BEFORE THE BOARD OF INQUIRY
TAMARIND DEVELOPMENT DRILLING APPLICATIONS

EEZ100016

IN THE MATTER	of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012
AND	
IN THE MATTER	of a Board of Inquiry appointed under s52 of the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 to decide on Tamarind Taranaki Limited's marine consent and marine discharge consent applications

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STATEMENT OF EXPERT EVIDENCE OF SHARON BETTY DE LUCA FOR TAMARIND TARANAKI LIMITED

Dated: 20 July 2018

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THE LAWYERS

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MAY IT PLEASE THE BOARD

1. Executive Summary

1.1 I have assessed the potential adverse effects of the proposal on benthic habitats and organisms based on surveys that have been carried out in 2018 and 2016 by SLR, and in previous years by Cawthron Institute. The approach, methodology, analyses and conclusions drawn by SLR are robust and appropriate.

1.2 The benthic habitat and species within the Tui field and control sites are similar to elsewhere within the 100-200m depth habitat of the South Taranaki Basin (**STB**), comprising moderate-high richness, abundance and diversity of benthic invertebrates, the presence of both tolerant and sensitive species, the marine sediments comprising primarily silt, sediment contaminants being largely below effects thresholds, few/nil invasive species present, and habitat modification moderate.

1.3 The proposed planned activities include temporary occupation and disturbance of the benthic habitat, mortality of some benthic invertebrate organisms, minor increases in turbidity, temporary vibration, discharge of drilling and milling fluid, discharge of cement, discharge of treated deck drainage and logistical support activities. Unplanned activities could include spill of chemicals or oil, dropping of supply materials or equipment, and collision of vessels.

1.4 My assessment of the planned activities indicates low and very low levels of effect, apart from the temporary occupation and disturbance of the benthic habitat and organisms, which I have assessed as a moderate level of effect in the short-term but a low level of effect in the long-term once natural re-colonisation and successional processes have occurred. It is my opinion that in the long-term, the benthic invertebrate assemblages within the temporarily affected areas will be similar to that of the surrounding area and control sites.

1.5 Assessment of the unplanned activities indicates, that with appropriate controls and management in place, those activities are highly-extremely unlikely to occur. Should they occur, there could be significant adverse effects on the benthic habitat and organisms.

1.6 Biosecurity controls, checks and permissions in order to bring a drilling rig into New Zealand will be put in place to ensure risks to benthic habitats and organisms and marine ecosystems are negligible.

1.7 I have reviewed the concerns raised by submitters and responded to those concerns. The submissions have not caused me to change my assessment or conclusions.

1.8 Based on the effects identified, I do not consider that the proposed conditions need to include any additional benthic habitat monitoring over and above that which is routinely carried out for monitoring of Production Discharges.

2. Introduction

2.1 My full name is Sharon Betty De Luca.

2.2 I hold the following qualifications:

2.2.1 Bachelor of Science (Zoology) and Doctor of Philosophy (Environmental and Marine Science) from the University of Auckland.

2.3 I am an Associate Partner and Senior Ecologist with Boffa Miskell Limited (**BML**) specialising in marine ecology. I have held this position for the past thirteen years. I have previously worked for City University of Hong Kong (as a Post-Doctoral Fellow) on a variety of research projects focussing on coastal ecology, ecotoxicology, marine microbiology and the development of new techniques for monitoring sublethal stress in marine invertebrates.

2.4 I am a registered member of The Royal Society of New Zealand, the New Zealand Coastal Society and the Environment Institute of Australia and New Zealand and have practised as an environmental scientist for more than 16 years. I am a Certified Environmental Practitioner with the Environment Institute of Australia and New Zealand and I am bound by the Institute's code of ethics. I have published 14 scientific papers in peer reviewed international journals. I am also a qualified Independent Hearing Panel Commissioner.

2.5 My relevant experience in marine ecology includes:

a) Shell Taranaki, 2017: Assessment of effects on benthic marine ecology and biosecurity of pre-installation works, jack-up rig installation, well drilling, servicing and commissioning, logistics operations, general field activities, the discharge of deck drain material, and cumulative effects. Preparation and presentation of expert witness evidence at a Decision Making Panel hearing.

b) Rena Consent to Abandon the Wreck, 2016-2017: Assessment of effect on marine ecological values of abandoning the wreck of the Rena and its remaining cargo. Preparation and presentation of expert witness evidence in Environment Court.

c) Maintenance Discharges from the Auckland Harbour Bridge, 2011-2015: Assessing effects on the marine environment of contaminants (including lead, zinc, paint and sand) from maintenance of the Bridge. This project won a Best Practice Award for Excellence in Integrated Planning at the NZPI 2015 Annual Awards and a merit award at the ACENZ Innovate Awards in 2016.

d) Assessment of Effects of Wastewater Discharges, 2014: Assessing the quality of the intertidal and subtidal marine receiving environment adjacent to the Omanu Beach (Tauranga) wastewater discharge point, including shellfish abundance, quality and diversity, sediment quality, faecal microbiology survey, and stable isotope assessment;

e) Waterview Connection (2009-2011): Assessing the effects of the proposed connection of SH16 and SH20 and widening of the existing SH16 causeway between the Waterview and Te Atatu Interchanges (Auckland). The construction phase effects on marine habitat included permanent loss of subtidal and intertidal habitat, reclamation works and disturbance of benthic sediment. The project was approved by a Board of Inquiry;

f) Pine Harbour Marina (Auckland), 2011-2012: Review of Commissioners' decision on resource consent applications for continued dredging and disposal of dredge spoil in a near shore area. Mediation formed a significant component of this project.

2.6 I have read the following information in preparation of my evidence:

2.6.1 The Marine Consent Application and Marine Discharge Consent Application (the "**Applications**"), the Impact Assessment and Annexures that accompanied the Applications (the "**IA**"), and in particular, the Benthic Ecological Survey Tui Field Facilities (Production Discharge Monitoring) Report (SLR, 2016) and the Tui Field Ecological Effects Monitoring Report (SLR, 2018)[1].

2.6.2 The statements of evidence by:

a) Mr Jason Peacock;
b) Mr Iain McCallum;
c) Dr Brian King;
d) Dr. David Thompson;
e) Dr. Simon Childerhouse;
f) Ms Nicola Gibbs;
g) Dr. Alison Lane;
h) Dr Alison MacDiarmid; and
i) Mr Fraser Colegrave.

2.6.3 Submissions.

2.6.4 Proposed consent conditions.

2.6.5 EPA Key Issues Report, dated July 2018.

2.6.6 The following independent reviews commissioned by the EPA (the "technical reviews"):

a. *Technical Review of Oil Spill Modelling*, prepared by Coffey Services (NZ) Limited, dated June 2018;
b. *Technical Review and Analysis of Operational Activities associated with Sidetrack Development Drilling and Marine Discharge Consent - Assessment Report*, prepared by Oil and Gas Solutions Pty Limited, dated 22 May 2018; and

[1] SLR, 2016. Benthic Ecological Survey Tui Field Facilities (Production Discharge Monitoring), Report Number 740.10040.
SLR, 2018. Tui Field Ecological Effects Monitoring Report, February 2018. Prepared for Tamarind Taranaki Limited.

c. *Review of Marine Environmental Impact Assessment*, prepared by SEAPEN Marine Environmental Services, dated 26 May 2018.

2.6.7 Tamarind's '*Response to the Board's Request for Further Information under section 54 EEZ Act'*, dated July 2018 ("RFI Response").

2.7 My role in relation to Tamarind's applications has been to undertake an independent review of the IA as it relates to benthic marine ecological values (excluding plankton, fish, commercial fisheries, marine mammals, seabirds and marine reptiles), and matters relating to biosecurity, and to consider and assess any potential impacts of the proposed activities on those marine ecological values and relating to biosecurity, and to prepare expert evidence and to respond to any questions raised by the Board, EPA and/or submitters on this topic. For clarity's sake, I was not involved in the preparation of the Impact Assessment.

Code of conduct

2.8 I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court of New Zealand Practice Note 2014 and that I have complied with it when preparing my evidence. Other than when I state I am relying on the advice of another person, this evidence is entirely within my area of expertise. I have not omitted to consider material facts known to me that might alter or detract from the opinions that I express.

2.9 My qualifications as an expert witness are set out above. The issues addressed in this brief relate to the application for a marine consent and marine discharge consent and are matters within my area of expertise.

Scope of evidence

2.10 In this evidence, I will discuss the following:

2.10.1 The approach I have taken to the assessment of level of effect.

2.10.2 Assessment of the existing ecological values of the marine benthic habitat and organisms.

2.10.3 Assessment of potential effects on marine benthic habitats and organisms from the proposed activities.

2.10.4 Response to issues raised by the EPA Key Issues Report and technical reviews, where these are relevant to my evidence.

2.10.5 Response to issues raised by submitters where these are relevant to my evidence.

3. APPROACH TO ASSESSMENT OF LEVEL OF EFFECT

3.1 There are no standard guidelines on how to assess the ecological value of marine habitats. For soft sediment benthic habitats, I have developed, over many years, a set of criteria to guide assessment of ecological value (Table **1**). I have applied these criteria to assess to value of the benthic habitat within the Tamarind permit area.

Table 1: Characteristics of soft sediment benthic marine sites with low, medium and high ecological values[2].

Ecological Value	Characteristics
LOW	• Benthic invertebrate community degraded with low species richness, diversity and abundance. • Benthic invertebrate community dominated by organic enrichment tolerant and mud tolerant organisms with few/no sensitive taxa present. • Marine sediments dominated by silt and clay grain sizes (>70%). • Surface sediment predominantly anoxic (lacking oxygen).

[2] Currently there are no guidelines for how to assess the ecological values of marine environments in New Zealand. The characteristics of soft sediment benthic habitats with low, medium and high ecological values have been developed by Dr De Luca to guide valuing benthic soft sediment environments, and to provide a transparent approach that can be replicated. The characteristics have been applied in EEZ hearing (Shell Todd Oil 2017), Environment Court and Board of Inquiry hearings, including a number of NZTA projects (Transmission Gully, MacKays to Peka Peka, and Puhoi to Warkworth). The characteristics have been modified over the years as improvements are recognised.

Ecological Value	Characteristics
	• Elevated contaminant concentrations in surface sediment, above ISQG-high effects threshold concentrations.[3] • Invasive, opportunistic and disturbance tolerant species dominant. • Habitat highly modified.
MEDIUM	• Benthic invertebrate community typically has moderate species richness, diversity and abundance. • Benthic invertebrate community has both (organic enrichment and mud) tolerant and sensitive taxa present. • Marine sediments typically comprise less than 50-70% silt and clay grain sizes. • Shallow depth of oxygenated surface sediment. • Contaminant concentrations in surface sediment generally below ISQG-high effects threshold concentrations. • Few invasive opportunistic and disturbance tolerant species present. • Habitat modification limited.
HIGH	• Benthic invertebrate community typically has high diversity, species richness and abundance. • Benthic invertebrate community contains many taxa that are sensitive to organic enrichment and mud. • Marine sediments typically comprise <50% silt and clay grain sizes. • Surface sediment oxygenated. • Contaminant concentrations in surface sediment rarely exceed the respective ISQG-low effects threshold concentrations. • Invasive opportunistic and disturbance tolerant species largely absent. • Habitat largely unmodified.

3.2 I then assessed the magnitude of ecological effects using the criteria in (Table 2).

[3] ANZECC (2000) Interim Sediment Quality Guideline (ISQG) High contaminant threshold concentrations.

3.3 I assessed the level of ecological effects by combining ecological value (determined in Table 1) and effect magnitude (Table 2) in general accordance with EIANZ (2018)[4] (Table 3).

Table 2: Criteria for describing effect magnitude (EIANZ, 2018)

Magnitude	Description
Very High	Total loss or very major alteration to key elements/features of the baseline conditions such that the post development character/composition/ attributes will be fundamentally changed and may be lost from the site altogether; AND/OR loss of a very high proportion of the known population or range of the element/feature.
High	Major loss or major alteration to key elements/ features of the baseline (pre-development) conditions such that post development character/ composition/ attributes will be fundamentally changed; AND/OR loss of a high proportion of the known population or range of the element/feature.
Moderate	Loss or alteration to one or more key elements/features of the baseline conditions such that post development character/composition/attributes of baseline will be partially changed; AND/OR loss of a moderate proportion of the known population or range of the element/feature.
Low	Minor shift away from baseline conditions. Change arising from the loss/alteration will be discernible but underlying character/composition/attributes of baseline condition will be similar to pre-development circumstances/patterns; AND/OR having a minor effect on the known population or range of the element/feature.
Negligible	Very slight change from baseline condition. Change barely distinguishable, approximating to the “no change” situation; AND/OR having negligible effect on the known population or range of the element/feature.

[4] Environment Institute of Australia and New Zealand, 2018. Ecological Impact Assessment. EIANZ guidelines for use in New Zealand: terrestrial and freshwater ecology. Second Edition. EIANZ, Melbourne.

3.4 The EIANZ guidelines were developed for terrestrial and freshwater ecology, but are equally applicable to the assessment of effects on marine ecological values[5].

Table 3: Matrix combining magnitude and value for determining the level of ecological impacts

EFFECT LEVEL		Ecological &/or Conservation Value				
		Very High	**High**	**Moderate**	**Low**	**Negligible**
Magnitude	**Very High**	Very High	Very High	High	Moderate	Low
	High	Very High	Very High	Moderate	Low	Very Low
	Moderate	High	High	Moderate	Low	Very Low
	Low	Moderate	Low	Low	Very Low	Very Low
	Negligible	Low	Very Low	Very Low	Very Low	Very Low
	Positive	Net Gain	Net Gain	Net Gain	Net Gain	Net Gain

4. EXISTING ENVIRONMENT

Description of the marine ecological values within the Tui Area

4.1 The Tui Field permit area (or area of interest (**AOI**)[6] is located within the South Taranaki Basin (**STB**) off the west coast of the North Island. The STB covers an area of approximately 330,000km^2. The Taranaki coastal environment is characterised by a high energy wave and wind climate. The predominant wind directions are south-west during August to February and south-easterly during March to July.

4.2 The Tui field production is serviced by the Tui Floating Production, Storage and Offloading (FPSO) vessel Umuroa. In addition to the FPSO Umuroa,

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[5] EIANZ is currently reviewing the guidelines and will be incorporating marine habitats in the next edition of the document. The EIANZ impact assessment guidelines state that the purpose of the document is to provide guidance on good practice in environmental management without being prescriptive. Further, the guidelines state that they are not binding, will be revised from time to time with user feedback and evolving good practice, and practitioners are able to deviate from the guidelines where they consider it is ecologically relevant and justifiable to do so.

[6] Area of Influence is the area within the boundaries of the Petroleum Mining Permit 38158.

the Tui field comprises nine anchor lines, five subsea wellheads and associated subsea trees (Tui 2H, Tui 3H, Amokura 2H, Pateke 3H and Pateke 4H), production flowlines, gas lift lines, and controls umbilicals.

4.3 A number of other oil and gas activities occur within the STB, including those within the Maari Field (**Maari**), which is operated by OMV New Zealand Ltd, those within the Kupe Field (**Kupe**), which is operated by Beach Energy Resources NZ (Kupe) Limited and those within the Maui field, including the Maui A and B platforms (**Maui A and B**), which are operated by Shell Taranaki Limited.

4.4 The AOI is influenced by the Kahurangi/Cape Farewell cold nutrient-rich upwelling plume[7], and the subtropical-originating D'Urville and Westland currents.

4.5 There are a number of marine protected areas, marine reserves and a marine mammal sanctuary along the west coast of the North Island and the top of the South Island[8], all outside of the AOI. In addition, to the west of the AOI the Challenger North Benthic Protected Area is located in deep water.

4.6 My assessment of the existing values within the benthic habitat of the AOI is based on Production Discharge Monitoring and Ecological Effects Monitoring carried out by other scientists, the most recent being SLR in 2018. I have reviewed the 2016 and 2018 SLR reports and conclude that their experimental design, methodology and analyses are robust and appropriate. Previous surveys were also carried out in 2012, 2013 and 2014 using the same approach[9].

4.7 Sampling locations were positioned to align with the predominant or major flow directions (northeast/southwest and north/south) and along the minor flow axis (east) (see Figures 1 and 2 in Appendix 1). Benthic surveys involved grab samples (for macrofauna and sediment quality) and video sled tows (for habitat topography and epifauna).

[7] This upwelling current is an important driver of plankton productivity in the STB.
[8] Drawing 0435786s_G002_R1.mxd within the Impact Assessment.
[9] Johnston et al., 2014, Elvines, et al., 2013, Johnston & Forest, 2012.

4.8 The seabed (or benthic habitat) within the AOI is between 100-120m water depth, where there is insufficient light penetration for photosynthesis[10]. The eastern boundary of the AOI is approximately 50 km off the Taranaki Peninsula. Typically, the seabed within the AOI is flat, with occasional mounds and hollows most likely caused by the burrowing of larger macroinvertebrates (worms and shrimp) to cause mounds and the feeding activities of rays and sharks forming hollows. The seabed is characterised by oxygenated, soft sediment (predominantly low relief silt and clay (c. 65-85%) and very fine and fine sand).

4.9 Total organic carbon (**TOC**) was within the range detected at control sites but lower in the 2018 survey (average 0.78%) compared to previous years (average 0.83-1.01%). There is a weak trend of increasing TOC with distance from the FPSO along the NE axis, which is consistent with, and related to, a higher proportion of silt and clay at those sites (i.e. finer particles have greater adsorption of organic matter).

4.10 The concentration of metals and metalloids in sediment detected in the 2018 surveys are all below ANZECC[11] Interim Sediment Quality Guidelines Low (ISQG-L). Nickel is naturally occurring in sediments within the STB and was detected close to the ISQG-L.

4.11 Polycyclic aromatic hydrocarbons (PAHs) were below analytical detection limits in almost all sediment samples collected in 2018. Past surveys have also indicated some PAHs present at low concentrations in benthic sediments throughout the STB, indicating that the presence of PAHs are unlikely to be due to activities within the Tui Field. Petroleum hydrocarbons were not found in any sediment samples in the 2018 (and all previous) surveys.

4.12 Barium[12], which is used as a weighting agent in drilling muds, was detected at high concentrations in sediment close to FPSO Umuroa (31-103 mg/kg in 2016) compared to control sites and background concentrations in 2012 (c.

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[10] Dysphotic zone (80-200m) - where there is insufficient sunlight for photosynthesis.

[11] ANZECC (2000) Australian and New Zealand Guidelines for Fresh and Marine Water Quality. Australian and New Zealand Environment and Conservation Council and Agriculture and Resource Management Council of Australia and New Zealand, Canberra, Australia.

[12] Barium is considered relatively inert and non-toxic (Neff, J., 2008. Estimation of bioavailability of metals from drilling mud barite. Integrated Environmental Assessment and Management, 4 (2), 184-193).

35 mg/kg). However, the 2018 survey data does not indicate a spatial gradient in Barium concentration. The highest concentration was detected at a site 4000m to the south (58 mg/kg), with other sites having a barium concentration of between 26-52 mg/kg.

4.13 In the 2018 survey, there were no notable signs of drilling or production materials such as drilling muds/gels, rust and paint flakes or cuttings in the sediment samples collected.

4.14 While coastal runoff and activities associated with gas and oil mining may affect the water quality within the AOI within localised areas and over short time scales, the primary factor influencing water quality are oceanic and local currents. Discharges from the existing Tui Field activities include produced water, comminuted food waste, oily water, and treated sewage and greywater. Produced water typically has lower oxygenation and lower pH than receiving environment water and can contain hydrocarbons, metals, metalloids and other contaminants. Laboratory toxicity tests indicated that produced water was not toxic after dilution by a ratio of approximately 23 parts seawater to 1 part produced water. This level of dilution is rapidly achieved when discharged to the marine receiving environment. Water quality data indicates the concentrations of contaminants in seawater collected from sites 500m and 1,000m downstream of the FPSO Umuroa are within ANZECC (2000) 95% species protection level[13].

4.15 The benthic macrofaunal assemblage within the Tui field comprised approximately 50% polychaete worms, whereas at the North and South control sites polychaete worms comprised approximately 65% of the assemblage. Other dominant organisms within the Tui field and control sites included bivalves (hinge shelled mollusc or shellfish, ostracods (seed shrimp), ophiuroidea (brittle stars), isopods (slater-like organisms), gastropods (snails or whelks) and cumacea (hooded or comma shrimp). The assemblages are typical of those previously described in the STB.

4.16 Eight of the ten most abundant taxa within the Tui field were also in the top ten taxa detected at both of the control sites, indicating similarities in assemblages among sites. However, a statistically significant difference in community composition was detected between the Tui field sites and the SE

[13] For those contaminants where ANZECC (2000) trigger guidelines exist.

control site, but not between the Tui field sites and the NW control site. The NW control site is located approximately 2km west of the recently completed Pateke 4H development well, whereas the SE control site is located >6.5km from any activities within the Tui field. The similarity between the Tui field sites and the NW control site could be due to both sets of survey sites being located close to well activities, or it could be natural variability. It is likely that the higher abundance of one group of sensitive polychaete worm (Maldanidae) at both the Tui field sites and the NW control site, compared to the SE control site, is contributing to the statistical similarity detected[14]. Benthic infauna communities are commonly reported in scientific literature as being highly spatially and temporally variable. Analysis of the benthic community composition across all sites surveyed among years (2012, 2013, 2014, 2016 and 2018) indicated significant differences in assemblages between all years which confirms that high natural variability.

4.17 The average number of taxa, abundance, Shannon-Wiener diversity index, and Pielou's evenness values were similar among sites in the 2018 survey. Within the Tui field, there was a significant difference in assemblage relating to distance from the FPSO Umuroa, solely driven by a higher abundance of three species of bivalve (two of which have known sensitivity to disturbance) at site NE300m compared to site NE4000m. A higher abundance of bivalves at sites closer to FPSO Umuroa has also been reported in previous years.

4.18 Many subtidal and deep-water species remain undescribed or there is little known about them. The most abundant species at Tui field and control sites are described further below[15].

a) Maldanidae

Maldanidae are a family of polychaete worms, also referred to as bamboo worms. They live below surface sediment in flimsy sediment tubes. They are bulk consumers of sediment, depositing sediment on the surface in earthworm-like casts. This group of worms are considered to be sensitive to disturbance. Maldanidae are locally common, occurring throughout New Zealand in both subtidal and intertidal

[14] Table 5, SLR (2018).
[15] NIWA Guide to Polychaetes.

habitats, with abundance at some sites up to approximately 400 individuals per m^2.

b) Paraonidae

Slender burrowing polychaete worms, which selectively feed on grain-sized organisms such as protozoans and diatoms. They are found throughout New Zealand in intertidal and subtidal habitats in sandy mud sediment where they build impermanent burrows. Their abundance is noted as uncommon to moderately common.

c) *Aglaophamus* sp.

A large, long-lived (5 years or more) intertidal and subtidal nephtyid polychaete worm that prefers a sandier, rather than muddier substrate. Some species are carnivorous, whereas others feed on detritus. They are common and occur throughout New Zealand in intertidal and subtidal habitats.

d) Cirratulidae

Opportunistic, sedentary, subsurface deposit feeding polychaete worms that prefer sands. This group of worms are small sized and tolerant of poorly sorted sediment. They are found in sediments comprising 5-70 % mud. Common to abundant from intertidal to continental shelf depths throughout New Zealand

e) Cumacea

Cumacea are small crustaceans, also known as hooded or comma shrimp. They feed mainly on microorganisms and organic material from the sediment. Mud-dwelling species are filter feeders. Cumacea are common to abundant, with a greater diversity in subtidal habitats compared to intertidal.

f) *Austrotindaria wrighti*.

This small subtidal bivalve is commonly found offshore throughout New Zealand, including the STB.

g) Ophiuroidea

This group is also known as brittle stars (echinoderms). They are scavengers or detritivores and in deep water live in or on benthic sediment. Ophiuroids are common throughout subtidal habitats in New Zealand.

h) Ampharetidae

This group of polychaete worms are a family of terebellid (or bristle worm).

i) *Varinucula gallinacea*

This small bivalve is common throughout New Zealand in shallow and deep water, including throughout the STB.

j) *Onuphis aucklandensis*

This polychaete is common subtidally in muddy substrata. It builds mud tubes and could be carnivorous or a scavenger feeder. This species is common throughout New Zealand.

k) *Anisodonta alata alata*

This small bivalve commonly occurs throughout New Zealand, including the STB.

l) *Spiophanes* spp.

This polychaete worm forms dense tubes that trap and stabilise sediment providing a substrate for surface deposit-feeders.

4.19 Epifauna and fish detected in video tows and drop camera surveys in 2016 indicate that seapens, whelks, flatfish and spiny dogfish are present within the Tui field and control sites.

4.20 All of the benthic infaunal and epifaunal species detected are common and abundant. A range of tolerant and sensitive taxa are present. No threatened or rare marine invertebrate species have been detected in the AOI (Freeman et al., 2014).

4.21 Based on the criteria in Table 1, I have assessed the benthic habitat and organisms within the AOI as having moderate ecological value due to the moderate-high richness, abundance and diversity of benthic invertebrates, the presence of both tolerant and sensitive species, the marine sediments comprising primarily silt, sediment contaminants being largely below effects thresholds, few/nil invasive species present, and habitat modification moderate.

5. POTENTIAL ECOLOGICAL EFFECTS FROM PROPOSED ACTIVITY

5.1 The activities for which consent is sought include:

5.1.1 Installation, operation and removal of a moored semi-submersible drilling rig, including placement of all equipment, well drilling and well commissioning activities, and rig removal;

5.1.2 Logistic support activities;

5.1.3 Environmental monitoring activities; and

5.1.4 Discharges of water from drilling rig deck drains.

5.2 A full description of the activities is contained in the evidence of Mr Iain McCallum.

5.3 Each of these activities is described and the effects on marine benthic habitats and organisms are assessed in the following sections.

5.4 I also consider and assess potential biosecurity effects.

A. Potential Impacts from Planned Activities

Installation, operation and removal of a moored semi-submersible drilling rig, including all placement of all equipment, well drilling and well commissioning activities, and rig removal

Mooring and removal of semi-submersible rig - Cumulative effect of occupation and disturbance

5.5 The type of semi-submersible drilling rig that Tamarind proposes to use is described in Mr McCallum's evidence[16]. Such rigs maintain their position over the well during drilling through the use of anchors. Tamarind propose to use an 8-point anchor system, comprising anchors, chain and wire for the rig, which will be placed on the seabed prior to the drilling rig's arrival at a particular location (pre-lay). It is anticipated that the rig anchors could be in place for up to three months prior to rig arrival. The rig also requires four (4) smaller anchors to be used to tether the BOP system, thus reducing the number or rig anchors required to be used. These comprise of either clump weights or driven/suction piles. The wire connecting the anchors to the BOP system will be suspended and not touch the seabed. Tamarind plan to place the drilling rig in four (4) locations over the donor wells within the Tui field, over a campaign period of five to nine months.

5.6 Location of anchors, chains and wires on benthic soft sediment habitat will likely smother benthic invertebrates directly beneath the equipment. Once the structures are removed, natural successional recolonisation processes will begin to occur, with the community composition recovering in the longer term (5-10 years).

5.7 Tamarind's RFI Response outlines the proposed anchoring design and provides calculations of area of benthic habitat that may be disturbed or temporarily occupied[17].

5.8 For each of the four installations, the area of benthic habitat occupied by the anchors, chains, wires and BOP anchors for each drill rig site is approximately 13,000m^2. For the four wells, the total area of benthic habitat disturbed or temporarily occupied is 52,000m^2. Existing occupation of benthic habitat within the Tui field is approximately 11,000 m^2 (0.002% of the Tui field (467.2km^2)), of which the proposed new four installations form an additional 0.01% of the benthic habitat within the Tui field.

5.9 In order to assess the cumulative effects of the additional area of occupation and disturbance of benthic habitats and species, the area within the wider

[16] Paragraphs 2.11-2.17 of Mr McCallum's Evidence

[17] Figure 3.2, Tui Field Drilling Activities, Further Information – Notified Marine Consent and Marine Discharge Consent Applications (EEZ1000016), dated July 2018. Prepared by ERM New Zealand Ltd.

STB that is currently occupied and/or disturbed has been estimated. Existing structures within Maari, Kupe, Maui A and B and the Tui field are estimated to occupy approximately 40,000m^2.[18] Recently approved jack-up rig installations within the Maui permit area are likely to occupy and/or disturb an additional 214,000 m^2,[19] bringing the total area of benthic habitat affected to 254,000 m^2, comprising 0.0019% of the 13,400km^2 area of the 100-200m depth benthic habitat within the STB. The current proposal increases that percentage to 0.0023%.

5.10 The additional area of benthic habitat occupation and/or disturbance proposed for the side-track drilling is a relatively small area and is temporary in nature. Benthic habitats will, in the longer term (i.e. 5-10 years), be recolonised and contain assemblages that are similar to the existing community. I have conservatively assessed the magnitude of effect of occupation and disturbance at the scale of the area of benthic habitat affected (i.e. 52,000m^2). As such, I consider the magnitude of effect on the 52,000m^2 of benthic habitat to be moderate in the short term and low in the long term.

5.11 Given the natural recolonisation after disturbance and removal of structures and other equipment, I do not consider that any mitigation of the moderate level of effect is necessary.

5.12 I assess the magnitude of the cumulative effect of occupation and disturbance as low, because the proposed activities add a further 52,000m^2 to the existing 254,000m^2, which combined only forms 0.0023% of the 100-200m benthic habitat in the STB, and 0.00009% of the total subtidal benthic habitat within the STB. Combined with moderate ecological values, the level of effect is determined to be low (Table 4).

[18] Maari structures occupy approximately 9,000m^2, Maui A and B 10,000m^2 each, Tui field existing structures occupy 11,000m^2.
[19] Estimated 110,000m^2 footprint for ten jack-up rig installations, plus 104,000 m^2 of additional benthic habitat disturbance.

Table 4: Summary of Effects of Occupation and Disturbance of Benthic Habitat

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature of Effect
Temporary occupation of the seabed	Moderate (benthic habitat)	Moderate (short-term) Low (long-term)	Moderate (short-term) Low (long-term)	Temporary
Disturbance of the seabed	Moderate (benthic habitat)	Moderate (short-term) Low (long-term)	Moderate (short-term) Low (long-term)	Temporary
Cumulative effect of occupation and disturbance of seabed	Moderate (benthic habitat)	Low	Low	Temporary

Turbidity

5.13 Installation and removal of the anchors, chains and wires is likely to involve some disturbance of the benthic sediment, some of which will become temporarily resuspended and deposited as sediment plumes settle.

5.14 A Remotely Operated Vehicle (**ROV**) will be used to assist in installation of the blow-out preventer on the well heads and production tree intervention (closing/opening valves, etc). There could be some minor disturbance, resuspension and subsequent deposition of benthic sediment through propulsion of the ROV.

5.15 Given the temporary nature and small scale of likely resuspended sediment, elevated turbidity and deposition, I consider the magnitude of effect to be negligible. Combined with moderate ecological values the level of effect is assessed as very low (Table 5).

Table 5: Summary of Effect of Increased Resuspension and Settling of Sediment

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature of Effect
Increase turbidity	Moderate (benthic habitat)	Negligible	Very Low	Temporary

Vibration

5.16 Installation and removal of anchors, chains and wires may involve temporary vibration which may disturb some benthic organisms. However, given that the effects on organisms would be temporary and relatively minor e.g. ceasing feeding or reproductive behaviours during the vibration, I consider the magnitude of effect to be negligible, with the level of effect being very low.

Table 6: Summary of Effect of Vibration

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature of Effect
Vibration	Moderate (benthic habitat)	Negligible	Very Low	Temporary

Discharges during side-track drilling

Drilling Fluid

5.17 Side-track drilling will produce drill cuttings which will be returned to the surface, sieved and the drilling fluid (Synthetic Based Mud) recycled and reused. The sieved drill cutting material will be packaged, sealed and shipped to shore for storage and processing. There will be no discharges to the marine environment and therefore no adverse effect.

Milling Fluids

5.18 Milling fluids (usually water or seawater with polymers added)[20] will be discharged offshore and will disperse in the water column. Milling fluid does not contain any ecotoxic substances[21] and will not have any adverse effects on benthic habitats or organisms.

5.19 Given the large dilution afforded by the seawater and benthic sediment, I consider the magnitude of effect of the discharge of milling fluids to be negligible as it is highly unlikely to affect benthic marine community

[20] Milling fluids are used to transport metal cuttings or swarf out of the donor well casing.
[21] Refer to Evidence of Iain McCallum, paragraph 2.51

composition. Accordingly, the level of adverse effect is likely to be very low (Table 7).

Cement

5.20 During construction of side-track wells cement from the existing well and the new side-track liner will be drilled and removed, separated from the drilling fluids by sieving and it will be collected in skips on the drilling rig and disposed of on shore. There may be a requirement to drill out a portion, or all of, an abandonment plug during the drilling activity. Tamarind therefore seeks approval to discharge quantities of cement during this process that will be deposited on the seabed. The maximum quantities of cement that may be discharged and deposited on the seabed as part of this process are estimated to be 22 m^3 [22] .

5.21 Cement is mixed for the purpose of fixing well casings into side-track wells. The volume of cement required is carefully calculated. However, on occasion small amounts of surplus cement may remain in the cement tanks or be returned from the well and needs to be discharged immediately before it hardens (typically up to 2 m^3)[23].

5.22 Concrete/cement is known to be a poor substrate for recruitment of marine organisms, likely due to the high surface alkalinity (pH c. 12-13 compared to pH c. 8.2 of seawater). Sessile community composition on concrete structures typically have lower biodiversity compared to natural rock.[24]

5.23 Cement that has not hardened before discharge to the marine environment will be diluted in the water column before deposition on the benthic sediment as particles. Given the small volumes of cement that may be discharged compared to the area of soft sediment habitat within the Tui field and the STB, I consider the magnitude of effect to be negligible as it is highly unlikely to affect benthic marine community composition. Accordingly, the level of adverse effect is likely to be very low (Table 7).

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[22] Refer to Evidence of Iain McCallum, paragraph 2.44.
[23] Refer to Evidence of Iain McCallum, paragraph 3.30.
[24] Abdus-Samad, S., 2013. The effect of the composition of concrete on biodiversity and ecology of benthic organisms. Unpublished research project carried out under the Urban Assembly New York Harbor School, Marine Biology Research Program, New York.

5.24 Wind-blown cement that may settle through the water column and deposit on the seabed is unlikely to be present in vast quantities but may have some small impact on the pH of benthic sediment in localised areas.

5.25 Given the large dilution afforded by the seawater and benthic sediment, I consider the magnitude of effect to be negligible as it is highly unlikely to affect benthic marine community composition. Accordingly, the level of adverse effect is likely to be very low (Table 7).

Table 7: Summary of Effect of Discharges during Side-Track Drilling

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature of Effect
Discharge of milling fluids	Moderate (benthic habitat)	Negligible	Very Low	Temporary
Discharge of cement	Moderate (benthic habitat)	Negligible	Very Low	Temporary
Discharge of wind-blown cement	Moderate (benthic habitat)	Negligible	Very Low	Temporary

Logistical support activities

5.26 Additional supply loads will be brought to site by vessels and helicopters from New Plymouth during side-track drilling. Vessels will not be moored or anchored in the field. Discharges, such as grey water and sewage, from the vessels will be in accordance with provisions of the Maritime Transport Act 1994 and associated Marine Protection and Maritime Rules and therefore will not adversely affect benthic marine habitats or organisms. As such, I assess the magnitude of effect as negligible and the level of effect as very low (Table 8).

Table 8: Summary of Effects of Logistical Support Activities

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature of Effect
Logistical support activities	Moderate (benthic habitat)	Negligible	Very Low	Temporary

Environmental Monitoring

5.27 There is ongoing and extensive environmental monitoring including benthic ecological surveys (the most current survey is reported in SLR, 2018). Surveys occur over 16 benthic sites within the Tui field and two far field control stations[25] and incorporate sediment chemical and physical characteristics and biological community composition. It is my opinion that the existing survey programme is robust and sufficient to capture any unforeseen effects arising from side-track drilling.

B. Potential Impacts from Deck Drain Discharges

5.28 The characteristics of deck drainage discharges are covered in the evidence of Dr Lane.

5.29 Deck drainage may be discharged to the marine environment during side-track drilling. Drilling fluids and cements are the highest risk substances as they are held in the greatest quantities, are present as residues on pipes, casings and other equipment that could be stored on deck. There are six potentially harmful substances that could be used in drilling fluids or cements (Table 1 of Dr Lane's Evidence). Dr Lane concludes that none of the six substances present a feasible risk to marine ecology (including benthic habitats and organisms) based on their lack of toxicity or concentrations.

5.30 Hazardous substances may enter deck drainage through minor residues from spills or splashes remaining behind after cleaning. The rig will have separate drainage for rainwater and parts of the deck where harmful substances may be used or stored. Residues will be highly diluted by rainwater prior to entering the treatment system, and then passing through the oily water separator. If there is concern regarding hazardous substances in the stored runoff, water will be stored, transported to shore and disposed of appropriately.

5.31 Pipes and lines relating to drilling activities that could discharge fluids overboard will have locked valves to ensure discharges are permissible prior

[25] See Drawing 0428300b_EEMP-G004_R0.mxd on page 63 of the Impact Assessment report.

to discharge. Below deck, drains relating to drilling activities, will not discharge to the sea.

5.32 Table 3.3 in the Impact Assessment lists the likely substances used that could potentially be discharged to deck drainage.

5.33 Given the processes in place and the large dilution afforded by the seawater and benthic sediment, it is unlikely that any harmful substance will be discharged via deck drains in a concentration or quantity that may cause a magnitude of effect on benthic habitats or organisms that is greater than negligible, with the level of effect being very low (Table 9).

Table 9: Summary of Effect of Discharge of Deck Drainage

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature
Deck drain discharges	Moderate (benthic habitat)	Negligible	Very low	Temporary

C. Potential Impacts from Unplanned Activities

5.34 Marine hydrocarbon or chemical spills or loss of well control are unplanned events that may occur from drilling rig and/or vessel activities. There are a number of chemical and physical processes that occur when hydrocarbons such as diesel or hydraulic oils are discharged to the marine environment, many of which occur in surface waters. Diesel, being lighter than seawater primarily remains on the surface, without impacting on offshore benthic habitats.

5.35 Shoreline oil accumulation could have significant adverse effects on marine habitats and organisms, largely dependent on volume of oil discharged. Modelling of loss of well control (both 45 and 110-day well release from Amokura-2H) indicates that surface slicks and entrained oil could reach the shorelines of South Taranaki (including the Marine Mammal Sanctuary) and New Plymouth districts as patches of solidified waxes (following weathering) in certain conditions. Accumulation of the solidified waxes on shorelines are likely to have adverse effects on most sessile and mobile organisms that come into direct contact. For the purposes of this assessment I have assumed the coastal benthic marine habitats to have very high ecological values.

5.36 The magnitude of effect of an oil spill as modelled on offshore subtidal soft sediment benthic habitats is considered to be low, whereas the magnitude of effect on coastal habitats and organisms could be high, resulting in a very high level of effect (Table 10). However, such an event is considered extremely unlikely (see IA).

5.37 Materials and supplies that could be dropped within the Tui field include drums of oil, fuel, chemicals, paint, sacks, pallets, equipment, rubbish, tools and equipment. Unrecovered containers of chemicals, fuel, oil and other hazardous substances present a risk to benthic habitats and organisms if they release their contents. However, the size and nature of a dropped object is relatively small and of low likelihood of occurring. The magnitude of effect of a dropped container of hazardous substances, given the limited size/volume likely involved, is assessed as low, with the level of effect being low (Table 10).

5.38 Collision between vessels and or the drilling rig could occur and involve the release of hazardous substances. Should a vessel sink, there are likely to be adverse effects on benthic habitats and organisms through smothering and contamination. The likelihood of occurrence is considered to be highly unlikely with appropriate mitigation and control measures in place. The magnitude of impact of a collision, should hazardous substances be released and the vessel sank, is likely to be high (but localised), with an overall moderate level of effect (Table 10).

Table 10: Summary of Effect of Unplanned Events

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Likelihood
Large Scale Oil Spill	Moderate (offshore benthic habitat)	Low	Low	Extremely unlikely
	Very High (coastal benthic habitat)	High	Very High	

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Likelihood
Dropping of materials or supplies	Moderate (benthic habitat)	Low	Low	Unlikely
Collision of vessels	Moderate (benthic habitat)	High	Moderate	Highly unlikely

D. Biosecurity

5.39 The drilling rig will be moved from South East Asia to New Zealand under its own power. As it will be a new rig, it will have new anti-fouling paint on its hull which will deter biological growth. However, prior to leaving the hull will be inspected and cleaned of biological growth if required and a report will be prepared and submitted to Tamarind (and to MPI) confirming that the hull is clean. The rig will refuel on its way to Taranaki, possibly either in Australia or Papua New Guinea. Refuelling will occur over 1-2 days after which the rig will move directly to the Tui field site. Tamarind advises that MPI have confirmed that the 1-2 days in-port fuelling does not present a biosecurity risk and the rig does not need to be cleaned again before leaving for New Zealand.

5.40 To mitigate the potential of biosecurity risks Tamarind and the drilling rig contractor will be strictly adhering to the requirements of the Ministry for Primary Industry's Craft Risk Management Standard for Biofouling, which came into force on 15 May 2018 and the Craft Risk Management Standard for Vessels, which came into force on 1 February 2018.

5.41 To this end, Tamarind and the drilling rig contractor will develop a Craft Risk Management Plan (**CRMP**) that will apply to the drilling rigs and any support vessels sourced from outside New Zealand. The CRMP will be submitted to the Ministry for Primary Industries for review and approval prior to the drilling rig or vessels entering New Zealand waters.

5.42 Tamarind is also bound by standards within the Biosecurity Act 1993, including the Import Health Standard (Ballast Water from All Countries) and the Craft Risk Management Standard (Biofouling on Vessels Arriving to New

Zealand). The Import Health Standard sets out requirements with respect to ballast water discharges and the Craft Risk Management Standard manages the risk of introduction of marine pests into New Zealand's territorial waters brought in on vessel hulls. The appropriate biosecurity checks and approvals will be applied prior to the rig arriving in New Zealand waters and being towed to the Tui field.

5.43 With the appropriate management, checks and approvals in place the risk to marine ecological values from invasive marine species can be managed to a very low level. The magnitude of effect with best practice management measures in place is assessed as negligible, with a very low level of effect.

Table 11: Summary of Biosecurity Effects

Potential Adverse Effect	Ecological Value	Magnitude of Effect	Level of Effect	Temporal Nature
Introduction of unwanted marine organisms	Moderate (benthic habitat)	Negligible	Very low	NA

6. Response to EPA Key Issues Report and Technical Review

EPA Key Issues Report

6.1 *Issue* – Paragraph 71 of the EPA Key Issues Report states that "Increases in turbidity and sedimentation are considered to be significant as naturally occurring levels are likely to be exceeded in and around the areas in which a rig is installed".

Response – Turbidity is considered primarily by Dr MacDiarmid, but also assessed as a negligible magnitude of effect in my evidence in paragraph 5.13. Sedimentation is considered part of habitat disturbance in my evidence. I have assessed habitat disturbance of 52,000m^2 as a moderate magnitude of effect, in the short term. I consider that the proposed management and mitigation measures proposed are adequate to minimise effects without the need for additional conditions.

7. Response to Issues Raised by Submitters

7.1 Several submitters raise concerns about spills and the discharge of harmful substances that may adversely affect marine organisms. Spills and harmful substances are largely addressed by Dr Lane in her evidence. I have reviewed the information on harmful substances and am comfortable that effects on benthic habitats are very unlikely due to the nature of the substances proposed to be used. With respect to spills, should a large-scale event of that nature occur, there could be significant adverse effects on benthic marine organisms and habitats, depending on the nature of the material spilled. However, I understand that spills are extremely unlikely due to the safety and management practices put in place, as described in the evidence of Mr McCallum and Mr Peacock.

7.2 Loss of, and damage/disturbance to, the seabed has been raised as a concern by some submitters[26]. In paragraph 5.8, I state that the current proposal is likely to involve disturbance and/or temporary occupation of benthic habitat of 52,000m^2 of benthic habitat. I acknowledge that disturbance and occupation of benthic habitat will involve the mortality of some macrofauna. However, it is my opinion that once the structures (anchors, chains, wires) are removed and once the disturbance ceases, natural recolonisation of the areas affected will occur, with there likely to be no permanent effect on benthic macrofaunal assemblages.

7.3 Climate Justice Taranaki Incorporated and other submitters who adopted the Climate Justice submission template raise concerns about cumulative impacts not being adequately considered when applications are assessed separately. With respect to the cumulative effect of temporary occupation and disturbance of benthic habitat, I have addressed this in paragraphs 5.8 and 5.12 above. I have put the current proposal into the context of occupation and disturbance within the Tui field and within the wider STB in order to understand and assess the cumulative effects and consider the cumulative effects on benthic habitats and species to be of a low level.

[26] Brent Barrett, Te Korowai o Ngaruahine Trust

8. Proposed conditions and Mitigation Measures

8.1 The proposed set of conditions do not include a requirement for additional benthic ecological monitoring. I agree that further monitoring is not required, given the likely location of the side-track drilling activities is close to existing drill sites[27], the lack of identification of any significant adverse effects on benthic ecology and the existing robust and appropriate benthic monitoring programme.

9. Conclusion

9.1 The potential effects of proposed planned activities all have a low or very low level of effect on benthic habitat and organisms. The exception is temporary occupation and disturbance of the seabed, which I have assessed as have a moderate level of effect in the short-term[28], but a low level of effect in the long-term. Based on the natural recolonisation and successional processes that will occur within benthic habitats upon removal of the structures and ceasing of disturbance activities, I do not consider that any mitigation is necessary.

9.2 With respect to unplanned activities such as large-scale oil spills or collision of vessels, whilst these activities could result in significant adverse effects on benthic ecology, with best practice management processes in place these activities are highly-extremely unlikely to occur.

9.3 With the appropriate checks, management and permissions in place, the biosecurity risk of bringing the drill rig into New Zealand can be minimised to a negligible level.

9.4 My review of the submissions has not given rise to any change in my assessment or recommendations.

9.5 Based on the lack of potential significant adverse effects on benthic habitats and organisms, I do not consider that additional monitoring is required,

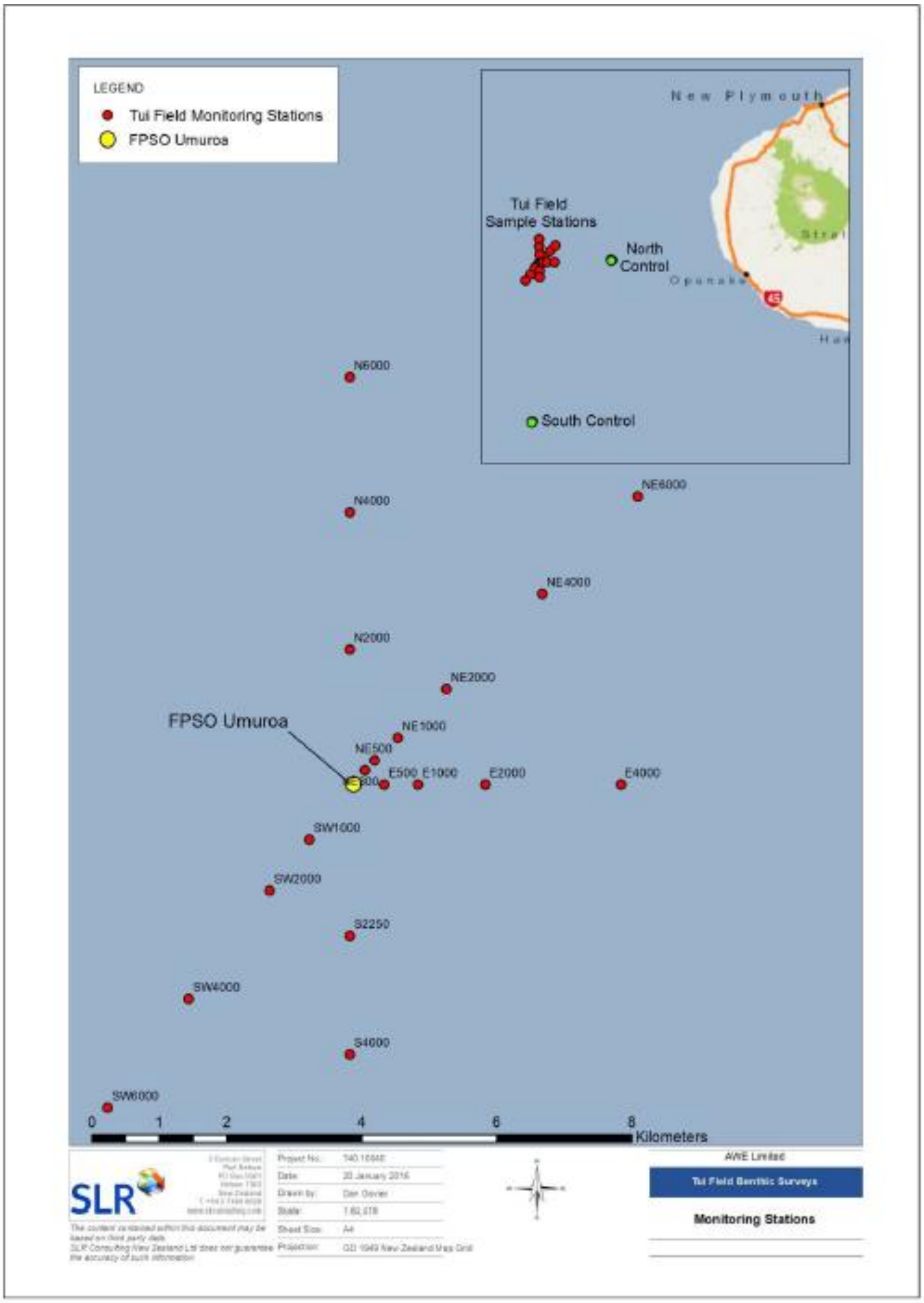
[27] I note that SLR (2018) recommend that the NW control site is relocated to a greater distance (currently approximately 2km west) from the Pateke 4H development well, which was established in 2014. With that modification to the monitoring programme in place, I am satisfied that the current monitoring adequately provides for the proposed side-track drilling.
[28] At the scale of the habitat affected i.e. 52,000m^2 of habitat.

beyond that which forms the current and ongoing Environmental Effects Monitoring programme.

SHARON BETTY DE LUCA
20 July 2018

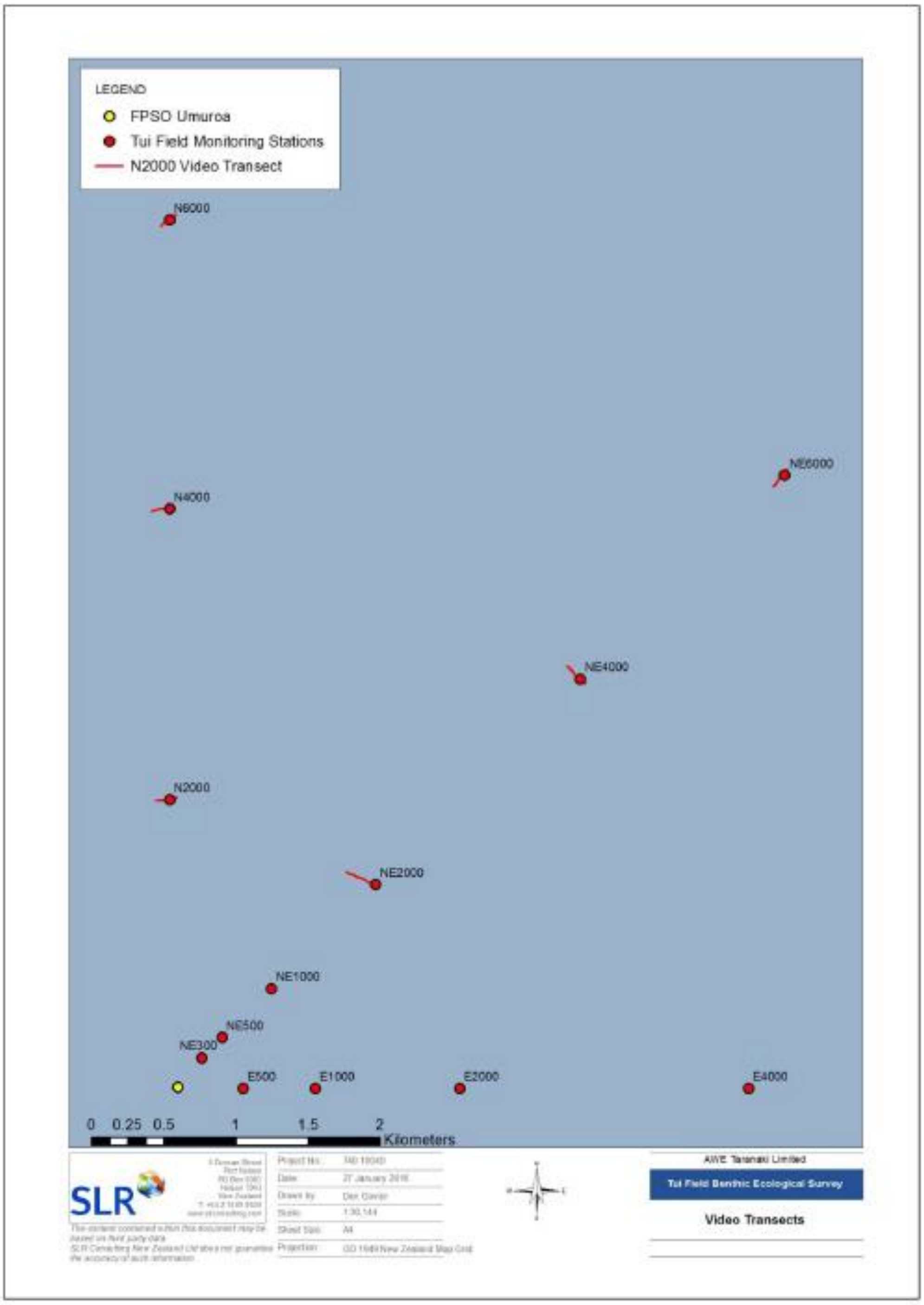
Appendix 1 – Survey site figures

Figure 1: Benthic grab locations at the Tui Field[29]



[29] SLR, 2016.

Figure 2: Video sled tow GPS trails at Tui Field[30]



[30] SLR, 2016.