Appendix 19.1 - Basis of Design - SSED

BFS Assumptions Register

Page - 900 Crawler

Original Data Source: Shawn Thompson 5 Nov 2013, File: "Crawler Advance Rate Comparison and Time Usage 5 Nov"

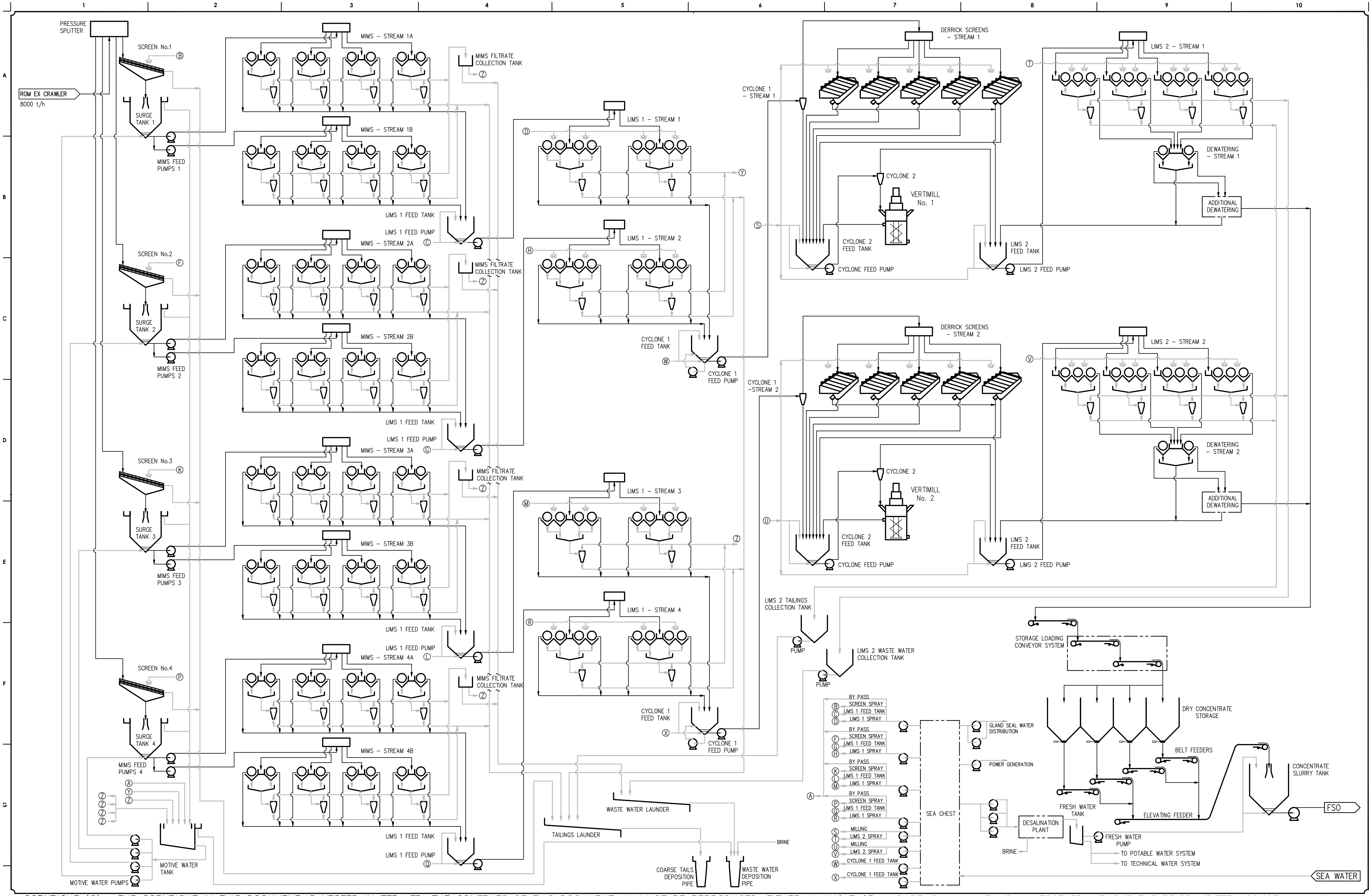
Revision Date: 8 November 2013
Revised By: Thomas Zink

Modified and reconfigured the table to ensure all inputs were visible. Changed the calculation for "Time Required to Mine Block". It had included a subtraction of reversing time, now has an addition of all crawler delay time.

Parameter	Value	Units	Comments
Block Width	300	m	
Block Length	300	m	
Average Mining Depth	5	m	
Block Volume m^3	450,000	m3	
Ave. SG of ROM	1.90		IHC Figure
Ave. mining rate	8,000	tph	IHC Figure - crawler/pump design rating
Weight of Average Block	855,000	tonne	
Number of Mining Lanes	15		Based on a 20m lane width
Ave. Time to Mine Block @ 8000tph	106.88	Hrs	Extraction Time
Crawler Extraction Delay Per Block	11.62	Hrs	Non-extraction time (refer calc below)
Time Required to Mine Block	118.49	Hrs	
Time for Extraction Per Lane	7.54	Hrs	Less positioning and reversing time
Ave. Forward velocity	39.78	m/hr	
Ave. Forward velocity	1.10	cm/s	Refer V_{wall} in pg 2 of 4 IHC Breach Memo
Total time allowed for sweeping per lane	7.13	hrs	Extraction time
Time per sweep	1.43	min	
Sweep length	24	m	IHC Figure
Velocity of Sweep m/hr	1,011	m/hr	
Velocity of Sweep m/min	16.84	m/min	Crawler Max Sweep velocity 30 m/min
Days per Block	4.94	days	

Crawler Extraction Delay Calculation	**Value**	**Units**	
Time to Position at Start per Lane	5	mins	Assumption
Position Operations Per Block	14		
Delay Due to Positioning Per Block	1.17	hr	
Reversing Speed	1.00	km/hr	IHC figure
Time to Reverse per Lane	18	mins	
Reverse Operations Per Block	14		
Delay Due to Reversing Per Block	4.20	hr	
Length of Forward Step	1	m	IHC Figure
Number of Sweeps per lane	300		One forward step per sweep
Time for step	5	sec	IHC Figure
Time to step forward per lane	0.42	hrs	
Delay Due to Step Per Block	6.25	hrs	
Position at start of lane	0.98%		Per block
Reversing	3.54%		Per block
Step	5.27%		Per block
Total	9.80%		Based on time that crawler is deployed on sea bed

Appendix 19.2 - DRA Process Flow Diagram



Notes

FOR INFORMATION ONLY
26/03/14

Drawing No.	Title
–	–
Reference Drawings	

Rev.	Description	Date	Drawn	Chkd	Eng	Appr	Client
0A	ISSUED FOR INFORMATION	03/14	TW	KP	–	TZ	ST

Client: TTR Trans-Tasman Resources

Project: OFFSHORE IRON SANDS PROJECT

Title: TRANS-TASMAN RESOURCES LTD
IRONSAND WET PROCESSING PLANT
SCHEMATIC

Project No. –
A1 Scale: NTS
Drg No. TTRL-05-DWG-52100
Sht. 01 of 01
Rev. 0A

Appendix 19.3 - BECA Operational Simulation Model

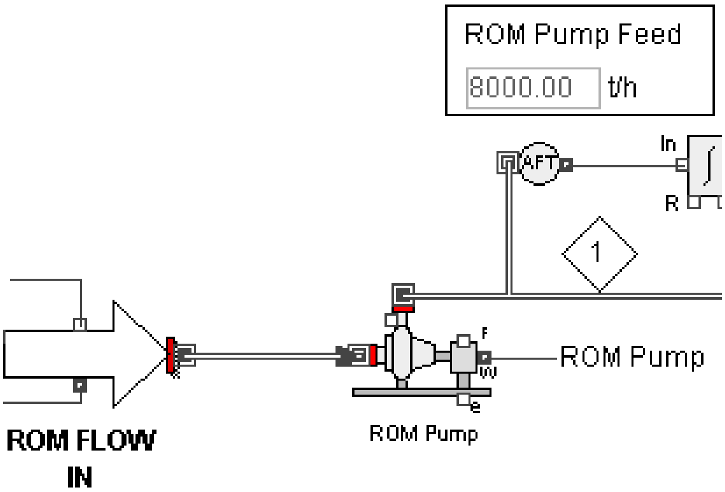
Report

Process Simulation Model: Offshore Iron Sands Project Feasibility Study

Prepared for Trans-Tasman Resources Ltd (Client)

By Beca Ltd (Beca)

5 March 2014



Revision History

Revision Nº	Prepared By	Description	Date
A	Suzanne Hay	Issue to TTRL	21/2/14
B	Chris Lee	Issue final to TTRL	26/2/14
C	Suzanne Hay	Issue final to TTRL	5/3/14

Document Acceptance

Action	Name	Signed	Date
Prepared by	Suzanne Hay	Suzanne Hay	5/3/14
Reviewed by	Chris Lee	pp Suzanne Hay	5/3/14
Approved by	Lee Roberts	pp [illegible]	5/3/14
on behalf of	Beca Ltd		

Summary

This report presents the results of process scenarios from an IDEAS™ process simulation model of a proposed offshore iron sand mining vessel to be located in the South Taranaki Bight, as part of a bankable feasibility study being undertaken by Trans-Tasman Resources Limited (TTRL).

The main process simulation starts with the ROM (Run Of Mine) sand feed from the Crawler and includes all major unit operations through to the FSO (Floating Storage and Offloading vessel) storage.

The model can be run in steady state, at a single rate of production to give a single power consumption answer. A number of scenarios were run in this mode to test the sensitivity of the power consumption to different variables. The alternative is to run the model stochastically (dynamically) with input variables varying in time according to defined probability distributions to predict the varying power requirements over time.

It is recommended that power consumption, and therefore fuel consumption, is critical to the financial viability of the project. Opportunities for process optimisation that significantly reduce overall power demand in the process plant were identified by TTRL during the course of the modelling work and the model outputs for the 8000 t/h case yielded the following results:

- Predicted peak power of 67.3 MW
- Predicted average power of 46.9 MW
- Predicted kWh/t ROM of 6.97

However, based on the information provided to Beca at the commencement and through the course of the modelling work, the total predicted power consumption results are as follows. (Note that figures have been rounded in some cases to better reflect the accuracy of these predictions).

For steady state production cases:

- 55 – 61MW at 6700t/h dry ROM feed, with 7.0 – 12.2% Fe
- 61 – 69MW at 8000t/h dry ROM feed, with 7.0 – 12.2% Fe

With stochastic (changing) input variables and a “most likely” mining rate of 6700t/h dry ROM feed, the power consumption required for the operation is:

- Predicted total power consumption peaks at 82MW
- Predicted total power consumption averages 55MW
- Average ROM feed rate achieved is 6300t/h (dry basis)
- The predicted kWh/t ROM is 8.8

In comparison, the stochastic case when the “most likely” mining rate is 8000t/h dry ROM feed, results in power consumption as follows:

- Predicted total power consumption peaks at 82MW
- Predicted total power consumption averages 57MW
- Average ROM feed rate achieved is 6700t/h (dry basis)
- The predicted kWh/t ROM is 8.4

It should be noted that there are a number of uncertainties in the variables used in constructing the model (specific mention of these are made in the body of this report) and in some cases these could

contribute quite significantly to the overall power requirements of the process. For this reason, while the results of this modelling provide a good basis for comparing options, the absolute values need to be viewed with caution.

Also note that the model does not currently incorporate any capacity limitations for individual unit operations and it is therefore possible that during stochastic modelling a combination of high mining rate and high ore grade produces product flows which may exceed the final design capacity of a particular unit operation and also reports power consumption in excess of the installed motor capacity.

Table of Contents

Appendices

1 Introduction

This report details the results from a process simulation model of a proposed offshore iron sand mining vessel in the South Taranaki Bight, for the Offshore Iron Sands Project undertaken by Trans-Tasman Resources Limited (TTRL).

TTRL is undertaking a confidential study into an off-shore iron sand mining operation off the west coast of the North Island, New Zealand. A process model of the proposed iron sand concentration process was constructing using IDEAS™ software for the prefeasibility study (PFS) in May 2013. The model took into account factors such as wave heights and sand grades. The project is currently in bankable feasibility study (BFS) phase and the process design has been developed further requiring the model to be updated. The process simulation determines expected power consumption for the process. Work was also started on a model which would provide a check on the storage capacity sizing at several key points in the process.

2 Model Description

A picture of the model and the process flow diagram (PFD) it is based on are included in Appendix A.

The main process simulation starts with the ROM (Run Of Mine) sand feed from the Crawler and includes all major unit operations through to the FSO (Floating Storage and Offloading vessel) storage, as follows:

- Mining vessel, positioning and mooring systems
- Power requirements for ship accommodation and services
- ROM Pump and Crawler hydraulic and jetting systems
- ROM Boil Box
- Trommel Screens
- MIMS (Medium Intensity Magnetic Separators) and associated feed tank
- LIMS1 (Low Intensity Magnetic Separators) and associated feed tank
- Cyclones 1 and 2 and feed tanks
- Vertimill
- LIMS2 and feed tank
- LIMS3 and feed tank
- Derrick Screens
- Dewatering Magnets
- Dry Concentrate Storage
- Concentrate Slurry Tank
- HBF (HyperBaric Filter) Dewatering
- FSO (Floating, Storage and Offloading vessel) Storage
- Desalination plant
- Process water tank
- Recycle process water, including coarse and fine tails collection

The simulation was constructed in IDEAS™ software.

The model can be run in steady state give a single power consumption answer. In this mode, a number of scenarios can be run to test the sensitivity of the power consumption to different production rates and different grades of the ROM feed.

The alternative is to run the model with input variables varying in time according to defined probability distributions. With sufficient variables the model is essentially stochastic and begins to simulate actual production albeit in a simplified way.

In this mode, a range and likelihood are given for certain key variables and the model randomly chooses a figure for each variable at a predetermined frequency. To reduce instabilities in the model and make the changes reasonably realistic the model ramps the parameters from the previous value to the new value all the while calculating instantaneous power requirements as the flows and compositions change through the process in response to the new conditions.

The variables in this mode of simulation are:

- ROM production rate
- ROM grade Fe content
- Wave height
- Wind speed
- VertiMill power consumption

Note that the ROM production rate and the ROM grade are ramped from one value to the next and when the plant is stopped the ROM rate is simply set to 0. The ramping combined with some delays through the remainder of the model result in buffering-like behaviour. However, the model does not make buffering decisions in the sense of allowing tank levels to rise and fall in accordance with what is happening downstream or upstream from the tank.

The model also introduces a maintenance schedule which simulates most of the plant stopping for 24 hours every two weeks.

Detailed comments on the stochastic modelling are provided in Table 9 in Appendix B.

3 Input Data and Assumptions

The simulations assume the maximum limit for normal production is 8500 t/h dry ROM feed material.

- Table 8, Appendix B lists the input data provided by TTRL.
- Section 7, References lists the reference documents used.

The distribution of iron content with mined grade changes considered in the simulation is shown in Figure 1.

The triangular distributions of mining rates considered, centred on “most likely” rates of 6700 t/h (ROM rate, dry basis) and 8000 t/h (ROM rate, dry basis), are shown in Figure 2 and Figure 3 respectively. “Most likely” being the apex of the triangular distribution.

The figure that inputs into the model of 6700 t/h ROM feed represents a longer term average mining rate, taking into account production operating delays and crawler extraction delays (refer to Reference 5, Time Usage Assumptions). Other reasons for not achieving design rate, including non-production due to planned maintenance, unplanned breakdowns, anchor relocation, sailing to a new location, are incorporated into a single recurring variable called the “maintenance” production stop in the model. The actual production rate that the model calculates is a result of operating at 6700 t/h when the plant is available and there is no stop in production.

Note that the mean rate is different from the "most likely" rate if the triangular distribution is skewed to one side or another (as it is in both these cases). The mean for each of these distributions will tend more toward the centre of a triangular distribution, resulting in:

- For the "most likely" 6700t/h ROM feed case, the mean rate will be 7066t/h
- For the "most likely" 8000t/h ROM feed case, the mean rate will be 7500t/h

The wave height and wind speed probability distributions used in the model to determine ship positioning power requirements are shown in Figure 4 and Figure 5 respectively.

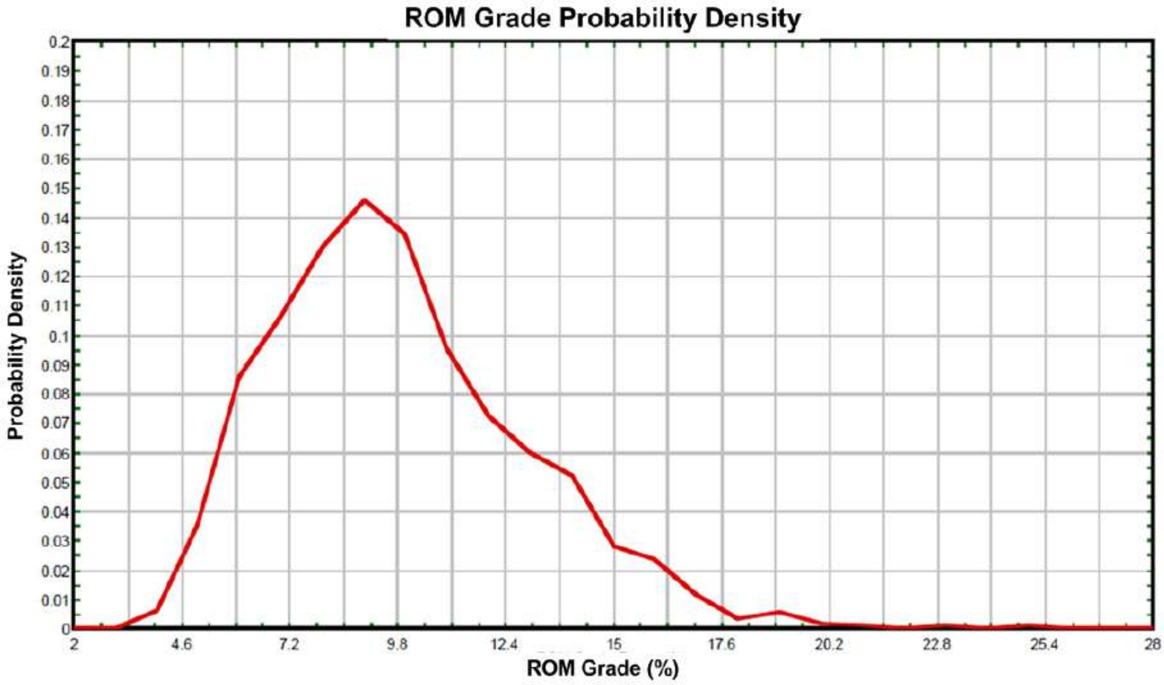


Figure 1: The distribution of the iron content in the mined sand used in the process simulation, showing ROM grade range in mass% Fe versus probability. Reference 6.

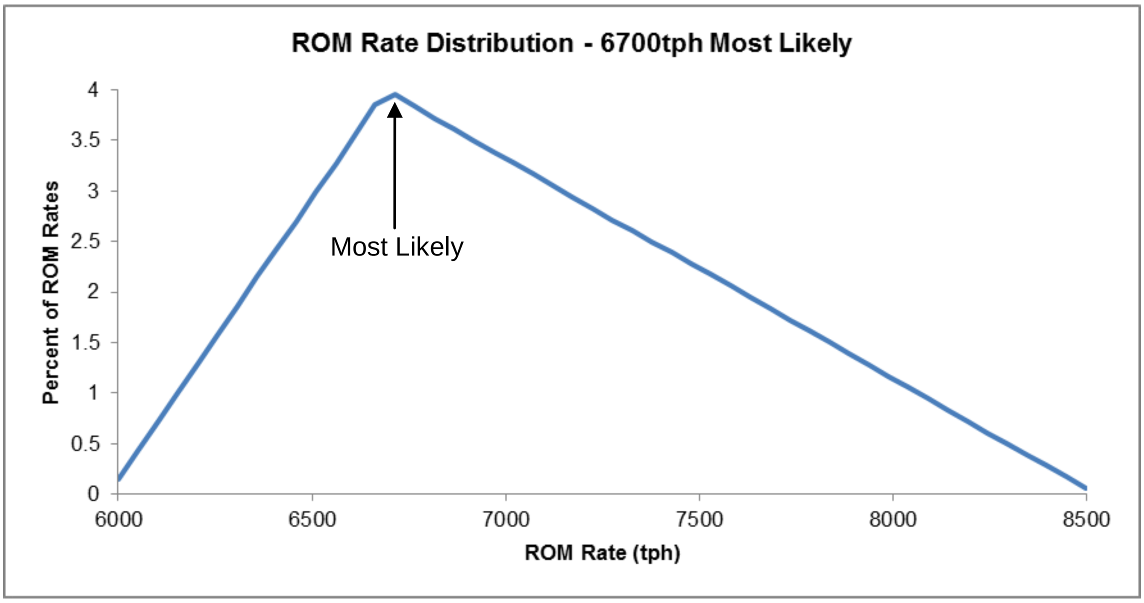


Figure 2: The distribution of the mining rate used in the process simulation when centred on a most likely 6700 t/h, showing ROM feed rate range in t/h dry basis versus probability, sample size one million.

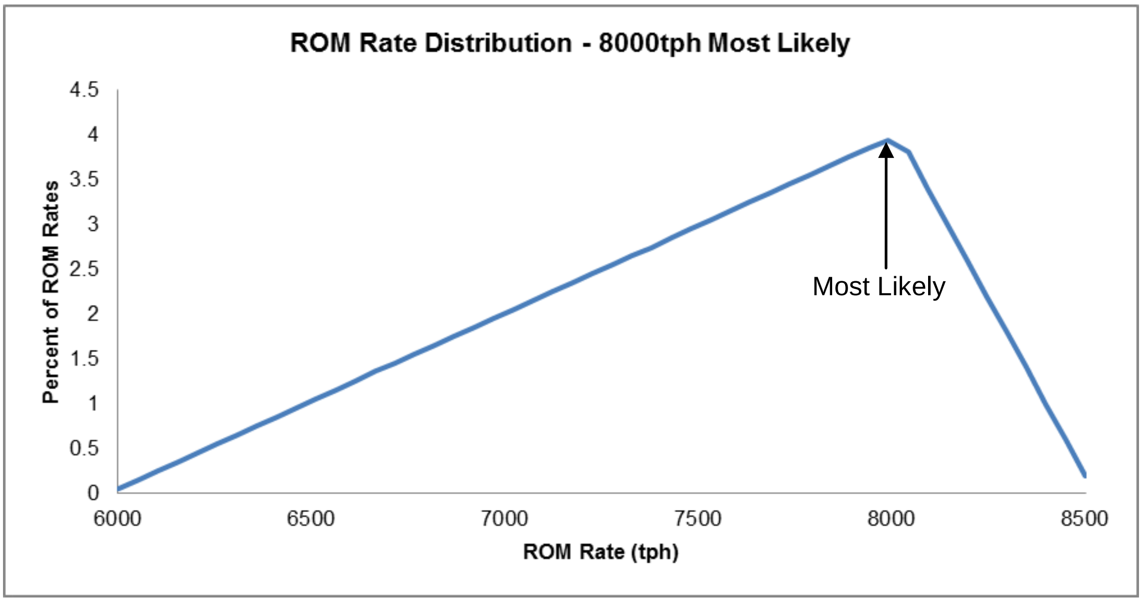


Figure 3: The distribution of the mining rate used in the process simulation when centred on a most likely 8000 t/h, showing ROM feed rate range in t/h dry basis versus probability, sample size one million.

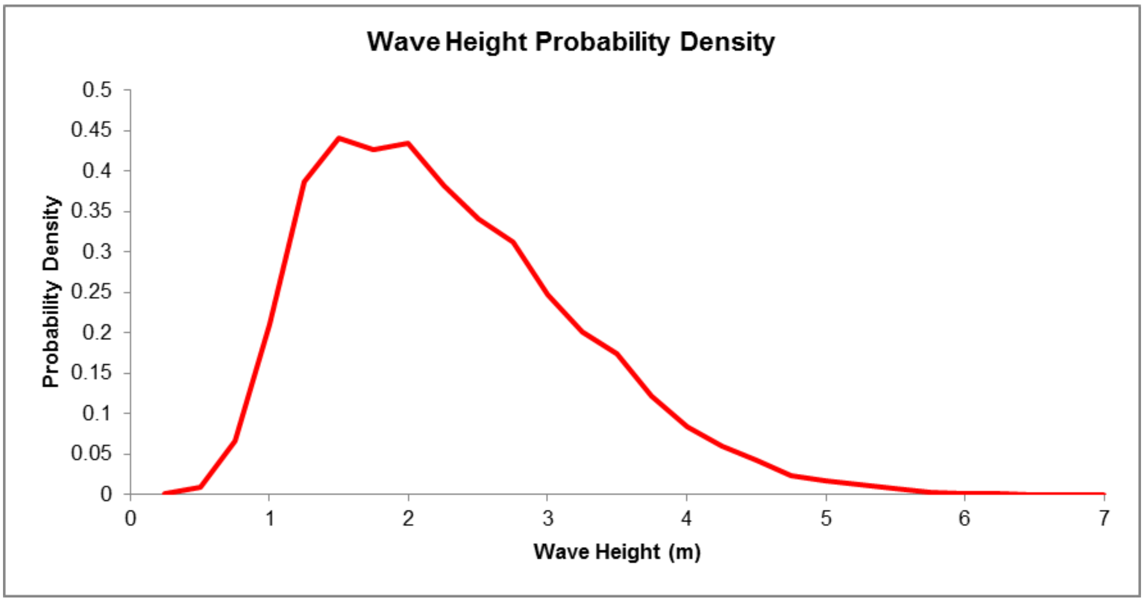


Figure 4: The wave height distribution used in the process simulation, showing Wave Height in m versus probability. Reference 10, Table 6.6.

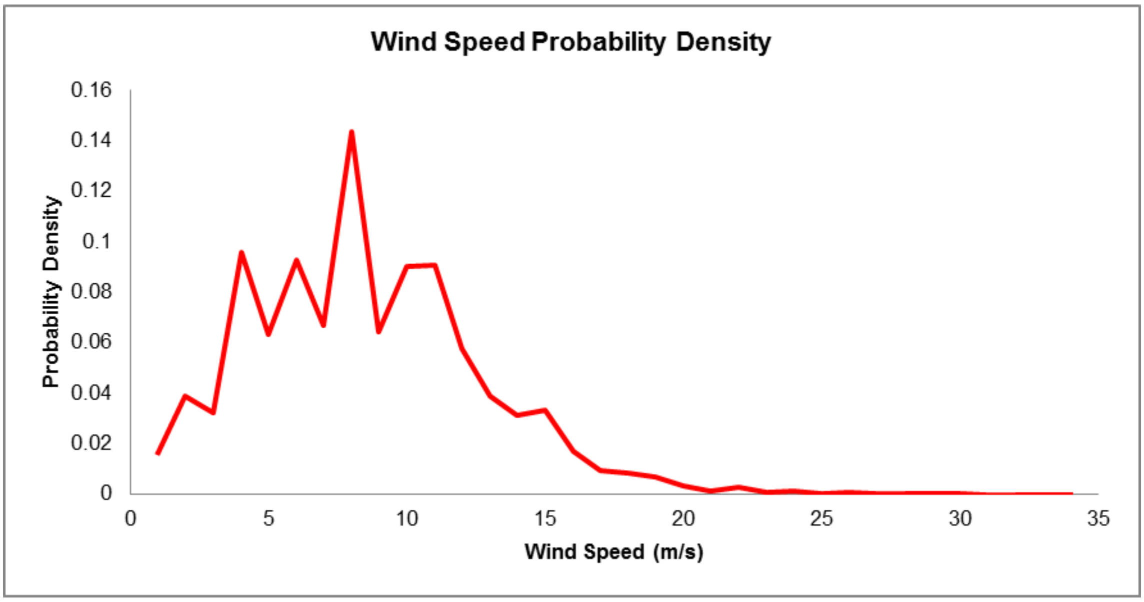


Figure 5: The wind speed distribution used in the process simulation, showing Wind Speed in m/s versus probability. Reference 10, Table 5.5.

As the wave height or wind speed increase (refer to Figure 4 and Figure 5 for distributions), the power consumption of the ship positioning system will also increase. The model currently stops the process while the significant wave height is equal to or greater than 4.0 metres. Exact details of how weather will affect operations are still to be confirmed. Current assumptions are detailed in Table 8, Appendix B.

3.1 Pump Power Calculation Method

When a stream is pumped, IDEAS™ calculates the pumping power from first principles using the:

- Volumetric flow rate of the stream
- Stream density
- Differential pressure for the pump
- Overall efficiency

The first two parameters are calculated in the model "on the fly". The last two parameters are set in the pump object according to information provided by TTRL.

The model calculates material flows, compositions, and densities based on the information provided by TTRL:

- The starting parameters of ROM feed rate and composition
- The solids concentrations at each stage of the process, and the separations of solids and recoverable iron at each stage of the process

In the IDEAS™ model, the ROM composition has been assembled from a small set of individual materials available from the suite of materials provided by IDEAS. At each stage in the process the density of the mix of materials can be determined from the composition of the stream. The density will not be an exact match for the actual material at that point because a small number of components have been chosen to approximate the ROM material.

IDEAS™ also has a dynamic pump object (not used in this model) which can incorporate actual pump curves. This object is used in pressure-network models which are also modelling pipes and tanks.

3.2 Other Power Consumers

Other power consumers that are included in the model are:

- Vertimills
- Magnetic Separators
- Conveyors
- Reverse Osmosis plant
- Vessel Positioning System
- Accommodation
- Services

Refer to Table 8 in Appendix B for details on how these were modelled.

4 Process Scenarios

4.1 Steady State Cases

Six steady state cases were run to include:

- 6700 and 8000 t/h ROM feed rate
- 7.0, 10.3 and 12.2% Fe due to changes in grade composition

Two mining rates were modelled, the design rate of 8000 t/h ROM feed (dry basis) and a comparison at 6700 t/h ROM feed. The figure of 6700 t/h ROM feed represents a longer term average mining rate, taking into account production delays and crawler delays.

In each differing iron content case, the separation of water, solids and iron content was changed with the input %Fe. Outputs for the six steady state cases are detailed in Table 1 through to Table 6 on the following pages.

From these cases, the model was refined and corrected to accurately reflect the expected outcomes before it was run in stochastic mode (with the various probability distributions switched on). Based on the current assumptions, Vertimill grinding is the largest single power consumer. Other significant power consumers include the ship positioning system, the coarse tails cyclone pumping system, the reverse osmosis plant, the trommel screens and the crawler system.

Total predicted power consumption ranges are:

- 54.8 – 60.8MW at 6700t/h dry ROM feed, with 7.0 – 12.2% Fe
- 61.4 – 68.8MW at 8000t/h dry ROM feed, with 7.0 – 12.2% Fe

The water pumps and coarse tails cyclone pumps use minimum power at 10.3% Fe compared to the 7 and 12.2% Fe cases. This is a result of the TTRL mass balance separation efficiencies for the three different grades (Reference 3).

Table 1: Outputs for 6700 t/h ROM feed rate and 7.0% Fe in feed.

							IDEAS Total	TTRL Installed	
	Grade	7.0	%				Power	Power	Difference
	ROM Rate	6700	tph				MW	MW	MW
							54.75	61.34	6.59
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**10594**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4357	5050	693
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					5557	6290	733
Variable Loads: Pumps Modelled in IDEAS							**14065**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	6700	16969	1444	1141	1420	279
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	6426	21422	1327	2838	3600	762
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	2448	9168	1275	956	1260	304
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	790	1083	2314	154	320	166
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	2186	3972	1763	1015	1800	785
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	116	647	1184	160	220	60
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	673	3163	1214	693	900	207
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	387	861	1553	226	930	704
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	5904	23191	1265	4567	4000	-567
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	408	5607	1075	789	1000	211
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	12854	1020	1527	1800	273
Variable Loads: Other							**18830**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					4612	5507	895
Other Process Equipment	VertiMill Power	Grinding	32	673	1451	1576	7718	6800	-918
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 2: Outputs for 8000 t/h ROM feed rate and 7.0% Fe in feed.

							IDEAS Total	TTRL Installed	
	Grade	7.0	%				Power	Power	Difference
	ROM Rate	8000	tph				MW	MW	MW
							61.35	61.34	-0.01
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**12156**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6522	6290	-232
Variable Loads: Pumps Modelled in IDEAS							**16706**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1444	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7674	25579	1327	3388	3600	212
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	2923	10946	1275	1141	1260	119
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	943	1295	2311	185	320	135
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	2612	4755	1760	1215	1800	585
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	139	770	1184	190	220	30
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	804	3773	1214	827	900	73
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	463	1028	1553	270	930	660
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	7049	27237	1270	5363	4000	-1363
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	487	6687	1075	940	1000	60
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15348	1020	1823	1800	-23
Variable Loads: Other							**21222**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	804	1741	1572	9215	6800	-2415
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 3: Outputs for 6700 t/h ROM feed rate and 10.3% Fe in feed.

							IDEAS Total	TTRL Installed	
	Grade	10.3	%				Power	Power	Difference
	ROM Rate	6700	tph				MW	MW	MW
							58.29	61.34	3.05
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**10104**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4357	5050	693
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					5068	6290	1222
Variable Loads: Pumps Modelled in IDEAS							**14191**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	6700	16969	1441	1141	1420	279
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	6438	21461	1331	2843	3600	757
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	2828	9454	1315	985	1260	275
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1214	1665	2306	237	320	83
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3295	5993	1755	1532	1800	268
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	200	716	1303	177	220	43
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1014	3377	1318	740	900	160
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	671	1491	1551	392	930	538
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	5476	18570	1315	3657	4000	343
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	552	6807	1081	957	1000	43
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	12877	1025	1530	1800	270
Variable Loads: Other							**22729**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					4612	5507	895
Other Process Equipment	VertiMill Power	Grinding	32	1014	2190	1571	11617	6800	-4817
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 4: Outputs for 8000 t/h ROM feed rate and 10.3% Fe in feed.

							IDEAS Total	TTRL Installed	
	Grade	10.3	%				Power	Power	Difference
	ROM Rate	8000	tph				MW	MW	MW
							65.91	61.34	-4.57
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**11712**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6078	6290	212
Variable Loads: Pumps Modelled in IDEAS							**17003**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1441	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7679	25600	1331	3391	3600	209
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3384	11310	1315	1179	1260	81
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1455	1998	2304	285	320	35
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3946	7173	1751	1833	1800	-33
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	240	858	1303	212	220	8
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1216	4051	1318	888	900	12
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	804	1788	1551	470	930	460
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	6533	22396	1310	4410	4000	-410
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	663	8162	1081	1148	1000	-148
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15361	1025	1825	1800	-25
Variable Loads: Other							**25936**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	1215	2622	1573	13929	6800	-7129
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 5: Outputs for 6700 t/h ROM feed rate and 12.2% Fe in feed.

Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m³	Power kW	TTRL Installed Power kW	Difference Power kW
							IDEAS Total Power	TTRL Installed Power	Difference
	Grade	12.2	%				MW	MW	MW
	ROM Rate	6700	tph				60.79	61.34	0.55
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**10857**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4357	5050	693
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					5821	6290	469
Variable Loads: Pumps Modelled in IDEAS							**15442**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	6700	16969	1440	1141	1420	279
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	6437	21454	1329	2842	3600	758
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3021	11368	1273	1185	1260	75
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1312	1927	2136	275	320	45
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3437	6248	1747	1597	1800	203
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	255	910	1304	224	220	-4
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1059	4117	1265	902	900	-2
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	834	1854	1551	487	930	443
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	5378	20882	1266	4112	4000	-112
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	488	8158	1063	1147	1000	-147
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	12872	1024	1529	1800	271
Variable Loads: Other							**23226**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					4612	5507	895
Other Process Equipment	VertiMill Power	Grinding	32	1057	2282	1575	12114	6800	-5314
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

Table 6: Outputs for 8000 t/h ROM feed rate and 12.2% Fe in feed.

Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m³	Power kW	TTRL Installed Power kW	Difference Power kW
							IDEAS Total Power	TTRL Installed Power	Difference
	Grade	12.2	%				MW	MW	MW
	ROM Rate	8000	tph				68.75	61.34	-7.41
Fixed Loads							**11264**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					4500	4500	0
Variable Loads: with Production							**12576**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6941	6290	-651
Variable Loads: Pumps Modelled in IDEAS							**18450**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1440	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7687	25616	1328	3393	3600	207
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3607	13571	1273	1415	1260	-155
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1565	2299	2136	328	320	-8
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	4101	7454	1744	1905	1800	-105
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	304	1088	1304	268	220	-48
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1262	4903	1265	1074	900	-174
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	997	2215	1551	582	930	348
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	6423	25030	1265	4929	4000	-929
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	581	9724	1063	1367	1000	-367
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15368	1023	1825	1800	-25
Variable Loads: Other							**26458**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	1261	2721	1575	14451	6800	-7651
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

4.2 Stochastic Cases

Two production rate distributions were used to create two stochastic runs. The distributions are depicted in Figure 2 and Figure 3 above.

In addition to the varying production rate, the model had an allowance for scheduled maintenance as described in Section 2. Overall, the duration and frequency of this allows for stopped production due to planned and unplanned maintenance, sailing times, and crawler repositioning.

A separate switch is used to model production stops due to excess significant wave height

Refer also to Reference 5, Time Usage page, and to Table 8 in Appendix B.

4.2.1 6700 t/h ROM Feed Dynamic Case

The power consumption for major groups of users and the total power required for the operation is shown in Figure 6 when the most likely mining rate is 6700t/h dry ROM feed:

- Predicted total power consumption peaks at 82.0MW (black trace).
- Predicted total power consumption averages 55.2MW.
- Total power consumption is broken down into mining (red trace), onship processing (green trace), mooring etc. (purple trace) and RO (blue trace) power requirements.
- Average ROM feed rate is 6266t/h (dry basis). The average rate is less than the “most likely” due to the triangular distribution chosen to represent the variation in mining rate and the production stoppages during the simulation.
- Although the model was run for 8760 hours (one year), the traces are for three months for clarity of the plot.

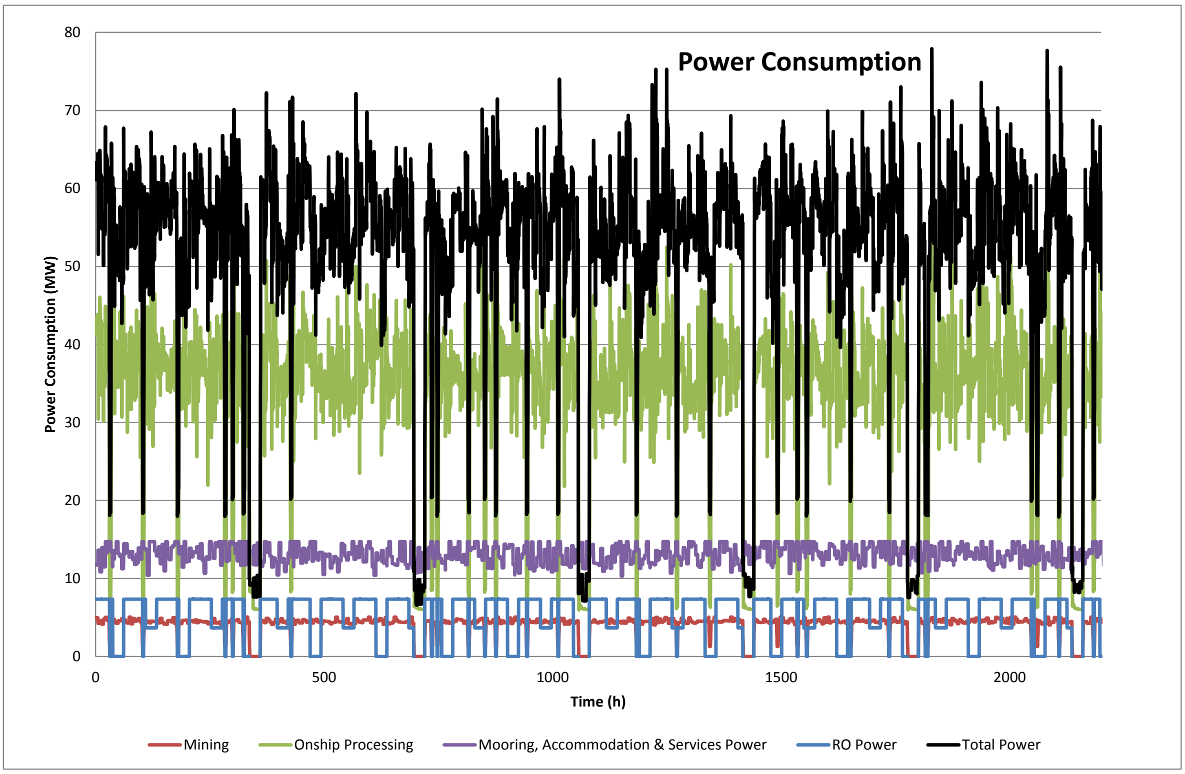


Figure 6: Predicted power consumption at a most likely mining rate of 6700t/h dry ROM feed.

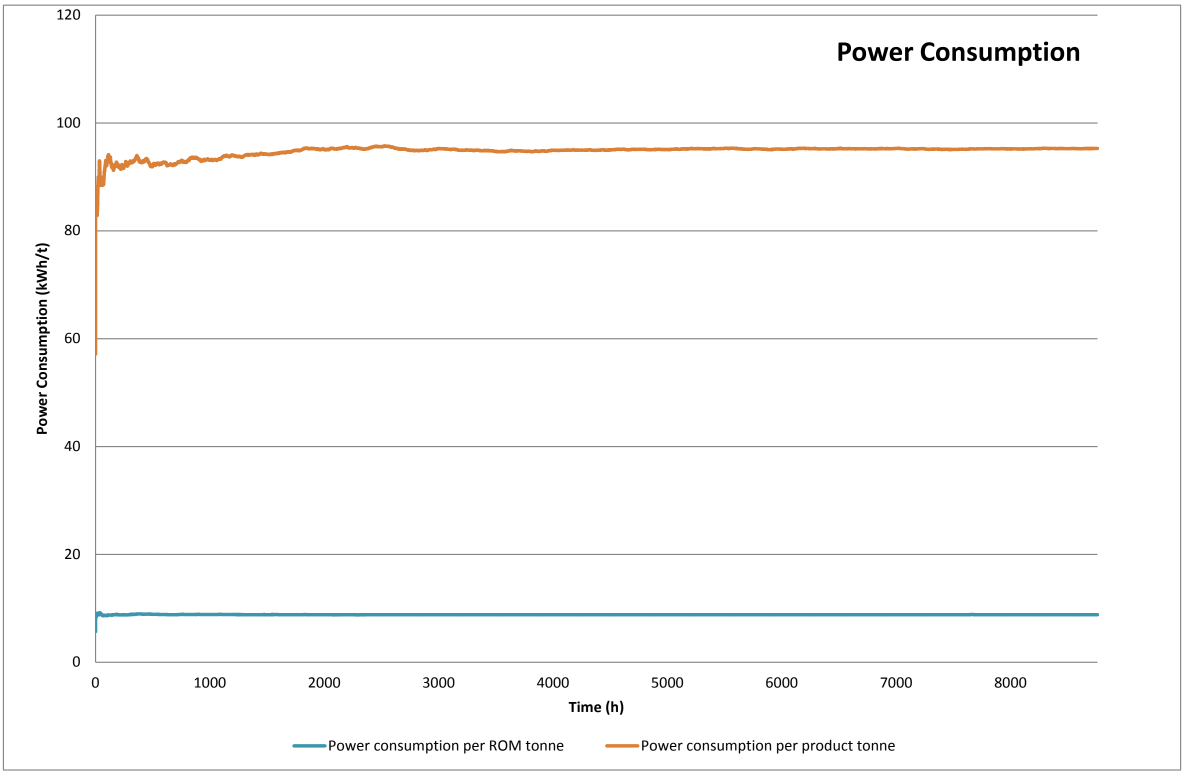


Figure 7: Predicted power consumption per tonne of (i) ROM feed and (ii) product at a most likely mining rate of 6700t/h dry ROM feed.

Power consumption per tonne of mine feed (blue trace) and product (orange trace) is shown in Figure 7:

- Per tonne of ROM feed, power consumption peaks at 9.18kWh/t and averages at 8.81kWh/t.
- Per tonne of product, power consumption peaks at 95.74kWh/t and averages at 94.73kWh/t.
- The plot shown is for the full 8760 hours (one year) of data.

A stacked plot of changing input variables and total power consumption is shown in Figure 8 in order to see how the variables affect power consumption:

- The plot shown is for the first three months of the simulation for clarity of the plot.
- ROM feed rate averages at 6266t/h with a maximum of 8418t/h (dry basis, blue trace).
- Product rate averages at 580t/h with a maximum of 1444t/h (dry basis, trace not shown).
- The average grade is 10.19%Fe in this simulation and ranges between 7 and 12.2%Fe (red trace).
- Wave height averages at 2.26m (green trace) and there are 440 hours over the year of simulation where wave height exceeds 4m, with a maximum of 5.99m (green trace).
- The frequency of plant stoppages have increased since the recent change from 4.5m to 4m for acceptable wave height for plant operation (wave height is green trace, ROM feed is blue trace). Refer to the prefeasibility study report, Reference 15.
- Wind speed averages at 8.5m/s with a maximum of 25.8m/s (purple trace).

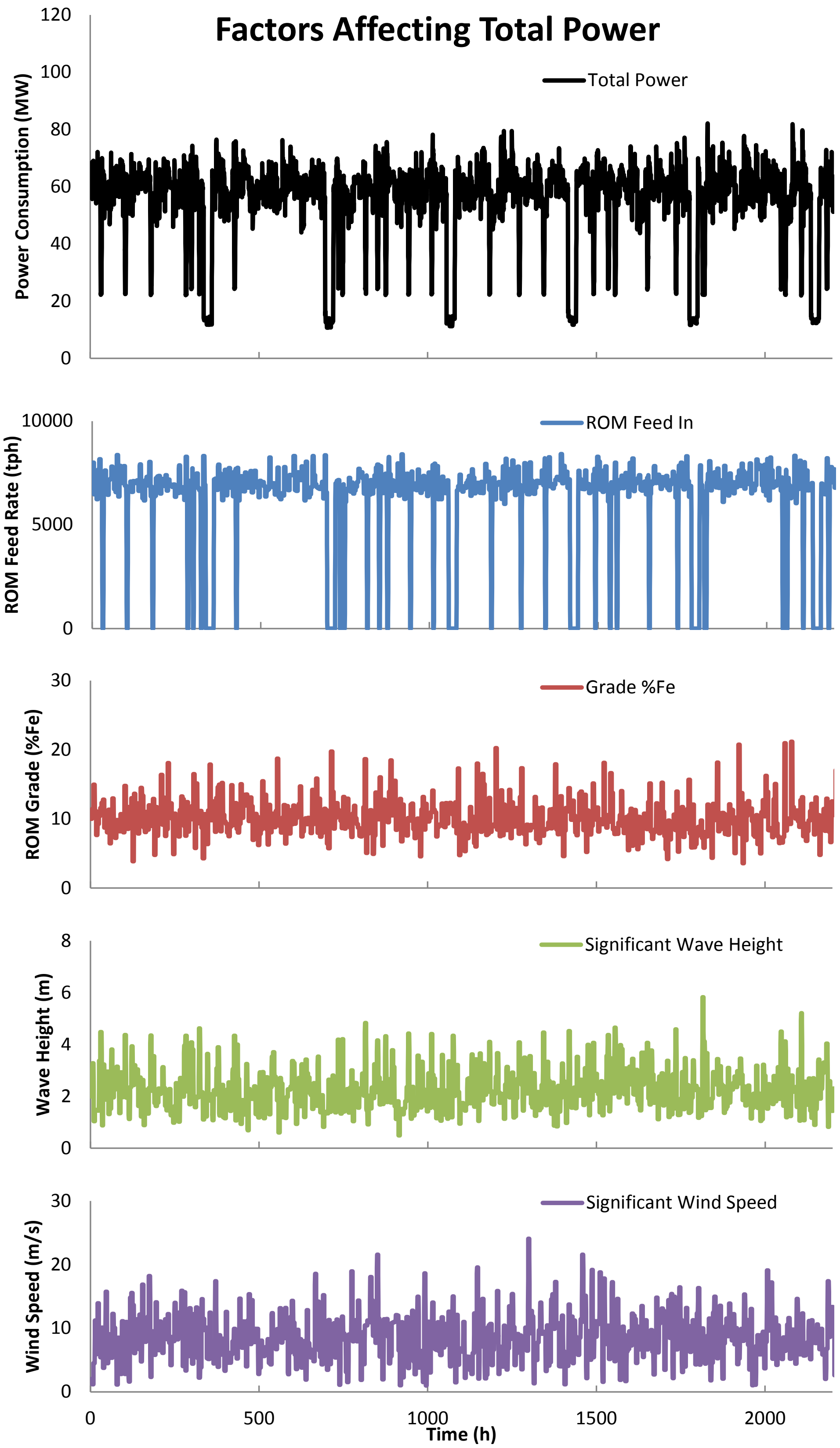


Figure 8: Stochastic variables influencing total power consumption at a most likely mining rate of 6700t/h dry ROM feed.

4.2.2 8000 t/h ROM feed Dynamic Case

The major users power consumption is shown in Figure 1 when the most likely mining rate is 8000t/h dry ROM feed:

- Predicted total power consumption peaks at 82.3MW (black trace).
- Predicted total power consumption averages 56.5MW.
- Total power consumption is broken down into mining (red trace), onship processing (green trace), mooring etc. (purple trace) and RO (blue trace) power requirements.
- Average ROM feed rate is 6702t/h (dry basis). As with the previous case, the average rate is less than the “most likely” due to the triangular distribution chosen for mining rate and the production stoppages.
- Although the model was run for one year, only three months of data are shown for plot clarity.

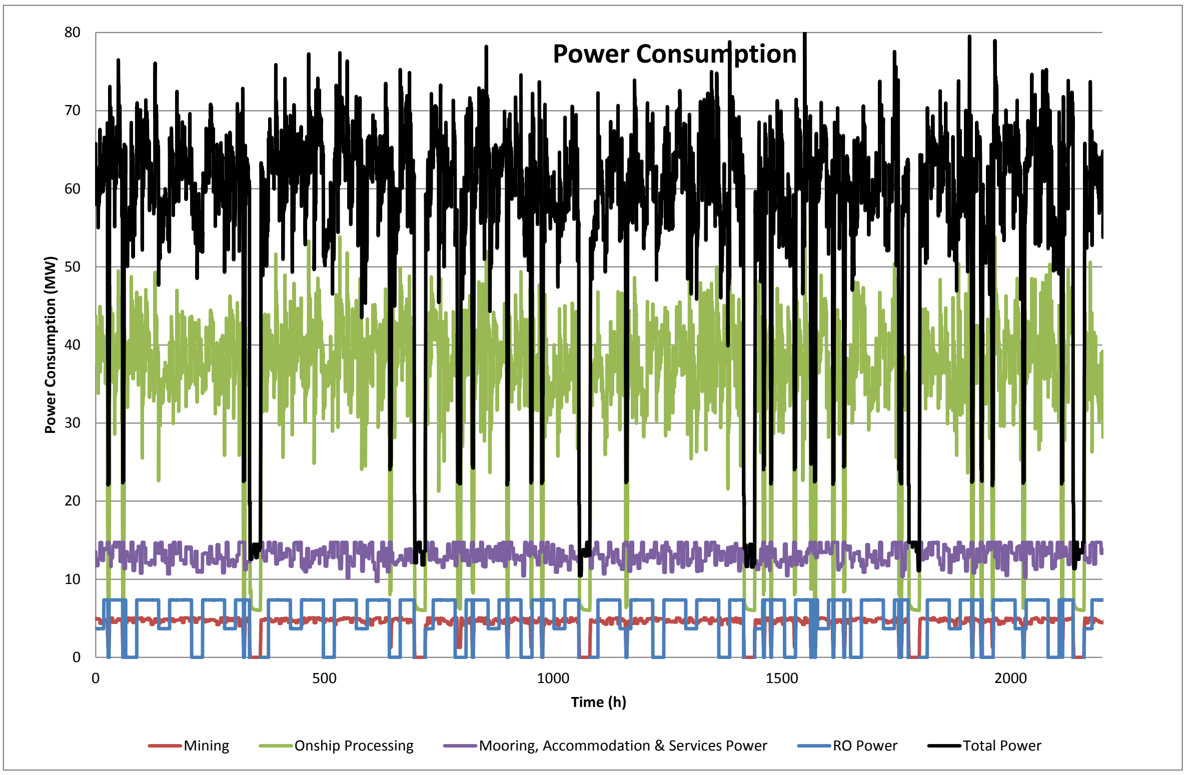


Figure 9: Predicted power consumption at a most likely mining rate of 8000t/h dry ROM feed.

Power consumption per tonne of mine feed (blue trace) and product (orange trace) is shown in Figure 10:

- Per tonne of ROM feed, power consumption peaks at 8.86kWh/t and averages at 8.41kWh/t.
- Per tonne of product, power consumption peaks at 93.50kWh/t and averages at 91.73kWh/t.
- The plot shown is for the full 8760 hours (one year) of data.
- Compared to the 6700t/h case, the power consumption per tonne has reduced slightly due to the base fixed power load being shared over a higher production rate.

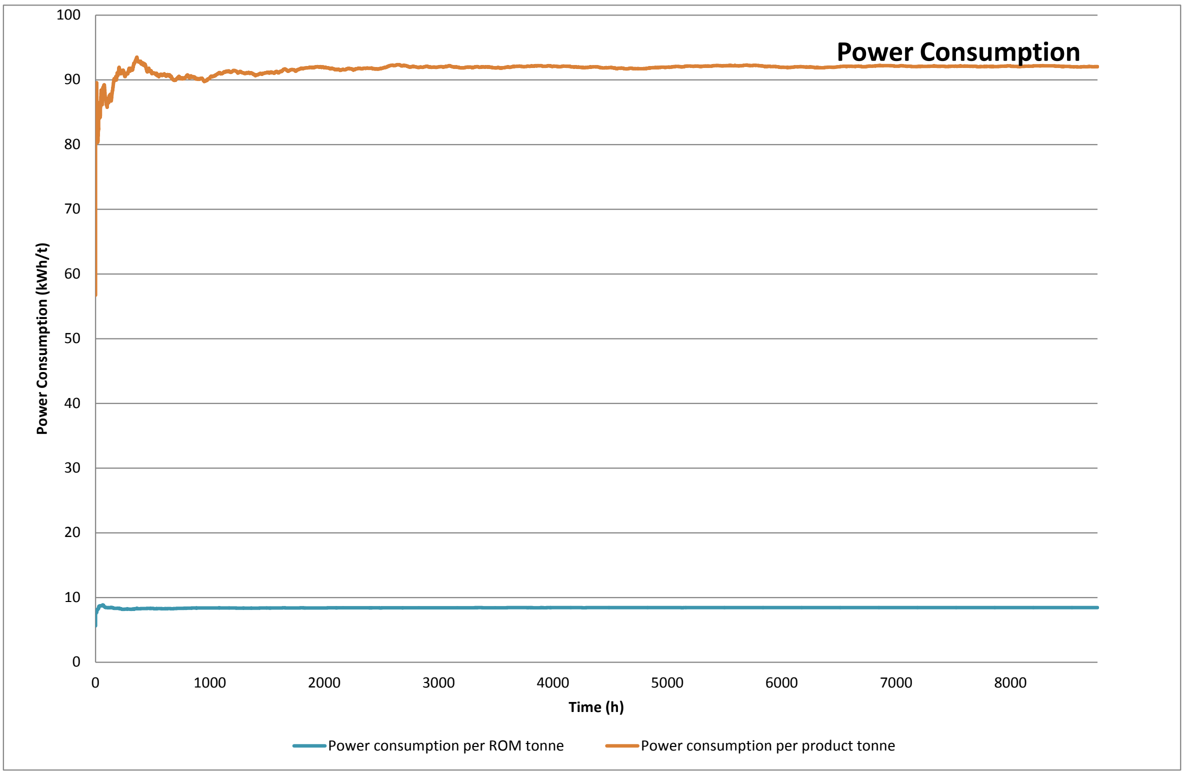


Figure 10: Predicted power consumption per tonne of (i) ROM feed and (ii) product at a most likely mining rate of 8000t/h dry ROM feed.

A stacked plot of changing input variables and total power consumption is shown in Figure 11 in order to see how the variables affect power consumption:

- The plot shown is for the first three months of the simulation for clarity of the plot.
- ROM feed rate averages at 6702t/h with a maximum of 8485t/h (dry basis, blue trace).
- Product rate averages at 614t/h with a maximum of 1514t/h (dry basis, trace not shown).
- The average grade is 10.04%Fe in this simulation and ranges between 7 and 12.2%Fe (red trace).
- Wave height averages at 2.30m (green trace) and there are 397 hours over the year of simulation where wave height exceeds 4m, with a maximum of 6.16m (green trace).
- The frequency of plant stoppages have increased since the recent change from 4.5m to 4m for acceptable wave height for plant operation (wave height is green trace, ROM feed is blue trace). Refer to the prefeasibility study report, Reference 15.
- Wind speed averages at 8.9m/s with a maximum of 27.4m/s (purple trace).
- Slight variation in average grade %Fe, wave height and wind speed can be expected compared to the 6700t/h case due to the method of generating random numbers within a given distribution during any simulation.

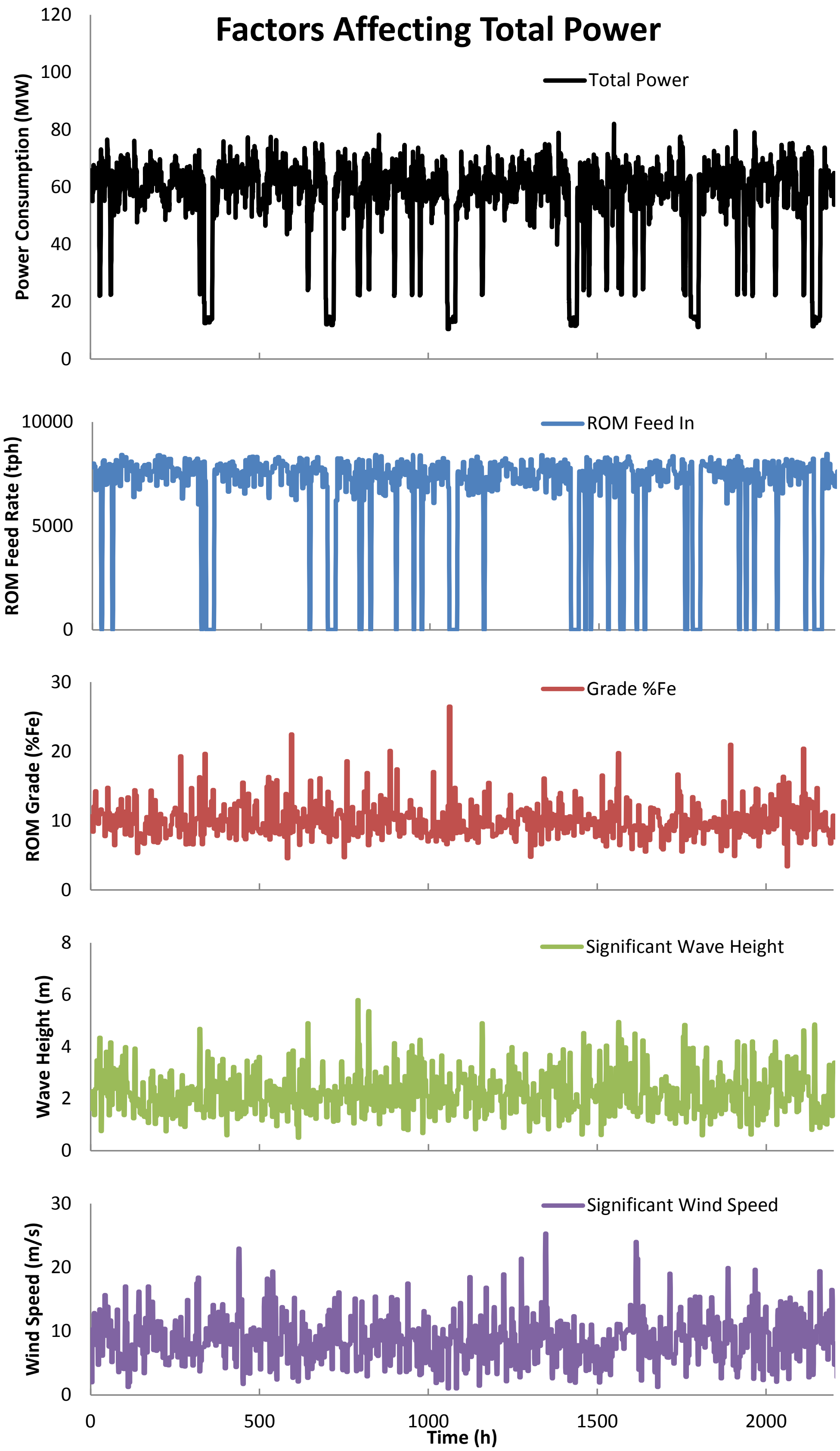


Figure 11: Stochastic variables influencing total power consumption at a most likely mining rate of 8000t/h dry ROM feed.

4.2.3 Scenario: 8000 t/h ROM feed with reduced power consumption by the Vertimills and Trommel Screens

A scenario was run where the following two variations were made:

- TTRL has advised that the Vertimill power consumption per tonne of milled material is being reviewed and is likely to reduce substantially. At present, the model output for the Vertimill exceeds the “installed” power. For example, for the primary design case of 8000t/h ROM at 10.3% grade the calculated power required for the Vertimill was approximately 4800 kW more than the “installed” power of 6800 kW in the current design. For this scenario the Vertimill power consumption for steady state was reduced from 11.46 kWh/t to 3.5 kWh/t.
- TTRL has also advised that the Trommel Screens may be replaced with vibrating screens and that the power requirements for the vibrating screens will be significantly less than for the Trommel Screens. For this scenario the power consumption for steady state was reduced from 4500 kW for four Trommel Screens to 400 kW for four Vibrating Screens.

Outputs for the steady state scenario are shown in Table 7. Total power consumption has reduced to 52MW from nearly 66MW with the previous Vertimill and Trommel Screen conditions.

Table 7: Steady state outputs for the reduced power scenario

							IDEAS Total Power	TTRL Installed Power	Difference
	Grade	10.3	%						
	ROM Rate	8000	tph				MW	MW	MW
							52.00	61.34	9.34
Group	Label	Area	Stream No.	Solids Flow t/h	Flow t/h	Density kg/m^3	Power kW	Power kW	Power kW
Fixed Loads							**7164**		
Services & Other	Accommodation	Accommodation					6000	6000	0
Services & Other	Services Power	Services					732	732	0
Other Process Equipment	Derrick Screens	Derrick Screens					32	32	0
Other Process Equipment	Trommel Screens	Trommel					400	4500	4100
Variable Loads: with Production							**11644**		
Crawler Pwr	Crawler Other Power (Jetting Pump + Crawler Hydraulic Drive), ROM Pump	Mining					4954	5050	96
Other Process Equipment	Mag Sep Power	MIMS1, LIMS 1,2,3					680	680	0
Primary Process Pump	Slurry Agitation Pump	Conc Storage					0	0	0
Water Pumps	Water Pumps	Process Water					6009	6290	281
Variable Loads: Pumps Modelled in IDEAS							**16935**		
Primary Process Pump	T1 Trommel Feed Pump	Boil Box	3	8000	20262	1441	1363	1420	57
Primary Process Pump	T1 MIMS Feed Pump	MIMS1	9	7679	25596	1331	3391	3600	209
Primary Process Pump	T1 LIMS1 Feed Pump	LIMS1	13	3385	11315	1315	1179	1260	81
Primary Process Pump	T1 Cyclone1 Feed Pump	Cyclone1	21	1456	1999	2304	285	320	35
Primary Process Pump	T1 Cyclone2 Feed Pump	Cyclone2	28	3948	7178	1749	1835	1800	-35
Primary Process Pump	T1 LIMS2 Feed Pump	LIMS2	30	240	859	1303	212	220	8
Primary Process Pump	T1 LIMS3 Feed Pump	LIMS3	34	1216	4052	1318	888	900	12
Primary Process Pump	Conc Slurry Pump	Conc Storage	70	805	1789	1551	470	930	460
									0
Secondary Process Pump	CoarseTailsCycPump	Tails Coarse	59	6531	22039	1316	4340	4000	-340
Secondary Process Pump	FineTailsCycPump	Tails Fine	65	663	8165	1081	1148	1000	-148
Secondary Process Pump	T1 MIMS Agitation Feed Pump	MIMS1	8	0	15357	1025	1824	1800	-24
Variable Loads: Other							**16262**		
Ship's Power	DP Positioning	Mooring System					6000	8000	2000
Services	RO Power	Desal					5507	5507	0
Other Process Equipment	VertiMill Power	Grinding	32	1216	2625	1572	4255	6800	2545
Other Process Equipment	Conveyor Power	Conveyor					500	500	0

The major users power consumption is shown in Figure 12 when the most likely mining rate is 8000t/h dry ROM feed:

- Predicted total power consumption peaks at 67.3MW (black trace).
- Predicted total power consumption averages 46.9MW.

- Total power consumption is broken down into mining (red trace), onship processing (green trace), mooring etc. (purple trace) and RO (blue trace) power requirements.
- Average ROM feed rate is 6700t/h (dry basis). As with the previous case, the average rate is less than the “most likely” due to the triangular distribution chosen for mining rate and the production stoppages.
- The model was run for three months.

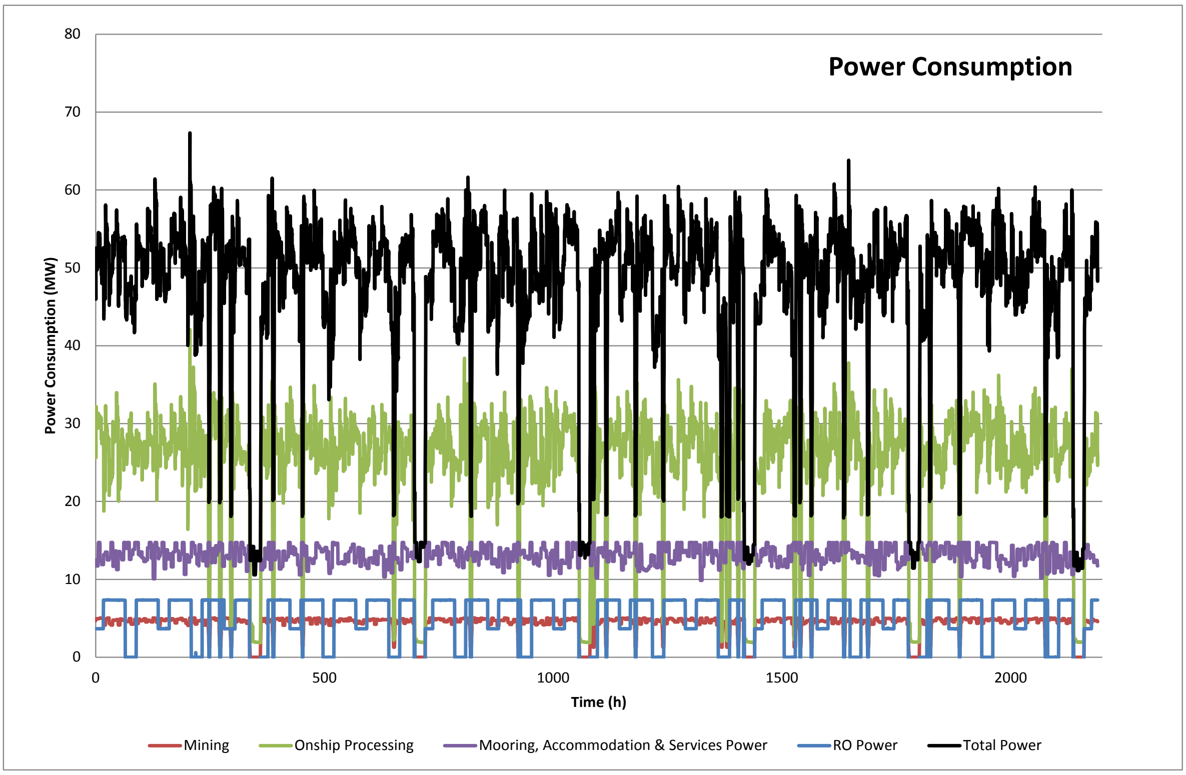


Figure 12: Predicted power consumption for the reduced power scenario.

Power consumption per tonne of mine feed (blue trace) and product (orange trace) is shown in Figure 13:

- Per tonne of ROM feed, power consumption peaks at 7.03kWh/t and averages at 6.97kWh/t.
- Per tonne of product, power consumption peaks at 94.89kWh/t and averages at 75.23kWh/t.
- The plot shown is for the three months.

Compared to the higher power 8000t/h case, the differences are quite significant although there is little difference in peak power demand.

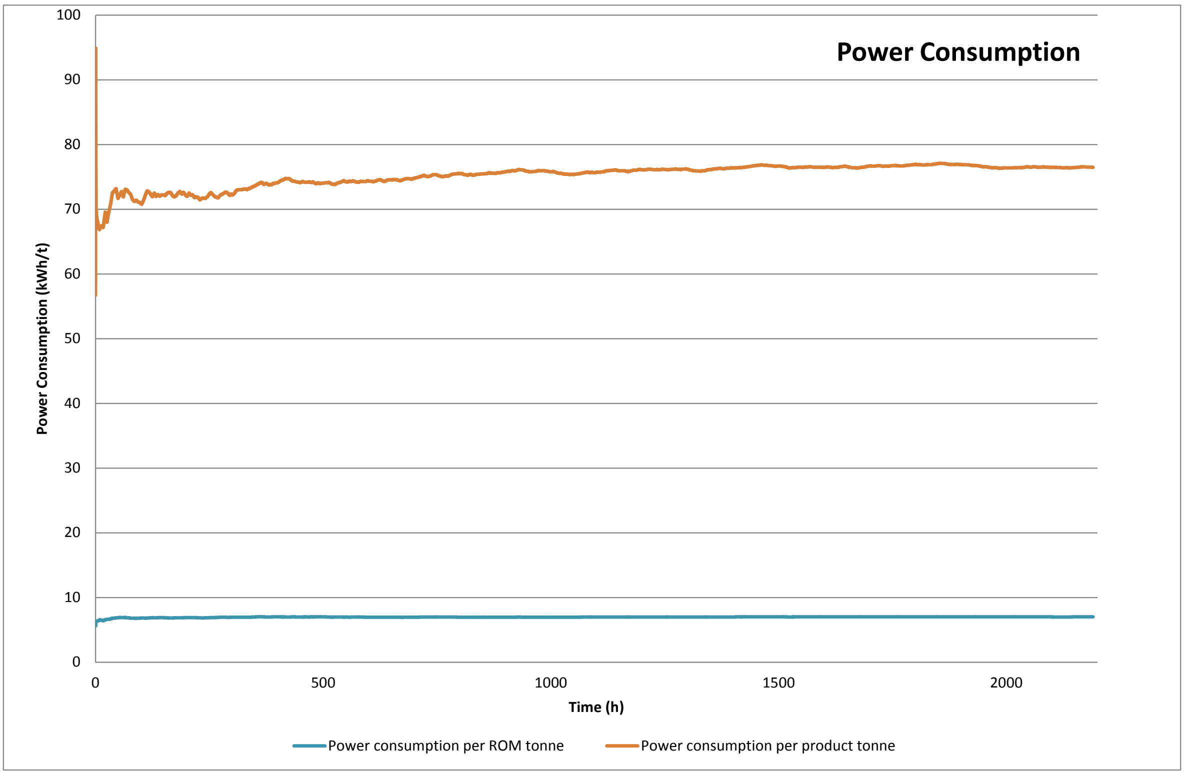


Figure 13: Predicted power consumption per tonne of (i) ROM feed and (ii) product for the reduced power scenario.

A stacked plot of changing input variables and total power consumption is shown in Figure 11 in order to see how the variables affect power consumption:

- ROM feed rate averages at 6700t/h with a maximum of 8493t/h (dry basis, blue trace).
- Product rate averages at 614t/h with a maximum of 1597t/h (dry basis, trace not shown).
- The average grade is 10.03%Fe in this simulation and ranges between 7 and 12.2%Fe (red trace).
- Wave height averages at 2.30m (green trace) and there are 94 hours over the 3 months of simulation where wave height exceeds 4m, with a maximum of 5.55m (green trace).
- The frequency of plant stoppages have increased since the recent change from 4.5m to 4m for acceptable wave height for plant operation (wave height is green trace, ROM feed is blue trace). Refer to the prefeasibility study report, Reference 15.
- Wind speed averages at 8.5m/s with a maximum of 28.4m/s (purple trace).

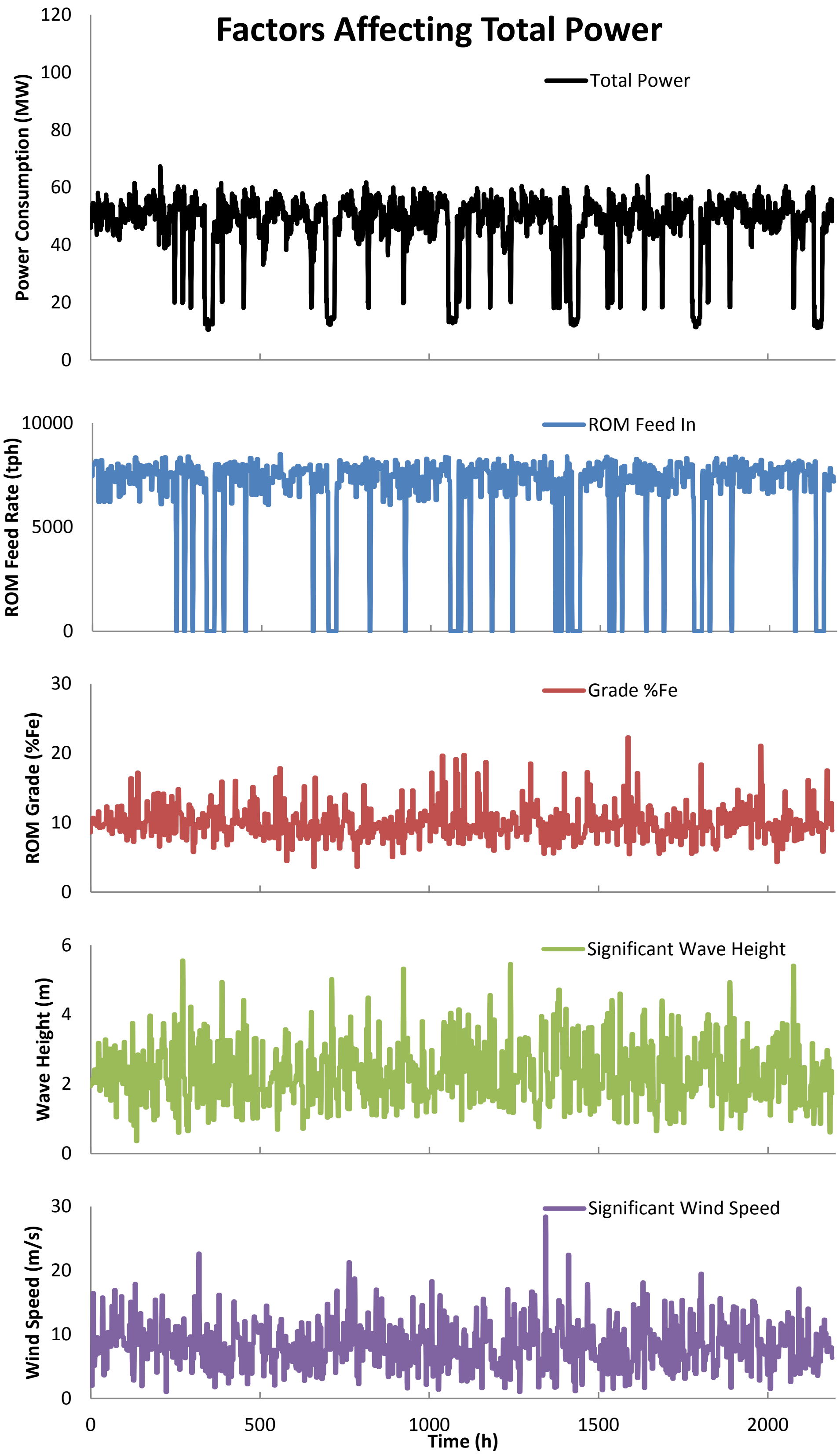


Figure 14: Stochastic variables influencing total power consumption for the reduced power scenario.

5 Modelling Limitations

5.1 Overall

The model incorporates the current process design, calculating power requirements using the information supplied by TTRL. However, there are a few provisos which we need to record:

- The process is currently being independently verified by TTRL and is therefore subject to change.
- Although we have used separation efficiencies provided by TTRL, there are some differences between our results and the TTRL calculations which should be examined in more detail.
- Some further work is desirable on separation efficiencies so that the model can properly address very low and very high grade feeds.
- Recycle streams may well be required in real life to balance flows around the plant and these have not been considered but may have some effect on required pumping capacities.
- Some of the major power consumers (positioning system, ROM pump, accommodation and services, and VertiMill) are either not modelled in a dynamic way or require refined modelling due to their contribution to the overall power demand. In particular:
  - The positioning power calculation does not consider any sort of relationship between wave height and wind speed (or between these and sea currents and ship's heading) and is also based on a preliminary interpretation of what might be required. As such, the positioning calculation can only be regarded as a preliminary first estimate.
  - The pump calculations are based on TTRL's estimate of discharge head and take no account of changes in dynamic head due to slurry flow or composition changes.
- The model does not have any cap on the capacity of unit operations downstream of the ROM pump. This means that combinations of high mining rate and high ROM grade may result in production rates which exceed the final design capacity of some unit operations.

5.2 Steady State Modelling

The mass balance results from the steady state modelling do not exactly match the results from TTRL's mass balance and it is most likely that this is caused by:

- Small offsets in some of the control loops used to converge the model
- Possible inaccuracies of some of TTRL's figures in a recycle situation

More work and collaboration between TTRL and Beca would be required to nail down the reasons for these variances.

The model also starts generating error messages for the low production rates with low grades and this is probably due to inaccuracies in the separation efficiencies for some of the fringe cases.

Ideally, it would be nice to have separation efficiencies provided as a function of the grade of the feed to the unit operation and also as a function of feed rate. However, we understand that these details are difficult to establish.

5.3 Stochastic Modelling

The stochastic modelling gives some idea of the variability of the instantaneous power demand and provides a calculation for the long run power requirement per tonne of ROM or product. However, the model in its present form is not capable of dynamically calculating friction losses and pump efficiencies as a function of flow rate and nor does it have a robust representation of separation efficiencies (as noted above).

6 Future Work

6.1 Inclement Weather

If further discussions with the ship builder yielded new or different information about the expected power consumption for ship positioning at different wind speeds and wave heights, then the simulation could be updated to see the effect on power consumption.

However, a realistic analysis of the effects of inclement weather on mining vessel operations and power consumption would need to involve temporal modelling of wind, waves, and current combined with management strategies for ship's heading.

These sorts of issues also bear on the transfer operation between the mining vessel and the FSO and also the product transfer from the FSO to the Cape Size vessel.

6.2 Other Production Cases

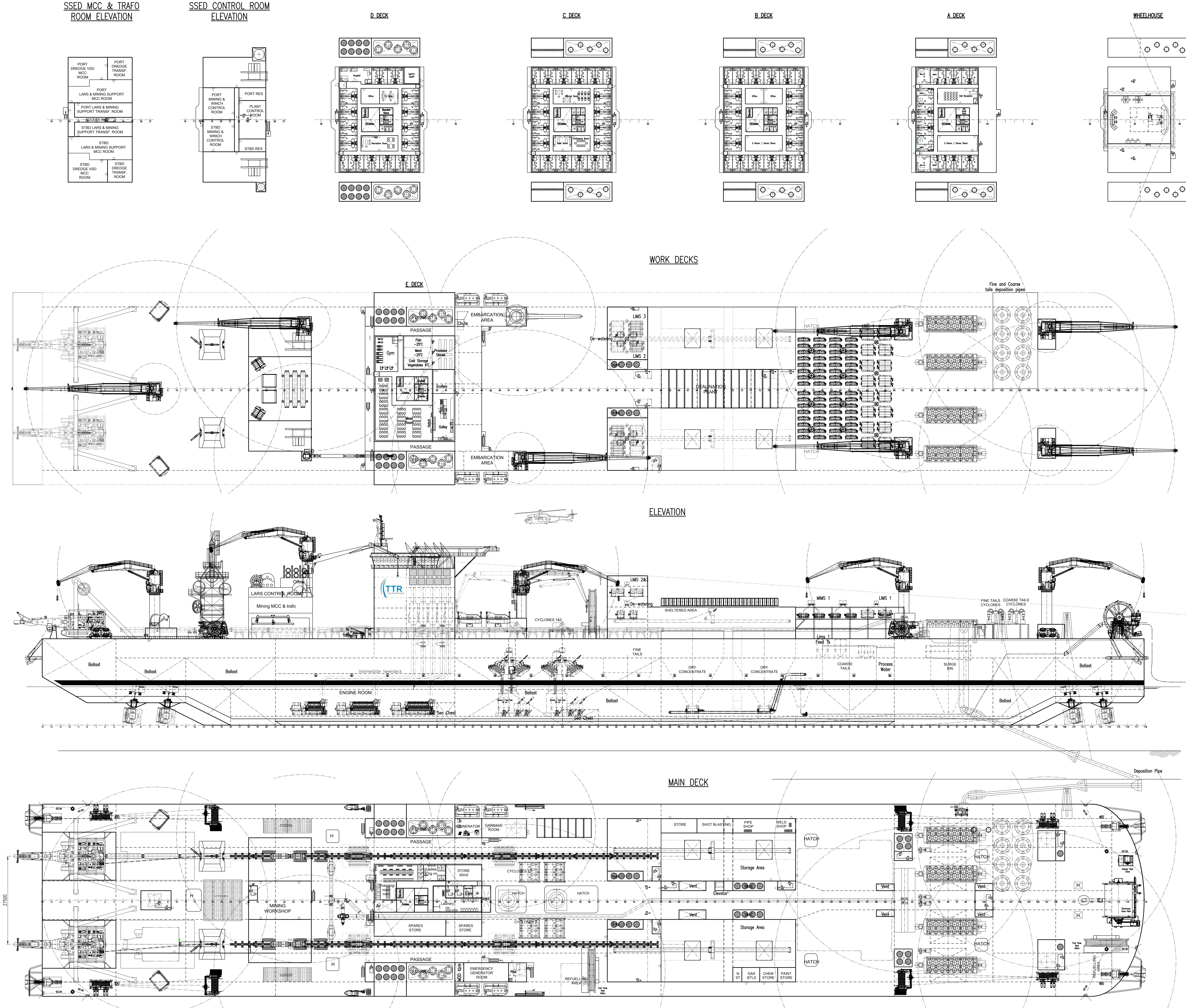
Other cases which could be simulated to improve the accuracy of the expected power consumption:

- New or better information on Vertimill power consumption.
- Desalination plant running and not running.
- Random equipment failures affecting one train or part of one train.
- Start up and shut down sequencing.
- More complex representation of product transfer to the FSO, the effect of FSO availability on production, and the effect of Cape Size availability on FSO availability.
- Updated process design following the impending process verification by an independent party.

7 References

1. TTRL-05-PFD-10002, rev 0E, Iron Sand Wet Processing Plant PFD – average flow
2. TTRL-05-DWG-52000, rev 0C, Iron Sand Wet Processing Plant Schematic
3. TTRL Grade Impact Overview spreadsheet rev P4
4. TTRL-04-BOD-12000 BFS Assumptions Register R6 20 Nov 2013 (KP) spreadsheet, FSO cycle tab
5. TTRL-04-BOD-12000 BFS Assumptions Register R5 15 Nov 2013 spreadsheet, Tabs: Design and Interface, Time Usage, 900 Crawler
6. TTRL-13-MEM-12000 Memo on ROM Grade Variation, 5 Nov 2013
7. TTRL-05-BOD-12000-R1 Bankable Feasibility Study Basis of Design, 3 Dec 2013
8. TTRL-04-CLC-13000-RO – Pump and Line Sizing Calculation spreadsheet, 29 Nov 2013
9. TTRL-05-SCH-13000, rev 5, Major Equipment Summary, Pump List
10. TTRL-13-EXT-05000, rev 0, Kupe Metocean Design Criteria
11. TTRL-13-BOD-00001, rev 0, Mining Resource Schedule, 20 Oct 2013
12. 2932288-PF-001, rev A, Desalination Plant PFD
13. NZ1-8221576-TTRL, rev A, Desalination Scoping Study – Motor List
14. TTRL-BFS-BFD, rev 0, Mass and Water Balance 22 Nov 2013
15. NZ1-7456818-3 0.3 Simulation Model TTRL Offshore Project Report, Prefeasibility Study, 23 May 2013

Appendix 19.4 - Intergrated Mining Vessel GA Drawings



CLASS NOTATION

American Bureau of Shipping
✠ A1, Special Purpose Ship

Service Notation: Mining vessel
Site specific South Taranaki Bight, NZ

✠ AMS, UWILD, CPS
ACCU, TAM,
HAB (OS)
SH-DLA,
SFA (20 years),
CIRCLE E, CIRCLE C
HELIDK
CRC

PRINCIPAL PARTICULARS:

Length over all	Loa	345.00 m
Length rule	L	332.00 m
Breadth moulded	B	60.00 m
Depth moulded	D	26.25 m
Draught scantling	Ts	15.00 m
Draught design	Td	15.00 m
Complement		120 pers

Status: FOR APPROVAL IN PRINCIPLE 4 MARCH 2014

REV.	DATE	REMARKS	DRAWN	CHECKED	APPROVED
B	04 Mar 2014	For approval in Principle	Dlr	DSM	SBo
A1-6		Progress issues	Dlr	RdV	SBo

Approved: yard Date: | Approved: class Date:
Approved: owner Date: | Approved: auth. Date:

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GENERAL ARRANGEMENT PLAN
MINING VESSEL TTRL

Principal:

Scale 1 : 400

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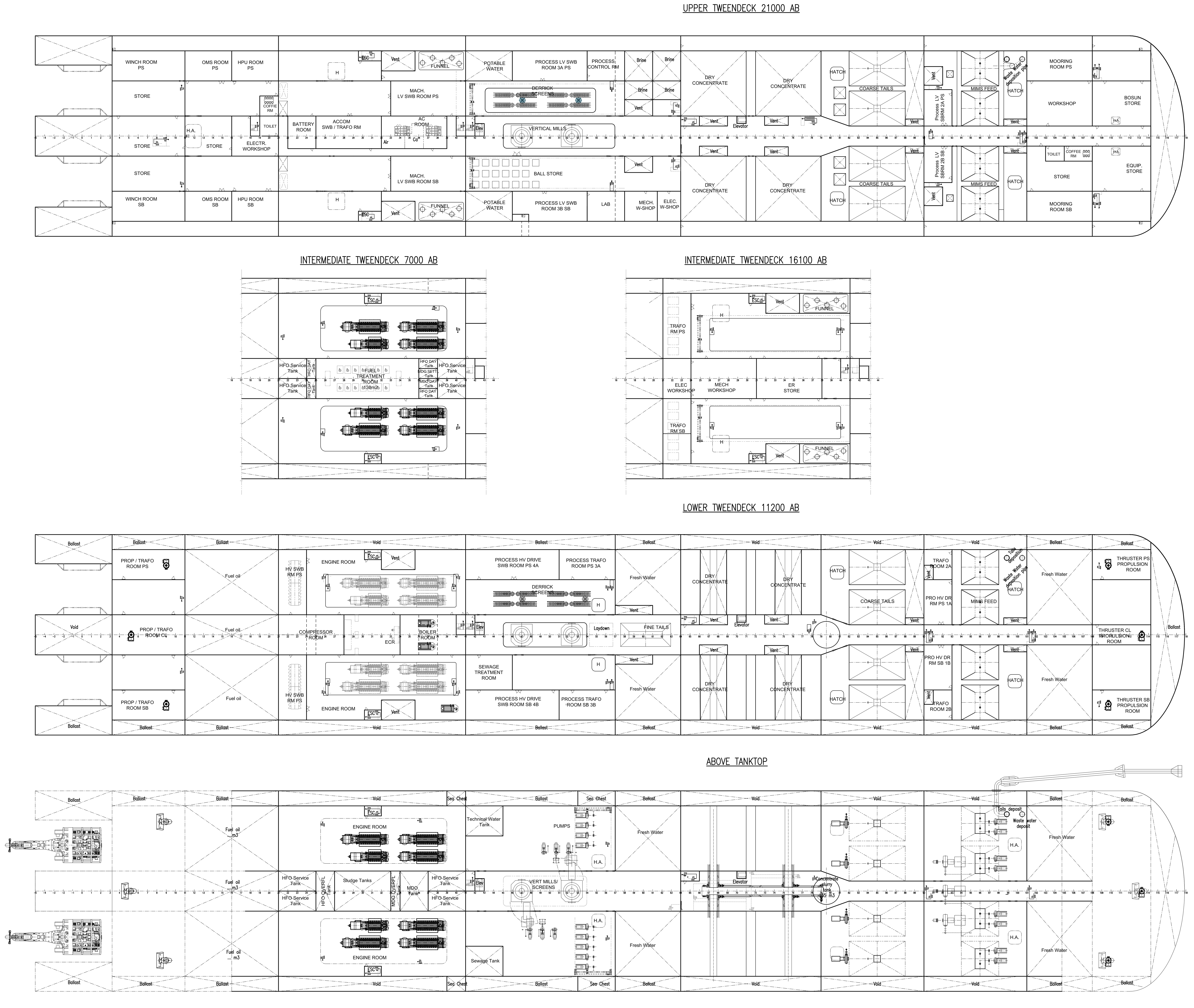

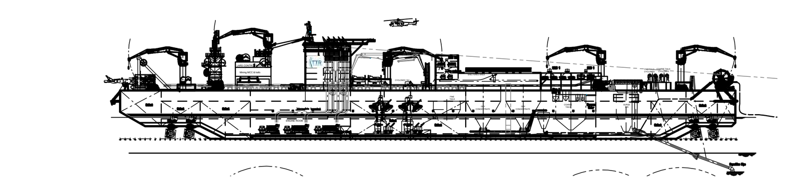

Status: **FOR APPROVAL IN PRINCIPLE 4 MARCH 2014**

REV.	DATE	REMARKS	DRAWN	CHECKED	APPROVED
B	04 Mar 2014	For approval in Principle	DIr	DSM	SBo
A1-6		Progress issues	DIr	RdV	SBo

Approved:	yard	Date:	Approved:	class	Date:
Approved:	owner	Date:	Approved:	auth.	Date:

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GENERAL ARRANGEMENT PLAN

MINING VESSEL TTRL

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Appendix 19.5 - Trans Tasman Resources Ship Personnel Assessment

Marine personnel per shift. (Two shifts required).

Level	Grade #1		Grade #2		Grade #3		Grade #4		Grade #5		Grade #6		Per vessel per shift	Total
Experience	15+ years, Marine Certification	No.	10+Years, Marine Certification	No.	10+, Technical Degree/Diploma, Marine Certification	No.	10+, Trade/Tech Qual , Marine Certification	No.	5+ years, + Trade/Qual + Marine Certification	No.	2+years, Certification	No.		
Operational Job Description	MV Captain	1	MV Mining Superintendant	1	Utility Engineer	1	MV Laboratory technicians	1	MV Medic	2	MV Cargo Operator (Deck Hand)	2		
	MV Installation Manager	1	MV Process Superintendant	1	Maintenance Engineer	1	MV Utility Operator	2	MV Camp Boss/Day Cook	1	MV Crane Driver	2		
			Marine H&S Officer	1			MV Utility Operator	2			MV Night Cook	1		
							MV Crawler Pilot	2			MV Steward	2		
							MV Crawler Relief Pilot	1			MV Steward	2		
							MV Plant operator (Feed & Mag Sep)	2			MV Kitchen Hand	2		
							MV Plant operator (Grinding)	2			MV Kitchen Hand	2		
							MV Relief operators	2			MV Trade Assistant	2		
							MV C&I Technician	2			MV Trade Assistant	2		
							MV C&I Technician	2						
							MV Electrical Tech	2						
							MV Electrical Tech	2						
							MV Hydraulic Tech	2						
							MV Snr. Cargo Operator (Deck Hand)	2						
							MV Mechanical Fitter/Welder	2						
							MV Mechanical Fitter/Welder	2						
	TOTAL IMV	2		3		2		30		3		17	57	114
	AHT Captain	1	AHT 1st Mate	1	AHT Second mate	1	AHT Able Body Seaman	2	AHT Steward	2	AHT Junior Engineer	2		
			AHT Chief Engineer	1	AHT First Engineer	1	AHT Second Engineer	2			AHT Cook	1		
					AHT Electrical Engineer	1	AHT Marine Electrician	2						
	TOTAL AHT	1		2		3		6		2		3	17	34
	TS Captain	1	TS 1st Mate	1	TS Third mate	1	TS Able Body Seaman	2	TS Steward	2	TS Junior Engineer	2		
			TS 2nd Mate	1	TS First Engineer	1	TS Able Body Seaman	2			TS Cook	1		
			TS Chief Engineer	1	TS Electrical Engineer	1	TS Utility Operator	2						
							TS Utility Operator	2						
							TS Second Engineer	2						
							TS Marine Electrician	2						
	TOTAL TS	1		3		3		12		2		3	24	48
	Geo Captain	1	Geo First mate	1	Geo Chief Engineer	1	Geo Drill Support Crew	1	Geo Tech Support	1	Geo Tech Support	1		
					Geo Geologist	1	Geo Drill Support Crew	1						
	TOTAL Geo Exp	1		1		2		2		1		1	8	16
	GRAND TOTAL	**5**		**9**		**10**		**50**		**8**		**24**	**106**	**212**

Appendix 19.6 - RN Barlow Maritime Operations Review

R. N. Barlow and Associates Limited

Trans-Tasman Resources Limited

South Taranaki Bight

Offshore Iron Sand Extraction and Processing Project

Report on the Maritime and Navigational Impacts of the Project

November 2015

Prepared by Captain R N Barlow Master Mariner MNI

In November 2015 I was provided with a summary of additional scientific work commissioned by TTR since 2014. The conclusions from my report dated August 2013 remain valid in light of TTR's additional information.
Ray Barlow 11 November 2015

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Appendix 1 **South Taranaki Bight Marine Traffic Study, Marico Marine (NZ) Ltd**

Appendix 2 **Import Health Standard for ships ballast water from all countries' issued under Section 22 of the Biosecurity Act 1995**

Appendix 3 **Ballast Water Declaration**

Appendix 4 **Craft Risk Management Standard (CRMS) for Biofouling on Vessels arriving to New Zealand' issued under section 24G of the Biosecurity Act 1993.**

Appendix 5 **R N Barlow Experience**

Glossary

AIS	Automatic Identification System
BWM Convention	International Convention for the Control and Management of Ships Ballast Water and Sediments
DP	Dynamic Positioning - a system of maintaining a required position or heading
FPSO	Floating Production Storage and Offloading Vessel
FSO	Floating Storage and Offloading Vessel
HFO	Heavy Fuel Oil 380 Cs
IACS	International association of Classification Societies
IMO	International Maritime Organisation
MARPOL	International Convention for the Prevention of Pollution From Ships
MEPC	Maritime Environment Protection Committee of the IMO
SOLAS	Safety of Life at Sea Convention
SSMS	Safe Ship Management System
TTR	Trans-Tasman Resources Limited
UNCLOS	United Nations Convention on the Law of the Sea

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In conducting the analysis in this report R.N. Barlow and Associates Limited has endeavoured to use what it considers is the best information available at the date of publication, including information supplied by the addressee. Unless stated otherwise, RNBA does not warrant the accuracy of any forecast or prediction in the report. Although RNBA exercises reasonable care when making forecasts or predictions, factors in the process, such as future market behaviour, are inherently uncertain and cannot be forecast or predicted reliably.

1. Executive Summary

Navigation Impacts of the project

The mining site in the South Taranaki Bight for which approval is sought is removed from regular marine traffic routes and activities and should not be in conflict with other marine traffic and activities in the area.

Exclusion Zone FPSO Operations

It is intended to apply to Maritime New Zealand to establish an exclusion zone (or an equivalent) around the FPSO when anchored on the mine site to safeguard other ocean users, members of the public and project vessels from harm.

The exclusion zone around the FPSO is unlikely to affect recreational opportunities in the mining area, the Marine Traffic Study indicates that the area is very lightly used by any vessels and the mine site, because of the nature of the sea bed material, is unlikely to support much marine life which would be of interest to recreational fisher or divers. The site is well removed from recreational boating launching and mooring sites.

Maritime Safety

All the major vessels employed on the project will be classed by a member of International Association of Classification Societies (IACS) and be compliant with the Safety of Life at Sea Convention (SOLAS) and all other International Maritime Organisation (IMO) Conventions as well as the Laws of New Zealand, any other smaller vessels will be registered under the New Zealand Safe Ship Management System (SSMS).

Bio security

Ballast Water and Biofouling

Bio security issues associated with the project essentially revolve around the management of ballast water and hull fouling of vessels arriving in New Zealand. All vessels arriving in New Zealand are required to make a 'Ballast Water Declaration' and comply with the 'Import Health Standard for ships ballast water from all countries' issued under Section 22 of the Biosecurity Act 1995 (Appendix 2)

In addition, arriving vessels will be required to meet the 'Craft Risk Management Standard (CRMS) for Biofouling on Vessels arriving to New Zealand' issued under section 24G of the Biosecurity Act 1993. (Appendix 4)

Operational discharges

Normal vessel operational discharges

Operational discharges will comprise of sea water used for cooling machinery and products of combustion from engines and turbines. Sewage and Garbage will be dealt with as required under MARPOL Annex IV and V.

Mining operational discharges from the FPSO

FPSO mining operational discharges will comprise of de-ored sand being replaced on the seabed in areas that have been mined and brine, which is a by-product of the reverse osmosis plant operation, this will be co-mingled with the de-ored sand.

Process operational discharge from the FSO

Process operational discharge from the FSO will comprise of brackish fresh water from the ore washing process.

Oil and oil products

All oils will be retained on board for disposal ashore at an approved facility.

Hazardous materials

Any hazardous materials will be retained on board for disposal ashore at an approved facility.

Ports

The project is likely to use a number of different ports to support the vessels engaged in the project depending on the services required and the method of delivering them. The ports of Wanganui, New Plymouth and Nelson are the closest to the mine site in that order and each may offer the project support in different ways according to their capabilities.

Personnel

TTR intends to incentivise the use of New Zealand citizens or New Zealand residents as employees of the company and its contractors to service the project.

It is envisaged that around 200 positions will be available to operate on marine vessels associated with the project.

It is envisaged that around 50 positions will be available to directly manage and operate TTR's projects on shore. There will be other direct employment effects resulting from TTR's project should it be approved. These will include maintenance and supply operations for the vessels.

2. Navigation Impacts of the project

2.1. Marine Traffic in South Taranaki Bight

A comprehensive study was commissioned from Marico Marine NZ Limited (Marico) into vessel movements in the South Taranaki Bight to establish the impact of the proposed mining project on vessel activity in the area. This is attached as Appendix A.

The study analysed 12 months of Automatic Identification System (AIS) data for the area extending from Cook Strait to Kahurangi Point and Cape Egmont including Tasman Bay.

AIS was developed primarily as a collision avoidance tool. Vessels that carry an AIS transponder broadcast at regular intervals key information such as their position, identity, type, speed, course, etc. AIS exists in two forms, Class A and Class B: the former is fitted in all vessels so mandated by International Maritime Organisation (IMO); the latter on a voluntary basis by non-SOLAS vessels such as recreational craft.

Regulation 19 of SOLAS Chapter V4 - sets out the navigational equipment to be carried on board ships according to ship type. AIS is required to be carried on:

- All ships of 300 and greater gross tonnage and engaged on international voyages;
- Cargo ships of 500 and greater gross tonnage not engaged on international voyages; and
- All passenger vessels irrespective of size.

The Marico study concluded that, the mining area proposed by Trans-Tasman Resources Limited in the South Taranaki Bight is well separated from the nearest regular shipping routes and commercial fishing grounds and should have 'very little impact, if any, on the safety of navigation in the adjacent areas'.

Figure 1 below shows the cumulative plot of all vessel types over 12 months monitoring of AIS data.

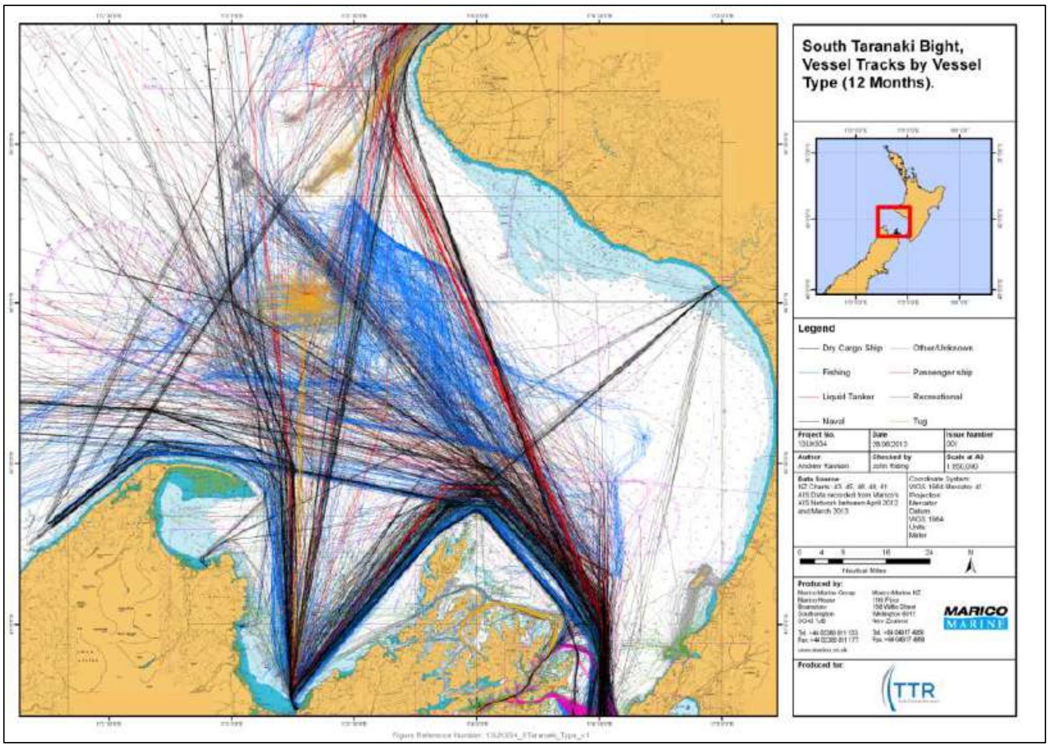

Figure1: cumulative plot of all vessel types over 12 months monitoring of AIS data

2.2. Proximity to Kupe Well Head Platform

The mining operations proposed by TTR will be adjacent and to the south east of the unmanned Kupe Well Head platform, but outside the exclusion zone around this installation and its associated pipelines. Marine activities associated with the platform will be easily accommodated by the mining operations and should not be in conflict.

2.3. TTR vessels' presence

The presence of TTR's manned vessels in the area will supplement the shore based surveillance of the platform's exclusion zone and add to the security of the Kupe operation. TTR's vessels will be equipped with Radar, AIS and an extensive communications suite to detect and communicate with vessels in the area.

2.4. Impacts on Other Marine Operations

Marine traffic in the areas that the project will be conducting these operations is very light, the areas relatively small and the impacts will be minor, if any.

3. Marine Vessel Operations – General Principles

The vessels, management, contractors and crews operating in mining, transporting and supporting the project will be compliant with IMO conventions and New Zealand Law.

It is intended that in addition to being fully compliant, 'best practice' will be the project's operating mantra.

3.1. Marine Vessel Operations – the FPSO

3.1.1. The mining and processing operations are planned to be undertaken continuously 24 hours per day, based on the FPSO which will be moored on a four anchor spread extending up to one nautical mile from the vessel, supplemented by a Dynamic Positioning system to ensure the loads on the mooring system do not exceed design limits.

3.1.2. The FPSO will show the lights and shapes for a vessel restricted in its ability to manoeuvre when at anchor, as required by the Maritime Rule 22.27. Working lights will also be very obvious to other marine traffic as required by Maritime Rule 22.30.

3.1.3. The FPSO will contain significant quantities of HFO. The FPSO's HFO tanks will meet international standards and will comply with the Maritime NZ's and the respective classification society's rules for the containment of fuel, particularly in regard to double containment.

3.1.4. The FPSO will be fitted with an AIS transmitter /receiver to alert traffic to its presence and for the officer of the watch to monitor nearby traffic. The AIS transmission gives position data sourced from GPS and can be monitored from the shore and if combined with mining logs will demonstrate that the vessel's location is in compliance with the consents

3.1.5. The position of each anchor will be marked by a buoy, which will be lit at night.

3.1.6. It is intended that an exclusion zone of one nautical mile radius be set up around the FPSO. This exclusion zone will move to the new location as the FPSO is moved.

3.1.7. The FPSO will move within the anchor pattern as mining and deposition of de-ored sand proceeds and the anchor pattern will be re-laid as extraction is completed in an area.

3.2. Marine Vessel Operations - the FPSO – FSO

3.2.1. The FSO will operate as the transfer vessel between the FPSO and the Export vessel.

3.2.2. The FSO will station itself by dynamic positioning (DP) adjacent to the bow of the FPSO and connect the product transfer hoses to receive the ore slurry.

3.2.3. Whilst approaching and when within the exclusion zone around the FPSO, the FSO will be restricted in its ability to manoeuvre and will show the lights and shapes as required by Maritime Rule 22.27 and 22.30.

3.3. Marine Vessel Operations – the FSO and Export vessel

3.3.1. The transfer operation between the FSO and the export vessel will take place with the export vessel at anchor and the FSO either moored to it or under dynamic positioning in close proximity to the export vessel.

3.3.2. The export vessel will show the lights and shapes required for a vessel at anchor under Maritime Rule 22.30 (1) and (2). The FSO, when transferring cargo and under dynamic positioning will show the lights required by Maritime Rule 22.27, otherwise the lights for a vessel at anchor as required under Maritime Rule 22.30.

3.4. Marine Vessel Operations - Anchor Handling Tug (AHTS)

3.4.1. The AHTS will be used to deploy and move the anchors of the FPSO as required, when doing so it will exhibit the lights of a towing vessel as required by Maritime Rule 22.24.

3.4.2. The AHTS may also be used to transfer stores and equipment to and from other vessels and the shore.

3.5. Marine Vessel Operations – Replenishment vessel

3.5.1. The replenishment vessel will be used to re-fuel the FPSO and the FSO with Heavy Fuel Oil, and supply other stores and spare parts; the fuel transfer will normally be undertaken whilst dynamically positioning alongside these vessels using the RAS method. The AHTS may undertake all or some of these functions.

3.5.2. The replenishment vessel's HFO tanks will meet international standards and will comply with the Maritime NZ's and the respective classification society's rules for the containment of fuel, particularly in regard to double containment.

3.5.3. Whilst replenishment is being undertaken, the replenishment vessel will be restricted in the way it can manoeuvre and show the lights and shapes as required under Maritime Rule 22.27.

3.5.4. Comprehensive operating manuals will be drawn up to manage the fuel transfer operation and a Project Oil Spill Response Plan submitted for approval to Maritime New Zealand.

4. Maritime Safety

4.1. General

4.1.1. All the major vessels employed on the project will be classed by a member of IACS (International Association of Classification Societies) and be compliant with the Safety of Life at Sea Convention (SOLAS) and all other International Maritime Organisation (IMO) Conventions as well as the Laws of New Zealand, any other smaller vessels will be registered under the New Zealand Safe Ship Management System (SSMS).

4.1.2. The vessels will be equipped with navigation equipment, (including charts both electronic and paper) as required by the IMO Conventions and New Zealand Maritime Rules.

4.1.3. The vessels will be equipped with Radar, AIS and an extensive communications suite to detect and communicate with other vessels in their proximity and the shore.

4.1.4. The vessels will be fitted with life-saving equipment as required by the SOLAS Convention and New Zealand Maritime Rules, the crews will be fully trained and competent to operate the life-saving equipment.

4.1.5. The presence of the project vessels in the South Taranaki Bight will be an asset to and enhance any search and rescue operations in the area.

4.1.6. The project will also be serviced by helicopter, which may be available to supplement the current rescue helicopter services in times of emergency.

4.2. Exclusion Zones

4.2.1. It is intended to apply to Maritime New Zealand to establish an exclusion zone, or an equivalent, around the FPSO when anchored on the mine site to safeguard other ocean users, members of the public and project vessels from harm.

4.2.2. The exclusion zone applied for will extend in a circle with a radius of approximately one nautical mile from the FPSO to extend beyond the extremities of the anchor pattern and cover the area where support vessels are manoeuvring and/or are constrained in their ability to manoeuvre.

4.2.3. It is intended that the exclusion zone will be monitored and all movements within the zone will be authorised by the Officer of the Watch on the FPSO.

4.2.4. If authorised by Maritime New Zealand this exclusion zone will be promulgated through Notices to Mariners and noted on Marine charts. Up to date position information of the FPSO will be promulgated to mariners through the vessel's AIS transmissions.

5. Transfer operations

5.1. FPSO to FSO

The FSO will station itself by dynamic positioning (DP) adjacent to the bow of the FPSO and connect the ore/fresh water slurry transfer hoses to receive the ore slurry. The mining operation will continue as the slurry is transferred.

5.2. FSO to Export Vessel

5.2.1. The transfer site for loading the export vessel will be chosen by the Master of the FSO in conjunction with the Master of the export vessel. The transfer site will be contingent on weather conditions at the time and the immediate forecast. It would be expected that the master of the FSO will be pre-eminent in this decision because of better local knowledge.

5.2.2. The transfer site nominated will be advised to Maritime New Zealand by the master of the FSO and a radio navigation warning issued to all vessels of the activity with a request to keep clear. All updates of position and notifications of completion of the operation to Maritime New Zealand will be the responsibility of the FSO master.

5.3. Fuel Transfer

5.3.1. Procedures for fuel transfer operations at sea will be as approved by Maritime New Zealand.

5.3.2. The commencement and completion of fuel transfer operations at sea will be notified to Maritime New Zealand by the Master of the replenishment vessel as required by Maritime Rule 103.

5.3.3. If this is to take place in a Harbour the relevant Harbour Authority will issue a fuel transfer permit as required by their by-laws.

6. Bio security

6.1. General

Bio security issues associated with the project essentially revolve around the management of ballast water and hull fouling.

6.2. Ballast Water

Since the introduction of steel hulled vessels around 120 years ago, water has been used as ballast to stabilize vessels at sea. Ballast water is pumped-in to maintain safe operating conditions throughout a voyage. This practice reduces stress on the hull, provides transverse stability, improves propulsion and manoeuvrability, and compensates for weight lost due to fuel and water consumption.

While ballast water is essential for safe and efficient modern shipping operations, it may pose serious ecological, economic and health problems due to the multitude of marine species carried in ships' ballast water. These include bacteria, microbes, small invertebrates, eggs, cysts and larvae of various species. The transferred species may survive to establish a reproductive population in the host environment, becoming invasive, out-competing native species and multiplying into pest proportions.

Preventing the transfer of invasive species and coordinating a timely and effective response to invasions requires cooperation and collaboration among governments, economic sectors, non-governmental organizations and international treaty organizations. The UN Convention on the Law of the Sea (UNCLOS) provides the global framework by requiring States to work together "to prevent, reduce and control human caused pollution of the marine environment, including the intentional or accidental introduction of harmful or alien species to a particular part of the marine environment."

The International Convention for the Control and Management of Ship's Ballast Water and Sediments 2004 (BWM convention) was adopted by consensus at a Diplomatic Conference held at IMO Headquarters in London on 13 February 2004. NZ is in the process of ratifying the BWM convention with Ministry of Transport and expect the process will be completed in about mid-2014.

The BWM convention requires all ships to implement a Ballast Water and Sediments Management Plan. All ships will have to carry a Ballast Water Record Book and will be required to carry out ballast water management procedures to a given standard. Parties to the BWM convention are given the option to take additional measures that are subject to criteria set out in the BWM convention and to IMO guidelines.

The vessels employed by the project will arrive in New Zealand from an overseas port and will be fully compliant with the requirements of the BWM convention with 'clean' water ballast and 'clean' tanks. In practice the vessels will have exchanged their ballast water in the tropics in deep water as recommended by IMO.

There will be operational ballasting and de-ballasting undertaken by project vessels in the EEZ and in the New Zealand Territorial Sea but this will be exchanging clean New Zealand ballast water.

All vessels arriving in New Zealand are required to make a 'Ballast Water Declaration' and comply with the 'Import Health Standard for ships ballast water from all countries' issued under Section 22 of the Biosecurity Act 1995.

All TTR's export vessels will arrive in New Zealand with compliant water ballast and 'clean' tanks. Ballast water will be pumped out of the export vessel when cargo is loaded as a normal operational discharge as is the case for most vessels loading cargoes in New Zealand waters.

6.3. Hull Biofouling

Vessels arriving in New Zealand will be required to comply with the IMO Biofouling Guidelines 2011 (Resolution MEPC 207(62), '2011 Guidelines for the Control and Management of ship's Biofouling to minimise the transfer of invasive aquatic species'. These guidelines will be enforced through the bio-fouling regulations which are currently being developed by the Ministry for Primary Industries.

The Guidelines include advice on the vessel's Biofouling Management Plan, Biofouling Record Book, Choosing the anti-fouling System, installing, and repairing the anti-fouling system, in water inspection, cleaning and maintenance

In addition arriving vessels will be required to meet the 'Craft Risk Management Standard (CRMS) for Biofouling on Vessels arriving to New Zealand' issued under section 24G of the Biosecurity Act 1993.

These standards will also apply to the export vessels and will be a pre-requisite for vessels uplifting cargoes from the project.

TTR's locally operated vessels will comply with the newly released "Controls for antifouling paints" put out by the EPA

7. Sewage

Sewage wastes will be treated on board the vessels in an approved manner and shipped ashore for treatment and disposal at an approved facility as detailed in the vessels' sewage management plan.

8. Garbage

Garbage will be treated on board the vessels in an approved manner and shipped ashore for treatment and disposal at an approved facility as detailed in the vessels' garbage management plan.

Appendix 1 South Taranaki Bight Marine Traffic Study

Supplied separately from this report.

Appendix 2

IMPORT HEALTH STANDARD FOR SHIPS' BALLAST WATER FROM ALL COUNTRIES

Issued pursuant to Section 22 of the Biosecurity Act 1993 Dated: 13 June 2005

1. REVIEW

The original standard was issued by Ministry of Fisheries in May 1998. It was reviewed to include improved procedures and transition to the format of Biosecurity New Zealand, Ministry of Agriculture and Forestry (MAF) in June 2005.

2. APPLICATION

This import health standard (IHS) applies to ballast water loaded within the territorial waters of a country other than New Zealand and intended for discharge in New Zealand waters. The IHS does not apply to: ballast water that will not be discharged in New Zealand waters; ballast water loaded in New Zealand waters; or emergency discharge of ballast water.

3. GENERAL CONDITIONS

It is the responsibility of the Master of the vessel to ensure that the ballast water and any associated sediment, intended for discharge in New Zealand, comply with the conditions in the standard. Ballast water that does not comply with the conditions must not be discharged in New Zealand waters.

Compliance with these controls must be consistent with the safety of the crew and the vessel. Nothing in these controls is to be read as relieving the Master of their responsibility for the safety of the vessel.

4. DEFINITIONS

Ballast water - water, including its associated constituents (biological or otherwise), placed in a ship to increase the draft, change the trim or regulate stability. It includes associated sediments, whether within the water column or settled out in tanks, sea-chests, anchor lockers, plumbing, etc.

Internal waters - means:

- harbours, estuaries, and other areas of the sea that are on the landward side of the baseline of the territorial sea of a coastal state; and
- rivers and other inland waters that are navigable by ships.

Inspector - an inspector appointed under section 103 of the Biosecurity Act, 1993

Nothing in this standard is to be read as relieving ship masters of their responsibility for the safety of the vessel, passengers and crew.

New Zealand waters - means:
• the internal waters of New Zealand; and
• the territorial sea of New Zealand.

Territorial sea – For New Zealand this is the sea within 12 nautical miles of the seaward side of the baseline of the territorial sea. (See section 3 of the Territorial Sea, Contiguous Zone and Exclusive Economic Zone Act, 1977 for definition of New Zealand baseline)

5. REQUIREMENTS FOR BALLAST WATER

5.1 No ballast water may be discharged into New Zealand waters without the permission of an inspector.
5.2 An inspector will only permit ballast water to be discharged if satisfied that the Master has met one of the criteria in section 6 below.
5.3 Part I of the Vessel Ballast Water Declaration approved by the Ministry of Agriculture and Forestry must be completed for all vessels. It should be completed before arrival in New Zealand and sent accompanying the Advance Notice of Arrival to the Ministry of Agriculture and Forestry Quarantine Service (MAFQS) office at the ship's first port of arrival.
5.4 For vessels indicating intention to discharge ballast in New Zealand, Part 2 of the Ballast Water Declaration must also be completed, except for the columns under Question 3 for Ballast Water Discharged. This should be sent to MAFQS before arrival in New Zealand, along with Part 1, in order for a vessel to be granted permission to discharge ballast water or be granted an exemption.

5.5 Permission to discharge ballast water is granted when an inspector approves the discharge, signs the 'Discharge of ballast permitted' form, and sends this back to the ship. Discharge of ballast is denied when an inspector does not approve the discharge, signs the 'Discharge of ballast denied' form and sends this to the ship.
5.6 Before the ship leaves New Zealand the original of Part 2 must be completed with details of the discharge in New Zealand. The original signed declarations must be kept on board while in New Zealand. In addition the copy faxed or emailed from MAFQS to the ship detailing the MAFQS direction to the vessel must also be retained. These are uplifted by MAFQS at the last port of call in New Zealand.
5.7 Sediment which has settled in ballast tanks, ballasted cargo holds, sea-chests, anchor lockers or other equipment must not be discharged into New Zealand waters. If the ship needs to discharge sediment in New Zealand, the sediment must be landed and taken to a landfill approved by an inspector.

6. OPTIONS FOR SATISFYING AN INSPECTOR

Option 1

Demonstrating the ballast water has been exchanged en route to New Zealand in areas free from coastal influences, preferably 200 nautical miles from the nearest land and in water over 200m in depth. Accepted techniques are either emptying and refilling ballast tanks/

Import Health Standard *Ships' Ballast Water From All Countries* June 2005 Page 2 holds with an efficiency of 95% volumetric exchange or pumping through the tanks a water volume equal to at least three times the tank capacity. Tanks should be pumped no more than two at a time and, if two tanks are pumped together, they should be a symmetrical pair of tanks to ensure the safety of the vessel.

Option 2

Demonstrating the ballast water is fresh water (not more than 2.5 parts per thousand sodium chloride).

Option 3

Ballast water has been treated using a shipboard treatment system approved by MAF.

Option 4

Ballast is discharged in an onshore treatment facility approved by MAF.

Note - there are presently no treatment systems or facilities approved by MAF for the purposes of options 3 and 4.

7. EXEMPTIONS

It is accepted that in some circumstances exchange may not be possible. Exemptions are granted by the same process as granting permission to discharge. An exemption will generally be granted when it can be demonstrated that:

Exemption 1

- The weather conditions on the voyage in combination with the construction of the vessel have precluded safe ballast water exchange; and
- the ballast water was not loaded in any area listed in Annex 1.

Exemption 2

- The construction of the vessel has precluded ballast water exchange; and
- the ballast water was not loaded in any area listed in Annex 1.

In the case of weather conditions or vessel construction precluding the safe exchange of ballast water from Annex 1 areas, the vessel must either redistribute the ballast water around the ship's ballasting spaces in order to load cargo or, if this is not possible to accomplish with a suitable margin of safety, the ship must leave New Zealand without loading some, or all, intended cargo.

Exempted vessels are asked to discharge the least amount of ballast water possible and discharge as far offshore as practicable.

8. COSTS

The costs of inspection, analysis, identification, delays, and any other costs associated with this standard are the responsibility of the owner and/or charterer. These costs shall be actual, fair and reasonable.

Import Health Standard *Ships' Ballast Water From All Countries* June 2005 Page 3

9. ENQUIRIES

Unless indicated to the contrary on communications, enquiries concerning this IHS should be addressed to:
Team Manager, Border Standards
Biosecurity New Zealand
Ministry of Agriculture and Forestry
PO Box 2526
Wellington
NEW ZEALAND
FAX: 64 - 4 - 498 9888

10. OFFENCES AND PENALTIES

Providing incorrect information to an inspector is an offence under the Biosecurity Act, 1993 section 154(b). It carries a penalty for individuals of up to 12 months imprisonment and/or a fine not exceeding NZ$50,000, and for corporations a fine not exceeding NZ$100,000. Failure to obey the directions of an inspector is an offence under section 154(o). It carries a penalty for individuals of a fine not exceeding NZ$5,000, and for corporations a fine not exceeding NZ$15,000.

11. OBTAINING INFORMATION

Ship masters should communicate with MAFQS inspectors prior to their arrival in New Zealand waters to determine requirements or discuss their options if permission has been denied (these may include carrying out an exchange and resubmitting a new declaration). Communications should be directed to the MAFQS office at the intended port of arrival or one of the following: MAF Quarantine Service
CPO Box 39
Auckland
Phone - (09) 303 3423
FAX - (09) 303 3037
Group Leader – 0272 924 820

MAF Quarantine Service
PO Box 3042
Wellington
Phone - 04) 473 8996
FAX - (04) 473 2079
Operations Manager 0274 361 345

MAF Quarantine Service
Private Bag 4765
Christchurch
Phone - (03) 328 7166
FAX - (03) 328 7186

Appendix 3 BALLAST WATER DECLARATION

BALLAST WATER DECLARATION: PART 1

TO BE COMPLETED FOR ALL VESSELS ARRIVING IN NEW ZEALAND

Vessel's Name:	**Arrival Date:**	**Arrival Port:**	**Inspector's Name:**
BALLAST WATER			
1	**Are you carrying ballast water?**	☐ YES ☐ NO	**If NO go to question 5**
2	**List any tanks loaded with ballast water in Port Phillip Bay, Victoria or Tasmania.**		**List Each Tank Number and Type (see codes below):**
3	**How will you comply with NZ's ballast water controls. (See NZ Import Health Standard for Ballast Water from all Countries.) Check the box indicating how you will comply**		**(A, B or C) below.**
	A. Not discharging any ballast water in New Zealand waters.	☐	
	B. Exchanging the ballast water mid-ocean in all tanks that are to be discharged in New Zealand waters. Indicate whether flow-through or empty/refill technique was used. Note: Flow-though requires 3 times the tank capacity to be pumped through the tank.	☐	**Flow-through** ☐ **or** **Empty/refill** ☐
	C. Discharging only fresh water. State when and where the water was loaded.	☐	**Date loaded:** **Port or Position:**
4	**If you cannot comply, check the box (A &/or B) indicating the reason(s). Give details.**		
	A. Vessel is not physically capable of either empty/refill or flow-through exchange	☐	**Specify Details:**
	B. Exchange would have caused unacceptable risk to crew or vessel due to weather conditions	☐	**Specify Details:**
CLEANING: SEDIMENTS			
5	**Do you intend to discharge sediment or other debris from ballast tanks/holds (excluding normal deballasting), anchors, chains or chain lockers in New Zealand waters? If YES, state when and where.**	☐ YES ☐ NO	**Date:** **Port or Position:**
	Please note that sediments must be discharged into an approved landfill.		
CLEANING: HULL FOULING			
6	**When and where was the vessel last dry-docked and cleaned?**		**Date:** **Port or Position:**
7	**Has the vessel been laid-up for 3 months or more since it was last dry-docked and cleaned? If YES, state when and where.**	☐ YES ☐ NO	**Date: Started:** **Date: Finished:** **Port or Position:**
8	**Do you intend to clean the hull of the vessel in New Zealand? If YES, state when and where.**	☐ YES ☐ NO	**Date:** **Port or Position:**

Ballast tank codes: Upper=U, Lower=L, Forepeak=FP, Aftpeak=AP, Double Bottom=DB, Deep Tank=DT, Wing Tank=WT, Topside=TS, Cargo Hold=CH, Other (specify), Port=P, Starboard=S, (eg 3UWTP):.

MASTER'S NAME AND SIGNATURE:	**MAF's directions to vessel:-**	**INSPECTOR'S SIGNATURE:**		
	☐ **Vessel not discharging** (Contact MAF if intentions change)	☐ **Discharge of ballast permitted**	☐ **Discharge of ballast denied** (Contact MAF to discuss options)	☐ **Exemption granted** (This voyage only)

New Zealand Ministry of Fisheries. Pursuant to section 22 of the Biosecurity Act 1993. Revised April 2004

BALLAST WATER DECLARATION: PART 2

TO BE COMPLETED FOR ALL VESSELS DISCHARGING BALLAST WATER IN NEW ZEALAND

1. VESSEL INFORMATION	Vessel's Name:	IMO Number:	Vessel's Call Sign:
Flag:	Vessel's Owner:	Vessel's Agent: PHOENIX SHIPPING	Gross Tonnage (MT):
Type of Vessel: ☐ Bulk ☐ Container ☐ Tanker ☐ RORO/Cars ☐ Fishing		Other(specify) Date Built:	Ballast pumping capacity : Pump A Pump B
Total Number of Ballast Tanks On Board Vessel:	Total Ballast Capacity (specify units):		
2. THIS VOYAGE Date of Arrival in New Zealand:		Arrival Port:	Last Overseas Port:
Date of Departure from New Zealand:		Departure Port:	Next Overseas Port:
Total Number of Tanks in Ballast on Arrival in New Zealand:		Total Ballast Volume on Arrival in NZ (specify units; m3, MT):	

3. BALLAST WATER DISCHARGED IN NEW ZEALAND (If none, go to bottom of page) TICK HERE IF THIS SECTION IS A CONTINUATION OF ANOTHER FORM ☐

IMPORTANT:
List the original **BALLAST WATER SOURCE**(s) for ballast taken on in countries other than **New Zealand**.
All tanks discharged in New Zealand that contained any ballast from another country prior to any exchange must be listed. Detail each ballast management operation for tanks listed.

TANK NO. and TYPE (see codes below)	BALLAST WATER SOURCE AT COMMENCEMENT OF VOYAGE				BALLAST WATER EXCHANGED E/R = Empty then Refill F/T = Flow Through					BALLAST WATER DISCHARGED		
	DATE LOADED (DD/MM/YY)	PORT or LAT./LONG.	VOLUME LOADED (specify units)	FINAL VOLUME IN TANK (specify units)	E/R or F/T	START DATE FINISH DATE (DD/MM/YY)	START TIME FINISH TIME (HH:MM)	START LAT. LONG FINISH LAT. LONG	VOLUME FLOWED THROUGH or being EXCHANGED (specify units)	DATE DISCHARGED	PORT or LAT./LONG.	VOLUME DISCHARGED (specify units)

Ballast tank codes: Upper=U, Lower=L, Forepeak=FP, Aftpeak=AP, Double Bottom=DB, Deep Tank=DT, Wing Tank=WT, Topside=TS, Cargo Hold=CH, Other (specify), Port=P, Starboard=S, (eg 3UWTP).

MASTER'S NAME AND SIGNATURE:

New Zealand Ministry of Fisheries. Pursuant to section 22 of the Biosecurity Act 1993. Revised April 2004

Appendix 4 CRAFT RISK MANAGEMENT STANDARD

Craft Risk Management Standard
For Vessel Biofouling
Short Name: CRMS - BIOFOUL

Issuing Authority

This standard is issued under section 24G of the Biosecurity Act 1993 (the Act).

It commences in four years on the day and month of signature below*.

Dated at Wellington this day of 20 _ _

Peter Thomson

Director, Plants, Food and Environment
Standards Branch, Ministry for Primary Industries (MPI)
(Issued under delegated authority)

* The four year lead-in period before commencement of enforcement of this standard is intended to allow shipping, and other vessel operators, time to make any adjustments needed to their hull maintenance regimes. It is also expected that during this time other jurisdictions will implement clean hull requirements and also that technology for acceptable in-water hull cleaning and provision of hull cleaning services will have developed to the extent that most vessels will be compliant when it comes in to force. Towards the end of the four year period, MPI will review the current hull maintenance practices and other factors to check that the expected improved environment for enforcing the standard has eventuated.

Voluntary compliance is encouraged during the lead-in period. MPI will monitor indicators of each arriving vessel's hull cleanliness through mandatory questions in the advance arrival information. These questions must be answered and false declaration can lead to prosecution under the Act. The information collected will used for the review.

Note: see Guidance Document for explanatory information

Ministry for Primary Industries
P.O Box 2526, Wellington 6011
New Zealand

For all matters relating to the interpretation, review and amendment of this standard, please contact:

Biosecurity and Environment Group
Ministry for Primary Industries
PO Box 2526
Wellington 6011
New Zealand

Phone: 0800 008333

Email: standards@mpi.govt.nz

For all matters relating to the operation of this standard, including inspections, audits and treatments, please contact MPI at your port of arrival. See listed at

http://www.biosecurity.govt.nz/regs/ships/ports-first-arrival

This Standard is accessible on: (*hyperlink to be inserted*)

www

Amendment record:

Table of Contents

INTRODUCTION

Vessel biofouling is a major pathway for the introduction of non-indigenous marine organisms into New Zealand territorial waters, some of which may be harmful to New Zealand resources, economy, environment, and/or people's health and well being. This CRMS manages the risk of introduction into NZ territory and surrounding waters of harmful organisms associated with arriving vessels.

BIOSECURITY REQUIREMENTS – VESSELS ARRIVING TO NEW ZEALAND

This standard applies to any vessel, which arrives into New Zealand territory, meaning a vessel that will anchor, berth or be brought ashore after a voyage originating outside New Zealand's Territorial Sea.

The risk to be managed is the introduction into New Zealand of harmful organisms carried as biofouling on the submerged or periodically submerged parts of the hull.

Outcome Statement:

The outcome of this standard is **to minimise the entry into New Zealand of those harmful organisms that constitute vessel biofouling[1] or are harboured in the biofouling[2].**

Requirements:

A vessel must arrive in New Zealand with a 'clean hull'.

'Clean hull' means that no biofouling of live organisms is present other than within the thresholds below.

'Clean hull' thresholds:

The following criteria are used in assessing whether a vessel has a 'clean hull' according to vessel category. There are two different vessel categories and applicable biofouling allowances – for 1) long-stay vessel and 2) short-stay vessel. The vessel category applies to a vessel for its entire visit to New Zealand (from time of arriving to time of departing NZ territory.

The meaning of 'hull' (including various hull parts in Table 1 and 2) is given in the Appendix.

a) 'Long-stay vessels' means those vessels intending to remain in New Zealand for 21 days or longer and/or visit areas other than those designated under section 37 of the Act as 'Places of First Arrival'.

Table 1: Biofouling Allowances for Long-Stay Vessels

Hull part	Allowable biofouling
All hull surfaces	Slime layer;

[1] Such as algae, barnacles, mussels and oysters
[2] Such as free living worms, sea-stars, fish or shrimps

	Goose barnacle

b) ‘Short-stay vessels’ means those vessels intending to remain in New Zealand for 20 days or less and to only visit places designated under section 37 of the Act as ‘Places of First Arrival’. These vessels generally remain under ‘biosecurity surveillance’ while in New Zealand territory rather than becoming fully cleared of risk goods.

Table 2: Biofouling Allowances for Short-Stay Vessels

Hull part	Allowable biofouling
All hull surfaces	Slime layer; Goose barnacles.
Wind and water line	Green algae growth of unrestricted cover and no more than 50 mm in frond, filament or beard length; Brown and red algal growth of no more than 4 mm in length; Incidental (maximum of 1%) coverage of one organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ isolated individuals or small clusters; and ▪ a single species, or what appears to be the same species.
Hull area	Algal growth occurring as: ▪ no more than 4 mm in length; and ▪ continuous strips and/or patches of no more than 50 mm in width. Incidental (maximum of 1%) coverage of one organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ isolated individuals or small clusters that have no algal overgrowth; and ▪ a single species, or what appears to be the same species.
Niche areas	Algal growth occurring as: ▪ no more than 4 mm in length; and ▪ continuous strips and/or patches of no more than 50 mm in width. Scattered (maximum of 5%) coverage of one organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ widely spaced individuals and/or infrequent, patchy clusters that have no algal overgrowth; and ▪ a single species, or what appears to be the same species; and Incidental (maximum of 1%) coverage of a second organism type of either tubeworms, bryozoans or barnacles, occurring as: ▪ isolated individuals or small clusters that have no algal overgrowth; and ▪ a single species, or what appears to be the same species.

Refer to the guidance document for illustrations and photo examples of the biofouling allowances.

ACCEPTABLE MEASURES FOR MEETING THE STANDARD

One of the following measures must be applied to achieve the outcome:

i. Cleaning before visit to New Zealand (or immediately on arrival in a facility approved[3] by MPI within 24 hours of arrival) – All biofouling must be removed from all parts of the hull and this must be carried out less than 30 days before arrival to New Zealand.

ii. Continual Maintenance using best practice including:- regular application of antifoul coatings; operation of marine growth prevention systems on sea-chests; and in-water inspections with biofouling removal as required. Following the IMO Biofouling Guidelines[4] is recognised as an example of best practice.

iii. Application of Approved Treatments[5]. Treatments are approved and listed under the Approved Biosecurity Treatment Standard MPI-STD- ABTRT

As an alternative a vessel operator may submit, for MPI approval, a Craft Risk Management Plan (which includes steps that will be taken to reduce risk to the equivalent degree as meeting the requirements of this standard).

Refer to the Guidance Document for information on: how to apply for approval of treatments, requirements for approval of treatments, and list of generally available approved treatments and for examples of evidence of measures i to iii that can be presented on arrival to expedite clearance.

COMPLIANCE

An operator, or the person in charge of a vessel, must take all reasonable steps to comply with this standard. Any vessel that does not meet the requirements of this standard is likely be directed under section 32 or 33 of the Act to take action to mitigate the risk and, if mitigation measures cannot be taken, is likely to be directed to leave New Zealand.

Deliberate non-compliance with the requirements of this standard or negligence leading to non-compliance will lead to increased intervention regimes (e.g. inspections or audits) and/or serving of a compliance order and/or prosecution of liable parties under the Act.

BIOFOULING INFORMATION

The following information is to be provided to MPI prior to arrival (via the Advanced Notice of Arrival)

- Intended length of stay within New Zealand territory and intentions in respect of places to be visited

[3] Means approved as a transitional facility under section 39 of the Act

[4] The current version, including templates for biofouling management plans and records, can be read on MPI's website here http://www.biosecurity.govt.nz/files/enter/ships/2011-imo-biofouling-guidelines.pdf. The Guidelines are available for purchase from the IMO. The English language version has the following reference: I662E ISBN 978-92-801-1545-1

[5] 'Approved Treatment' includes any treatment or other means for meeting the outcome of standard that has received MPI approval.

- Whether the vessel has spent an extended period mainly stationary in a single location. If so, the location and duration of the most recent occurrence of such a stay.
- If the vessel is coming in to undergo biofouling cleaning on arrival, any formal arrangement for cleaning or treatment that will be undertaken immediately upon arrival
- What measures have been or will be used to meet the requirements of the standard, or
- Whether the operator has chosen to operate an MPI approved Craft Risk Management Plan (CRMP) as an alternative to meeting the requirements of the standard (See section 2.5, Approved Treatments, in the Guidance Document for explanation of CRMPs).

The following information (if relevant) must be held on the vessel and provided to MPI in an appropriate form if requested. (This is in addition to information to be provided prior to arrival).

- Information on the antifouling regime and any marine growth prevention systems used. If applying the IMO Biofouling Guidelines, a biofouling management plan showing the hull maintenance and inspection regime and the records kept, preferably consistent with the template in the IMO guidelines[6].
- If applicable to the vessel, its latest International Anti-fouling System Certificate or International Anti-fouling System Declaration,
- Date and reporting from the latest hull biofouling inspection (undertaken either on land or in-water) that was initiated by the vessel operator.

Appendix - TERMS & DEFINITIONS

The following terms and definitions apply to this Standard. Other terms used are as per the Biosecurity Act 1993.

algal growth
Growth of algae that is visible to the naked eye. Algae may be either single celled filamentous forms or multi-celled macroalgae (seaweed) species and includes coralline algae.

biofouling
The accumulation of aquatic organisms such as micro-organisms, plants and animals on surfaces and structures immersed in or exposed to the aquatic environment.

goose barnacles
Also called stalked barnacles or gooseneck barnacles, goose barnacles are ubiquitous foulers of tropical, subtropical and temperate seas, with a wide oceanic distribution that includes attachment to drift wood, floating plant debris and vessel hulls, as well as turtles and whales.

[6] The current version, including templates for biofouling management plans and records, can be read on MPI's website here http://www.biosecurity.govt.nz/files/enter/ships/2011-imo-biofouling-guidelines.pdf. The Guidelines are available for purchase from the IMO. The English language version has the following reference: I662E ISBN 978-92-801-1545-1

harmful organisms
Organisms that may cause unwanted harm to natural and physical resources or human health in New Zealand

hull
The immersed (including occasionally immersed) surfaces of a vessel including the following three parts. Includes pontoons.

> **hull area**
> The immersed surfaces of a vessel excluding niche areas and wind/water line.
> **niche areas**
> Areas on a vessel hull that are more susceptible to biofouling due to different hydrodynamic forces, susceptibility to coating system wear or damage, or being inadequately, or not, painted, e.g., sea chests, bow thrusters, propeller shafts, inlet gratings, dry-dock support strips, etc. Includes appendages.
> **wind and water line**
> The area of the hull that is subject to alternating immersion due to a vessel's movement or loading conditions (also known in shipping as the Boot-top).

IMO
International Maritime Organisation

New Zealand's Territorial Sea
Is the sea bounding New Zealand out to 12 nautical miles from an internal baseline as described in the Territorial Sea, Contiguous Zone, and Exclusive Economic Zone Act 1977

slime layer
A layer of microscopic organisms, such as bacteria and diatoms, and the slimy substances that they produce.

vessel or sea-craft
Is a subset of 'craft' as defined by the Act and means every description of boat or other craft used in water navigation, whether or not it has any means of propulsion; also includes: a barge, lighter, hovercraft or floating drilling rig. It does not include aircraft.

vessel operator
Operator of a vessel, either the master or skipper or a land-based ships' operations manager.

Appendix 5

Captain Ray Barlow MNI

Qualifications

Master Mariner (1st Class) Certificate

Experience

Port Operations Management
Successfully operating a surge affected port
Pilotage
Towage
Contracting
Nautical Advice
HSE Management in Port and Marine environment
HR and Industrial Relations
Specialties:

Petro chemical terminals
Offshore support operations
Dynamic under keel clearance
Waterfront labour relations
Oil Spill Response planning
Harbour Towage
Tug and Launch design choice and construction supervision
Container Terminal development and management
Port Planning and optimisation
Ship motions and their affects on safe operations in shallow water
Port and Marine Safety Management

Positions Held

Chairman Global Air And Water Limited

May 2011 – Present (2 years 4 months)

Infection Control and bio security programmes
Health and Phyto sanitary solutions. Food Safety Solutions

Principal R N Barlow and Associates Limited

April 2010 – Present (3 years 5 months)

Advisory services in transport, marine and engineering sectors
Governance positions in engineering, logistics, infection control and bio security solutions

Director Engineering Taranaki Consortium

June 2010 – July 2012 (2 years 2 months) New Plymouth NZ

Independent Director

Operations Manager at Port Taranaki Limited
September 1988 - April 2010 (21 years 8 months)
Deputy Chief Executive, responsible for all operations, engineering and procurement.
Marine
Services – pilotage, towage, launches, moorings, hydrography.
Engineering Design and Maintenance. Container Terminal Operations, Petro-chemical terminal operations, Security. Statutory compliance.
Harbourmaster Port Taranaki at Taranaki Regional Council
September 1988 - December 2009 (21 years 4 months)
Responsible for management of safety of navigation at Port Taranaki. Development and implementation of Marine Oil Spill response plan
Relief Pilot and Loading Master at NZ Steel Mining Ltd
January 1980 - December 1995 (16 years)
Acting as relief pilot and loading master at the Taharoa Marine Terminal for the export of ironsands in slurry form into bulk carriers up to 135,000 dwt through an SBM moored in the Tasman Sea
Harbour Pilot at Taranaki Harbours Board
October 1970 - August 1988 (17 years 11 months)
Harbour Pilot, Tugmaster, Dredgemaster

Recent Projects

Review of New Zealand's Oil Spill Preparedness and Response Capability

Work as part of a team with Thompson Clarke Shipping Limited to review and report on NZ's oil spill preparedness and...View

Review operating parameters for pilotage of vessels entering and departing the Port of Gisborne

Full review of berthing criteria applying qualitative risk assessment techniques and recommendations on weather parameters

Value for Money Review Maritime New Zealand

Part of a team of industry players assisting MNZ to evaluate its performance and identify where value for money could be better spent

Review of New Zealand's Oil Spill Preparedness and Response CapabilityEditRe-order section

November 2010 – February 2011

Work as part of a team with Thompson Clarke Shipping Limited to review and report on NZ's oil spill preparedness and response capability

Safety Management system for Port Otago and Otago Regional Council

Assist development of a Safety Management system in compliance with the NZ Port and Harbour Safety CodeView

Marine advice to ALARP review of Wire lining at Kupe Offshore Platform Origin Energy

Acted as marine advisor to Operational safety review of proposed well maintenance procedures on Kupe Offshore platform

Marine advisor project to extend pipelines and relocate SBM at Taharoa Offshore Loading Terminal NZ

1. Marine advice for launching 450m triple pipeline at Port Taranaki NZ 2. Marine advice for 70nm bottom tow to Site

Report on Future Towage requirements for the Port of Gisborne

Review existing towage arrangements and forecast shipping arrivals. Report on requirements to meet current and future

Marine Advisor to Trans Tasman Resources Ltd Marine Advisor for Consenting

Provide advice on the effects of proposed marine operations in preparation of evidence for resource consent applications for mining ironsands

Project to improve Mooring Safety at Port Taranaki

Development of Port Numerical Wave Model to describe current wave climate under storm conditions and test various mooring

Project to advise on depth required for future operations at Eastland Port NZ

Project to assess depth required for future operations at Eastland Port to assist in Resource Consent application for dredging

Memberships

Member of the Institute of Directors

Member of the Nautical Institute

Past President of the New Zealand Maritime Pilots Association

Appendix 19.7 - DRA Equipment List

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
	PFD NO: C8381-PFD-20-110	**ROM & SCALPING**								
20-PU-1102	Dredge Booster Pump	Weir	750MCM	14706	m³/hr					
20-PU-1118	Stream #1 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-PU-1218	Stream #2 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-PU-1318	Stream #3 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-PU-1418	Stream #4 Agitation water pump	Weir	550MCU	3704	m³/hr					
20-SC-1106	ROM Scalping Screen #1	Vibramech		2000	tph					
20-SC-1206	ROM Scalping Screen #2	Vibramech		2000	tph					
20-SC-1306	ROM Scalping Screen #3	Vibramech		2000	tph					
20-SC-1406	ROM Scalping Screen #4	Vibramech		2000	tph					
20-CH-1112	ROM Scalping Screen #1 Underpan									
20-CH-1212	ROM Scalping Screen #2Underpan									
20-CH-1312	ROM Scalping Screen #3 Underpan									
20-CH-1412	ROM Scalping Screen #4 Underpan									
20-TK-1110	Elutriator #1			3971	m³/hr					
20-TK-1210	Elutriator #2			3972	m³/hr					
20-TK-1310	Elutriator #3			3973	m³/hr					
20-TK-1410	Elutriator #4			3974	m³/hr					
20-DB-1104	Feed Pressure Splitter			14706	m³/hr					
20-CH-1108	Screen #1 Oversize Chute									
20-CH-1208	Screen #2 Oversize Chute									
20-CH-1308	Screen #3 Oversize Chute									
20-CH-1408	Screen #4 Oversize Chute									

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
Issued For	COMMENT
Revisions Marked	B

TTR Trans-Tasman Resources

DRA

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-PU-1120	Stream #1 & #2 Spillage Pump	Weir								
20-PU-1220	Stream #3 & #4 Spillage Pump	Weir								
	PFD NO: C8381-PFD-20-210	**MIMS - STREAM 1**								
20-PU-2102	MIMS Stream 1 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2104	MIMS Stream 1 - Feed Distributor									
20-MS-2112A	MIMS Stream 1 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2112B	MIMS Stream 1 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2122A	MIMS Stream 1 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2122B	MIMS Stream 1 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2132A	MIMS Stream 1 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2132B	MIMS Stream 1 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2142A	MIMS Stream 1 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2142B	MIMS Stream 1 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2114	MIMS Stream 1 - MagSep #1 Underpan									
20-CH-2124	MIMS Stream 1 - MagSep #2 Underpan									
20-CH-2134	MIMS Stream 1 - MagSep #3 Underpan									
20-CH-2144	MIMS Stream 1 - MagSep #4 Underpan									
20-CY-2116	MIMS Stream 1 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2126	MIMS Stream 1 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2136	MIMS Stream 1 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2146	MIMS Stream 1 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-220	**MIMS - STREAM 2**								
20-PU-2202	MIMS Stream 2 - Feed Pump	Weir	350MCU	2462	m³/hr					

Project Name	OFFSHORE IRON SANDS PROJECT
Document Title	MECHANICAL EQUIPMENT LIST
Reference No	C8381-PRO-MEL-001
Revision	Rev B
Date	17-Mar-14
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						No.	Duty (kW)	VSD	S/By Unit	
20-DB-2204	MIMS Stream 2 - Feed Distributor									
20-MS-2212A	MIMS Stream 2 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2212B	MIMS Stream 2 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2222A	MIMS Stream 2 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2222B	MIMS Stream 2 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2232A	MIMS Stream 2 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2232B	MIMS Stream 2 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2242A	MIMS Stream 2 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2242B	MIMS Stream 2 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2214	MIMS Stream 2 - MagSep #1 Underpan									
20-CH-2224	MIMS Stream 2 - MagSep #2 Underpan									
20-CH-2234	MIMS Stream 2 - MagSep #3 Underpan									
20-CH-2244	MIMS Stream 2 - MagSep #4 Underpan									
20-CY-2216	MIMS Stream 2 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2226	MIMS Stream 2 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2236	MIMS Stream 2 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2246	MIMS Stream 2 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-230	**MIMS - STREAM 3**								
20-PU-2302	MIMS Stream 3 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2304	MIMS Stream 3 - Feed Distributor									
20-MS-2312A	MIMS Stream 3 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2312B	MIMS Stream 3 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2322A	MIMS Stream 3 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					

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20-MS-2322B	MIMS Stream 3 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2332A	MIMS Stream 3 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2332B	MIMS Stream 3 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2342A	MIMS Stream 3 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2342B	MIMS Stream 3 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2314	MIMS Stream 3 - MagSep #1 Underpan									
20-CH-2324	MIMS Stream 3 - MagSep #2 Underpan									
20-CH-2334	MIMS Stream 3 - MagSep #3 Underpan									
20-CH-2344	MIMS Stream 3 - MagSep #4 Underpan									
20-CY-2316	MIMS Stream 3 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2326	MIMS Stream 3 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2336	MIMS Stream 3 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2346	MIMS Stream 3 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-240	**MIMS - STREAM 4**								
20-PU-2402	MIMS Stream 4 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2404	MIMS Stream 4 - Feed Distributor									
20-MS-2412A	MIMS Stream 4 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2412B	MIMS Stream 4 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2422A	MIMS Stream 4 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2422B	MIMS Stream 4 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2432A	MIMS Stream 4 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2432B	MIMS Stream 4 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2442A	MIMS Stream 4 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					

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20-MS-2442B	MIMS Stream 4 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2414	MIMS Stream 4 - MagSep #1 Underpan									
20-CH-2424	MIMS Stream 4 - MagSep #2 Underpan									
20-CH-2434	MIMS Stream 4 - MagSep #3 Underpan									
20-CH-2444	MIMS Stream 4 - MagSep #4 Underpan									
20-CY-2416	MIMS Stream 4 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2426	MIMS Stream 4 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2436	MIMS Stream 4 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2446	MIMS Stream 4 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-250	**MIMS - STREAM 5**								
20-PU-2502	MIMS Stream 5 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2504	MIMS Stream 5 - Feed Distributor									
20-MS-2512A	MIMS Stream 5 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2512B	MIMS Stream 5 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2522A	MIMS Stream 5 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2522B	MIMS Stream 5 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2532A	MIMS Stream 5 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2532B	MIMS Stream 5 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2542A	MIMS Stream 5 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2542B	MIMS Stream 5 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2514	MIMS Stream 5 - MagSep #1 Underpan									
20-CH-2524	MIMS Stream 5 - MagSep #2 Underpan									
20-CH-2534	MIMS Stream 5 - MagSep #3 Underpan									

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						No.	Duty (kW)	VSD	S/By Unit	
20-CH-2544	MIMS Stream 5 - MagSep #4 Underpan									
20-CY-2516	MIMS Stream 5 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2526	MIMS Stream 5 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2536	MIMS Stream 5 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2546	MIMS Stream 5 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-260	**MIMS - STREAM 6**								
20-PU-2602	MIMS Stream 6 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2604	MIMS Stream 6 - Feed Distributor									
20-MS-2612A	MIMS Stream 6 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2612B	MIMS Stream 6 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2622A	MIMS Stream 6 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2622B	MIMS Stream 6 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2632A	MIMS Stream 6 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2632B	MIMS Stream 6 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2642A	MIMS Stream 6 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2642B	MIMS Stream 6 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2614	MIMS Stream 6 - MagSep #1 Underpan									
20-CH-2624	MIMS Stream 6 - MagSep #2 Underpan									
20-CH-2634	MIMS Stream 6 - MagSep #3 Underpan									
20-CH-2644	MIMS Stream 6 - MagSep #4 Underpan									
20-CY-2616	MIMS Stream 6 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2626	MIMS Stream 6 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2636	MIMS Stream 6 - Cyclone #3	Multotec		558	m³/hr					

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20-CY-2646	MIMS Stream 6 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-270	**MIMS - STREAM 7**								
20-PU-2702	MIMS Stream 7 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2704	MIMS Stream 7 - Feed Distributor									
20-MS-2712A	MIMS Stream 7 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2712B	MIMS Stream 7 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2722A	MIMS Stream 7 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2722B	MIMS Stream 7 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2732A	MIMS Stream 7 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2732B	MIMS Stream 7 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2742A	MIMS Stream 7 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2742B	MIMS Stream 7 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2714	MIMS Stream 7 - MagSep #1 Underpan									
20-CH-2724	MIMS Stream 7 - MagSep #2 Underpan									
20-CH-2734	MIMS Stream 7 - MagSep #3 Underpan									
20-CH-2744	MIMS Stream 7 - MagSep #4 Underpan									
20-CY-2716	MIMS Stream 7 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2726	MIMS Stream 7 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2736	MIMS Stream 7 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2746	MIMS Stream 7 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-280	**MIMS - STREAM 8**								
20-PU-2802	MIMS Stream 8 - Feed Pump	Weir	350MCU	2462	m³/hr					
20-DB-2804	MIMS Stream 8 - Feed Distributor									

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						No.	Duty (kW)	VSD	S/By Unit	
20-MS-2812A	MIMS Stream 8 - MagSep #1A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2812B	MIMS Stream 8 - MagSep #1B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2822A	MIMS Stream 8 - MagSep #2A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2822B	MIMS Stream 8 - MagSep #2B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2832A	MIMS Stream 8 - MagSep #3A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2832B	MIMS Stream 8 - MagSep #3B	Steinert	single - 1s - 4500G	250	tph					
20-MS-2842A	MIMS Stream 8 - MagSep #4A	Steinert	single - 1s - 4500G	250	tph					
20-MS-2842B	MIMS Stream 8 - MagSep #4B	Steinert	single - 1s - 4500G	250	tph					
20-CH-2814	MIMS Stream 8 - MagSep #1 Underpan									
20-CH-2824	MIMS Stream 8 - MagSep #2 Underpan									
20-CH-2834	MIMS Stream 8 - MagSep #3 Underpan									
20-CH-2844	MIMS Stream 8 - MagSep #4 Underpan									
20-CY-2816	MIMS Stream 8 - Cyclone #1	Multotec		558	m³/hr					
20-CY-2826	MIMS Stream 8 - Cyclone #2	Multotec		558	m³/hr					
20-CY-2836	MIMS Stream 8 - Cyclone #3	Multotec		558	m³/hr					
20-CY-2846	MIMS Stream 8 - Cyclone #4	Multotec		558	m³/hr					
	PFD NO: C8381-PFD-20-310	**LIMS - STREAM 1**								
20-TK-3102	LIMS 1 Stream 1 - Feed Tank									
20-PU-3104	LIMS 1 Stream 1 - Feed Pump	Weir	350MCU	1899	m³/hr					
20-DB-3106	LIMS 1 Stream 1 - Feed Distributor									
20-MS-3112A	LIMS 1 Stream 1 - MagSep #1A	Steinert	single - 1s - 1250G							
20-MS-3112B	LIMS 1 Stream 1 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3112C	LIMS 1 Stream 1 - MagSep #1C	Steinert	single - 1s - 1250G							

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						No.	Duty (kW)	VSD	S/By Unit	
20-MS-3112D	LIMS 1 Stream 1 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3122A	LIMS 1 Stream 1 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3122B	LIMS 1 Stream 1 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3122C	LIMS 1 Stream 1 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3122D	LIMS 1 Stream 1 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3114	LIMS 1 Stream 1 - MagSep #1 Underpan									
20-CH-3124	LIMS 1 Stream 1 - MagSep #2 Underpan									
20-CY-3116	LIMS 1 Stream 1 - Cyclone #1	FLSmidth		1245	m^3/hr					
20-CY-3126	LIMS 1 Stream 1 - Cyclone #2	FLSmidth		1245	m^3/hr					
	PFD NO: C8381-PFD-20-320	**LIMS - STREAM 2**								
20-TK-3202	LIMS 1 Stream 2 - Feed Tank									
20-PU-3204	LIMS 1 Stream 2 - Feed Pump	Weir	350MCU	1899	m^3/hr					
20-DB-3206	LIMS 1 Stream 2 - Feed Distributor									
20-MS-3212A	LIMS 1 Stream 2 - MagSep #1A	Steinert	single - 1s - 1250G							
20-MS-3212B	LIMS 1 Stream 2 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3212C	LIMS 1 Stream 2 - MagSep #1C	Steinert	single - 1s - 1250G							
20-MS-3212D	LIMS 1 Stream 2 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3222A	LIMS 1 Stream 2 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3222B	LIMS 1 Stream 2 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3222C	LIMS 1 Stream 2 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3222D	LIMS 1 Stream 2 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3214	LIMS 1 Stream 2 - MagSep #1 Underpan									
20-CH-3224	LIMS 1 Stream 2 - MagSep #2 Underpan									

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20-CY-3216	LIMS 1 Stream 2 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3226	LIMS 1 Stream 2 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-330	**LIMS - STREAM 3**								
20-TK-3302	LIMS 1 Stream 3 - Feed Tank									
20-PU-3304	LIMS 1 Stream 3 - Feed Pump	Weir	350MCU	1899	m³/hr					
20-DB-3306	LIMS 1 Stream 3 - Feed Distributor									
20-MS-3312A	LIMS 1 Stream 3 - MagSep #1A	Steinert	single - 1s - 1250G							
20-MS-3312B	LIMS 1 Stream 3 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3312C	LIMS 1 Stream 3 - MagSep #1C	Steinert	single - 1s - 1250G							
20-MS-3312D	LIMS 1 Stream 3 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3322A	LIMS 1 Stream 3 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3322B	LIMS 1 Stream 3 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3322C	LIMS 1 Stream 3 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3322D	LIMS 1 Stream 3 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3314	LIMS 1 Stream 3 - MagSep #1 Underpan									
20-CH-3324	LIMS 1 Stream 3 - MagSep #2 Underpan									
20-CY-3316	LIMS 1 Stream 3 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3326	LIMS 1 Stream 3 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-340	**LIMS - Stream 4**								
20-TK-3402	LIMS 1 Stream 4 - Feed Tank									
20-PU-3404	LIMS 1 Stream 4 - Feed Pump	Weir	350MCU	1899	m³/hr					
20-DB-3406	LIMS 1 Stream 4 - Feed Distributor									
20-MS-3412A	LIMS 1 Stream 4 - MagSep #1A	Steinert	single - 1s - 1250G							

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						No.	Duty (kW)	VSD	S/By Unit	
20-MS-3412B	LIMS 1 Stream 4 - MagSep #1B	Steinert	single - 1s - 1250G							
20-MS-3412C	LIMS 1 Stream 4 - MagSep #1C	Steinert	single - 1s - 1250G							
20-MS-3412D	LIMS 1 Stream 4 - MagSep #1D	Steinert	single - 1s - 1250G							
20-MS-3422A	LIMS 1 Stream 4 - MagSep #2A	Steinert	single - 1s - 1250G							
20-MS-3422B	LIMS 1 Stream 4 - MagSep #2B	Steinert	single - 1s - 1250G							
20-MS-3422C	LIMS 1 Stream 4 - MagSep #2C	Steinert	single - 1s - 1250G							
20-MS-3422D	LIMS 1 Stream 4 - MagSep #2D	Steinert	single - 1s - 1250G							
20-CH-3414	LIMS 1 Stream 4 - MagSep #1 Underpan									
20-CH-3424	LIMS 1 Stream 4 - MagSep #2 Underpan									
20-CY-3416	LIMS 1 Stream 4 - Cyclone #1	FLSmidth		1245	m³/hr					
20-CY-3426	LIMS 1 Stream 4 - Cyclone #2	FLSmidth		1245	m³/hr					
	PFD NO: C8381-PFD-20-410	**CLASSIFICATION & MILLING STREAM 1**								
20-TK-4102	Stream 1 - Cyclone #1 Feed Tank									
20-PU-4104	Stream 1 - Cyclone #1 Feed Pump	Weir	250MCU	1042	m³/hr					
20-PU-4106	Stream 1 - Sheer Pump	Weir	250MCU	1042	m³/hr					
20-CY-4108	Stream 1 - Cyclone 1	Multotec		1042	m³/hr					
20-DB-4110	Stream 1 - Derrick Screen Feed Distributor									
20-DB-4112A	Stream 1 - Derrick Scalping Screen 1 Feed Distributor									
20-DB-4112B	Stream 1 - Derrick Scalping Screen 2 Feed Distributor									
20-DB-4112C	Stream 1 - Derrick Scalping Screen 3 Feed Distributor									
20-DB-4112D	Stream 1 - Derrick Scalping Screen 4 Feed Distributor									
20-DB-4112E	Stream 1 - Derrick Scalping Screen 5 Feed Distributor									
20-SC-4114A	Stream 1 - Derrick Scalping Screen 1	Derrick								

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DRA

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	Duty (kW)	VSD	S/By Unit	Comments
20-SC-4114B	Stream 1 - Derrick Scalping Screen 2	Derrick								
20-SC-4114C	Stream 1 - Derrick Scalping Screen 3	Derrick								
20-SC-4114D	Stream 1 - Derrick Scalping Screen 4	Derrick								
20-SC-4114E	Stream 1 - Derrick Scalping Screen 5	Derrick								
20-TK-4116	Stream 1 - Cyclone #2 Feed Collection Tank									
20-PU-4118	Stream 1 - Cyclone #2 Feed Pump	Weir	250MCU	1460	m³/hr					
20-CY-4120	Stream 1 - Cyclone 2	FLSmidth		1460	m³/hr					
20-VM-4122	Stream 1 - Mill	Metso	VTM-3000-WB Vertimill®							
20-SC-4124	Stream 1 - Mill Discharge Screen									
20-PU-4188	Stream 1 - Mill Discharge Sump Spillage pump	Weir			m³/hr					
	PFD NO: C8381-PFD-20-420	**CLASSIFICATION & MILLING Stream 2**								
20-TK-4202	Stream 2 - Cyclone #1 Feed Tank									
20-PU-4204	Stream 2 - Cyclone #1 Feed Pump	Weir	250MCU	1042	m³/hr					
20-PU-4206	Stream 2 - Sheer Pump	Weir	250MCU	1042	m³/hr					
20-CY-4208	Stream 2 - Cyclone 1	Multotec		1042	m³/hr					
20-DB-4210	Stream 2 - Derrick Screen Feed Distributor									
20-DB-4212A	Stream 2 - Derrick Scalping Screen 1 Feed Distributor									
20-DB-4212B	Stream 2 - Derrick Scalping Screen 2 Feed Distributor									
20-DB-4212C	Stream 2 - Derrick Scalping Screen 3 Feed Distributor									
20-DB-4212D	Stream 2 - Derrick Scalping Screen 4 Feed Distributor									
20-DB-4212E	Stream 2 - Derrick Scalping Screen 5 Feed Distributor									
20-SC-4214A	Stream 2 - Derrick Scalping Screen 1	Derrick								
20-SC-4214B	Stream 2 - Derrick Scalping Screen 2	Derrick								

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						No.	Duty (kW)	VSD	S/By Unit	
20-SC-4214C	Stream 2 - Derrick Scalping Screen 3	Derrick								
20-SC-4214D	Stream 2 - Derrick Scalping Screen 4	Derrick								
20-SC-4214E	Stream 2 - Derrick Scalping Screen 5	Derrick								
20-TK-4216	Stream 2 - Cyclone #2 Feed Collection Tank									
20-PU-4218	Stream 2 - Cyclone #2 Feed Pump	Weir	250MCU	1460	m³/hr					
20-CY-4220	Stream 2 - Cyclone 2	FLSmidth		1460	m³/hr					
20-VM-4222	Stream 2 - Mill	Metso	VTM-3000-WB Vertimill®							
20-SC-4224	Stream 2 - Mill Discharge Screen									
20-PU-4288	Stream 2 - Mill Discharge Sump Spillage pump	Weir			m³/hr					
	PFD NO: C8381-PFD-20-510	**LIMS 2 - Stream 1**								
20-TK-5101	LIMS 2 Stream 1 - Feed Tank									
20-PU-5102	LIMS 2 Stream 1 - Feed Pump	Weir	350MCU	1984	m³/hr					
20-DB-5104	LIMS 2 Stream 1 - Feed Distributor									
20-MS-4112A	LIMS 2 Stream 1 - MagSep #1A	Steinert	single - 1s - 950 G							
20-MS-5112B	LIMS 2 Stream 1 - MagSep #1B	Steinert	single - 1s - 950 G							
20-MS-5112C	LIMS 2 Stream 1 - MagSep #1C	Steinert	single - 1s - 950 G							
20-MS-5122A	LIMS 2 Stream 1 - MagSep #2A	Steinert	single - 1s - 950 G							
20-MS-5122B	LIMS 2 Stream 1 - MagSep #2B	Steinert	single - 1s - 950 G							
20-MS-5122C	LIMS 2 Stream 1 - MagSep #2C	Steinert	single - 1s - 950 G							
20-MS-5132A	LIMS 2 Stream 1 - MagSep #3A	Steinert	single - 1s - 950 G							
20-MS-5132B	LIMS 2 Stream 1 - MagSep #3B	Steinert	single - 1s - 950 G							
20-MS-5132C	LIMS 2 Stream 1 - MagSep #3C	Steinert	single - 1s - 950 G							
20-MS-5142A	LIMS 2 Stream 1 - MagSep #4A	Steinert	single - 1s - 950 G							

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Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-MS-5142B	LIMS 2 Stream 1 - MagSep #4B	Steinert	single - 1s - 950 G							
20-MS-5142C	LIMS 2 Stream 1 - MagSep #4C	Steinert	single - 1s - 950 G							
20-CH-5116	LIMS 2 Stream 1 - MagSep #1 Underpan									
20-CH-5126	LIMS 2 Stream 1 - MagSep #2 Underpan									
20-CH-5136	LIMS 2 Stream 1 - MagSep #3 Underpan									
20-CH-5146	LIMS 2 Stream 1 - MagSep #4 Underpan									
20-CY-5118	LIMS 2 Stream 1 - Cyclone #1	Multotec		832	m³/hr					
20-CY-5128	LIMS 2 Stream 1 - Cyclone #2	Multotec		832	m³/hr					
20-CY-5138	LIMS 2 Stream 1 - Cyclone #3	Multotec		832	m³/hr					
20-CY-5148	LIMS 2 Stream 1 - Cyclone #4	Multotec		832	m³/hr					
20-MS-5106A	LIMS 2 Stream 1 - Dewatering Magnet #A	Steinert	single - 1s - 6000G							
20-MS-5106B	LIMS 2 Stream 1 - Dewatering Magnet #B	Steinert	single - 1s - 6000G							
20-CH-5107	LIMS 2 Stream 1 - Dewatering Magnet Underpan									
20-SC-5109A	LIMS 2 Stream 1 - Dewatering Screen #1	Derrick								
20-SC-5109B	LIMS 2 Stream 1 - Dewatering Screen #2	Derrick								
20-SC-5109C	LIMS 2 Stream 1 - Dewatering Screen #3	Derrick								
20-SC-5109D	LIMS 2 Stream 1 - Dewatering Screen #4	Derrick								
	PFD NO: C8381-PFD-20-520	**LIMS 2 - Stream 2**								
20-TK-5201	LIMS 2 Stream 2 - Feed Tank									
20-PU-5202	LIMS 2 Stream 2 - Feed Pump	Weir	350MCU	1984	m³/hr					
20-DB-5204	LIMS 2 Stream 2 - Feed Distributor									
20-MS-4212A	LIMS 2 Stream 2 - MagSep #1A	Steinert	single - 1s - 950 G							
20-MS-5212B	LIMS 2 Stream 2 - MagSep #1B	Steinert	single - 1s - 950 G							

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						No.	Duty (kW)	VSD	S/By Unit	
20-MS-5212C	LIMS 2 Stream 2 - MagSep #1C	Steinert	single - 1s - 950 G							
20-MS-5222A	LIMS 2 Stream 2 - MagSep #2A	Steinert	single - 1s - 950 G							
20-MS-5222B	LIMS 2 Stream 2 - MagSep #2B	Steinert	single - 1s - 950 G							
20-MS-5222C	LIMS 2 Stream 2 - MagSep #2C	Steinert	single - 1s - 950 G							
20-MS-5232A	LIMS 2 Stream 2 - MagSep #3A	Steinert	single - 1s - 950 G							
20-MS-5232B	LIMS 2 Stream 2 - MagSep #3B	Steinert	single - 1s - 950 G							
20-MS-5232C	LIMS 2 Stream 2 - MagSep #3C	Steinert	single - 1s - 950 G							
20-MS-5242A	LIMS 2 Stream 2 - MagSep #4A	Steinert	single - 1s - 950 G							
20-MS-5242B	LIMS 2 Stream 2 - MagSep #4B	Steinert	single - 1s - 950 G							
20-MS-5242C	LIMS 2 Stream 2 - MagSep #4C	Steinert	single - 1s - 950 G							
20-CH-5216	LIMS 2 Stream 2 - MagSep #1 Underpan									
20-CH-5226	LIMS 2 Stream 2 - MagSep #2 Underpan									
20-CH-5236	LIMS 2 Stream 2 - MagSep #3 Underpan									
20-CH-5246	LIMS 2 Stream 2 - MagSep #4 Underpan									
20-CY-5218	LIMS 2 Stream 2 - Cyclone #1	Multotec		832	m³/hr					
20-CY-5228	LIMS 2 Stream 2 - Cyclone #2	Multotec		832	m³/hr					
20-CY-5238	LIMS 2 Stream 2 - Cyclone #3	Multotec		832	m³/hr					
20-CY-5248	LIMS 2 Stream 2 - Cyclone #4	Multotec		832	m³/hr					
20-MS-5206A	LIMS 2 Stream 2 - Dewatering Magnet #A	Steinert	single - 1s - 6000G							
20-MS-5206B	LIMS 2 Stream 2 - Dewatering Magnet #B	Steinert	single - 1s - 6000G							
20-CH-5207	LIMS 2 Stream 2 - Dewatering Magnet Underpan									
20-SC-5209A	LIMS 2 Stream 2 - Dewatering Screen #1	Derrick								
20-SC-5209B	LIMS 2 Stream 2 - Dewatering Screen #2	Derrick								

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Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	DRIVES Duty (kW)	DRIVES VSD	DRIVES S/By Unit	Comments
20-SC-5209C	LIMS 2 Stream 2 - Dewatering Screen #3	Derrick								
20-SC-5209D	LIMS 2 Stream 2 - Dewatering Screen #4	Derrick								
	PFD NO: C8381-PFD-20-600	**PRODUCT HANDLING, PRODUCT STORAGE, TRANSFER**								
20-CH-6102	Stream 1 Product Diverter Chute									
20-CH-6202	Stream 2 Product Diverter Chute									
20-CV-6104	Product Transfer Conveyor #1	DRA								
20-CV-6204	Product Transfer Conveyor #2	DRA								
20-CH-6106	Bin 1 - Bin 2 Diverter Chute									
20-CH-6206	Bin 3 - Bin 4 Diverter Chute									
20-CV-6108	Product Storage Bin #2 Feed Conveyor	DRA								
20-CV-6208	Product Storage Bin #4 Feed Conveyor	DRA								
20-CH-6110	Bin 1 Distribution Chute									
20-CH-6210	Bin 2 Distribution Chute									
20-CH-6310	Bin 3 Distribution Chute									
20-CH-6410	Bin 4 Distribution Chute									
20-BN-6112	Product Storage Bin #1									
20-BN-6212	Product Storage Bin #2									
20-BN-6312	Product Storage Bin #3									
20-BN-6412	Product Storage Bin #4									
20-CH-6114	Product Storage Bin #1 Discharge Chute									
20-CH-6214	Product Storage Bin #2 Discharge Chute									
20-CH-6314	Product Storage Bin #3 Discharge Chute									
20-CH-6414	Product Storage Bin #4 Discharge Chute									

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Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-CV-6116	Product Belt Feeder #1	DRA								
20-CV-6216	Product Belt Feeder #2	DRA								
20-CV-6316	Product Belt Feeder #3	DRA								
20-CV-6416	Product Belt Feeder #4	DRA								
20-CH-6118	Product Belt Feeder #1 Head Chute									
20-CH-6218	Product Belt Feeder #2 Head Chute									
20-CH-6318	Product Belt Feeder #3 Head Chute									
20-CH-6418	Product Belt Feeder #4 Head Chute									
20-CV-6120	Product Conveyor	DRA								
20-TK-6122	Product Dilution Tank									
20-PU-6124	Product Transfer Pump	Weir	350MCU	2654	m³/hr					
20-PU-6126	Product Storage Spillage Pump #1	Weir			m³/hr					
20-PU-6128	Product Storage Spillage Pump #2	Weir			m³/hr					
20-PU-6130	Product Storage Spillage Pump #3	Weir			m³/hr					
	PFD NO: C8381-PFD-20-700	**PROCESS WATER - SEA CHEST**								
20-TK-7002	Motive water tank									
20-FL-7100	Stream #1 Process Water Supply Filter									
20-FL-7200	Stream #2 Process Water Supply Filter									
20-FL-7300	Stream #3 Process Water Supply Filter									
20-FL-7400	Stream #4 Process Water Supply Filter									
20-PU-7102	Stream #1 Process Water Supply	Weir	350MCU	2592	m³/hr					
20-PU-7202	Stream #2 Process Water Supply	Weir	350MCU	2592	m³/hr					
20-PU-7302	Stream #3 Process Water Supply	Weir	350MCU	2592	m³/hr					

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TTR Trans-Tasman Resources

DRA

Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
20-PU-7402	Stream #4 Process Water Supply	Weir	350MCU	2592	m³/hr					
20-FL-7110	Stream #1 Process Water Supply Filter									
20-FL-7210	Stream #2 Process Water Supply Filter									
20-PU-7112	Stream #1 Process Water Supply	Weir	350MCU	2416	m³/hr					
20-PU-7212	Stream #2 Process Water Supply	Weir	350MCU	2416	m³/hr					
20-FL-7220	GSW Filtration Supply Pump Filter									
20-PU-7222A	GSW Filtration Supply Pump	Weir	150MCU	460	m³/hr					
20-PU-7222B	GSW Filtration Supply Pump - Standby	Weir	150MCU	460	m³/hr					
20-FL-7130	Stream #1 HP Process Water Supply Filter									
20-FL-7230	Stream #2 HP Process Water Supply Filter									
20-PU-7132	Stream #1 HP Process Water Supply	Weir	150MCU	621	m³/hr					
20-PU-7232	Stream #2 HP Process Water Supply	Weir	150MCU	621	m³/hr					
20-FL-7240	Desalination Plant Feed Pump #1 Filter									
20-PU-7242A	Desalination Plant Feed Pump #1	Weir	250MCU	1562.5	m³/hr					
20-PU-7242B	Desalination Plant Feed Pump #2	Weir	250MCU	1562.5	m³/hr					
20-PU-7242C	Desalination Plant Feed Pump Standby	Weir	250MCU	1562.5	m³/hr					
	PFD NO: C8381-PFD-20-710	**PROCESS WATER DISTRIBUTION**								
	PFD NO: C8381-PFD-20-715	**PROCESS WATER DISTRIBUTION**								
	PFD NO: C8381-PFD-20-720	**GSW DISTRIBUTION**								
20-FL-7202	GSW Filter									
20-TK-7204	GSW Collection Tank									
20-PU-7206A	GSW Feed Pump	Weir			m³/hr					
20-PU-7206B	GSW Feed Pump Standby	Weir			m³/hr					

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Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES No.	DRIVES Duty (kW)	DRIVES VSD	DRIVES S/By Unit	Comments
	PFD NO: C8381-PFD-20-800	**TAILINGS AND WASTE WATER**								
20-TK-8007	LIMS 2 Waste Water Collection Tank									
20-TK-8027	LIMS 2 Tailings Collection Tank									
20-PU-8012	LIMS 2 Waste Water Transfer Pump	Weir		6300	m³/hr					
20-PU-8032	LIMS 2 Tailings Transfer Pump	Weir		460	m³/hr					
20-LA-8017	Waste Water Collection Launder									
20-CH-8022	Waster Water Disposal Pipe									
20-LA-8037	Tailings Collection Launder									
20-CH-8042	Tailings Disposal Pipe									
	PFD NO: C8381-PFD-20-010	**COMMON SERVICES**								
20-AC-0102	Compressor - Engine Air									
20-AC-0202	Compressor - Workshop Air									
20-FL-0104	Compressed Air Filter / Strainer									
20-FL-0204	Compressed Air Filter / Strainer									
20-AR-0106	Air Receiver - Engine Air									
20-AR-0206	Air Receiver - Workshop Air									
	PFD NO: C8381-PFD-30-100	**SERVICES AND RETICULATION, DESALINATION**								
30-TK-1102A	Desalinated Water Storage Tank #1									
30-TK-1102B	Desalinated Water Storage Tank #2									
30-TK-1102C	Desalinated Water Storage Tank #3									
30-TK-1102D	Desalinated Water Storage Tank #4									
30-PU-1104	Product Transfer Dilution Pump	Weir	350MCU	2056	m³/hr					
	PFD NO: C8381-PFD-40-100	**SERVICES AND RETICULATION, POWER GENERATION**								

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Eq No.	Description	Supplier	Specifications	Design	Units	DRIVES				Comments
						No.	Duty (kW)	VSD	S/By Unit	
40-HX-1002	Generator Heat Exchanger									

Appendix 19.8 - IHC Merwede Crawler Report

IHC Mining B.V.

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www.ihcmerwede.com

Date	Reference	Status	
23 May 2013	M10.002	FINAL	Taco de Boer

Crawler Viability Workshop Report

Titano-Magnetite Resource Project
For
Trans Tasman Resources Limited

Client: Trans-Tasman Resources Limited
Document no: IHC IMAS-NS01
Version: Final
Date: 23 May 2013
Prepared by: T. de Boer; L.J. de Jonge; C. Jermyn
IHC Mining Advisory Services (IMAS)

IHC MERWEDE

Date	Reference	Status
23 May 2013	M10.002	FINAL

This report has been reviewed and approved in accordance with the policies of IHC Merwede.

Prepared:	Ir. T. de Boer		
		Signed	Date
Prepared:	Ir. L.J. de Jonge		23 May 2013
		Signed	Date
Reviewed:	Dr. J. Feenan		23 May 2013
		Signed	Date
Approved:	Mr. R. Norman		
		Signed	Date

Disclaimer

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Date	Reference	Status
23 May 2013	M10.002	FINAL

This document is dated 23 May 2013.

List of figures

List of tables

Date	Reference	Status
23 May 2013	M10.002	FINAL

Content

1 Executive Summary

The Crawler Viability Workshop provided an opportunity for Trans Tasman Resources Limited (TTRL) to rapidly assess the key parameters and levels of confidence to deploy IHC Merwede's technology for iron sands mining in New Zealand. Both parties understood that within a limited timeframe there was a need to focus attention upon the key technology issues in order to seek out any potential showstoppers, and if there were no showstoppers then what are the levels of confidence in the system and associated costs to deliver and operate to the required performance criteria.

IHC Merwede committed its senior Mining and Advisory personnel to the workshop and brought in naval architect and environmental engineering expertise as required. A lot of productive thinking and work was undertaken during the workshop with the key findings that crawler mining technology represents:

1. A viable technical solution for TTRL's iron sands project;
2. An opportunity to achieve minimum requested production levels for iron concentrate once the known parameters of a "DeBeers scale" system are fully engineered for increased capacity;
3. A viable process to deliver "at site" backfill of tailings to avoid the need for multiple transhipments of materials; and
4. A level of system flexibility to optimise mining operations and account for local conditions that is not possible with standard dredging technologies.

All mining projects have unique characteristics that will only be fully assessed through detailed feasibility engineering and studies. Further learning will also occur once the mining system is installed and brought into production. The benefit of working closely with an Original Equipment Manufacturer in IHC Merwede is that we are available to work closely with the project operator, understand the project issues and if new operating information means new challenges, then to find a successful engineering solution to keep the project working at optimum performance.

IHC Merwede brings a long history of successful crawler operations to the market, technology that is unmatched, and IHC rightly seeks to protect that intellectual property as the basis for its future success in marine mining projects. However, IHC Merwede acknowledges that successful mining projects also require collaboration between different project participants and always works actively to manage project collaboration and relationships to the benefit of the mining project and the mining client. Our commitment to this Crawler Viability Workshop reflects the passion to achieve success and to work closely with our clients as a partner through the mining lifecycle. IHC Merwede welcomes the opportunity and challenges to bring TTRL's project from a viable concept to a successful reality.

2 Introduction

As part of a value improvement review requirement of the Pre Feasibility Study (PFS) phase, Trans-Tasman Resources have requested IHC Merwede to assist in the evaluation of the crawler mining system as employed by DeBeers Marine off the coast of Namibia. As the designers of the DeBeers mining system IHC are best placed to provide both a technical viability and financial assessment of the crawler mining system in the TTRL scenario.

The assessment was accomplished by way of a rigorous seven day workshop attended by senior project and technical personnel from TTRL and the IHC divisions of Deep Sea Mining, Mining Advisory Services and MTI Holland. The workshop was held at the IHC Merwede premises in Kinderdijk, The Netherlands between Wednesday 3rd April to Friday 12th April 2013. Q&A discussions with TTRL subsequent to the Workshop have been included in this Final version of the report.

TTRL		**IHC**	
Name	*Position*	*Name*	*Position*
Tim Crossley	CEO	Rodney Norman	PMC Director Deep Sea Mining
Shawn Thompson	Project Director	Taco de Boer	Sr. Consultant IMAS
Matt Brown	GM Exploration	Laurens de Jonge	Manager Design & Engineering DSM
Andre Mouton	Process Lead	Henk van Muijen	PMC Director IMAS
		John Feenan	Director Asia Pacific
		Courtney Jermyn	Project Engineer IMAS

Additional subject matter experts were also included to review specific applications of the crawler mining system. These SME's included:

- Naval Architect, Marc Oele from Vuyk Engineering — Mooring Analysis
- Environmental Engineer, Aleyda Ortega — Tailing Plume Analysis

The terms of reference for the workshop were provided by TTRL to ensure that the workshop focussed on the major issues, assessing the most serious likely impacts and identifying any fatal flaws. In order that the value opportunity was properly assessed TTRL required that the assessment be largely a quantitative exercise using both established and verified data.

The timing of this value improvement initiative has enabled TTRL to consider detailed risks and challenges inherent within the current PFS configuration, risks and challenges that unless mitigated is carried over into the next project phase i.e. BFS. It is envisaged that the recommendations emerging from this workshop will be able to be incorporated into the project PFS.

3 Design Basis

3.1 Starting points for the workshop

Before the start of the workshop specific starting points and objectives were defined by TTRL, which were described in the Terms of Reference as attached in Appendix A: Pre-Workshop Terms of Reference TTRL.

Additionally some general starting points were defined at the beginning of the workshop:

- The crawler mining system should be based on existing technology, not on new concepts.
- Tailings management is very important with respect to environment and should be incorporated in the mining solution. Backfilling is required in the mined out area with minimum impact on ecology.
- The total mining solution should have as minimum transhipments as possible
- The targeted concentrate production of the total mining system should be 5.000.000 tds. per annum
- Recoverable yield: 9,8%

3.2 Deposit characteristics

The most important iron sands deposit characteristics with respect to the crawler mining operation are listed below. These figures have been supplied by TTRL as an input for the workshop and these were used to size and forecast production levels of the crawler mining system:

Deposit type	: Iron Sands, flat lying deposit
Thickness deposit	: Average 5 meter Maximum 12 meter Minimum 2 meter
Deposit characterisation	: Sediment is assumed to be of free flowing nature, some clay lenses are present but not taken into account during evaluation
Sediment average specific gravity	: 3,2 t/m³
Sediment in situ density (wet)	: 2,35 t/m³
Sediment bulk density (dry)	: 1,9 t/m³
Seawater density	: 1,03 t/m³
Average particle size distribution	: see table below

(μm)	%Dist (-2mm)	%Passing (-2mm)	**%Dist (ROM)**	**%Passing (ROM)**
2000			4	96
1000	1.13	98.87	1.1	94.9
710	1.42	97.46	1.4	93.6
500	4.02	93.44	3.9	89.7
355	8.12	85.32	7.8	81.9
250	21.96	63.36	21.1	60.8
212	15.77	47.58	15.1	45.7
150	33.34	14.24	32.0	13.7
125	8.97	5.27	8.6	5.1
106	3.02	2.25	2.9	2.2
90	1.01	1.23	1.0	1.2

(µm)	%Dist (-2mm)	%Passing (-2mm)	**%Dist (ROM)**	**%Passing (ROM)**
63	0.60	0.64	0.6	0.6
45	0.23	0.41	0.2	0.4
38	0.05	0.36	0.1	0.3
-38	0.36	0.00	0.3	0.0
			100.0	

Table 3-1: Average particle size distribution Iron Sands sediment

3.3 Site conditions

The most important site conditions with respect to the mining area are listed below:

- Water depth between 30-45 meter.
- Weather conditions and sea state according to data used in the prefeasibility study of Taharoa project. The conditions are very similar to offshore conditions in Namibia, where crawler mining systems are operational currently.
- Mining Area is on average 15 Nm from coastline.
- Presence of rolling stones on the seabed.

<u>TTRL Question 23 April 2013</u>
Please elaborate on the assumption of rolling stones on the seabed?

> <u>IHC Response 25 April 2013</u>
> 2.1: In the MTI Holland report MB94 entitled “TTRL Iron Sands Dredge Mining Concept Study” in paragraph 2.3 Wave currents and climate, it was mentioned that rolling stones, rocks or boulders occur in this area. These rolling stones may have a negative influence on the mining efficiency of the crawler. To what extent it influences the mining efficiency should be taken into consideration in the BFS phase.
>
> <u>TTRL Response 30 April 2013</u>
> No rolling stones, rocks or boulders have been observed in any of the areas demarcated within our mine plan.

3.4 Exclusions

Due to the limited period of time available during the workshop, some parts of the entire logistic mining system were outside the scope, these include:

- Transshipment of concentrate from Mining Support Vessel (MSV) to FSO and further on
- Processing of iron sands onboard
- Sizing of processing buffer capacities onboard
- Re-fueling of the Mining Support Vessel
- Other support vessel operations (such as tugs)
- Mining support vessel sizing
- Port maintenance and offloading facilities

It should be noted that the mining system and operation, although evaluated separately in this workshop, cannot be seen as an standalone system, but forms an integral system with the other parts of the logistic chain, especially with the processing plant and the transshipment between the Mining Support Vessel and the FSO.

4 Crawler mining system

The following section is intended to describe, at a high level, the breakdown of a crawler based system for mining iron sands.

4.1 Seafloor Mining Tool

The concept design of the seafloor mining tool (SMT) which will extract the iron sands from the seafloor is described below. It is purely based on existing technology readily available from operational diamond mining systems, with limited extrapolation and adaptation due to the limited time available within the workshop for concept development and engineering.

The basis for the concept is a tracked vehicle with a submersible dredge pump and slewing boom configuration. The concept is based on many years of experience of the mining and dredge processes, and the designing of offshore mining/dredge systems, submerged pumps, dredge components and subsea tracked vehicles within the IHC Merwede group.

Figure 4-1 shows the selected SMT concept. The respective parts constituting the SMT, as well as equipment and systems located on the SMT, are detailed below. The installation to power, operate and control the SMT will be located on the mining support vessel.

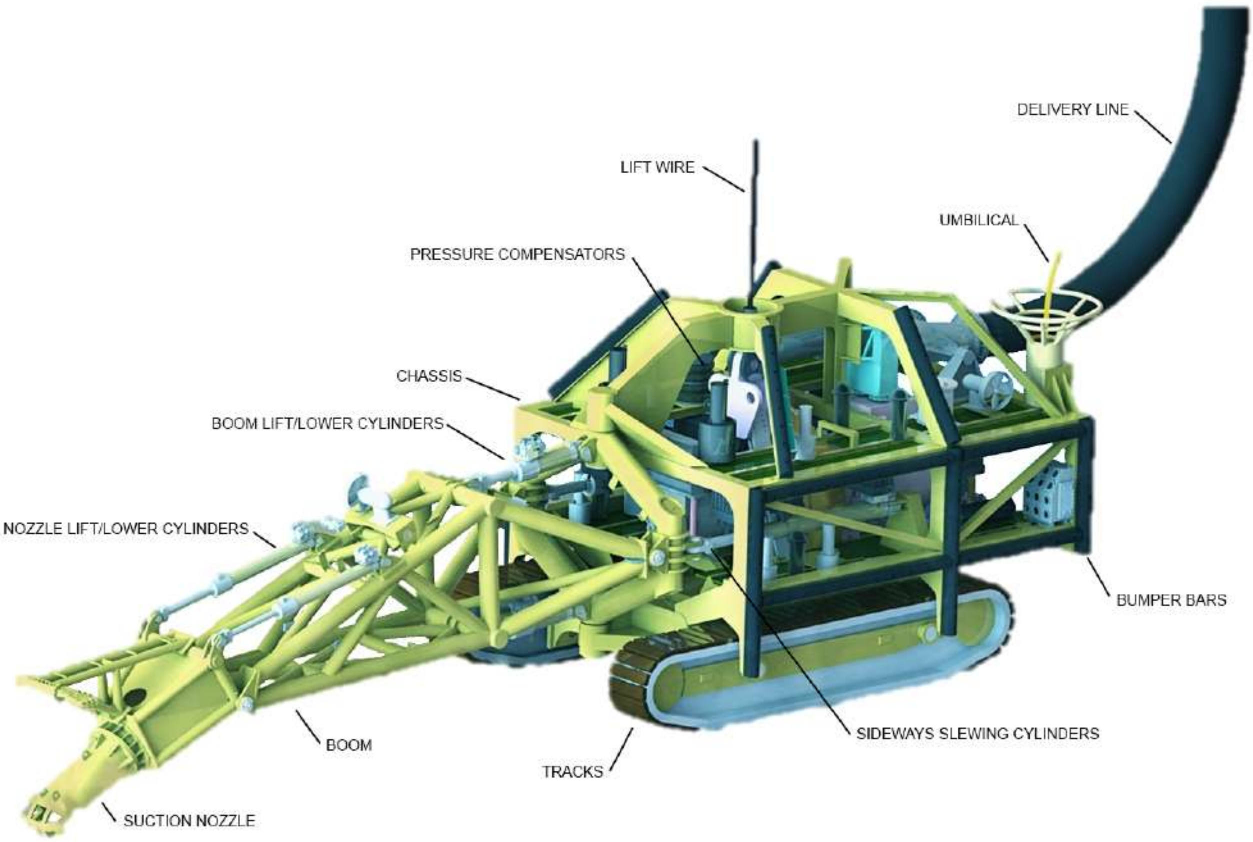


Figure 4-1: Seafloor mining tool (SMT) concept.

4.1.1 General Arrangement

The SMT structure comprises a box girder construction chassis to which the following are attached:

- a track system;
- the slewing boom configuration with the suction head and the slurry system;
- and lift wire, umbilical and riser connection.



Figure 4-2 Seafloor Mining Tools

4.1.2 Slewing boom configuration

The suction head of the slurry system is located at the end of a slewing boom configuration attached to the chassis with a gimbal. The gimbal allows the boom configuration to slew left to right and up and down with hydraulic cylinders. With a boom length of 12m and 30 degree sideway angles it can reach a mining window of approximately 12m width by -1m to +8m . The boom needs to reach below the tracks to be able to dig itself down into the seafloor. Effectively this will allow for a lane width of approximately 10m.

The length and reach of the slewing boom configuration is limited due to limitations in the balancing of all digging and other forces. In comparison with a spud on a cutter suction dredge, the tracks on the crawler need to transfer all cutting and slewing forces to the seafloor. The combination of track type and seafloor conditions determines the balance.

Depending on the required mining face, cleanup and below track capabilities a knuckle can be attached to the boom allowing for a more flexible up and down reach of the suction nozzle and a better alignment with the seafloor.

For a high density production with this configuration it is required to have free flowing material that breaches into the suction head. The suction nozzle can then be positioned right at the bottom of the face allowing the material to flow in slowly slewing side to side.

If the material does not breach then the suction nozzle needs to be slewed along the face side to side. Starting at the top moving down with each slew in approximately 1 meter steps. Obviously this will require much longer time to mine the full face, limiting the maximum achievable densities and production. Furthermore allowance can be made to attach an active cutting tool like a wheel cutter head.

4.1.3 Slurry System

The slurry system is the starting point of the slurry transport and comprises a suction head, pump system and delivery line. The suction head engages the sea bed, eroding and fluidising the material and effecting the entrainment. The slurry system is built up from standard and commonly used dredging equipment.

Suction head Suction Line

- Suction head (including jetwater nozzles if required);
- Waste gate valve;
- Flexible hose section in the gimbal;
- Expansion joint;
- Inspection piece; and
- Jet-water pump and electric motor.

Pump System

- Dredge pump; and
- Dredge pump electric motor.

Delivery Line

- Expansion joint
- Dump valve; and
- Turning gland.

4.1.4 Suction head

The suction head forms the starting point of the slurry suction line which is connected to the dredge pump. It can use jet to fluidise and entrain the soil. The suction head can erode the material but works best with free flowing material allowing high density flows.

The production efficiency of the suction head is the ability of the mining / excavation method to achieve the optimum velocity to entrain the material. It is inevitable that during the mining process; losses could occur that would influence the ability to effectively entrain the material. This could be due to the ineffective ability of the mining / excavation method to positively engage the seabed.

4.1.5 Jet-water

Jetwater can assist in to allow fluidising of the soil matrix when eroding. The jet pump is driven by a submersible electrical motor.

TTRL Question 23 April 2013
Is Jet water taken into consideration when evaluating concentration?

IHC Response
No. Jet water is not taken into consideration when evaluating concentration as it would take empirical analysis to determine the varying effects of jet water upon concentration.

4.1.6 Waste Gate Valve
In case of a blockage, by clay for instance, the waste gate valve allows water to enter the suction line thus relieving the vacuum and prevents the slurry flow from stopping. The valve is by the suction pressure transmitter.

4.1.7 Flexible hose section
A flexible hose section allows the slewing boom gimbal cylinders to position the boom horizontally and vertically from the seabed.

4.1.8 Expansion Joint
An expansion joint in the suction and delivery line will isolate pump vibrations, preventing transfer to the rest of the slurry system. Any effect due to thermal expansion and contraction will also be absorbed by the joint.

4.1.9 Dredge Pump
The dredge pump is driven by a submersible electric motor and provides the flow and pressure to allow slurry transport to the MSV.

4.1.10 Dredge Pump Submersible Electric Motor
The submersible electric motor provides the power for driving the dredge pump. The dredge pump is directly coupled to the electric motor and is pressure compensated to prevent water entering the housing. The electric motor is supplied via the umbilical by a variable speed drive, located on the MSV.

4.1.11 Dump Valve
The dump valve is located in a bend of the delivery line. The valve is hydraulically actuated and allows slurry to be drained from the riser string in case of unplanned stoppages.

4.1.12 Turning Gland
A turning gland between the flexible riser and SMT delivery line allows the riser to rotate freely around the longitudinal axis. A second turning gland, mounted to a pivot arm on the SMT chassis, provides swivel in the lateral direction, allowing the flexible riser string freedom during launch and recovery. This configuration allows the crawler to make turns.

4.1.13 Chassis
The chassis is fabricated from high strength steel using a simple but strong box girder construction. The main chassis structure is connected to the tracks which are located on either side on the SMT. The slurry system is located above the chassis, including the suction line, dredge pump and delivery line.

A secondary structure is located above and integrated into the main chassis, providing mounting areas for all the associated equipment and instrumentation, such as the subsea electronics pod, hydraulic power unit (HPU), valve tanks, junction boxes and the lift umbilical termination for the control and monitoring system as well as launch and recovery. The secondary structure also comprises a bumper bar system for guiding the

SMT onto the vessel during launch and recovery. Cameras and sonar for surveillance of subsea mining operations are mounted in appropriate locations.

Hydraulic hoses and harnesses are routed externally on the upper surfaces of the vehicle, aiming to provide the best compromise between protection and accessibility for maintenance, inspection and repair.

4.1.14 Tracks

The hydraulic driven tracks are bolted to the chassis of the SMT and allow for driving and steering the vehicle. The tracks also need to transfer all digging and slewing forces to the soil. The soil needs to provide for enough bearing capacity and friction to allow traction and slewing. Spill, clay and loose soil can limit the slewing force and speed.

4.1.15 Hydraulic System

The hydraulic system is composed of motors, pumps, filtration units, hydraulic cylinders, flexible hoses and instrumentation. In general flexible hoses with SAE 3000 series stainless steel fittings are used for all connections between the valve tanks, intermediate couplings and hydraulic cylinders. The design will generally minimise the number of connections to improve integrity. A key feature of the hydraulic design is provision to minimise the effect on the operation of the remainder of the vehicle through a hose failure or leak at any individual function.

4.1.16 SMT Control system

Equipment on the SMT is fitted with the required instrumentation to facilitate the monitoring and control of the complete mining system in a safe manner. The control system architecture is based on distributed networked nodes controlled from central processing units, using an industry standard PLC (Programmable Logic Controller) platform, distributed I/O (Input/Output) and SCADA (Supervisory Control and Data Acquisition) system. Incorporating these industry standard technologies allows for a reliable and open system that is easily maintainable.

The SMT is remotely controlled and powered via the umbilical by means of fibre optic connection, from the surface equipment, located on the mining support vessel.

4.1.17 Instrumentation

Equipment on the SMT is fitted with the required instrumentation to facilitate the monitoring, control and operation of the unit in a safe manner, whilst maximising system availability.

Instrumentation catered for would include amongst others:

- LVDT's (Linear Voltage Displacement Transducers);
- ICT's (In Cylinder Transducers);
- Angular Encoders;
- Pressure Transmitters;
- Temperature Transmitters;
- Accelerometers;
- Water Ingress Sensors; and
- Subsea Proximity Sensors.

In order to facilitate the safe and efficient operation of the mining system, the following positioning and visualisation equipment is fitted to the SMT:

- Gyro (including pitch, roll, yaw and heave);
- Submersible Cameras and lights;

- Pan and Tilt Units for cameras and lights where applicable;
- Multi-beam Sonar;
- Sound velocity probe;
- Altimeter; and
- USBL Transponder.

4.2 Vertical Transport System

The VTS enables the transport of slurry from the SMT to the MSV. The VTS allows for quick deployment and retrieval as well as mining at variable mining depths.

The VTS consists of the following components:

- The coupling between the seafloor mining tool and the first riser segment;
- A riser hose string consisting of individual riser hose segments; and
- A coupling between the riser and the plant connection.

The riser hose string consists of riser hose sections, with integrated floatation as required, and be stored on board the vessel through the use of a riser train handling system. The riser train consists of framed rollers, allowing the riser string to be stored on the vessel. The riser train includes several riser tensioners, used to launch and recover the riser string. The hose connects to the plant through the use of a ball joint connection, allowing for simple connection and disconnection during operations.

Figure 4-3 Riser hose handling

4.3 Mining Support Vessel

The Mining Support Vessel (MSV) provides the platform from which the SMT will be operated (note TTRL use the acronym FPSO for Floating Production Storage Offtake vessel). The MSV houses the SMT Launch and Recovery System (LARS), Vertical Transport System (VTS), Power generation, Propulsion, System support infrastructure (workshops/stores/cranes etc.), Accommodation, Auxiliary equipment.

The mining system service and auxiliary equipment on board the MSV generally comprises of the following major components:

- LARS structure with integrated A-Frame and sheaves;
- Passive heave compensator;
- Bumper bars;
- Umbilical winch and umbilical cable;
- Main lift winch and wire rope;

- The on-board hydraulic power unit;
- Deckhouses facilitating the required workshops, electrical equipment, hydraulic power units control rooms;
- Electrical equipment;
- Control equipment; and
- The vertical transport system.

The hydraulic and electrical auxiliary services supply equipment are housed in deckhouse areas, located on the aft deck of the MSV. The deckhouses also incorporate the control rooms for the mining system, including the LARS. The isometric view of the aft deck model shown as *Figure 4-4* provides a typical representation of the aft deck layout.

Typically an area of 45x24m would be required to house all the equipment excluding the aft sponsoons and the length required for the riser train.

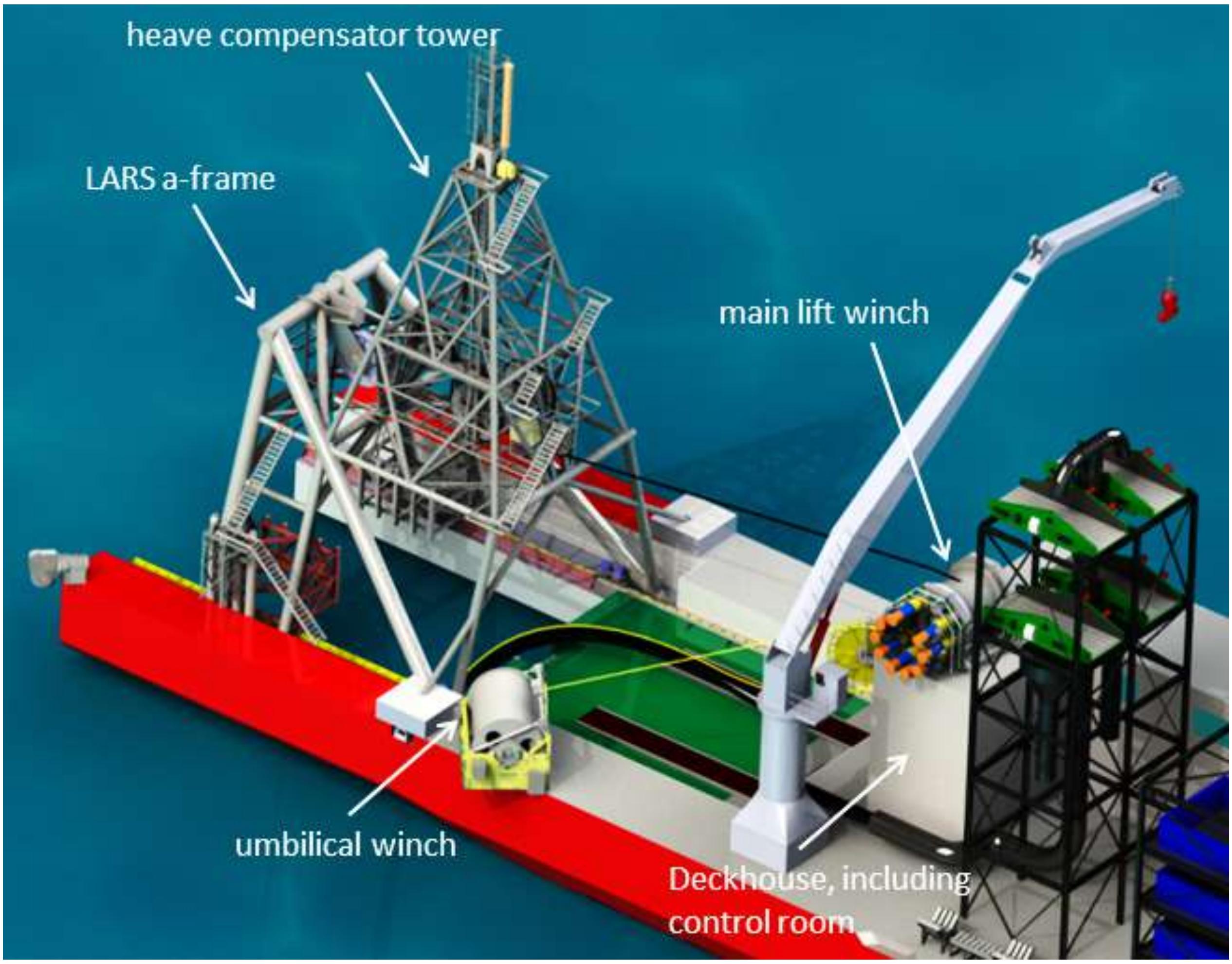


Figure 4-4 Typical isometric view of a MSV aft deck layout.

4.3.1 Launch and Recovery A-Frame

The static A-frame is fabricated using high strength steel, allowing for a reduction in self-weight, resulting in reduced deck loadings. The A-Frame structure incorporates the passive heave compensator structure and swivelling sheave. The design would take cognisance of the load paths required to reduce stresses imposed on the vessel structure. The main structural members will be designed to be integrated into the vessels deck structure, reducing the need for under-deck or above-deck stiffening. The A-Frame and Compensator Tower will have sufficient access and walkways for inspection and maintenance.

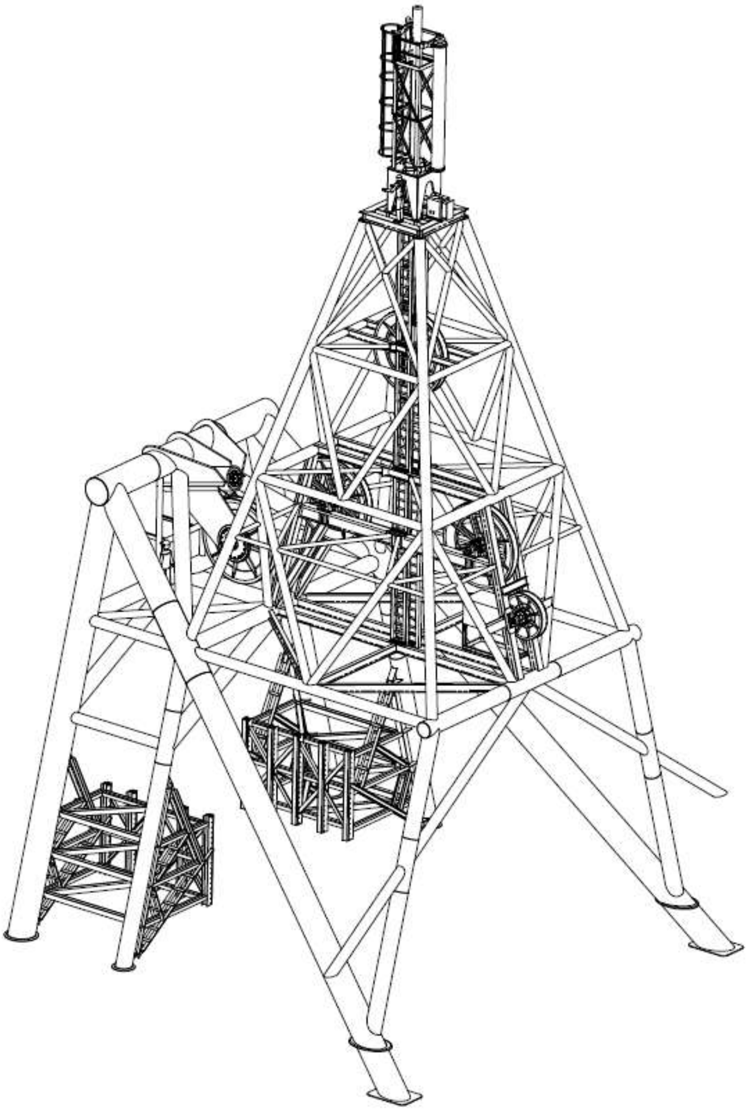


Figure 4-5: Typical isometric view of an A-Frame and Heave Compensation Tower

4.3.2 Passive Heave Compensator

The passive heave compensator is required to compensate for sea swells during operations. The passive heave compensator system provides a constant tension in the main lift wire rope through a system of fixed sheaves.

4.3.3 Sliding Door

In SMT is located on a sliding door located beneath the A-Frame and compensating tower on the aft deck of the vessel. The sliding door facilitates the launch and recovery of the SMT. The main lift wire rope lifts the SMT off the sliding door, the door is retracted and the SMT is launched into the water.

In addition to the launch and recovery purposes, the sliding door also allows for the SMT to be effectively moved to a safe maintenance position on the aft deck.

4.3.4 Umbilical Winch System

The umbilical winch is located on the aft deck, adjacent to the SMT deck. The umbilical is routed through a powered sheave, taking up the slack between the sheave and the umbilical winch.
The umbilical winch system would generally comprise of the following major components:

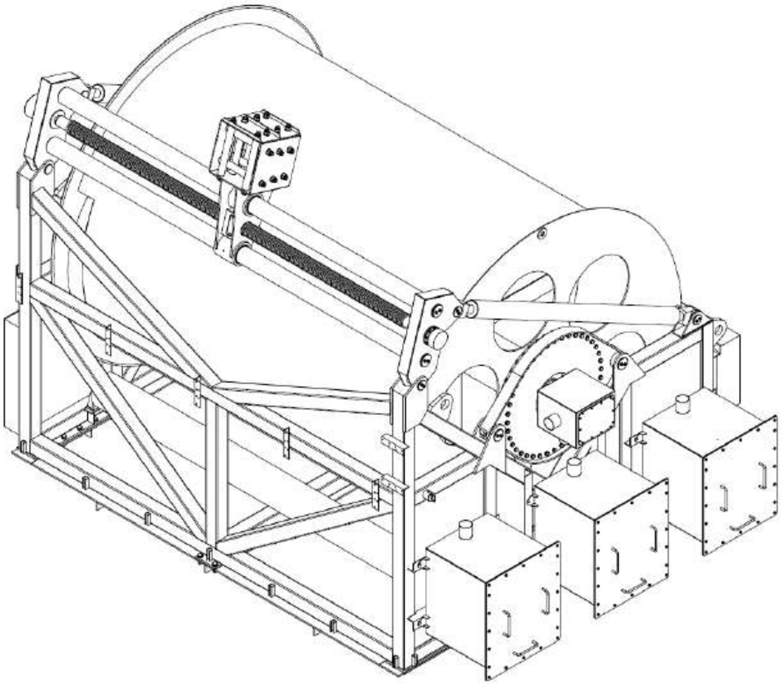


Figure 4-6: Typical isometric view of an Umbilical Winch

4.3.5 Main Lift Winch

The main purpose of the main lift winch is to power and control launch and recovery operations of the SMT. The lift winch consists of a drum with grooved sleeve (for accurate spooling and storage of the wire rope), a structural support frame and a spooling device. Electric motors, reduction gearboxes and a ring gear and pinion system provide power to the winch drum and spooling system.

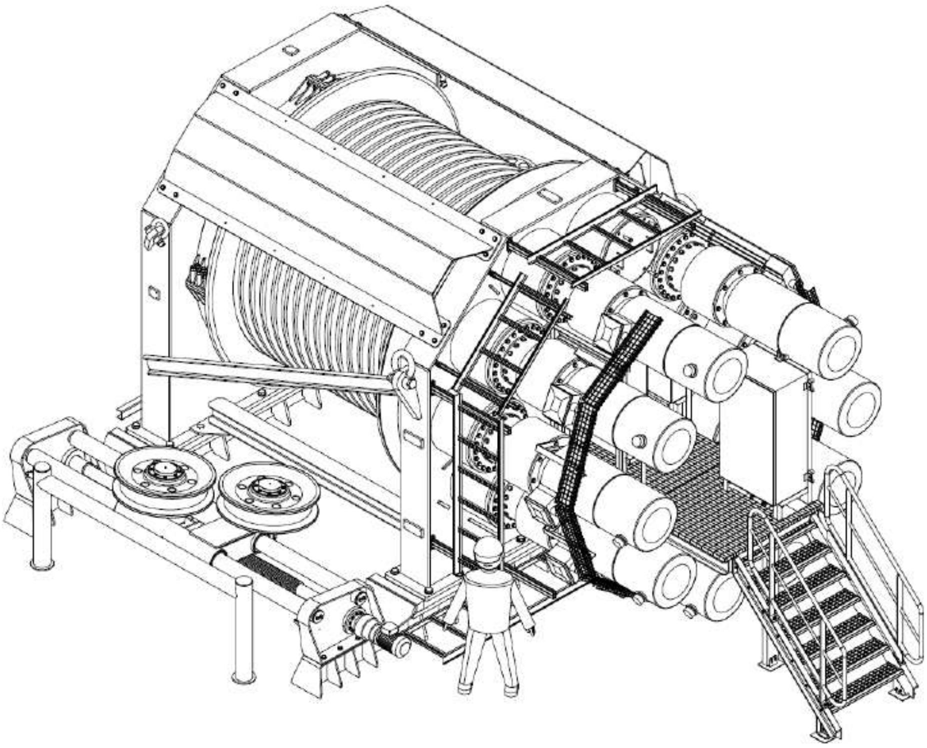


Figure 4-7: Typical isometric of a Main lift winch.

4.3.6 Hose Handling

Whilst on deck, the riser hose string is stored in the riser train consisting of rollers mounted on frames routed throughout the vessel. The riser train handling system would consist of multiple riser tensioner units positioned along the riser train. The riser tensioners would assist with the launch and recovery of the riser string. Any excess or spares lengths is stored in a dedicated riser hose storage rack and would typically be handled by either an overhead gantry crane or ships utility crane.

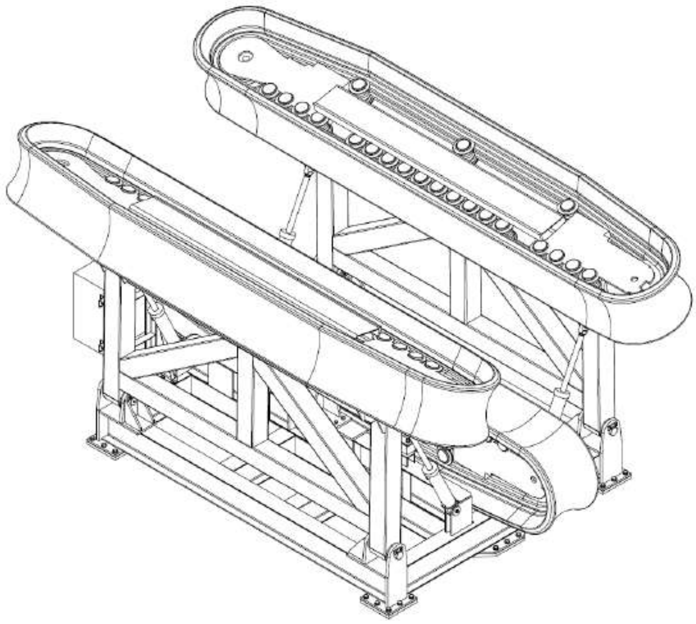


Figure 4-8: Typical isometric of a riser hose handling tensioner.

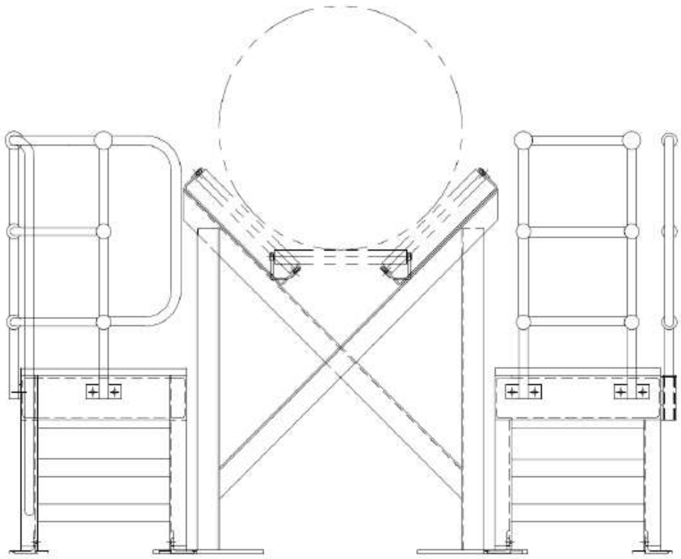


Figure 4-9: Typical Riser train layout.

4.3.7 Electrical System

Typically the electrical components and equipment is located in the following areas on board the mining support vessel:

- Mining system transformer room;
- Mining system MV switchgear room;
- Mining system LV switchgear room; and
- Mining system control room.

All SMT supplies are independently switchable at the surface and protected against:

- Overloads;
- Line insulation faults; and
- Earth continuity faults.

4.3.8 Control and Instrumentation System

The operator is able to control the mining system in its selection of modes from an operator control console, located inside the control cabin. The control cabin is designed to provide a comfortable environment for the operators incorporating good ergonomic practice regarding layout and seating, etc. Typically two stations is provided, one for the Pilot and one for the Co-Pilot. All SMT, LARS and riser train handling functions will be controlled and monitored from the control stations located inside the control cabin.

Operator system monitoring and control is achieved through a combination of SCADA and HMI (Human Machine Interface) systems. The operator will be able to obtain information regarding equipment functions such as hydraulic actuators, cameras, lighting, instrumentation and survey equipment. A typical layout of an operator control console, located inside the control cabin is provided in figure 11.10 below.

Figure 4-10: Typical operator control console.

4.3.9 Deck Cranes

The MSV should be equipped with enough crane capacity to allow for independent offshore and in port maintenance. The aft deck crane for the Mining system is typically located on the aft deck in a position determined by the crane reach and the positions of deck equipment and the SMT.

4.3.10 Mining Support Vessel Requirements

The mining support vessel should be classed for worldwide operations in accordance with the relevant maritime class requirements. The mining support vessel must meet the following requirements:

- Capable of station keeping and tracking during mining operation;
- Capable of supporting and housing the mining system, launch and recovery system, vertical transport system and auxiliary services;
- Capable of supporting and housing a treatment plant;
- Capable of buffering and stockpiling slurries and concentrates to allow for a continuous process;
- Capable to offload tailings;
- Capable to offload concentrate to a FSO;
- Capable of supplying sufficient power to drive the mining system, launch and recovery system, vertical transport system and auxiliary services;
- Capable of providing sufficient office space and accommodation for the mining system operational staff complements; and
- Capable of supporting a helideck in order to facilitate personnel transfer.

4.4 Double Crawler System

The crawler mining system as described in the above paragraphs has been based on existing systems consisting of a single crawler. To meet higher production requirements or if full redundancy is required a two crawler system has been investigated at a very high level. Basically it implies placing two complete independent systems next to each other on the aft deck.

Figure 4-11: Artist impression of double crawler system vessel configuration

It requires a footprint of at least 45x45m and the MSV needs to be able to support the mass and operation of two systems. Technically the crawler systems are very similar to a single crawler system, however the operational viability of the systems needs to be fully investigated and engineered. A double crawler system of this size has no operating predecessor.

At a minimum following items need to be considered:

- Launching and recovering of two crawlers close to each other
- Operation of two crawlers next to each other, the independency of the operation, advance rates, mobility and manoeuvrability,
- Influence on mine plan: turning and rotating two crawlers is either difficult or will take a long time therefore long parallel lanes seem better for continuous production
- Full DP favourable of 4 point mooring:
    - Increased production requires more anchor handling
    - Long lanes v. block mining
    - Might give a slightly higher weather uptime, depending on DP system
- Two crawlers does not imply double production:
    - no full face for at least one of the crawlers
    - advance rate needs to be equal
    - less flexibility in crawler operating mobility

        - Alignment of two crawlers
    - Weather uptime probably lower:
        - Crawlers off-centre therefore maximum accelerations in less seastate
        - Less offset allowed between vessel heading and crawlers
        - Launch and recovery of 2 crawlers more hazardous in higher seastates

4.5 Building confidence of a two crawler system [post workshop evaluation]

The current known technology for a crawler based mining system is a unit with a 700 x 650 Dredge Pump and a 650 mm ID slurry discharge line. Increasing this to a crawler with an 800 x 800 Dredge Pump and an 800 mm ID slurry discharge line represents an increase in size of 50%. To build confidence in a single crawler operation with an 800 x 800 Dredge Pump and 800 mm ID slurry discharge line will require further engineering during the BFS to ensure that there are no fatal flaws, which cannot be foreseen at this stage.

This will include but is not limited to:

- Is there an umbilical available which is able to supply the required power to the crawler.
- Design a flexible hose with 800 mm ID and sufficient buoyancy.
- Specify and select the pump and electric motor. Determine the auxiliary requirements (depth compensator and gland water pump) and the mass of all components.
- Specify and select the slurry train components. Determine the mass of all components.
- Design the crawler boom, suction nozzle and frame.
- Select the tracks required for the crawler.
- Determine the mass of thel crawler with all its components.
- Carry out initial FEA and fatigue analysis on the crawler.
- Is there a wire rope available which can handle 400 tonnes, the initial estimate of the mass, to lift/lower the crawler. With a rope safety factor of 6 this means a MBL of 2 400 tonnes.
- Investigate the exact power requirements of the crawler (pump + jet pump + tracks).
- Initial design and sizing of the launch & recovery system. This will include initial FEA work.

For a two crawler system additional engineering will be required to:

- Investigate the impact of having a two crawler systems outside the centerline of the vessel (more movements) and redefine workability.
- Investigate detection sensors and automation for a two crawler operation.
- Initial design and sizing of the double launch & recovery system. This will include initial FEA work.

Besides this, the operation of the two crawler system will have to be investigated as there are no current operations with 2 crawlers next to each other. The operating limitations will have to be defined, such as:

- Safe operating distance between the two crawlers
- Design of cuts and mine plan
- Prediction of mining face processes and production rate
- Advance rate of the two crawler operation
- Turning with two crawlers at the end of the lane
- Operating flexibility between vessel and crawler at given water depths.

In short it means a lot of work has to be done in the design of the system to increase the level of confidence and we reckon that this will take an additional 6-8 months of engineering. The upside potential of a single crawler 800 ID slurry delivery crawler has been evaluated and further upside on both the single and double crawler options could be pursued during the engineering required for the BFS.

5 Crawler mining operation for TTRL

A crawler mining operation off the coast of New Zealand has some different constraints than the diamond mining operation in Namibia. The main differences are:

	Diamond Mining operation	TTRL operation
Area	Namibia	New Zealand
Material	All materials, clay, shell, gravel, boulders to cemented sands	Free flowing sands
Mineral	Diamond mining	Iron Sands
Water depth	90-200m	35-45m
Mining	Precision cleanup mining	Bulk mining
Production measure	Square M of cleaned seabed	M3 of mined bulk
Required production	Estimated 600m2 per hour	8000 tph dry solids
Concentrate transhipment	Helicopter	FSO offload every 3 days
Buffer requirements	Limited	ROM, Processing plant buffers, Tailings buffers, Concentrate buffers
Processing Plant	Large	Probably larger

5.1 Minimum operating depth crawler, risks and mitigation [post workshop evaluation]

The crawler in itself has no minimum working depth limitations. However, as the crawler is working very close to the Mining Support Vessel (MSV) and possibly partly under the vessel, a safe distance should be taken into account between the draught of the vessel and the crawler. The crawler height of the PIA is around 6 meters. Furthermore, the thrusters for the DP system underneath the MSV will increase the draught of the vessel. Another item is that the distance between the seabed and the keel of the vessel should have a safe distance as well. When considering a significant wave height of 4,5 meter, that means the maximum wave height can be 2.5 to 3 times this height.

During the workshop TTRL was considering a vessel draught of 12-15 meters. Suppose the water depth is 20 meter, than the vessel can hit the seabed only due to the sea-state. Once the real dimensions of the vessel are known, Vuijk can calculate what the minimum safe water depth is for the vessel to operate in and when considering a crawler operation.

Another consideration is the freedom of motion and maneuverability of the crawler with such a reduced length of hoisting wire, hose and umbilical. With the possible motions of the vessel taken into account a significantly reduced workability due to weather and an increase in downtime due to unforeseen damage of these items can be expected.

At this status and considering the dimensions of the vessel used in the workshop, a minimum water depth of 30 meter will be required for safe operation of the crawler.

5.2 Annual mining efficiency

For comparison the annual mining efficiency of several systems is shown in *Table 5-1*. The 700mm crawler system is fairly close to existing technology (650mm for PIA of DeBeers Diamond Mining Crawler) to have a high confidence level in the engineering feasibility of such a system. The 800mm system is a step beyond existing technology and requires further engineering regarding:

- mass of the crawler and tracks

- power and umbilical
- delivery hoses
- including all interfaces and other systems

All figures in this table are based on field experience for the availability and efficiency under similar circumstances as the TTRL operation. However each operation has its own characteristics and all steps in the specific overall logistic mining chain will have their own availability and influence on the separate systems. Therefore these figures are only indicative and can only be used with great care and no guarantee. The overall system availability and productivity needs to be assessed during BFS and finally in the field.

Mining crawler system (Slurry system ø in mm)		**700**	**800**	**800**	**2x 700**	**2x 800**
Annual Efficiency		**Anchor spread single**	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Annual operating days	d/y	365	365	365	365	365
Daily operating hours	h/d	24	24	24	24	24
Port Visits (incl. Dry Docking)	d/y	30	30	30	30	30
Transhipment Constraints	d/y	12	12	12	12	12
Anchor spread handling	d/y	18	18	0	0	0
Maintenance	d/y	26	26	26	26	26
Mining crawler system (Slurry system ø in mm)		**700**	**800**	**800**	**2x 700**	**2x 800**
		Anchor spread single	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Days lost		86	86	68	68	68
Mining system availability	%	76%	76%	81%	81%	81%
Mining efficiency	%	80%	80%	80%	75%	75%
Weather uptime	%	90%	90%	90%	85%	85%
Total operational Availability	**%**	**55,0%**	**55,0%**	**58,6%**	**51,9%**	**51,9%**
Operating time	**h/y**	**4.821**	**4.821**	**5.132**	**4.544**	**4.544**

Table 5-1: Annual mining efficiency

In *Table 5-1* following items are defined as:

- Annual operating days — Year days, 365 in total
- Daily operating hours — Daily hours, 24 in total
- Port Visits (incl. Dry Docking) — Based on dry docking and port calls for emergency or maintenance
- Transhipment Constraints — Time reserved for delays due to issues with FSO transhipment, re-fuelling and all other ship-to-ship transfers
- Anchor spread handling — Time required for repositioning of anchors
- Maintenance — Time required for regular maintenance of the crawler system
- Days lost — Total of days lost
- Mining system availability — Percentage of time the Crawler Mining system is ready and available for pumping
- Mining efficiency — Percentage of time the mining system will do 100% production, inefficiencies due to no full face, turning, hoisting, etc.

-	Weather uptime	Percentage of time the weather allows the crawler system to work
-	Total operational Availability	Percentage of time the crawler mining system is operational available
-	Operating time	Equivalent of full production hours

Remarks:
1. the 700 system is put in for comparison reasons
2. the double systems are only considered on DP operation
3. all systems need to be compared on many more aspects like: CAPEX, OPEX, operational workability, risks, etc.

TTRL Question 23 April 2013
Are we not double counting with Mining system availability and Mining Efficiency?

IHC Response 25 April 2013
2.5: There is a distinct difference between the mining system availability and the efficiency. The availability of the mining system includes the hours the crawler is available for operation and could be pumping sediment (ROM) from the seabed. In the table in this memo these hours have now been calculated and included. Taking into account the weather delays gives a reduction on this availability.

The mining efficiency is the efficiency of the crawler system while available. In theory the crawler system is capable to mine sediment at a 100% production rate all the time. However, in practice the crawler is not producing at a 100% efficiency all the time. Inefficiencies included in this factor are amongst others:
- manoeuvring and positioning of the crawler, turning – advancing – aligning
- seabed/ore conditions, full or half face – face conditions – spill – variations in face
- mine plan and operational philosophy, lane efficiency – grades – sediment variations – tailings philosophy
- operational skill level, spill – slewing – pumping – manoeuvring.

In effect, multiplying the mining efficiency with the available mining system hours will result in the effective number of hours the crawler is operating at full capacity.

5.3 Production capacity considerations

In practice the achievable production is not only calculated availability but also a balance between more factors that come into play. Limiting it to the activities on the seafloor a balance needs to be found between:

1. Production efficiency -> to achieve the highest possible production per hour;
2. Mining efficiency -> to achieve the highest use of the equipment and taking all of the ore out, this means a proper mining plan;
3. Spill (loss of ore) -> reducing mining and production efficiency due to inefficient operation, but also limiting the traction of the crawler;
4. Tailings management -> the best method for return of tailings to the mined out area for both environment and minimize dilution of ore sediments.

To determine this balance is a trade-off that partly can be engineered and designed for but also needs to be determined in day to day practice, operation and ongoing training of operators.

5.4 Pump production

On the mining crawler a hydraulic transport system is installed which consists of a suction mouth with jet water nozzles, a suction pipe, a flexible delivery pipe and a centrifugal pump which transports the dredged sediment from the seabed to the mining support vessel and delivers it to the feed intake of the processing plant onboard.

For determination of the required pump production and pump power, the following starting points were used:

- Particle size distribution as stated in the design basis
- Specific gravity of the grains 3,2 t/m³
- In situ density sediment 2,35 t/m³
- Dry bulking density sediment ± 1,9 t/m³
- Dredging depth 45 m
- Geodetic height 20 m above the sea level for discharging the ROM
- Discharge pipeline configuration 100 m, considered with 10x 90° bends (1.5D)
- No limitations on suction production (30-35% vol. sediment concentration)
- Maximum velocity in pipeline is restricted to 6,5 m/s to prevent excessive wear.

This results in the following output for two types of crawlers:

Description	Unit	700 mm ID HRMD pump	800 mm ID HRMD pump
Average concentration	%	30% by volume	30% by volume
Required Power on pump shaft	kW	2011	2525
Production sediment	dry tonnes/h	5000 tph	6440 tph
Slurry volume	m³/h	8.770 m³/h	11.300 m³/h

For both scenarios 700 mm and 800 mm, a centrifugal dredge pomp type HRMD with 4 bladed impeller is selected. This centrifugal pump will be directly driven by a submerged electric motor with frequency drive to control the flow with varying conditions. Depending on the suction production the concentration can be higher, which results in a lower mixture velocity in the pipeline or a lower concentration, in which the mixture velocity increases. This can be prevented by installing a pump speed limiter.

<u>TTRL Question 23 April 2013</u>
When extracting as a slurry, is using the dry bulk density (1.9 t/m3) to calculate the mass flow rate of solids mined justifiable? Should not the SG be used?

TTRL query the calculation in 5.3.2. For the calculation of the slurry vol.% solids the dry bulk density has been used instead of the SG. Using the SG, the vol % solids for the dry solids equivalent (6,440t/h) in the IHD calculation is only 17.8%. Increasing the solids vol.% back to 30% gives 10,850 t/h solids (57.1 wt% solids; slurry density 1.68 t/m3). Please review these calculations also with respect to the pump capacity.

> <u>IHC Response 25 April 2013</u>
> 2.2: In the IHC standard calculations of pump productions the in-situ volume is used for production. In the dredging industry this is the main acknowledged way of calculating productions. Dry solids

calculations are more common in the mining industry. Dredging equipment is always extracting volumes and not tonnages.

In the pump calculations, the 30% concentration by volume is defined as the mined volume (in situ) is 30% of the mixture flow with an in-situ density of 2,32 t/m3. This corresponds to a dry bulk density of 1,9 t/m3 (= same volume, but taking out the water, but still considering the voids in the material).

The in-situ production of the crawler is calculated at 3390 m3/h. This results in a dry solids production of 6441 tph and the mixture density of the slurry feeding the plant will be 1,401 t/m3.

Appendix A Production Calculation shows the calculations for the 30% scenario.

TTRL Response 30 April 2013
Due to conflicting sources, TTRL continue to query the use of “Dry Bulk Density” against that of the “Specific Gravity” or even the “Wet Bulk Density” when calculating the production limits of the proposed system.

IHC Response (email to Andre Mouton) 1 May 2013
Please find enclosed my adaptions to your calculations (attached pdf: TTRL ROM Density Calcs P4). The reason we have started with the 30% vol of situ material, as it is the standard way of calculating in the dredging industry and this situ value is of great importance when considering the suction production of the crawler and the related advance rate.

Of course within a mining operation only the tonnes solids are of interest, so we have to be convert these figures into solids delivered to the plant and this is around 17,1%, when considering only true solids with a specific gravity of 3,2 t/m3 (This volume only accounts for about 60% of the total situ volume).

TTRL Question 23 April 2013
The limiting settling velocity of the slurry will also be affected. TTRL calculations for a slurry with 30 vol% TTR ROM the limiting settling velocity becomes 6.47m/s.

IHC Response 25 April 2013
2.4: The critical velocity of a solid – liquid mixture is defined as the velocity below which particles are starting to settle out in the pipeline. Above this velocity all particles will stay in suspension within the turbulent flow.

This critical velocity in the pipeline depends on:

- The internal diameter of the pipeline (800 ID)
- The mixture concentration (30%vol in situ)
- The particle size distribution (d50 = 230 micron)
- and the specific gravity of the particles (3.2 t/m3)

For an 800 ID pipeline system the settling velocity of particles with average specific gravity of 3,2 t/m3 is around 4,9 m/s. With 6,5 m/s velocity in the pipeline this is well above the critical velocity.

TTRL Response 30 April 2013
The critical velocity has been calculated using Durand’s equation with the parameter F_L of 1.1 (d50 of 200micron). The TTRL calculation yields 6.46 m/s far in excess of the IHC value of 4.9 m/s.

IHC Response (telecom)
Recommend using Wilson's equation for this parameter. However further review of the properties of iron sands may be required to justify the preference of the equation used.

5.5 Assessment of upside potential of crawler operation [post workshop evaluation]

TTRL has requested IHC to assess the upside potential of the single crawler operation to determine what the maximum annual production capacity can be for this mining system. IHC believes there is a significant upside potential of the crawler mining alternative. Appendix B shows the results of this short assessment done by IHC Mining.

- The total effective production time has an upside potential of 5949 hours or a total operational availability of 67,91%.
- The suction production of the crawler has an upside potential of 6870 tonnes dry solids per effective pump hour.
- Combining these two figures results in an upside potential for the ROM production of ± 40,87 Mt per annum.

It should be noted that part of the upside potential lies in the non-availability of the other parts of the complete mining and transport system, which results in non-availability of the crawler system as well. A significant portion of this upside potential is related to operations and lies with TTRL.

The upside potential of the crawler mining operation is to be confirmed during a BFS stage.

5.6 Suction production

The suction production of the crawler depends on the soil properties, the deposit characteristics, the crawler operation and the design of the suction mouth. The most important parameters to be considered are:

- Free flowing material (This means that the material is not packed and will flow easily to the suction mouth)
- Swing speed (This is the speed of the boom of the crawler swinging from left to right and vice versa, normal practice of crawlers is around 30 m/min)
- Width of cut (This is the width of a total swing of the crawler suction boom, normally 30° to both sides)
- Step size (forward movement of the crawler after each cut or advance rate)
- Sediment bed thickness (This can be considered as the entire bench height of the mining face in front of the crawler.)

The suction production is the product of the width of cut times the bed thickness times the step size. To meet the pump production, this production should be the same or higher than the pump production. In other words enough sediment should be presented at the suction mouth. If more production is presented than this results in spillage. The crawler operation should be adapted in such a way that the suction production and the pump production are balanced by varying swing speed and step size. The use of jet water nozzles on the suction mouth supports the loosening of the soil (create free flowing material) and the slurrification.

When considering a crawler boom length of 12 meter and 60 degrees swing angle, the width of cut is ± 12 meter. Some overlap between the cuts is required to minimize losses and therefore the effective width of cut will be around 10 meter. When considering an average bed height of 5 meter the advance rate of the crawler will be 70 m/h to reach the pump production of 6500 tph. When considering some spillage (15-20%) during suction the advance rate will be even higher. When the thickness of the deposit varies, the advance rate of the crawler should be adapted accordingly.

Best practices on suction production in similar thickness layers and free flowing material with plain suction dredgers justify the above production figures. In case the material is not free flowing the suction production will be less.

5.7 Mooring system for Mining Support Vessel (MSV)

The current crawler operations in Namibia use a four point mooring system with mining blocks of 300x300m. Unlike the TSHD mining system with the single point moored FPSO configuration, which is a static operation, the MSV is actively following the crawler and the MSV is continuously moving. Although at first sight similar to the crawler operation in Namibia, there are some significant differences for the TTRL project:

Location	New Zealand	Namibia
Water depth	30-45 m	90-200m
MSV size	LxB = 250x40 or 300x45	LxB = 175x24
Mining blocks	600x300m	300x300m

Limited by rope diameter (90mm) and length (2500m) (and hence winch size) and experience of operational limitations of these systems it is envisaged that a combined 4 point mooring and DP system is required for the safe operation of the MSV.

IHC Merwede subsidiary Vuyk Engineering performed a preliminary investigation on the feasibility of such a combined system and preliminary results are presented in the report (ref. 30481JBe13059) in Appendix B: Vuijk Report on Mooring and DP

Some important results:

- Minimum mooring wire length for self-handling of the Anchor Spread is 4000m so an anchor handling tug is most probably required
- For Mining operations the required DP power is 3.0+6.4 = 9.4 MW
- Minimum required installed DP power is 35MW

This shows that in all cases a significant DP system is required and running. A trade-off between a 4 point mooring + DP system and a Full DP system on the CAPEX, OPEX, Mining and operational practices is recommended. Operational considerations could be:

- More flexible mine layout → longer lanes or larger mining blocks
- No anchor handling
- Fuel consumption – refueling
- Longer on station with incoming bad weather

On a double crawler mining system it is recommended to use a full DP system. A 2 crawler system with higher productions would imply more anchor handling and less mining efficiency. With a full DP system mining over longer, double lanes is possible, which improves the mining efficiency.

5.8 Description of dedicated crawler mining operation

The crawler is first lowered onto the seabed by the launch and recovery system (LARS), together with the discharge hose and umbilical. Around 2-3 sections of the discharge hose will be floating on the water to allow for flexibility of the crawler.

The most ideal mining operation for the crawler are long cuts. In this way the crawler can continue mining for a long time. At the end of each cut with a single crawler system the crawler will have to turn 180° and mine the adjacent cut the other way, see figure below. The total mining cut of the crawler boom is 12 meter, however the effective cut will be only 10 meter wide, this allows for 1 meter overlap on both sides of the cut to minimize spill (losses). This spill is created because of free flowing sediment flowing outside the reach of the crawler.

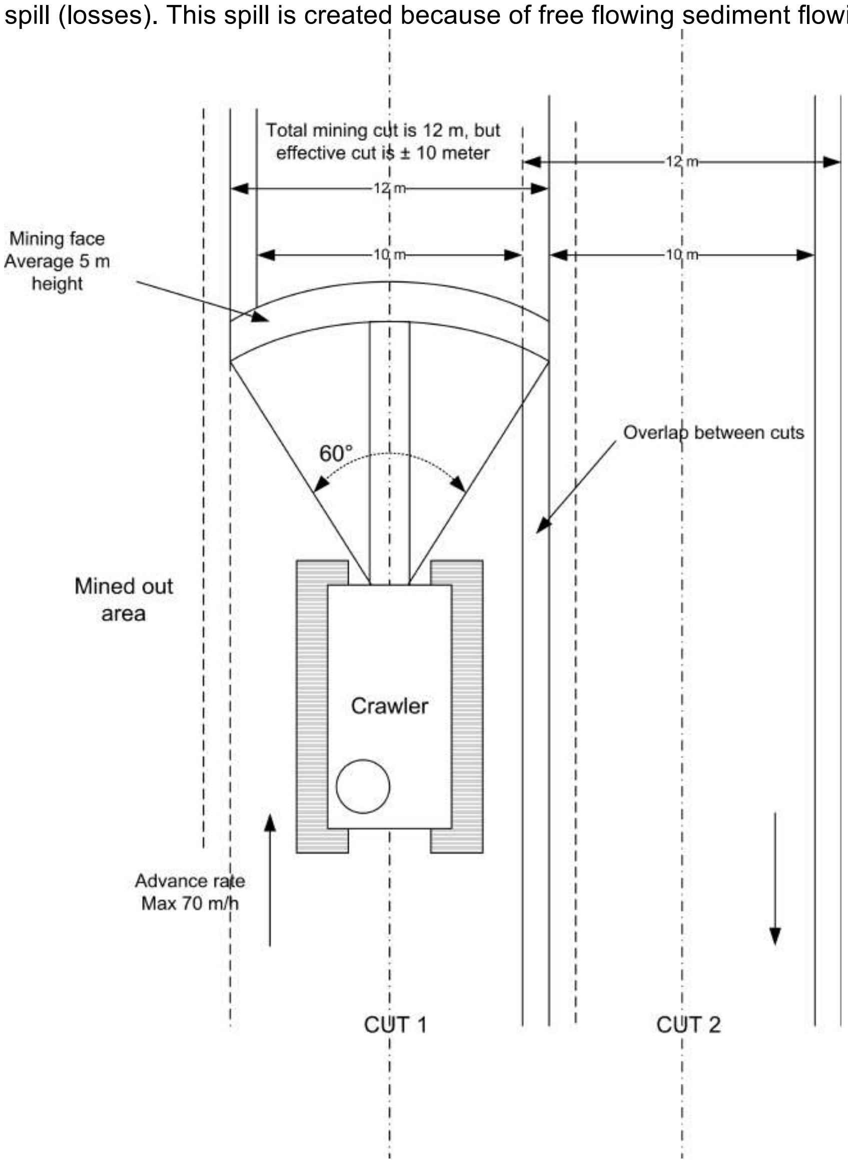


Figure 5-1 Mining lanes

When considering an average bed height of 5 meter and a production rate of 6500 tph, the advance rate of the crawler will be 70 m/h to match with the pump production. In total ±700 m² (70x10m) of seabed is mined per effective pump hour. One swing of the boom of the crawler will take around 25-30 seconds including deceleration and acceleration in the corners of the cut. This means that after each swing the crawler needs to move forward by 0.5 meter.

It should be noted that the flow of the material is the driving force for the suction production. Sediment should be free flowing and the suction mouth should be kept at the foot wall. In case the material is not free flowing, the boom will need multiple swings at various heights to mine the material. This will significantly reduce the suction production and advance rate of the crawler. When the thickness of the deposit varies, the advance rate of the crawler should be adapted accordingly.

The Mining Support Vessel (MSV) will need to follow the crawler with the same advance rate. When considering a four point mooring system the maximum length of the cut will be limited. De Beers was using a 300x300 meter mining block and also the mooring spread had the same dimensions. On average De Beers needed around 10 days to mine out the complete block, before the anchors had to be shifted. For TTRL a 300x300m mining block will be mined out in around 5 days, thus the mining block selected is 600x300 m and accordingly the mooring spread. As the water depth is much less in the TTRL case, this is possible. The cut of the crawler will than be 10x600m.

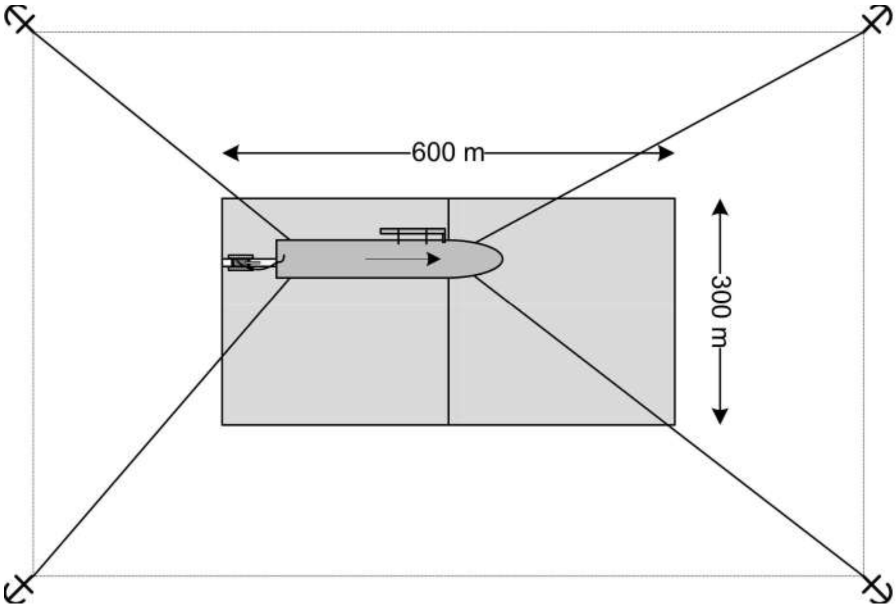


Figure 5-2: Anchor spread

Some considerations on the dedicated crawler mining operation:

- When using full DP system, the mining block could be even larger as there is no restriction by anchors. This results in lower changes of crawler direction.
- The layout of the mining blocks and direction of cuts need to be in such a way that the MSV is positioned with her bow against the dominant swell.
- In the situation where the length of the MSV is 300m, one could consider mining blocks of 300x300m. If the tailings are discharged at the front of the vessel and the vessel is behind the crawler, the tailings will always be discharged in the previously mined out area. However the crawler needs to turn more often, this results in slightly lower efficiency.
- In case of a double crawler operation, two parallel cuts will be made. The crawlers will need to keep up with each other with respect to the advance rate. For safety reasons, some berm should be left between the two cuts, possible the width of a cut. In the return, this berm could be mined by one of the crawlers. However this operation needs more investigation in a next phase.

TTRL Question 23 April 2013
The dry bulk density was also used to calculate the advance rate. For the advance rate should the in situ density not be used? At this time the best estimate for the in situ density is the wet bulk density of 2.35 t/m3. Hence the advance rate also needs to be recalculated in view of the comment above. Also the implications for the size of the mining blocks need consideration.

IHC Response 25 April 2013
2.3: Both the dry bulk density and the in situ density can be used for calculation of the advance rate. This rate is determined by the volume mined. The volume mined for the in situ density is the same as the volume mined for the dry bulk density. The dry bulk density only considers the tonnes dry solids in the volume, whereas the in situ density also takes the weight of the water in the pores into account.

TTRL Response 30 April 2013
Advance rate will be affected by (the decision to use Dry Bulk Density, Wet Bulk Density or Specific Gravity when calculating the production limits).

5.9 Tailings management

One of the most important issues on the mining operation is the handling of the tailings from the processing installation. It is envisaged that roughly 90% of the mined material will end up in the tailings.

Due to strict legislation set by the government, TTRL needs to backfill these tailings in the mined out area in a controlled manner. Therefore a backfilling system for the tailings is required.

For this system two important considerations have to be taken into account:
- The backfilling of the tailings needs to take place as close as possible to the seabed to minimize plume dispersion.
- The tailings will be backfilled in the mined out area, but should not disperse in such a way that they are diluting the virgin iron sands, which the mining crawler still needs to mine.

5.9.1 Tailings backfilling system requirements

In order to fulfill the above mentioned considerations and to handle the offshore conditions, there are several requirements set to the system:
1. The system must be operational in water depths ranging from 30 to 45 m.
2. The solids concentration of the tailings should be as high as possible and the velocity at the end of the pipe should be as low as possible.
3. The system should be capable of compensating for the vessel movements due to the sea state and maintain at a constant depth and distance to the seabed.
4. The end of pipe should be designed for best control at depth.
5. The system should be capable of handling 6000 tph solids.

5.9.2 Trade off backfilling system

Three different systems were evaluated for the backfilling of the tailings.

1 Flexible Hose
The flexible hose is used in normal dredging operations, but is not a viable option if the tailings are to be discharged close to the seabed. The hose will be difficult to control with respect to discharge location and positioning. On top of that the sea state will put a lot stresses in the hose and it will be easily destroyed by the sea state.

Figure 5-3: Flexible hose

2 Fall pipe through the ship

The fall pipe system is used normally for covering a pipeline on the seabed with rocks or sand, to protect the pipeline against other activities at sea, such a fishing with nets. It consists of a vertical large diameter pipeline to which pipe sections can be added or removed depending on the water depth. For accurate positioning of the outflow of the pipe an ROV is used with thrusters, see figure below. Technology may be difficult to handle in 40m water depth as it is a dynamically challenging area, deeper than 100m is no problem.

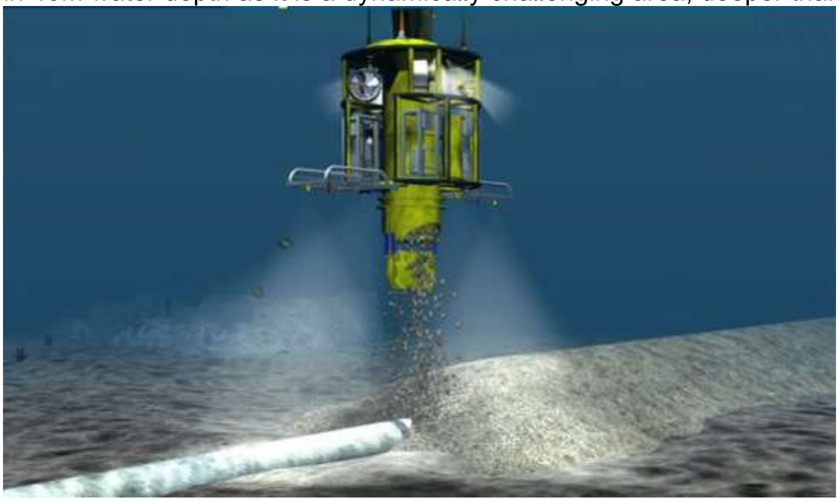


Figure 5-4: Fall pipe ROV

3 Modified suction tube of a TSHD

The normal suction tube of a TSHD can be modified in such a way that backfilling can be executed via the suction tube. This technology is used for covering pipelines with sand in water depth less than 100 m. The system consists of a rigid inclined pipeline with flexible connections and a draghead at the end of the pipe. The suction tube is put overboard along the side of the vessel with gantries. Depending on the water depth the pipe can be lowered or elevated. For accurate disposal of the backfilling material the suction tube is equipped with positioning sensors and an angle measurement system.

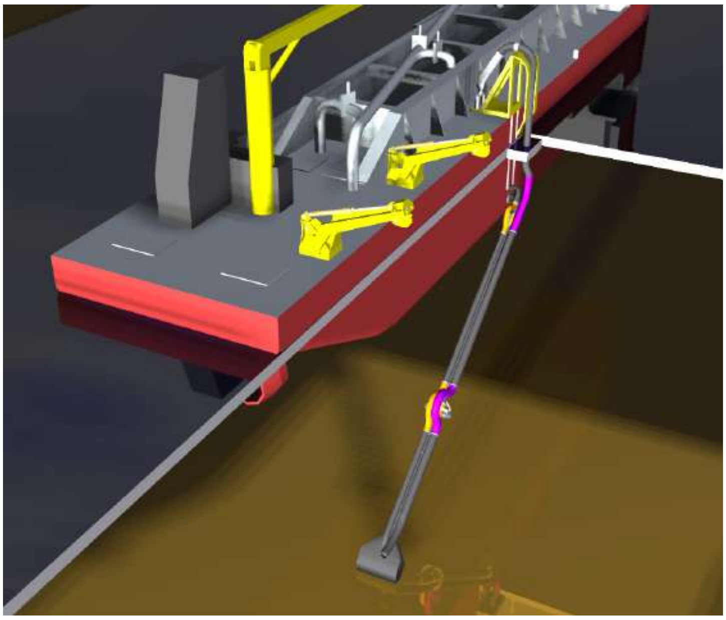


Figure 5-5: Modified suction tube of TSHD

The modified suction tube system is the most suited system for the TTRL backfilling operation of tailings, due to its ability to operate in shallow depths. Furthermore as the system is installed at the side of the vessel the distance between the cut of the crawler, which is in the centerline of the vessel and the outflow of the pipe is larger compared with a fall pipe. This can be seen in the figure below for a vessel width of 45 meter.

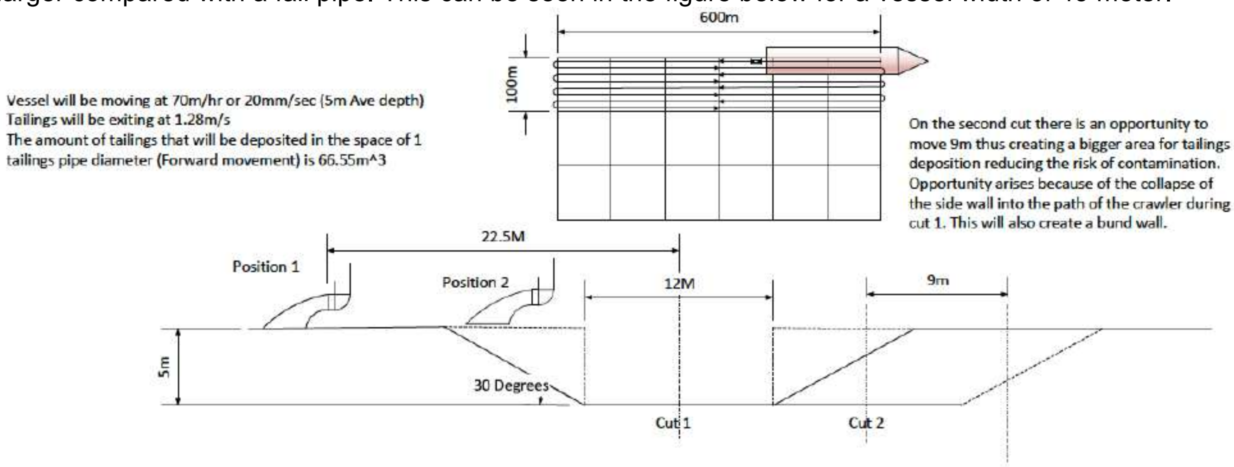


Figure 5-6: TTRL Mine & Tailings Plan

5.9.3 Plume modelling model

The control of the backfilling of the tailings is essential to minimize the dispersion of the material. To gain a better insight in this dispersion of the tailings, a first rapid assessment was carried out during the workshop and a CFD-model was developed and run. Below figure gives an preliminary result of the dispersion of the tailings as a first order estimate, when considering a current of 0,5 m/s (worst case scenario). The total results of this rapid assessment are enclosed in Appendix F: MTI Report: Rapid assessment of TTRL-tailings.

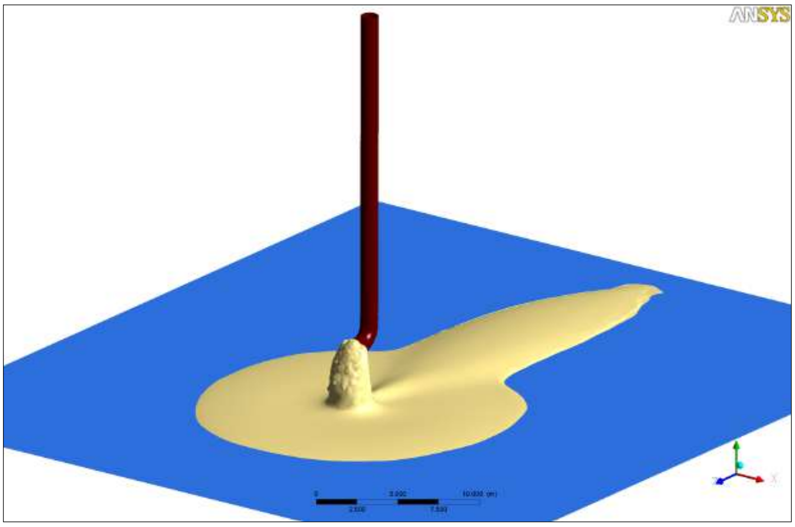


Figure 5-7: Dispersion of tailings

In a next study phase it is recommended to build a more sophisticated dispersion model as this requires more computational time and input parameters.

5.9.4 Adaptation of the tailings plume model [post workshop evaluation]

The rapid assessment of the tailings plume modelling was done to obtain a first insight into the behaviour of the tailings when deposited close to the seabed. This model did not incorporate vessel movement and assumed the Mining Support Vessel to be stationary. The difference between long mining runs and shorter block mining cannot be derived from this model at this stage.

It is possible to develop a more dynamic model for the tailings dispersion. However this would require extensive modelling, which cannot be achieved in the two weeks available. It is advised to do this modelling during the BFS stage.

6 Crawler mining system viability

In this chapter the viability of the Crawler Mining system is checked against other systems and the stationary FPSO concept.

6.1 Static FPSO mining system and proposed crawler mining system

How does the crawler mining system compare to the static FPSO mining system?

Crawler Mining System:

- Mining support vessel including crawler mining system, processing plant, tailings disposal and four point mooring system with DP
- Transhipment using FSO vessels.

Static FPSO system with TSHDs

- Trailing suction hopper dredgers
- Static FPSO with processing plant with single point mooring
- Transhipment using FSO vessels
- Tailings disposal using barges.

Assuming the FSO vessel operation is the same, the crawler mining system offers a significant reduction in the number of vessels in operation by combining mining, processing and tailings management in one single vessel. The logistic chain can be shortened with less transhipments, however this might imply a reduction in capacity.

Because the static FPSO becomes a sailing Mining Support Vessel, it becomes a fully operational maritime vessel including sailing crew and requirements for docking, port accessibility, class etc. This also implies the owner becomes a maritime operator.

6.2 High level system trade off Crawler / TSHD

IHC and TTRL compared different mining systems in order to identify the most probable solution for TTRL's activities. Mining systems were weighted on a system level not on equipment. Mining systems evaluated include: crawler, TSHD, drill, Ro-Ro, and PSD and measured against mining efficiency, depth from 30-45 m, 6500 tph capacity, mining flexibility, logistic complexity, and tailings dispersal parameters (*Table 6-1*).

Parameters	Weight Factor (0-10)	Crawler	TSHD	Drill	Ro-Ro	PSD
Mining Efficiency	7	9 63	8 56	5 35	4 48	6 42
Depth (30-45m)	10	10 100	10 100	0 0	8 80	10 100
Capacity (6500tph)	10	9 90	10 100	4 40	80 80	10 100

Parameters	**Weight Factor (0-10)**	**Crawler**	**TSHD**	**Drill**	**Ro-Ro**	**PSD**
Mining Flexibility (sediment thickness, direction, location, depth soil conditions, etc)	8	9 72	9 72	9 72	7 56	5 40 - not accurate
Logistic Complexity – Integrated vessel multi system	7	9 63 - FSO connection is more complicated in combination with mooring	5 35	9 63	5 35	8 56
Tailings (get it to the bottom with the most control and less disturbance)	10	9 90	5 50 - different than crawler, tailings will not act the same	9 90	5 50	9 90 -limited sediment depth
Total		**470**	**413**	**300**	**329**	**428**
		- puts material back in place Bearing capacity is the only problem out of these parameters	- dredgers don't have processing on board	- Relocation is an issue, very limited not designed for bulk	- more complex than TSHD	- dependent on free flowing material

Table 6-1: Mining System Comparison Matrix

Results from the comparison indicate that the drill, Ro-Ro, and PSD are not a viable option. The drill is discarded as an option because it is not applicable for extracting bulk sediments and working at shallow depths. Its design function is to extract rock in deep waters. The drilling system is also difficult to relocate and is of very limited in use. Ro-Ro system did not produce a strong weight because of its complexity over the TSHD suction tube and its ability to operate under TTRL's conditions. The PSD system was weighted high but the sediment depth is too limited. In addition, PSD system is not accurate and is dependent on free flowing material. As a result of the sensitivity of the TTRL environment and the importance of accurate and efficient production, PSD was removed as an option.

In further discussion the option of a dustpan dredge was considered. This is a wide suction mouth stuck forward directly into the soil and mainly in use on the Mississippi River. A general concern with this system is the limitation in suction width when the sides of the suction mouth are filled with clay and stuck. In those cases only a limited width is left and it will be very hard to move the dustpan forward. First option considered was a direct attachment to the MSV. This was discarded considering the high seastates and the danger of rocking the dustpan to disintegration. Second option considered an attachment to the crawler. This was discarded considering the inflexibility of the system to changing seabed circumstances and the danger of getting stuck.

The TSHD and crawler systems were found to be the best two options for TTRL's mining operations. The TSHD comprises different capabilities than the crawler. Main differences between the two systems include: scalability, tailing dispersal, operation logistics, and mineral processing. The TSHD is easily scalable, where as, the crawler is reaching its limits in individual size. In regards to tailings dispersal, a TSHD system cannot control the tailings dispersion and can generate a large plume. Conversely, crawlers can return the material back to the original location in a controlled way. Operation logistics between the two systems are also different; the TSHD system must have the processing plant located off site, whereas, the crawler vessel can have everything on board.

IHC and TTRL concluded that the crawler provided the best overall mining solution because it has better tailings management, coverage and accuracy. It should be noted that the crawler is not without difficulties. Free flowing material is essential and the bearing capacity of the soil was found to be the main problem considering all the parameters. Therefore, further evaluation and engineering is required to realize the best crawler system configuration.

6.3 Crawler mining systems evaluation

In the preceding chapters several crawler mining systems have been investigated. In the following table these different systems are evaluated:

Yield (Concentrate from Sediment)			*9.8%*			
Target Concentrate tpa			*4,500,000*			
Mining crawler system (Slurry system ø in mm)		**700**	**800**	**800**	**2x 700**	**2x 800**
Annual Efficiency		**Anchor spread single**	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Annual operating days	d/y	365	365	365	365	365
Daily operating hours	h/d	24	24	24	24	24
Port Visits (incl. Dry Docking)	d/y	30	30	30	30	30
Transshipment Constraints	d/y	12	12	12	12	12
Anchor spread handling	d/y	18	18	0	0	0
Maintenance	d/y	26	26	26	26	26
Days lost		**86**	**86**	**68**	**68**	**68**
Mining system availability	%	76%	76%	81%	81%	81%
Mining efficiency	%	80%	80%	80%	75%	75%
Weather uptime	%	90%	90%	90%	85%	85%
Total operational Availability	%	**55.0%**	**55.0%**	**58.6%**	**51.9%**	**51.9%**
Operating time	h/y	**4,821**	**4,821**	**5,132**	**4,544**	**4,544**

Mining crawler system (Slurry system ø in mm)	700	800	800	2x 700	2x 800	
Annual Efficiency		**Anchor spread single**	**Anchor spread single**	**DP single**	**DP double**	**DP double**
Production Crawler (First)	t/hr	5000	6500	6500	5000	6500
Production Crawler (Second)	t/hr				3000	3300
Yearly production of dry solids ROM	t/a	24,105,600	31,337,280	33,359,040	36,352,800	44,532,180
Recoverable concentrate	t/a	2,362,349	3,071,053	3,269,186	3,562,574	4,364,154
Shortfall to Target Concentrate Production	t/a	-2,137,651	-1,428,947	-1,230,814	-937,426	-135,846
Confidence of Success						
Crawler Success		100%	80%	80%	90%	80%
LARS Success		100%	90%	90%	70%	60%
Operating Success		90%	90%	90%	60%	60%

Table 6-2: Crawler mining systems evaluation

In the table the target production is compared to the indicative production levels for the different systems and the level of confidence in the success of these systems. The confidence of success is directly related to the level of new technology, unknowns in deposit/environmental conditions/logistic chain and the unpredictable operational workability of the complete mining system.

Remarks:

- The lower production of the double crawler accounts for the smaller face and spill due to free flow of the middle lane.
- The single systems are on top of output.
- The double systems have a higher level of uncertainty regarding the operation of a dual system. However they offer as well more ability to improve and possibly increase the production levels.

6.4 Risks / opportunities / mitigation

IHC and TTRL evaluated risks, impacts, and mitigation strategies for the crawler mining operations. Components of the mining operations evaluated includes:

System Function	Risks	Impacts	Mitigation
Anchor Mooring	Limited with sea state	-unsecured vessel, loss of crawler, loss of production	DP & Mooring multi-system
Crawler	- Suction Capacity and advance rate to achieve 6500tph -Unexpected downtime for port maintenance - no soil bearing capacity figures to configure tracks	- heterogeneous flow and inefficient processing -loss of production and project value - tracks cannot function, may sink, can't gain traction	- mine operation planning - production simulation inputs to design. - can put a limit on the crawler to control plant -spare crawler at port ready for a switch - CPT analysis inputs

			to design
Crawler Production Hose	- geometry of hose	- failure through too much tension on hose	-load test engineering
Crawler LARS	- umbilical size and stresses - location of crawler launch - mass of crawler vs max. load of a single wire rope	-Power failure - inefficient with operations - crawler cannot be mobilized by LARS - loss of equipment	-Engineering design - keep LARS at aft
Production Rate	-material is not free flowing	- affects advance rate and production	- Take field and lab measurements
Product Transfer at Sea between FPSO and FSO	-FSO connection to unload material creates high risk of collision -FSO slurry transfer fails in heavy seas -56% availability reduced by unexpected down time in transfer operations	-loss of life or damages - production delay -lowers production and project value	- Thorough investigation planning and engineering. - slurry pipe simulation tests - Engineering design and modeling of working conditions and operations
Tailings	-recirculation of tailings -adverse environmental impact from dispersion	- inefficient production and loss of product -breach of environmental license conditions stops production	- mining plan and tailings modeling. -plume simulation and design engineering
Refueling at sea	- fires -lost mining time via connection failures - oil spill	-loss of life and/or property -lowers production and project value - breach of environmental license conditions stops production	-Consider MDO-MGO - Engineering design -oil spill modeling and equipment deployment planning
Local Port Facilities	-unable to use local port for routine or unplanned maintenance	-lowers production and project value -no port available.	- vessel designed access New Plymouth harbour and docks
Dry Dock Port Facilities	-Only remote ports available	-long steaming time and loss of production	- vessel designed to suite local dry docking facilities

Table 6-3: Risks

7 Capex Mining System

The capital cost estimate covers the cost for the mining system as detailed in the desktop study.

7.1 Accuracy of Estimate

The accuracy of the estimate has been compiled in accordance with the requirement of ± 30%. An overall project contingency of 10% for the Mining system and items as mentioned in this list has been allowed for.

Due to the limited time and no allowance for engineering all prices are based on estimates and assumptions from previous projects.

DISCLAIMER: Due to the limited time allowed all CAPEX figures are not based on actual quotes nor on detailed calculations or engineering. CAPEX figures are also prepared without a clear scope of work, demarcation and battery limits with the client. Therefore the CAPEX figures as presented are only indicative and can only be more detailed during the BFS.

7.2 Base Date, Base currency and Exchange Rates

The base date of this capital estimate is April 2013. The estimate does not allow for escalation. The base currency are EUROS €, all figures in this estimate have been converted to US$ Dollars for your convenience at the following exchange rate:

Currency	US $ (USD)
1 Euro €	1.30

7.3 CAPEX breakdown on Single crawler system

Project Activity / Item Designation	Main item	Final costs EUROS	Final costs DOLLARS
SMT Engineering services, Project Management and Travel	Project Management & Engineering	€ 4,450,000.00	$ 5,785,000.00
LARS Engineering services, Project Management and Travel			
Installation support and commissioning (not the actual installation)			
Seafloor Mining Tool (SMT)	Seafloor Mining Tool 2x	€ 21,000,000.00	$ 27,300,000.00
Spare Seafloor Mining Tool (SMT)			
LARS System	LARS, VTS + control systems	€ 28,250,000.00	$ 36,725,000.00
Lift Winch			
Lift Rope			
Heave compensator			
A-frame			
Sliding door			
Vertical Transport System			
Hoses			
Plant connection			
Hose tensioners			
Umbilical and Umbilical Management System			
Umbilical			
Umbilical Winch			
Guiding Sheaves and systems			
Electrical System			
Hydraulic System			
Control System			
SMT			
LARS			
Mooring system	4 point Mooring System	€ 10,000,000.00	$ 13,000,000.00
Mooring winches			
Mooring cables			
Mooring anchors			
Tailings system	Tailings system 2x	€ 4,000,000.00	$ 5,200,000.00
Pipe			
Gantries			
Heave compensation			
Spare package	Spare parts package	€ 5,000,000.00	$ 6,500,000.00
Mooring cables			
Lift Wire			
Umbilical			
VTS Hoses			
Slurry train wear parts (pump, piping)			
Hydraulic and electrical			
Miscellaneous – Shipping, duties etc.	Miscellaneous – Shipping, duties etc.	€ 1,900,000.00	$ 2,470,000.00
	Total	**€ 74,600,000.00**	**€ 96,980,000.00**
10%	Contingency	€ 7,460,000.00	€ 9,698,000.00
	Grand Total (± 30%)	**€ 82,060,000.00**	**$ 106,678,000.00**

TTRL Question 23 April 2013
Does the CAPEX numbers include an allowance for a limited DP capability in addition to the winch system?

IHC Response 25 April 2013
2.6: In none of the CAPEX figures is the DP system is taken into account. This is because for any of the systems a full DP system is required and is considered as an integral part of the mining vessel. Only if the 4 point mooring system is deployed the DP system can work in a reduced mode. Also in the OPEX figures the DP system is not taken into account.

TTRL Response 30 April 2013
TTRL confirm that within the base case, the FPSO will make use of a 4 point winch mooring "assisted" by DP system and specialised anchor handling tug/vessel. TTRL will include this within the vessel supply scope.

7.4 CAPEX breakdown on Double crawler system

Project Activity / Item Designation	Main item	Final costs EUROS	Final costs DOLLARS
SMT Engineering services, Project Management and Travel	Project Management & Engineering	€ 7,175,000.00	$ 9,327,500.00
LARS Engineering services, Project Management and Travel			
Installation support and commissioning (not the actual installation)			
Seafloor Mining Tool 1 (SMT)	Seafloor Mining Tool 2x	€ 42,000,000.00	$ 54,600,000.00
Spare Seafloor Mining Tool (SMT)			
LARS System	LARS, VTS + control systems	€ 56,276,768.00	$ 73,159,798.40
Lift Winch			
Lift Rope			
Heave compensator			
A-frame			
Sliding door			
Vertical Transport System			
Hoses			
Plant connection			
Hose tensioners			
Umbilical and Umbilical Management System			
Umbilical			
Umbilical Winch			
Guiding Sheaves and systems			
Electrical System			
Hydraulic System			
Control System			
SMT			
LARS			
Mooring system	4 point Mooring System	€ -	$ -
Mooring winches			
Mooring cables			
Mooring anchors			
Tailings system	Tailings system	€ 4,000,000.00	$ 5,200,000.00
Pipe			
Gantries			
Heave compensation			
Spare package	Spare parts package	€ 7,000,000.00	$ 9,100,000.00
Lift Wire			
Umbilical			
VTS Hoses			
Slurry train wear parts (pump, piping)			
Hydraulic and electrical			
Miscellaneous – Shipping, duties etc.	Miscellaneous – Shipping, duties etc.	€ 2,850,000.00	$ 3,705,000.00
	Total	**€ 119,301,768.00**	**€ 155,092,298.40**
10%	Contingency	€ 11,930,176.80	€ 15,509,229.84
	Grand Total (± 30%)	**€ 131,231,944.80**	**$ 170,601,528.24**

TTRL Question 23 April 2013

Should the CAPEX cost of crawlers be less? We only need a 3rd crawler not 4.

IHC Response 25 April 2013

2.6: For a two crawler system 2 spare crawlers are taken into account. When an exchange system is adopted two are required. Take into account as well that no critical spares for the crawlers are taken into account as the spare crawlers are considered spares. If the second spare crawler is taken out, a similar amount of spare parts will need to be put in.

8 OPEX mining system

This section describes the input for the OPEX calculations and results for mining system only.

Since the OPEX of the crawler mining system is part of the complete Mining Platform only those components of the OPEX are presented that need to be added to TTRL's financial model for OPEX of the complete system:

- Power Consumption of Mining system;
- Extra personnel for operation of Mining System only;
- Critical spares for the Mining system

8.1 Accuracy of Estimate

The OPEX estimate has been compiled based on high level estimates and accuracy cannot be guaranteed. Some aspects of the OPEX are depending on the operational philosophy of the entire operation and can be best determined by TTRL.

DISCLAIMER: Due to the limited time allowed all OPEX figures are not based on actual quotes nor on detailed calculations or engineering. OPEX figures are also prepared without a clear scope of work, demarcation and battery limits with the client. Therefore the OPEX figures as presented are only indicative and can only be more detailed during the BFS.

8.2 OPEX for single crawler system

Following items need to be included in the TTRL Financial model:

8.2.1 Power Consumption

Only the power requirements for continuous operation of the crawler and its slurry pump are taken into account. This does NOT include peak power requirements!!

System	Type	Installed power MW
Crawler Power requirement	Continuous	5MW
4 point Mooring System Power requirement	Continuous	0.5MW
DP during Mining (high level estimate)	Continuous	5MW (Peak 10MW)

Table 8-1 Power consumption for single crawler system

8.2.2 Mining System Personnel

The following table represents personnel breakdown.

Personnel	Qty per 12 hr shift	Shifts per 24 hr period	Total crew per operational rotation	Total compliment
Operating Staff				
Mining System Superintendent	1	1	1	2
Mining System Supervisor	1	1	1	2
SMT Pilot	1	2	2	4
SMT Co-Pilot	1	2	2	4
Sub Total			**6**	**12**
Maintenance Staff				
A&I Technician	1	2	2	4
Electrical Technician	1	2	2	4
Hydraulic Technician/Fitter	1	2	2	4
Mechanical Fitter	1	2	2	4
Boilermaker/Artisan	1	2	2	4
Sub Total			**10**	**20**
Total			**16**	**32**

Table 8-2: Personnel for single crawler system

Excluded from this list but assumed to be included in the Mining Platform personnel are (but not limited to):

- Mine manager
- Geologists
- Mine Planners
- Surveyors
- Complete Marine crew
- Processing plant operating and maintenance crew

8.2.3 Critical spares

In the CAPEX a certain figure is allowed for critical spares. Maintenance and repair is dependent on the operational philosophy and the production requirements. System redundancy, preventive maintenance and stock of critical spares determine the overall uptime of the system and the sensitivity of the complete mining operation to incidents and showstoppers. Occurrence and impact of these risks needs to be taken into account.

The following items are expected to be replaced regularly:

- VTS riser hoses is expected to be replaced regularly, it is estimated the interval be every 6 months;
- Umbilical cable is expected to be replaced regularly, it is estimated the interval be every 12 months.
- Mooring Wires is expected to be replaced regularly, it is estimated the interval to be every 12 months;
- Life expectancy of a crawler system is expected to be 6 years, depending on the wear and tear and fatigue related weakening of the structure.
- Slurry systems wear and tear is hugely dependent on the type of soil and operational parameters. A BFS should determine the life expectancy of the slurry lines and the requirements for special wear resistant materials.

Yearly operational expenditure on critical spares is estimated at: **€ 5.000.000 or 6.500.000 USD** consisting of:

- VTS hoses
- Umbilical cable
- Mooring wires
- Main slurry wearing parts

8.2.4 Maintenance, Repairs, Spares and Consumables

Additionally all other maintenance, repairs, spares and consumables can be shared with the are determined as the average percentage of the CAPEX used for high density technology items.

8.3 OPEX for double crawler system

Following items need to be included in the TTRL Financial model:

8.3.1 Power Consumption

Only the power requirements for continuous operation of the crawler and its slurry pump are taken into account. This does NOT include peak power requirements!!

System	Type	Installed power MW
Crawler Power requirement	Continuous	8MW
DP during Mining (high level estimate, NOT BASED ON ANY CALCULATION)	Continuous	12MW

Table 8-3: Power consumption for double crawler system

8.3.2 Mining System Personnel

The following table represents personnel breakdown.

Personnel	Qty per 12 hr shift	Shifts per 24 hr period	Total crew per operational rotation	Total compliment
Operating Staff				
Mining System Superintendent	1	1	1	2
Mining System Supervisor	1	1	1	2
SMT Pilot	2	2	4	8
SMT Co-Pilot	2	2	4	8
Sub Total			**10**	**20**
Maintenance Staff				
A&I Technician	2	2	4	8
Electrical Technician	2	2	4	8
Hydraulic Technician/Fitter	2	2	4	8
Mechanical Fitter	2	2	4	8
Boilermaker/Artisan	2	2	4	8
Sub Total			**20**	**40**
Total			**30**	**60**

Table 8-4: Personnel for double crawler system

Excluded from this list but assumed to be included in the Mining Platform personnel are (but not limited to):

- Mine manager
- Geologists
- Mine Planners
- Surveyors
- Complete Marine crew
- Processing plant operating and maintenance crew

8.3.3 Critical spares

In the CAPEX a certain figure is allowed for critical spares. Maintenance and repair is dependent on the operational philosophy and the production requirements. System redundancy, preventive maintenance and stock of critical spares determine the overall uptime of the system and the sensitivity of the complete mining operation to incidents and showstoppers. Occurrence and impact of these risks needs to be taken into account.

The following items are expected to be replaced regularly:

- VTS riser hoses is expected to be replaced regularly, it is estimated the interval be every 6 months;
- Umbilical cable is expected to be replaced regularly, it is estimated the interval be every 12 months.
- Mooring Wires is expected to be replaced regularly, it is estimated the interval to be every 12 months;
- Life expectancy of a crawler system is expected to be 6 years, depending on the wear and tear and fatigue related weakening of the structure.
- Slurry systems wear and tear is hugely dependent on the type of soil and operational parameters. A BFS should determine the life expectancy of the slurry lines and the requirements for special wear resistant materials.

Yearly operational expenditure on critical spares is estimated at: **€ 5.000.000 or 6.500.000 USD** consisting of (all for 2 crawlers):

- VTS hoses
- Umbilical cable
- Main slurry wearing parts

8.3.4 Maintenance, Repairs, Spares and Consumables

Additionally all other maintenance, repairs, spares and consumables can be shared with the are determined as the average percentage of the CAPEX used for high density technology items.

8.4 Excluded Items

Following components are excluded as they are assumed to be calculated by the Client as part of their overall OPEX estimates:

- Overall mining platform Fuel consumption and Cost;
- All other Personnel required; Indirect support staff and costs (catering / housekeeping etc);
- Depreciation and Interest for the complete Mining Platform including the Mining System;
- Insurance for the complete Mining Platform including the Mining System
- Concession sampling and evaluation;
- Geological testing;
- Environmental impact studies;
- Personnel transportation and logistics (helicopter/boat) for crew change;
- Training;
- Insurance;

- Licensing;
- All overhead (shore based staff, hire of offices, electricity, communications, computers, copiers, emergency evacuation costs, technical department, lubricants, water, laying up and idle time, mobilization and demobilization, modifications, cost of flights, food, hotel and work permit if any required);
- Land based workshop for vessels (containers, water truck, compressor, generator, light set, fuel, chief workshop, workers, consumables etc);
- Land based warehouse for Spare Crawler system and all other spares and consumables; and
- No survey vessel / crew change (helicopter or boat) / emergency vessel.

9 Workshop conclusions

- The crawler mining system is a viable technical option for mining the iron sands tenements of TTRL. It can be deployed in a single or a double configuration.
- The single crawler configuration is a well known mining operation, however on its technological limits at 800mm ID.
- The double crawler configuration is not known in operation, however it has many opportunities for improvement on operational production performance.
- The expectation is that with additional detailed engineering the level of confidence in technology and operations will be significantly improved.
- Crucial for the production performance is the assumption that the Iron Sands are free flowing material once fluidised. It is recommended to undertake laboratory testing, site soil investigation and bulk sampling activities.
- The crawler mining system was evaluated during the workshop independent of the complete mining system integration; by combining mining, processing, offloading and tailings disposal on one vessel it is recommended to perform a Total Mining System Assessment to optimize system integration and interfacing.

9.1 Post Workshop Evaluation Conclusions

The main conclusions that can be drawn from the upside potential assessment:

- The minimum required water depth for the crawler operation is 30 meter. This is more dependent on the Mining Support Vessel draught and the sea states than on the crawler itself
- There is an upside potential to 40,87 Mt per annum for a single crawler with an 800 ID delivery line. However this figure is to be confirmed during a BFS stage.
- To bring the double crawler mining operation to an acceptable level of confidence requires about 6-8 months of engineering to ensure that there are no fatal flaws.

Appendix A: Pre-Workshop Terms of Reference TTRL

TERMS OF REFERENCE
TTRL/IHC Viability Workshop 2 – 12 April

Trans Tasman Resources have requested IHC to assist in the evaluation of a specific mining solution.

TTRL require that the Viability analysis be largely a quantitative exercise. A solid data base using established and verified data and solutions is to be utilised.

The aim of workshop is to determine whether the proposed alternative is technically viable and, if it is, whether it is the best alternative. The ideal scenario for the TTRL project is an alternative that fulfils all the objectives with the smallest possible risk and challenges. ***It must be stressed that even though an alternative best accomplishes the objectives but still carries severe risks and challenges it will not regarded as the best choice.***

The priority of the workshop will be to first perform a viability analysis on the "Crawler Mining" option against a fixed list of imperatives (Must haves!), then to compare it against any other identified alternatives including the current PFS alternative.

1 Imperatives (MUST HAVES)

1.1 Total Capex intensity for the whole project including FSO (50kt-80kt) type vessel and transhipment vessel (Capesize 180kt) must be ≤ USD$100 per tonne of annualised concentrate capacity

1.2 Opex costs per tonne of concentrate loaded into export vessel (FOB) have to be less or comparable to the current PFS solution.

1.3 Integrated Tailings Management. The continuous deposition of tailings on the seabed behind the progressing mining unit is to be an essential component of any successful alternative. This will require mining down to full depth of mineralisation (basement level) in each mining location prior to moving forward to the next anchor location. This is important to ensure a void is created to allow continuous discharge of tailings behind the mining operation.

1.4 Production of ≥ 5mtpa Concentrate. This will require the extraction of 8000tph of ROM material. (50mtpa ROM)

1.5 High Mining Utilisation of at least 80%. Able to work in conditions 3-4m Hs

1.6 High Certainty with regards to both CAPEX and OPEX estimates (90%). This can only be accomplished with the reference to actual historical data.

2 Wants

No	Description	Priority	Weighting
2.1	Minimum environmental effects, i.e. plumes		
2.2	Reduced operational risks		
2.3	Reduced Marine operations Less vessels, reduced interdependencies		
2.4	Reduced Power Requirements		

3 Deliverables

3.1 A viability report for the "crawler mining option" detailing the process of analysis, identified risks and mitigations and the estimated associated CAPEX and OPEX.

3.2 Sufficient verified information to facilitate a detailed comparative analysis between the Crawler Option and the Trailer Hopper Suction Dredge.

Questions to be addressed:

- What is a realistic production rate for a single dredge/FPSO and is the dredge scaleable and or able to be duplicated?
- What is the best solution for continuous discharge of tailings without contaminating future mining areas?
- What is the best solution for transferring concentrate to an FSO?
- What is our fresh water solution?

General Comments:

- Size of the FPSO and FSO will be critical drivers to capex
- Build an operating cost model and NPV model to allow a transparent comparison to the Technip process. Must be able to be integrated into a "combined" PFS!
- Why do we really need 170 kt FSO's? based on 5mtpa concentrate production we would be producing c.15000 tpd con. , I think we are better off with a smaller FSO vessel (panamax size?) shuttling concentrate and water on a 3 -4 day cycle? back to a permanently moored large floating dock/barge in a safe anchorage location. Concentrate is then transferred to this dock which then re-handles to export vessels as they arrive. Vale have built one of these systems recently off the coast of Malaysia.

Appendix B: Vuijk Report on Mooring and DP

Naval architects, Marine Engineers, Consultants

CALCULATION NOTE

To: IHC Mining
Origin: JBe
Chkd: DBr, MNo
Distr:
Date: 10-Apr-2013
Project: TTR Mining **Ref.no.:** 30481JBe13059
Subject: Mooring estimation

Introduction

IHC Mining requested Vuyk Engineering Rotterdam B.V. to perform a preliminairy DP and mooring analysis for two possible vessel designs that could be used for the TTRL mining project at the coast of New Zealand. All calculations are based on limited information and are performed in a very short time window, for this reason it is advised to use the results for information only. For the design of the final mooring spread, more detailed calculations are required.

Input and Assumptions

Vessel properties

The following properties for the two possible vessel designs are used. This data is partly based on representative reference vessels.

	250 m vessel	300 m vessel
Length [m]	250.0	300.0
Breadth [m]	40.0	45.0
Max Draught [m]	12.0	16.0
Wind area front [m^2]	1400.0	1575.0
Wind area side [m^2]	6250.0	7500.0

Used coefficients

Wind	1.00	[-]
Current front	0.30	[-]
Current side	0.90	[-]
Wave side	0.044	[-]
Wave front	0.063	[-]

Typical transmission ratio azimuthing thruster: 0.16 kN/kW

Mooring layout

The mooring system consist of a 4 point mooring with an equal spread. The vessel should be able to operate in a mining grid of 600 m * 300 m with a water depth of 50 meters.

The used mooring wire has the following properties:

Diameter [mm]	88.9
Weight [kg/m]	33.8
MBL [kN]	5520
EA [MN]	378

A safety factor of 2.0 on the MBL is used in the calculations. This is according GL-ND.

Environmental condition
In the calculations the following environmental condition is considered:

Wind speed [m/s]	15.0
Sig. wave height [m]	4.5
Current speed [m/s]	0.5

Based on a reference vessel, the maximum expected 1st order wave motion offset is 4.5 m for an environmental direction of 30 deg.

The speed of the crawler is estimated to be 0.5 m/s. This speed needs to be added to the wind and current speed to calculate the environmental load when operational at the by the client specified environmental condition.

Results

Environmental loads for station keeping
Based on the calculations, the total environmental loads are given in the table below. This includes the wind, current, and second order mean wave drift load:

	250 m vessel		300 m vessel	
Env. dir. [deg]	Fx [kN]	Fy [kN]	Fx [kN]	Fy [kN]
Front, 0	627.8	0.0	706.2	0.0
Side, 90	0.0	4581.5	0.0	5497.7
30	502.1	1592.6	564.8	1911.1

Minimum required thruster capacity for full DP
Based on the environmental loads the estimated minimum required total DP capacity of the thrusters is presented. This calculation does not take into account any DP-class requirements.

	250 m vessel	300 m vessel
Env. dir. [deg]	Power [MW]	Power [MW]
Front, 0	3.92	4.41
Side, 90	28.63	34.36
30	10.44	12.45

The actual overall installed power for the thrusters will be higher, this to cover different failure modes, different environmental conditions etc.

Minimum required mooring line lengths
Based on the operational grid, vessel dimensions and the environmental loads, the mooring layout is determined. The mooring lines are at an angle of 45 deg relative to the vessel coordinate system, with an offset of 1500 m from the corners of an ‘box shaped area’ of 300 m + vessel breadth * 600 m + vessel length. This to be able to cover the operational grid of 600 m * 300 m. The diagonal of this ‘boxed area’ is close to 1000 m. This results into a minimum effective line length on the winch of 2500 m. If the vessel deploys and retrieves the anchors by itself, a length of 1500 m + 1000 m + 1500 m = 4000 m is required.

When moving the centre of the vessel to the corners of the ‘boxed area’, the angles in the spread change. For this position the environmental loads are introduced on the vessel at an angle of 30 deg of the bow, and 30 deg of the stern. In this position on the grid one of the lines will almost have the same direction as the environmental load, therefore it will take a large contribution in counteracting the environmental load.

Quasi static load calculation

The calculated environmental loads are for a mean static condition. Due to first order wave motions it is assumed that there will be an inline dynamic offset of 4.5 m (amplitude) in the mooring line This causes an increase in the line loads. (Quasi static approach). This effect should not exceed the maximum allowable tension in the mooring line.

For the determination of the maximum catenary shape the maximum allowed load in the mooring line is used: MBL / Safety factor, 2760 kN. The line length in is 1500 m un-stretched in a water depth of 50 m. Applying a load of 2760 kN results in a total line length of about 1510 m. During maximum loading the horizontal distance will be about 1509 m between the anchor and winch.

To determine the maximum allowable static load on the catenary, the horizontal offset is subtracted from the 1509 m (without changing the mooring line length), resulting in a horizontal distance between the anchor and winch of approx. 1504.5 m and a reduced line load of 1750 kN. This tension of 1750 kN is the maximum allowable static load on the highest loaded line, without the 1st order wave motions.

Additional required DP power for mooring assist

The maximum allowable static tension of 1750 kN is lower than the tension due to the calculated environmental loads, and therefore additional DP power is required to reduce the tension in the mooring line. In the table below the required DP thrust is calculated:

	250 m vessel	300 m vessel
	Tension [kN]	Tension [kN]
Max static line load due to environmental loads	1890.1	2239.5
Max allowable static line load	1750.0	1750.0
Required additional DP thrust	140.1	489.5

Based on the additional required DP thrust the required DP power to counteract the 1st order wave motions is given:

	250 m vessel	300 m vessel
	Power [MW]	Power [MW]
Required DP power	0.88	3.06

Anchor capacity

The maximum load on the mooring line will be 2760 kN, therefore the anchors should have an identical or higher holding capacity. When assuming the usage of the Flipper Delta anchor type, an anchor with a weight of 15 ton or larger is required for sandy soils. For clay a minimum weight of 20 ton is required.

Additional required DP power for crawling
When crawling, it is assumed the vessel will move with a speed of about 0.5 m/s. The extra load due to this speed is calculated by adding 0.5 m/s to the wind and current speed.

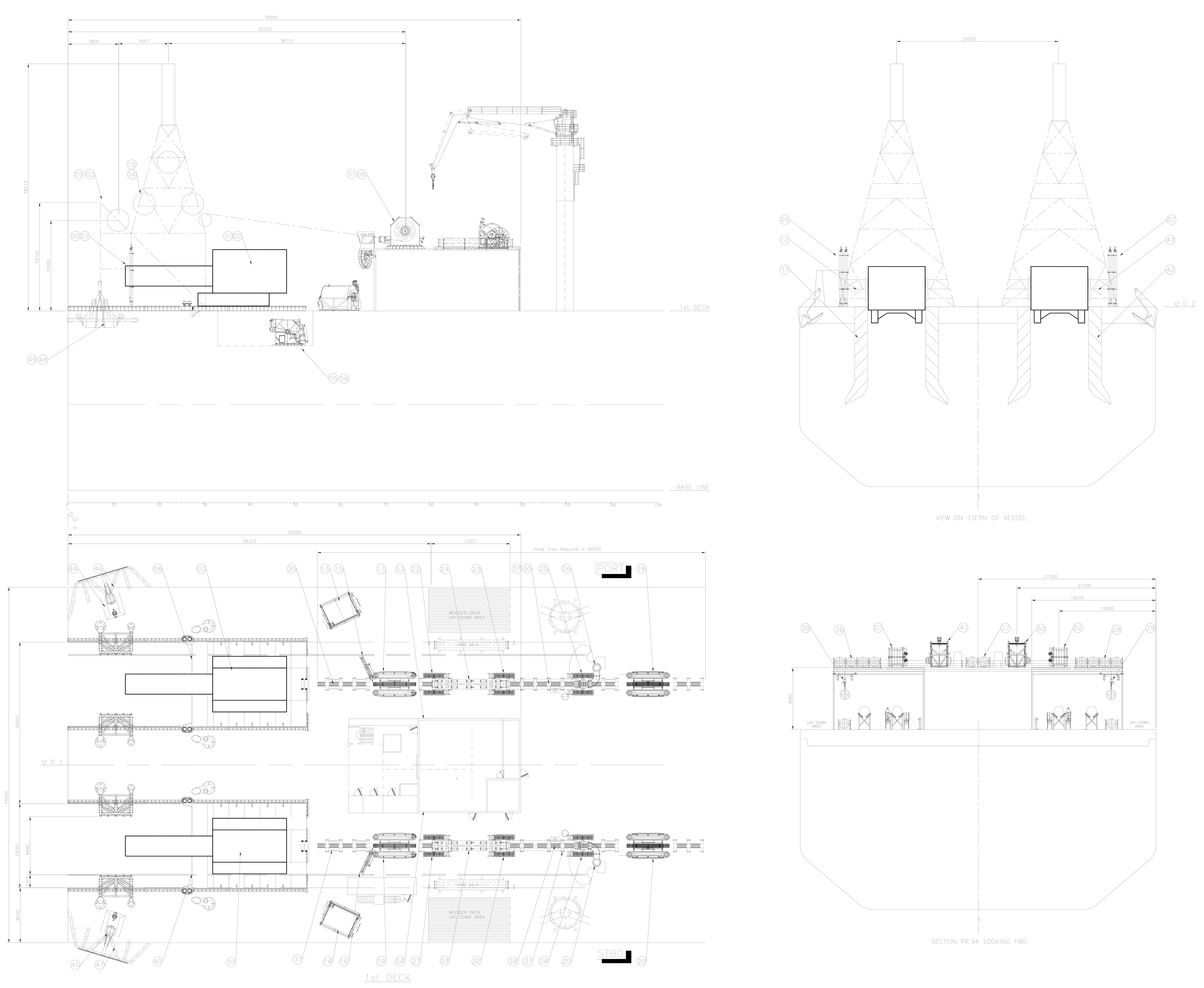
This speed cannot be guaranteed by the winches, because the maximum allowable load on the wire is already reached. Therefore the DP system is required to move the vessel. The results of this calculation is given in the table below:

	250 m vessel	300 m vessel
DP Thrust [kN]	851.8	1024.1
DP Power [MW]	5.32	6.40

Remarks

- When the operational grid is reduced in size, the angles of the mooring spread will become closer to 45 degrees, this will result in lower line loads. This also means when the vessel is operating more to the centre of the field, the loads on the mooring lines will reduce.
- Due to the relative shallow water depth, the effect of the catenary of the mooring line is limited. This results in a relatively stiff mooring system, causing high loads due to dynamic offsets (1^{st} order wave motions).
- In the calculations line lengths of 500 - 1000 m or more are in contact with the seabed. Due to the manoeuvring over the grid, the lines will be dragged transversely over the seabed. This will result in bellies in the mooring wire, which could at once release during manoeuvring, causing unexpected offsets of the vessel.

Appendix C: Mining System – Aft Vessel Drawing



DO NOT SCALE - IF IN DOUBT, ASK

REFERENCE DOCUMENTS

DOCUMENT NUMBER	TITLE

REVISION TABLE

REV	BY	DATE	DESCRIPTION

GENERAL TOLERANCES

MACHINING	FABRICATION
0 to 100 ± 0,2	0 to 500 ± 2
100 to 500 ± 0,4	500 to 2500 ± 3
500 to 1000 ± 0,6	2500 to 5000 ± 4
Above 1000 ± 1,0	Above 5000 ± 5

GENERAL NOTES
UNLESS OTHERWISE NOTED

1. MASSES IN TONNES
2. DIMENSIONS IN METRES
3. X IS TAKEN LONGITUDINALLY FROM VESSEL STERN
4. Y IS TAKEN TRANSVERSE FROM VESSEL CENTERLINE. (P-PORT, S-STB'D)
5. Z IS TAKEN VERTICALLY FROM 1ST DECK
6. ESTIMATED MASSES AND COG's: ±30% ACCURACY

ITEM	DESCRIPTION	MASS	X	Y	Z
57	NITROGEN STORAGE BOTTLES (STB'D)	60	10.6	S6.7	5.3
56	MOORING WINCH AFT (ø80 X 2000M) (PORT)	125	34	P4.5	−3
55	MOORING WINCH AFT (ø80 X 2000M) (STB'D)	125	34	S4.5	−3
54	DECKHOUSE EQUIPMENT STBD (EXCLUDING STRUCTURAL STEELWORK)	50	56.7	S3.6	6.0
53	DECKHOUSE EQUIPMENT PORT (EXCLUDING STRUCTURAL STEELWORK)	50	56.7	P3.6	6.0
52	SPARE ROPE + STORAGE WINCH (ø141 x 300m) (STB'D)	55	66.6	S12.5	11.4
51	MAIN HOIST WINCH + ROPE (ø141 x 300) (STB'D)	220	52.2	S12.5	12.1
50	SPARE UMBILICAL STORAGE WINCH (STB'D)	20	65.5	P5.9	11.8
49	ANCHOR (AFT STB'D)	15	6.0	S26.4	2.3
48	ANCHOR (AFT PORT)	15	6.0	P26.4	2.3
47	ANCHOR RACK (AFT STB'D)	4	6.7	S27.0	−0.5
46	ANCHOR RACK (AFT PORT)	4	6.7	P27.0	−0.5
45	FAIRLEADER + SUPPORT STRUCTURE + BEND SHEAVES (STB'D)	45	7.7	S13.2	4.0
44	FAIRLEADER + SUPPORT STRUCTURE + BEND SHEAVES (PORT)	45	7.7	P13.2	4.0
43	CRAWLER RESTRAINING SYSTEM (UPPER) (STB'D)	15	7.5	S12.5	2.8
42	CRAWLER RESTRAINING SYSTEM (LOWER) (STB'D)	30	7.5	S12.5	−4.2
41	SPARE UMBILICAL STORAGE WINCH (PORT)	20	65.5	S5.9	11.8
40	LONGITUDINAL SLIDING DOOR (STB'D)	90	27.7	S12.5	0.3
39	SPARE HOSE HANDLING GANTRY & GANTRY CRANE (PORT)	28	63.0	P20.5	6.8
38	HOSE ON RISER TRAIN (STB'D)	24	74.3	S12.5	2.3
37	HOSE ON RISER TRAIN (PORT)	24	74.3	P12.5	2.3
36	SPARE HOSES + STORAGE RACKS (PORT)	24	63.0	S18.6	10.5
35	HOSE CLAMPING SWIVEL (STB'D)	10	81.4	S12.5	1.9
34	HOSE CLAMPING PLATFORM (STB'D)	1.5	79.6	S12.5	1.0
33	RISER HOSE ROTATION SYSTEM (STB'D)	10	62.0	S12.5	1.6
32	BOLTING STATION PLATFORM NO.2 (STB'D)	1.5	67.4	S12.5	1.0
31	RISER TRAIN (STB'D)	12	43.2	S12.5	1.3
30	RISER TRAIN (PORT)	12	43.2	P12.5	1.3
29	SPARE HOSE HANDLING GANTRY & GANTRY CRANE (STB'D)	28	63.0	S20.5	6.8
28	SPARE HOSES + STORAGE RACKS (STB'D)	24	63.0	P18.6	10.5
27	SPARE HOSES + STORAGE RACKS (CENTRE)	12	63.0	–	10.5
26	HOSE CLAMPING SWIVEL (PORT)	10	81.4	P12.5	1.9
25	HOSE CLAMPING PLATFORM (PORT)	1.5	79.6	P12.5	1.0
24	RISER HOSE ROTATION SYSTEM (PORT)	10	62.0	P12.5	1.6
23	BOLTING STATION PLATFORM NO.2 (PORT)	1.5	67.4	P12.5	1.0
22	BOLTING STATION PLATFORM NO.1 (PORT)	1.5	56.6	P12.5	1.0
21	BOLTING STATION PLATFORM NO.1 (STB'D)	1.5	56.6	S12.5	1.5
20	RISER TENSIONER 2 (STB'D)	21	89.7	S12.5	1.5
19	RISER TENSIONER 1 (STB'D)	21	50.5	S12.5	1.5
18	RISER TENSIONER 2 (PORT)	21	89.7	P12.5	1.5
17	RISER TENSIONER 1 (PORT)	21	50.5	P12.5	1.5
16	POWERED UMBILICAL SHEAVE (STB'D)	6	46.2	S15.0	7.6
15	POWERED UMBILICAL SHEAVE (PORT)	6	46.2	P15.0	7.6
14	UMBILICAL WINCH (STB'D) + UMBILICAL	30	42.0	S23.9	2.2
13	UMBILICAL WINCH (PORT) + UMBILICAL	30	42.0	P23.9	2.2
12	CRAWLER RESTRAINING SYSTEM (UPPER) (PORT)	15	7.5	P12.5	2.8
11	CRAWLER RESTRAINING SYSTEM (LOWER) (PORT)	30	7.5	P12.5	−4.2
10	COMPENSATOR SYSTEM (STB'D)	120	13.6	S12.5	18.8
09	A–FRAME (STB'D)	130	8.9	S12.5	9.5
08	LONGITUDINAL SLIDING DOOR (PORT)	90	27.7	P12.5	0.3
07	SPARE ROPE + STORAGE WINCH (ø141 x 300m) (PORT)	55	66.6	P12.5	11.4
06	MAIN HOIST WINCH + ROPE (ø141 x 300) (PORT)	220	52.2	P12.5	12.1
05	NITROGEN STORAGE BOTTLES (PORT)	60	10.6	P6.7	5.3
04	COMPENSATOR SYSTEM (PORT)	120	13.6	P12.5	18.8
03	A–FRAME (PORT)	130	8.9	P12.5	9.5
02	750 SUBSEA CRAWLER (PORT)	400	25.7	P12.5	4.7
01	750 SUBSEA CRAWLER (STB'D)	400	25.7	S12.5	4.7

PARTS LIST

IHC MARINE AND MINERAL PROJECTS (Pty) Ltd

MERWEDE

PROJECT	TTRL IRON SANDS NEW ZEALAND
TITLE	TTRL VESSEL CONCEPT - MINING EQUIPMENT
DRAWN	HNE
DATE	2013/05/09
TYPE	GENERAL ARRANGEMENT
APPROVED	

3RD ANGLE PROJECTION U.O.N

DRAWING NUMBER	REVISION
13019-000-0001	D

SIZE	A0	SCALE	1:100	SHEET NUMBER	1 of 1

Appendix D: ROM Density Calculations

In Situ

	SG (t/m3)	Volume (m3)	Weight (t)	Vol%	Wt%
Solids SG	3.20	0.594	1.90	59.4	82.0
Water in pores SG	1.03	0.406	0.42	40.6	18.0
In Situ		**1.00**	**2.32**	**100.0**	**100.0**

As Mined Vol% solids (IHC calc)

ROM Vol% solids	**30.00**				
	SG (t/m3)	Volume (m3)	Weight (t)	Vol%	Wt%
Solids SG	**3.2**	**0.178**	0.57	17.8	40.2
Water in pores SG	**1.03**	**0.122**	0.13	12.2	8.9
Situ Solids SG	2.32	0.300	0.70	30.0	49.1
Seawater SG	1.03	0.700	0.72	70.0	50.9
ROM Slurry		**1.00**	**1.417**	**100.0**	**100.0**

Alternative Case:

As Mined Vol% solids

ROM Vol% solids	**17.10**				
	SG (t/m3)	Volume (m3)	Weight (t)	Vol%	Wt%
Solids SG	3.20	0.171	0.55	17.1	39.1
Seawater SG	1.03	0.829	0.85	82.9	60.9
ROM Slurry		**1.00**	**1.401**	**100.0**	**100.0**

		1 Crawler (800 ID)
Slurry volume	m3/h	11,771
Slurry weight	t/h	16,674
Seawater weight	t/h	9,965
Seawater volume	m3/h	9,674
Solid weight	**t/h**	**6,709**

Actual Vol % true solids 17.8% by SG

solids t/h	t/h	6500
solids density	t/m3	1.9
Effective cut width	m	10
Face height	m	5
Advance Rate	m/h	68.4
Hose ID	mm	800
Area	m2	0.503
Slurry Velocity	m/s	6.50

		1 Crawler (800 ID)	
Slurry volume	m3/h	11,771	11,771
Slurry weight	t/h	16,492	16,492
Seawater weight	t/h	4,721	10,051
Seawater volume	m3/h	4,583	9,758
Solid weight	**t/h**	**6,441**	**6,441**

Actual vol % solids 17.1% by SG

solids t/h	t/h	10,850
solids density	t/m3	2.35
Effective cut width	m	10
Face height	m	5
Advance Rate	m/h	92.3
Hose ID	mm	800
Area	m2	0.503
Slurry Velocity	m/s	6.50

Appendix E: ROM Production Calculations

PRODUCTION CALCULATIONS FOR CRAWLER 800 ID OPERATION

In situ material (ROM)

Average density solids	3,200	t/m3
Density water	1,030	t/m3
Voids (porosity)	40,63%	vol
Dry Bulk density	1,900	t/m3
Wet bulk density ROM (incl moisture)	2,318	t/m3
Moisture in ROM	18,05%	wt
True Operating Hours per year	4821	hrs
Feed production	3390	m³/h

Output figures

Description	m3/h	t/h	m3/y	t/y
Production in situ	3390	7860	16.343.190	37.890.665
True solids production delivered	2013	6441	9.703.769	31.052.061
Production water	1377	1419	6.639.421	6.838.604

Cv true solids in situ	**59,38%**
Cm true solids in situ	**81,95%**
Check volumes	OK

PUMP PRODUCTION

			critical vel	
Diameter discharge pipe dredge	800	mm		
Diameter suction pipe dredge	800	mm		
Mixture velocity in dicharge pipeline	6,50	m/s	*4,85*	m/s
Mixture velocity in suction pipeline	6,50	m/s	*4,85*	m/s
Duty point (DAS)	3,270	m3/s		
Cv in situ (DAS)	30%			
Total mixture flow	11771	m3/h	16492	t/h
Production in situ material (theory)	3531	m3/h	8187	t/h
Transport factor	0,96			
Mixture density in pipeline	1,401	t/m3		

Output figures

Description	m3/h	t/h	m3/y	t/y
Production in situ delivered	3390	7860	16.343.190	37.890.665
True solids production	2013	6441	9.703.769	31.052.061
Production water	9758	10051	47.043.418	48.454.721
Total mixture flow	11771	16492	56.747.188	79.506.782

Cv true solids	**17,10%**
Cm true solids	**39,06%**
Cv in situ (del)	**28,80%**
Cm in situ	**47,66%**
Check volumes	OK

Appendix F: Crawler Potential Upside Production Assessment

Base Case: Single Crawler with 800mm ID Slurry Delivery Line

Rev.: 0 **26-apr-13**

Variable	**Unit**	**Base case**	**Upside potential IHC**	**Proposed Value TTRL**	**TTRL Rationalisation**	**Upside Potential Responsibility**	**Upside Potential Comments**
Annual operating days	days	365	365	365			
Port visits (incl. dry docking)	days	30	15	15	TTRL has confirmed that a new vessel requires a dry docking every 5 yrs. to inspect the hull and propulsion.	TTRL	TTRL to ensure that: (i) the vessel will be designed to access the local port. (New Plymouth), (ii) the 15 day allowance per annum is sufficient allowance for dry docking and transit to and from the nearest dry dock facility and (iii) Classification Society Rules and Regulatioons are adhered to. **Note:** The 15 day allowance assumes no dry docking or port call for unforeseen breakdowns.
Maintenance	days	26	26	12	TTRL consider the availability of the second crawler, either on deck or at the local port will significantly reduce the number of days lost to unscheduled maintenance delays.	IHC	IHC advises that an allowance of 26 days per annum should be made for regular maintenence. This includes weekly maintenance of the crawler on deck and swopping out the crawler in-port once per annum. **Note:** The 26 day allowance assumes no dry docking or port call for unforeseen breakdowns.
Transhipment Constraints	days	12	0	0	TTRL has confirmed the methodology and operation of transhipment transfers with an experienced shipping operator. All transfers will be accomplished without the interruption of the mining operation.	TTRL	Downtime is not dependent on crawler operation. TTRL has full responsibility for he consequences of any downtime related to concentrate transshipment, refueling of MSV and transhipment of supplies and crew changes.
Anchor Spread Handling	days	18	0	0	TTRL has indicated that an anchor handling tug can shift the anchors during mining operation and that DP will take over	TTRL	A combined four point mooring system together with DP will allow anchor handling days to be reduced by the use of an anchor handling tug. TTRL has full responsibility for the consequences of any downtime rellated to anchor handling and must ensure the full DP system is available during anchor handling.
Mining System Availability	**days**	**279**	**324**	**338**			
	hours	**6696**	**7776**	**8112**			
		76,44%	**88,77%**	**92,60%**			
Weather uptime		90%	90%	90%		TTRL	
Mining Efficiency		80%	85%	85%	The IHC value has been selected based on experience with the MV Peace In Africa diamond mining operation. The mining efficiency is a factor which has to be taken into consideration for the inefficiencies during the crawler operation, which include: creating a first face (digging in), no full face, spill, turning at the end of a cut and irregularities in the soil.	IHC	IHC believes there is a potential to increase the mining efficiency due to the larger block size and lane length. This needs further investigation during the BFS as it depends on the abilities of the final mooring system chosen, the mine plan and the skill level of the operators.
Total effective production time	**days**	**201**	**248**	**259**			
	hours	**4821**	**5949**	**6206**			
		55,04%	**67,91%**	**70,84%**			
Maximum Slurry Velocity		6.5 m/s	6.05 m/s	7.5 m/s	The IHC value has been selected as an average velocity, based on experience in other dredging operations. A slurry feed is never completely constant as mixture concentration changes and these are strongly dependent on each other. When concentration goes down velocity will go up and if concentration goes up velocity will go down.	IHC	The pump system is not the limiting factor nor is the slurry velocity in the pipeline. Higher velocity does not directly result in more production, the limiting factor is the amount of soil which can enter the suction mouth and this is dependent on the deposit characteristics (free flowing, thickness and stratification) and the advance rate of the crawler. This, however, needs further field testing and investigation during the BFS as this parameter and average sediment concentration are inter-related and depend on the variables mentioned above.
Sediment Concentration (vol) Average		30%	35%	40%	The IHC value has been selected based on experience with the similar dredging operations in free flowing sands with jetting. TTRL believe there is an opportunity to raise this average concentration when extracting the less cohesive iron sands and also by using mechanical assists such as jetting or mechanical feeding. It is interesting to note that the Taharoa operation achieves far higher slurry concentrations in their dredging operations.	IHC	IHC sees the potential for optimising the slurry velocity and sediment concentration. This, however, needs further field testing and investigation during the BFS as this parameter and slurry velocity are inter-related and depend on the variables mentioned above.
Total effective production	**hours**	**4821**	**5949**	**6206**			
	tph	**6441**	**6870**	**9909**			
	tpa	**31.052.834**	**40.867.157**	**61.492.083**			

Appendix G: MTI Report: Rapid assessment of TTRL-tailings

MTI Holland B.V.

Memo

To
T. de Boer

From
A. Ortega
Z. Sulaiman

Copy to
E. Munts

Date	Reference
April 12, 2013	M013-103

Subject
Rapid Assessment TTR-Tailings

Mining Advisory Services has requested MTI-Sustainability and CFD to make a rapid assessment of the tailings return behaviour as currently being planned by TTR.

The main question was *"how the tailings from iron-sands mining will fall and initially disperse in the near-bed environment, as a first order estimate?"*

Input parameters

• Pipe diameter	1100 mm
• Specific gravity sand	3
• D50 (mean diameter)	250 µm
• Fines content (<63 µm)	5%
• Flow velocity pipe outflow	1.28 m/s
• Distance from seabed	4 m
• Mass concentration of solids	70%
• Sea water temperature (bottom)	4-5 °C
• Ambient current velocity	0.5 m/s

Initial dispersion model

Setting up a 3D-CFD model was the best approach as a pipe outflow is initially investigated. For the CFD calculations, "ANSYS-CFX" software package was used. A flat bed was assumed as well as a uniform ambient velocity. For a presentation of the model grid and the position of the pipe with respect to the seabed and the point of interest (from 16.5 m right of the pipe outflow) refer to Figure 1.

Parameters used in the model:

- Mixture density: based on input (sand and water density) an estimated mixture density of 1904 kg/m^3 was used. Volume fraction was calculated as 44%.
- Grain size: mean diameter (D50) was used. Fines content was not used because of increased complexity of the model and increased computational time.
- Flow velocity pipe outflow.
- Ambient current velocity (near seabed).
- Pipe, layout, diameter and location from seabed.

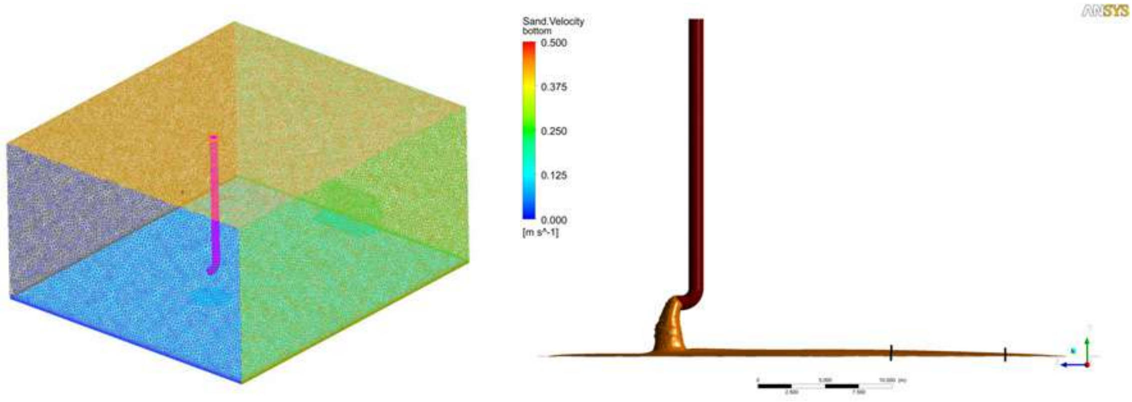


Figure 1 Computational domain and model set up

Initial results: rapid assessment CFD model

For the computation the ambient velocity (perpendicular to the pipe –worst case scenario) and the velocity at the outflow of the pipe are used. Figure 2 shows the velocity field, magnitude and direction around the pipe. At the right side of the pipe velocity magnitude reduces whereas at the left side the ambient current is affected by the outflow increasing in magnitude to approximately 1.6 m/s. It should be noted that this computation is done for a steady-state case and therefore the results are not time-dependent. This velocity magnitude influences the dispersion of sediment towards the point of interest.

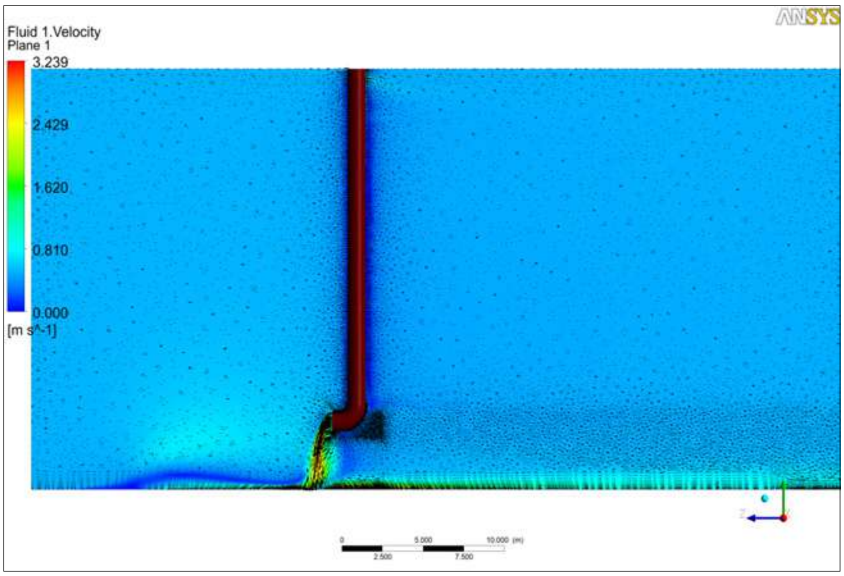


Figure 2 Tailings return near-seabed. Velocity magnitude and direction

Figure 3 shows the sediment dispersion around the pipe and near-seabed. Considering that the ambient current velocity is approaching perpendicular to the pipe, it can be concluded that the sediment dispersion is influenced by the outflow velocity (radial dispersion) and the ambient current (towards the left side of the pipe) in the direction of the point of interest. Figure 4 shows the density field in the surroundings of the pipe.

The result of the simulation is an estimation of the steady flow field pattern around the pipe. This means that the result is given for the moment where flow patterns are stabilised.

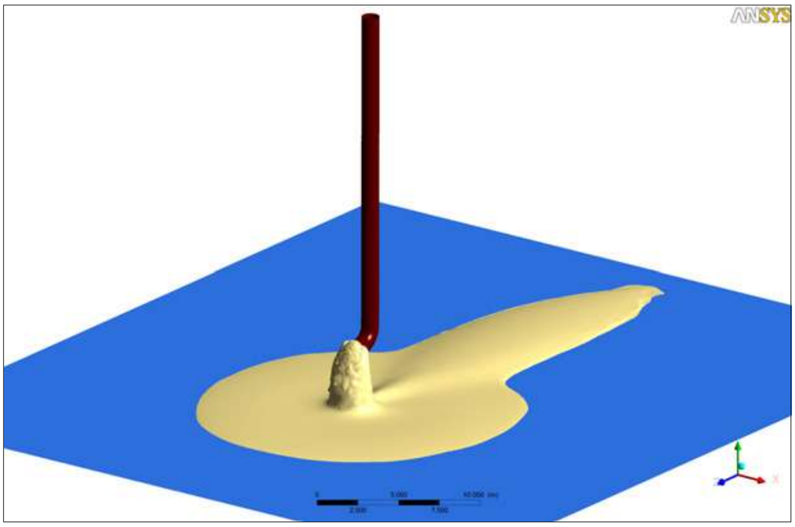


Figure 3 Sediment dispersion around the pipe and near-seabed

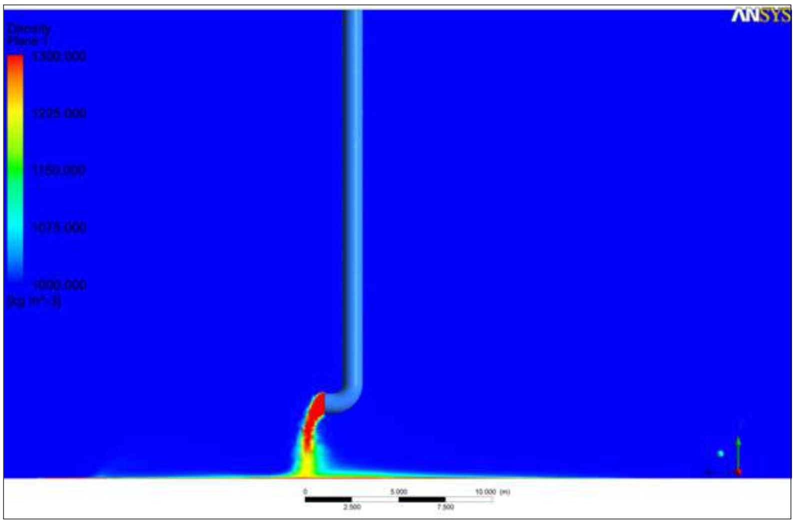


Figure 4 Density field pipe outflow and near-seabed

Recommendations for further investigation

- For more accurate CFD calculations a mesh convergence study is recommended. This will reduce uncertainty of the results caused by mesh dependency.
- These computations were done for a steady-state case because of time-constraints, for inclusion of time-dependent solutions, “Transient case” is recommended. However, this will certainly increase the computational time.
- CFD calculations serve to schematise the sediment source coming from discharges (e.g., tailings pipe). For this study only the main grain size is used (D50). A multi-flow computation for different sediment fractions could be implemented in CFD, these type of computations require a more detailed model set up and require longer computational times. Alternatively, a separate study for the outflow behaviour of the fines’ fraction could be performed.
- CFD computations do not include factors such as erosion and resuspension which affect the formation and dispersion of a sediment plume. This has to be done by means of hydrodynamic and sediment dispersion models (e.g., Delft3D). The sediment source used for a near and far field dispersion model could be estimated by means of accurate CFD calculations.

Appendix 19.9 - HR Wallingford Tailings Plume Review

HR Wallingford
Working with water

Support to Trans-Tasman Resources

Independent review of plume modelling

DDM7316-RT001-R01-00

August 2014

Document information

Document permissions	Confidential - client
Project number	DDM7316
Project name	Support to Trans-Tasman Resources
Report title	Independent review of plume modelling
Report number	RT001
Release number	R01-00
Report date	August 2014
Client	Trans-Tasman Resources
Client representative	Shawn Thompson
Project manager	Tom Matthewson
Project director	Dr Mike Dearnaley

Document history

Date	Release	Prepared	Approved	Authorised	Notes
15 Aug 2014	01-00	AMM	MPD	MPD	

Document authorisation

Prepared	Approved	Authorised
A. J. Morris	M.P. Dearnaley	M.P. Dearnaley

Contents

1. Introduction

1.1. Background

Trans-Tasman Resources Ltd (TTR) plans to extract titanomagnetite sand (ironsand) from an area in South Taranaki Bight. As input to the Environmental Impact Assessment (EIA) for the proposed mining project, NIWA was commissioned by TTR to investigate the potential environmental impacts of the proposed extraction operation.

Following the refusal of consent by the Decision Making Committee in June 2014, TTR are re-assessing their scientific case as background for a possible appeal and re-hearing. One issue that has arisen is the need to re-assess the degree of uncertainty and conservatism in the sediment plume modelling. In July 2014 TTR commissioned HR Wallingford to review the plume modelling work undertaken by NIWA.

1.2. Scope of review

This review concentrates on the NIWA studies pertaining to the assessment of effects from sediment plumes, focussing on the following documents:

- NIWA (2013) South Taranaki Bight Iron Sand Extraction Sediment Plume Modelling , Phase 3 studies, report for Trans-Tasman Resources Ltd, October 2013.
- NIWA (2014) South Taranaki Bight Sediment Plume Modelling: the Effect of Revised Source Particle-Size Distributions, report for Trans-Tasman Resources Ltd, March 2014.

Where relevant to the assessment of effects from sediment plume modelling the following documents will also be referred to:

- MTI (2013a) Assessment of sediment deposition and re-suspension behaviour of tailings, report for Trans-Tasman Resources Ltd, Report DZ 57, June 2013.
- MTI (2013b) Assessment of sediment deposition and re-suspension behaviour of tailings, Phase 2: influence of surface waves, Report DZ 58, July 2013.
- NIWA (2012) South Taranaki Bight Iron Sand Mining: Oceanographic measurements data report, report for Trans-Tasman Resources Ltd, August 2012.
- NIWA (2013) Optical effects of an iron-sand mining sediment plume in the South Taranaki Bight region, report for Trans-Tasman Resources Ltd, October 2013.

1.3. Report structure

The remainder of this report comprises a further 7 sections. In Section 2 the source terms used for the modelling are considered. The near bed processes associated with the release of the sediment from the mining operation are reviewed in Section 3 including results of our own near field modelling using our SEDTRAIL model. The flow model used to drive the sediment plume modelling is discussed in Section 4. Consideration of the sediment properties used for the sediment plume modelling is provided in Section 5. The calibration and application of the sediment transport model is commented upon in Section 6. The key findings of our review are discussed in Section 7 and conclusions arising from this review are provided in

Section 8. Two Appendices accompany this review report: Appendix A describes the SEDTRAIL model and Appendix B the background to the potential for mixing of an initial near bed suspension into overlying waters

2. Source-terms

2.1. Suitability of the source terms used for sediment release

There is no description in NIWA (2013a, 2014) regarding evidence for the productivity used in the NIWA assessment (removal of 1.195 m^3/s of in situ material, Section 3.2.3, NIWA 2013a). This productivity is however within the bounds of what could reasonably be expected given the methodology and plant proposed to undertake the works. It is noted that this productivity relies on achieving a relatively large velocity (~5.75m^3/s) and density (~1,300 kg/m^3) in the suction pipe. It is assumed that this productivity has been supplied to NIWA by TTR.

Given the productivity of 1.195 m^3/s of in situ material (2200 kg/s) then the returns to the bed of around 2000 kg/s are appropriate with about 10% of the in situ material recovered. It is however noted that there is a typographical error in the NIWA sediment plume modelling report (p33, Section 3.2.3 paragraph 2 of NIWA, 2013a) **–** the dry density is 1860 kg/m^3 (not the bulk density as stated in the report). The true bulk density is 2272 kg/m^3. The dry density of 1860 kg/m^3 gives a volume concentration of 0.6 which is consistent with typical sand deposits (e.g. Soulsby, 1997).

There are some apparent differences in the figures given for in situ fines content in the resource. Table 3-7 of NIWA (2013a) provides an indication of the particle size distribution of seabed material adjacent to the area being mined. This indicates that around the resource the fines content (<63 microns) in the bed is about 2.2% (1.6% less than 38 microns and about half of the 1.2% of material in the 38 to 90 micron fraction).

Table 3.2 of NIWA (2013a) provides the estimates of the particle size distribution and release rates for the predominantly fine material released from the hydrocyclone (about 87kg/s of material less than 63 microns). Table 3.3 of NIWA (2013a) presents similar information for the predominantly sandy material released from the de-ored sand (about 34kg/s of material less than 63 microns). On the basis that the in-situ material is removed at 2,200kg/s then the total fines released from the mining (~ 121kg/s)is equivalent to about 6% of the in-situ mass. Of this release rate about 32kg/s is assumed to be less than 8 microns in size and 23kg/s between 8 to 16 microns.

We understand that these numbers were provided to NIWA by TTR and that there is considered to be conservatism in these numbers in terms of inclusion of some mud layers within the resource in the average fines content. We understand from TTR that in practice the mining of the resource will be managed so as to avoid significant removal of muddy areas of the bed. We also note that if the samples used for providing the information in Table 3-7 are surface samples rather than samples over the top 5 to 10m of the bed then they are likely to have a higher fines content consistent with the large waves experienced in the area which will tend to winnow out fine sediment from the surface of the bed.

Table 3.4 of NIWA (2013a) summarises the assumption that NIWA make as to how much of the fine material released from the hydrocyclone and from the return of de-ored sand is available in suspension for introduction as a source in the plume modelling. This assumption is informed by the results of the MTI modelling where it is demonstrated that some of the coarser fines is deposited along with the sand fraction. We discuss this further in Section 3. Based on NIWA (2013a) the rate of fines less than 63 microns introduced into the model is about 113kg/s whilst this was reduced to 82kg/s in subsequent testing reported in NIWA (2014). These rates of release are substantially higher than the rates of release of fines associated with typical aggregate dredging activities in the UK (order 10kg/s) (HR Wallingford, 2011). Note also that typical aggregate dredging activity would have an intermittent release at the dredge site with the dredger spening time away from the site sailing to and fro to a port to discharge the materials arising.

2.2. Comparison with river inputs

In the sediment transport modelling NIWA assume (Section 3.1, NIWA2013a) that all the material input from the eleven rivers they include in their inner model is fine (less than 63 microns). The combined mean annual sediment release rate from these rivers is equivalent to an average of 373kg/s with a combined mean discharge of 593m^3/s.

NIWA suggest that there will be a linear relationship between river discharge and suspended sediment concentration. NIWA also assume that 50% of the river discharge is in the size range 4 to 16 microns.

The release of fines (both less than 63 microns and less than 16 microns) from the mining activity is about one-third of the assumed average fine sediment input from the rivers. In their modelling NIWA include a time varying discharge from the rivers to represent this average discharge.

3. Near-field modelling

3.1. Introduction

The plume modelling does not account for the near-field behaviour of the released sediment immediately after release. This can be an acceptable simplification of the sediment transport if the near-field behaviour does not lead to a significant difference in plume behaviour and if the focus of the investigation is far-field and longer term. This section considers what will happen in reality and whether this simplification is valid.

This review will consider both the scenario as modelled of releases of sediment at 10m above the bed and 4m above the bed, and also the revised methodology (*pers.comm.,* Shawn Tompson, TTR, Telecon 4/07/2014, UK time) of a single release at 4m above the bed.

3.2. Description of near-field processes

For both releases the released sediment discharge will form a negatively buoyant plume which will accelerate towards the bed under the effect of gravity. As the plume accelerates downwards it will entrain adjacent sea water, increasing the diameter of the plume and diluting the plume concentration, and also reducing the speed of the plume and its rate of acceleration (Chu and Goldberg, 1974, Fischer et al, 1979, Lee and Cheung 1990). Given the water depth at the site the plume will impact on the bed within a few seconds of release from the discharge pipe. During these several seconds the plume will dilute by an order of magnitude or more. The result will be the creation of a density current which will collapse over the sea bed under the action of gravity, expanding outwards and reducing in thickness as this expansion continues. The expansion will continue until the sediment in the density current settles out of suspension or the density current mixes into the overlying waters. This process is well known as an important feature of the physical processes of disposal of dredged sediment (e.g. Brandsma and Divoky, 1976; Johnson et al, 1993; Dankers, 2002; Saremi et al, 2014). As the density current settles the sand grains will displace the fine particles and this process will tend to leave a layer of fine sediment on top of a layer of sandy sediment (Amy et al, 2006). Generally this discharge and spreading will occur within a previously excavated resource area with dimensions of order 300m by 300m and depth of up to 11m below the ambient sea level.

3.3. Scenario as modelled

The scenario modelled by NIWA involves the release of 113 kg/s of fines (NIWA, 2013a), now revised down to 82 kg/s of sediment (NIWA, 2014a) in a discharge of 8.8 m^3/s, at 10 m above the bed and a release of 1900 kg/s in a discharge of 1.4 m^3/s at 4 m above the bed.

We used our numerical model SEDTRAIL-RW, developed to reproduce the near-field mixing of sediment releases from dredging and mining activities, to investigate the mixing from these two releases (Spearman, 2003, 2007 – now further developed to include axisymmetric, or stationary, releases as well as those from moving releases. The relevant part of the model is explained in Appendix A).The lower, larger and (predominantly sand) discharge will descend under gravity, entraining surrounding water as it does so, and collapse over the bed as a slurry with an initial concentration of around 45 kg/m^3, initially a few metres deep, which will then collapse over the bed as a result of being heavier than the surrounding water. As it does so it will entrain further water at the head of the expanding density current. The sand will settle out leaving a near bed suspension of fines about 0.5m deep with a concentration of fines of around 140 mg/l.

The upper (predominantly fine sediment) discharge will also descend to the bed (due to gravity and the initial momentum of the release)and collapse over the bed as a slurry, but with a much lower initial concentration of around 4 kg/m^3. As before, additional entrainment will further dilute the density current. The density current will initially be a few metres deep but will collapse to around half a metre in thickness. The sand will settle out leaving a near bed suspension of fine sediment of around 750 mg/l.

In practice these two releases will interact and combine into a single body of water with the mass of sediment being additive because one plume will be entrained into the other. This would result in a concentration of around 900 mg/l in a near bed layer about 0.5m thick. Such a concentration is likely to remain as a concentrated suspension near the bed. This is because while in general the waves are sufficient to re-erode this sediment (e.g. using the equations for wave orbital velocity and wave shear stress presented in Soulsby,1997) and prevent it from depositing, the stirring effect of waves on the sediment is largely confined to the wave boundary layer (Soulsby, 1997) and waves (in this case) only augment to a small extent the ability of currents to diffuse the sediment upwards (Soulsby and Clarke, 2004). The turbulence generated by waves and currents in this case is insufficient, or at best marginal, to mix such a near bed suspension into the overlying waters. This is explained in detail in Appendix B. Note also that for much of the time the suspension created will be contained within the previously excavated area. In the latter stages of filling each previously excavated area the fine suspension may be able to spread over a larger area and may be proportionately more readily entrained into the water column by the action of waves.

Broadly speaking this result is supported by the results of the CFD modelling (MTI, 2013a, 2013b). The MTI modelling only considers the lower release and predicts that the vast majority of sediment left in suspension at a distance of 100m from the release is within the bottom 2m of the water column. This is even for the most energetic conditions of peak current speeds of 0.5 m/s and 4 m waves with a period of 10 seconds. This is a similar result to the argument made above and in Appendix B but resulting in a somewhat thicker near bed suspension. It is noted that the CFD model does not take additional account of the upper release and that the CFD modelling does not allow the radial collapse of the density current (MTI, 2013a, 2013b) and hence will over-estimate the thickness of the near bed suspension.

As near bed suspensions continue to be generated near the release, without mixing into the overlying waters, three additional effects will happen:

- fining of the substrate will start to occur and this will cause the bed to become smoother. The turbulence generated at the bed will reduce. This may lead to deposition of fine as well as coarse sediment;
- the concentrations of near bed fine sediment will increase locally, the vertical gradient of density will increase and this also will lead to the “damping” or reduction in turbulence (Munk and Anderson, 1948; Toorman, 2000) and further deposition of fine sediment;
- the more fine sediment deposited on the bed or trapped in a near bed suspension, the less fine sediment that will be available to be advected as a plume mixed into the water column.

These effects will occur regardless of whether the suspension of fines is confined well within a previously excavated pit or has effectively spilt out of a confined pit in the latter stages of the filling of an individual pit.

3.4. Revised scenario

The scenario now proposed by TTR involves the combined release of the upper and lower sources – i.e. release of 1974 kg/s in a discharge of 10.2 m^3/s, at 4 m above the bed with an additional discharge of hyper-saline brine. At present we do not know the volume of brine discharge but we assume that any such discharge will be small compared to the overall mixture discharge and small compared to the volume of water entrained into the plume.

A re-run of SEDTRAIL-RW indicates that the discharge will collapse over the bed as a slurry with an initial concentration of around 120 kg/m^3, initially a few metres deep, which will then further collapse over the bed as a result of being more dense than the surrounding water. As it does so it will entrain further water at the head of the expanding density current. The sand will settle out leaving a near bed suspension of fines about 0.25m deep with a concentration of fines of around 800 mg/l. As stated above such a concentration is likely to remain as a concentrated suspension near the bed.

3.5. Other factors influencing near-field processes

A factor that could result in additional fines being made available from the near bed suspensions described above would be the effects of disturbance from propeller wash. For a typical trailer suction dredger undertaking overflow in modest water depths then the action of propeller wash on the recently formed near bed suspension can substantially mix that material into the water column and lead to increased quantities of fines to be dispersed into the far-field.

For the TTR method of production the FPSO will generally move over the site controlled by anchors. This will significantly reduce the potential for enhanced release of fines from the near bed suspension. Other vessel movements will be less frequent and will have limited effects on resuspension of fines from the near bed suspension.

4. Flow modelling

4.1. Introduction

The flow model forms an important input to the plume impact assessment since it controls:

- The direction of the movement of the plume;
- The shear dispersion of the plume – i.e. the mixing caused by spatial differences in currents;
- The mixing of sediment through the water column (via turbulence);
- The deposition and resuspension of sediment from the bed (via shear stress).

However, it should be realised that once a model has been validated against measurements of currents and water levels with reasonable care any uncertainty in the flow model prediction will be smaller than the uncertainty in the source terms (Section 3) or due to sediment properties (Section 5). It should be recognised that error in the flow model will always exist – no flow model is perfect – but in our experience as long as the model can provide confidence that it can predict current strength and direction with reasonable accuracy it will be sufficient to identify the extent of plume impacts.

4.2. Flow model performance

The flow model performance is measured by decoupling the currents caused by tidal forcing and the residual currents (referred to as "subtidal" in NIWA (2013a)). The performance of the model in reproducing the tidal currents is measured using parameters such as semi-major axis, eccentricity, inclination and phase of the tidal ellipse. The performance of the model in reproducing the residual currents is measured by comparing the same parameters but additionally including mean magnitude and mean direction of the residual current. These comparisons show that the model performs well overall with tidal currents being particularly well reproduced. Residual currents are also on the whole well reproduced with directions mostly predicted within 10 degrees and within 2 cm/s. Exceptions to this occur for small (~0.01 m/s) residual currents near the bed, which are more susceptible to noise in the ADCP measurement, and also at location 10 where the flow model consistently predicts residual current directions 14 - 23 degrees northward of the measured easterly/south-easterly residual currents. The time series of comparisons of residual flow (Appendix C of NIWA 2013a) also indicate that the model reproduces the general fluctuation in residual flow well.

The assessment of flow model performance would be improved by adding a measure of the root-mean-square or mean-absolute error in current speed and direction (i.e. which are more normal parameters used to measure flow model performance). The parameters used in the report tend to reflect mean overall properties rather than a measure of the ability of the model to predict currents at any particular time. An attempt to capture this is made using the correlation coefficient *r* but this is an opaque parameter to grasp in this context.

The flow model is validated against ADCP data at 5 locations with three of these locations (5, 6, 7) being compared against 5 months of data (06/09/2011 to 09/02/2012 excepting a week between deployments) and two (locations 8 and 10) being compared against a little over 2 months of data (24/04/2012 to 01/07/2012). It is not known how this validation was undertaken – if the model was initially calibrated against the data from location 5, 6 and 7 and then validated (without further parameter adjustment) against the later data from locations 8 and 10, then the model could reasonably be said to perform well against the whole data set representing 10 months of the year.

4.3. Sensitive sites

Where there are sensitive sites in the vicinity of a mining area and the potential impacts at these sites are critical to the licensing of the mining, it is obviously more important for the model to predict the currents well in the vicinity of these areas and in the area between the mining and these areas. This needs to be considered in the light of the tendency for residual currents at Location 10 to be predicted more northwards of the real residual current direction. This introduces some (albeit modest) uncertainty as to the potential for the plume to extend over Graham Bank or OB site 155 (see Figure 4.1). Ideally this uncertainty would be reduced through better calibration of the flow model. However, if this option is impractical given the constraint of the appeal process, a thorough examination of the potential for any of these sites to experience the plume (when they are not predicted to experience the plume) or to more directly experience the plume or to experience the plume more frequently should be examined. This exercise will be helpful if it can be clearly reasoned that, even allowing for uncertainty in the model, sensitive areas cannot possibly experience the plume. It may be that it is helpful to use the measured ADCP data in this respect.

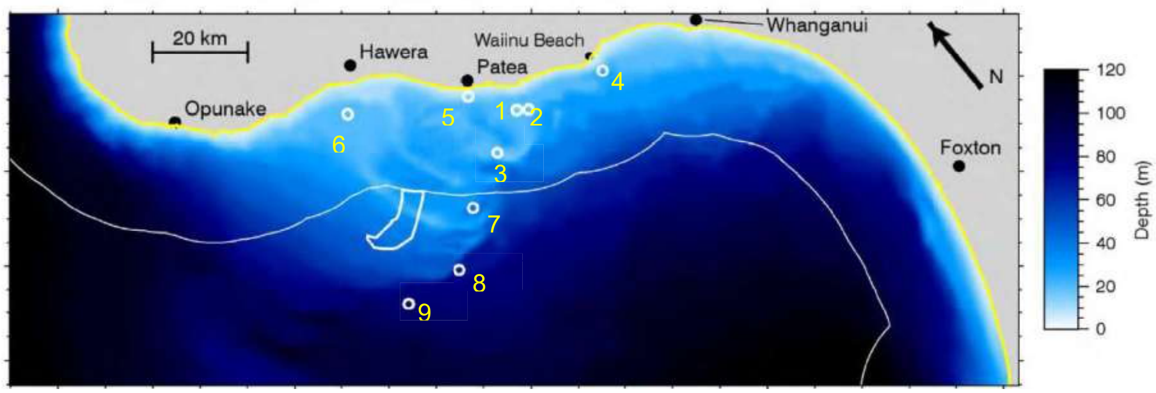


Figure 4.1: Locations of ecologically sensitive areas in the vicinity of the proposed mining

Source: NIWA (2014b). Numbered locationsare as follows: 1: North Trap. 2: South Trap. 3: Graham Bank. 4: Wainu Reef. 5: Patea Reef. 6: Four mile reef. 7: OB site 155. 8: OB site 113. 9: OB site 130. Mining area is shown as a polygon white a thin white border.

4.4. Oceanographic inter-annual variation

It can often be the case with environments strongly influenced by oceanic currents that currents may vary from year to year or even over longer periods such as those caused by El Nino events. It is a useful exercise to examine existing data or existing oceanographic models for conditions from other years to see if the ocean currents influencing Taranaki Bight change significantly – particularly if they (from time to time) fall outside of the range of behaviours modelled in the plume study. If there are potentially conditions which would result in a significant change in the movement of the plume nearer to sensitive areas (see Figure 4.1) then these conditions should be included in the sediment plume assessment along with the reasoning why these particular conditions are important and how they were selected.

4.5. Conclusions regarding flow model performance

Overall the flow model compares well with the measured flows – with slightly more northward currents predicted in the vicinity of the mining area. This model performance is considered to be satisfactory for the proposed studies but there needs to be some additional thought as to whether the small amount of uncertainty in the residual current direction at the mining site or inter-annual variation in oceanic currents could result in the plume moving to ecologically sensitive sites which are not predicted to be affected at present.

5. Sediment properties

Assumed sediment properties for riverine inputs and in-situ sea bed material are presented in Table 3.1 of NIWA (2013a). NIWA select a minimum settling velocity of 0.1mm/s for the finest material (4-16 microns) on the basis that this material can flocculate in the marine environment. For the remaining fine material (16 to 63 microns) and the coarser sand fractions they calculate a settling velocity assuming non-cohesive sediment properties based around the mid-point grain size of each class band.

The assumed sediment properties for the sediment released back into the marine environment from the mining operations are presented in Table 3.4 of NIWA (2013a). Sediment with a size less than 8 microns is assumed to have a settling velocity of 0.01mm/s. That with a grain size of between 8 to 16 microns 0.1mm/s and that of the coarser size fractions assuming non-cohesive sediment behaviour. NIWA state (Para 1 of Section 3.2.1, NIWA 2013a) that the mining derived sediment is not expected to flocculate as readily as natural sediment. The basis of this statement should be clarified with NIWA. NIWA also estimated critical erosion thresholds for the different size fractions based on published literature and assumed a minimum level of 0.1 Pa characteristic of the unconsolidated muds.

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5.1. Flocculation and salinity

Fine grained sediments, in particular clay particle surfaces have ionic charges creating forces comparable to or exceeding the gravitational force, and these cause the clay particles to interact electrostatically. The cohesive forces exerted between two clay particles depends both on the mineralogy of the clay, and on the electro-chemical nature of the suspending medium. Most of the individual clay particles, made up from the common clay minerals, have a negative charge on the face of each platelet mainly due to the exposed oxygen atoms in the broken bonds of the crystal lattice. The mutual forces experienced by two or more clay particles in close proximity, are the result of the relative strengths of the repulsive and attractive forces (see van Olphen, 1977; Manning, 2001).

In fresh water suspensions (containing very few positive ions or low electrolyte concentration), the repulsive forces between the negatively charged particles dominate and the particles will repel each other. The particles thus tend to settle as individuals.

In saline water the attractive forces dominate due to the abundance of sodium ions forming a cloud of positive ions (cations in a high electrolyte concentration) around the negatively charged clay particles resulting in the formation of flocs (e.g. Krone, 1962).Consequently, the sediment particles do not behave as individual particles, but tend to stick together. This process is known as flocculation, and the aggregates formed are referred to as flocs, whose size and settling velocity are much greater than those of the individual particles, but whose overall floc density is significantly less. Krone (1963) found that flocculation quickly reaches an equilibrium situation at a salinity of about 5-10ppt, which is much smaller than that of sea water (~35ppt). The potential for fine particles to flocculate is partly governed by their cohesion and this can vary with mineralogy and the electrolytic level of the suspending fluid. Inevitably flocculation is controlled by a series of inter-related kinetics that tend to be site specific in nature (Mikeš and Manning, 2010). In terms of gauging the importance of salt flocculation, engineering practice (as a simple rule-of-thumb) categorises this behaviour in terms of NaCl concentration. Critical salinity for coagulation of three common clays (expressed in parts per thousand or milliequivalents per litre) are (Winterwerp and van Kesteren, 2004):

- Kaolinite 0.6 ppt or 10 $mEq.L^{-1}$;
- Illite 1.1 ppt or 19 $mEq.L^{-1}$;
- Smectite (or Montmorillonite) 2.4 ppt or 36 $mEq.L^{-1}$.

In predominantly seawater environments (e.g. for marine dredging operations) it could be expected that these critical values of salinity are greatly exceeded. On that basis the role of salt flocculation should not be one that induces a clay mineral dependency. Dredging operations in brackish environments could however lead to slight dependency of mineral type of the clays present.

Within a mixed sediment environment, the degree of cohesion between the various sediment fractions tends to increase with the content of fine clay minerals within the sediment, and starts to become significant when the sediment contains more than 5-10% of clay by weight (Whitehouse et al, 2000, van Ledden, 2003).

It is also increasingly recognised that there is strong mediation of the physical behaviour of particles and flocs by the biological components of the system. Mineral cohesion effects are further enhanced by the presence of extra-cellular polymeric substances (EPS; e.g. Tolhurst et al., 2002), such as mucopolysaccharides produced by microphytobenthos. For example, epipelic diatoms (e.g. Paterson and Hagerthey, 2001) secrete EPS as they move within the sediments. EPSs are regarded as highly effective stabilisers of muddy sediments (e.g. de Brouwer et al. 2005; Gerbersdorf et al. 2009; Grabowski et al., 2011) and can significantly enhance inter-particle cohesion. Smith and Friedrichs (2011) state that a dredge plume produced in a microbiologically active environment (e.g. Ayukai and Wolanski, 1997; van der Lee, 2000; Fugate and Friedrichs, 2003) is likely to experience faster rates of flocculation than in less biologically active environments. In general, flocs held together by polymers are stronger than those held together solely by electrostatic London-van de Waals forces (Kitchener, 1972).

5.2. Potential mixed sediment fraction interactions / effects

When modelling sediment transport, it is common practice to assume a single representative sediment type, such as a non-cohesive sand or cohesive mud. Modelling single sediment types would typically be a pre-cursor to any more complex modelling of mixed sediment types and fractions. This is due to the well-documented transport formulae developed for solely muddy or sandy sediments.

Sediment mixtures may behave either in a segregated way, or may interact through flocculation. The phenomenon of mud:sand segregation considers the mud and sand to operate as two independent suspensions (van Ledden, 2002). When a segregational regime dominates, there is very little bonding and flocculation interaction between the fine fraction and the larger non-cohesive sediment fractions is non-existent. Mixed sediment experiments have shown that fine sediment particles and sand grains which behave in a segregated manner, settle simultaneously (but at different speeds) at the bed/water interface, thus forming two well-sorted layers (Ockenden and Delo, 1988; Migniot, 1968; Williamson and Ockenden, 1993, Torfs et al., 1996).

However, where the fine fraction and the larger non-cohesive sediment co-exist as a single mixture (Mitchener et al., 1996) this creates the potential for these two fractions to combine and exhibit some degree of interactive flocculation (Manning et al., 2009, 2013). Whitehouse et al. (2000) describe a process whereby cohesive sediments mixed into a predominately cohesionless sandy region can create a 'cage-like' structure which can fully encompass the sand grains, thus trapping the sand within a clay floc envelope.

In terms of flocculation kinetics (Overbeek, 1952), the macroflocs (typically parameterised as D > 160 μm; Manning, 2001 ; Manning and Dyer, 2007; Soulsby et al., 2013) tend to control the fate of purely muddy sediment in an estuary (Mikeš and Manning, 2010), because the smaller microflocs generally settle at less than 1 mm/s, whereas macroflocs settle in the 1-15 mm/s range, enabling them to deposit to the bed (Pouët, 1997). However, when mixed sediment flocculation effects occur, the microflocs (D < 160 μm) can potentially demonstrate settling velocities comparable to those of the macroflocs (Manning et al., 2010).

It should be noted that any mixed sediment flocculation effects and intra-fraction interaction can only be truly demonstrated empirically through rigorous laboratory settling experiments.

5.3. Comments on flocculation resulting from dredging operations

Based on dredging plume monitoring in San Francisco Bay, Smith and Friedrichs (2011) showed that flocs represented 68% of the suspended sediment mass and comprised over three quarters of the vertical mass transport; whilst fine sand (D < 100 μm) only comprised a small fraction of the plume (this implies either that only a small fraction of fine sands passed over the weir and the bulk was, in this case, retained in the hopper, or few are entrained outside the dynamic plume).

Trailing suction hopper dredges, through: hydraulic removal and transport of sediment to the hopper; turbulent conditions within the hopper; and turbulent stresses during overflow (Land and Bray, 1998; van Raalte, 2006) are likely to break bed aggregates into small fragments. Additionally, hopper dredges may preferentially retain larger bed aggregates within the hopper (Smith, 2010). Smith and Friedrichs (2011) observed that the remainder of sediment entrained into the water column within 20-minutes of passing out of the dredger overflow already existed in a highly flocculated state and this suggests that flocculation occurs within the high-concentration slurry within the hopper and/or very rapidly soon after overflow. Similar effects can be anticipated associated with the discharge and the creation of the near bed suspension for the TTR case.

From particle size and floc analysis, Smith (2010) found the presence of at least two distinctly different sediment size classes within a dredge plume. For estuarine dredging he observed a smaller, but denser particle fraction in the form of bed aggregates and a less dense floc population. From further analysis, Smith and Friedrichs (2011) found that the denser bed aggregates (typically comprising consolidated, dense bed fragments) demonstrated time invariant size and velocity, whereas both floc sizes and their respective settling velocities tended to increase with time within a dredge plume and therefore they recommended the use of a time-dependent flocculation function and also a multiple-class model when modelling dredge plumes. Milligan and Hill (1998), Mikkelsen and Pejrup (2000), and Winterwerp (2002) all have suggested that time-variant flocculation effects must be included in sediment transport models for assessing potential environmental impacts within coastal zone regions. Importantly, Smith and Friedrichs (2011) state that denser bed aggregates may also interact with the less dense floc population (see earlier Section 5.2 on mixed sediment floc interactions). Although the ambient conditions in San Francisco Bay are most probably muddier than the South Taranaki Bight, this illustrates how important flocculation can be within a dredging plume.

For example, Hayter et al. (2012) used the SEDZLJ sediment bed model (Jones and Lick, 2001) to investigate sediment transport processes relating to short- to mid-term dredge material management strategies for the Federal Navigation Project at Grays Harbor, Washington. The SEDZLJ can be divided into multiple layers to represent existing sediment bed as well as new bed layers that form due to deposition during model simulations. Based on an analysis of available data, six sediment grain sizes (i.e. 10, 22, 222, 375, 750 and 4,000 μm) were deemed necessary to adequately represent the wide range of sediment within the SEDZLJ model domain (Hayter et al., 2012). Of these six fractions, two of these size classes (i.e. 10 and 22 μm) were used to represent the erosion, transport and settling of the fine-grain sediment placed at the dredge matertial placement sites. The 10 μm cohesive class was used to represent the flocs whose settling speeds were measured using the Particle Imaging Camera Sysem - PICS (Smith and Friedrichs, 2011), whilst the 22 μm cohesive class was used to represent the bed aggregates. A mean settling velocity of 0.35 mm/s for flocs was determined using PICS data, and a mean settling velocities of bed aggregates of 1.1 mm/s.

The NIWA model includes a number of size fractions (as available in the ROMS model set-up). The properties of these materials are given in Tables 3.1 and 3.4 of NIWA 2013a (see Section 5.1). It is our view that the settling velocities of these smaller size classes are significantly underestimated with fall velocities of 0.1 and 0.01mm/s and would not represent true fall velocities if these fractions flocculated(NIWA, 2013a).

The flocculation process is dynamically active which is directly affected by its environmental conditions, primarily being dependent on a complex set of interactions between sediment, fluid and flow within which the particles aggregation plays a major role (Manning, 2004). A conceptual model which attempts to explain the linkage between floc structure and floc behaviour in an aquatic environment is provided by Droppo (2001). As a result of dynamic inter-particle collisions, floc growth implies large variations in the sediment settling flux with direct implications on the vertical distribution of fine sediment throughout the water column. Flocculation is therefore a principle mechanism which controls how fine sediments are transported within many aquatic environments.

In order for flocculation to occur, suspended particles must come into contact with each other and then stick together. Particles in suspension collide due to a variety of different mechanisms, and the frequency of contact depends on the mechanism that brings about the contact, as well as on the particle size and the concentration of the particles. There are three principle mechanisms of collision:Brownian motion; differential settling; and turbulent shear principally created by velocity gradients generated within the fluid. The latter is the most significant collision mechanism in natural waters (Van Leussen, 1988) and would be the most applicable for dredging related operations.

The flocculation process requires turbulent mixing in order for particles to collide and flocs to grow (Krone, 1962; van Leussen, 1994; Manning, 2004; Winterwerp and van Kesteren, 2004). Turbulence creates inter-particle collisions and stimulates flocculation (McAnally and Mehta, 2001). Too much turbulence though can break flocs apart (Eisma, 1986; Dyer, 1989). Turbulent energy is transferred to decreasingly smaller eddies and this energy is dissipated by viscosity (van Leussen, 1997). These small eddies are defined by the Kolmogorov microscale of turbulence (Kolmogorov, 1941a,b). McCave (1984) found that turbulence determines the maximum floc size in tidally dominated estuaries.

Flocs released by the dredging process may originate either from any low-density muddy surficial sediment layer or those formed during the dredging process (high-concentration and low-moderate turbulence within hopper dredges are favourable to floc formation; Smith, 2010).

The hydrodynamics stresses produced during dredging operations can greatly exceed the typical, natural stresses exerted in natural aquatic environments. If we examine the hydrodynamic conditions produced during the proposed dredging operations, during the tailings release the pipe outflow velocity is calculated to be 1.522 m/s (MTI, 2013a). This fast discharge speed from a 1.1m diameter release pipe (MTI, 2013a), could potentially create a very high level of turbulent shear and create disruption to the flocculation process at the point of discharge. This hydraulic stress would limit floc growth and these ambient conditions would favour smaller, denser aggregates and possibly stronger microflocs, all with slow floc settling velocities. As the distance increases between the fine sediment fraction and the release pipe in the near bed sus[pension formed by the release processes the turbulence level would decay to a level more conducive for macrofloc formation. However, flocculation is not an instantaneous process and requires time to occur. This is referred to as the flocculation time (e.g. van Leussen, 1994), and is a function of shear stress and suspended sediment concentration.

5.4. Comments on settling velocity used in the MTI studies

In the assessment of sediment deposition and resuspension behaviour of tailings during their first phase of near field studies (MTI, 2013a), flocculation is assumed to occur in the two smaller size fractions ($1^{\#}$ is $0<d<38\mu m$ and $2^{\#}$ is $38\mu m<d<63\mu m$). Representative floc diameters of 95 μm and 250 μm, have been attributed settling velocities of 1.2 mm/s and 7.3 mm/s respectively in MTI (2013a). These nominal floc settling rates were calculated using Winterwerp's (1999) mud floc formula. Although these floc settling velocities appear within a realistic range, it should be noted that the various Winterwerp floc settling velocity equations (e.g. Winterwerp, 1999; Winterwerp et al., 2006) are based on fractal physics. Fractal theory is dependent on the successive aggregation of self-similar flocs producing a structure that is independent of the scale considered. This is similar to Krone's (1963) order of aggregation. In fractal geometry different floc structures are characterised by distinctly different fractal dimensions, nf (Kranenburg, 1994).

Fractal dimensions of 1.4 are representative of low effective density, fragile structured aggregates, whilst values of 2.5 indicate strongly bonded, less porous flocs. However, in order to make a fractal based model solvable analytically within a numerical simulation, an average nf value is requires and this ignores important floc density variations (Dyer and Manning, 1999). Furthermore, a single primary particle size (d_p) needs to be selected, however in reality flocs may be composed from a much wider range of primary particles. The fractal geometry then calculates the resultant floc diameter and the corresponding settling velocity based in part on these nf and d_p values.

No flocculation is assumed to occur for fractions between 63um and 2.8mm, and settling velocities were calculated using Van Rijn (1993). This therefore suggests that it is assumed that these larger fractions do not directly interact with the small, flocculating fraction.

In subsequent investigations (MTI, 2013b) did not continue with the use of these settling velocities for the finest material. NIWA did not pick up and use these settling velocities in their far-field modelling.

6. Sediment transport model

6.1. Calibration of the sediment transport model

The calibration/validation of the sediment transport model for baseline conditions presented in Section 4 of NIWA (2013a) is primarily undertaken by comparing against near-shore measurements of fine sediment concentration 3m below the surface and against the ABS measurements of suspended sand concentration.

The comparison with measured fine sediment concentrations indicates that the model over-predicts suspended sediment concentration by around a factor of 2. During the period of comparison there is a significant peak in observed concentrations which the model generally significantly over predicts. It will be important to understand what data has been used to calibrate the observations as this may be less applicable to this period of peak observations. The model over-prediction in the near surface waters may be as a result of the choice of settling velocity parameters (see Section 7.2) but the model may also require further work in a more general choice of sediment parameters.

The comparison with ABS measurement of sand concentrations presented in Section 4.3 of NIWA 2013a is, at least partially, a result of coarse vertical resolution near the bed in the model. It may be prudent to model the sand first in a 1DV model to understand how the 3D model needs to be modified in order to achieve a better result.

These two measures of baseline model performance do not invite confidence in the baseline sediment transport model and it would be prudent to improve the calibration of the sediment transport model particularly for the fines fractions which are so important for the assessment of optical effects (NIWA 2013b).

A demonstration of the ability of the model to reproduce the observed vertical distribution of fine sediment through the water column under a range of conditions near the mining site and in the vicinity of the closest sensitive receptors would be valuable. The available offshore measurements in and around the mining site (NIWA 2012) indicate that near surface fine suspended sediment concentrations were in the range 10 to 25 mg/l and that near bed suspended sediment concentrations were in the range 10 to 80 mg/l. It is not clear why this data has not been used for comparison with the baseline modelling.

6.2. Sand transport – patch sources

NIWA have simulated a scenario which represents a condition after one year of productivity (Section 5.5 of NIWA 2013a). The scenario represents the situation where a patch of seabed 2km by 3km has been backfilled with de-ored sediment. This is then used as a source in the model to predict the fate of this material over the next 800 days.

In the NIWA simulations the assumption is that the patch is a homogenous mixture of all the material (including about 0.4% fines less than 63 microns) released by the mining process that has not dispersed in the initial plume created at the time of release of the fines (see Section 3.2.3 of NIWA 2013a). The surrounding bed is characterised as having about 2% fines.

We consider that this approach may need to be reviewed if it can be demonstrated (see Section 3 above) that rather less of the fines is released into the plume at the time of initial discharge because this would tend to imply the development of layers of muddier material overlying less muddy sand in the patch areas. If more mud remains in the de-ored areas in the form of patches of mud or muddier material overlying a sand deposit it is possible that the first more extreme wave events that each patch receives after completion will lead to localised sources of greater fines content than is presently the case.

It may be possible to manage the placement of the de-orded material back onto the sea bed using sand spreading technology to promote mixing and/or burial of the finest material into the bed to recreate a deposit more similar to the adjacent areas of seabed.

7. Key findings of review

7.1. The implications of near-field mixing

The assessment of near-field modelling (Section 3) identifies that the release of sediment is likely to lead to a near-bed suspension which will not readily mix into the water column. These processes are not in the ROMS sediment transport model. Instead the ROMS model represents the upper release as releasing 15m below the surface and the lower release 1.5m above the bed. The ROMS model has a grid resolution of 1000 m and a vertical layer resolution defined by having 20 layers in the vertical. The vertical layers do not have equal spacing. We estimate from the information provided in Appendix A of NIWA 2013a that in a water depth of about 20m the sediment is released into a layer of between about 1m and 1.5m thickness and in a water depth of 40m the sediment is released on to a layer of about 2 to 3m thickness. Therefore in the ROMS model the sediment released from the two sources is immediately, upon release, mixed into a total volume of at least 2,500,000 m^3. This serves to artificially mix the plume in the cell where the release takes place and essentially precludes any of the near-field processes discussed in Section 3 because the concentrations are immediately diluted upon release. The sensitivity tests on a 500 m grid model would result in mixing into a volume of at least 625,000 m^3. In any case the ROMS model (as used in this study) is not designed to reproduce the complexity of mixing of near bed suspensions as the vertical resolution is insufficient to represent the gradients in velocity and density.

Were it not for the fact that the near bed suspensions caused by the release do not readily mix into the overlying waters as a result of the action of waves and currents, the ROMS model could have still been entirely appropriate for the plume dispersion study in the longer-term in the far-field. This is because over these larger scales the nature of the origin source of sediment becomes unimportant in plume dispersion (Fisher et al, 1979). However, Section 3 has shown that the near-field mixing turns out to be significant in terms of the fate of fine sediment in the mining release and is likely to significantly reduce the release of fine sediment from the mining site compared to what has been used in the NIWA model.

7.2. The implications of the choice of settling velocity

Consideration of whether flocculation will occur in the fine sediment fractions released during the mining process is discussed in Section 5.

In the NIWA ROMS Sediment Plume model both the natural River and Seabed fractions listed in Table 3.1 have had their settling velocities capped at just 0.1 mm/s(NIWA, 2013a). This value was used as it was meant to be representative of some flocculation effects occurring (flocculation is discussed in Section 5). This is potentially a significant under-estimation of a flocculation setting velocity. This very slow settling velocity is typically representative of either small, low order flocculi aggregates (e.g. microflocs of nominally only 10-20 μm in diameter), and this would be an under-estimate if floc growth occurs. Flocculation of this size fraction would potentially increase the settling velocity of these fines (when in a floc formation) by at least an order of magnitude, or even more (potentially within the range of 1 to 5 mm/s; the absolute value would be governed by the level of flocculation achieved). There is also further potential for the fines to flocculate and then interact with the slightly larger size fractions of material and include a portion of these within their floc matrix; this would ultimately be a factor of the relative particle bonding potential.

The effect of this is two-fold:

- Under calmer conditions when flocculated fine sediment could settle to the bed, thereby reducing the suspended sediment concentrations in the water column, the model will not represent the finer fractions as settling.
- The fine fractions will normally, especially as in this case where current speeds are not high, form higher concentrations near the bed and reduced concentrations near the surface. This phenomenon reduces the attenuation of light in the water column and contrasts with the assumptions used by NIWA that flocculation does not occur to the mining discharges which results in near uniform distributions of the finest sediment fractions included in the through the water column with disproportionate effects on light attenuation within the water body influenced by the plume.

Thus the choice of settling velocity results in an over-estimate of the turbidity in the water column, particularly in the upper part of the water column and hence results in an overestimate of impact on light reduction.

8. Conclusions

From our review process we draw the following conclusions:

1. The flow model used to drive the sediment transport models is fit for purpose.
2. Further information is required to be presented to support the validation of the baseline sediment transport model. Comparisons against measured near surface and near bed observations should be presented.
3. The source terms provided by TTR to NIWA for use in the modelling are understood to be conservative (original tests indicated ~6% fines in the resource compared to 2% fines in the adjacent area) but may benefit from being presented or justified in further detail with supporting evidence to demonstrate that they are conservative. There may be a justification for sensitivity testing with a reduced source to illustrate a more representative scenario. Albeit some testing of a reduced source (~4%) has already been undertaken.
4. Near-field process modelling has been undertaken by MTI for NIWA to assist in providing source terms for the NIWA sediment plume modelling. Further assessment and schematisation of these source terms will be required to better represent the effect of turbulent damping creating a near bed suspension of fine material at the discharge site and thereby reducing the amount of fines available for dispersion in the NIWA plume modelling. As a consequence the amounts of fine material generally being dispersed from the mining activity are likely to be over-estimated.
5. The settling velocities for the fine material in the NIWA modelling are too low and do not adequately represent the processes of flocculation that will be occurring. In addition there is no justification for the finest fraction of the mining derived fines having a settling velocity an order of magnitude lower than that of naturally derived fines.
6. The under estimate of settling velocities will lead to a more uniform distribution of fine material through the water column and consequential effects on light attenuation and associated deposition rates at times of low wave and flow energy.

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Appendices

A. SEDTRAIL-RW model

<HOLD – This will be provided in a future release of the report>

B. Potential for mixing of initial near bed suspension into overlying waters

Turbulence becomes insufficient to mix a fluid when the gradient Richardson number, $Ri_g = \frac{g\frac{\partial\rho}{\partial z}}{\rho_w\left(\frac{\partial v}{\partial z}\right)^2}$ exceeds a value of around 0.25 (Turner,1973; Monin and Yaglom,1971). We will use this result to show that the currents in the vicinity of the mining area are insufficient, or at most barely sufficient to mix the near-bed fine sediment suspensions resulting from release.

Section 5 of the main text indicates that the release of sediment will lead to a layer in the region of 0.5m thick with a concentration of 1 kg/m^3. We use the gradient Richardson number result, along with some assumptions about the value of $\frac{\partial\rho}{\partial z}and\frac{\partial v}{\partial z}$to investigate whether this layer can mix into the overlying waters given the hydrodynamic conditions.

Firstly we approximate $\frac{\partial\rho}{\partial z}$ by $\frac{\rho_{plume}-\rho_w}{h_{plume}}$ where $\rho_{plume}$and ρ_w are the densities of the plume and seawater, respectively, and h_{plume} is the thickness of the plume upon forming a near bed suspension.

We estimate $\frac{\partial v}{\partial z}$in two ways. The first is by using figure C-2 of Appendix C of NIWA (2013a). At locations 7 and 10 the value of $\frac{\partial v}{\partial z}$in the lower 2m of the water column can be estimated as 0.1 s^{-1} for a depth-averaged current of about 0.3 m/s. For a higher current speed of 0.5 m/s this value can reasonably be expected to be (assuming linear scaling) about 0.17 s^{-1}. The second method is by using the theory developed by Soulsbv and Clarke (2004).Soulsby and Clarke develop a framework for the interaction of currents and develop a formula for the velocity profile outside of the wave boundary layer,

$$v(z) = \frac{u_{*m}^2}{\kappa u_{*e}} ln\left(\frac{\delta}{z_0}\right) + \frac{u_{*m}}{\kappa} ln\left(\frac{z}{\delta}\right) \quad (1)$$

which leads to

$$\frac{dv}{dz} = \frac{u_{*m}}{\kappa z} \quad (2)$$

Soulsby and Clarke give u_{*m}as ,

$$u_{*m} = \frac{1}{2a}\left[(b^2 + 4a\bar{V})^{1/2} - b\right] \quad (3)$$

Where$a$and$b$are given by,

$a = \frac{1}{\kappa u_{*m}} ln\left(\frac{\delta}{z_0}\right)$and $b = \frac{1}{\kappa} ln\left(\frac{h}{e\delta}\right)$, $h$is the water depth, $\delta$is the thickness of the wave boundary layer, e is the value 2.718 and z_0 is the physical roughness, in this case taken to be 0.0004 m.

This method gives similar values for $\frac{dv}{dz}$ as figure C-2.

Taking values of $\rho_{plume} - \rho_w = 0.67$ kg/m^3, and $h_{plume} = 0.5$ and $\bar{V}$ = 0.3 m/s gives a value for u_{*m} of 0.017 m/s and a value for Ri_g of 0.6-0.9. This indicates the plume will not mix. For $\bar{V}$ = 0.5 m/s you get a value of 0.4-0.6 which is still above the threshold for mixing.

These calculations are approximate but suffice to show that a near bed suspension of 1 kg/m^3 will not readily mix. It should also be noted that this calculation is conservative since there will be a density gradient in the sand suspension which will also act to reduce turbulence.

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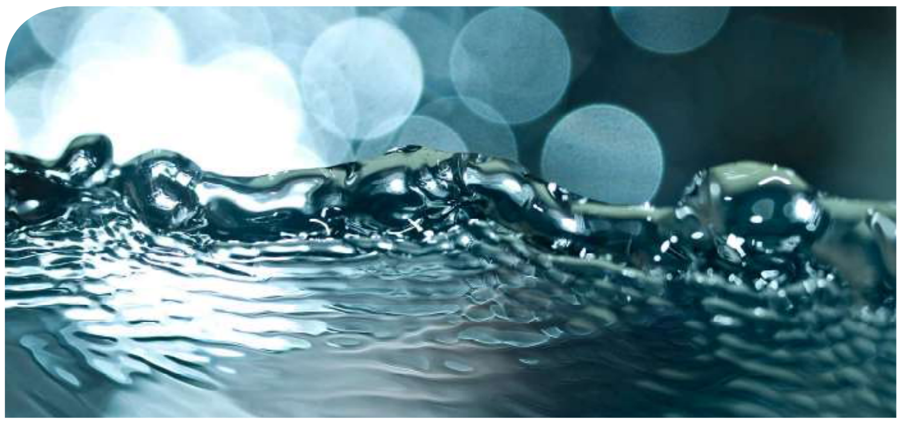

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Appendix 19.10 - Golder Associates Mine Reserve and Schedule Report

30 May 2014 Project No. 137641046-003-L-Rev0

Matt Brown
GM Exploration
Trans-Tasman Resources Limited
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WELLINGTON NZ 6143

ORE RESERVES STATEMENT – SOUTH TARANAKI IRONSAND PROJECT – AREA 2

Dear Matt

Golder Associates (Golder) has completed an ore reserves estimate update for Area 2 of the Trans-Tasman Resources Ltd (TTR) South Taranaki Ironsand Project which comprises a sub-sea titano-magnetite deposit. The ore reserves estimates are based on all available mineral resources data available as of 25 November 2013.

The mineral resource estimates were prepared and classified in accordance with the Australasian Code for the Reporting of Identified Mineral Resources and Ore Reserves (JORC Code, 2012).

1.0 ASSUMPTIONS AND METHODOLOGY

This Ore Reserves estimate is based on a number of factors and assumptions:

- The Davis Tube Concentrate (DTC) samples have analyses for Fe, Al_2O_3, P, SiO_2, Ti, CaO, K_2O, MgO, Mn and LOI (magnetic concentrate grades).
- Vertically, the Mineral Resource is constrained by a mineralisation envelope defined by a nominal 4% Fe_2O_3 edge cut-off grade.
- The Mineral Resource was estimated using an Ordinary Kriging algorithm. Head grades were estimated using samples weighted by recovery.
- Head grades were estimated for Fe_2O_3, Al_2O_3, P_2O_5, SiO_2, TiO_2, CaO, K_2O, MgO, MnO, LOI, Recovery and DTR. DTC grades were estimated for Fe, Al_2O_3, P, SiO_2, Ti, CaO, K_2O, MgO, Mn and LOI.
- The Mineral Resource estimates have been classified as Indicated Resource where the drill spacing is on a 1000 m by 1000 m grid or closer, and Inferred Resource where the deposit is less systematically drilled but geological continuity can be interpreted.
- No Inferred material has been included within the Ore Reserves estimate.

2.0 MODEL VALIDATION

The 2013 mineral resource model was used to prepare the Mineable Resource Model for use in a mineable schedule. The mineral resource model was first ‘flattened’ such that block centres equated to the depth below the ocean floor.

A *depth* field was added to the mining model, and then a lava script (*rmg_block_depthbelsurf.lava)* was run to calculate the depth of the block centre below the ocean floor. The model blocks were exported to a csv file, manipulated by transferring the block *zcentre* field to a new field *b_centroid_z*. The *depth* field was then copied to the *zcentre* field. The modified csv file was imported into the scheduling model *sia_dtr_est_post_a_TRANS.bmf.* This model has the same block dimensions and parameters as the resource model.

An additional *mine* variable was added to the block model to flag the model according to the planned mining region. The variable was flagged using the code 1=Outside of 12 nautical mile (NM) but inside Mining Area revision 2, 2=Inside of the 12NM limit and inside of the Mining Area Revision 2, -99 outside of the Mining Area Revision 2 boundary.

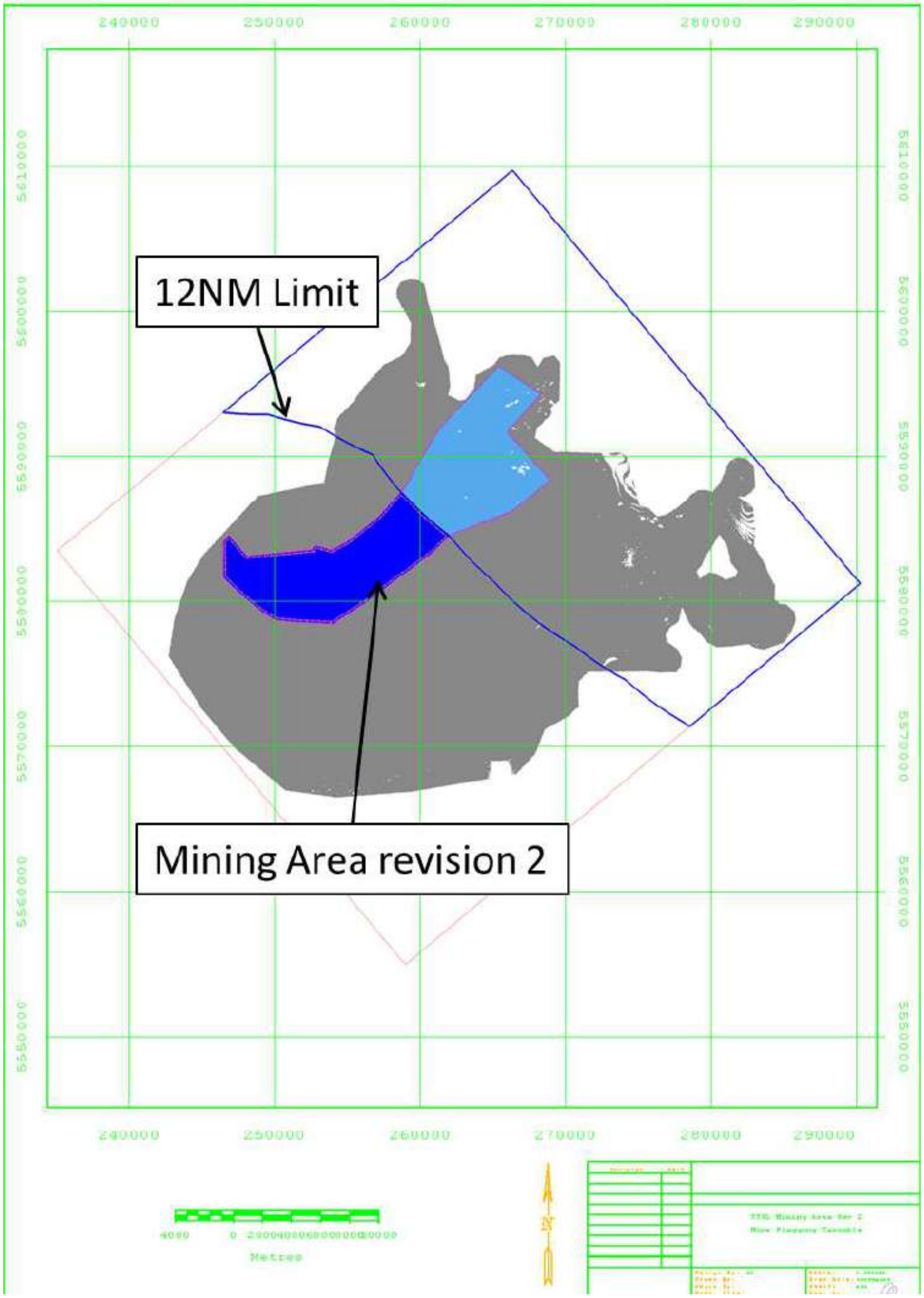

Figure 1: Mining Area Revision 2

The Mineable Resource Model was then used as the basis for tonnage and grade calculations.

3.0 SCHEDULING

3.1 Creation of mining regions

Within the boundary of Mining Area Revision 2 (MAR2), a grade shell representing areas above a 7% Davis Tube Recovery (DTR) grade was created. The creation of this 7% cut-off boundary enabled mining areas to be planned within the MAR2 region that targeted the maximum value of the contained resource. An initial cut-off of 7% DTR has been chosen in that it enables a potential balance between rapid return on investment without risking undue sterilisation of future mining potential. Following depletion of the 7% cut-off blocks, a subsequent lower grade mining region within the MAR2 has been scheduled to maximise resource extraction from the resource.

The MAR2 was separated by the 12NM boundary, as this will form a separation of two separate mining application permits. The initial mining application will focus on the area within MAR2 that is outside of the 12NM boundary, whilst the subsequent mining application will seek approval to mine the blocks within the 12NM boundary.

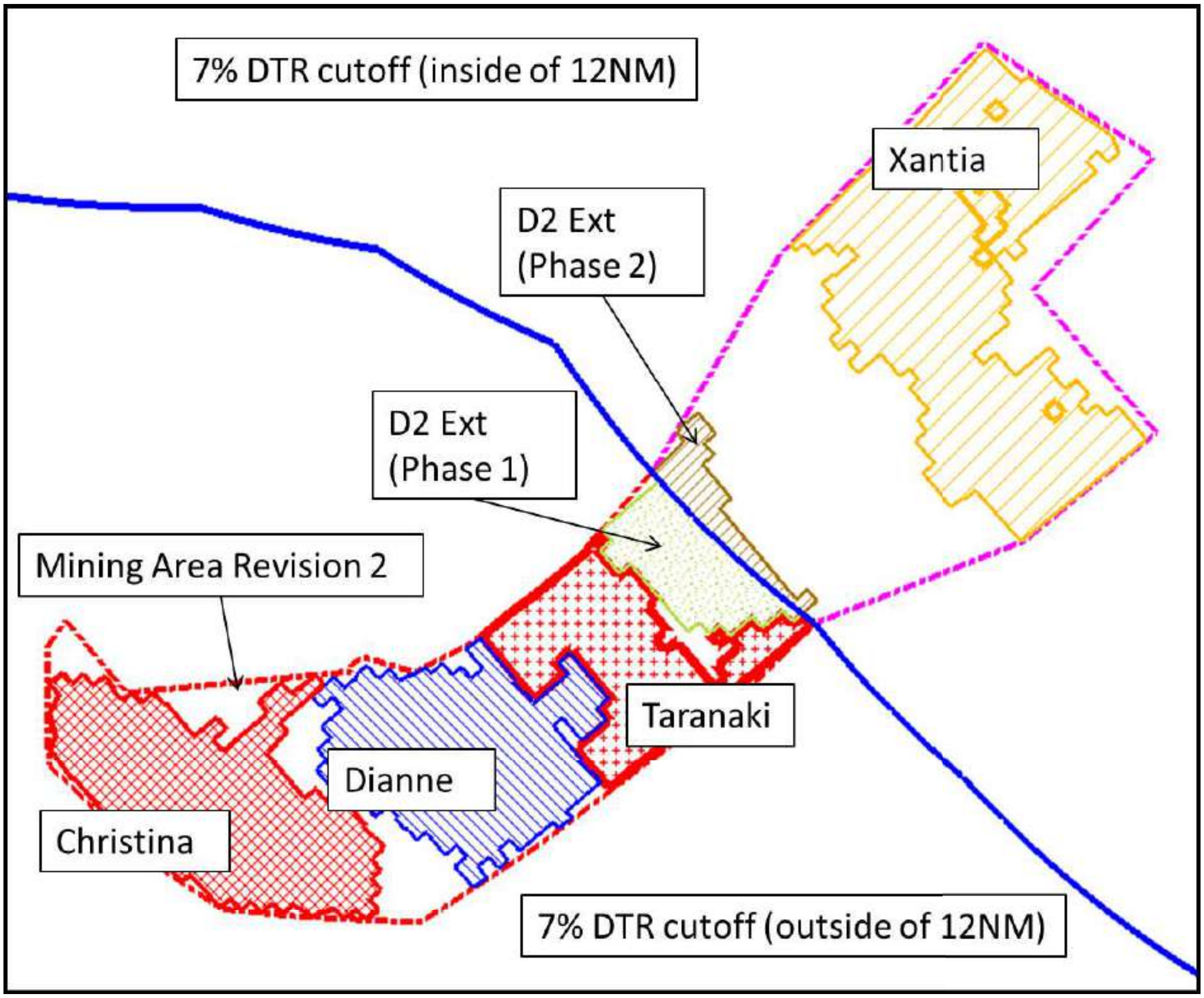

Figure 2: Mining Regions within MAR2

Within each of the mining regions, Christina, Dianne, D2 extension Phase 1 D2 extension Phase 2, and Xantia, mining panels of 300 m × 300 m were defined to enable the sub-sea crawler dredge and Integrated Mining Vessel (IMV) to operate. Based upon the current metocean data, the mining panels have been orientated to optimise the placement of the IMV.

3.2 Creation of mining panels

Within each of the mining regions, targeted mining strips and panels were defined. The mining strips represent the 300 m × 300 m wide 'lanes' of material that have been defined within the DTR cut-off grade. Each of the strips was then divided into individual mining panels that represent a practical mining area of 300 m × 300 m. The mining panel dimension assists in minimising anchor movements of the IMV. The crawler dredge unit will mine the 300 m × 300 m wide panels in 22 m wide 'lanes' giving an effective 20 m strip width with 1 m overlap on each side to ensure minimising ore losses. Vertical control is by a combination of sonar and positional monitoring equipment.

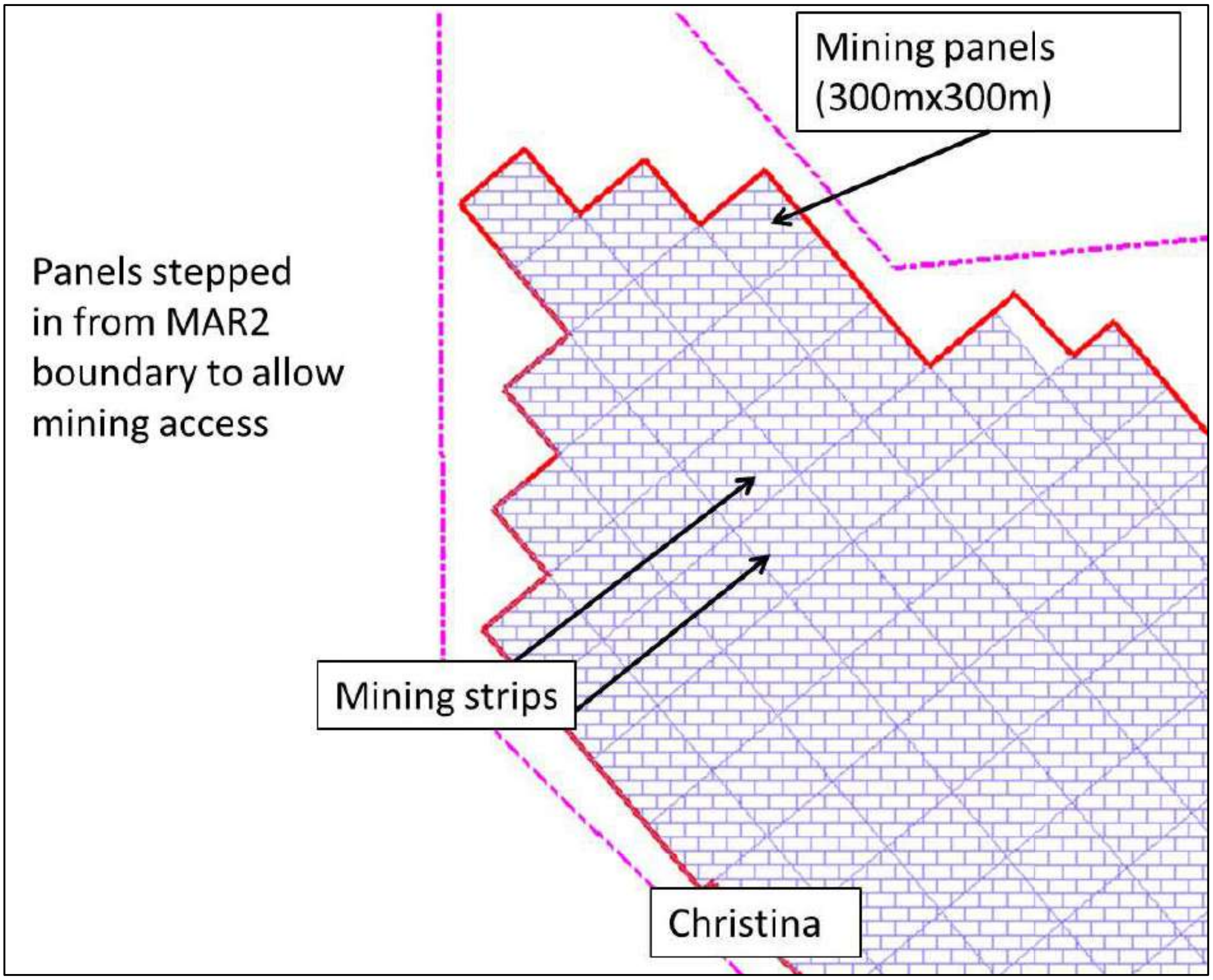

Figure 3: Mining Panels and Strips within a mining region

After creation of the mining strips and panels, the resource block model was interrogated against the defined areas to provide tonnage and grade estimates for each of the mining panels. The total for each of the mining regions was then compared against the total for the mining panels within each region.

The Mining regions would of necessity include areas that were not practical to include in a full mining panel. The total available resource tonnage within each of the mining regions equated to some 368 Mt above 7% DTR cut-off. With an additional 107 Mt being available at a 4% DTR cut-off for the Taranaki blocks, giving a total targeted resource tonnage of some 475 Mt.

Table 1: Resource tonnage per region

Mining Region	Resource Tonnes above Cut-Off
Christina	125.2
Dianne	123.3
D2ext Phase 1	37.4
D2ext Phase 2	6.7
Xantia	75.6
Taranaki	107.5
Grand Total	**475.7**

After allowing for potential ore losses at boundaries of the first block in a strip and possible horizon control errors for the crawler head an estimated 451 Mt of feed material will be available for processing by the IMV. The allowance of a 5% material loss has been advised by TTR, which was determined through recent breach testing (overseen by IHC Merwede B.V) as well as input from DeBeers Marine based on their operational experience. The use of the 5% material loss is the lower expected efficiency factor that could be expected from the crawler dredging unit. IHC are an international company that specialise in the design and construction of marine dredging solutions, with DeBeers Marine (an experienced marine mining operator) providing technical and operation advice to TTR. It is useful to note that a recent breach test carried out at TTR in Wellington demonstrated that extraction percentages in excess of 95% could be expected.

Table 2 below shows the tonnage within the mining panels for each of the mining regions and identifies the stage application for each of the regions.

Table 2: Mineable resource per stage and region

Mining Region	First Stage Tonnes (M)	Second Stage Tonnes (M)
Christina	118.9	
Dianne	117.1	
D2 extension – Phase 1	35.5	
D2 extension – Phase 2		6.4
Xantia		71.8
Taranaki (4% DTR Cut off)		102.1
Total	271.5	180.3
Grand Total Tonnes (M) at 7% DTR cut-off (except for Taranaki)	**451.8**	

The total grade and tonnage for each region is summarised below in Table 3 for the first stage application being the mining area outside of the 12NM limit.

Table 3: Grade and Tonnage for Stage 1 application

Stage 1	Tonnes (M)	DTR (%)	Fe (%)	Al_2O_3 (%)	LOI (%)	P_2O_5 (%)	SiO_2 (%)	TiO_2 (%)	CaO (%)	K_2O (%)
Christina	125	9.65	9.77	11.18	1.33	0.27	50.26	1.40	11.26	1.03
Dianne	123	10.44	9.63	12.26	2.31	0.27	49.23	1.41	11.22	1.07
D2 Ext – Ph 1	37	10.32	9.76	11.71	1.93	0.29	49.57	1.43	11.13	1.12
Total	285	10.07	9.71	11.71	1.82	0.27	49.73	1.41	11.22	1.06
Taranaki (4% DTR Cut-off)	107	5.12	4.65	13.73	2.49	0.26	51.62	0.95	11.97	1.15

For the second stage of mining, the remainder of the D2 extension resource and the Xantia mining region have been identified. The tonnage and grades for the mining areas within that stage are shown below in Table 4 all tonnes and grade relate to material above the specified 7% DTR cut-off.

Table 4: Grade and Tonnage for Stage 2 application

Stage 2	Tonnes (M)	DTR (%)	Fe (%)	Al_2O_3 (%)	LOI (%)	P_2O_5 (%)	SiO_2 (%)	TiO_2 (%)	CaO (%)	K_2O (%)
D2 Ext – Ph 2	7	8.32	7.15	10.96	2.48	0.23	54.46	1.04	10.70	1.18
Xantia	76	8.92	9.30	9.35	3.37	0.20	51.28	1.32	12.05	0.91
Total	82	8.87	9.13	9.48	3.30	0.21	51.54	1.30	11.94	0.93

3.3 Creation of scheduling resource

The defined mining panels were used as resource targets for the mining scheduling programme.
A scheduling model was created using the MineMax Scheduler that allowed each of the mining panels to be mined at a defined rate of extraction. The available hours per period for extraction were incorporated into the scheduler with a three month ramp up phase being applied in the first year of operation. The ramp up factors applied during the first three months of operation assumes that wet commissioning of the plant and crawler has occurred prior to first mining. The maximum allowable hours for the first month was set at 30% of available planned hours, with 80% being targeted for month two and 90% of planned hours for month three of the ramp up period.

The available time per year for use of the Crawler and IMV were supplied by TTR, and reviewed by DeBeers Marine, in terms of a minimum time usage model used by TTRL. The time usage model identifies some 6 326 hours per year available for production by the Crawler/IMV system at a stated throughput of 8 000 tonnes per hour.

The summary of the Time Usage Model is shown in Figure 4.

TTR Mining system time usage model		
Total available hrs per year	8760	
Deduct non work hours (Christmas day and boxing day)	0	24/7 operation
Deduct non production hrs to due inclement weather	438	Based on Metocean data <4mHs
Deduct non production hours due to planned maintenance	52	Time for raising and lowering Crawler to replace on breakdown
Deduct non production hours for crawler reversing and lane set up		Included in Crawler(See Extraction breakdown below)
Deduct non production hours due to operating delays	672	28 days (See Availability breakdown below)
Deduct non production hours due to anchor relocation	156	Contingency. Despite availability of AHT
Sail to new Location	120	10 Occurrences of Ship steaming to new location within mine plan
Sub Total	7322	System Availability
Deduct Crawler Extraction Delay	732	See Extraction breakdown below
Available production hours at design capacity	6590	
Deduct break downs (unplanned)	264	
Available production hours at design capacity	6326	

Figure 4: Time Usage Model

Factors used in the Scheduler model were supplied by TTR are listed below in Table 5. Dredge rate is the Basis of Design provided by IHC.

Table 5: Factors used in MineMax Scheduler model

Factor	Value
Process plant recovery efficiency	92%
Process cost	USD 24.81/tonne per tonne Fe concentrate processed
Dredge rate	8000 tph
Dredge system efficiency (incl. loss & dilution)	95%
Dredge Mining Cost	USD 1.97/tonne ROM
Fe Price of concentrate (FOB)	USD 70.00/tonne concentrate

The scheduling model is used to determine a practical mining sequence and allocates costs and revenue per process to determine a high-level financial assessment. The scheduler is not intended to replace a fully costed financial model, the primary purpose of the scheduling model is to provide a time dependant set of material physical properties that can be used to further assess the project viability.

The numbering (sequencing) of the mining panels has been set up to follow the 'Z-Mining' direction of the IMV/Crawler system in order to minimise anchor movements and sailing time between strips. At the completion of one strip the subsequent strip is mined in the opposite direction as shown in Figure 5.

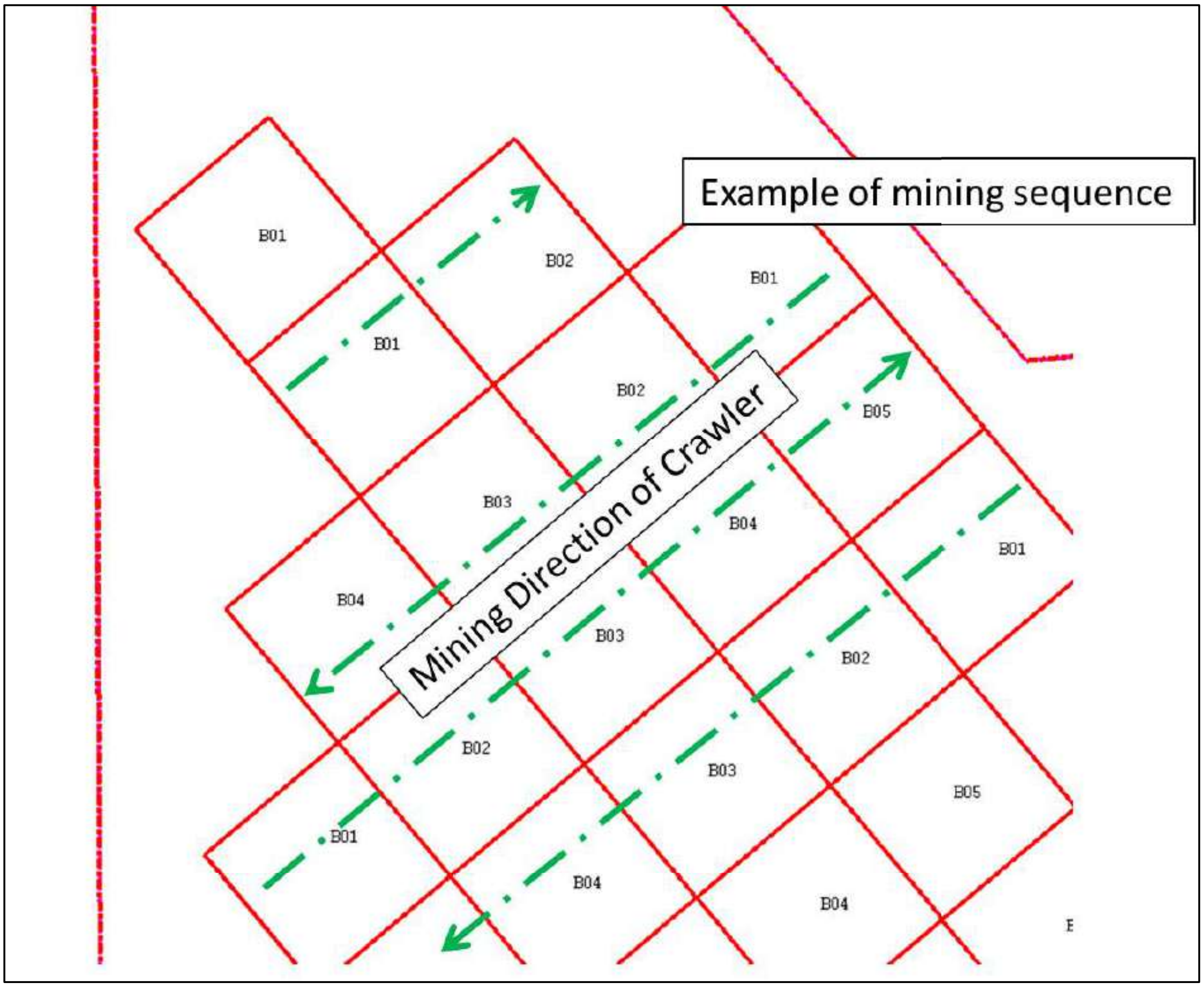

Figure 5: Mining Direction per strip

Within the first mining stage the scheduling model is configured to sequentially mine the regions in a defined sequence commencing in the higher grade Dianne region and then the D2 extension Phase 1 region before moving on to the Christina mining region. The subsequent stage (Stage 2) will mine the remainder of the D2 Extension region and then the Xantia mining region.

The scheduling constraints are assigned in terms of maximum permissible running hours per year, maximum recoverable concentrate tonnes, and maximum total material movement.

The maximum annual material movement is set to 50.6 Mt after the first year, the first year includes a three month phased build up and has been limited to 46.4 Mt. The recovered concentrate restriction is a function of the concentrate holding capacity on the IMV and the estimated time taken to transfer the concentrate to the FSO during rough sea conditions. The annual concentrate limit has been set to 5.068 Mt. Maximum system operating hours have been limited to 6326 hours after year 1, with the year 1 being constrained to 5797 to reflect ramp-up conditions.

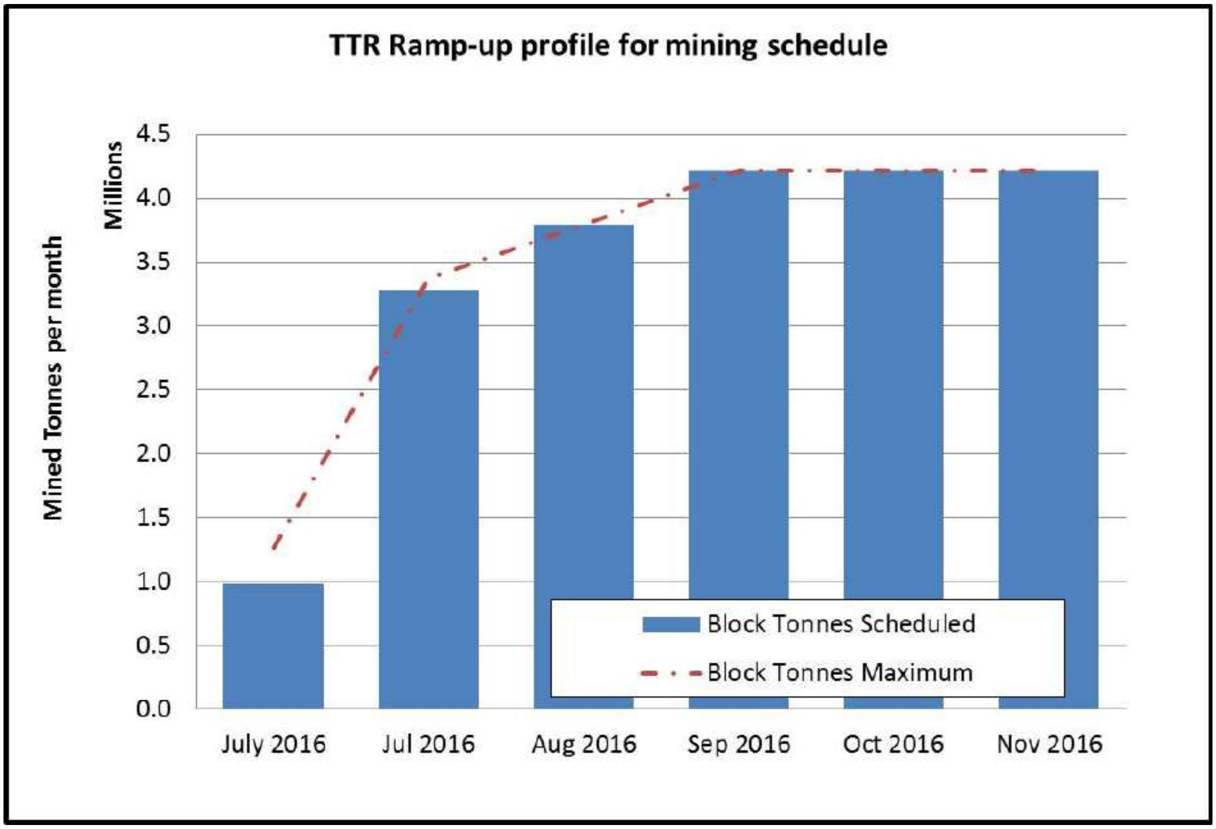

Figure 6: Ramp up profile applied to mining schedule

The scheduler sequence is then defined in terms of the strip mining and block sequence, with the aforementioned ‘Z-Mining’ direction being applied to the majority of the mining regions.

Volumes mined and concentrate product are constrained by either the available hours (volume mined) or storage capacity of the system (concentrate product). Both of these constraints have been applied to the logic of the scheduling tool with periods of high concentrate production then limiting the processing hours of the IMV. Figure 7 shows the annual process feed tonnes from the MAR2, the reduction in recovered concentrate tonnes towards the tail of the schedule is a reflection of the lower grade Taranaki blocks being mined.

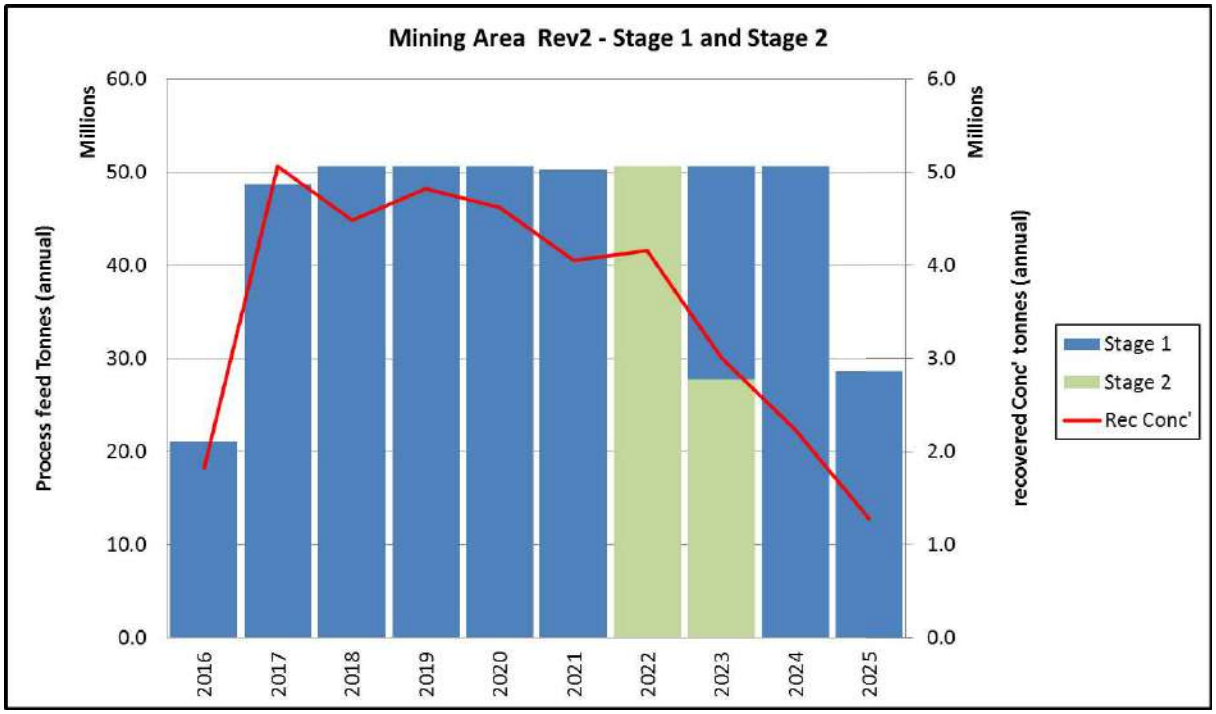

Figure 7: Ore mined versus Concentrate production for MAR2 stage 1

Ore Reserves estimated tonnage from the schedule has been broken into the two distinct stages represented by the separate mining lease applications and is reported by stage below (Table 6).

Table 6: Mining Area Revision 2 Resource tonnage

MAR2	Stage 1 tonnes (M)	Stage 2 tonnes (M)
Tonnes depleted	286	190
Process feed tonnes	267	172
Concentrate recovered	24.85	10.66

Concentrate product specification forecast from the schedule is as shown in the grade table below (Table 7).

Table 7: Concentrate product by stage

Mining Area	Stage 1	Stage 2	Total
Concentrate tonnes (Mt)	24.85	10.66	35.51
Fe %	57.04	57.31	57.12
SiO_2 %	3.75	3.64	3.72
Al_2O_3 %	3.65	3.65	3.65
Ti %	5.07	5.02	5.06
MgO %	3.26	3.23	3.25
K_2O %	0.10	0.10	0.10
CaO %	1.00	0.99	1.00
DTR* %	10.10	7.39	9.28
Fe Yield %	0.62	0.52	0.59
Mag Fe %	5.76	4.27	5.31
P %	0.11	0.10	0.11

*DTR is the estimate based analytical DTR and calculated DTR values.

4.0 ORE RESERVE STATEMENT

The Ore Reserve estimates were classified in accordance with the Australasian Code for Reporting of Identified Mineral Resources and Ore Reserves (JORC Code, 2012).   .

The Ore Reserves are based on the block model *sia_dtr_est_post_a_TRANS.bmf* and applicable modifying factors.

The Ore Reserves have been reported at 7.0% DTR cut-off grade with only Indicated resource category material used in the generation of these reserves, there is no measured resource material within the mining lease application area at this time. There is an estimated 35.5 Mt of recoverable concentrate product (56% Fe) within the lease application areas that have been scheduled for mining and processing as shown in Table 8.

Table 8: Probable Ore Reserves for TTR Mining Area Revision 2

Mining Area	Concentrate Tonnes (M)	Fe (%)	SiO_2 (%)	Cut-Off Used
Stage 1	24.85	57.04	3.75	7% DTR
Stage 2*	10.66	57.31	3.64	7% DTR
Total	**35.51**	**57.12**	**3.72**	**7% DTR**

*Stage 2 includes Taranaki (4% DTR cut-off)

The physical recovery has been applied to the models. Head grades and tonnages are for all material less than 2 mm in diameter. Concentrate grades are for the magnetically recoverable portion of the sample. Concentrate tonnage is calculated from the head tonnage and DTR.

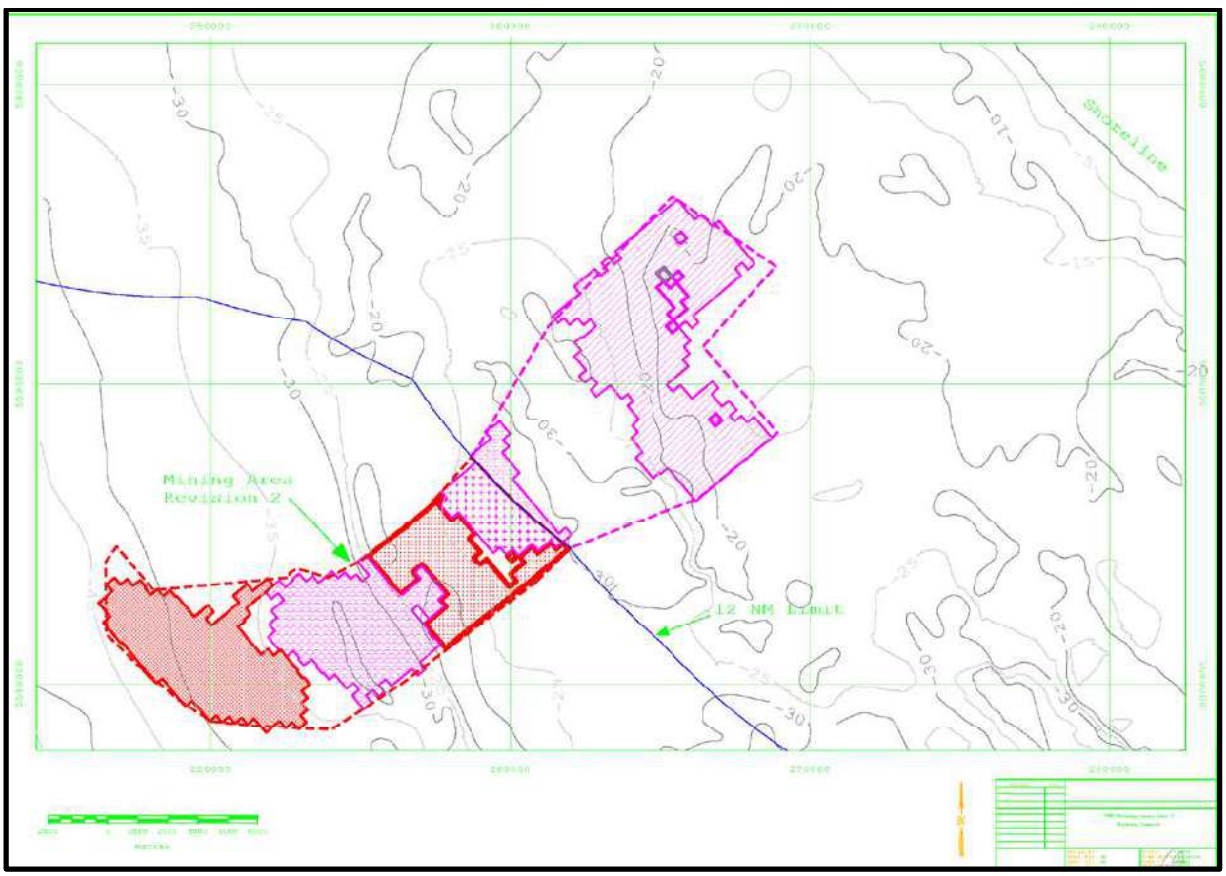

Figure 8: Mining Area Revision 2 location

The information in this report that relates to Ore Reserves is based on information compiled by Mr Glenn Turnbull who is a member of The Australian Institute of Mining and Metallurgy. Mr Glenn Turnbull is a full time employee of Golder Associates and has sufficient experience which is relevant to the engineering and economics of the types of deposits which are covered in this report and to the activity which he is undertaking to qualify as a Competent Person as defined in the 2012 edition of the 'Australian Code for Reporting of Exploration Results, Mineral Resources and Ore Reserves'.

Glenn Turnbull consents to the inclusion in this report of matters based on his information in the form and context in which it appears.

5.0 COMPLIANCE WITH THE JORC CODE ASSESSMENT CRITERIA

The JORC Code (2012) describes a number of criteria, which must be addressed in the documentation of Ore Reserves estimates, prior to public release of the information. These criteria provide a means of assessing whether or not parts of or the entire data inventory used in the estimate are adequate for that purpose. The Ore Reserves estimate stated in this document was based on the criteria set out in Table 1 of that Code.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Mineral Resource estimate for conversion to Ore Reserves	Description of the Mineral Resource estimate used as a basis for the conversion to an Ore Reserve. Clear statement as to whether the Mineral Resources are reported additional to, or inclusive of, the Ore Reserves.	The material being sampled is subsea sand originally deposited in marine and terrestrial environments. Indicated mineral resources of 35.5 Mt at 57.1% Fe concentrate have been identified across two mining area application regions. No inferred material is included within the TTRL planned mining area. The Mineral Resources are reported as wholly inclusive of the Ore Reserves.
Site visits	Comment on any site visits undertaken by the Competent Person and the outcome of those visits. If no site visits have been undertaken indicate why this is the case.	A site visit was made to the TTRL locality from the 23 November 2013 to the 27 November 2013 with Mr Matt Brown (TTR) and Mr Glenn Turnbull (Golder).
Study status	The type and level of study undertaken to enable Mineral Resources to be converted to Ore Reserves. The Code requires that a study to at least Pre-Feasibility Study level has been undertaken to convert Mineral Resources to Ore Reserves. Such studies will have been carried out and will have determined a mine plan that is technically achievable and economically viable, and that material Modifying Factors have been considered.	Previous onshore mining activities have been carried out in the Waipipi area, with shallow mineral exploitation having been abandoned in 1987 due to economic conditions. A Pre-Feasibility Study has been completed with the Ore Reserves part of this study.
Cut-off parameters	The basis of the cut-off grade(s) or quality parameters applied.	A 7% DTR cut-off grade has been used and was selected on the basis of $US80/t concentrate CFR (57% Fe) at an exchange rate of 0.82NZD:1USD.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Mining factors or assumptions	The method and assumptions used as reported in the Pre-Feasibility or Feasibility Study to convert the Mineral Resource to an Ore Reserve (i.e. either by application of appropriate factors by optimisation or by preliminary or detailed design). The choice, nature and appropriateness of the selected mining method(s) and other mining parameters including associated design issues such as pre-strip, access, etc. The assumptions made regarding geotechnical parameters (e.g. pit slopes, stope sizes, etc.), grade control and pre-production drilling. The major assumptions made and Mineral Resource model used for pit and stope optimisation (if appropriate). The mining dilution factors used. The mining recovery factors used. Any minimum mining widths used. The manner in which Inferred Mineral Resources are utilised in mining studies and the sensitivity of the outcome to their inclusion. The infrastructure requirements of the selected mining methods.	The method used to convert Mineral Resource to Ore Reserves is based upon a grade shell optimisation identifying the economic shell within which a practical mining design has been applied. The mining method chosen is a sub-sea crawler dredge feeding directly to an Integrated Mining Vessel (IMV), with the concentrate slurry being pumped to a Floating Storage and Offloading (FSO) vessel for transhipment to cargo carriers for export. The nature of the titano-magnetite deposit lends itself to dredge mining in defined lanes up to 11 m thick mining horizons. Several extraction lanes will be mined per mining block with a 1 m overlap at the edges of the lanes to ensure minimal material loss. A dredge system efficiency of 95% has been allowed for by allocating 5% of mineral depletion tonnes to losses. The operating design criteria have been provided by IHC. No specific mining dilution has been allowed for other than the combined losses allocated to the 5% system loss stated above. No Inferred material has been included within the mine design. The mining operation will require a purpose built sub-sea crawler dredge unit and dedicated mineral processing vessel.
Metallurgical factors or assumptions	The metallurgical process proposed and the appropriateness of that process to the style of mineralisation. Whether the metallurgical process is well-tested technology or novel in nature. The nature, amount and representativeness of metallurgical test work undertaken, the nature of the metallurgical domaining applied and the corresponding metallurgical recovery factors applied.	A dedicated purpose built process plant (IMV) is planned for the operation with the concentrate off loaded to a dedicated FSO vessel for transhipment for export. Bulk and laboratory sample tests have been carried out by Spectrachem/CRL with validation QA/QC samples carried out by Ultratrace (Perth). A process plant recovery of 92% of concentrate feed has been allowed based upon design criteria provided by TTR.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
	Any assumptions or allowances made for deleterious elements. The existence of any bulk sample or pilot scale test work and the degree to which such samples are considered representative of the orebody as a whole. For minerals that are defined by a specification, has the ore reserve estimation been based on the appropriate mineralogy to meet the specifications?	The Ore Reserve has been defined based upon an Iron concentrate product in excess of 56% Fe. Deleterious elements have been estimated as part of the processing stream with estimates for SiO_2, Al_2O_3, TiO_2, MgO, K_2O, CaO and P_2O_5 being included as concentrate product elements.
Environmental	The status of studies of potential environmental impacts of the mining and processing operation. Details of waste rock characterisation and the consideration of potential sites, status of design options considered and, where applicable, the status of approvals for process residue storage and waste dumps should be reported.	A Minerals Mining Permit was granted under the Crown Minerals Act (1991) on 2 May 2014 to undertake iron ore extraction and processing operations offshore from Patea in the South Taranaki Bight. In October 2013 TTR lodged a marine consent application under the Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 (EEZ Act) to the Environmental Protection Agency (EPA). ArgoEnvironmental have advised that there are no foreseen material reasons for the applications to be withheld. All likely environmental effects associated with the project have, as far as have been identified, been addressed by TTR.
Infrastructure	The existence of appropriate infrastructure: availability of land for plant development, power, water, transportation (particularly for bulk commodities), labour, accommodation; or the ease with which the infrastructure can be provided, or accessed.	TTR have commissioned IHC Merwede a global leader in Dredging solutions to design the IMV and sub-sea crawler dredging units.
Costs	The derivation of, or assumptions made, regarding projected capital costs in the study. The methodology used to estimate operating costs. Allowances made for the content of deleterious elements. The derivation of assumptions made of metal or commodity price(s), for the principal minerals and co- products.	Capital costs have been estimated from equipment suppliers for the purpose built process plant and infrastructure costs have been provided from the process engineering consulting company employed on the feasibility study. Royalty has been estimated based on the NZ Governments formula for calculating mining royalties for material extracted inside and outside the 12 Nautical Mile exclusion zone.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
	The source of exchange rates used in the study. Derivation of transportation charges. The basis for forecasting or source of treatment and refining charges, penalties for failure to meet specification, etc. The allowances made for royalties payable, both Government and private.	Processing, dredging, maintenance and operating costs have been provided by TTR based upon operational experience and estimates reviewed by De Beers Marine.
Revenue factors	The derivation of, or assumptions made regarding revenue factors including head grade, metal or commodity price(s) exchange rates, transportation and treatment charges, penalties, net smelter returns, etc. The derivation of assumptions made of metal or commodity price(s), for the principal metals, minerals and co-products.	Head grade and metal content are derived from the Mineral Resource and modifying factors described above. The financial analysis in this report is based on an Iron concentrate (>56% Fe) and 0.82 exchange rate. The Iron slurry concentrate will be transhipped from the FSO to cargo carriers for export to Asia and the far East.
Market assessment	The demand, supply and stock situation for the particular commodity, consumption trends and factors likely to affect supply and demand into the future. A customer and competitor analysis along with the identification of likely market windows for the product. Price and volume forecasts and the basis for these forecasts. For industrial minerals the customer specification, testing and acceptance requirements prior to a supply contract.	Historical Iron concentrate price and forward looking estimates have been used for the iron concentrate price. Price flexing has been carried out to determine the robustness of the project viability.
Economic	The inputs to the economic analysis to produce the net present value (NPV) in the study, the source and confidence of these economic inputs including estimated inflation, discount rate, etc. NPV ranges and sensitivity to variations in the significant assumptions and inputs.	Inputs to economic analysis include factors described above including ore & metal quantities from mining/processing schedule, (incl. described recovery/processing parameters), cost quotes & estimates and price assumptions.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Social	The status of agreements with key stakeholders and matters leading to social licence to operate.	Applications for iron ore extraction and processing have been lodged with the New Zealand government and a decision is expected in early 2014. In July 2013 TTR applied for mining permit 55581 for the South Taranaki Bight Project. In October 2013 TTR applied for marine consents under the new Exclusive Economic Zone and Continental Shelf (Environmental Effects) Act 2012 for this area.
Other	To the extent relevant, the impact of the following on the project and/or on the estimation and classification of the Ore Reserves: Any identified material naturally occurring risks. The status of material legal agreements and marketing arrangements. The status of governmental agreements and approvals critical to the viability of the project, such as mineral tenement status, and government and statutory approvals. There must be reasonable grounds to expect that all necessary Government approvals will be received within the timeframes anticipated in the Pre-Feasibility or Feasibility study. Highlight and discuss the materiality of any unresolved matter that is dependent on a third party on which extraction of the reserve is contingent.	TTR holds a Continental Shelf Act prospecting licence in the exclusive economic zone in the South Taranaki Bight and a Crown Minerals exploration permit offshore between Oeo and Patea. TTR has applied for subsequent offshore exploration permits under the Crown Minerals Act for iron sands between Patea and Santoft, and between the Waikato River and Awakino on the west coast of the North Island.
Classification	The basis for the classification of the Ore Reserves into varying confidence categories. Whether the result appropriately reflects the Competent Person's view of the deposit. The proportion of Probable Ore Reserves that have been derived from Measured Mineral Resources (if any).	Indicated Resources have been converted to Probable Ore Reserves. There are no Measured Mineral Resources within the Mining Area Revision 2 mining application area. The estimated Ore Reserves and mining method are in the opinion of the Competent Person appropriate for this style of deposit.
Audits or reviews	The results of any audits or reviews of Ore Reserve estimates.	All inputs to the estimation of Ore Reserves have been subject to internal reviews.

JORC Code, 2012 Edition – Table 1, Section 4 Estimation and Reporting of Ore Reserves		
Discussion of relative accuracy/confidence	Where appropriate a statement of the relative accuracy and confidence level in the Ore Reserve estimate using an approach or procedure deemed appropriate by the Competent Person. For example, the application of statistical or geostatistical procedures to quantify the relative accuracy of the reserve within stated confidence limits, or, if such an approach is not deemed appropriate, a qualitative discussion of the factors which could affect the relative accuracy and confidence of the estimate. The statement should specify whether it relates to global or local estimates, and, if local, state the relevant tonnages, which should be relevant to technical and economic evaluation. Documentation should include assumptions made and the procedures used. Accuracy and confidence discussions should extend to specific discussions of any applied Modifying Factors that may have a material impact on Ore Reserve viability, or for which there are remaining areas of uncertainty at the current study stage. It is recognised that this may not be possible or appropriate in all circumstances. These statements of relative accuracy and confidence of the estimate should be compared with production data, where available.	The assessment of relative accuracy using statistical or geostatistical techniques is not considered appropriate. The local estimate of Ore Reserves available for technical and economic evaluation is 35.5 Mt of Iron Concentrate (>56% Fe). There are no additional factors or areas of uncertainty remaining to be disclosed which could have material adverse impacts on project viability.

The summary in Table 9 shows the probable Ore Reserves for the Mining Area Revision 2 for the first and second stage of mining.

Table 9: Probable Reserves – Mining Area revision 2 (Stage 1 – Outside of 12NM, Stage 2 – Inside of 12NM)

Mining Area	Conc' (Mt)	Fe %	SiO_2 %	Al_2O_3 %	Ti %	MgO %	K_2O %	CaO %	DTR* %	Fe Yield %	Mag Fe %	P %
Stage 1	24.85	57.04	3.75	3.65	5.07	3.26	0.10	1.00	10.10	0.62	5.76	0.11
Stage 2	10.66	57.31	3.64	3.65	5.02	3.23	0.10	0.99	7.39	0.52	4.27	0.10
Total	**35.51**	**57.12**	**3.72**	**3.65**	**5.06**	**3.25**	**0.10**	**1.00**	**9.28**	**0.59**	**5.31**	**0.11**

6.0 CONCLUSIONS AND RECOMMENDATIONS

The sub-sea titano magnetite deposit being considered by TTR for seaborne exploitation is an extension of the land based titano magnetite sands formerly worked at Waipipi.

Further exploration and sampling of the marine deposits in the South Taranaki bight would be expected to further increase the mineable potential of similar deposits in the vicinity.

7.0 LIMITATIONS

Your attention is drawn to the document “Limitations”, which is included in Attachment A of this letter report. The statements presented in this document are intended to advise you of what your realistic expectations of this letter report should be, and to present you with recommendations on how to minimise the risks associated with this project. The document is not intended to reduce the level of responsibility accepted by Golder Associates, but rather to ensure that all parties who may rely on this letter report are aware of the responsibilities each assumes in so doing.

GOLDER ASSOCIATES PTY LTD

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Attachments: A – Limitations

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ATTACHMENT A

Limitations

LIMITATIONS

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