



**Environment, Social, Health and Safety
Management System (ESHS MS)**

Marine Monitoring Program

**Document Number:
02/ES/QM/IR/001/A01**

TABLE OF CONTENTS

1.0	INTRODUCTION AND ARRANGEMENT OF THIS DOCUMENT.....	3
1.1	Background	3
1.2	Program outline.....	4
1.3	Program schedule.....	5
1.4	Project team and management	15
1.5	Project personnel contact details and responsibilities	17
2.0	THE ENVIRONMENTAL MONITORING PROGRAM	17
2.1	Overall sampling and analytical approach	17
2.2	Sediment sampling in dredging channel	18
2.2.1	Objectives	18
2.2.2	Approach and scheduling	18
2.3	Marine sediment monitoring	19
2.3.1	Objectives	19
2.3.2	Scheduling.....	19
2.3.3	Approach	19
2.4	Marine ecosystem monitoring (including marine biological monitoring).....	21
2.4.1	Objectives	21
2.4.2	Scheduling.....	21
2.4.3	Approach – Marine ecosystem monitoring (abiotic parameters)	21
2.4.4	Approach – Marine biological monitoring	22
2.5	Benthic invertebrate sampling in dredging channel and breakwater footprints	27
2.5.1	Objectives	27
2.5.2	Approach and scheduling	27
2.6	Reporting	28
2.6.1	Objectives	28
2.6.2	Approach and scheduling	28
2.6.3	Deliverables	28
3.0	SUMMARY OF SAMPLE COLLECTION AND ANALYTICAL PROCEDURES	28
3.1	Sampling methods	29
3.1.1	Water	29
3.1.2	Sediments	29
3.1.3	Macrobenthos.....	30
3.1.4	Plankton	30
3.1.5	Fish.....	30
3.2	Analytical methods/protocols	30

4.0	SAFETY	34
4.1	ERT Risk Assessment Record.....	35
5.0	REFERENCES.....	38

1.0 INTRODUCTION AND ARRANGEMENT OF THIS DOCUMENT

This Work Plan details the marine environmental effects monitoring work to be conducted by ERT (Scotland) Ltd (ERT) and its subcontractors on behalf of Peru LNG at its new Liquefied Natural Gas (LNG) Plant facility at Pampa Melchorita. The original version was produced in November 2006. This amended version incorporates additional elements introduced into the monitoring program following recommendations made by the Lender group.

The introductory sections below provide an overview of the whole environmental monitoring program, including a summary of the parameters, timing and locations of all required sampling in Table 1, and maps of sampling stations in Figures 2 to 7.

Section 2 provides further details of each of the separate components of the monitoring program, (dredging channel and breakwater footprint sampling, ecosystem monitoring, marine biological monitoring and sediment monitoring), addressing the scope and strategy/survey design elements, while Section 3 defines the sampling and analytical methods and protocols. Further details on survey methods and documentation are included in the appendices.

1.1 BACKGROUND

Peru LNG plans to construct a Liquefied Natural Gas (LNG) Plant facility at Km 169 of the Pan American Highway (near Melchorita beach) to process natural gas from the onshore Camisea II Field for transport overseas. The LNG plant facility will include surface installations, storage tanks and a marine terminal. The marine terminal will consist of a trestle and platform extending approximately 1.5 km from the shore, a rock load out jetty and a tanker loading jetty, which is to be protected by an approximately 800 m long breakwater lying parallel to the shoreline. The natural water depth in the vicinity of the jetty is just less than 15 m (Figure 1).

As part of the overall construction plan of the new LNG Plant facility, PLNG will undertake marine environmental monitoring studies at the LNG plant site and adjacent areas before and during the construction phase of the project. The objective of these studies will be to characterise the conditions of the marine environment and the local artisanal fishing, to allow the early detection and management of any impacts to the marine environment from construction activities.

PLNG conducted physical, chemical and biological baseline sampling in the area of the future marine terminal as part of the Environmental Impact Assessment (EIA) carried out between 2002 and 2003, and the EIA amendment (Golder Associates, 2003; 2005). The present work program has been developed to fulfill the requirements from the EIA that were incorporated into the Environmental Management and Monitoring Plan (EMMP). The EIA also identified the need for the effective communication of the results of the monitoring program to stakeholders, and the development of a training program aimed at the local fishermen so that they may become involved in the monitoring.

ERT (Scotland) Ltd (ERT) has been awarded overall project management of the study, acting as the international contractor for PLNG's requirements, and will contract the services of approved Peruvian contractors Knight Piésold Consultores S.A. and ALS Environmental.

Figure 1 Location of PLNG's Liquefied Natural Gas (LNG) Plant facility



1.2 PROGRAM OUTLINE

Reliable data for the physical, chemical and biological conditions of the water, sediments and biota must be obtained prior to the commencement of construction in order to provide a detailed baseline with which further monitoring data obtained during the construction phase can be compared. This will augment the data already gathered during the EIA (Golder Associates, 2003; 2005).

The monitoring program scope of work incorporates the requirements of data sheets SM-5 (Monitoring of the Marine Sediment) and SM-6 (Monitoring of the Marine Ecosystem) of the EMMP (Golder Associates, 2003). Copies of these data sheets are included in Appendix 1 of this work plan. PLNG has augmented the program with a more detailed specification for monitoring the biological components, involving additional sampling stations and increased frequency of sampling. Control stations have been introduced to allow comparison of changes observed at the work site with those occurring along the coast to the north and south. Sampling of sediments in the dredging channel before any dredging takes place has also been incorporated into the program. Sampling of benthic invertebrates within the footprints of the dredging channel and breakwater prior to construction was introduced in July 2007 to provide specific baseline data on the fauna that will be removed in these areas, as recommended by the Lender group. Table 1 summarises the scope and timing of the

individual monitoring elements, and Figures 2 to 7 show the locations of the sampling stations. Full details of the scope of each element are presented in Section 2 of this work plan.

Survey and analytical methods follow, as closely as practicable, those utilized for the initial baseline study conducted during the EIA. Modified approaches will be used for ongoing monitoring and analysis where it is recognized that improved technologies will provide better precision or levels of detection. Information on the sampling and analysis methods is presented in Section 3 of this work plan.

All work will be carried out within ERT's general quality control and quality assurance procedures. Knight Piésold staff will manage the field activities with support from experienced ERT marine survey staff. Knight Piésold will also co-ordinate the analysis of samples and collation of data using laboratories operated by ALS Environmental and CERPER. ERT staff will provide quality assurance of the data sets and interpretation of the environmental data and submit the required progress and monitoring reports to PLNG. Trends, tendencies, projections or other indicators of change will be reported to PLNG together with recommendations for corrective action to reduce the potential risks. Specific action plans will be prepared if conditions fall outside of normal or baseline ranges.

A program of communication and environmental training will be undertaken with the local artisanal fishermen, government agencies and other stakeholders. These components of the project will be developed and led by ERT utilising Knight Piésold environmental staff and co-ordinating with PLNG's Community Relations team and Knight Piésold's social staff (under separate contract to PLNG).

1.3 PROGRAM SCHEDULE

The program schedule for the first year's operations is outlined in Table 2. This is based on four survey events per year starting in September 2006. The timeline for the main events is summarised as follows.

Activity	Week beginning
Kick-off meeting (Lima)	4 September 2006
Training workshop	11 September 2006
SPRING SURVEY – full baseline survey ¹	25 September 2006
Analytical program (for September 2006 survey)	mid-October 2006
REPORTS – Quarterly progress reports	18 Dec 2006; 12 Mar 2007
SUMMER SURVEY – Marine biological survey ²	8 January 2007
Analytical program (for January 2007 survey)	starting mid-January 2007
AUTUMN SURVEY – full ecosystem survey ³	26 March 2007
Data review/assessment for baseline survey	from March 2007
Analytical program (March 2007 survey)	starting April 2007
REPORT – baseline survey (1 st year only)	7 May 2007
Presentation of 'baseline' survey report (one-off)	21 May 2007
WINTER SURVEY – Marine biological survey ²	2 July 2007
Analytical program (for July 2007 survey)	mid-July 2007
Data review/assessment for all first year surveys	mid-August 2007
REPORT – first year surveys	10 September 2007
Presentation of report on first year surveys	17 September 2007
2007/2008 Program	mid-September 2007

¹ Includes sediment sampling in dredging channel, marine ecosystem monitoring, marine biological monitoring, and marine sediment monitoring (see Table 1).

² Includes marine biological monitoring only (see Table 1), supplemented by *in situ* water quality readings.

³ Includes marine ecosystem monitoring, marine biological monitoring and marine sediment monitoring (see Table 1)

Table 1 - Summary of monitoring program

Survey/sampling	Parameters	Timing/frequency	Number/location of sampling stations	Date of survey(s)
Sediment sampling in dredging channel	Surficial sediments: physical characteristics; standard metals suite (see SM-5 below); total petroleum hydrocarbons; aromatic hydrocarbons; total and speciated arsenic	- Before dredging starts - Once only	Seven stations within dredging area – see Figure 2	September 2006
Marine ecosystem monitoring (SM-6 of EMMP)	Hydrography: temperature, salinity, currents Seawater quality: dissolved oxygen, pH, total suspended solids, total nitrogen, organic nitrogen, total phosphorus, sulphates, chlorophyll and total arsenic Sediments: granulometry; Microbiology & organic contamination (of seawater): BOD, total coliform, faecal coliform Biology: plankton, macrobenthos, fish (also covered in marine biological monitoring described below)	- Before start of construction Biological components: four times per year Most other components: two times per year in autumn and spring - Arsenic and total suspended solids four times per year	Macrobenthos: - Five stations on each of three transects (T2, T4 & T5) as shown on Figures 3 and 4 (SM-6.1) - plus three stations (to be selected by ERT and approved by PLNG) on each of three additional transects (T1, T3 and T6) as shown on Figure 4 - plus three stations at each of four control sites (two to the north and two to the south of the LNG plant site) determined by ERT prior to survey mobilisation (Figure 6). Plankton: - Four stations on each of three transects (T2, T4 & T5) as shown on Figure 3 (SM-6.1) - Plus two reference stations (C2-12 and C3-12), one each to the north and south of the LNG plant site (Figure 6). Fish*: - Representative samples from the LNG plant site - Representative samples from each of four control sites (two to the north and two to the south) All other components: - Five stations on each of three transects (T2, T4 & T5) as shown on Figure 3 (SM-6.1) - Three stations at each of four control sites being sampled for macrobenthos also need to be	Biological components: September 2006, January, March and July 2007 All other components: September 2006 and March 2007 (following same timing for ongoing years)

Survey/sampling	Parameters	Timing/frequency	Number/location of sampling stations	Date of survey(s)
			sampled for sediment granulometry (Figure 6)	
Hydro-biological (marine biological) monitoring	Fish, plankton and key selected benthic communities: abundance, diversity, spatial and temporal distribution and health; chemical contaminants of fish tissue; stomach contents of bottom feeding fish; quarterly ranking of commercial fish species	Four times per year	As for biological components above	September 2006, January, March and July 2007 (following same timing for ongoing years)
Hydro-biological (marine biological) monitoring	Fish, plankton and key selected benthic communities: abundance, diversity, spatial and temporal distribution and health; chemical contaminants of fish tissue; stomach contents of bottom feeding fish; quarterly ranking of commercial fish species	Four times per year	As for biological components above	September 2006, January, March and July 2007 (following same timing for ongoing years)
Marine sediment monitoring (SM-5 in EMMP)	Surficial sediments: Metals (As, Ca, Cu, Cr, Hg, Ni, Pb, Zn); total petroleum hydrocarbons; aromatic hydrocarbons	• Before start of construction • Two times per year in autumn and spring	• Ten stations, co-ordinates provided by PLNG in Figure 5 (SM-5.1) • Four of the 12 control stations (C1-12, C2-12, C3-12 and C4-12) being sampled for macrobenthos also to be sampled for sediment chemistry (Figure 6)	September 2006 and March 2007 (following same timing for ongoing years)
Benthic invertebrate sampling in dredging channel and breakwater footprints	Macrobenthos: abundance, diversity, biomass, spatial distribution and health	• Before dredging or construction starts • Once only	Four stations within dredging area and breakwater footprint – see Figure 7	July 2007

* As fish will be sampled using gill nets and trammel nets, they cannot be sampled from the single sample points as indicated in SM-6, but quantitative samples will be obtained as suggested.

Table 2 - Program schedule, 1st year

1.3.1.1		2006																								2007															
		July		August					September					October					November					December				January					February					March			
k	Tas	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37			
Fishermen's workshop visit																																									
Contract award and finalization of work program																																									
Procurement, preparation and delivery of equipment and supplies																																									
Preparation of training materials																																									
Kick-off meeting (Peru)																																									
Project approval and initiation (Peru)																																									
TRAINING - First marine monitoring training event																																									
Preparation for baseline survey																																									
SPRING SURVEY – 'baseline' survey																																									
Analytical program (baseline survey)																																									
PLNG environmental database support																																									
REPORT – Quarterly progress reports																																									
Preparation for marine biological survey																																									
SUMMER SURVEY – Marine biological survey																																									
Analytical program (marine biological survey)																																									
Preparation for full ecosystem and sediment survey																																									
AUTUMN SURVEY – full ecosystem survey																																									
Data review/assessment for main environmental report for baseline survey																																									

Table 2 - Continued

1.3.1.3	2007																									
	April				May					June				July				August					September			
1.3.1.4 Task	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	1	2	3	4	5	6	7	8	9	10	11
PLNG environmental database support																										
Analytical program (full ecosystem survey)																										
Data review/assessment for main environmental report for baseline survey																										
REPORT - Submission of main environmental report for baseline survey (1 st year only; later years replaced by quarterly progress report)																										
Presentation of main environmental report for baseline survey (one-off)																										
Preparation for marine biological survey																										
WINTER SURVEY – Marine biological survey																										
Analytical program (biological survey)																										
Data review/assessment for main annual environmental report for 2006/2007 (four surveys)																										
REPORT - Submission of first main annual report for ecosystem surveys Sept/Oct 2006 and Mar/Apr 2007																										
Presentation of first main annual report for ecosystem monitoring																										
Start of 2007/2008 Program																										

Figure 2 Dredging channel sampling stations for sediments (September 2006)

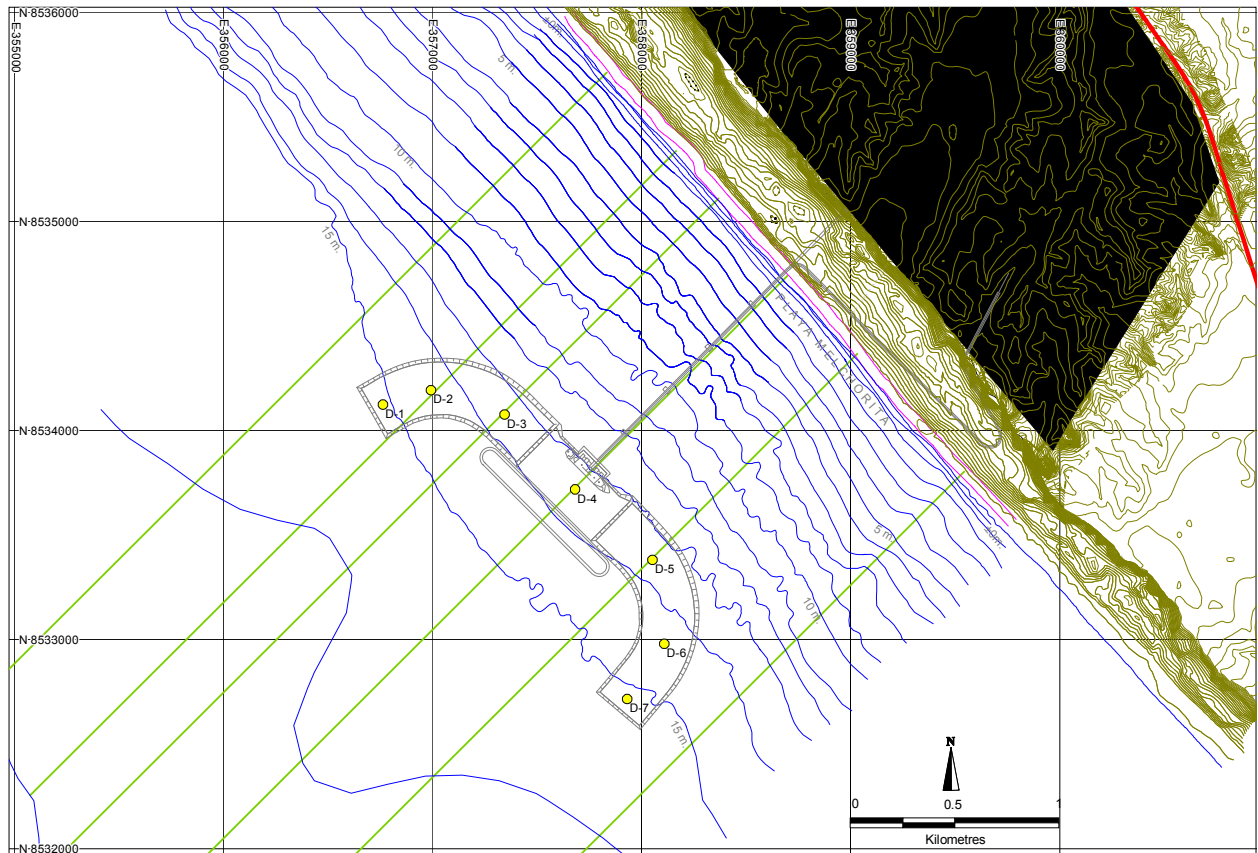


Figure 3 Marine Ecosystem monitoring stations in the work area (based on SM-6.1)

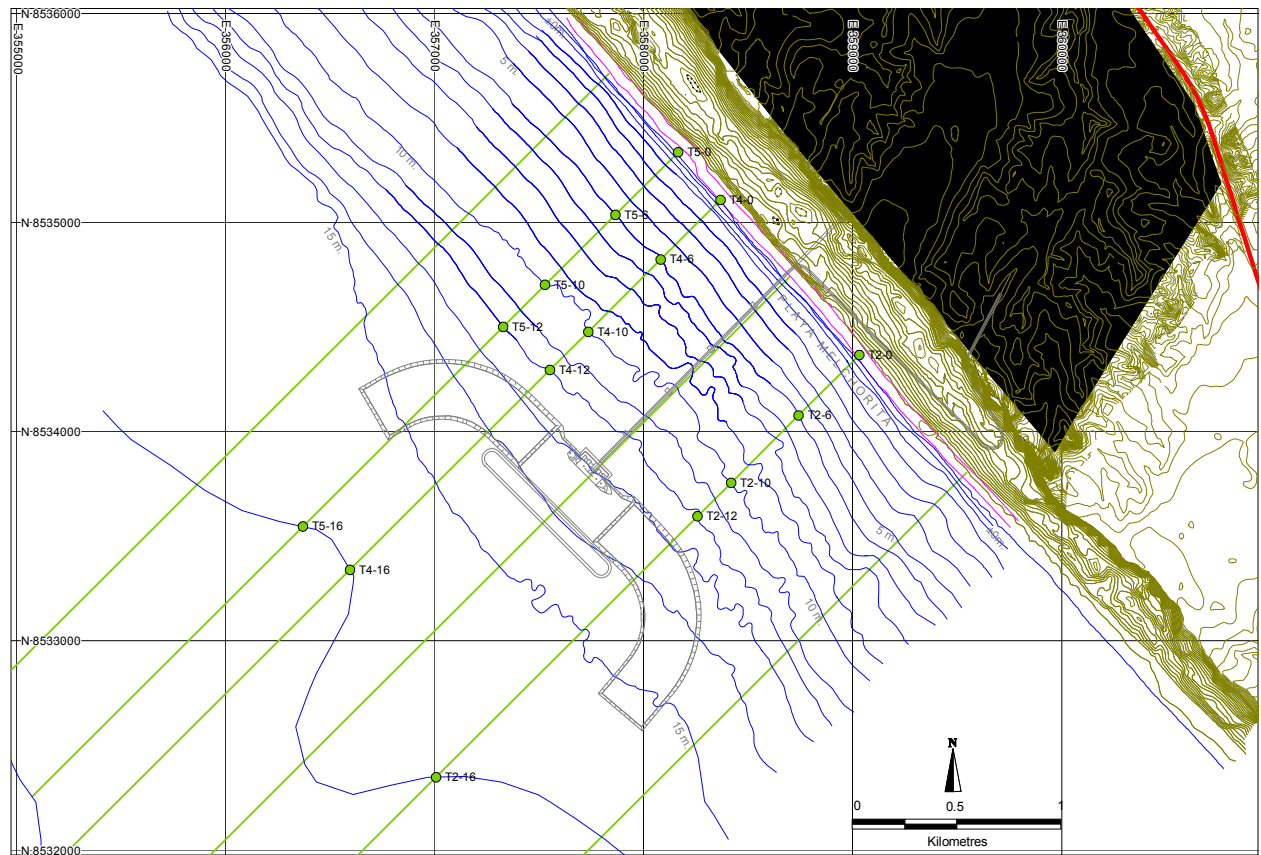


Figure 4 Marine biological monitoring stations in the work area (based on SM-6.1 with additional selected stations)

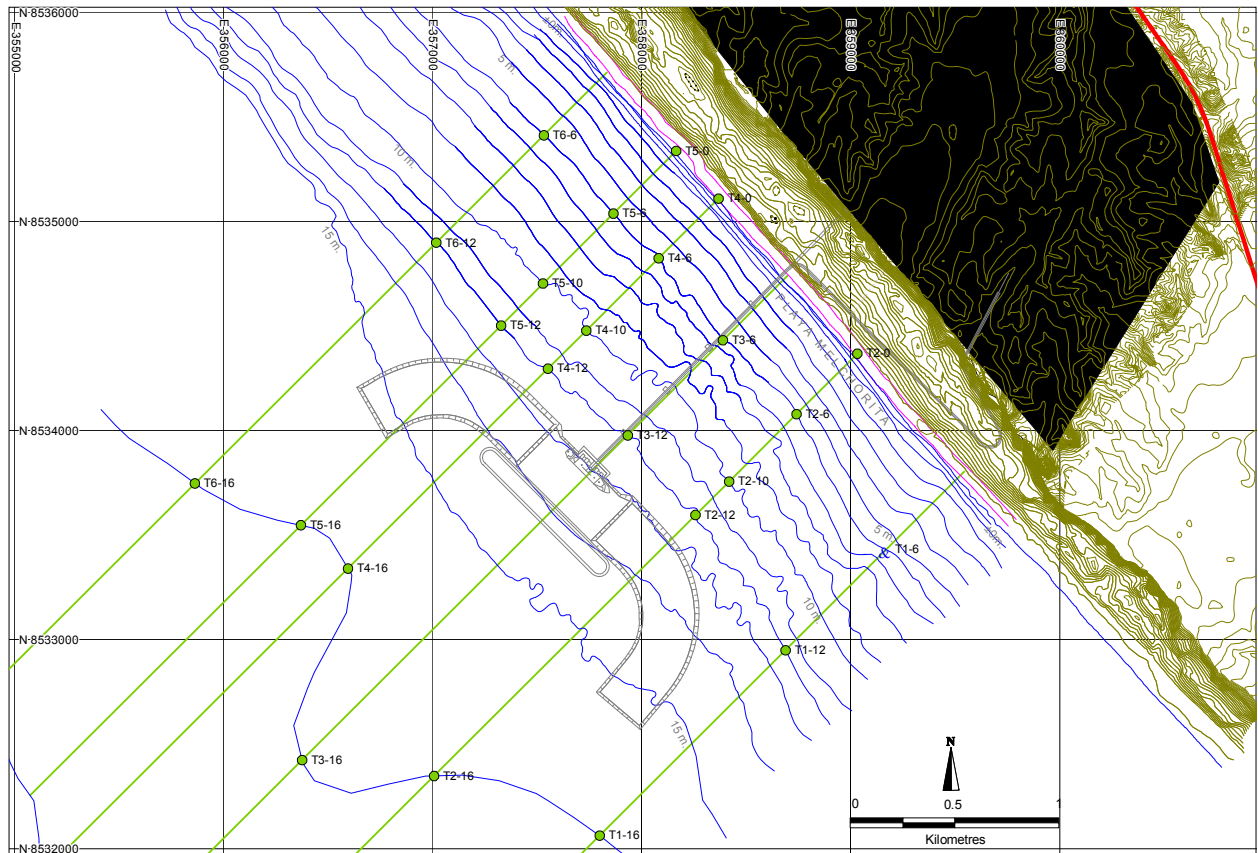


Figure 5 Marine Sediment monitoring stations in the work area (based on SM-5.1)

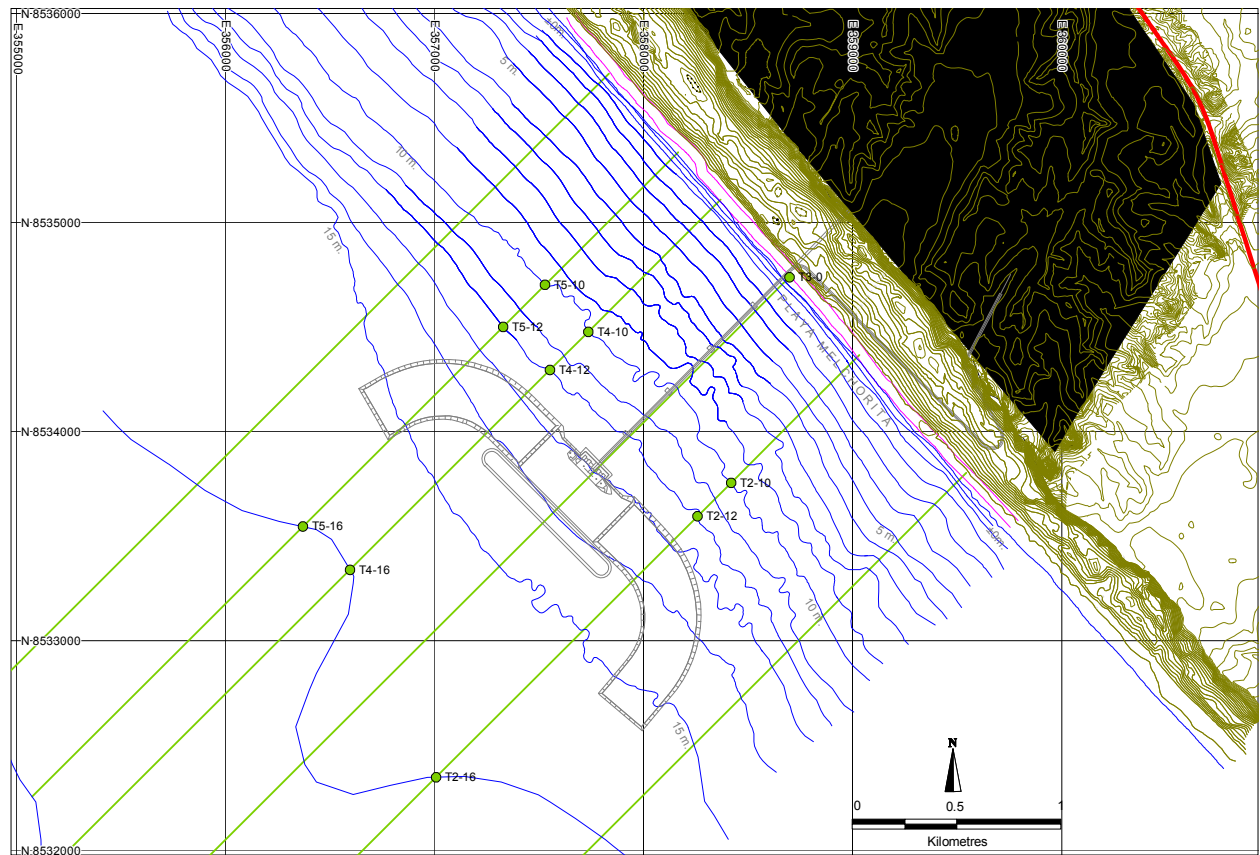


Figure 6 Control monitoring stations (shown in purple)

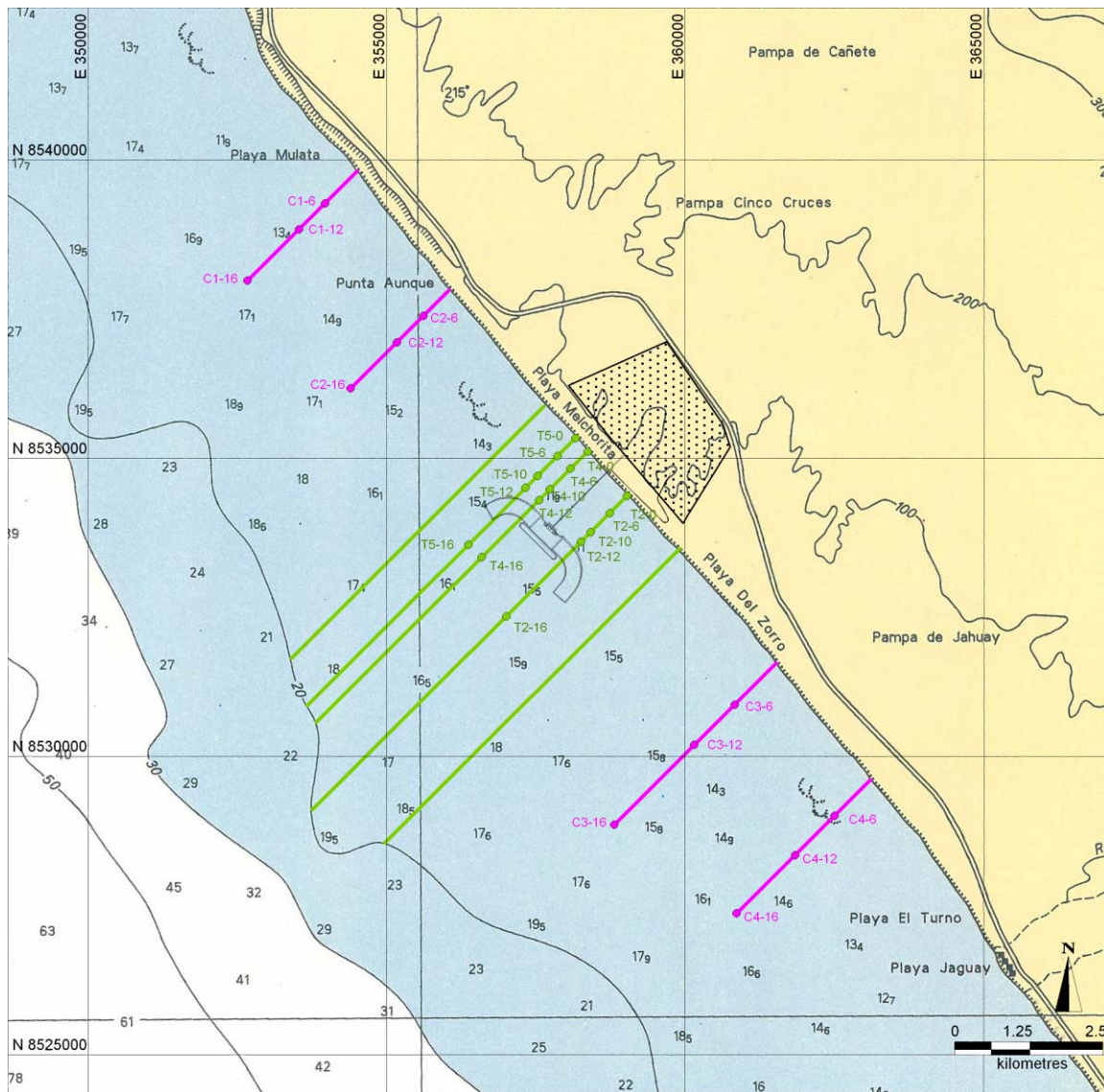
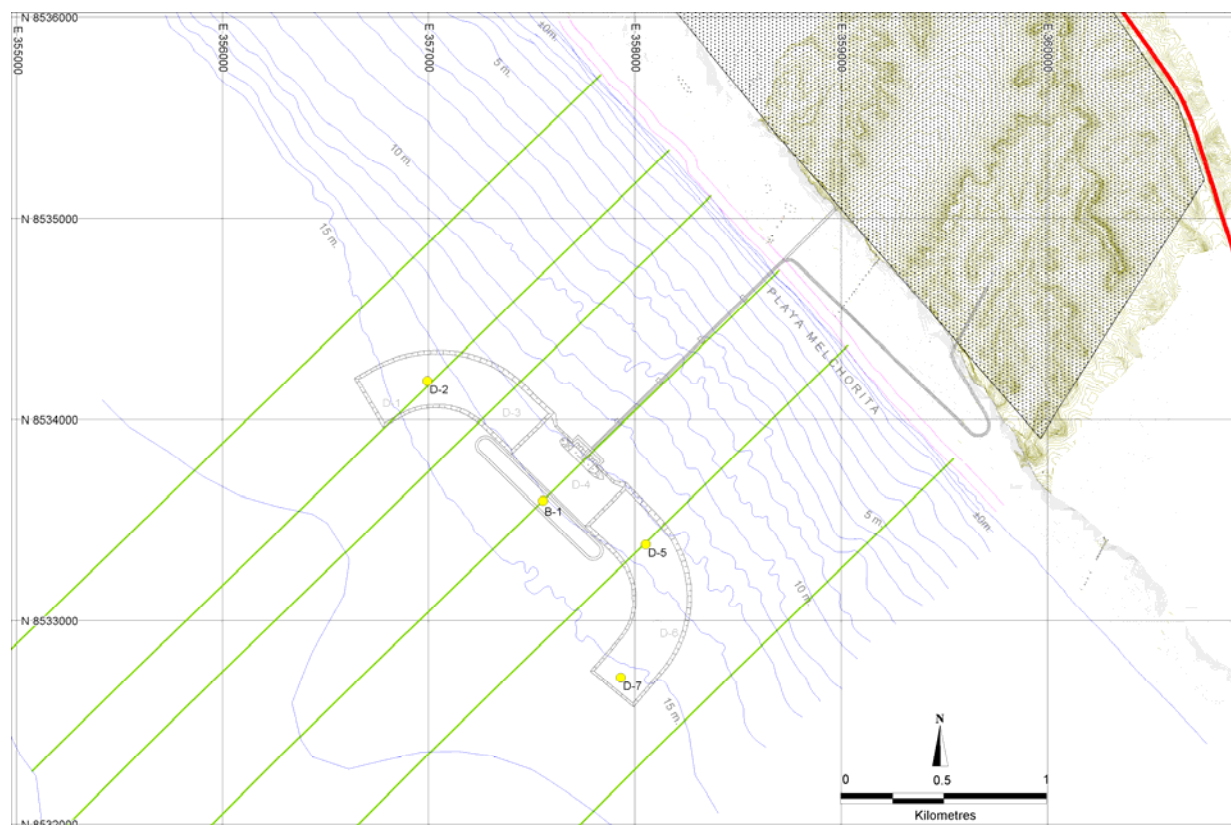


Figure 7 Dredging channel and breakwater sampling stations for macrobenthos (July 2007)



1.4 PROJECT TEAM AND MANAGEMENT

For fulfilling the workscope of this project, ERT has formed a partnership with Knight Piésold Consultores S.A. (Knight Piésold), part of the international engineering and environmental consulting group Knight Piésold Consulting. Based in Lima, Knight Piésold has extensive experience of providing environmental management services for all types of development, with a staff made up of highly qualified scientists and engineers. Knight Piésold's expertise will complement that of ERT, and they will play a major role in the coordination of the marine monitoring and environmental training programs as well as undertaking the biological analysis aspects of the program.

The physical/chemical analysis for the program will be subcontracted to ALS Environmental (via Knight Piésold), an international environmental testing company. The work will be undertaken by qualified chemists who conduct analytical testing using well-documented procedures based on the universally recognized methodologies of American Public Health Association (APHA), United States Environmental Protection Agency (EPA) and others. A few of the types of analyses required are not part of ALS's normal capability, and will be subcontracted to CERPER, which is also a certified laboratory.

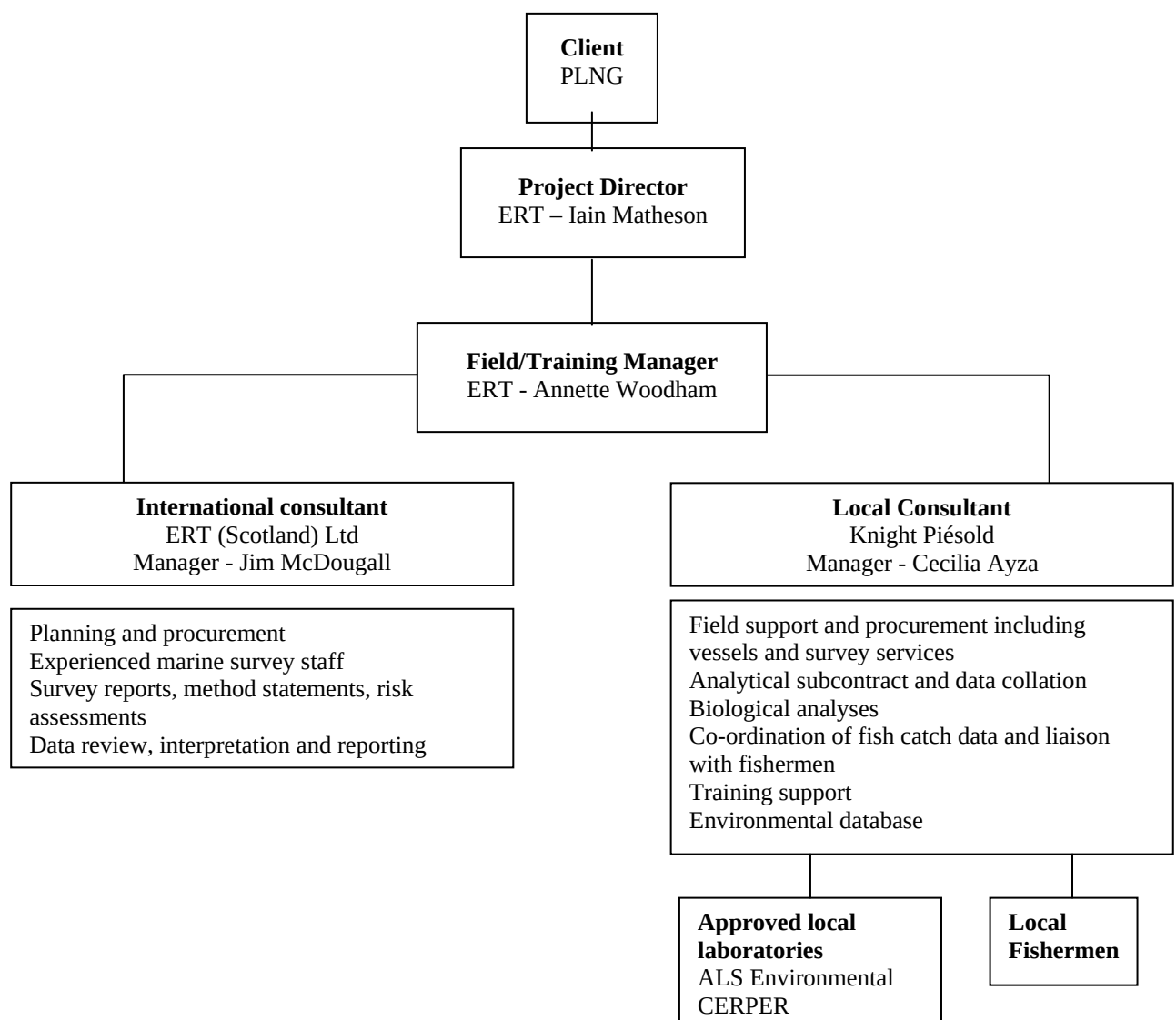
The proposed project team for the work is shown in Figure 7. Iain Matheson (Managing Director) will be Project Director for the program. In-country support to the program will be facilitated by Senior Consultant Annette Woodham who is the designated Field Manager, with an intensive 5-week initial period in Peru following the kick off meeting working with Knight Piésold staff and liaising with other subcontractors (eg ALS Environmental) and the client (PLNG). Dr Iain Dixon will deputise for Annette if required. Support for the program from ERT's Edinburgh base will be through Jim McDougall, Manager of Environmental

Services, acting in the capacity of Project Manager. The training components of the scope of work will also be led by Annette Woodham. She will be supported by Dr Alba Lucia Mulford, an associate consultant of ERT with experience in conducting environmental and marine biological training courses in Latin America. Field activities and training will also be supported utilising ERT's experienced marine scientists (Peter Campbell/Jonathan Hunt) but a pool of other suitably experienced scientific/consultant/technical staff can be called upon to support the survey/training program. These staff will also be utilised in data assessment/QA roles specific to their area of training/expertise (eg Gordon Todd, Senior Chemist).

Knight Piésold's project manager, who would be available for attending meetings with PLNG, is Cecilia Ayza. The key members of her team will be Edmundo Juscamayta and Cristian Terry. Edmundo Juscamayta and Cristian Terry will participate in the fieldwork (including fieldwork practical training) and oversee the biological analyses, and Edmundo Juscamayta will contribute to the training program.

ERT staff will be involved in the survey and training work when available in-country. ERT's involvement in the field survey team will reduce to two members only, after Year 1. Database support will be provided by Knight Piésold staff, as will the coordination of ongoing monthly meetings and the provision of office facilities. Continued training events will be dependent on PLNG requirements. It is envisaged that Year 2 will see greater involvement of local fishermen in the monitoring team following the training in Year 1.

Figure 8 - Project team, management structure and key program responsibilities



1.5 PROJECT PERSONNEL CONTACT DETAILS AND RESPONSIBILITIES

Client – PLNG	Project role	Contact details	
Raymi C Beltran	Project Manager	Office tel Office fax Mobile E-mail	+51 17 072100 +51 17 072499 98 19 19 84 rbeltran@colp.com.pe
ERT Project Team			
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Fiorella Malasquez	Survey	Office tel: E-mail:	+51 17 029090 fmalasquez@kplima.com.pe

2.0 THE ENVIRONMENTAL MONITORING PROGRAM

2.1 OVERALL SAMPLING AND ANALYTICAL APPROACH

All sampling and analyses will be conducted using internationally recognised methodologies. The sampling methods and storage/preservation of collected samples will follow (as closely as possible) those utilised for the baseline sampling program since 2003 and are summarised, together with the analytical procedures, in Section 3 and associated appendices.

Certain water quality parameters (current, depth, temperature, salinity, depth, dissolved oxygen, pH, chlorophyll and turbidity) will be recorded *in-situ* by utilising a multi-probe and a Doppler system deployed from the survey vessel. Specifications for this equipment are provided in Appendix 2. These methods should provide more accurate data on water-

column stratification, as well as minimising the number of 'grabbed' water samples for the determinands required in SM-6. Alternative current measurement methods will be used where necessary, and may be more appropriate where short-term readings are required from each of the designated sample stations.

Sampling will be conducted from suitably certified and classified vessels, sourced locally by Knight Piésold. Fish sampling will be conducted using local fishing vessels of at least 5 m length. For the first survey, in September 2006, sampling will be conducted from the *Carol 1* and the *Tiburón III* (see Appendix 2), mobilising from Paracas and Tambo de Mora respectively.

Positioning at sample stations will be by use of a hand-held GPS (global positioning system). Water depth will be checked as required using a hand-held depth meter.

Template forms for daily progress reporting and logging survey details have been included in Appendices 6 and 7. Safety considerations are summarised in Section 4, which also includes the risk assessment along with appropriate MSDS/COSHH forms (Appendix 8) and incident reporting forms (Appendix 9).

2.2 SEDIMENT SAMPLING IN DREDGING CHANNEL

2.2.1 Objectives

To conduct a one-off sampling event of the superficial layers of the seabed sediment and subsequent sediment analysis, prior to dredging activities within the navigational channel.

2.2.2 Approach and scheduling

Sampling will take place in September 2006 in conjunction with the baseline survey. Seven sampling stations are located within the area to be dredged for the navigation channel, four of which are aligned with transects already established for the monitoring program (Table 3 and Figure 2), as follows:

- Three stations in the shallower (northeastern) part of the dredging area, at water depths of approximately 13 to 14 m;
- two stations at intermediate water depths of approximately 14 to 15 m (one each in the northern and southern arms); and
- two stations in the deeper (southwestern) parts at water depths of >15 m (one each in the northern and southern arms).

A single sample will be collected at each station using a 0.025 m² van Veen grab. The baseline study reported by Golder Associates (2003) indicated relatively homogeneous sediments in the area. As sampling will be carried out using a small hand-held grab, it is only possible to collect a composite sample of surface sediment (down to approximately 8 cm) for analysis.

The analytical scope follows international protocols for marine sediment analysis, and includes analysis for total and aliphatic hydrocarbons, aromatic hydrocarbons (PAHs including EPA16) and a suite of metals by an acid digest protocol (EPA 3050/3051; nitric acid) as this gives a good estimate of bioavailable metals. Of particular importance is the quantification and speciation of the arsenic content of the sediments, as relatively high levels were indicated by the sampling and analysis conducted during the EIA. Grain size analysis will also be undertaken on these samples as this is important for interpreting the chemical data.

Samples will be transported under Knight Piésold's coordination to ALS Environmental laboratories for physical and chemical analysis, under reliable chain-of-custody procedures (see example form in Appendix 5 and details of storage, preservation and analysis methods in Section 3). ALS Environmental will produce data sheets which will be collated and checked by Knight Piésold before forwarding to ERT for final QA and interpretation.

The samples for arsenic speciation will be transported to the UK by ERT and analysed by PS Analytical.

The data will be included in the quarterly progress report to be submitted to PLNG in December 2006. Full interpretation of data from this survey will be provided in the main environmental report for the baseline survey (May 2007). The data will be held on an environmental database to be prepared for PLNG by Knight Piésold with support from ERT as required

Table 3 - Dredging channel sampling plan, September 2006

Station	UTM Coordinates		Sampling Equipment*	Surface samples (0-8 cm)		
	East	North		Granulometry	HC/PAH**	HM***
D1	356764	8534123	Grab	1	1	1
D2	356993	8534192	Grab	1	1	1
D3	357345	8534075	Grab	1	1	1
D4	357682	8533718	Grab	1	1	1
D5	358052	8533381	Grab	1	1	1
D6	358109	8532979	Grab	1	1	1
D7	357931	8532715	Grab	1	1	1

* 0.025 m² van Veen.

** Hydrocarbons/polynuclear aromatic hydrocarbons.

*** Heavy metals suite as specified for SM-5 (As, Hg, Cd, Cu, Cr, Ni, Pb and Zn); in addition analysis for As speciation will be carried out.

2.3 MARINE SEDIMENT MONITORING

The requirement for monitoring the chemical composition of marine sediments is defined in SM-5 of the EMMP in the EIA (see Appendix 1).

2.3.1 Objectives

To carry out monitoring of the marine sediments to ensure that construction activities do not affect normal conditions of the project site.

2.3.2 Scheduling

The initial sampling event will be carried out in September in conjunction with the one-off sediment sampling in the navigation channel (Section 2.2) and the first ecosystem monitoring survey (Section 2.4). This combined sampling program will provide a quantitative baseline for comparison with subsequent monitoring surveys, and will augment the baseline data already obtained during the EIA. An on-going March/September sampling sequence will then be implemented for the sediment monitoring program.

2.3.3 Approach

SM-5 stipulates that samples are to be taken from ten transect stations in the development area as shown on Figure 5 (see Section 1). Nine of these are subtidal stations and coincide with nine of the 12 subtidal stations to be used for the ecosystem monitoring (see Figure 3).

Sediment chemistry monitoring will also be conducted at four of the twelve control sites (one in each control area) that will be established for macrofaunal monitoring (Section 2.4), giving a total of 14 stations (Table 4).

Samples of sediment will be obtained using a 0.025 m² van Veen grab at the subtidal stations, and a corer at the intertidal station. As the baseline study reported by Golder Associates (2003) indicated relatively homogeneous sediments in the area, only a single sample will be taken at each station, with the resources focused on sampling at a relatively high number of stations.

Samples will be transported under Knight Piésold's coordination to ALS Environmental/CERPER laboratories for chemical analysis, under reliable chain-of-custody procedures.

The scope follows international protocols for marine sediment analysis (see Section 3.1.2 and 3.2), and includes analysis for total and aliphatic hydrocarbons, aromatic hydrocarbons (PAHs including EPA16) and a suite of metals as indicated in SM-5. Grain size analysis will also be undertaken on these samples as part of the ecosystem monitoring, which will facilitate interpretation of the chemical data.

ALS Environmental/CERPER will produce data sheets which will be further analysed by experienced staff at ERT. All data reports generated by the laboratories will be integrated by ERT into fully interpretative reports for PLNG. The data will be held on an environmental database to be prepared for PLNG by Knight Piésold with support from ERT as required. The data will be included in the quarterly progress reports to PLNG. Full interpretation of data will be provided in the main annual environmental reports.

Table 4 - Marine sediment monitoring (SM-5) sampling plan, bi-annual surveys

Station	UTM Coordinates		Sampling Equipment*	Surface samples (0-8 cm)	
	East	North		HC/PAH**	HM***
T2-10	358419	8533755	Grab	1	1
T2-12	358259	8533596	Grab	1	1
T2-16	357008	8532348	Grab	1	1
T3-0 ****	358698	8534739	Core	1	1
T4-10	357736	8534478	Grab	1	1
T4-12	357553	8534295	Grab	1	1
T4-16	356596	8533340	Grab	1	1
T5-10	357529	8534702	Grab	1	1
T5-12	357329	8534502	Grab	1	1
T5-16	356371	8533546	Grab	1	1
C1-12	353533	8538836	Grab	1	1
C2-12	355172	8536940	Grab	1	1
C3-12	360153	8530189	Grab	1	1
C4-12	361842	8528342	Grab	1	1

* 0.025 m² van Veen.

** Hydrocarbons/polynuclear aromatic hydrocarbons.

*** Heavy metals suite as specified for SM-5 (As, Hg, Cd, Cu, Cr, Ni, Pb and Zn). (Grain size analysis of these sediments is detailed in the ecosystem monitoring program in Section 2.4).

**** Intertidal station.

2.4 MARINE ECOSYSTEM MONITORING (INCLUDING MARINE BIOLOGICAL MONITORING)

The requirement for ecosystem monitoring is defined in SM-6 of the EMMP in the EIA (see Appendix 1).

2.4.1 Objectives

- To manage and implement an on-going (five-year) program of physical, chemical, microbiological, biological/hydro-biological (marine biological) and hydrographical monitoring of the marine ecosystem at the PLNG site, including all sampling, sample analyses, interpretation and reporting.
- To work with PLNG in the development of PLNG's marine environmental database.
- To produce a quarterly ranking of commercial fish species for use as a baseline in the compensation component of the PLNG project.

2.4.2 Scheduling

The initial sampling event will be carried out in September 2006 in conjunction with the one-off sediment sampling of the dredging channel (Section 2.2) and the marine sediment sampling program (Section 2.3). Then an on-going March/September sampling sequence will be implemented for the full marine ecosystem monitoring program, with additional surveys in January and July to provide quarterly surveys for marine biological parameters.

2.4.3 Approach – Marine ecosystem monitoring (abiotic parameters)

Sampling will be undertaken at the 15 transect stations as required by PLNG and shown on Figure 4 (SM-6.1). Sampling equipment for the 12 sub-tidal stations includes a multiprobe and a direct reading self-recording current meter for various hydrographic and *in situ* seawater quality parameters (depth, temperature, salinity, pH DO, turbidity and chlorophyll), a Niskin Bottle for obtaining seawater samples for subsequent laboratory analyses, and a 0.025 m² van Veen grab for sediments. Sediment samples for granulometric analysis will be obtained from the three intertidal stations using a corer. As the baseline study reported by Golder Associates in 2002 indicated relatively homogeneous sediments in the area, only a single sample will be taken at each station, with the resources focused on sampling at a relatively high number of stations.

Sediment sampling for granulometry will also be conducted at the twelve control sites (Figure 6) that will be established for macrobenthos monitoring, giving a total of 27 stations (Table 5). These data will enhance interpretation of the macrobenthic data, and show to what extent the control sites selected have similar conditions to the development sites (this effort may be reduced for subsequent surveys).

ALS will provide all pre-cleaned sampling containers and chemicals for the field work, and cool boxes to store samples until their arrival at the laboratories. Samples will be analysed primarily at ALS Environmental, with some parameters analysed at CERPER. All data reports generated by the laboratories will be integrated by ERT into fully interpretative reports for PLNG.

Knight Piésold will work on the environmental database for PLNG, with support from ERT as required.

2.4.4 Approach – Marine biological monitoring

Earlier baseline sampling conducted during the EIA established biological sampling two times per year in spring and autumn. The present program continues this pattern but supplements it with additional sampling in the summer and winter, ie four times per year in total. The number of sampling stations has also been increased to include additional transects in work area and at control locations.

Plankton

Because it drifts in the water column, plankton is not very suitable for monitoring impacts from particular sources. Impacts on plankton could occur due to changes in suspended sediment/turbidity levels, but cause and effect is very difficult to establish.

Due to the relatively shallow water depths in the survey area, no significant variability with depth is expected in the plankton communities. Since no plankton indicator species in the area have a diurnal/nocturnal or vertical migrational profile, night-time sampling is not considered necessary.

Phytoplankton will be sampled quantitatively from the surface waters using a Niskin bottle.

Zooplankton samples will be taken using 10 m vertical trawl nets (5 m for the three shallower stations). Sampling will be carried out at the twelve sub-tidal stations identified in SM-6 (Figure 4) along with two control stations, giving a total of 14 sampling stations (Table 6). Analysis of plankton abundance, composition and diversity will be conducted by experienced personnel at CERPER and overseen by Christian Terry. There are no approved laboratories for plankton analysis in Peru, but some samples may be sent to the San Marcos University in case of further specialist input being needed.

Macrobenthos

Benthic macrofaunal communities are particularly useful in monitoring because they are largely sedentary and therefore impacts can be measured quantitatively at specific locations in relation to the source of disturbance. The predicted impacts from dredging and construction activities are physical disturbance and smothering. Although severe physical disturbance may cause mortalities immediately, most effects will be sublethal, such as impairment of feeding or respiration. Also, changes in the surface sediments may alter recruitment or survival patterns.

All of these factors can lead to changes in community composition and structure. Many benthic invertebrates will have an annual recruitment cycle, and any changes in the community will be integrated throughout the year, so it is not possible to monitor in real time. A large number of sampling stations has rightly been indicated at the start, but it is possible that, as the program progresses, meaningful monitoring can be focused on fewer stations in later years.

In addition to the 15 transect stations shown in Figure 4 (SM-6.1), nine additional stations will be sampled in the construction area on the 6, 12 and 16 m depth contours of T1, T3 and T6, assuming samples can be collected near to the jetty on T3. Sampling stations will also be selected to ensure that all key benthic community types are represented in the monitoring program. Four control areas have been identified: two north of the development and two south of it, each containing three sampling stations (Figure 6), giving a total of 36 sampling stations for macrofauna (Table 6).

Sampling at the subtidal stations will be undertaken using a 0.025 m² or 0.05 m² van Veen grab and a 0.5 mm mesh sieve. Macrobenthic communities will be assessed for species abundance, diversity, spatial and temporal (including seasonal) variability, and general condition or status (health). Photographic records of the megabenthos will be collected

which will be beneficial in the communication program. The three intertidal stations be sampled using a corer.

Sample analysis will be conducted by UNALM, overseen by Edmundo Juscamayta. There are no approved laboratories for macrofaunal analysis in Peru, but UNALM and Edmundo have wide experience in the assessment of marine benthos. The Standard Operating Procedures used in ERT's macrobenthos laboratory will be provided as a QC/QA auditable system, and ERT specialists will work closely with Knight Piésold in specifying methods and reporting requirements.

The initial replication (for intra-station and survey-episode variability) for macrofaunal sampling will consist of a minimum of three replicates per station, giving a total of 108 samples to be worked up per quarter. The sampling strategy will be reviewed after Year 2.

Fish

Because they are often highly mobile, the causes of any observed changes in fish populations are also very difficult to establish. Impacts on fish from the construction activities could occur at any stage in the life cycle and may be greatest if there is a disturbance of breeding, nursery or feeding grounds. Adult fish may simply avoid areas of increased noise or sediment plumes.

Since artisanal fisheries are very important in the vicinity of the development, changes in the key catch species need to be monitored. However, relatively large representative samples will be taken from within and outside of the zone of impact, since there is no value in sampling at the same numerous locations used for the seabed and benthos monitoring.

Knight Piésold, with support from ERT, will coordinate the effort required for the fish catches, data assimilation and use of standardised equipment, which will be supplied by local fishermen.

Due to the transitory nature of fish, samples will be taken in five sampling areas (not specific stations). These will be the four control sites, with the work area taken as a single entity for the fifth area. Pelagic and demersal sampling will be carried using a combination of gill nets and bottom trammel nets, for approximately five days in total.

The fish sampled in each catch will be analysed quantitatively to provide the total number of species, the abundance of each species, total weight, weight of representative sample of each species, and biometric evaluation. Tissue samples of representative samples of fish will be analysed for total petroleum hydrocarbons, PAH and metals, and stomach contents will be analysed to obtain information on macrobenthic food species. It is intended that at least five samples per area will be analysed during each survey, but this will be dependent on the occurrence of fish in these areas.

In addition, information on the variability in fish catches from the shore will be obtained by gathering effort and landings data from artisanal fishermen in the area. This will be achieved by walking along the shore at the work site and control locations for six-hour periods at different times of the day and night to speak to fishermen and record fishing activities and catch details, using a pro-forma question sheet.

Table 5 - Ecosystem monitoring (SM-6) sampling plan, bi-annual surveys

Station	UTM Coordinates		Location	Current/speed measurement*	In-situ water quality measurements**	Water quality measurements***	Granulometry****	MOC*****
	East	North						
T2-0	359032	8534367	intertidal		✓	✓	1	✓
T2-6	358742	8534078	subtidal	✓	✓	✓	1	✓
T2-10	358419	8533755	subtidal	✓	✓	✓	1	✓
T2-12	358259	8533596	subtidal	✓	✓	✓	1	✓
T2-16	357008	8532348	subtidal	✓	✓	✓	1	✓
T4-0	358369	8535109	intertidal		✓	✓	1	✓
T4-6	358083	8534824	subtidal	✓	✓	✓	1	✓
T4-10	357736	8534478	subtidal	✓	✓	✓	1	✓
T4-12	357553	8534295	subtidal	✓	✓	✓	1	✓
T4-16	356596	8533340	subtidal	✓	✓	✓	1	✓
T5-0	358166	8535336	intertidal		✓	✓	1	✓
T5-6	357866	8535037	subtidal	✓	✓	✓	1	✓
T5-10	357529	8534702	subtidal	✓	✓	✓	1	✓
T5-12	357329	8534502	subtidal	✓	✓	✓	1	✓
T5-16	356371	8533546	subtidal	✓	✓	✓	1	✓
C1-6	353971	8539273	subtidal				1	
C1-12	353533	8538836	subtidal		✓		1	
C1-16	352669	8537974	subtidal				1	
C2- 6	355617	8537384	subtidal				1	
C2-12	355172	8536940	subtidal		✓		1	
C2-16	354400	8536170	subtidal				1	
C3- 6	360832	8530866	subtidal				1	
C3-12	360153	8530189	subtidal		✓		1	
C3-16	358816	8528855	subtidal				1	
C4-6	36250	852900	subtidal				1	

Station	UTM Coordinates		Location	Current/speed measurement*	In-situ water quality measurements**	Water quality measurements***	Granulometry****	MOC*****
	East	North						
	2	1						
C4-12	36184	852834	subtidal		✓		1	
	2	2						
C4-16	36086	852736	subtidal				1	
	0	3						

* Single point measurements will be taken at each of the 12 ecosystem stations during the September 2006 baseline survey. It may be more valuable during future surveys to obtain data for a complete tidal cycle or longer, from a few selected locations such as one at the work site and one at each of the four control site.

** Taken in-situ from throughout the depth profile using a YSI 6600 Sonde multi-parameter probe (pH, DO, salinity, turbidity, temperature, depth, chlorophyll a). In the event of failure or unavailability of this equipment, water samples will be retrieved from three water depths using a Niskin bottle and measurements taken on board the vessel using alternative probes.

*** Samples collected from surface waters using a Niskin bottle; samples filtered on receipt at laboratory (0.45 µm) then preserved/stored as per Table 7. Samples collected for total suspended solids (TSS), total Nitrogen, organic nitrogen, total phosphorus, sulphates and total arsenic.

**** Samples collected by grab (0.025 m² van Veen); 0-8 cm depth.

***** Microbiological and organic contamination parameters: biochemical oxygen demand (BOD), Total coliform and faecal coliform.

Table 6 - Marine biological monitoring (SM-6) sampling plan, quarterly surveys

Station	UTM Coordinates		Location	Plankton *	Macrobenthos **	Fish ***
	East	North				
T2-0	359032	8534367	intertidal		3	5
T2-6	358742	8534078	subtidal	✓	3	
T2-10	358419	8533755	subtidal	✓	3	
T2-12	358259	8533596	subtidal	✓	3	
T2-16	357008	8532348	subtidal	✓	3	
T4-0	358369	8535109	intertidal		3	
T4-6	358083	8534824	subtidal	✓	3	
T4-10	357736	8534478	subtidal	✓	3	
T4-12	357553	8534295	subtidal	✓	3	
T4-16	356596	8533340	subtidal	✓	3	
T5-0	358166	8535336	intertidal		3	
T5-6	357866	8535037	subtidal	✓	3	
T5-10	357529	8534702	subtidal	✓	3	
T5-12	357329	8534502	subtidal	✓	3	
T5-16	356371	8533546	subtidal	✓	3	
T1-6	359170	8533430	subtidal		3	
T1-12	358689	8532949	subtidal		3	
T1-16	357800	8532062	subtidal		3	
T3-6	358389	8534431	subtidal		3	
T3-12	357935	8533977	subtidal		3	
T3-16	356377	8532423	subtidal		3	
T6-6	357534	8535412	subtidal		3	
T6-12	357019	8534898	subtidal		3	
T6-16	355865	8533747	subtidal		3	5
C1-6	353971	8539273	subtidal		3	
C1-12	353533	8538836	subtidal		3	
C1-16	352669	8537974	subtidal		3	5
C2- 6	355617	8537384	subtidal		3	
C2-12	355172	8536940	subtidal	✓	3	
C2-16	354400	8536170	subtidal		3	5
C3- 6	360832	8530866	subtidal		3	
C3-12	360153	8530189	subtidal	✓	3	
C3-16	358816	8528855	subtidal		3	5
C4-6	362502	8529001	subtidal		3	
C4-12	361842	8528342	subtidal		3	
C4-16	360860	8527363	subtidal		3	

* Sampled using standard plankton nets using 10 m vertical trawls (for 3 stations – 5 m trawls).

** Sub-tidal stations sampled using 0.025 m² van Veen grab; intertidal stations sampled using a corer. Three replicates per station, sieved on a 0.5 mm mesh.

*** Both pelagic (using gill nets) and demersal (by bottom trammel nets) species will be collected at five sampling areas: the four control areas and the work area. Five (if available) representative samples will be taken for analysis of stomach contents and for levels of total hydrocarbons, aromatic hydrocarbons and metals (including total arsenic) in tissues.

2.5 BENTHIC INVERTEBRATE SAMPLING IN DREDGING CHANNEL AND BREAKWATER FOOTPRINTS

2.5.1 Objectives

To sample and characterise the macrobenthic fauna that will be removed or buried during construction of the breakwater and dredging of the navigation channel, prior to the commencement of these activities, as recommended by the Lender group.

2.5.2 Approach and scheduling

Following an environmental and social due diligence review in May 2007, the Lender group noted that there was no macrobenthic or fish sampling within the actual footprints of the breakwater or the dredging channel. The sediments within the breakwater footprint will be permanently buried during the construction and the associated benthic communities, which are predominantly infaunal (living within the sediments), will be destroyed in this area. It is expected that the breakwater itself will become colonised by benthic invertebrates, but these will be different from the existing communities due to the difference in substratum. The benthic communities within the navigation channel will be removed during dredging. Colonisation of the newly exposed sediments within the channel is expected to occur rapidly, but the communities may be somewhat different from those removed, due to changes in water depth, sediment type and water conditions.

The comprehensive macrobenthos sampling plan being implemented as part of the marine ecosystem monitoring (Section 2.4) is intended to provide information representative of the entire survey area. The data obtained will describe the composition and distribution of the communities and factors influencing them, and detect changes that may occur during the construction and operation of the terminal. Data collected during the first three baseline surveys (September 2006, January 2007 and April 2007) showed that water depth and sediment type were the main factors governing macrobenthos distribution, as would be expected. The seven sediment samples taken in the dredging channel at depths of 13.5 to 15.0 m in September 2006 showed the sediment granulometry to be similar throughout the channel and consistent with the trends observed over the entire survey area. The breakwater footprint is adjacent to the dredge channel footprint and within its depth range. There is no reason to suspect any markedly different type of fauna in these areas from those in the rest of the survey area and the loss of these small areas of habitat is unlikely to be significant. However, in order to provide specific baseline data for these areas, the following additional macrobenthos sampling was introduced for the July 2007 survey as part of the seasonal baseline survey program:

- one additional station (named B1) on the central transect T3, where it passes through the breakwater footprint (approximately 14.1 m water depth);
- three of the stations previously sampled for sediments in the dredging channel (Section 2.2), namely D2, D5 and D7 (approximately 14.5, 13.5 and 15.2 m water depth).

Together these four stations should provide optimum information on the range of water depths in the combined footprint areas (Figure 7 and Table 7). Sampling and analytical methods will be the same as those used for macrobenthos in the marine ecosystem monitoring program, ie three replicates will be taken per station using a 0.05 m² van Veen grab and sieved on a 0.5 mm mesh sieve, and sample analysis will be conducted by UNALM and overseen by Edmundo Juscamayta. Macrobenthic communities will be assessed for species abundance, diversity and spatial variability, and compared with those occurring in the wider area.

Full interpretation of the data will be provided in the annual environmental report for the baseline survey, to be drafted in September 2007. The data will be held on an environmental database to be prepared for PLNG by ERT.

Table 7 - Dredging channel and breakwater sampling plan, July 2007

Station	UTM Coordinates		Location	Macrobenthos*
B1	357554	8533598	Subtidal (breakwater)	3
D2	356993	8534192	Subtidal (dredge channel)	3
D5	358052	8533381	Subtidal (dredge channel)	3
D7	357931	8532715	Subtidal (dredge channel)	3

* Sampled using 0.05 m² van Veen grab.

2.6 REPORTING

2.6.1 Objectives

- To identify and report to PLNG any trends or significant changes in the parameters being monitored
- To provide suggested action plans to reduce the potential risk in the event that the monitoring shows deterioration in environmental quality compared to baseline conditions.

2.6.2 Approach and scheduling

Following each survey, the data obtained will be checked and then analysed using appropriate univariate and multivariate statistical techniques and compared with all previous data including that collected during the baseline surveys conducted during the EIA program. It is anticipated that multivariate techniques such as multidimensional scaling will be particularly useful in detecting early signs of change. Based on existing baseline data, it is proposed to establish key indicators of change in consultation with PLNG.

Quarterly progress reports in December, March and May will contain data available at the time, while a fully interpreted report will be provided each year in September. In May 2007, however, an interpreted report will also be provided, to allow communication of baseline data.

2.6.3 Deliverables

- The quarterly progress reports will highlight any particular concerns generated by the data. The main annual reports will contain sections specifically identifying any trends in the datasets, and comparing the monitoring data with background levels, as part of the fully interpretative reporting process.
- Action plans if required.
- Presentation and communication of the findings as part of the communication and training program.

3.0 SUMMARY OF SAMPLE COLLECTION AND ANALYTICAL PROCEDURES

Sampling, preservation and storage of the water, sediment and biological samples will be carried out according to internationally accepted standards and as described in Section 3.1 below. As far as practicable, they are in-line with the methods used on the previous baseline surveys for PLNG. Table 7 provides details of containers and volumes, preservation

methods and holding times for the various determinants. ALS Environmental and CERPER laboratories will provide all pre-cleaned sampling containers and chemicals for the field work, and cool boxes to store samples until their arrival at the laboratories. Summary analytical protocols are presented in Section 3.2.

3.1 SAMPLING METHODS

3.1.1 Water

Hydrophysical/chemical data for temperature, salinity, turbidity, dissolved oxygen, pH and chlorophyll a will be measured *in situ* using a YSI 6600 multiparameter probe system (see Appendix 2 for specifications). Readings will be logged manually at the time of recording using a handheld display unit and downloaded later to a PC. The system calibration will be checked prior to survey operations and at suitable intervals throughout to provide evidence of stability of measurement.

Current speed and direction will be recorded using a Doppler measurement system (Argonaut-XR; see Appendix 2 for specifications) or other suitable method. During the September 2006 survey, half-hourly readings were taken at each of the 12 subtidal stations for the SM-6 program using a jelly pendulum method operated by specialist Dr Cabrera, under contract to Knight Piésold. It is suggested that during future surveys, current depth profiles are obtained at a few selected locations over a longer period of at least a full tidal cycle.

Water samples (for laboratory analysis) will be collected using a Niskin water sampler with the collected samples split for the following parameters:

- Total suspended solids (TSS).
- Total and organic nitrogen.
- Total phosphorus.
- Sulphates.
- Total arsenic.
- Biological oxygen demand (BOD).
- Total and faecal coliform.

The sampler will be flushed with water at each of the sample points prior to collecting each sample. A partial volume of each collected sample will be decanted off into each of the specified receptacles and discarded prior to collecting samples for each determinant.

Note - No filtration will be attempted offshore to avoid possible contamination issues. With the exception of those for arsenic analysis, samples will be stored cooled but unpreserved, and filtered on a 0.45 µm membrane on arrival at the laboratory prior to adding any preservative required (Table 7). The full sampling protocol for use in the field is provided in Appendix 3.

3.1.2 Sediments

Hydrocarbon samples will be taken from the grab sample using a metal scoop and placed in a solvent-cleaned glass jar and stored according to specifications in Table 7. Samples destined for metals analysis will be collected using plastic scoops and stored in jars or double-wrapped plastic bags. Granulometric samples will be taken using a plastic scoop and stored in jars or double-wrapped plastic bags (see Table 7 for preservation methods). All scoops should be appropriately cleaned between sampling stations to avoid cross-contamination.

Possible sources of contamination must be minimized when collecting samples, e.g. oiled/greased wires, smoking near to sample collection/preparation, using contaminated gloves, sticking fingers in samples/containers, oily bilge water on sea surface during sampling. The full sampling protocol for use in the field is provided in Appendix 3.

3.1.3 Macrobenthos

Macrobenthos samples will be obtained using a van Veen grab designed to sample an area of 0,025 m² or 0.05 m², with at least three replicates taken per station. The samples will be then filtered using the 500 um sieve (bag) and then stored in plastic bags or containers until their arrival to shore. Then, samples in bags are transferred into plastic containers and samples are fixed with 10% formalin neutralized with borax, and sealed tightly ready for later laboratory analysis. The full sampling protocol for macrobenthos is presented in Appendix 4.

3.1.4 Plankton

Full sampling protocols for phytoplankton and zooplankton are presented in Appendix 4.

3.1.4.1 Phytoplankton

A Niskin bottle will be used to take the samples at a known volume and depth. A 500 ml aliquot of the water sampled will be placed in a plastic container of similar capacity that contains 5% formalin buffered with 40% borax, used as preservative agent. The containers will be sealed tightly and labelled to record the date and time of sampling, ready for later laboratory analysis.

3.1.4.2 Zooplankton

Qualitative samples will be taken at the deepest stations. Vertical hauls will be carried out using a standard plankton net with a metallic ring of 30 cm and 300 µm net pore. The sample taken in the collector cylinder will be emptied into a container after every throw of the net. The samples will be stored in 500 ml plastic containers containing 10% formalin buffered with 40% borax.

3.1.5 Fish

The full sampling protocols for fish are presented in Appendix 4.

Fish sampling will be conducted separately from the other sampling, from a fishing vessel using a combination of surface and benthic gill nets of various mesh sizes, to sample pelagic and demersal species. All specimens sampled will be identified, counted, measured and weighed, and at least five representative specimens from each area (dependent on the occurrence of sufficient fish in these areas) retained for tissue and stomach contents analysis.

To avoid contamination issues, specimens collected for hydrocarbon/metals analysis will be stored whole and samples of muscle tissue will be removed for analysis under controlled laboratory conditions. Samples destined for hydrocarbon analysis will be wrapped in solvent-cleaned foil and placed in double-wrapped plastic bags. Specimens for metals analysis will be placed in double-wrapped plastic bags. All samples will be stored in a cool state during sampling and frozen (after tissue samples are taken) pending work-up/analysis.

3.2 ANALYTICAL METHODS/PROTOCOLS

Table 8 presents a summary of the proposed physical and chemical methods and detection limits (where applicable) for the analytical program.

Full analytical protocols for the biological analyses (macrobenthos, plankton and fish) are presented in Appendix 4.

Table 7 Containers*, preservation* and holding times* for survey samples, September 2006

Determinant	Container	Preservation	Holding time
Water samples (samples collected by Niskin water sampler unless specified otherwise)			
Temp, pH, DO, turbidity, chlorophyll a, salinity	Measured <i>in situ</i> using YSI 6600 sonde		
Current (speed/direction)	Measured using Sontek Argonaut-XR Doppler system or alternative current measurement system		
TSS	min 250 ml plastic	Cool 4°C	preferably within 24 hrs; max 7 d; filter as soon as possible
Total and organic nitrogen	min 500 ml plastic	Acidify to <pH 2 (sulphuric) and cool 4°C	7 d
Total phosphorus	min 250 ml glass; containers should be acid rinsed with distilled water; DO NOT use detergents containing phosphates	Acidify to <pH 2 (sulphuric) and cool 4°C	28 d
Sulphates	min 250 ml plastic	Cool 4°C	28 d
Total arsenic	min 500 ml plastic; rinse with acid prior to use	Acidify to <pH 2 (2 ml nitric/litre); use only high purity acid; cool 4°C	6 months (for low level concentrations, analyse as soon as possible)
BOD ₅	1 litre glass	Cool 4°C	recommended as short as possible; in no case more than 24 hr
Total and faecal coliform	min 250 ml glass; pre-cleaned with final rinse of distilled water and then sterilised (170±10°C)	Cool 4°C	As short as possible; should not exceed 24 hr
Phytoplankton	500 ml	Buffered formalin	months
Zooplankton	Vertical haul using plankton net	Buffered formalin	months
Sediments (samples collected by 0.025 m² van Veen grab)			
Total hydrocarbons	250 ml glass; pre-cleaned with solvent	Cool 4°C; recommend frozen storage	14 days to extract; 40 days after/Frozen – 6 months
Aromatic hydrocarbons	250 ml glass; pre-cleaned with solvent	Cool 4°C; recommend frozen storage	14 days to extract; 40 days after/Frozen – 6 months
Metals (including speciated As)	100 ml; acid-rinsed prior to use	Cool 4°C; recommend frozen storage	6 months; except Hg – 28 days unless frozen
Granulometry	Plastic or sealable plastic bag	Cool 4°C; recommend frozen storage	months
Macrobenthos	0.5 mm sieved; plastic tub with sealable lid	Buffered formalin	months
Tissue (whole fish collected except for stomach contents for macrobenthos identification)			
Total hydrocarbons	Wrapped in solvent-cleaned foil and bagged (plastic)	4°C initially; then frozen storage	6 months
Aromatic hydrocarbons		4°C initially; then frozen storage	6 months
Metals	Bagged (plastic)	4°C initially; then frozen storage	6 months
Fish (stomach contents)	Dissected and placed in plastic tub	Buffered formalin	months

* Based on Standard Methods for the Examination of Water and Wastewater APHA/AWWA/WEF 19TH Ed. 1998.

Reference APHA-AWWA-WEF (1995). *Standard Methods for the Examination of Water and Wastewater*. 19th ed., American Public Health Association, Washington, D.C

Table 8 Analytical method references and detection limits for survey samples, September 2006

Determinant	Laboratory and method reference	Level of reporting (LOR) or detection limit (DL)
Water		
TSS	APHA 2540 D	Approx 1 mg l ⁻¹
Total and organic nitrogen	APHA 4500-n and 4500-N _{org}	Approx 0.5 mg l ⁻¹
Total phosphorus	APHA 4500-P	Approx 0.5 mg l ⁻¹
Sulphates	APHA 4500-SO ₄ ²⁻	Approx 0.5 mg l ⁻¹
Total arsenic	APHA 3030 D, 3120 B and 3500 series	1 µg l ⁻¹
BOD ₅	APHA 5210 B	Approx 2 mg l ⁻¹
Total and faecal coliform	APHA 9221 or 9222	n/a
Phyto- and zooplankton	APHA 10200 F and G	n/a
Chlorophyll a (for any post calibration required)	APHA 10200 H	0.2 µg l ⁻¹ DL
Sediment		
Total hydrocarbons	ALS Environmental, Prague TPH (C ₁₀₋₄₀) extraction by acetone/hexane, measurement by GC/FID (EN 14039)	1.8 mg kg ⁻¹
Aromatic hydrocarbons	HPLC (EPA 610, 3550)	0.39 mg kg ⁻¹ (total) 0.007 to 0.25 mg kg ⁻¹ (per component)
Metals (including speciated As)	EPA 3050/3051 nitric acid digestion followed by instrumental techniques: Multi-elements – ICP-OES (EPA 6010B) As – cold vapour atomic absorption (EPA 7000, 7062) Cd – cold vapour atomic absorption (EPA 7000) Hg – cold vapour atomic absorption (EPA 7000, 245.7)	As – 0.05, Cu – 1.0, Ni – 5.0, Cd – 0.1, Cr – 2.0, Pb – 2, Zn – 1.0, Hg – 0.005 mg kg ⁻¹
Granulometry	ALS Environmental, Vancouver. CSSS/SSMA-Carter	n/a
Macrobenthos	Quantitative and qualitative enumeration of species	n/a
Fish tissue		
Total hydrocarbons	To be confirmed by CERPER (USEPA 3550B and 8015B)	To be confirmed by CERPER
Aromatic hydrocarbons	To be confirmed by CERPER (USEPA 3550B, 8260B and 8270C)	To be confirmed by CERPER
Metals	Acid digestion (Puget Sound Water Quality Authority, 1995) followed by atomic absorption: As, Se – APHA 3114C; Ba – APHA 3111D; Cd, Co, Cu, Cr, Fe, Mn, Ni, Pb, Zn – APHA 3111B; Hg – APHA 3112B	Hg – 0.002; As – 0.01; Cd, Cu, Mn, Se, Zn – 0.05; Cr, Ni – 0.2; Co, Fe, Pb – 0.3; Ba – 1.0 mg kg ⁻¹
Fish stomach contents – macrobenthos	Quantitative and qualitative enumeration of species	n/a

4.0 SAFETY

The following points highlight main aspects relating to safety consideration for the marine survey operations to be undertaken as part of the monitoring program for PLNG.

- All survey team members have attended PLNG safety induction course.
- A contact list for key personnel/companies involved in the survey operations is provided in Section 1.5 of this document (copies will be made available to personnel as appropriate).
- Prior to sailing a meeting will be held to familiarise all personnel with survey objectives, equipment and procedures. A risk Assessment will be undertaken onboard the vessel/s to assess any boat and equipment specific issues.
- Prior to each task and/or shift commencing a tool box talk will be conducted.
- Incident reporting (*if in doubt...report!*) for ERT/survey personnel will be made by completion of ERT's report form and RIDDOR form (details and copy of each form are included in Appendix 9 for reference; copies will be held by ERT survey leader) and communication of incident to the appropriate personnel onboard. Should the incident require modification to working procedures/scope these should be documented and communicated to/agreed by all parties prior to proceeding again with operations. Reporting will also be to appropriate PLNG personnel as agreed prior to each survey.
- All rigging, fittings and equipment will be certified and in a condition which is fit for purpose.
- During storage, rigging will be maintained in good condition.
- All lifting gear will be used safely with due regard to risks involved.
- COSHH Assessment and Material Safety Data Sheets for all substances to be used must be read and complied with prior to operations commencing (see Appendix 8).
- Appropriate PPE will be worn by operatives when carrying out the tasks identified in this procedure and associated risk assessments.

With regard to field work, risks are accounted for in the risk assessment (see following section for example used for the first survey), which includes all the items considered in the ERT risk assessment requirements. Following risk assessment, all residual risk ratings were judged to be acceptable, but a new risk assessment will be conducted prior to each survey.

4.1 ERT RISK ASSESSMENT RECORD

Project no	1581	Location							
ACTIVITY	Baseline Survey	Assessment team							
Hazard	Consequence	Risk			Control measures to minimise risk	Residual risk			
		HI	Prob	RR		HI	Prob	RR	
Climate									
Onset of rough seas and weather – causing vessel movement.	Personal injury, seasickness, or damage to equipment and vessel.	B	Med	11	Assess weather forecasts. Continuous on-site assessment. Professional judgement and termination of operations if necessary. Ships captain in charge. Secure any loose equipment.	D	Low	5	
Heat	Personal injury, dehydration and heatstroke.	B	Med	11	Use of sunscreen, appropriate PPE including hat with brim/peak. Adequate protection from direct sun and plenty of drinking fluids.	C	Low	6	
Low surface visibility (fog)	Collision – damage to equipment injury/death	B	Med	11	Assess weather forecasts. Continuous on-site assessment. Professional judgement and termination of operations if necessary. Ships captain in charge.	D	Low	5	
Habitat									
Slips, trips and falls on vessel	Injury	C	Med	10	Safety briefings and personal awareness. Adequate first aid provisions. Wear appropriate PPE and general house keeping. Secure equipment from movement.	E	Low	1	
Access to vessel	Injury/death	A	Med	12	Use correct gangway or access ladders. Personal awareness.	E	Low	1	
Use of unfamiliar equipment on vessel	Injury	B	Med	11	Experienced and competent personnel. Personal awareness. Follow safe operating procedures and use safety features. Wear appropriate PPE	E	Low	1	
Equipment									
Heavy equipment	Injury and equipment damage	B	Med	11	Experienced persons on deck. Awareness of manual handling issues. Appropriate resources (eg call for assistance). Good communication between deck crew.	D	Neg	1	
Grab sampling, deployment and recovery	Injury and equipment damage	B	Med	11	Experienced and competent persons for rigging and safe use of equipment. On deck training. Follow safe working practices. Wear appropriate PPE. Good communication between deck crew.	E	Low	1	
Improperly maintained vessel and equipment	Injury or risk to personnel, survey objectives	C	Med	10	Vessel equipment inspected before use.	E	Low	1	
Human									
3 rd party.	Injury	B	Med	11	Qualified or experienced persons. On-site assessment of conditions. On-site training to on deck personnel.	D	Neg	1	
Other sea users	Entanglement in fishing line, buoy lines, collision with boats	A	Med	12	Competent and qualified ships captain and crew.				

HI = Hazard Impact

Prob = Probability

RR = Risk Rating

Med = Medium

Neg = Negligible

Project no	1581		Location					
ACTIVITY	Baseline Survey		Assessment team					
Hazard	Consequence	Risk			Control measures to minimise risk	Residual risk		
		HI	Prob	RR		HI	Prob	RR
Chemicals								
Chemical spill (Formaldehyde)	Injury or damage to environment	B	Med	11	Experienced persons to handle. Awareness of COSHH forms. Safety briefings and training. Follow safe working practices. Wear appropriate PPE. Good communication between deck crew	D	Low	5
Residual risk acceptable?	Yes							
Assessment completed by:								
Name:	Date:							
Position: Survey Leader	Sheet: 1 of							

HI = Hazard Impact Prob = Probability RR = Risk Rating Med = Medium Neg = Negligible

ERT risk assessment matrix					
Consequence	Hazard impact	Risk rating			
Widespread and long-term damage to environment/extreme harm to human health (fatality)/major property loss. Major long term risk to company reputation.	A	4	8	12	16
Damage to environment/major harm to human health (hospitalisation)/significant property damage. Minor short-term risk to company reputation.	B	3	7	11	15
Localised and short-term damage to environment/minor harm to human health/minor property damage. Minor short-term risk to company reputation.	C	2	6	10	14
Negligible or no damage to environment/harm to human health/trivial or no property damage. No risk to company reputation.	D	1	5	9	13
		Negligible	Low	Medium	High
		Probability			

5.0 REFERENCES

PRSS (2006). EXHIBIT A: Scope of Work for Environmental Monitoring, Communication & Training at the LNG Plant Site and associated attachments

Golder Associates (2003). Peru LNG Export Project, Pampa Melchorita, Peru: Environmental Impact Assessment. July 2003.

Golder Associates (2005). Modification to the environmental impact study of the Pampa Melchorita, Peru LNG Export Project. Peru LNG Export Project, EIA Amendment, November 2005.