Cartesian-type receptors, either individually or in grid form.

Compliance with the 24-hour average World Bank Guidelines is based on comparing the 98th percentile value predicted for the source to the guideline value. For the 24-hour averaging period, the 98th percentile value is equivalent to the seventh highest value which is determined by multiplying 2 percent by 365 (the number of 24-hour average periods in a year).

Source and Emission Data

The stack design, operating, and emission information was based on data supplied by Kellogg Brown & Root Inc. (KBR), the Front End Engineering Design (FEED) contractor for the Project. These data were used in the modeling analysis.

The stack, operating, and emission data used in the air quality modeling analyses for the Project are presented in Table 9. The air modeling analysis was performed assuming all sources were operating at maximum capacity (i.e., at 100 percent maximum continuous rating) and were co-located. For the GT Power Generators, two of the three units operate at the same time while the third is shutdown. Therefore, only two of these units were modeled.

Those sources identified as operating continuously were modeled for every hour in the year. Certain sources, such as the emergency generators and pumps, operate infrequently. These sources are tested 1 hour each week for maintenance and operate up to 100 hours per year. For modeling purposes, the maximum hourly emissions for these sources were adjusted based on the averaging period. For the 1-hour averaging period, no adjustment was made. For the 8-hour and 24-hour averaging periods, the sources were assumed to operate for 1 hour in those periods. Therefore, the emissions for those periods were obtained by multiplying the hourly emissions by factors of 1 hour/8 hours and 1 hour/24 hours, respectively. Similarly, the annual average emission rates were obtained by multiplying the hourly emissions by a factor of 100 hours/8,760 hours.

Table 9. Stack, Operating, and Pollutant Emission Data for the Project Used in the Air Dispersion Modeling Analysis

Emission Point Source	Continuous (C) or Intermittent (I)	Stack Data		Operating Data					Pollutant Emission Data											
		Height (m)	Diameter (m)	Flow		Velocity	Temperature		NOx		SO ₂		CO		PM		PM ₁₀		VOC	
				(kg/hr)	(m³/hr)	(m/s)	(°C)	(K)	(kg/hr)	(g/s)	(kg/hr)	(g/s)	(kg/hr)	(g/s)	(kg/hr)	(g/s)	(kg/hr)	(g/s)	(kg/hr)	(g/s)
AGR Regenerator Reflux Drum (V-1104)	C	28	0.457	23,150	15,128	25.6	50	323		NA		NA		NA		NA		NA		NA
GT Driver (KT-1410) to LP/MP MR Compressor	C	36	4.94	1,074,000	2,567,422	37.2	537.2	810	40.4	11.22	Neg.	Neg.	15	4.17	4	1.11	2	0.56	4.5	1.25
GT Driver (KT-1420) to HP MR/Propane Compressor	C	36	4.94	1,074,000	2,567,422	37.2	537.2	810	40.4	11.22	Neg.	Neg.	15	4.17	4	1.11	2	0.56	4.5	1.25
GT Power Generator No. 1 (G-4001)	C ^a	36	4.00	439,000	985,085	21.8	488.3	761	14.1	3.92	Neg.	Neg.	10	2.78	2	0.56	1	0.28	4.1	1.14
GT Power Generator No. 2 (G-4002)	C ^a	36	4.00	439,000	985,085	21.8	488.3	761	14.1	3.92	Neg.	Neg.	10	2.78	2	0.56	1	0.28	4.1	1.14
GT Power Generator No. 3 (G-4003)	C ^a	36	4.00	439,000	985,085	21.8	488.3	761	14.1	3.92	Neg.	Neg.	10	2.78	2	0.56	1	0.28	4.1	1.14
Dehydration Regeneration Fired Heater (H-1301)	C ^b	35	1.32	13,927	20,088	4.1	229	502	1.12	0.31		NA		NA		NA		NA		NA
Hot Oil Heater (H-4101A)	C	44	1.75	20,655	27,242	3.1	186	459	2.14	0.59		NA		NA		NA		NA		NA
Hot Oil Heater (H-4101B)	C	44	1.75	20,655	27,242	3.1	186	459	2.14	0.59		NA		NA		NA		NA		NA
Emergency Diesel Generator Package (GD-4001A)	I ^c	3.05	0.305	NA	25,200	95.8	460	733	14.56	4.04	1.69	0.47	1.19	0.33	0.26	0.072	0.26	0.072	0.32	0.089
Emergency Diesel Generator Package (GD-4001B)	I ^c	3.05	0.305	NA	16,313	62.0	471	744	13.54	3.76	1.19	0.33	1.86	0.52	0.24	0.067	0.24	0.067	0.33	0.092
Freshwater Fire Diesel Pump (PD-7601A)	I ^c	3.05	0.215 ^f	NA	7,546	57.8	466	739	6.65	1.85	0.43	0.12	1.35	0.38	0.11	0.031	0.11	0.031	0.1	0.028
Freshwater Fire Diesel Pump (PD-7601B)	I ^c	3.05	0.215	NA	7,546	57.8	466	739	6.65	1.85	0.43	0.12	1.35	0.38	0.11	0.031	0.11	0.031	0.1	0.028
Seawater Fire Diesel Pump (PD-6101)	I ^c	3.05	0.215	NA	7,546	57.8	466	739	6.65	1.85	0.43	0.12	1.35	0.38	0.11	0.031	0.11	0.031	0.1	0.028
Dry Gas Flare Stack (B-6220)	C	150	1.53	NA	NA	0.1 ^d	18	291	0.28	0.08		NA	1.45	0.40		NA		NA	0	0.00
	I ^e						46	319	2.01	0.56 ^e			10.45	2.90 ^e					101.5	28.19 ^e
Wet Gas Flare Stack (B-6210)	C	150	0.915	NA	NA	0.1 ^d	18	291	0.05	0.01		NA	0.25	0.07		NA		NA		NA
	I ^e								171	47.50 ^e			888.5	246.81 ^e		˘				
LNG Tank/Ship BOG Flare (B-3710)	C	35	0.305	NA	NA	0.1 ^d	18	291	0.01	0.003		NA	0.07	0.02		NA		NA		NA
	I ^e								10.8	3.00 ^e			56	15.56 ^e						
Diesel Storage Tank (T-5301)	C	7	0.025	NA	NA	0.1 ^d	18	291		NA		NA		NA		NA		NA	3.5	0.97

^a 2 power generators operate at the same time while the third is shutdown.

^b Unit operates 50% of the time at full duty; 50% in standby.

^c Operated for 1 hour per week for maintenance; 100 hours maximum per year.

^d Assumed velocity since flow not provided. ^e Maximum at emergency flare load.

^f Effective diameter based on two stacks with diameters of 0.152 m each.

These assumptions are conservative since lower impacts would generally be predicted if the sources were modeled at lower operating capacities and were located at their actual locations. For those sources that were assumed to operate continuously, an additional conservative assumption is made since it is unlikely that they would operate for every hour in the year.

It should be noted that most of the nitrogen oxides (NO_x) emitted from the sources is predominantly in the form of nitric oxide (NO) and nitrogen dioxide (NO₂). NO is the predominant form of NO_x emitted from combustion sources. NO is readily converted in the atmosphere to NO₂ by chemical reaction with ozone. However, a portion of NO₂ is converted to nitric acid (HNO₃) and ammonia salts. Therefore not all of the NO_x emitted remains as NO₂ in the atmosphere.

Ambient air quality guidelines and standards are defined in terms of NO₂. In this analysis, the NO_x emissions for each source were modeled. To account for the NO₂ concentrations, 75 percent of the predicted NO_x concentrations were assumed to be NO₂ concentrations. This approach is consistent with EPA modeling guidelines.

Meteorological Data

Meteorological data needed to perform air dispersion modeling consist of the following five meteorological parameters:

- Wind direction that determines the transport directions toward which the plume will travel and potentially affect receptors downwind of the PLNG Plant;
- Wind speed that determines the amount of dilution of plume concentration and height to which the plume will rise;
- Temperature that affects the height to which the plume will rise and also is used in estimating afternoon mixing heights;
- Atmospheric stability that determines the extent of plume spread or dispersion in the vertical and horizontal directions;
- Mixing height that determines the maximum vertical extent or volume of air in which the plume can disperse.

Wind direction, wind speed, and temperature can be measured directly. Atmospheric stability and mixing heights are inferred from other parameters. For instance, stability can be inferred from hourly observations of ambient temperature, total opaque sky cover and cloud ceiling height.

There is limited meteorological data collected near the Project site. Meteorological data were collected for approximately five months at the Pampa Clarita site located about 15 km to the north of the current Project site. The weather station at Pampa Clarita was relocated to the current site and has been collecting data since June 2002.

Because these meteorological data have been collected for a limited time period, modeling was performed using hourly surface meteorological data available from nearby weather stations located at airports. In general, the surface meteorological data reported at these weather stations include the necessary parameters required for modeling. The parameters reported include wind direction, wind speed, temperature, total opaque sky cover, and cloud ceiling height.

The nearest airport to the Project site that collects the necessary meteorological data is the airport in Pisco, located within about 50 km of the Project site. One year of hourly 1996 surface meteorological data were obtained which was the most recent complete data that were readily available. The meteorological data were obtained from International Surface Weather Observations, available on CDROMs that are jointly produced by the U.S. Air Force Climatology Center and the National Climatic Data Center (NCDC). These data were edited for missing values and processed in a modified version of RAMMET, a U.S. EPA preprocessor meteorological program. The RAMMET program was modified to account for the format of the data collected.

Based on a review of the Pisco data, there were no reported wind direction and wind speed values for about 40 percent of the annual observations. In this situation, the lack of wind data can be attributed to calm conditions or missing data. For these hours when wind data are not reported, the ISCST3 model does not calculate any concentration. As a result, the number of potential pollutant concentrations that can be compared to ambient air quality guidelines or standards are reduced by about 40 percent. To determine if the use of these limited data would affect the maximum concentrations predicted by the model, meteorological data were reviewed from the weather station in Lima located approximately 160 km to the north of the Project. This station also reported the

necessary data required for modeling but the meteorological data, including wind direction and wind speed, were available for more than 97 percent of the observations.

Since the meteorological data from both the Pisco and Lima stations are considered to be representative of weather conditions in the region that the Project is located, the Pisco and Lima surface meteorological data were selected for use in the modeling.

Hourly mixing heights are generally calculated from surface temperature measurements and upper-air temperature soundings using an approach developed by Holzworth (1972). Because upper-air sounding data are not available for this study, a mechanically-driven mixing height, based on the hourly wind speed, was assumed for the air modeling analysis. This procedure is described in the U.S. EPA SCREEN3 Model User's Manual (U.S. EPA, 1995). From the procedure, hourly mixing heights can be calculated as follows:

$$Z_m = (0.3 \times u^*) / f$$

Where:

Z_m = mixing height, meters;

u^* = surface frictional wind speed, m/s;

= 0.1 x wind speed measured at 10 meters; and

f = Coriolis force = $2 \times (7.20 \times 10^{-5}) \times \sin$ (station latitude, degrees).

For a latitude of 12 degrees (based on the Lima station), the value of Z_m is approximately equal to 860 times the wind speed. Because this value would produce relatively high mixing heights and not account sufficiently for the occurrence of low-level temperature inversions, Z_m was reduced by approximately a factor of three and set equal to 300 times the wind speed. The reduction of Z_m produced mixing height values that are more typical for the area and therefore produced reasonable values. In addition, mixing heights estimated with these reduced values produce conservative (higher than expected) impacts.

Receptor Locations

Concentrations were calculated at receptors located in a radial grid that had 36 lines or radials extending from the Project site out to 10,000 meters. A total of 648 receptors were used in the analysis. Receptors were located along the 36 radials spaced at 10-degree interval with a grid centered on the modeled sources. Receptors were located on each radial at distances of 100; 200; 300; 500; 600; 700; 800; 900; 1,000; 1,200; 1,500; 2,000; 3,000; 4,000; 5, 000; 6,000; 8,000; and 10,000 meters. Terrain elevations were included at each receptor location. A conservative approach was used in selecting the terrain for the receptors. First, the terrain elevations were reviewed at a given downwind distance for all directions. Then the highest terrain from among those directions was selected to represent the terrain elevation at that distance for all directions.

Building Wake Effects

The ISCST3 model includes algorithms used to estimate the effects of building wakes on effluent dispersion. The wake-effect algorithms may be applied to any stack on, or adjacent to, a building. Under moderate to strong wind speed conditions, the effluent emanating from a stack or building may not totally escape the aerodynamic wake region on the downwind edge of the building. This results in a downwash condition where the effluents are mixed into the wake region. Building shape and orientation of the building to the wind affect the dimensions of the turbulent wake and the intensity of the downwash. The stack height, building height and width, horizontal wind speed, plume exit velocity, and plume buoyancy determine which portion of the plume, if any, will remain above the wake of a structure.

The criteria used to determine whether building downwash can occur are based on EPA recommendations (EPA, 1985) for determining good engineering practice (GEP) stack height. Based on that criterion, if the stack height is less than GEP, then atmospheric downwash eddies and wakes created by nearby structures will influence the stack plume causing higher ground-level concentrations very close to the stack. In the United States, a GEP stack height has been defined as follows:

$$GEP = H + 1.5 L$$

Where:

H = height of a nearby building or structure, and

L = lesser dimension of the height or projected width of the nearby structure.

A structure is defined as nearby if its distance is:

- Less than or equal to five times the lesser of the height or maximum projected width (i.e., diagonal) of the structure; and
- Not greater than 0.8 km from the stack.

Based on information provided for this Project, the highest solid structures are the structures for the gas turbines with heights of approximately 15 meters high. Since the proposed stack heights for the gas turbine drivers, gas turbine power generators, and dehydration regeneration fired heater will be 36 meters or less, building downwash effects were considered for those sources in the modeling.

Ambient Background Concentrations

To estimate the total air quality concentrations, a background concentration must be added to the modeling results. The background concentration is considered to be the air quality concentration contributed by sources not included in the modeling evaluation.

Existing background ambient air quality monitoring data were collected at the Project site as described in Section 4 of Chapter III. The maximum 24-hour average concentrations measured at the four monitoring stations are also presented in Section 4 of Chapter III. The pollutants measured included NO₂, PM₁₀, SO₂, and CO that provided baseline data prior to the construction and operation of the Plant.

The ambient air quality data were used to estimate the 24-hour and annual average background concentrations. The highest 24-hour average concentration for each pollutant measured at the monitoring stations was used to represent the 24-hour average background concentration. The lowest concentration of the highest values measured among the monitoring stations was used to represent the

annual average background concentration. Based on this analysis, the 24-hour and annual average concentrations were used as background concentrations are as follows:

Pollutant	Background Concentration ($\mu\text{g}/\text{m}^3$)	
	24-Hour Average	Annual Average
NO ₂ ,	4	3
PM ₁₀	71	33
SO ₂	5	5
CO	390	NA

NA= not applicable

Note: 24-hour average CO concentration used for 1- and 8-hour average background concentration.

These concentrations were added to the maximum predicted for the Project to estimate total air quality concentrations. The total air quality concentrations were then compared to the World Bank Ambient Air Quality Guidelines, the Peru Air Quality Standards, and U.S. Ambient Air Quality Standards.

Air Quality Modeling Results

Maximum air quality impacts predicted for the emission sources for the Plant using 1 year of meteorological data for Pisco and Lima are summarized in Table 10. Results of the Air Dispersion Model are included in Appendix 3. A summary of the total air quality concentration of air pollutants, consisting of the overall maximum concentrations predicted due to emission sources for the Plant operations, together with the measured background concentrations, is presented in Table 11.

As shown in Table 11, the maximum NO₂, PM₁₀, SO₂, and CO concentrations predicted for the Project site comply with the 1998 World Bank Guidelines, the Peru Air Quality Standards, and U.S. Ambient Air Quality Standards. The maximum concentrations were predicted to occur generally within about 1 km to the north of the Project site.

As shown in these tables, the maximum concentrations predicted for both meteorological datasets were very similar. As a result, the following comparisons of the total air quality impacts to the ambient air quality guidelines and standards are based on using the higher concentrations predicted using either meteorological dataset.

Table 10. Maximum Pollutant Impacts Predicted for the Project Sources Using 1996 Meteorological Data from Pisco and Lima, Peru

Pollutant	Averagin g Period	Value	Maximum Predicted Concentrations (µg/m³) ^a							
			Total- All Modeled Sources	GT Drivers	GT Power Generators	Heaters	Flares	Emergency Diesel Generators	Fire Diesel Pumps	Seawater Fire Pump
Pisco Meteorological Data										
Nitrogen Dioxide (NO2) b	Annual	Highest	4.0	0.15	0.20	2.9	0.022	0.59	1.2	0.58
	24-Hour	Highest	25.8	0.77	0.78	8.1	0.07	7.4	10.9	5.4
		98th Percentile	24.2							
Particulate Matter	Annual	Highest	0.054	0.019	0.037	NM	NM	0.014	0.026	0.013
(PM10)	24-Hour	Highest	0.52	0.102	0.15	NM	NM	0.17	0.25	0.12
		98th Percentile	0.49							
Sulfur Dioxide (SO2)	Annual	Highest	0.23	NM	NM	NM	NM	0.078	0.104	0.052
	24-Hour	Highest	2.3	NM	NM	NM	NM	1.0	0.94	0.47
		98th Percentile	2.2							
Carbon Monoxide (CO)	24-Hour	Highest	5.6	0.38	0.74	NM	0.58	1.1	3.0	1.5
	8-hour	Highest	25.7	0.93	1.5	NM	1.2	5.5	13.9	7.0
	1-hour	Highest	294	4.2	4.8	NM	4.1	75.2	156	78.2
Lima Meteorological Data										
Nitrogen Dioxide (NO2) b	Annual	Highest	3.7	0.093	0.14	3.0	0.029	0.51	1.1	0.53
	24-Hour	Highest	27.6	0.69	0.57	9.3	0.14	6.6	12.0	6.0
		98th Percentile	22.1							
Particulate Matter	Annual	Highest	0.046	0.012	0.027	NM	NM	0.012	0.023	0.012
(PM10)	24-Hour	Highest	0.57	0.092	0.11	NM	NM	0.15	0.27	0.14
		98th Percentile	0.45							
Sulfur Dioxide (SO2)	Annual	Highest	0.20	NM	NM	NM	NM	0.067	0.094	0.047
	24-Hour	Highest	2.4	NM	NM	NM	NM	0.87	1.0	0.52
		98th Percentile	1.9							
Carbon Monoxide (CO)	24-Hour	Highest	6.1	0.34	0.53	NM	1.2	1.0	3.3	1.7
	8-hour	Highest	28.3	1.0	1.3	NM	2.8	5.0	15.7	7.8

NM= not modeled due to minimal emissions

^a Maximum concentrations were predicted with the USEPA ISCST3 model using one year of hourly 1996 meteorological data from Pisco and Lima.

^b Maximum NO_x concentrations were multiplied by the following ratio to account for the NO₂ portion of NO_x emissions: 0.75

^c 98th Percentile or seventh-highest concentration for 24 hour averaging period (equivalent to the 2% value or 0.02 x 365 (number of 24-hour values in a year)).

^d Intermittent sources that operate for 1 hour per week for maintenance; maximum of 100 hours per year.

For modeling purposes, the maximum hourly emissions for these sources were adjusted based on the averaging period.

For the 1-hour averaging period, no adjustment was made. For the 8-hour and 24-hour averaging periods, the sources were assumed to operate for 1 hour in those periods.

Therefore, the emissions for those periods were obtained by multiplying the hourly emissions by factors of 1 hour/8 hours and 1 hour/24 hours, respectively. Similarly, the annual average emission rate was obtained by multiplying the hourly emissions by a factor of 100 hours/8,760 hours.

Table 11. Summary of Maximum Total Air Quality Predicted for the Project Sources and Background for Comparison to Ambient Air Quality Guidelines

Pollutant	Averaging Period	Value	Maximum Predicted Concentrations (µg/m³) ^a			1998 World Bank Guidelines (µg/m³)	Peru Ambient Standards (µg/m³)	U.S. Ambient Standards (µg/m³)
			Total- All Modeled Sources	Background ^b	Total- All Sources			
Pisco Meteorological Data								
Nitrogen Dioxide (NO ₂)	Annual	Highest	4.0	3	7.0	100	NA	100
	24-Hour	Highest	25.8	4	29.8	NA	200	NA
		98th Percentile	24.2	4	28.2	150	NA	NA
Particulate Matter	Annual	Highest	0.054	33	33.1	50	NA	50
(PM ₁₀)	24-Hour	Highest	0.52	71	71.5	NA	150	150
		98th Percentile	0.49	71	71.5	150	NA	NA
Sulfur Dioxide (SO ₂)	Annual	Highest	0.23	5	5.2	80	NA	80
	24-Hour	Highest	2.3	5	7.3	NA	365	365
		98th Percentile	2.2	5	7.2	150	NA	NA
Carbon Monoxide (CO)	24-Hour	Highest	5.6	390	396	NA	30,000	NA
	8-hour	Highest	25.7	390	416	NA	NA	10,000
	1-hour	Highest	294	390	684	NA	NA	40,000
Lima Meteorological Data								
Nitrogen Dioxide (NO ₂)	Annual	Highest	3.7	3	6.7	100	NA	100
	24-Hour	Highest	27.6	4	31.6	NA	200	NA
		98th Percentile	22.1	4	26.1	150	NA	NA
Particulate Matter	Annual	Highest	0.046	33	33.0	50	NA	50
(PM ₁₀)	24-Hour	Highest	0.57	71	71.6	NA	150	150
		98th Percentile	0.45	71	71.5	150	NA	NA
Sulfur Dioxide (SO ₂)	Annual	Highest	0.20	5	5.2	80	NA	80
	24-Hour	Highest	2.4	5	7.4	NA	365	365
		98th Percentile	1.9	5	6.9	150	NA	NA
Carbon Monoxide (CO)	24-Hour	Highest	6.1	390	396	NA	30,000	NA
	8-hour	Highest	28.3	390	418	NA	NA	10,000
	1-hour	Highest	291	390	681	NA	NA	40,000

NA= not applicable

^a See previous tables that show the maximum concentrations predicted with worst-case meteorology and the one year of hourly 1996 meteorological data from Pisco and Lima.

^b Background concentrations were based concentrations measured at the Project site.

^c Second highest concentration

^d 98th Percentile or seventh-highest concentration for 24 hour averaging period (equivalent to the 2% value or 0.02 x 365 (number of 24-hour values in a year)).

Total Air Quality NO₂ Concentrations

The maximum total annual and 24-hour average NO₂ concentrations for the Project and background are respectively predicted to be:

- 7.0 µg/m³, which represents 7 percent of the annual World Bank Ambient Air Quality Guideline of 100 µg/m³; and
- 28.2 µg/m³, which represents 19 percent of the 24-hour average World Bank Ambient Air Quality Guideline of 150 µg/m³.

The maximum total air quality concentrations are also predicted to be below the Peru Air Quality Standards and U.S. Ambient Air Quality Standards that are equal to or higher than the World Bank Guidelines.

Total Air Quality PM₁₀, Concentrations

The maximum total and 24-hour average PM₁₀ concentrations for the Project and background are respectively predicted to be:

- 33.1 µg/m³, which represents 66 percent of the annual average World Bank Ambient Air Quality Guideline of 50 µg/m³; and
- 71.5 µg/m³, which represents 48 percent of the 24-hour average World Bank Ambient Air Quality Guideline of 150 µg/m³.

These total particulate impacts are due mainly to the background concentration from monitoring data. The Project contributes less than 1 µg/m³ or less than 1 percent to the total impacts. The high background concentration of particulates are associated with wind blown dust and background sources (vehicle traffic).

The maximum total air quality concentrations are also predicted to be below the Peru Air Quality Standards and U.S. Ambient Air Quality Standards that are equal to or higher than the World Bank Guidelines.

Total Air Quality SO₂ Concentrations

The maximum total annual and 24-hour average SO₂ concentrations for the Project and background are respectively predicted to be:

- 5.2 µg/m³, which represents 7 percent of the annual World Bank Ambient Air Quality Guideline of 80 µg/m³; and
- 7.2 µg/m³, which represents 5 percent of the 24-hour average World Bank Ambient Air Quality Guideline of 150 µg/m³.

Similar to the total air quality analysis for PM₁₀ concentrations, these total SO₂ impacts are due mainly to the background concentration from monitoring data. The Project contributes less than 30 and 5 percent to the total 24-hour and annual average concentrations, respectively.

The maximum total air quality concentrations are also predicted to be below the Peru Air Quality Standards and U.S. Ambient Air Quality Standards that are equal to or higher than the World Bank Guidelines.

Total Air Quality CO Concentrations

There are no World Bank ambient air guidelines for CO concentrations. The maximum total concentrations were compared to the Peru and U.S. ambient air quality standards. The maximum CO concentrations for the Project and background are predicted to be:

- 396 µg/m³, which represents 1.3 percent of the 24-hour average Peru Ambient Air Quality Standard of 30,000 µg/m³;
- 418 µg/m³, which represents 4.2 percent of the 8-hour average U.S. Ambient Air Quality Standard 10,000 µg/m³; and
- 684 µg/m³, which represents 1.7 percent of the 8-hour average U.S. Ambient Air Quality Standard 40,000 µg/m³.

These total CO impacts are due mainly to the background concentration from monitoring data. The Project contributes less than 45, 10, and 2 percent to the total 1-hour, 8-hour, and 24-hour average concentrations.

Conclusions

Based on these results, the total air quality concentrations for NO₂, SO₂, and CO are predicted to be less than 20 percent of the ambient air quality guidelines or standards. For PM₁₀, the total air quality concentrations are predicted to be less than 66 percent of the guidelines or standards. The Project sources contribute less than 1 percent to the total PM₁₀ concentrations; the majority of the total concentrations is due to the background concentrations estimated from monitoring data. Similarly, the majority of the total SO₂, and CO concentrations are also due the background concentrations; the Project sources contribute 30 percent or less to the maximum total concentrations.

As a result, the maximum total air quality concentrations due to the Project sources and background are expected to be well below and comply with the 1998 World Bank Guidelines, the Peru Air Quality Standards, and U.S. Ambient Air Quality Standards.

4.1.2 Noise

Construction Phase

Noise impacts from construction of the Project will be temporary. All construction activities will be carried out more than 6 kilometers from the nearest residences at Wakama Eco Beach or illegal dwellings at Nuevo Ayacucho Village. The construction camp located at the south end of the Project site is the only inhabited area near the source. In the early stages of the construction of the Plant and Marine portions of the Project, work performed onsite will consist entirely of grading, surveying, soil boring, and test drilling required to determine specific geophysical characteristics. Active construction will begin with site preparation work and will proceed in accordance with the project schedule. Construction activity will be continuous until completion of the Project.

Typical LNG plant construction equipment will be used, including light and heavy earth-moving equipment, large cranes, lighter mobile cranes and hoisting equipment, concrete placement

equipment, miscellaneous pumps and compressors, welding and metalworking equipment, and heavy trucks and other vehicles.

There will be some construction activities, such as grading, compaction, and pile driving that will increase instantaneous and short-term ambient sound levels significantly. Site preparation activities are relatively short in duration and could dramatically increase near ambient sound levels at the property boundary. Construction of roads and piping will produce elevated noise levels for short periods, relative to the duration of the construction of the entire plant.

The noise levels generated during the construction phase of the Plant and Marine Loading facilities are expected to be localized, intermittent, and of short-term duration. The noise level is not expected to constitute a significant adverse impact. Noise levels produced during construction may cause the limited wildlife in the area to migrate temporarily away from the Project site to areas where they will not be disturbed.

Operation Phase

Description of Sound Sources

The noise impacts associated with the operations of the Project were calculated using KBR's Plant Noise Modeling System (PNMS) combined with SoundPLAN, a commercial modeling software program. SoundPLAN is an integrated software package used to determine noise propagation of industrial facilities.

The basic plant noise model was developed and predictions made based on KBR's project and field experience with similar design/capacity equipment. The noise levels were predicted based on normally accepted levels of installed noise control, typical for facilities of this design/capacity of likely noise levels at the sensitive receptors and/or at the property boundary during normal operation of the Plant (See Appendix 3).

The modeling software utilizes the prediction methodology defined by the Engineering Equipment and Material Users Association (EEMUA) and the CONCAWE, the oil companies' European organization for environment, health and safety protection in the CONCAWE report: "The

propagations of Noise from Petroleum and Petrochemical Complexes to Neighboring Communities”, 1981.

Total and A-weighted Sound Pressure Levels (SPLs) were calculated. Short-term (15-minute Leq) background noise levels were measured for this Project during a 24-hour monitoring interval and were used in the program to calculate overall SPLs (See section 4 of Chapter III).

Equipment noise limits for the Project were based on a general requirement of 85 dB(A) @ 1 meter from equipment casings or surfaces.

Noise source levels were entered as octave band frequencies for the sound power levels of each unit or piece of equipment described below:

- Pumps and drivers
- Compressors and drivers
- Compressor suction/discharge, and recycle piping
- Air coolers
- Generators and drivers
- Fired Heaters

Valves and downstream piping were not included in the noise model. The above equipment noise levels are estimates. The review and verification of all vendor noise data will take place, as the Project proceeds and vendor data becomes available.

A background value of 40 dBA was selected as representative of the average short-term noise level during the daytime and 30dBA for nighttime around the area of the proposed PLNG Plant. The average short-term background noise level was measured for daytime and nighttime was 64 and 62 respectively at Noise Monitoring location NM-2, near the highway. These levels generally reflect higher activity of traffic on the Pan-American Highway, which was observed during the 24-hour continuous monitoring. Measured daytime background noise levels at Wakama Eco Beach and the illegal Nuevo Ayacucho Village were 53 and 58 dBA, respectively and while nighttime measurements at these locations were measured at 55 and 58, respectively.

The noise levels and octave band analysis for the PLNG Plant impact analysis are generally conservative; that is, the model calculates the noise impacts at assigned receptors assuming that all of the identified noise sources are operating above their actual octave band frequencies. Therefore, the impact results of the model may be considered worst-case scenario and are typically greater in magnitude than that measured in the field.

In the vicinity of the Project, the major noise source is the Pan-American Highway, which creates intermittent noise during its normal daytime and nighttime hours when traffic is generally heavier. Other than the highway source and wind and surf sources, there are no other continuous major noise sources in the area of the proposed Project.

Noise Impact Analysis Results

Figure 1 represents the isopleths of dBA that are predicted for the proposed Project. The isopleths are indicated in 5 dB(A) increment, starting at 40 db(A).

Table 12 present the background ambient noise level measured in the vicinity of the site and Figure 2 present the location of nearest receptors located at 6 kilometers south of the Project site and east of the Panamerican Highway at the illegal Nuevo Ayacucho Village and west of the highway Wakama Eco Beach.

The predicted sound level impacts at the Property boundary as shown on Table 12, indicate that the noise levels resulting from the normal operation of the Plant do not exceed the World Bank Noise Guidelines of 70 dB(A) (day and night) for industrial land-use categories or 55 dB(A) (day)/ 45 dB(A) (night) for residential, institutional and educational categories.

The predicted sound level impacts for the permanent community range from less than 40 dB(A) and in compliance with the World Bank Guidelines for residential receptors.

The predicted sound levels resulting from normal PLNG Plant operations at the illegal Nuevo Ayacucho Village and Wakama Eco Beach site are 37 and 24 dB(A) which are considerably lower than the background noise measured .

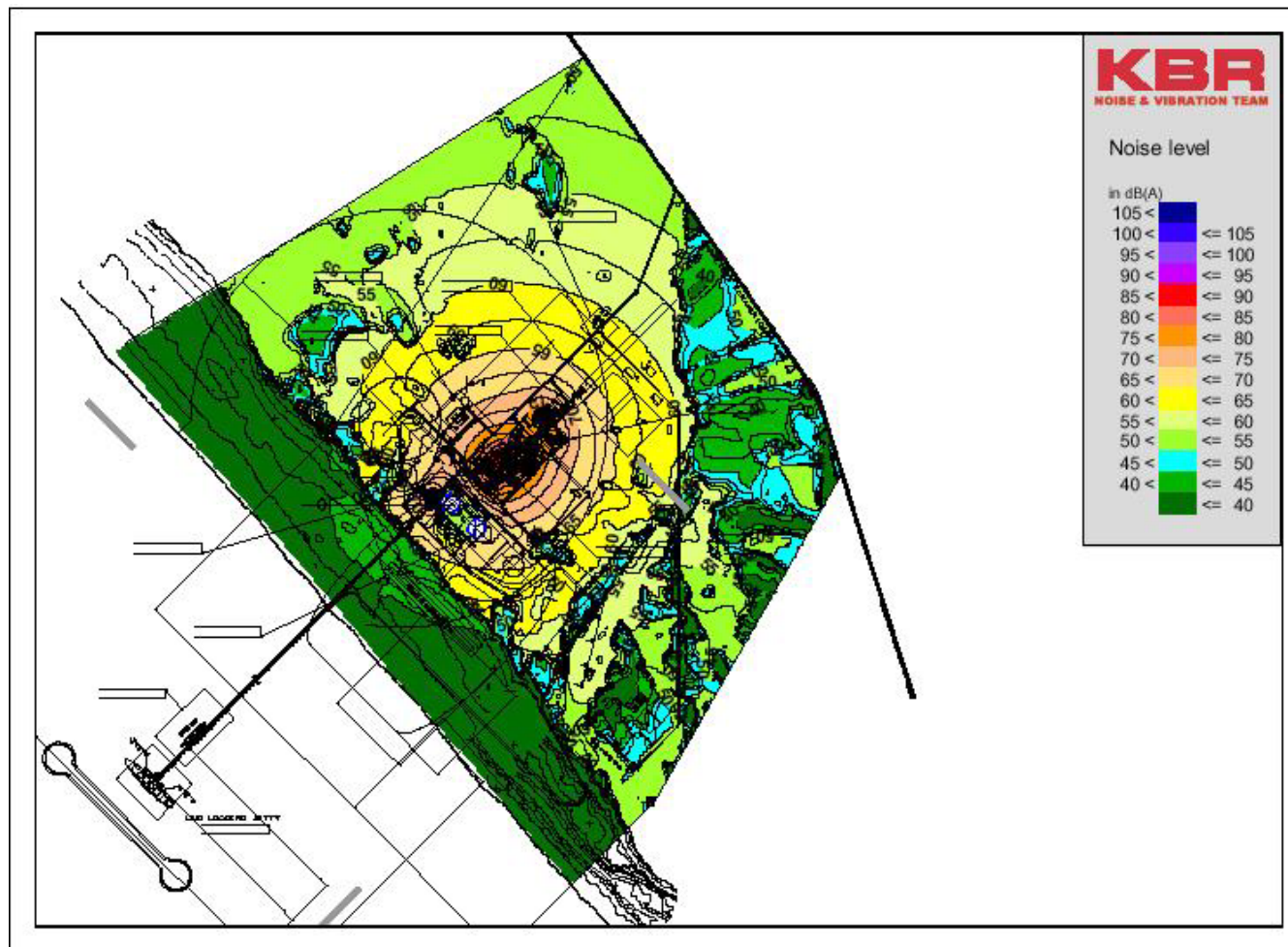


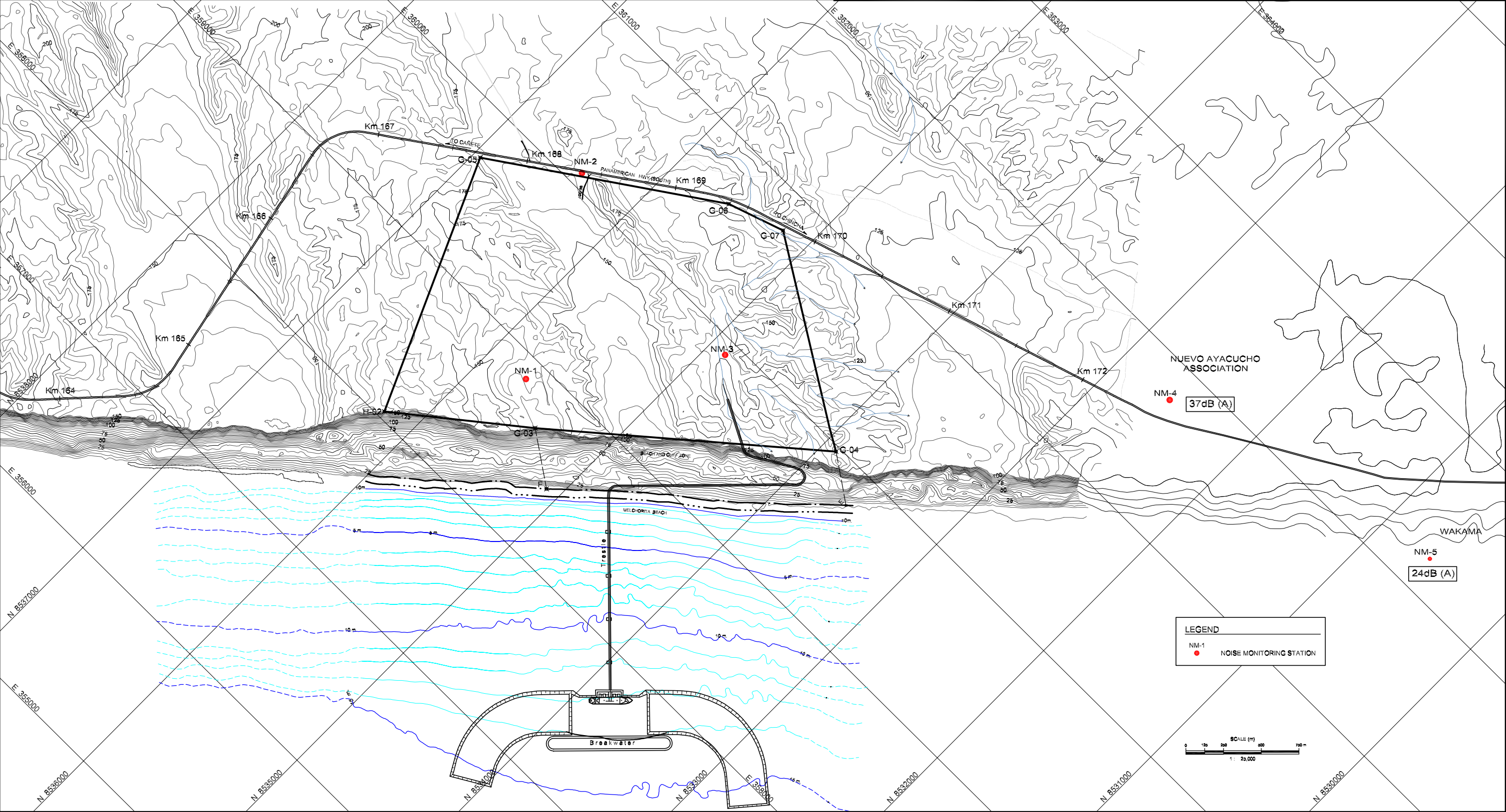
Figure 1 Isopleths of dB(A) Predicted for the PLNG Plant Area, Pampa Melchorita

**Table 12 Predicted Noise Levels and Measured Ambient Noise Levels at Receptors for Night Time
(22:00-7:00)**

Location		Coordinates (Meters)		Predicted Noise Levels dB(A)	Measured Ambient Noise Levels dB(A)	Description
		East	North			
In-Plant	NM1	358862	8535703	57.1	30.6	Northwest from Meteorological Station at Pampa Melchorita
	NM2	360092	8536401	53.6	62.3	Northeast From Meteorological Station at Pampa Melchorita. East border of Panamerican Highway
	NM3	359905	8534879	60.7	29.8	Southeast from Meteorological Station at Pampa Melchorita
Residential	NM4	361768	8532578	36.5	52.8	At K172+500 m on Panamerican Hwy near to North end of "Nuevo Ayacucho" settlement.
	NM5	362235	8530613	25.4	58.4	At North end of Wakama housing resort

PERU LNG S.R.L.
LNG EXPORT PROJECT
LOCATION OF NOISE MEASUREMENT STATIONS
AND RECEPTORS

FIGURE 2



Aug 01, 2003 - 8:22pm
Por: William Ynga
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Date JULY 2003
Project 029-4217

Golder Associates

Drawn J.W.Y.V.
Rev. R.L.

4.1.3 Soils and Landforms

Construction Phase

The most significant impact during the construction of the PLNG Plant is related to the alteration of the landforms from activities related to site preparation during the construction of the land based infrastructures such as: tank area, process area, internal accesses roadways, permanent buildings and temporary laydown areas. The PLNG Plant will be constructed on a greenfield of 521 hectares, which is currently composed of sand dunes and gently rolling hills, which are typical characteristics of the Peruvian coastal desert (see Section 2, Chapter III). The modification of landforms will result from an estimated material that will be removed (cut material) of 6,250,000 m³ and the structural fill that will be utilized in cut areas beneath foundations and bases of the new structures. The estimated structural fill (fill material) utilized will be 1,155,000 m³. The earthwork activity will be carried out within the first one and one-half years of the construction period.

The alteration of the physical and chemical quality of the soil by accidental hydrocarbon spills during the construction (machinery, equipment and motor vehicles) is estimated as a slightly significant impact since during the maintenance, on-site repair and fueling activities appropriate control and handling measures will be applied for counteracting these types of incidents.

Operation Phase

The impacts during the operation of the PLNG plant are related to the potential changes on the coastline morphology as a result of altered sediment transport caused by the construction of the breakwater that will be constructed 1.3 kilometers from the beach on the isobath of 14 meters depth. This breakwater structure has been designed to reduce or eliminate the wave action during the LNG loading. The breakwater structure may result in the alteration of sediment transport that may have the potential to gradually lead to changes in the beach morphology in the area of influence north and south of the trestle.

The alteration of the physical and chemical quality of the soil by accidental hydrocarbon spills or other process-related substances during the operation of the Plant is estimated as a slightly negative impact. In the Plant, all the process areas will be connected to an API/CPI separator system and, the

LNG Storage Tanks will have a secondary containment structure with capacity for containing up to 110 % of the volume of the largest tank stored in the containment system.

Earthquake Hazard

The Project site is located in a seismically active region of Peru and may be subjected to moderate to severe earthquakes during the life of the Project. The Project site lies in a high seismic zone within a Modified Mercalli (MM) scale of X to XI, which is equivalent to a level 8.0 on a Richter scale. This zone is considered a major seismic risk with potential for major damage and thus would require that the project structures and equipment be designed and built to Unified Building Code (UBC) Zone 4 criteria, vol. 2, Chapter 16, Division IV (Earthquake Design). LNG structures and systems shall be designed to a higher standard to resist earthquake forces in accordance with NFPA 59A. LNG Storage Tanks have been designed in accordance with API 620 and their anchorage with Appendix E of API 650 Zone 4 and Appendix L of API 620.

Tsunami/Flood Hazards

Because the site is located in an arid area of Peru, no impacts from flooding are anticipated. The Project site will be designed to provide adequate stormwater protection and will be sloped and graded as necessary for effective drainage. Other climatic events such as snow, hail or cyclones activity in the area are rare.

The PLNG Plant and the LNG Storage Tanks are located at an elevation of 135 and 127 meters above sea level (masl), respectively and are sufficiently elevated to withstand a tsunami. The trestle will be designed to withstand the force of a tsunami wave and associated currents.

4.1.4 Water Resources

Construction Phase

During the construction phase, water will be used for dust control, soil compacting and concrete mix. Water required for these activities will be extracted mainly from the lower part of the Cañete River, while the desalination plant that will supply water required for the PLNG Plant operation is being

constructed. It is estimated that the water volume that will be extracted daily from the Cañete River during the first year of construction will be approximately 200 m³, which will be transported by tank trucks to the Project site.

The water volume required for the hydrostatic tests will be supplied by the desalination plant and will be re-used to complete all the necessary hydrostatic tests. The maximum water volume required for testing of one of the tanks is 64,900 m³.

The impact on the water quantity is considered slightly negative because the water volume required for the construction that will be extracted from the lower reaches of the Cañete River; but, it will not compete with other uses of the resource in the area, and will not affect the seasonal variations of flows in the river or the eco-system conditions during these lower periods.

The marine construction activities will produce a temporary increase in the turbidity of the seawater. The degree of re-suspension of the material in the water (turbidity plume) is related to several factors such as sediment characteristics (type of material and size), oceanographic characteristics (sea currents, mainly) prevailing during the execution of the marine activities and the type of construction and methods used (see Chapter III, Section 2). The turbidity plume can adversely affect the marine species and habitats causing a reduction of light and obstructing the respiratory mechanisms of the marine species. The effects of the turbidity plume analyzed according to the above referenced factors, indicate that the impact can vary from a negative to slightly negative. This takes into consideration that the oceanographic characteristics in the area have a seasonal variation and the species and habitats of the study area have some level of tolerance to the increase of suspension materials and to the light reduction and their ability to migrate to avoid temporary increases in turbidity. The proposed dredging of the navigation channel, followed by the construction of the breakwater are considered to be the activities generating the type of impact defined above.

The alteration of the physical and chemical quality of the water by accidental hydrocarbon spills (fuel, grease and oils) or other substances from work barges and ships, equipment and machinery used during the marine construction activities are considered as a slightly negative impact. All possible precautions will be taken during the construction of the Project to avoid hydrocarbon spills. The potential for a spill will be minimized by using trained fuel handling personnel, establishing spill

prevention procedures and maintaining spill cleanup equipment in accordance with the contingency plan.

Operation Phase

All of the water required for the operation of the plant and for providing for the needs of staff and other personnel will be processed from raw seawater. Seawater will serve as the only source of water for the PLNG Plant. A Reverse Osmosis (RO) Unit will produce fresh service quality water for storage. This service water will be used for the Drinking Water System, Demineralizer Water System, Service Water and Firewater. The primary source of firewater for the PLNG Plant will be service water with seawater available as a back-up.

Water will be supplied to the desalination plant by two water pumps, each having an average rate of 80 m³/hour. The water requirements for the operation are described in Chapter II; the total demand of water for the operation will be 30 m³/hour (5 m³/hour for drinking water, 6 m³/hour for demineralized water for the process, 12 m³/hour for drinking water for the employee camp, and 7 m³/hour for diverse uses).

The fire-fighting system of the PLNG Plant can supply 5,819 m³ of water, which will be produced in the desalination plant (this volume will be stored in a surface tank). It is estimated that this volume will supply the system for 4 hours and then will additionally have a back-up seawater source designed for supplying 900 m³/hour.

The impact on the water quantity required for the operation is considered as non-significant, since the water volumes required will be extracted from the sea and will not compete with other uses of the resource in the area, and also will not be a detriment to the resource supply.

The impacts related to the management of surface drainage and discharge of effluents from the PLNG Plant during the operation phase are considered as slightly negative; however, the magnitude of the effect will be reduced in a short-term when all the systems designed for its management and treatment are completely stabilized and the monitoring of the effluent discharge parameters for ensuring the compliance with both Peruvian and international discharge standards are implemented in order to establish adequate controls.

The environmental management and treatment systems that will be utilized during the operation of the PLNG Plant are described in general terms below:

Industrial and Domestic Wastewater Discharges

During operation, the Project will generate the following streams of industrial and domestic wastewater discharges from the plant, and equipment:

- Dehydrator condensate;
- Desalination Unit effluent;
- Laboratory wastewater;
- Drainage from specific process drains, sumps, and curbed areas; and
- Sanitary effluent.

A potential impact to the water environment is the discharge of contaminated water to the sea. However, the Project has been designed to include the following treatment systems for residual waters prior to discharge:

- An API oil/water separator for surface water runoff contaminated with oil and grease,
- An CPI separator for hydrocarbon liquids from processes,
- A slop oil storage tank to hold waste oils until they are removed to offsite recycle or disposal, and
- Sanitary sewage treatment units will be used to treat sanitary waste from the permanent employee camp, and to treat sewage from plant facilities.

Waste streams from the desalination unit consist of concentrated brine (less than 50 m³/hr), and filter backwash from the desalination unit (intermittent flow). All other continuous waste streams are discharged to sea after treatment through the CPI and API separator.

Water collected from the process areas and utility areas will be routed to the API oil/water separator. Oil effluent from the oil/water separator is then routed to the CPI separator and then to a slop oil tank.

The slop oil stored in the tank is then trucked to the plant incinerator or for offsite disposal at an approved recycle/disposal facility.

Sanitary waste collected at the employee camp and at the PLNG Plant facility will be treated in a sewage treatment plant and the treated effluent will be used for site irrigation. The treated sanitary sewage from the PLNG Plant and permanent camp has a design capacity of 30 and 50 m³/day, respectively.

PLNG Plant effluent will be monitored to ensure compliance with the World Bank Guidelines for Liquid Effluents for Process Wastewater, Domestic Sewage and Contaminated Stormwater Discharge to Surface Waters and the Peruvian effluent limits for those parameters applicable to this type of industry.

4.2 Biological Environment

4.2.1 Terrestrial and Marine Flora and Fauna

Construction Phase

The PLNG Plant will occupy approximately 521 hectares of land, of which approximately half of the site area will be used for infrastructure and roadways. The vegetation present at the site consists predominantly of *Tillandsia latifolia* with an approximate coverage of 2,500 m² on the total area of the plant of 521 hectares (less than one-half of one percent of the plant area). Tillandsias (a bromeliad species), is an endemic air plant that grows on the ground in sandy soils. A portion of this vegetation lies within the location of the proposed construction of the access roads, process units and administrative offices for the Plant, and will be removed where necessary to a nursery area for storage and re-planting until construction completion. This impact is considered as slightly negative.

Though no formally designated marine critical habitats exist near the Project site, and the benthic survey revealed no seagrass communities, nor significant sensitive communities in the proposed trestle/breakwater area, there are benthic and planktonic communities offshore of the Project site. Some of these communities will be lost through displacement by the LNG trestle, breakwater and mooring structures, and from the associated obstruction of light to the benthic communities. Other

disturbances and impacts may occur from sediments suspended during construction of the trestle, navigational channel, and; breakwater and mooring structures.

The effects of substrate removal, loss of area, and turbidity increase are considered as highly negative which will result in a temporary decrease of fisheries in the construction area and a migration to areas outside the area of disturbance. However, these impacts will occur during a short-term (during the construction phase) and will be subsequently replaced by the re-establishment of new benthic and planktonic communities that will adapt to the new habitat conditions (during the operation phase). This re-establishment of new communities is considered a positive impact, in that the new habitat conditions formed will provide opportunistic species that are of interest to the local fisherman with favorable conditions.

Table 13 presents a list of the dominant benthic and planktonic species identified during the analysis of the communities in the intertidal and subtidal zones located in the direct area of influence during the construction of the project (see Chapter III, section 3). Table 14 presents a list of typical fish catches in the direct area of influence.

Table 13. Dominant Benthic and Planktonic Species Determined in the Study Area

Species of the Inter-tidal Zone	
Mollusca	<i>Donax marincovichii</i>
Polichaeta	<i>Glycera sp.</i>
	<i>Hemipodus triannulatus</i>
Crustacea	<i>Excirollana braziliensis</i>
	<i>Emerita analoga</i>
Species of the Sub-tidal Zone	
Anthozoa	<i>Actina</i>
Turbellaria	<i>Turbellario</i>
Mollusca	<i>Nassarius gayi</i>
	<i>Xanthochorus buxea</i>
	<i>Sinum cymba</i>
	<i>Donax marincovichii</i>
	<i>Semmimitylus algosus</i>
	<i>Mulinia edulis</i>
Polichaeta	<i>Magelona</i>
	<i>Diopatra rhizoicola</i>

Species of the Inter-tidal Zone	
	<i>Pherusa sp</i>
	<i>Syllis sp</i>
	<i>Cossura sp</i>
	<i>Nereis sp</i>
	<i>Nephtys ferruginea</i>
	<i>Parandalia fauveli</i>
Crustacea	<i>Isocheles pacificus</i>
	<i>Cumacea sp</i>
Asteroidea	<i>Ophiuroidea</i>

Table 14 Typical Fish Species Captured in the Study Area

Common Name	Scientific Name
Cachema or Ayanque	<i>Cynoscion anales</i>
Chita	<i>Anisotremus scapularis</i>
Curaca or Babunco	<i>Doydixodon laevifrons</i>
Guitarra	<i>Rhinobatos planiceps</i>
Jerguilla or Samba	<i>Aplodactylus punctatus</i>
Lenguado	<i>Paralichthys adspersus</i>
Lisa	<i>Mugil cephalus</i>
Lorna	<i>Sciaena deliciosa</i>
Bobo or Mismis	<i>Menticirrhus ophicephalus</i>
Mojarrilla	<i>Stellifer minor</i>
Pampanito	<i>Peprilus medius</i>
Pastelillo	<i>Psammobatis brevicaudatus</i>
Pejerrey	<i>Odonthesthes regia regia</i>
Raya	<i>Myliobatis peruvianus</i>
Tramboyó	<i>Labrisomus sp.</i>
Tollo	<i>Mustelus spp.</i>
Zorro	<i>Albula culpes</i>

Several species of marine fauna (birds, mammals and reptiles) have been seen at the project site. These species are included in conservation ranking established in the Peruvian regulations and in

international conservation agreements (See Table 15). These species identified in the conservation lists do not feed or nest in the project areas however, the project site and its surroundings provide a temporary migratory route to these species. These species are all capable of relocating to other areas once the site preparation activities commence. The impacts on these species are considered slightly negative.

Table 15 presents the conservation ranking list of rare, vulnerable and protected marine fauna species established in the Supreme Decree 013-99-AG of Peru and by international agreements: Convention of Migratory Species of Wild Animals (CMS) and Convention of International Trade of Endangered Species of Wild Fauna and Flora (CITES).

Table 15 Species of Marine Fauna and Conservation Ranking

Scientific Name	Common Name	Peru	International
BIRDS			
<i>Phalacrocorax buoganvillii</i>	Guanay	Vulnerable	
<i>Sula variegata</i>	Piquero	Vulnerable	
<i>Pelecanus thagus</i>	Pelicano	Vulnerable	
<i>Pandion haliaetus</i>	Águila pescadora		CMS app II
<i>Heamatopus palliates</i>	Ostrero común	Rare	
<i>Larus dominicanus</i>	Gaviota dominicana	Vulnerable	
MAMMALS			
<i>Otaria flavescens</i>	Lobo chusco	Vulnerable	CMS appendix II
<i>Lontra felina</i>	Gato marino, Nutria (1)	Endangered	CMS app. I; CITES app I
<i>Tursiops truncates</i>	Bufo	Protected (3)	
<i>Delphinus sp.</i>	Delfín nariz de botella	Protected (3)	
<i>Phocoena spinipinnis</i>	Marsopa espinosa	Protected (3)	
REPTILES			
<i>Chelonia mydas</i>	Tortuga verde (1,2)	Vulnerable	CMS app. I; CITES app I
<i>Dermochelys coriacea</i>	Tortuga dorso de cuero (2)	Vulnerable	CMS app. I; CITES app I

Notes: (1) Specie registered by references or direct surveys with fisherman
(2) Specie registered by remains observed during field work
(3) Law 26585 (4/9/1996)

Operation Phase

During the operation phase, the most significant impacts of the marine ecosystem are the new substratum conditions, established around the trestle, breakwater and the navigation channel and its re-colonization by an opportunistic biota adapted to the new conditions. This impact, previously mentioned, is considered a positive impact since it will provide for new fish habitats and hatcheries for species of interest to the local fishing community.

During the life of the Project, the navigational channel may require maintenance dredging. The impacts associated with the routine maintenance will be infrequent in of short-duration.

The changes in the structure and the composition of the benthic and planktonic communities caused by a new substratum will effect the type and quantity of fish caught in the littoral zone. The species of fishes typically caught in the zone will present a change in their structure and composition. This impact to the modification of the substratum is considered as positive impact since the type of fish caught attracted to this new habitat includes species having a greater commercial interest to the local fishing community (see list of fishes in Table 14).

Other improbable impacts considered as moderately negative during the operation phase are, the alteration of physical and chemical quality of the seawater related with accidental releases of non controlled substances during either the plant operations or accidental releases of hydrocarbons during loading operations. These potential impacts will not appear during the operation stage of the project, with the implementation of designed control measures for drainages, effluents and spills at the PLNG Plant and at the loading and unloading operations.

4.3 Social, Economical and Cultural Environment

4.3.1 Social

Construction

Alteration in the Demographic Composition (Induced Migration)

During the baseline studies, Golder observed that areas close to the Project site exhibited a pattern of population invasion (induced migration) characterized by the proliferation of sub-standard settlements on properties belonging to the Ministry of Agriculture (due to the proposed Plantanal Irrigation Project). This population invasion is caused by the migration of individuals and families from coastal and mountain regions of the country in pursuit of property and employment. The main characteristic of these settlements is that very few people live on these properties. The invaders usually install small shelters on these properties, not to inhabit, but to lay claim to the land and a small group of people guard the “invasion” in areas close to the Panamerican Highway. The groups of people in charge of guarding the “invasion” work in shifts to accomplish the task. There is some evidence that these settlers have been organized by land speculators who are hoping to capitalize on any eventual development in the zone by forcing any prospective developer to relocate them or to buy their property.

The commencement of the construction of the Project will likely increase the migration of people looking for employment and will likely accelerate the invasion of lands in the vicinity of the project area. This type of impact is considered as moderately negative during the construction phase.

Alteration of the Local Customs

The arrival of people, with different customs, from other regions of the country will interact with the local communities near the project site and may alter the pre-established local customs and social relations system. This construction phase impact is considered as moderately negative, during the initial construction phase. The inter-relation impacts will decrease as soon as the non-local labor is housed in the employee camp installed on the plant property. The construction of the pioneer camp

will occur almost immediately virtually eliminating any interaction with the local community. Once the camp is installed the impact will be considered as slightly negative. The frequency of interaction between the foreign and the local population will be more frequent initially when the construction begins and will diminish as the construction of the project starts to end, at which time the interactions between the local community and construction personnel will cease.

Nuisances to the Population

The terrestrial and maritime transportation of equipment, machinery and supplies to the project site will create temporary nuisances to the population. The terrestrial route that will be mainly used during the construction phase will be the Panamerican Highway from Pisco (San Martin Port) to Melchorita. This route, which already has a high volume of vehicle traffic traveling from the southern region of the country, crosses the western edge of the city of Chincha creating a slight impact from the additional transportation of equipment, materials and personnel and the potential increase of accidents. Control measures will be implemented to minimize the impacts associated with these activities.

The maritime routes related to this impact are the transportation of materials by sea to the ports of San Martin or Callao and the transportation, and installation of materials for the breakwater. A portion of these routes may be in areas traditionally used by artisanal fishermen, which will increase the risk of collisions and the potential destruction of their fishing nets. Control measures will be implemented to reduce this effect to a minimal level. One of the measures is to inform the fishing community about the schedules of maneuvers and transit by seaway. This construction impact is considered as slightly negative.

Interruption and Deterioration of the Road Infrastructure

The interruption of the normal traffic patterns during the construction of the project will be caused by transporting oversize and large heavy equipment and machinery exceeding the current weight limits of the road bridges (see Chapter II). To accommodate these loads, the bridges will be reinforced or modified if it is necessary as a result of the study to be submitted to and approved by Ministry of Transportation and Communication. This construction impact is considered as moderately negative and temporary.

Access Restriction to Fishing Zones

During the construction of the marine facilities, access to a limited portion of the beach will be restricted. The access is restricted to protect the fishermen population and casual passers-by from the hazards related to the construction of a project of this magnitude. The access and transit restriction of a limited portion of the traditional fishing zone to artisanal fishermen in Playa Melchorita is considered to be moderately negative impact.

Operation

Access Restriction to the Fishing Zone

The access through the plant and its marine installations during the operation phase will be restricted because of risk management concerns to the operation of the Plant and its installations and the safety of any personnel (fishermen, passersby and workers) in the area. Two alternative access routes will be provided to the fishermen, in a way that they can have access to the shoreline on the north and south side of the plant. If the fishermen decide to transit the area, they will require more time to travel around the boundaries of the new plant. Restricted access to a limited portion of the historical fishing area of artisanal fishermen in Playa Melchorita is considered as moderately negative impact during the operation phase for the exclusion to a small group of approximately 40 - 50 artisanal fishermen from a small portion (1.5 km) of their usual fishing areas that extend for more than 50 kilometers.

Fishermen in boats will have a short detour around the trestle and loading terminal.

4.3.2 Economic

Construction

The proposed Project will result in a capital investment of the PLNG Facility of \$969 MM U.S. and a \$865 MM U.S. investment will be made for the development of the Camisea Gas Fields and the expansion of the gas pipeline for a total capital investment in Peru of approximately \$1,834 MM U.S. The local component of this investment is \$736 MM US and will result in an

increase in the Gross Domestic Product (GDP) of Peru by an estimated 0.5% per year during the construction phase from 2004 to 2007. For the all of the reasons mentioned, the effects of the construction phase are considered as highly positive.

Increase in the Tax Revenue and Fees

At regional and national level, the importing of equipment and materials for the construction of the plant will also represent an increase of the tax collection by customs. The impact from an increase in income tax revenues and royalties to the corresponding region associated with the Project will be highly positive, and it will affect regional and national levels.

Increase of the Demand of Goods and Services

At the national level, benefits will be derived from the development of the LNG Export Project, the development of the Camisea Gas Field and the expansion of the gas pipeline. The Project will cause a general increase in business activity, which will affect local, regional and national economies in a positive manner. The production and sale of LNG provides a diversification of industry beyond the traditional agriculture and agro-businesses in the area, as well as increasing the potential of developing complimentary industries in other sectors of the regional and national economy.

The construction phase of the Project will generate an increase in the demand for goods and services directly and indirectly associated with the project. This increase in demand will enhance the local economy by the production of goods and supplies of construction materials, local support services (hotels, restaurants, transportation, stores, warehouses) and an increase in trade among the districts. The Project will require a high standard of goods and services and therefore this demand will result in an increase in the quality and the supply of some goods and services offered locally. For the all of the reasons mentioned above, the effect on goods and services of the construction phase is considered as highly positive.

Job Creation

Considering the limited availability of jobs at the local level, the construction of the plant provides a new source of employment, that could increase per capita income in the local area of influence, and

could result in an indirect benefit to traditional sectors such as the local fishing and agriculture by the increased demand of these goods. The creation of new employment opportunities will allow an influx of capital to areas that have been traditionally lacking of funds to meet the basic necessities. Such increases in employment may likely lead to the improvement of social conditions such as housing, health, education, etc.

The construction of the Project will require skilled as well as semiskilled laborers and a certain level of training to meet the requirements of the construction activities that will assist in raising the level of skills of the local community. Training provided to employees hired or contracted during the construction of the Project will provide useful skills that can be applied to other industries and/or similar projects.

This impact is significant considering the fact that in the 1993 census, construction and factory workers represented 8.73% of the Gainfully Occupied Population (GOP) of Cañete, while the mid-level technicians were 3.13% and the unskilled workers represented the 33.88% of the GOP of Cañete. In Chinchipe, construction and factory workers represented 10.8% of the GOP of the province, mid-level technicians represented 3.86% and the unskilled workers represented the 21.1% of the GOP of Chinchipe. The construction of the plant will provide the opportunity for the local labor force to obtain better training levels and work specialization, which may result in improved marketable skills.

The various construction activities will provide employment to a variety of workers throughout the 3 and one-half year- construction period. The direct on-site labor demand is estimated at 120 workers for the first year, 1,324 workers for the second year, 2,670 workers for the third year and 670 workers for part of the fourth year.

The Peruvian Association of Construction – “Cámara Peruana de la Construcción” (CAPECO) estimates that construction activity generates at least 5 indirect jobs for each direct job position. Therefore, the induced jobs derived from the construction of the plant can be estimated as follows: 600 works for the first year, 6,620 for the second year, 13,350 for the third year and 3,350 for part of the fourth year. In June, the consulting firm, Macroconsult, completed a separately commissioned study entitled "Impacto Economico del Proyecto de Exportacion de Gas Natural Licuado de Camisea" in which they estimated that the Project (gasfield, pipeline, and LNG plant) would imply the creation of an average 35,000 direct and indirect jobs in Peru for each year during the period 2004 to 2007. A

portion of these jobs will be from the local area. It is estimated that the impact on the area of influence from locally hired workers and services during the construction phase will exceed \$6MM.

The temporary increase in employment in the area both directly and indirectly (induced) during the construction phase will result in a labor demand approximately equivalent to 30 % of the GOP of San Vicente de Canete (estimated at 50,048 in 1993) or approximately 50% of the GOP of Chinchá (estimated at 39,451 in 1993). For the all of the reasons mentioned above, the effect of job creation during the construction phase is considered as highly positive.

Alteration of the Income Derived from Artisanal Fishing

The decrease of a limited area of available coastline might imply a reduction in the size of the fish catch available for sale, and potentially reduce the income derived from fishing. However, with the mitigation measures proposed consisting of providing access to the beach at the north and south ends of the plant property and transportation around the Plant at designated hours, the time required for traveling to the fishing areas near the Plant will not reduce the available fishing time for the local fisherman. For this reason, this impact is considered as a moderately negative for the forty or so fishermen who have transited the property in the last year.

Operations

The impact of the Project to the Peruvian economy, considering investment, value of production and other related investments, is \$4,900 MM (present value) U.S. for the period 2004 to 2026. The production of LNG for export will allow Peru to become a net exporter of energy. The export project will generate an annual production of 6,700 million cubic meters of gas. It is estimated that this production can be maintained during a 20-year period and therefore tax revenues and royalties associated with the Project will continue during the same period of time. For the all of the reasons mentioned, the effects of the operation phase is considered as highly positive.

Increase in the Tax Revenue and Fees

The operation of the plant will provide an increase in tax revenues that the local government of San Vicente de Cañete will receive through taxes that will be paid by PLNG as proprietor of the Plant and

its facilities. San Vicente de Cañete is a district that receives tax revenue and Funds of Municipal Compensation (Fondos de Compensación Municipal) and thus, their revenues depend on the property taxes, contributions and other municipal taxes collected, which at present are not significant. Currently Cañete's largest source of revenue is derived from the sale of beach lots to private development companies. It is estimated that the annual tax bill (impuesto predial) related to the plant site will be in excess of \$26M per year. The revenue will consist of permit fees and property taxes. This effect is considered highly positive since the construction of the plant will increase the revenues that the local government of San Vicente de Cañete will obtain.

Increase of the Demand of Goods and Services

The operation phase of the Project will generate an increase in the demand for goods and services directly and indirectly associated with the project. This increase in demand will enhance the local economy by the production of goods and supplies, local support services (hotels, restaurants, transportation, stores, warehouses) and an increase in trade among the districts. The Project will require a high standard of goods and services and therefore this demand will result in an increase in the quality and the supply of some goods and services offered locally. For the all of the reasons mentioned above, the effect on goods and services of the operation phase is considered as highly positive.

Job Creation

The Macroconsult study June 2003 "Impacto Economico del Proyecto de Exportacion de Gas Natural Licuado de Camisea" estimated 3,000 direct and indirect jobs within the local area during the period of plant operation phase from 2007 to 2026. During the operation phase, it is estimated that approximately 75 permanent jobs drawn from the local area will be needed for facility requirements. It is estimated that the economic impact on the area of influence from these locally hired workers during the operation phase will exceed \$125M per year. For the all of the reasons mentioned above, the effect of job creation during operation phase is considered as highly positive.

Alteration of the Income Derived from Artisanal Fishing

The decreased available coastline might imply a reduction in the size of the fish catch available for sale, and potentially reduce the income derived from fishing. However, with the mitigation measures proposed consisting of providing access to the beach at the north and south ends of the plant property and transportation around the Plant at designated hours, the time required for traveling to the fishing areas near the Plant will not reduce the available fishing time for the local fisherman. For this reason, this impact is considered as a moderately negative for the forty or so fishermen who have transited the property in the last year.

The construction of the marine terminal facilities and breakwater will serve to create a natural breeding ground for fish and other marine life in a manner similar to an artificial reef. As a result, the fish takes for the artisanal fishermen will ultimately be impacted positively. This impact will be moderately positive.

4.3.3 Cultural

Alteration or Destruction of the Archaeological Heritage

During the preparation of the baseline studies, detailed and extensive archaeological surveys of the 521 hectares that will be occupied by the Project and its facilities was performed. The results of this survey show that the possibilities of finding archaeological resources in the areas where earthworks will be performed are very low and thus, no impact will be produced. However, proper precautions will be taken during the earthwork in case unexpected archaeological elements are found in the subsoil.

5.0 REFERENCES

5.1 Air

- (1) AUER, A.H., 1978. Correlation of Land Use and Cover with Meteorological Anomalies. Journal of Applied Meteorology, Vol. 17.
- (2) HOLZWORTH, G.C., 1972. Mixing Heights, Wind Speeds and Potential for Urban Air Pollution Throughout the Contiguous United States. U.S. EPA Pub. No. AP-101.
- (3) U.S. ENVIRONMENTAL PROTECTION AGENCY, 2002. Industrial Source Complex Short-Term (ISCST3) Dispersion Model, Version 02035. Available on U.S. EPA's Support Center for Regulatory Air Models (SCRAM), Technology Transfer Network (TTN) Internet Site. User's Guide for the Industrial Source Complex (ISC3) Dispersion Models, Volumes 1 and 2. EPA Report Nos. EPA-454/B-95-003a and -300b.
- (4) U.S. ENVIRONMENTAL PROTECTION AGENCY, 2001. Guideline on Air Quality Models (Revised). Appendix W, 40 Code of Federal Regulations (CFR) Part 51.
- (5) U.S. ENVIRONMENTAL PROTECTION AGENCY, 1995. Screening Procedures for Estimating the Air Quality Impact of Stationary Sources, Revised. Update to SCREEN3 Model User's Manual, 1995. EPA Report No. EPA-454/R-92-019.
- (6) U.S. ENVIRONMENTAL PROTECTION AGENCY, 1985. Final Stack Height Regulation. Federal Register, Volume 50. Page 27892. July 8.
- (7) WORLD BANK, 1999. Pollution, Prevention, and Abatement Handbook, Toward a Cleaner Production.

5.2 Impact Assessment and Project Information

- (8) CONCAWE, 19981. The propagation of Noise From Petroleum and Petrochemical Complexes to Netghboring Communities Report 4/81.
- (9) DEPARTMENT OF THE ARMY CORPS OF ENGINEERS, 1983. Dredging and Dredged Material Disposal. Engineer Manual EM 1110-2-5025.
- (10) International Finance Corporation IFC, 1998. Gas Terminal Systems Guideline.
- (11) INTERNATIONAL FINANCE CORPORATION IFC, 1998. Port and Harbor Facilities Guidelines.
- (12) KBR. 2002. Front End Engineering Design (FEED) Consequence Analysis Report Document 6825-00-MZI-3D.
- (13) KBR. 2002. Front End Engineering Design (FEED) Consequence Analysis Report – Thermal Radiation Document 6825-00-MZI-4D.
- (14) KBR. 2002. Front End Engineering Design (FEED) Plant Emission and Discharges Document 6825-71-EV23-EV33-EV43-001.
- (15) MINISTERIAL MEETING OF THE OSPAR COMMISSION, 1998. Guidelines for the Management of Dredged Material Number: 1998-20. OSPAR Convention for the Protection of the Marine Environment of the North-East Atlantic.
- (16) MINISTERIO DE ENERGIA Y MINAS REPUBLICA DEL PERU. 2000. Guía para Elaborar Estudios de Impacto Ambiental Volumen XVIII. Dirección General de Asuntos Ambientales.
- (17) MINISTERIO DE MEDIO AMBIENTE DE ESPAÑA, 1998. Guía para la Elaboración de Estudios del Medio Físico. Secretaría de Medio Ambiente de España, Madrid.
- (18) MOFFAT & NICHOL INTERNATIONAL. 2002. Marine Facilities E.P.C. Design Basis Pampa Melchorita, Peru Document F-10-MN-6825-002.

- (19) Philips Petroleum Company, Australia PTY LTD & URS Australia PTY LTD, 2002. Public Environmental Report of the DARWIN 10MTPA LNG FACILITY.
- (20) PORTER, A. L, & FITTIPALDI, J. J. , 1998. Environmental Methods Review: Retooling Impact Assessment for the New Century. The Press Club. North Dakota.
- (21) RONALDO JOSÉ TORRES, 2000. Uma Análise Preliminar dos Processos de Dragagem do Porto de Rio Grande, RS. Dissertação de Mestrado em Engenharia Oceânica Fundação Universidade Federal do Rio Grande (FURG).
- (22) TARBUCK, E.J & LUTGENS, F.K, 2002. Earth an Introduction to Physical Geology. Seventh Edition, Prentice Hall, New Yersey.
- (23) THE WORLD BANK, 1997. Environmental Assessment Sourcebook update. Environmental Hazard and Risk Assessment.
- (24) THE WORLD BANK. 1991. Environmental Assessment Sourcebook, Volumes I (Policies, Procedures, and Cross-Sectoral Issues), II (Sectoral Guidelines) and III (Guidelines for Environmental Assessment of Energy and Industry Projects). Technical Papers Number 139, 140 and 154.
- (25) U.S Environmental Protection Agency, 1992. Evaluating Environmental Effects of Dredged Material Management Alternatives, EPA 842-B-92-008.
- (26) US ARMY CORPS OF ENGINEERS, 1989. Environmental Engineering for Coastal Protection. Engineer Manual. EM 1110-2-1204.
- (27) US ARMY ENGINEER WATERWAYS EXPERIMENT STATION, 1989. Monitoring Dredged Material Consolidation and Settlement at Aquatic Disposal Sites. Environmental Effects of Dredging, Technical Notes EEDP-01-5.
- (28) US ARMY ENGINEER WATERWAYS EXPERIMENT STATION, ENVIRONMENTAL LABORATORY, 1986. Fate of Dredged Material during Open-Water Disposal. Environmental Effects of Dredging, Technical Notes EEDP-01-2.

- (29) WORLD BANK GROUP, 1998. Pollution Prevention and Abatement Handbook, General Environmental Guidelines.
- (30) WORLD BANK GROUP, 1998. Pollution Prevention and Abatement Handbook. Oil and Gas Development (onshore) Guideline.

5.3 Noise

- (31) KBR, 2002. Front End Engineering Design (FEED) Noise Report Document 6825-00-EV56-0001.