CHAPTER III

DESCRIPTION OF EXISTING ENVIRONMENT

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1.0 INTRODUCTION

This chapter describes the physical, biological, social-economical, and cultural environments within the local and regional areas of influence of the LNG Export Project. The information in this chapter is the result of a literature review and field investigations conducted during the preparation of the Environmental Impact Assessment of the Project.

The LNG Export Project is geographically located within the San Vicente de Cañete district, in the province of Cañete, department of Lima, Perú. The UTM coordinates (datum WGS 84) of the project are: 8 535 250 N 359 750 E

The project area comprises 521 hectares at a location known as Pampa Melchorita. This Project site is bounded to the east by the Panamerican Highway (the segment between 167 to 170 kilometers (km) south of the city of Lima) and to the west by the Pacific Ocean.

The Project site comprises two areas: a strip of land, including an old alluvial fan over a terrace of about 140 meters (m) above sea level, and seacliffs along the beach area, where the LNG Plant is proposed for construction. The marine portion of the project where a marine trestle and a breakwater structure are proposed to be located at 1.3 km length and a bearing of 225 degrees from true north.

The regional area of influence (see Figure 1-1) for the physical, biological, and cultural features of the Project study area were established as described below:

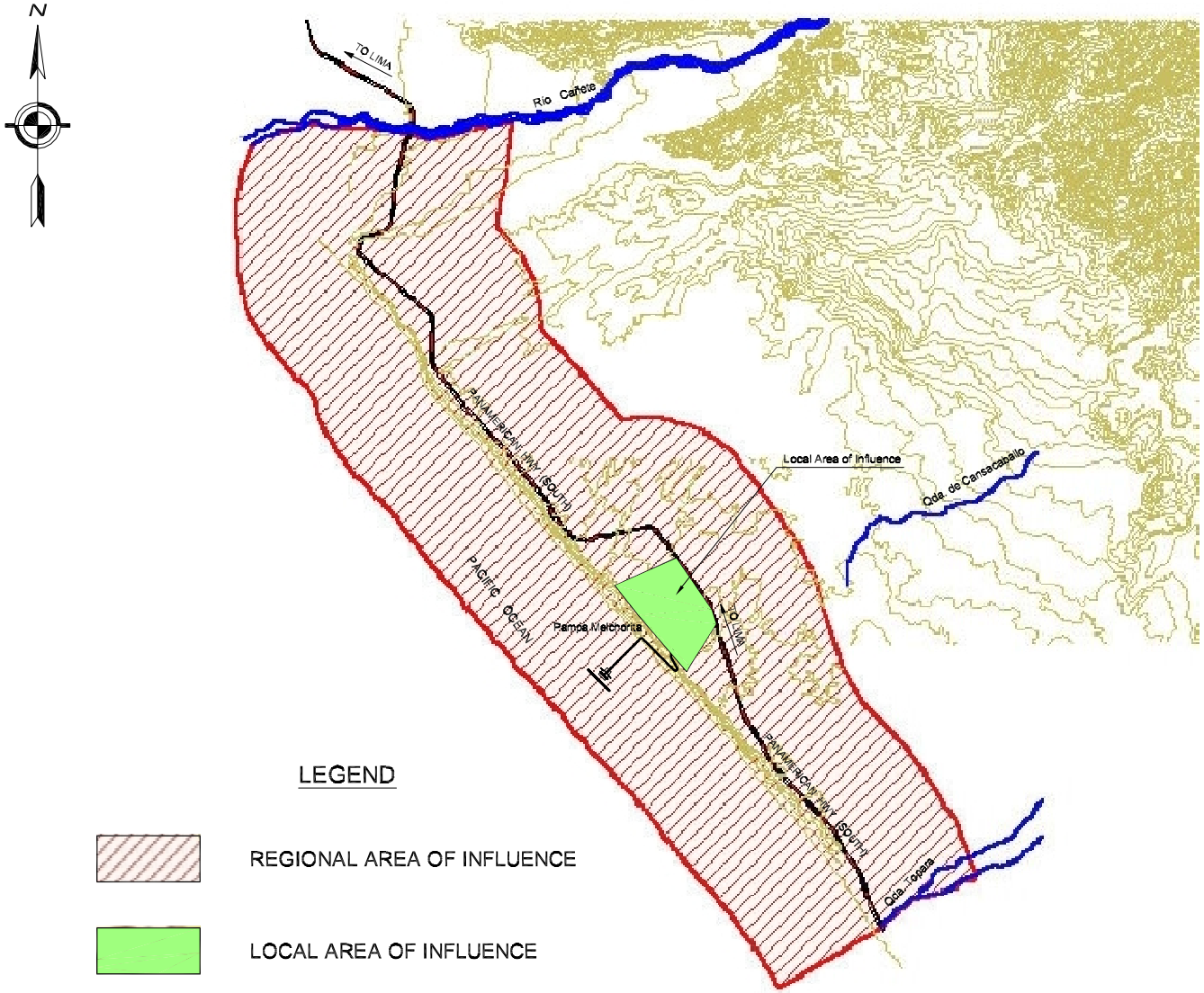
Limit		Criteria
North	Southern bank of the Cañete River	Natural barrier at 15 km from Project area.
South	Northern bank of the Topará Creek	Natural barrier at 12 km from Project area.
East	2 km east from the Panamericana Sur Highway	Close anthropic activities to the Project area
West	3 km west from the coast line	Marine facility planned of 1.3 km length from the coast line

The boundaries of the local area of influence for the Project was defined as the boundaries of the property, including both its terrestrial and marine portions.

The area of influence for the socioeconomic features of the Project study was defined as follows (see Figure 1-2):

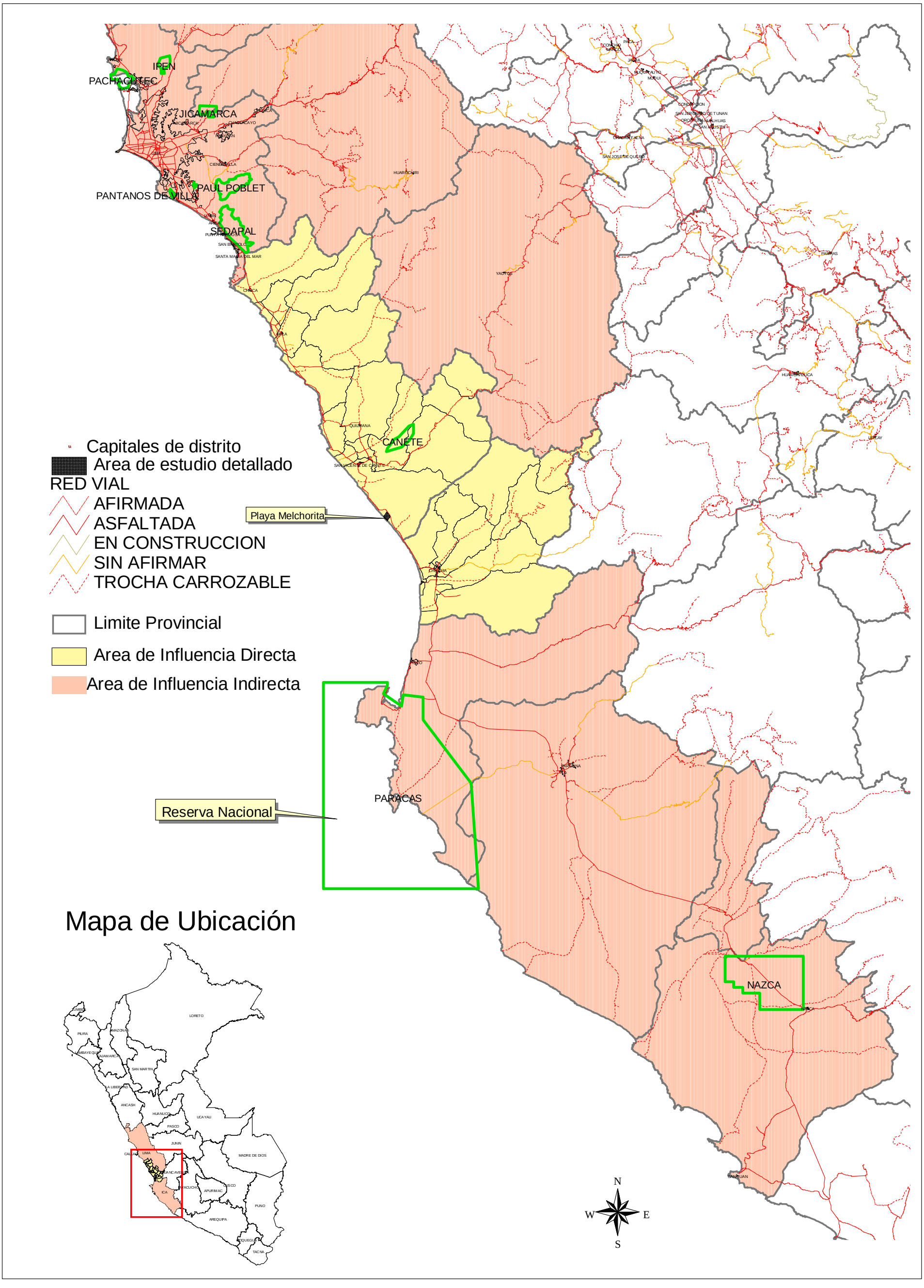
- An area of direct influence or local incidence is comprised by the district of San Vicente de Cañete in the province of Cañete and the five districts in the province of Chincha that include Grocio Prado, Sunampe, Chincha Alta, Tambo de Mora, and Pueblo Nuevo.
- The area of indirect influence or regional incidence comprises the provinces of Cañete and Chincha and their correspondent departments Lima and Ica, respectively.

Figure 1-1: Regional / Local Area of Influence - Biophysical



Golder Associates

Figure 1-2: Regional / Local Area of Influence - Socioeconomics



2.0 PHYSICAL ENVIRONMENT

2.1 Climatology

The climate in the southern coastline of Peru, including the Project site is classified as a sub-tropical that is greatly influenced by the presence of the Andes Mountain Range, the anticyclonic circulation of the south Pacific and the cold current of the Humboldt. The coastal area, where the study area is located, has an unusual type of arid climate caused by the northward-flowing cold waters of the Humboldt Current. These cold waters maintain low temperatures with very minor variation differences in temperature from month to month. The predominant arid climate in the area maintains annual temperatures at a level that are conducive to growing a wide variety of crops. Likewise, the light-to-moderate winds combined with high atmospheric humidity of the winter season reduces evaporation, and therefore, reduces also the water requirements for crops. The average annual precipitation in the region ranges from about 0 to 2.5 millimeters (mm), while the average annual temperatures in the region vary from about 15 to 23 degrees Celsius (°C).

The coastal area's climate is characterized by high atmospheric humidity among several months of low cloud, fog, and fine drizzle ("garúa"). This factor contributes to maintaining the near-surface soils moist, and thus, reducing the erosion during the winter season. During the summer months when the soil is dry, wind is the primary force causing soil erosion.

2.1.1 Site Meteorology

The Project site is located 168 km south of Lima. The nearest source of climatological data was obtained from the two meteorological stations are present in the region: the National Service of Meteorology and Hydrology (SENAHMI), located in Cañete; and the Naylamp Project of the Direction of Hydrography and Sailing of the Marina de Guerra del Perú (Pisco station).

Although, the Cañete station was used to provide climatic information in the project region presented below, the meteorological data used for evaluating environmental air quality impacts, due to the Project, was obtained from the Lima airport where the data included a more complete set of observations of wind direction, wind speed, wet and dry bulb temperature, pressure, dew point, cloud cover, and cloud height for each hour of the day.

Cañete Station

The Cañete Station is located in the province of Cañete, Nuevo Imperial district at an elevation of 150 masl, at geographic coordinates:

13° 04' South and 76° 20' West

Temperature and precipitation were recorded from 1986 to 2001, while relative humidity was recorded for the period 1995-2001.

Pisco Station

The Sutrón Meteorologic station, located in Pisco is part of a network of meteorological coastal stations that are managed by the Naylamp project. The Pisco station was constructed to provide climatic information to the sailors such as a timetable for tides, surf, wind, and navigational conditions. The Naylamp project has been in operation for one year, and therefore, the data obtained from this source comprises the period 2000-2002.

Sutrón station coordinates are: 13°48'09" South and 76° 17' 23" West.

2.1.2 Temperature

As shown in Figure 2-1, the average median monthly temperature for the Project area (based on the Cañete station weather data) is about 19.6°C with average monthly temperatures that vary from a minimum of 16.5°C to a maximum of 23.7°C. The average monthly median temperature varies little from month to month throughout the year (i.e., less than 2°C). The maximum monthly average temperature of 23°C occurs during the summer months (January through March), while the minimum monthly average temperature of 16°C occurs during the winter months (July through August).

2.1.3 Precipitation

The annual precipitation as recorded from 1985 to 2001 at the nearest meteorological station in the region is presented in Figure 2.2. Precipitation for the recorded period indicates that April is the driest month, and that June through August are the most humid months. Average monthly precipitation varies from 0 to 2.5 mm. As presented in Figure 2-2, some sporadic extreme values of

precipitation have been recorded such as the 10 mm of rainfall recorded in January 1998, which is unusual for the study area (see Figure 2-2).

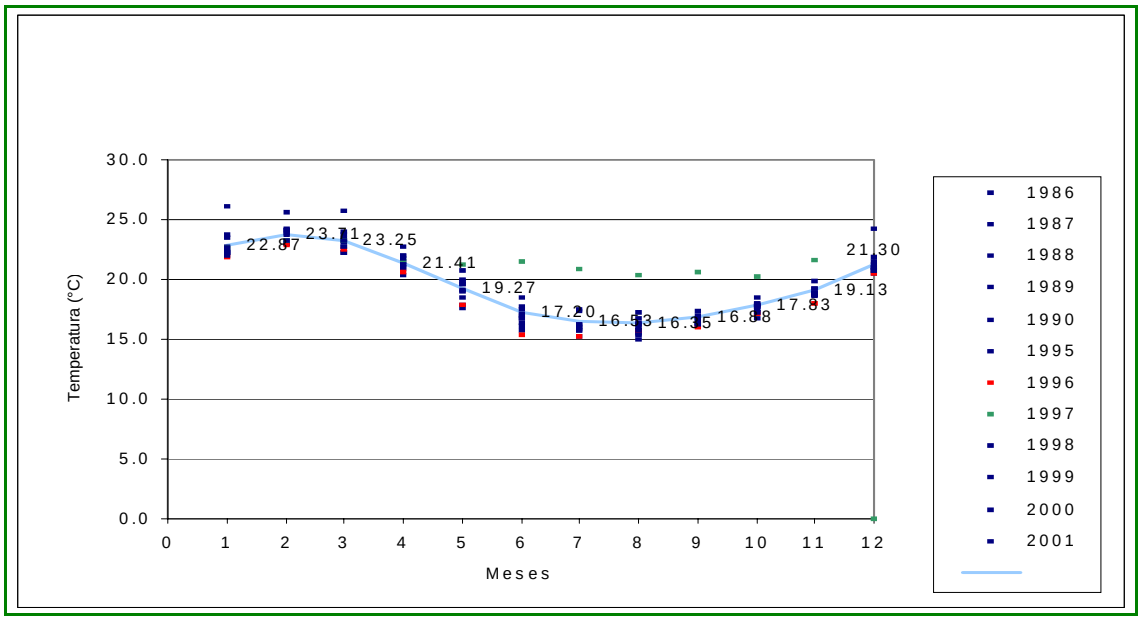


Figure 2-1 Monthly Average Temperature

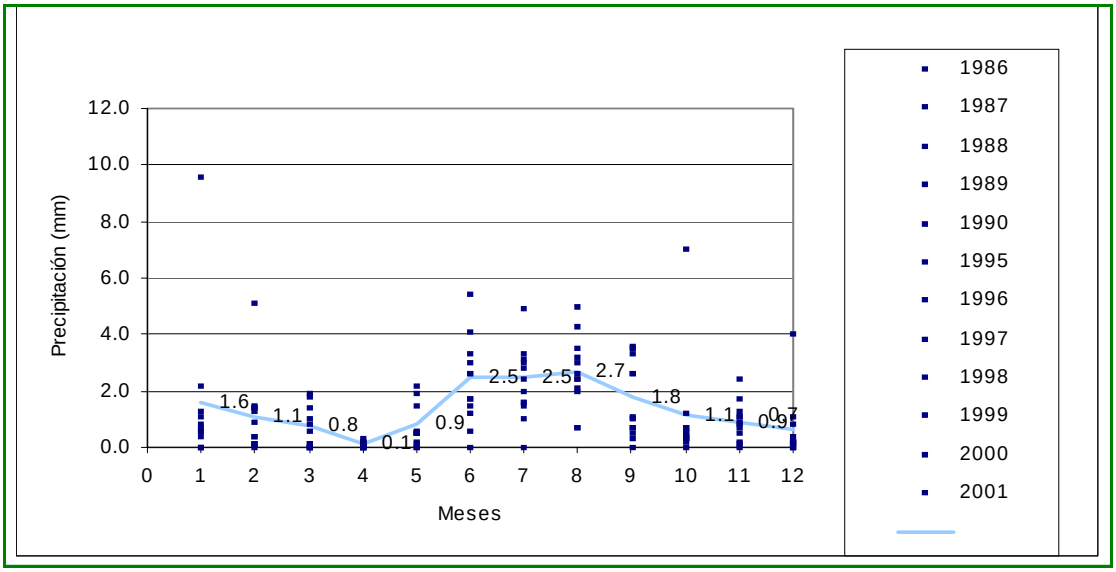


Figure 2-2 Annual Rainfall for Cañete Station

2.1.4 Relative Humidity

The average monthly relative humidity as recorded in the Cañete station, varies from 82 to 88 percent, with maximum values recorded in winter (June through September) and minimum values recorded in summer (February through March). As presented in Figure 2-3, the driest years were 1997 and 1998, and the most humid year was 1996.

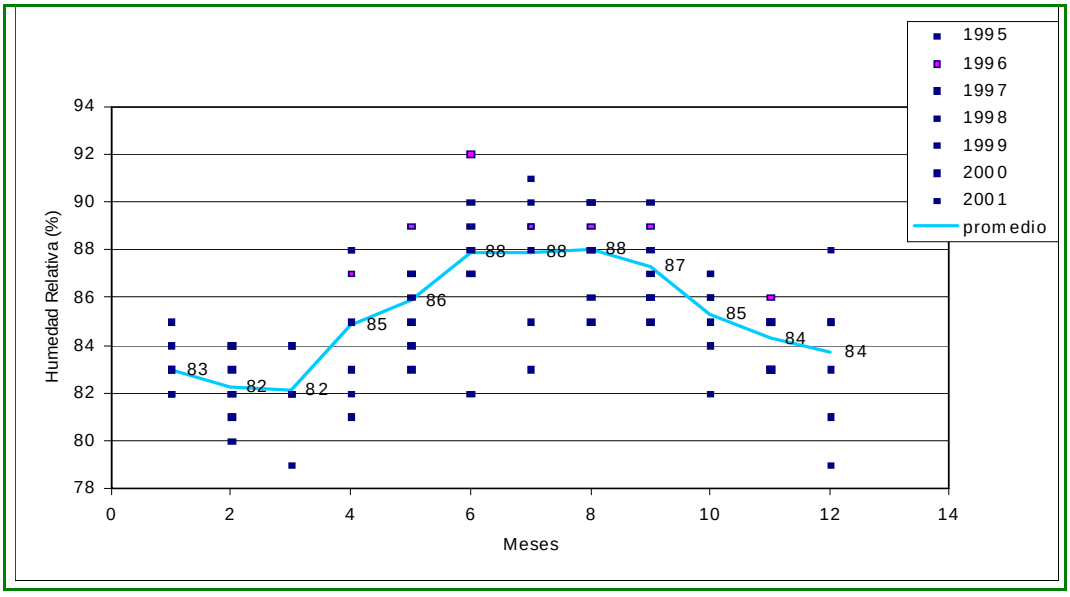


Figure 2-3 Relative Humidity for Cañete Station

2.1.5 Predominant Wind

Wind data was obtained from the Lima and Pisco airports. The Lima and Pisco airports are located approximately 167 km north and 63 km south of the Project site. According to the data reviewed, the average wind speed of 3.48 meters per second (m/sec) was recorded at the Lima station with a predominant wind direction from the south. Average wind speed recorded at Pisco is 4.25 m/sec with a predominant wind direction from the south. Windrose diagrams for Lima and Pisco are presented in Figures 2-4 and 2-5, respectively.

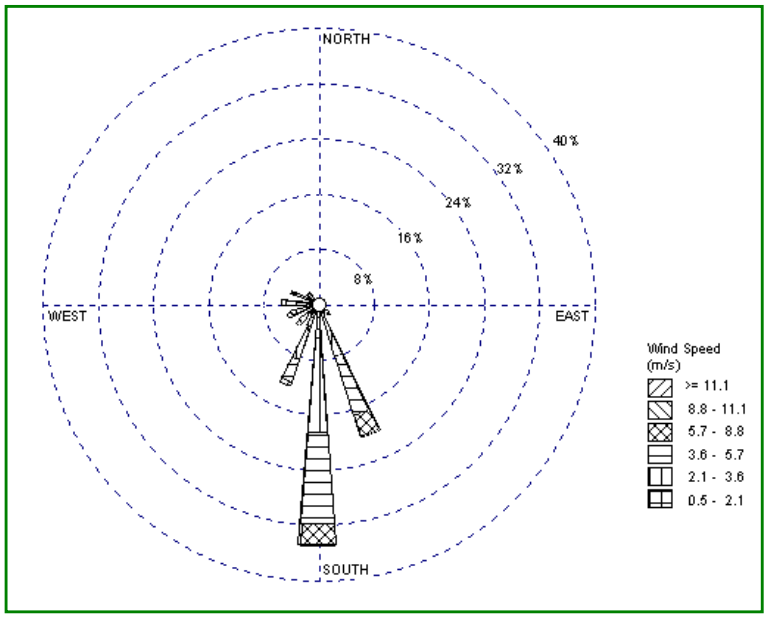


Figure 2-4 1996 Annual Wind Rose for Lima, Peru (Station N° 842680)

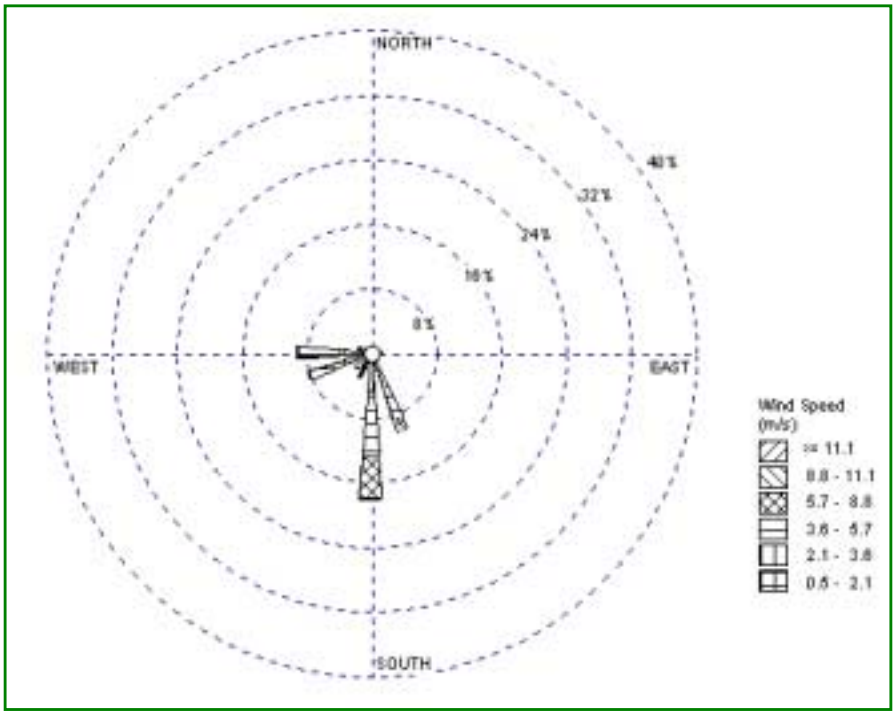


Figure 2-5 1996 Annual Wind Rose for Pisco, Peru (Station No. 846910)

2.2 Geology

2.2.1 Regional and Local Setting

The proposed Project is located in a region along the west coast of Peru, which comprises a coastal stretch from the Cañete River on the north to the Topara Creek on the south and extending east of the Panamerican Highway to an elevation of 200 masl. The region is characterized by deeply incised hills, broad alluvial fans and plains, and wide incised recent (Holocene) alluvial plains and valleys (MMI, 2002).

The regional stratigraphy as presented in Map PE-01 shows that bedrock underlying the alluvial deposits consists of lower Cretaceous sedimentary and granite-dioritic rocks. The narrow beaches along the study region are present in narrow alcoves between the bedrock of coastal cliffs ranging in heights from 60 to 170 m formed by a series of old to recent deep-seated landslides and littoral erosion. Steep seacliffs drop almost vertically down to the beach area and produce terraces with an average width of 300 m and height ranging from 50 to 70 m.

The alluvial fans, which form the broad coastal plains (pampas), are about 2 km wide between the sea and the coastal bedrock hills from K 153 to K 180 along the Panamerican Highway. These broad fans exhibit a conical shape with heights of up to 30 m. The wind-deposited (eolian) sand sheets and dunes cover the bedrock and or alluvial fans. The soils underlying the sand dunes are formed by partially consolidated, densely packed and cemented deposits of the Pleistocene Cañete Formation. Numerous old and recent drainage valleys are incised into the fan surface that discharge over the seacliffs. Table 2-1 and Map PE-02 presents the stratigraphy of the Pampa Melchorita area.

Satellite images show numerous bedrock faults parallel to the Andes range in a northwest and southeast direction (NW-SE). These faults generally are parallel to the subduction zone. Three faults system were observed with the following bearings: N 340°-350° W; N 290°-310° W; and N 70°-75° W. A fault alignment that traverses to those described above parallels the rivers that discharge to the Pacific Ocean and was observed at a bearing of N 40° - 50°E.

2.3 Soils

2.3.1 Regional and Local Characteristics

The regional and local soils at the study area are classified as Entisols and Aridisols. These soils are characterized by not having a recognizable pedogenic horizons and are commonly associated with recent flood plains, steep eroding slopes, sand dunes, and wind deposited sands. These soils exhibit a characteristic of being highly susceptible to wind erosion and being dry most of the year. These soils contain calcium carbonates, silica, salts, and gypsum.

The regional and local classification of the soils in accordance to the Taxonomic System of the U.S. Department of Agriculture (USDA, 1994) and its corresponding with the FAO classification system (1994) is shown at Table 2-2 and Maps PE-03 and PE-04, respectively.

Soils are grouped in accordance to the regional geomorphology characteristics into the following groups:

The Playa Group (Py)

The Playa Group soils are comprised of gravel and sand along a narrow beach strip that is subject to the affects of surf weathering. This strip also contains soils of intermediate terraces formed by the influence of high and low tides and wind erosion.

The Acantilado Group (T)

The Acantilado Group consists of soils that make up the steep seacliffs resulting from old and recent landslides and erosion.

The Cerro Group (CR)

The Cerro Group consists of wind deposited sand that overly the top of seacliffs and are characterized as the plains (pampas) with gentle to steep slopes ranging from 8 to 15 percent with rock outcrops forming hills and dunes.

The local soil characteristics were evaluated by collecting soil samples at five locations and conducting chemical and physical analysis. The soil profiles and the laboratory results are presented in Appendix 2.

The results of the analysis indicate that the soils at the Project site are slightly acidic to slightly alkaline and are with high salinity and low organic matter (less than 2 percent). The grain-size analysis conducted on these soils show that the soils are predominantly sandy and considered highly permeable. Gravels are generally present at deeper layers of the soil profiles (Profiles 1, 2, and 3), which restricts their use root type plants (i.e., potatoes, asparagus) but are suitable for fruit plants and landscaping species.

The regional and local soils have slopes ranging from fairly level to 2-percent slope. The salinity of the soils analyzed at the Project site is high and range from 16 to more than 25 dS/m. The A horizon consist of medium-to-coarse sand, while the C horizon contains dense layers of salt deposits (caliche). These soils have a high permeability and require large quantities of water for irrigation.

The productivity and potential use of these soils are limited by the high salt content, drainage, erodeability, and the lack of available fresh water for irrigation. According to the Ministry of Agriculture regulation on Land Classification in Peru (Reglamento de Clasificación de Tierras del Ministerio de Agricultura, Decreto Supremo Nº 062/75-AG and Oficina Nacional de Evaluación de Recursos Naturales ONERN) the major use of these soils at the regional and local level is shown on Table 2-3 and Maps PE-05 and PE-06.

The agricultural value of the soils at the local study area ranges from medium to low and is considered of lower quality than those encountered at the regional level.

2.4 Hydrogeology

2.4.1 Surface Water

The study area lies between two main rivers; the Cañete River located 15 km to the northwest and the Topara Creek located 12 km to the southeast that flow perpendicular to the coastline and discharge to the Pacific Ocean. The headwaters of these rivers are in the Andes Mountain where precipitation provides the source of water.

The Cañete River flows during the entire year whereas the Topara Creek flows only during the rainy season when precipitation occurs in the mountains during the months of December through April. Due to the very low amount of precipitation in the region (50 mm per year), recharge of these rivers at their lower reaches is non-existent and thus both rivers lose water to the underlying formations.

The Topara River presents sporadic flows, and it is also called by the locals and depicted in the cartography as Dry River (Rio Seco or Quebrada Seca); this river acts as a bound between the Pampas of Cañete and of Chincha, and the limit of two provinces and of the Departments of Lima and Ica.

There are several other small dry bed creeks in the area that flow only during high rainfall events. There are no other surface water bodies in the area.

The Cañete River, represents a important water resource in the region; born at lagoon Ticllacocha, 4600 meters above sea level on the Andes mountain range it extends towards the Pacific Coast in a longitude of approximately 230 km creating a basin of 6189 km2. The distribution of the rainfall in the basin varies among 50 mm/year in the coastal area up to more than 1000 mm/year in the mountain area.

Due to their permanent water regime, the Cañete River supports the irrigation systems and the agricultural activity developed in the narrow valleys. The administration and handling of the water resources in the valley of the Cañete River is the responsibility of the Technical Administration of the District of Mala-Cañete-Omas and of the Committee of Water Users, which is mainly formed by farmers' groups to control the irrigation channels.

On their journey from the mountains to the coast, the Cañete River receives waters from several important tributaries known by their longitude and amount of water, among those stands out: Huangascar, Cacra, Tupe, Pampas Creek, Huantan, Laraos, Alis, Aucampi Creek, Yauyos and Miraflores Creek.

As all the coastal rivers, the Cañete River is characterized by being of torrential character, feeding its water courses, mainly of the seasonal rainfall that occurred at the upper part of the basin, and producing the biggest water discharges during 3 or 4 months in a year, mainly during December through March. These greater water discharges are of relative short duration and with a transportation capacity of large amounts of suspended matter.

In the basin of the Cañete River several hydrological studies has been carried out which are mainly based on data from the two existent hydrometric stations in the basin, which are the following:

Station	Latitude	Longitude	Altitude (masl)	Average Flow m3/seg	Data Available
Imperial intake	13°00'	76°12'	300	53.3	1925-71, 94-2000
Socsi	13°02'	76°12'	340	62.2	1965-2000

Source: SENAMHI

The average monthly flows from 1994 to 1998 recorded at Socsi hydrometric station are shown at Table 2-4.

According to the data in Table 2-4, the Cañete River has period of low waters between May and November, registering the minimum flow values in the month of September. Starting from December, the water volume begin to be increased due to the rainfall in the mountain area, presenting a maximum value during the months of February and March. During the years 1 994 to 1 998, the maximum observed flow was of 334.8 m^3/s in the month of February of 1994 and the minimum flow was 7.8 m^3/s in the month of September of 1997. However, reports of maximum flows recorded were of up to 946 m^3/seg in March of 1975, as long as the flow average recorded was of 62.2 m^3/s in the years 1 965 to 2 000.

2.4.2 Ground Water

Groundwater has not been encountered to a depth of 100 m, the maximum depth explored, during the geotechnical investigation and geophysical evaluation at the site. Based on piezometer information installed in the region, groundwater if present tends to flow toward the northeast to southwest toward the Pacific Ocean. Groundwater near the coastline is considered brackish and does not have beneficial uses and for this reason the proposed project intends to use seawater as the only source of water for potable and plant operations.

2.5 Natural Hazards

The natural hazards associated with the study area include: earthquakes, tsunamis, cliff slope stability, and flooding.

Earthquake Hazard

The project site is located along the central coastline of Peru in a seismically active region that is related to the convergence of the Nazca and South America plates along the subduction zone. Consequently, Peru is one of the countries with the highest seismic risks in South America resulting

from the converging of these two plates. Along the South American coastline from Colombia to Chile, the heavier Nazca plate is subducted under the lighter continental South American plate. This tectonic crashing of the plates have forced the leading edge of the Nazca plate into the earth's mantel, which have resulted in the formation of volcanic eruptions and the creation of the high seismic activity and the creation of the Andes Mountains.

Numerous large subduction zone earthquakes ranging in moment magnitude (Mw) from Mw 8 from Mw 9.0 have been recorded (Wyss, 2000; West, 1999). Between 1942 and 1996, earthquakes were recorded ranging in magnitude from V to VII on the Modified Mercalli (MM) scale. The maximum historical earthquake observed in the area was MM IX (Alva *et al*., 1984).

Historical earthquakes with epicenters located along the coast of Lima have included the following earthquakes: 1586 (Mw = 8.1), 1687 (Mw=8.4 – 8.8), 1746 (Mw=8.6-9.5), 1966 (Ms=7.5), in 1940 (Mw=9.0) and in 1974 (Mw=8.1). Table 2-5 shows the significant seismic events that have occurred in the central and south of Peru.

Mercalli intensity is a subjective measure of earthquake strength, as opposed to magnitude. Richter (1958) presents Wood and Neumann's scale of measurement for seismic intensity based on earlier work by Mercalli, Cancini, and Seiberg, known as the Modified Mercalli scale of 1931 (MM). Table 2-6 shows a description of the felt effects represented by each of the MM scale's grades. Because of the limitations in various earthquake magnitude scales a new, more uniformly applicable extension of the magnitude scale, known as moment magnitude, or Mw was developed. This scale, in particular, for very large earthquakes moment magnitude gives the most reliable estimate of earthquake size.

The seismic activities along the continental crust zone, outside the plate interface area, have been observed to occur at shallow depths. The seismic activity in this zone has been attributed to the potentially active Huaytapallana fault (Macharé et al., 1991), located northeast of Huancayo and at approximately 165 km east of the Project site. Figure 2-6 presents a summary of spatial distribution of earthquake epicenters occurring at 70 km depth during the recorded period from 1963 to 2000.

Figure 2-7 indicates the location of probable active faults (Huamán, 1999) in the vicinity of the Project site. The following faults and proximity to the Project site include: the Huamaní fault (13 km from the Project site), the Ica fault (100 km), the Condoray fault (130 km), and the Quinua-Razuwilca fault (250 km).

Figure 2-6: Surficial Seismic Activity (0-70 Km) - Surficial Seismogenic Sources

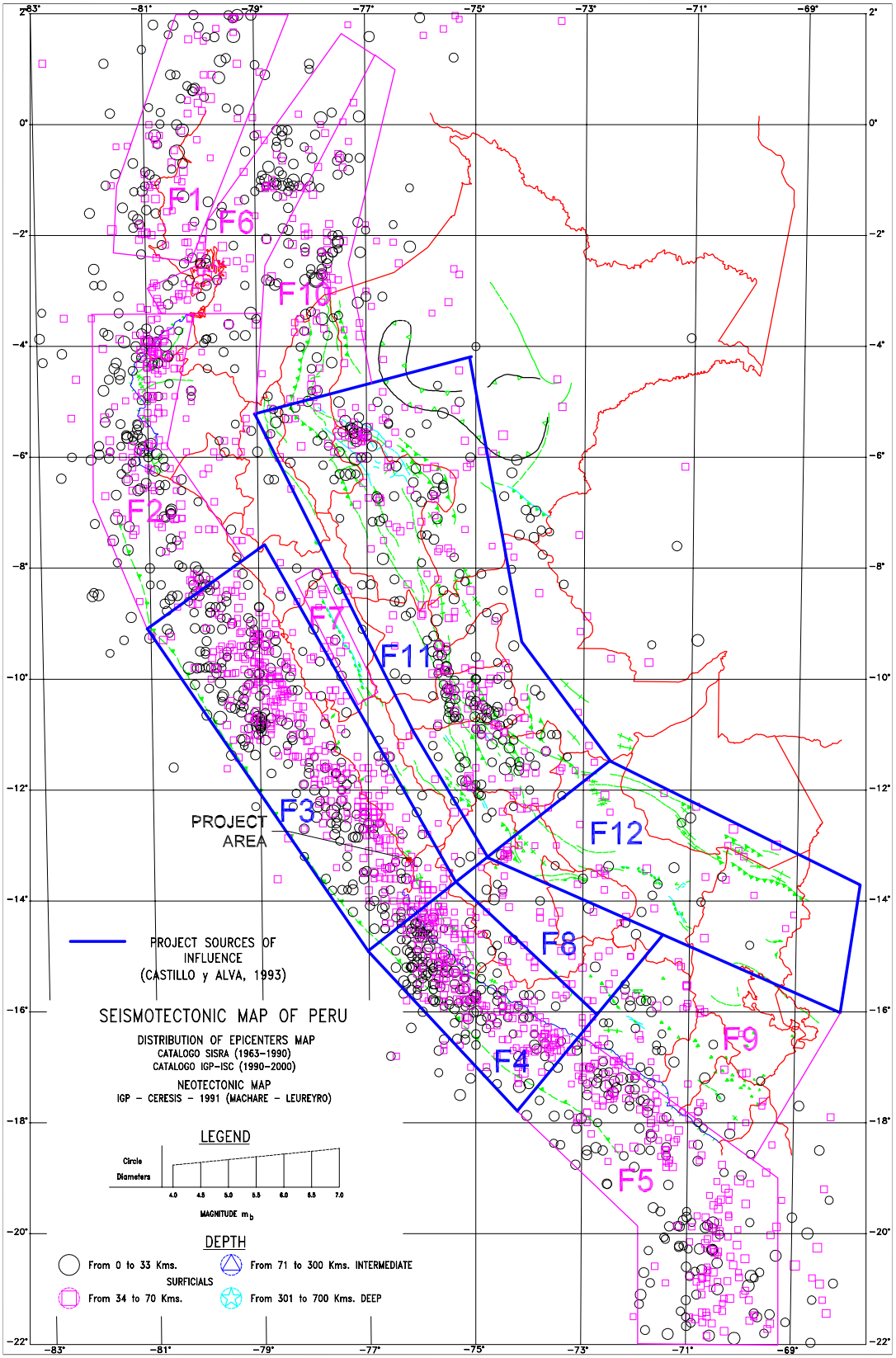
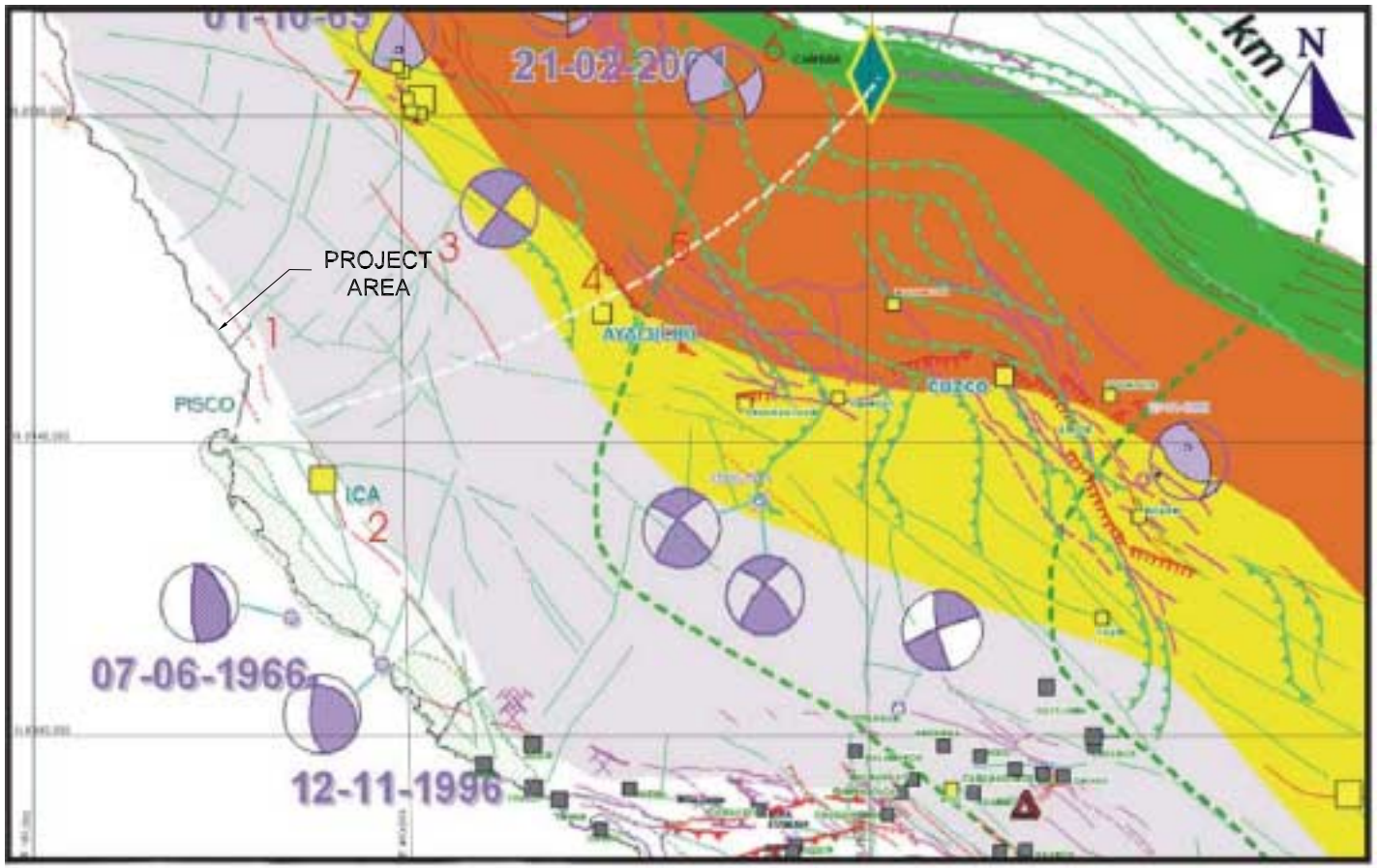


Figure 2-7: Neotectonic Fault Locations



1. Huamani 2. Ica 3. Condoray 4. Quinua-Razuwilca 5. Apurimac 6. Urubamba 7. Huaytapallana (HUAMAN, 1999)

REFERENCE: Huamán, 1999

Figure 2-8 shows the epicenters at the intermediate and deep zones located at depths of 71 to 300 km and the depths of 300 to 900 km, respectively. (Castillo and Alva, 1993). Figures 2-9 and 2-10 presents a cross-section through the project site, showing the epicenter distribution.

Tsunami Hazard

The coastal zone of Peru including the Project site has experienced the effects of many destructive tsunamis (Silgado, 1974), with wave heights ranging from 2 to 20 m. Table 2-7 presents the summary of significant earthquakes that have caused tsunamis in the Peruvian coast (Dorbath, 1990; Langer, 1995). The earthquake of the year 1746, produced wave ranging from 15 to 20 m in height. Recent earthquakes of 1940, 1942, 1966, and 1974 have produced wave heights ranging between 1.6 to 3 m (Dorbath *et al*., 1990) and the earthquake of 2001 (Mw=8.3) produced a wave height between 7 and 8 m in cities of Camaná and Arequipa located south of the Project site (Tavera *et al*., 2001).

Earthquakes with magnitudes greater than 7.5 Richter and an epicenter depth less than 60 km (Kuroiwa, 1983; Dorbath et al, 1990) located near the subduction zone, between the dorsal of Nazca fault and the Mendaña fault line (Dorbath et al, 1990; Langer et al, 1995) can cause a tsunami at the project area (see Figure 2-11).

A study was conducted to estimate the character of tsunamis at the Pampa Melchorita site caused by earthquakes. Potential tsunamigenic characteristic earthquakes were identified and possible return periods were estimated and used to define models of ground deformation for use in hydrodynamic simulations to model tsunami heights and velocities in the vicinity of the planned breakwater and trestle. The detailed bathymetry and landform shapes for the Pampa Melchorita site were used in the study. The planned design for the breakwater and trestle system were included and tsunamis arriving from south, south-west and westerly directions were simulated.

It was estimated that on event comparable in size to the 2001 Camana earthquake, but located closer to Pampa Melchorita, would have a return period of 60 years and result in a sea runup of up to 2 meters in height with a current of 1.5 meters per second. Similarly, larger events, modeled after the 1687 Pisco earthquake, would have a return period of 110 years and result in a runup of up to 8 meters with currents of up to 2.5 meters per second.

Figure 2-8: Deep and Intermediate Seismic Activity (71-900 Km) - Subduction Seismogenic Sources

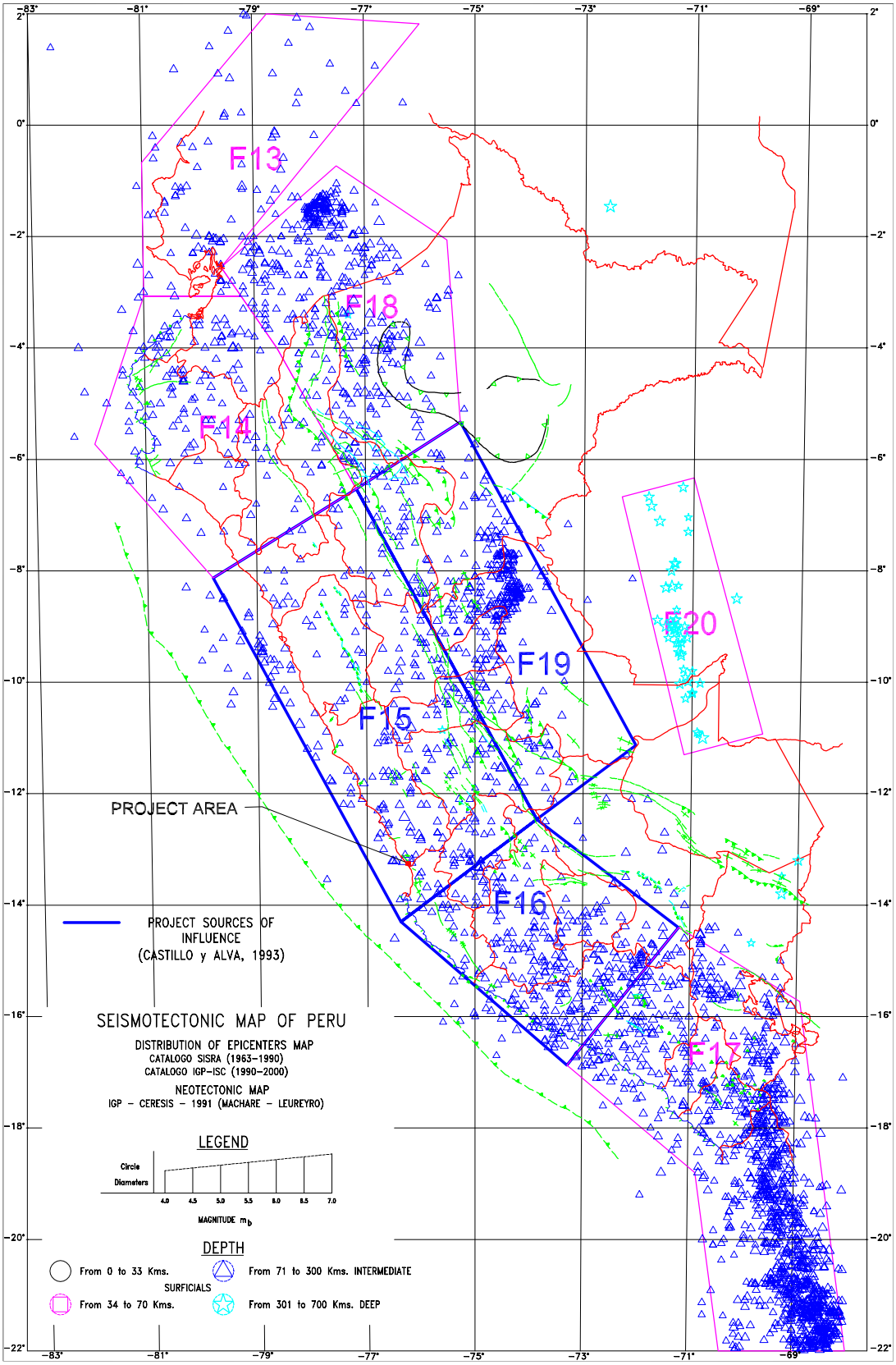


Figure 2-9: Epicenter Distribution in Relation to the Project Area

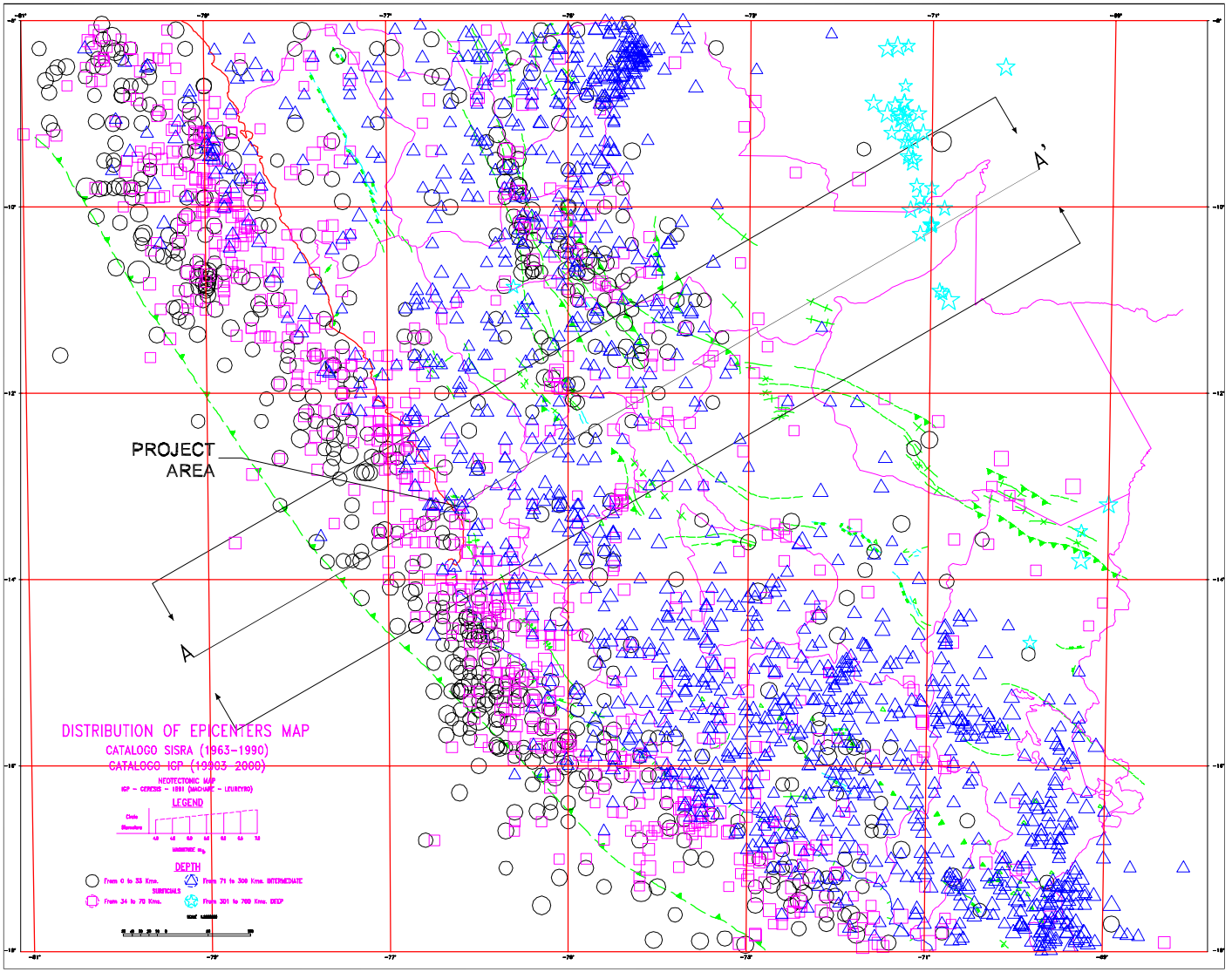


Figure 2-10: Hipocenter Profile

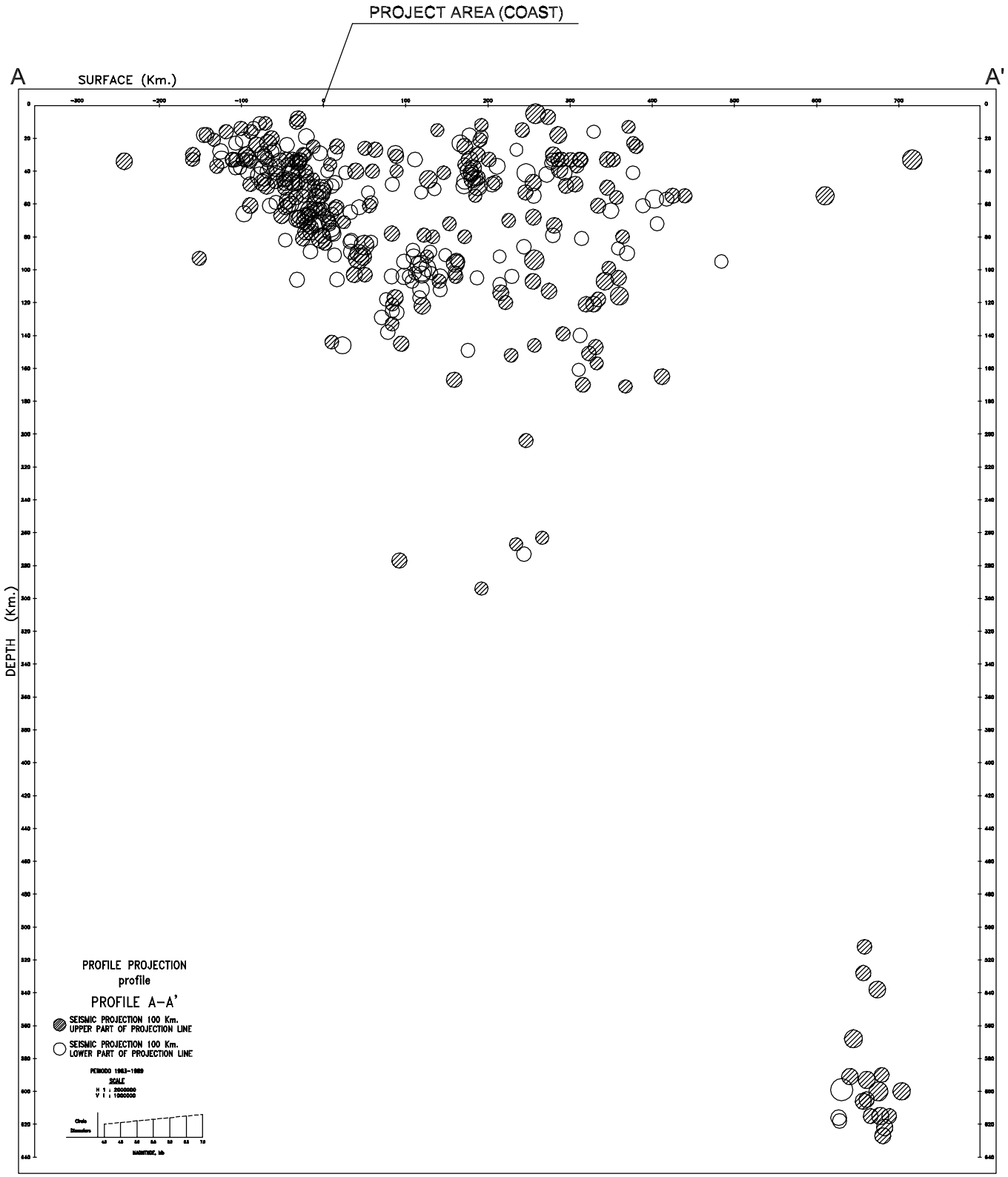
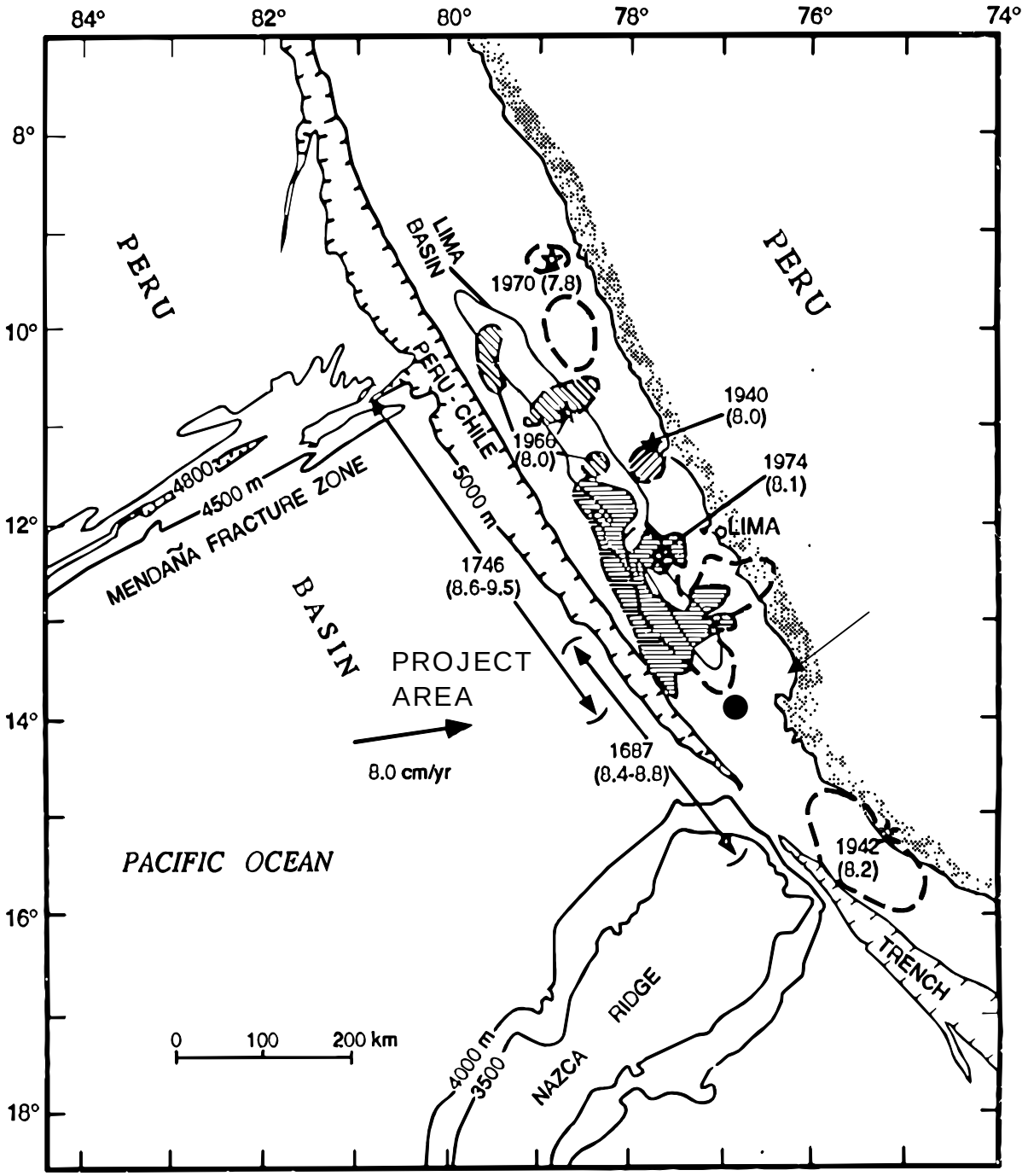


Figure 2-11: Seismic Fracture Zones in the Central Area of Peru



REFERENCE: **Langer (1995).**

Slope Stability

The steep slopes of the coastal cliffs and the high seismic activity in the area pose potential slope instability. A tsunami at the Project site could cause erosion of the beach and possibly undermine the toe of the cliff adding to the instability of the coastal cliffs (see Figure 2-12). Equipment should be set back from the sea side. In the vicinity of the plant, the cliff area should be shaped to provide a reduced slope down the original natural cliff for the pipeway and vehicle access to establish a safe angle of repose. Equipment such as the LNG Storage Tanks, compressors, etc. should be set back from the beginning of the new slope as an added measure to avoid any potential concern from landform instability from seismic activity or undercutting of the slope.

Flooding

The site is not subject to flooding due the lack of precipitation in the area and the distance from the closest drainage basins associated with the Cañete River, located 15 km to the northwest, and the Topara River, located 12 km to the southeast of the site, and the elevation of the project site relative to the surrounding area. The Cansa Caballo Creek, located 3 km east of the Project site, is a dry bed creek most of the year and does not pose a flooding risk to the site. In addition, the Pan American Highway provides a drainage divide that isolates the site from the creek (see Figure 2-13).

2.6 Marine Environment

2.6.1 Physiographic Aspects

The area of influence for the marine baseline extends from Cañete River north of the Project site to Topara Creek, south of the Project site, and 3 km offshore as presented in Figure 1-1. The marine environment along the area of influence of the project is greatly influenced by the regional coastline extending from the Callao Bay to the Paracas Peninsula as presented in the adjacent satellite image of the region.



Figure 2-12: Typical Cliff Profile

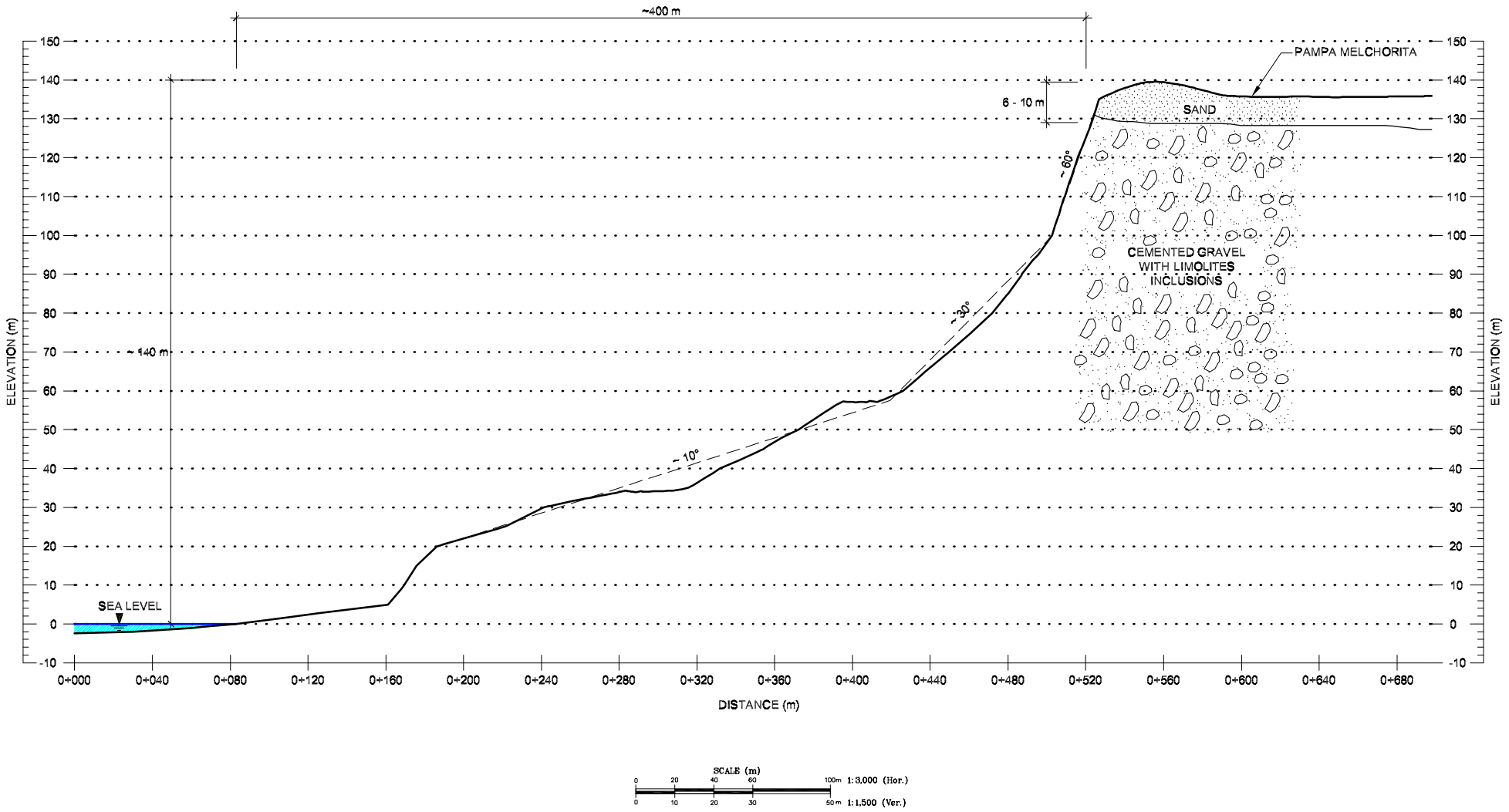


Figure 2-13: Area Morphology



The coastline from Callao Bay follows a general SSE orientation until Chincha Alta, south of the Project site, where the coastline orientation extends in a southerly direction to the Paracas Peninsula. The coastline is characterized by some prominent features such as the San Lorenzo Island just west of Lima at Callao Bay, which provides a natural breakwater to the Port of Peru.

Other features along the northern coastline include the extension of land area offshore at Pucusana and Cerro Azul that provide protected inlets for local fishing vessels and the small islands outcrop along the coastline within 3 km of the shoreline. These islands increase in numbers near the Paracas Peninsula and many function as sanctuaries for birds and marine mammals. These islands were once part of a former barrier island that once paralleled the coastline and formed a protected shallow intercoastal waterway.

The coastline at the project site is characterized by deeply incised coastal hills, alluvial fans, and wide beaches as depicted in Figure 2-14. The coastal cliffs commencing at Punta Iguana consists of clayey soils ranging in elevation from 50 to 173 m with narrow sand beaches that extend for 40.28 km to the Port of Tambo de Mora. Along this coastal stretch there are several beaches: Cóndor, Mulata, Melchorita, Del Zorro, El Turno, Jahuay, Carrizal. At Jahuay Beach, located approximately 6 km south of the Project site lays a small beach resort, Wakama that consists of isolated summer homes.

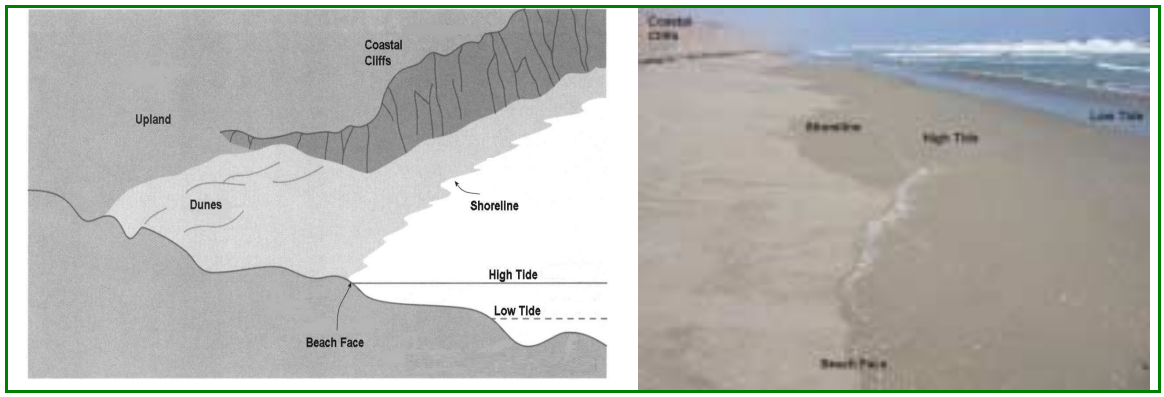


Figure 2-14. (Left) A schematic of coastal characteristics of the study area indicating the upland areas and coastal cliffs. (Right) Actual coastal characteristics of the Playa Melchorita.

2.6.2 Bathymetric

The bathymetry and marine geophysical survey for the proposed LNG marine terminal is presented in Figure 2-15. The bathymetric survey covered two areas designated as Grids 1 and 2. Grid 1 encompassed the pipeline trestle, loading platform, while Grid 2 encompassed the immediate approaches and the deep-water approach area.

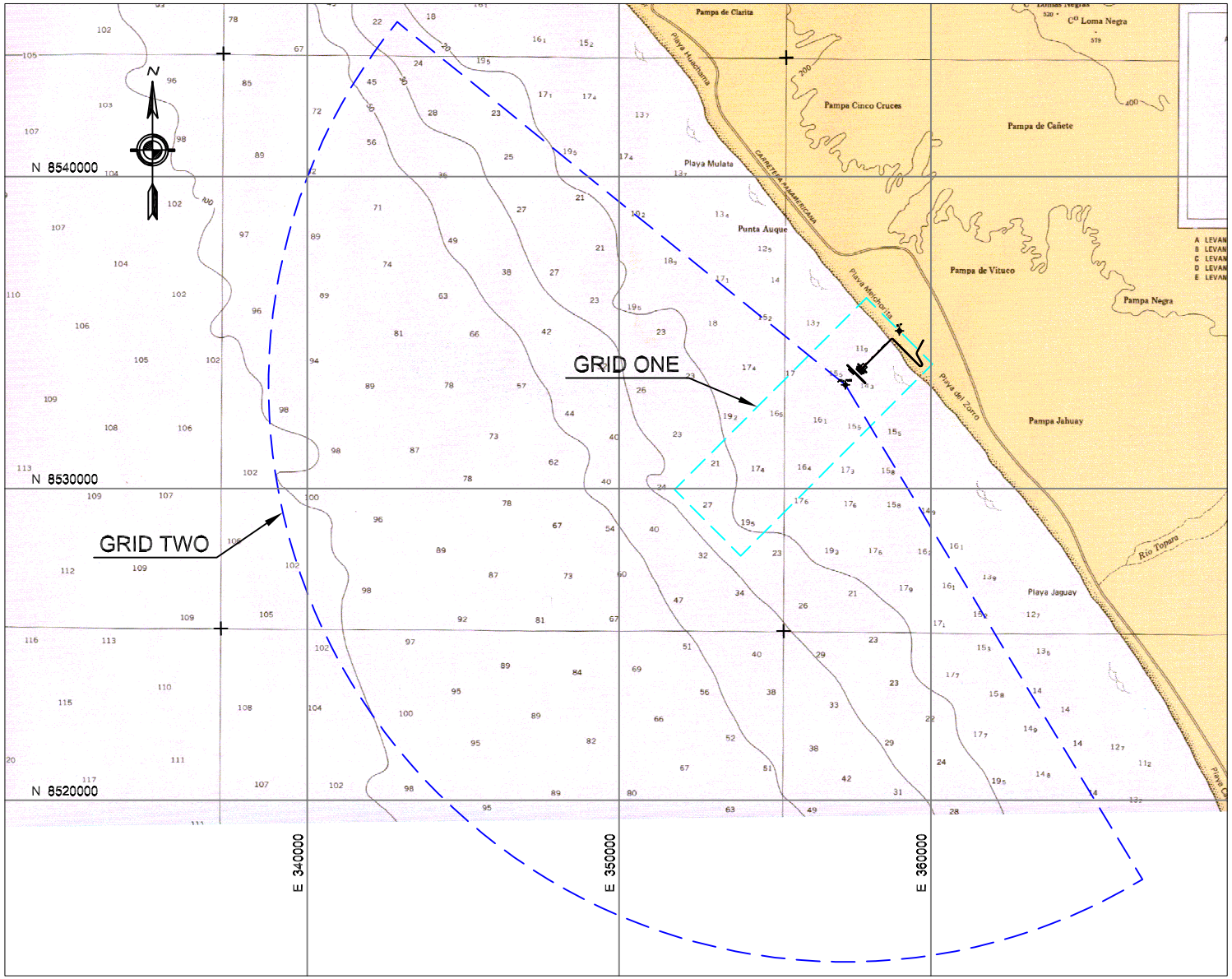
The Grid 1 study was conducted to characterize the seafloor and subsurface stratigraphy and geology, identify possible geohazards such as faults and zones of subsidence, and identify the presence of cultural artefacts or sunken vessels that could represent hazards to navigation or impact construction of the marine facility. A combination of multi- and single-beam echo sounding, side-scanning sonar, and seismic reflection profiling techniques were used during this study. The region study for Grid 2 included confirming water depths and identifying hazards to navigation in the deep-water approach area using a combination of single- and multi-beam echo sounding techniques and side scanning sonar.

The coverage area for Grid 1 consisted of a 3-km-wide area that extended 8-km offshore from the surf zone. Approximately 420 km of bathymetric and geophysical data were acquired in Grid 1 with survey transects oriented parallel to the planned trestle alignment (perpendicular to the shoreline) and spaced at 50 to 100-m intervals. The survey area for the Grid 2 deep-water approach area covered a radial distance of 10 nautical miles (18.5 km) seaward, from the outer edge of the planned offshore loading facilities.

The bathymetric study reported an exceptionally uniform and relatively horizontal seafloor with a slope that increases in depth from 5 m near the surf zone to 34 m at the seaward edge of Grid 1. The bathymetry survey for Grid 2 also reported a uniform seafloor, with the seafloor slope increasing at a constant grade from 15 to 105 m. No unusual bathymetric features, such as bedrock outcrops or regional lineaments, were reported in the interpreted data.

Based on the interpreted side-scan and seismic reflection data in the Grid 1 area, the seabed is mantled with fine-to-medium-grained sediment, except in the near shore area where gravel and cobbles were noted in localized discontinuous zones. In addition, an increase in presence of organic material was noted on the seabed from the middle of the site and seaward.

Figure 2-15: Bathymetry of the Offshore Study Area



A wedge of sediment, increasing in thickness from less than 1 m in the near shore area to approximately 22 m thick at a distance of 3.3 km from the shoreline was identified on the seismic reflection data. Boring BH-1, conducted in this area, disclosed this wedge as surficial deposits of fine-grained silty sand. The lower contact of this unit was reported as acoustically hard reflector that corresponds to a compact to very dense clayey sand and gravel material. Below this contact, distinct seismic reflectors were more difficult to identify and were not contiguous.

Seaward of the 16 m depth contour and at approximately the 22 m sediment isopach contour, the subsurface seismic subsurface penetration is limited to 5 to 12 m. Two possible causes are the presence of dense sediment in the near surface, and/or the presence of organic debris and biogenic gas in the sediment.

There was no interpreted evidence on the bathymetric or side-scan sonar data suggesting the presence of large sunken vessels, cultural artifacts or geohazards that might pose a risk to vessels or activities associated with construction of the trestle.

2.6.3 Physical Characteristics of Marine Sediments

To physically characterize marine sediments standard tests for soils classification were conducted. These commonly utilized tests in Engineering were used to know the granulometric characteristics, consistency limits and specific gravity of the sediment samples taken at the study area.

Granulometry and Plasticity

The granulometric characteristics have been obtained using the methods of Sieve Analysis (ASTM-D2487) for the coarse fraction of sediments whose particles were bigger to the mesh number 200 (0.075 mm) and Sedimentation Analysis (ASTM-D422) for the fine fraction of sediments which had a granulometric distribution under the sieve number 200 (0.075 mm) up to smaller grain size of 0.001 mm.

To define the presence of silts and clays the System of Group Classification by AASHTO (T-88) was utilized; in our particular case it has been considered the fine fraction which defines silts among a particle size of 0.075 mm to 0.005mm and the clays from 0.005mm to 0.001 mm. Additionally these classification system considers as colloids all the smaller material to 0.001 mm , finer than the silts and clays respectively.

The consistency limits or Atterberg Limit´s are defined by two variables: The Plasticity Limit (PL) defined as the humidity content below which it is consider that soils have no longer plasticity and the Liquid Limit (LL) as the humidity content below which it is consider that soils have plasticity up to the point where this soil humidity content is close to turn into a viscous fluid. The index of plasticity (IP) it associates these two previously aforementioned variables to a plasticity chart developed by A. Casagrande (1910) in which it is reflects the proportion of clay in the fine portion under analysis.

The results of the analysis shows the presence of materials type SM (silty sands) in the bottom of the study area according to the U.S.S.C classification (Unified System of Soils Classification ASTM-D2487). This classification is corroborated by the off-shore geophysical works carried out by Golder Associates in October 2002 in which it is reported that superficial sediments are primarily sands of fine grain and materials such as gravels and smooth cobblestones were only detected in areas near to the shoreline by the side scan sonar.

Likewise the on-shore geotechnical investigation for foundations also carried out by Golder in October of the 2002 indicated that sub-superficial conditions of the studied terrain it is of alluvial origin formed by thinner cemented superficial Eolic Deposits of the type SM (silty sands) and SP-SM (poorly grade silty sands) with lenses of fine materials ML (silt) and CL (clays) to variable depths from 0.3 meters to 6 meters.

The average percentage of sands found at stations T2-12 m (M-1), T2-16 m (M-1), T3-15 m (S-1) and T3-16 m (M-1) was 85% and the average of fine material was 15%. It was only in the sample from T3-12 m (M-1) where the percentage of sands was 70.1% and the percentage of fine material 29.9 % was greater than the average found on the previous samples. The humidities vary from 30.7% and 37.5% and the specific gravity between 2,70 and 2,75.

Regarding the Total Suspended Solids value, the highest values are located in the bottom sampling carried out at the stations T2-12 m (71 mg/L) and T3-16 m (49 mg/L). These values are lower at bottom sampling stations T2-16 m (17 mg/l) and T3-12 m (27mg/l).

The granulometric results using the hydrometer method has shown a greater portion of fine silts than fine clay in the analyzed samples from stations T3-15 m (S-1) and T3-12 m (M-1) according to ASSHTO T-88. It is important to highlight that these fines have no plastic characteristics according to the Consistency Limits carried out where non plasticity (NP) values were produced for the index of

plasticity (IP); this indicates that none to almost none presence of clays was found in the sediment sample (see Table 2-8).

The total results from the physical characterization of the sediment samples as well as for the TSS values obtained during the marine biological sampling can be revised at Table 2-9.

Currents and Bottom Erosion

The current speeds found during the marine biological sampling conducted in this study could generate certain erosion above the 20 cm/s estimated as a permissible value in muddy bottoms if they exists in the area. Speeds of bottom currents reported in other transects (T1,T4,T5,T7) at the perimeter of the trestle present values between 8.78 cm/s and 10.63 cm/s. These conservative values would not produce erosion in the bottom but other associated factors as turbulence in the area could cause turbidity maintaining the particles in constant suspension.

In the case of carrying out a dredged work, the silty sand material (SM) of fine characteristics found in the study area, according to the Stokes law, will have a falling speed of average < to 5 cm/s at calmed waters. The law doesn't take into account the turbulence of the area among other factors that it could delay the process of deposit of the particles thru the time or generating the transport of the particles towards the surface where greater current speeds would be originating a bigger distribution of sediments in the area. The election of the adequate dredging equipment should take into account the sediment plume that can be produced and the greater distances that it can cover from the disturbed area.

2.6.4 Current and Tides

The currents of the South Pacific show the effects of the atmosphere anticyclonic circulation. Two major currents are present along the west coast of South America: the South Equatorial Current and the Peru or Humboldt Current.

The South Equatorial Current flows east to west just south of the Equatorial Countercurrent that on reaching its western limit, turns south and flows along Australia's east coast until it reaches the West Wind Drift Current that flows across the Pacific Ocean along the 50th parallel and flows north as the Peru or Humboldt Current. At 7 or 6° south latitude (Pimentel, Bayóvar) the current turns to the

west toward the Galapagos Islands and follows a NW-W direction changing its name to South Pacific Equatorial Current and completing the circuit.

The Humboldt Current has a general direction of south to northwest-north northwest, with local variations and with an average speed of 30 km per day. The Humboldt Current system is one of the major upwelling systems of the world responsible for high levels of organic production, cold, low salinity waters flowing between the coast and 1,000-km offshore. The coast of Chile and Peru as a result of the Humboldt Current is recognized as the most productive marine ecosystems in the world with the upwelling effect bringing nutrient-rich water to the surface. Approximately 18 to 20 percent of the world's fish comes from the marine ecosystem affected by the Humboldt Current.

The average monthly direction of surficial currents in the study area as a function of time (January 2002 to July 2002) is presented in Figure 2-16. The surficial currents in the region between Tambo de Mora and Cañete generally have a south-north direction during the majority of the year except during summer months (January and February) where the direction is predominantly from the north and a maximum speed of 0.55 knots.

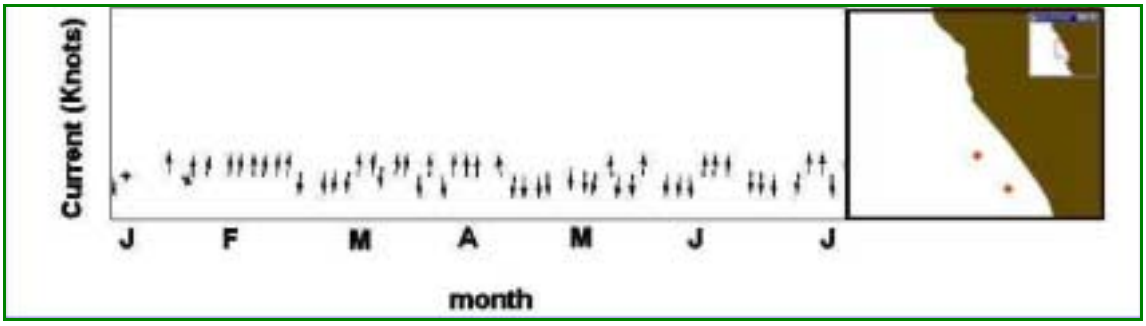


Figure 2-16. Monthly Distribution of the Direction of Currents (January to July 2002).

The coastline in the vicinity of the Project from the surf zone to 30-m offshore is greatly affected by the wind and wave action. The Pampa Melchorita area is characterized with incoming waves with varying angles, which generate long shore and rip currents as shown on Figure 2-17. These types of currents occurring near the beach provide a mechanism for sediment transport. Rip currents (or currents returning to the sea) have the affect of transporting sediments to the sea resulting in steeper

beach slopes near shore, while the long shore currents provide the mechanism of transporting sediments from rivers discharging to the Pacific Ocean such as the Cañete River.



Figure 2-17. Circulation Model of Pampa Melchorita Beach

Tides

The tidal influence in the project area is minor. The tide is semi-diurnal, with mean amplitudes of 0.58 m. The forced tides reach mean values of 0.76 m.

2.6.5 Water Masses

Surface Water Masses

The Peruvian coastal waters are subject to the influence of upwelling and mixing of water. These masses of water have been designated names based on their origin and salinity concentrations by Zuta and Guillén (1970). Figure 2-18 presents the location of these water masses during normal conditions and during the periods where the El Niño is in full force.

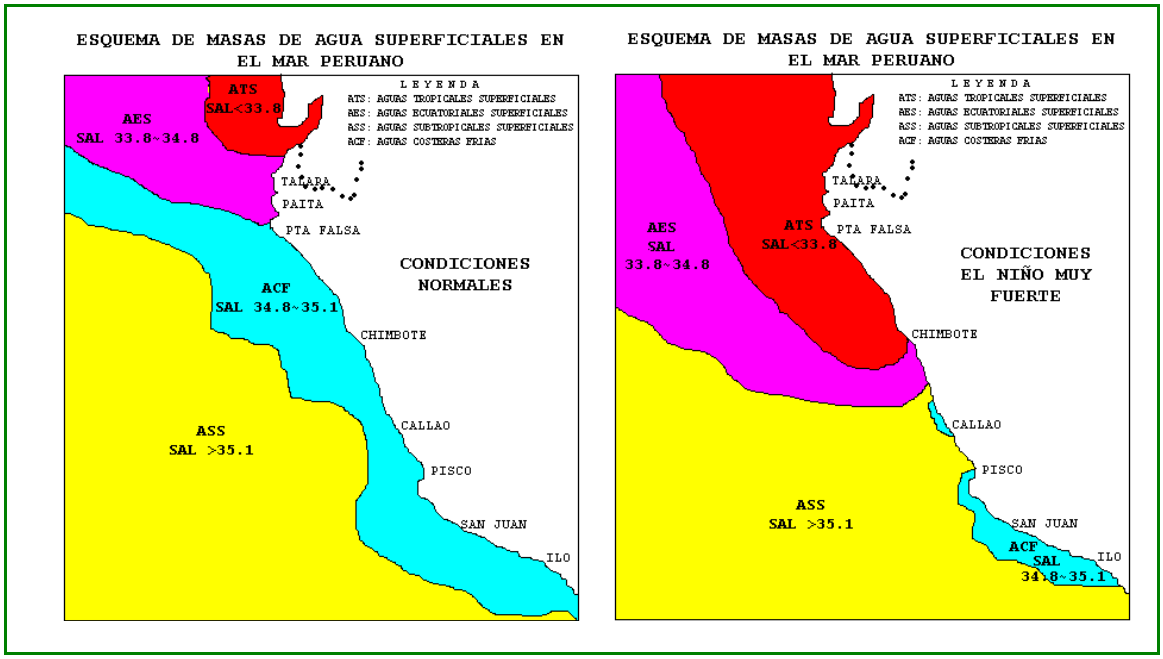


Figure 2-18. Distribution of Surface Water Masses in the Peruvian Pacific during Normal and El Niño conditions

ATS (Tropical Surface Waters) - These waters are generally present north of latitude 4ºS, and can advance southerly when "El Niño" phenomenon occurs. These waters have an equal temperature (homothermal) and equal salinity (homohaline) surface layer of up to 20 m of thickness, located over a huge thermocline.

AES (Equatorial Surface Waters) - These waters are generally present north of latitude 6ºS. Similarly to ATS , these waters have an equal temperature (homothermal) and equal salinity (homohaline) surface layer of approximately 20 m of thickness over a thermocline. The AES masses extend more toward the North in autumn and in winter by the effect of the intense flow of the Peruvian Coast Current, which is reinforced by the upwelling that is developed between 4-6ºS.

ASS (Subtropical Surface Waters) - These waters extend along the Peruvian coast with significant movement toward the coast during the four seasons near Supe and Pisco in summer and winter and near Chimbote and Callao in autumn and spring. The variation in temperature between summer and winter can be significant.

ACF (Coastal Cold Waters) - These waters are present along the Project site coastal area and generally have salinity ranging from 34.8 to 35.1 percent and lower temperatures when compared with the other water masses, since they are affected by an intense upwelling.

Both ATS (Tropical Surface Waters) and ASS (Subtropical Surface Waters) are poor in nutrients. Only coastal cold waters (ACF) are exceptionally rich in nutrients by effect of upwelling.

2.6.6 Surface Sea Temperature (SST)

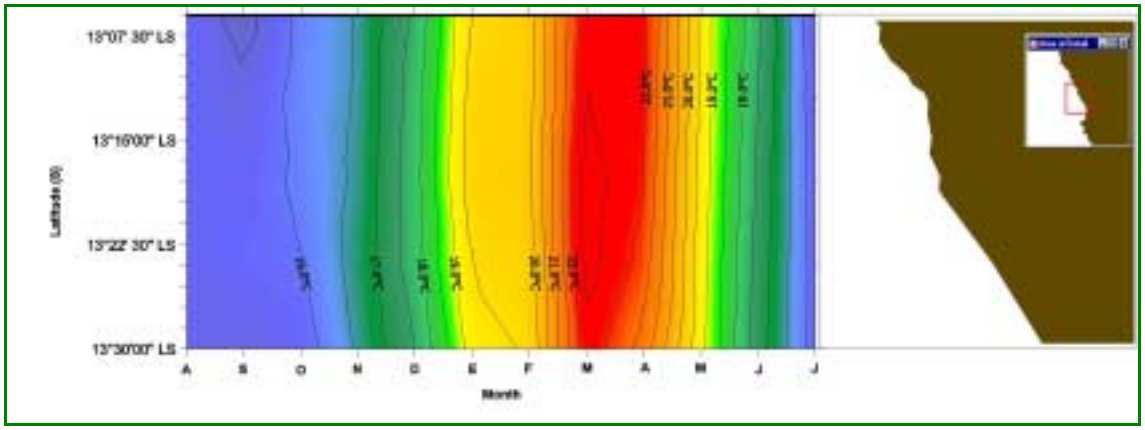


Figure 2-19. Monthly Distribution of Surface Water Temperatures (August 2001 to July 2002).(ref: AVHRR (Advanced Very High Resolution Radiometer) sensor of the NOAA polar orbit satellites)

Figure 2-19 presents isotherms of surface sea temperature (SST) as interpreted from satellite images that indicate a variation in temperature along the coastline of the Project site with little to no latitudinal variations. The coldest water temperatures are generally occur from August to December, with a range of temperatures from 16 to 18 °C, reaching a maximum temperature of 22 °C in the months of March and April. Figure 2-19 demonstrates that the transition period from warm to cold temperatures is faster than the transition period from cold to warm temperatures at the end of the year.

Similar distribution of surface seawater temperatures were measured at the Port of Pisco as presented in the Figure 2-20.

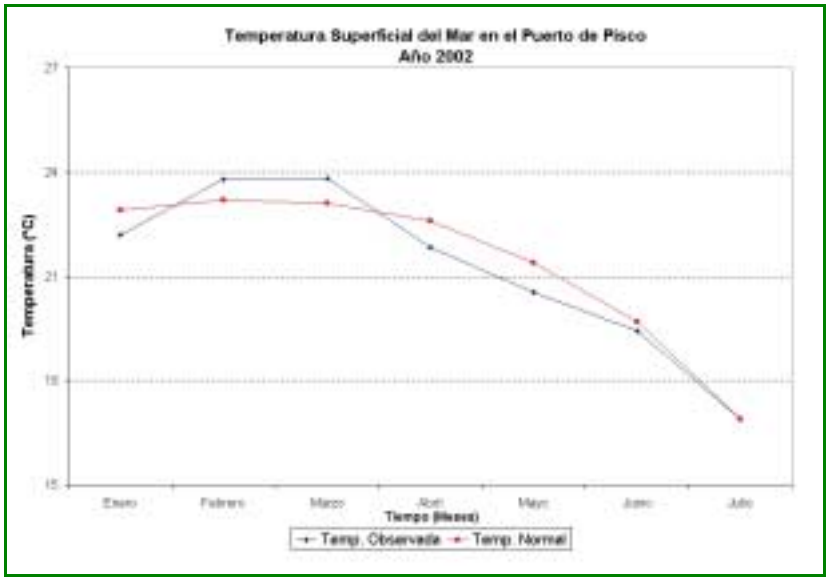


Figure 2-20. Surface Seawater Temperatures Measurements at the Port of Pisco (Source: Boletín Semanal IMARPE)

TABLES

Table 2-1. Local Stratigraphy of the Pampa Melchorita

Era	Period	Epoch	Unit	Description
Cenozoic	Quaternary	Holocene	Eolian Deposits (Qr-e)	Loose sand with incrustations and cemented sand lenses with salts.
			Beach Deposits (Qr-m)	Gravel and loose sand deposit by marine action.
			Colluvial Deposits (Qr-col)	Collapsed alluvial terraces, debris cones.
			Alluvial Deposits (Qr-al)	Clay, sand and rounded gravel layers
		Pleistocen	CAÑETE Formation (Qp-C)	Conglomerate, rounded gravels and slightly cemented

Table 2-2. Soils Classification at Regional and Local Study Area

Soil Taxonomy (1994)			Fao (1994)	Soils
Order	Sub-Order	Great Group	Great Group	
ENTISOL	Fluvent	Torrifluvent	Fluvisols	Herbay, Ribereño Seco, Planicie,
	Orthent	Torriorthent	Regosol	San Jerónimo, Chacramar
	Psamment	Torripsamment	Regosol	Pasamayo, Arenal, Jaguay Alto, Venturosa, Lomadas
ARIDISOL	Orthid	Salorthid	Solonchaks	Melchorita, Terraza Antigua, Ñoco Bajo, Cooperativa, Piaña, Clarita, Cinco Cruces, Cruz Pampa, Granja

Table 2-3. Major Use of Soils at Regional and Local Level

Major Use Capacity					
Group		**Class**		**Subclass**	
Symbol	**Major Use**	**Symbol**	**Agricultural Value**	**Symbol**	**Limiting Factors**
A	Land fitted for clean cultivation	A2	Medium	A2s	Soil restriction
				A2s(r)	Soil restriction and lack of available water for irrigation
				A2sl(r)	Soil restriction
		A3	Low	A3s	Soil restriction
				A3sl	Soil restriction and salt content
				A3slw	Soil restriction, salt content and poor drainage
				A3s(r)	Soil restriction and lack of water for irrigation
				A3sl(r)	Soil restriction, salinity restrictions and lack of water for irrigation
C	Land fitted for permanent cultivation	C3	Low	C3s (r)	Soil restriction and lack of water for irrigation
				C3se (r)	Soil and erosion restrictions and lack of water for irrigation.
				C3sl(r)	Soil, erosion and salinity restrictions. Obligatory irrigation.
F	Land fitted for Forestry	F3	Low	F3sl(r)	Soil and salinity restrictions. Obligatory irrigation.
P	Land fitted for pasture	P2	Medium	P2s (r)	Soil restriction. Obligatory irrigation.
		P3	Low	P3sl (r)	Soil and salinity restrictions. Obligatory irrigation
X	Protected Land			Xs Xse	Soil restrictions. Soil and erosion restrictions.

Table 2-4. Average monthly flows registered at Socsi Hydrometric Station in the Cañete River (m^3/seg)

Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
1994	151	334.8	211.1	74.7	64.7	30.2	19.8	17.1	12.4	10.9	19.3	17.2
1995	23.2	106.3	195.6	52.	123.5	16.2	11.7	9	8.9	10.3	24.7	25.2
1996	133	176.3	184.3	122.3	48.2	17.3	13.6	9.3	9.3	9.5	11.3	19.7
1997	87	150.7	80.1	20.4	16.5	13.1	10.5	9	7.8	8.7	25.1	73.9
1998	184.1	189.1	217.2	135.7	29.5	17.3	16.1	13.7	11.7	11.9	14.7	30

Source: SENAMHI

Table 2-5. Intensities Observed in the Project Area

Date	Magnitude	Intensity Mm In The Project Area	Reference
7/9/1586	M_w 8.1	IX	Sisra-Ceresis, 1985
10/20/1687	M_w 8.4-8.8	IX	Sisra-Ceresis, 1985
10/28/1746	M_w 8.6-9.5	VII-VIII	Sisra-Ceresis, 1985
05/24/1940	M_w 9.0	VI	Salgado, 1978
08/24/1942	M_s 8.2	VI-VII	Salgado, 1978
10/17/1966	M_s 7.5	VI	Salgado, 1978
10/03/1974	M_w 8.1	VI-VII	Gieseche, L. Ocola and Silgado, 1980
04/18/1993	M_w 6.4	IV	P. Huaco and Y. Zamudio, 1993
11/12/1996	M_w 7.7	V-VI	Chatclain et al, 1997
06/23/2001	M_w 8.3	IV-V	Tavera et al, 2001

Table 2-6. Earthquake Measurements and Effects

Intensity	Magnitude	Horizontal Ground Acceleration	Estimated UBC Zoning	Human Reactions and Damages
[Modified Mercalli Scale (abridged) 1931]	(Richter Scale)	(Assumed Approximate Acceleration)	(Uniform Building Code 1982)	(Effects in Term of Life and Property)
I	2.0			Felt only by few in especially favorable circumstances.
II				Felt only by few at rest, especially on upper floors. Delicately suspended objects may swing.
III	3.0		Zone 0	Felt quite noticeably indoors, especially on upper floors. Many do not recognize as earthquake. Standing cars may rock slightly. Vibrations seem like a truck passing. Duration may be estimated.
IV	4.0	0.0069 *g*		Daytime felt indoors by many and outside by few. At night some awakened. Dishes, windows, doors disturbed. Walls creak. Standing cars rock considerably. Sensation like a heavy truck striking building.
V		0.0150 g	Zone 1	Felt by nearly all, many awakened. Some dishes, windows, etc. broken. Some cracked plaster. Unstable objects overturned. Trees, poles, disturbed. Pendulum clocks may stop.
VI	5.0	0.0322 *g*		Felt by all. Many frightened and run outside. Some movement of heavy furniture. Few cases of fallen plaster and damaged chimney, but slight.
VII	6.0	0.0694 *g*	Zone 2	All run outdoors. Negligible damage in well-designed and well-constructed buildings. Slight to moderate in normal

Intensity	Magnitude	Horizontal Ground Acceleration	Estimated UBC Zoning	Human Reactions and Damages
				buildings, considerable in badly built structures, some broken chimneys. Shock noticed by drivers.
VIII		0.1498 *g*		Slight damage to a seismically designed structures; considerable in ordinary and partial collapse; great damage in poorly built. Panel walls thrown from framed structures. Fall of chimneys, columns, walls. Heavy furniture overturned. Disturbs drivers. Small quantities of sand and mud ejected.
IX	7.0	0.3221 *g*	Zone 3	Considerable damage to specially designed structures. Well designed frame structures out of plumb. Partial collapse of substantial buildings. Buildings shifted off foundations. Ground conspicuously cracked. Underground pipes broken.
X		0.694 *g*	Zone 4	Some well-built wooden structures destroyed. Most masonry and frame structures destroyed with foundations. Rails bent. Landslides considerable from riverbanks. Sand and mud shifted. Water slopped over banks.
XI	8.0	1,498 *g*		Few, if any, structures standing. Bridges down. Broad fissures in ground. Underground pipelines completely out of service. Rails greatly bent. Earth slumps and landslips on soft ground.
XII		3.221 *g*		Damage total. Waves seen on ground surface. Objects thrown upwards into the air. Riverbeds displaced. Numerous and extensive landslides.

Table 2-7. Significant Earthquakes in the Central and South Zones of Peru

Date	M_w [1]	Location [2]		Rupture Longitude	Height of the Tsunami	Max. Int.
		Lat.°S	Long °W	(km)	(m)	MM
January 22, 1582	7.5	16.3	73.3	80	1-2	X
July 9, 1586	8.1	12.2	77.7	175	5	IX
November 24,1604	8.7	18.0	71.5	450	10-15	X
May 12, 1664	7.5	14.0	76.0	--.--	--.--	VIII
October 20, 1687	8.4-8.8	13.0	77.5	300	5-10	X
October 28, 1746	8.6-9.5	11.6	77.5	450	20	X-XI
May 13, 1784	8.4	16.5	72.0	300	2-4	X
August 13, 1868	8.8	18.5	71.2	500?	14	X-XI
May 24, 1940	9.0	10.5	77.7	200	--.--	VIII
August 24, 1942	8.2	15.0	76.0	100	Small	VIII
October 17, 1966	7.5	10.6	78.6	100	Medium	VIII
May 31, 1970	7.7	9.2	78.8	200	--.--	VIII
October 3, 1974	8.1	12.3	77.8	250	1.5	VIII

Note: L_{rup}=500km for the event of year 1868 has been obtained from the longitude along the coast of Zone VIII.

(1) Dorbath, 1990, Langer, 1995.

(2) Silgado, 1978.

Table 2-8. Distribution of Bottom Sediments using the Hydrometer Method < mesh 200

Station: T3-15m			**Station: T3-12m**		
Sample: S -1/M-1			**Sample: M-1**		
Mesh Opening (mm)	Cumulative % that goes thru	Fine Material	Mesh Opening (mm)	Cumulative % that goes thru	Fine Material
0.06533	10.00		0.067302	21.1	
0.0555	6.70		0.056630	14.2	
0.04915	5.10		0.049222	13.1	
0.03496	4.40		0.034931	11.9	
0.02486	3.90	Silt	0.025070	8.2	Silt
0.01769	3.40		0.017752	7.8	
0.01297	3.00		0.012982	7.3	
0.00919	2.80		0.009210	7.1	
0.00651	2.60		0.006264	6.9	
0.00497	2.50		0.003935	6.6	Clay
0.00157	2.50	Clay	0.003266	6.4	

Notes:
- Hydrometer Method based on ASTM D-422
- The classification of the fine material was based on ASSHTO T-89 for group.
- The fine part of the samples is only presented with respect to 100% of the total.
- The coarse portion > Mesh No. 200.

Table 2-9. Analysis of Total Suspended Solids and Granulometry in Pampa Melchorita

Station No.	UTM Coordinates (WGS-84)		No. of Sample (1)	Depth (m)	Depth Level	TSS (mg/L)	No. of Sample (2)	USSC Clasific.	W (%)	Size of Grain			Atterberg Limit			Specific	Date of Sampling
	East	North								Gravels	Sands	Fines	LL	LP	IP	Gravity (SG)	
T3-15m	357239	8533298	S-1	15.00	Bottom	-	M-1	SM	30.7	0.00	85.6	14.4	NP	NP	NP	2.70	21/06/2002
T2-16m	357009	8532348	T2-A/ Surface	0.00	Surface	< 5	-	-	-	-	-	-	-	-	-	-	-
			T2-A/8m	8.00	Mid	< 5	-	-	-	-	-	-	-	-	-	-	-
			T2-A/16m	16.00	Bottom	17	M-1	SM	34.8	0.00	85.3	14.7	NP	NP	NP	-	23/06/2002
T2-12m	358259	8533596	T2-B/Surface	0.00	Surface	6	-	-	-	-	-	-	-	-	-	-	-
			T2-B/6m	6.00	Mid	8	-	-	-	-	-	-	-	-	-	-	-
			T2-B/12m	12.00	Bottom	71	M-1	SM	36.5	0.00	86.6	13.4	NP	NP	NP	-	23/06/2002
T3-16m	356376	8532709	T3-A/Surface	0.00	Surface	< 5	-	-	-	-	-	-	-	-	-	-	-
			T3-A/08	8.00	Mid	< 5	-	-	-	-	-	-	-	-	-	-	-
			T3-A/16m	16.00	Bottom	49	M-1	SM	34.7	0.00	82.5	17.5	NP	NP	NP	-	23/06/2002
T3-12m	357934	8533977	T3-B/Surface	0.00	Surface	8	-		-	-	-	-	-	-	-	-	-
			T3-B/6m	6.00	Mid	6	-	-	-	-	-	-	-	-	-	-	-
			T3-B/12m	12.00	Bottom	27	M-1	SM	37.5	0.00	70.1	29.9	NP	NP	NP	2.75	23/06/2002

Notes:

- The No. of Sample (1) corresponds to the seawater samples for total suspended solids analysis (TSS).
- The No. of Sample (2) corresponds to the sediment samples for granulometric analysis.
- The method for TSS is: Standard Method for the examination of Water and Waste Water APHA/AWWA/WEF 19th Ed.1995.
- The physical characterization of the sediments is based on ASTM D-2216, D-421, D-2487,D-4318 and D-854.
- The location of the stations is according to the marine biological survey conducted during this EIA.
- The station T3-15m was not part of this marine biological survey and it is related to the sediment sample S-1 taken by FUGROS-GEOS dated 21-06-02.
- T2 is a lineal transept located at 500m to the south of the central axis of the projected jetty .T2 A it is the sampling area to a depth of 16m and T2B to a depth of 12m.
- T3 is a lineal transept located on the central axis of the projected jetty.T3 A it is the sampling area to a depth of 16m and T3B to a depth of 12m.



MELCHORITA SITE VIEW

LEGEND

ERA	PERIOD	EPOCH	LITHOSTRATIGRAPHIC UNITS
CENOZOIC	QUATERNARY	HOLOCENE	Qr-i: Industrial Deposit: Waste land fill (unconfined).
			Qr-e: Eolian Deposit: Loose sand with surficial crust and lens of cemented sand with salts.
			Qr-m: Beach Deposit: Gravel and loose sand distributed by wave action.
			Qr-col: Colluvial Deposit: Collapsed Alluvium terrace and fan.
			Qr-al/d: Alluvial Desertic Deposit: Silty gravel, clayey gravel (angular to subangular).
			Qr-al: Alluvial Deposit: Interbedded layers of clay, sand and rounded gravel.
		PLEISTOCENE	Qp-c: Cañete Formation: Conglomerate, poorly cemented rounded gravel.
			Disc.
	TERCIARY	PLIOCENE	Ts-p: Pocoto Fm: Coarse grained sandstone, volcanic conglomerate. Andesitic lava. Lava fragments and piroclastics.
			Disc.
		EOCENE	Ti-pa: Paracas Fm: Sandstone with interbedded light brown to light green siltstone.
MESOZOIC	CRETACEOUS	UPPER	
		LOWER	Kis-q: Quilmana Fm: Volcanic-sedimentary sequence at the base, with volcanic rocks in upper section.
			Ki-i: Imperial Fm: Gray limestone intercalated with marly limestone.

SIMBOLOGY

- DEFINED GEOLOGICAL CONTACT
- INFERRED GEOLOGICAL CONTACT
- SCARP
- RIVER
- LOCAL STUDY AREA
- REGIONAL STUDY AREA BOUNDARY

NOTES:

1.- ALL ELEVATIONS ARE IN METRIC UNITS.

2.- THE GRID IS IN THE PSAD-56 COORDINATE SYSTEM.

3.- LAND SURVEY IS BASED ON DRAWING PROVIDED BY PETT (JULY, 2002).

SCALE
0 750 1,500 3,000m
1:50,000

CLIENTE/ *CLIENT*

PERU LNG S.R.L.

TITULO/ *TITLE*

LNG EXPORT PROJECT
PAMPA MELCHORITA, PERU
REGIONAL GEOLOGY

Golder Associates
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DIBUJO/ *DRAWN*	J.W.Y.V.	FECHA/ *DATE*	JULY 2003
EJECUTADO/ *MADE BY*	F.M.	JOB N°.	029-4217
REVISADO/ *REVIEWED*	R.L.	DIRECTORY	.
APROBADO/ *APPROVED*	R.L.		
ESCALA/ *SCALE*	1:50,000	FIGURA/ *FIGURE*	PE-01
FILE	ChapIII_MAP_PE-01		

Aug 01, 2003 - 3:56pm
Por: William Yrga
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MELCHORITA SITE VIEW

LEGEND

Qr - dp — MARINE DEPOSIT
- FINE LOOSE SAND, MOIST, DISTRIBUTED BY WAVE ACTION DURING TIDES.

Qr - em — MIGRANT EOLIAN SAND
- FINE SAND, LOOSE, DRY (DUNE).

Qr - e — EOLIAN DEPOSIT
- SANDS ON COLLUVIALS, ALLUVIALS AND CONGLOMERATES OF CAÑETE FORMATION.

Qr - cr — RECENT COLLUVIAL DEPOSIT
- COBBLES, GRAVEL AND SAND ON COLLAPSED CLIFF AREAS (CONGLOMERATES, SILTSTONE).

Qr - ca — OLD COLLUVIAL DEPOSIT
- COLLAPSED CLIFF AND REMODELED BY EROSION (CONGLOMERATES, SILTSTONE, SANDSTONE, EVAPORITES).

Qr - ad — ALLUVIAL DESERTIC DEPOSIT
- SILTY SAND, WELL GRADUATED SAND AND SANDY GRAVEL, SAND CEMENTED BY SALTS, WITH SILT LENS; VERY DENSE TO CEMENTED HORIZONS.

Qp - al / c — ALLUVIAL DEPOSIT ON CAÑETE FORMATION, CONGLOMERATE WITH SECTIONS OF WEAK, MODERATE AND STRONG CEMENTATION AND HIGH CARBONATE CONTENT. ALTERNATING HORIZONS OF LOW RESISTANCE Ro-R1 BROWN AND GREEN SILTSTONE, LOW RESISTANCE Ro-R1 FRIABLE SANDSTONES AND EXTREMELY SOFT LODOLITE Ro.

SIMBOLOGY

- G-07 — SURVEY BENCH MARK
- TOPOGRAPHICAL DEPRESSION
- 20° — STRIKE AND DIP OF STRATUM
- DEFINED GEOLOGICAL CONTACT
- INFERRED GEOLOGICAL CONTACT
- CLIFF ESCARPMENT
- POSSIBLE COLLAPSED TREND

NOTES:

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4.- THE BATHYMETRY IS BASED ON SEHIDRO'S REPORT (JULY, 2002).

SCALE
0 75 150 300m
1:5,000

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TITULO/ TITLE
LNG EXPORT PROJECT
PAMPA MELCHORITA, PERU
LOCAL GEOLOGY

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ESCALA/ SCALE	1:5,000	FIGURA/ FIGURE	PE-02
FILE	ChapIII_MAP_PE-02		

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Per: William Yrigo
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MELCHORITA SITE VIEW

SOILS NATURAL CLASSIFICATION

SOIL TAXONOMY (USDA, 1999)			FAO (1994)	NAME
ORDER	SUB ORDER	GREAT GROUP	GROUP	
ENTISOLS	Fluvent	Torrifluvent	Fluvisols	Herbay (Hb) Ribereño Seco (RS) Planicie (Pl)
	Orthents	Torriorthents	Regosol	Chacramar (Chm)
	Psamments	Torripsamments	Regosol	Pasamayo (Pm) Arenal (Ar) Jaguay Alto (Jg) Venturosa (Vt)
ARIDISOL	Ortids	Salorthids	Solonchack	Melchorita (Mch) Terraza antigua (Ta) Ñoco bajo (Ñb) Cooperativa (Co) Piaña (Pl) Clarita (Cl) Cinco Cruces (Cs) Cruz Pampa (Cp) Granja (Gj)

CARTOGRAPHIC UNITS SURFACE

CARTOGRAPHIC UNITS		SURFACE	
NAME	SYMBOL	Ha	%
CONSOCIACIONES			
HERBAY	Hb	18.95	0.18
PLANICIE	Pl	358.17	3.33
CHACRAMAR	Chm	441.54	4.11
PASAMAYO	Pm	354.40	3.30
ARENAL	Ar	999.44	9.30
JAGUAY ALTO	Jg	450.63	4.19
VENTUROSA	Vt	614.03	5.71
MELCHORITA	Mch	96.26	0.90
TERRAZA ANTIGUA	Ta	845.87	7.87
COOPERATIVA	Co	222.31	2.06
PIAÑA	Pi	673.30	6.26
CLARITA	Cl	664.60	6.18
CINCO CRUCES	Cs	1315.03	12.23
CRUZ PAMPA	Cp	1915.28	17.81
GRANJA	Gj	34.79	0.32
	SUBTOTAL	9004.60	83.75
MISCELLANEOUS LANDS			
BEACH	Py	468.12	4.35
RIVER BED	L	55.53	0.52
HILL	CR	782.49	7.28
CLIFF	T	441.29	4.10
	SUBTOTAL	1747.43	16.25
TOTAL		10752.03	100.00

SIMBOLOGY

RIVER

REGIONAL STUDY AREA BOUNDARY

NOTES:

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3.- LAND SURVEY IS BASED ON DRAWING PROVIDED BY PETT (JULY, 2002).

SCALE

0 750 1,500 3,000m

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LNG EXPORT PROJECT
PAMPA MELCHORITA, PERU
REGIONAL SOILS

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ESCALA/ *SCALE*	1:50,000	FIGURA/ *FIGURE*	PE-03
FILE	ChapIII_MAP_PE-03		

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Peter Williamson
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MELCHORITA SITE VIEW

SOILS NATURAL CLASSIFICATION ON THE LOCAL AREA OF STUDY

SOIL TAXONOMY (USDA, 1999)				FAO (1994)	NAME
ORDER	SUB-ORDER	GREAT GROUP	SUB-GROUP	GROUP	
ENTISOLS	Psamments	Torripsamments	Typic Torripsamments	Regosol	Lomadas (Lo)
ARIDISOLS	Orthids	Salorthids	Typic Salorthids	Solonchaks	Melchorita (Mch)

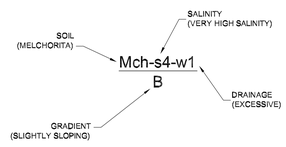
EXTENSION AND APPROXIMATE PERCENTAGE OF SOILS

SOIL NAME	SYMBOL	PHASES			AREA	
		GRADIENT	SALINITY	DRAINAGE	Ha	%
CONSOCIACIONES						
LOMADAS	Lo	B	s4	w1	8.20	1.57
		C	--	--	6.97	1.33
		C	s4	w1	47.22	9.04
		C	s5	w1	56.07	10.73
		D	s4	w1	30.65	5.86
		D	s5	w1	40.82	7.81
MELCHORITA	Mch	A	s4	w1	46.94	8.98
		A	s5	w1	27.73	5.31
		B	s4	w1	139.11	26.62
		B	s5	w1	12.69	2.43
SUB-TOTAL					416.40	79.68
MISCELLANEOUS LANDS						
CLIFF	T	F	--	--	62.11	11.89
		G	--	--	29.74	5.69
		H	--	--	14.34	2.74
SUB-TOTAL					106.19	20.32
TOTAL					522.59	100.00

SOIL PHASES

PHASE	SYMBOL	VALUE	DESCRIPTION
GRADIENT %	A	0 - 2	FLAT or ALMOST TO LEVEL
	B	2 - 4	SLIGHTLY SLOPING
	C	4 - 8	MODERATELY SLOPING
	D	8 - 15	HEAVILY SLOPING
	E	15 - 25	MODERATELY STEEP
	F	25 - 50	STEEP
	G	50 - 75	VERY STEEP
	H	> 75	EXTREMELY STEEP
SALINITY (Electrical Conductivity dS/m)	s4	16 - 25	VERY HIGH SALINITY
	s5	> 25	EXTREME SALINITY
DRAINAGE	w1		EXCESSIVE

SYMBOL EXPLANATION



NOTES:

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4.- THE BATHYMETRY IS BASED ON SEHIDRO'S REPORT (JULY, 2002).

SCALE

0 75 150 300m

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TITULO/ TITLE

LNG EXPORT PROJECT
PAMPA MELCHORITA, PERU
LOCAL SOILS

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ESCALA/ SCALE	1:5,000	FIGURA/ FIGURE	PE-04
FILE	ChapIII_MAP_PE-04		

Aug 01, 2003 - 7:24pm
By: William Yon
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MELCHORITA SITE VIEW

LEGEND

LAND USE MAJOR CAPACITY - REGIONAL STUDY AREA

USE MAJOR CAPACITY							
GROUP		CLASS		SUB-CLASS		AREA	
Symbol	Main Use	Symbol	Agrological Quality	Symbol	Limiting Factors	Ha	%
A	Soils Suitable for annual crops	A2	Media	A2s	Restricted by soil.	430.16	4.00
				A2sl	Restricted by soil and salts.	343.47	3.19
				A2s (r)	Restricted by soil. Requires irrigation.	24.42	0.23
				A2sl (r)	Restricted by soil and salts. Requires irrigation.	96.26	0.90
		A3	Baja	A3s	Restricted by soil.	31.65	0.29
				A3sl	Restricted by soil and salts.	35.83	0.33
				A3sw	Restricted by soil, poor drainage.	19.64	0.18
				A3slw	Restricted by soil, salinity and poor drainage.	53.56	0.50
				A3sl (r)	Restricted by soil and salinity. Requires irrigation.	3481.36	32.38
C	Soils Suitable for permanent crops	C3	Baja	C3s (r)	Restricted by soil. Requires irrigation.	113.50	1.06
				C3sl (r)	Restricted by soil, erosion and salinity. Requires irrigation.	2441.89	22.71
P	Soils Suitable for Pasture	P2	Media	P2s	Restricted by soil.	104.09	0.97
				P2s (r)	Restricted by soil. Requires irrigation.	1163.32	10.82
		P3	Baja	P3sl (r)	Restricted by soil and salinity. Requires irrigation.	760.49	7.07
X	Protection Soils			Xs	Restricted by soil.	309.69	2.88
				Xse	Restricted by soil and erosion.	1342.70	12.49
					TOTAL	10752.03	100.00

SIMBOLOGY

RIVER

REGIONAL STUDY AREA BOUNDARY

NOTES:

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2.- THE GRID IS IN THE PSAD-56 COORDINATE SYSTEM.

3.- LAND SURVEY IS BASED ON DRAWING PROVIDED BY PETT (JULY, 2002).

SCALE

0 750 1,500 3,000m

1:50,000

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PERU LNG S.R.L.

TITULO/ *TITLE*

LNG EXPORT PROJECT
PAMPA MELCHORITA, PERU
LAND USE MAJOR CAPACITY - REGIONAL STUDY AREA

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DIBUJO/ *DRAWN*	J.W.Y.V.	FECHA/ *DATE*	JULY 2003
EJECUTADO/ *MADE BY*	J.R.	JOB N°.	029-4217
REVISADO/ *REVIEWED*	J.R.	DIRECTORY	.
APROBADO/ *APPROVED*	R.L.		
ESCALA/ *SCALE*	1:50,000	FIGURA/ *FIGURE*	PE-05
FILE	ChapIII_MAP_PE-05		

Aug 01, 2003 - 7:34pm
Por: William Tirga
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MELCHORITA SITE VIEW

LEGEND

LAND USE MAJOR CAPACITY - LOCAL STUDY AREA

USE MAJOR CAPACITY					
GROUP		CLASS		SUB-CLASS	
Symbol	Main Use	Symbol	Agrological Quality	Symbol	Limiting Factors
A	Soils Suitable for annual crops	A2	Medium	A2sl (r)	Restricted by soil
		A3	Low	A3sl (r)	Restricted by soil, salinity and drainage.
C	Soils Suitable for permanent crops	C3	Low	C3sl (r)	Restricted by soil and salinity. Requires irrigation.
P	Soils Suitable for Pasture	P3	Low	P3sl (r)	Restricted by soil and salinity. Requires irrigation.
F	Soils Suitable for Forestation	F3	Low	F3sl (r)	Restricted by soil and salinity. Requires irrigation.
X	Protection Soils			Xs	Restricted by soil
				Xse	Restricted by soil and erosion.

EXTENSION AND APPROXIMATE PERCENTAGE OF SOIL UNITS

GROUP	CLASS	SUB-CLASS	AREA	
			Ha	%
A	A2	A2sl (r)	74.67	14.29
	A3	A3sl (r)	155.57	29.77
C	C3	C3sl (r)	110.28	21.10
P	P3	P3sl (r)	38.92	7.45
F	F3	F3sl (r)	36.98	7.08
X		Xs	62.11	11.88
		Xse	44.08	8.43
		TOTAL	522.59	100.00

NOTES:

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2.- THE GRID IS IN THE WGS-84 COORDINATE SYSTEM.

3.- LAND SURVEY IS BASED ON AIRPHOTO RESTITUTION FROM EAGLE MAPPING PERU (MAY, 2002).

4.- THE BATHYMETRY IS BASED ON SEHIDRO'S REPORT (JULY, 2002).

SCALE

0 75 150 300m

1:5,000

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LNG EXPORT PROJECT
PAMPA MELCHORITA, PERU
LAND USE MAJOR CAPACITY - LOCAL STUDY AREA

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EJECUTADO/ MADE BY J.R.	JOB N°. 029-4217
REVISADO/ REVIEWED J.R.	DIRECTORY
APROBADO/ APPROVED R.L.	
ESCALA/ SCALE 1:5,000	FIGURA/ FIGURE PE-06
FILE ChapIII_MAP_PE-06	

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