SANDPIPER PROJECT

Verification Programme Report: Mining Licence Area No. 170

SECTION B:

IMPACT ASSESSMENT VERIFICATION

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SECTION B
IMPACT ASSESSMENT VERIFICATION

B1.1 Water Column and Sediments
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B2.0 Cumulative Effects

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CONDITIONS OF USE OF THIS REPORT

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SUMMARY

The verification programme addresses the impacts associated with dredging within the target dredge area SP-1.

The Environmental Impact Assessment (of 2012) concluded, "***The opinion of the specialists and the independent reviewer is that there are presently no identified issues of environmental significance to preclude the dredging of phosphate-enriched sediments from the Mining Licence Area No. 170. In order to verify these conclusions, a programme of work specified by the relevant specialists, has been included in the Environmental Management Programme that will be undertaken prior to the commencement of dredging to substantiate the findings provided in the impact assessment. Going forward, all environmental matters will need to be managed through the environmental management plan."***

An expanded verification programme was undertaken following discussions with and information provided by external reviewers, (as commissioned by the Environmental Commissioner, MET) MFMR and I&APs) during 201 and 2014. NMP's specialist consultants and the independent reviewing parties confirm, based on the results of the verification programme that the assessments as presented in the EIA (2012) are reliable and that these assessments now can be reported with a high degree of confidence.

The impacts assessed in the 2012 EIA are reassessed here. Details of various specialist assessments that allowed for the confirmation of the impact risk and its significance are to be found in the individual specialist reports (Section C). The content and approach to the verification programme and its findings have been subjected to:

1. Independent peer review of the specialist study reports, supporting studies and documentation;
2. Independent review by the University of Namibia of the processes followed during the undertaking of the Verification Programme; and,
3. Independent review of the Verification Programme Report by the CSIR.

The full scope of the verification programme is detailed in Section D, Appendix 4, with the specialists' assessments reported in Section C. The programme considered three main categories of assessment, including:

- Water column and sediments;
- Fish, mammals and seabirds; and,
- Benthic fauna.

These three main categorises of assessment, included a several integrated programmes. A verification programme related to jellyfish (which were assessed in the EIA of 2012) was not undertaken, primarily because of the significance of the four impacts assessed being reported as low (2) and very low (2). However, the impact tables for jellyfish are presented here, since the general outcome of the verification programme has information relevant to the impact assessment of jellyfish.

The verified impact statements of the respective specialists are presented in this section. All confirmed their original assessments with a greater degree of confidence as determined from site-specific data.

Overall the level of confidence in the original assessment has been raised from medium to high. Some of the original assessments are unchanged because they were deemed to be of low or no significance with the confidence level being high. A key change with respect to the assessment of fisheries impacts is the reduction of the extent (area of influence) from that of the MLA (2233 km^2) to the specific site SP-1 dredge site (176 km^2).

The significance ratings of the impacts re-evaluated following the completion of the verification programme are presented in the table on pages viii to xi.

Water Column and Sediments: Summary of impact assessment determinations: Re-evaluated following the verification assessment.

Reference table number refers to the individual impact table number found in the specialists section.

Ref. Tbl No.	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	1.1.9	1.1.10	1.1.11
Risk Area	**Vessel Operation**		**Overspill discharge**					**Seabed dredging**			
Impact	**Pollution from wastes**	**Alien spp. in ballast water**	**Turbid plume**	**H_2S toxicity at surface**	**Oxygen deficient water at surface**	**Nutrients added at surface**	**Trace/heavy-metal toxicity at surface**	**Trace-metal toxicity on seabed**	**H_2S toxicity on seabed**	**Lowered oxygen levels on seabed**	**Increase of H_2S flux.**
Extent	Dredge area	National	Dredge area	Dredge area	Dredge area	Dredge area	Dredge area	Annual Mining Area	Dredge area	Annual Mining Area	Dredge area
Duration	Very short term	Short term to permanent	Very short term	Short term	Very short term	Short term	Short term	Short term	Medium term	Medium term	Medium term.
Intensity	No lasting effect	None to serious	No lasting effect	Minor effects	No lasting effect	No lasting effect	Minor effects	Minor effects	Minor effects	Minor effects	Minor effects
Probability	Possible	Possible	Possible	Possible	Improbable	Possible	Possible	Possible	Possible	Possible	Improbable
Status	Negative	Negative	Negative	Negative	Negative	Neutral	Negative	Negative	Negative	Negative	Negative
Significance (no mitigation)	None	Can be high	Low	Low	Low	None	Low	Low	Low	Low	Low
Mitigation	System maintenance	IMP guidelines	Built in	None possible	Non	None possible	None possible	None possible	None possible	Not possible	n/a
Significance (with mitigation)	None	None	Low	Low	Low	None	Low	Low	Low	Low	Low
Confidence level 2012	High	High	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium
Re-evaluated 2014 confidence level	**High**	**High**	**High**	**High**	**High**	**High**	**High**	**High**	**High**	**High**	**High**
Reason	MARPOL 73/78 discharge standards apply	IMO guidelines for ballast water apply	Dredge area >20mg/ℓ suspended sediment concentration. Plume disperses 1 to 2 days	Mine site sediment property data indicate low H_2S presence, pyrite sulphide will have low solubility	Mixing factors are therefore <1%; and dissolved oxygen concentration reductions will be negligible (<0.1ml/ℓ).	Mine site sediment pore water volumes are low	Mine area Heavy metals have low solubility and bioavailability, trophic transfers are attenuated at primary consumer level	Mine area Heavy metals have low solubility and bioavailability, dredging should not increase exposures	Mine site sediment property data indicate low H_2S presence	POM in sediments is relatively refractory	Mine site sediment property data indicate low H_2S presence and release from iron pyrites should be low.

Fish Mammals and Seabirds: Summary of impact assessment determinations: Re-evaluated following the verification assessment.

Reference table number refers to the individual impact table number found in the specialists section.

Ref. Tbl No.	1.2.1	1.2.2	1.2.3	1.2.4	1.2.5
Risk Area	**Seabed dredging: Fish Mammals and Seabirds**				
Nature of the impact	Fishing operations	Ecologically important species	Recruitment of key commercial species	Biodiversity	Seabirds and Mammals
Extent 2012	MLA	MLA	MLA	MLA	MLA
Extent re assessed 2014	**Specific mine site**	**Specific mine site**	**MLA**	**Specific mine site**	**Specific mine site**
Duration	Long term	Permanent	Permanent	Permanent	Long term
Intensity	Serious effect	Moderate effect	Minor effect	Minor effect	Minor effect
Probability	Definite	Highly probable	Improbable	Improbable	Probable
Status (- ve of + ve)	Negative	Negative	Negative	Negative	Negative
Significance (no mitigation)	Medium	Medium	Low	Low	Medium
Significance (with mitigation)	Medium to low	Medium	Low	Low	Low
Confidence level 2012	High	Low to medium	Low to medium	Low to medium	Medium
Re-evaluated 2014 confidence level	**High**	**High**	**High**	**High**	**High**

Macrofauna: Summary of impact assessment determinations: Re-evaluated following the verification assessment.

Reference table number refers to the individual impact table number found in the specalists section.

Ref. Tbl. No.	1.3.1	1.3.2	1.3.3	1.3.4	1.3.5	1.3.6	1.3.7	1.3.8	1.3.9
Risk Area	**Seabed dredging: Benthic Macrofauna**								
Nature of the impact	**Sediment removal: benthos re establishment**	**Exploration activities and removal of benthos**	**Change of hydrographical conditions**	**Removal of sulphur oxidizing mats**	***Clostridium botulinum exposure***	**Sediment smothering benthos: Drag head**	**Benthos smothering: Dredge overspill plume**	**Nutrients added at surface: overspill plume**	**Increase of H_2S flux.**
Extent	Dredge area	Dredge area	Specific mine site	Specific mine site	Specific mine site	Dredge area	Local to regional	Local	Local
Duration	Long term >20 years	Short term	Long term >20 years	Medium to long term	Sort term	Very short	Very short	Very short	Short term
Intensity	Moderate to serious	No lasting effects	Moderate to serious	Moderate to minor	Serious	Minor	Minor	Minor	Moderate
Probability	Definite	Probable	Probable	Improbable	Improbable	Highly probable	Probable	Possible	Probable
Status	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative	Negative
Significance (no mitigation)	Medium	Non	Medium	Low	Low	Low	Low	Low	Low
Mitigation	Leave residual sediment layer / un mined areas	None required	Leave residual sediment layer / un mined areas	Non	Non	Non	Non	Non	Non
Significance (with mitigation)	Medium	None required	Low to Medium	Low	Low	None necessary	Low	Low	Low
Confidence level 2012	Medium	High	Medium	Medium	Medium	High	Medium	Medium	Medium
Re-evaluated 2014 confidence level	**High**	**No change**	**High**	**High**	**No change**	**No change**	**No change**	**High**	**High**

Jellyfish. Summary of impact assessment determinations: A verification assessment specifically related to jellyfish was not undertaken.

Reference table number refers to the individual impact table number found in the specialists section.

Ref. Tbl No.	1.4.1	1.4.2	1.4.3	1.4.4
Risk Area	**Dredging: Jellyfish**			
Nature of the impact	Blocking sea water intakes of vessel	H_2S mortalities to Jellyfish	Turbidity cause mortalities	Hard substrate exposed
Extent	Dredge event	Dredge event	Dredge event	Annual mining area
Duration	Extremely short term	Extremely short term	Extremely short term	Very short term
Intensity	No lasting effects	No lasting effects	Minor effects	Minor effects
Probability	Highly probable	Possible	Rare	Rare
Status (- ve of + ve)	Negative (to Jellyfish)	Negative (to Jellyfish)	Negative (to Jellyfish)	Positive (to jellyfish)
Significance (no mitigation)	Low	Low	Very low	Low
Significance (with mitigation)	Very low	Low	Very low	Very low
Confidence level 2012	High	Low	Low	High
Re-rated 2014 confidence level	**High**	**Low**	**Low**	**High**

Introduction

In September 2011 an impact assessment for the proposed offshore phosphate dredging project was initiated and submitted to the Environmental Commissioner on 12 of April 2012. Following processes guided by the office of the Environmental Commissioner and the management commitments of the 2012 EMP, Namibian Marine Phosphate undertook through their specialist consultants a Verification Programme during 2013 to 2014. The impacts as described in the EIA of 2012 were reconsidered in light of the information gathered during the Verification Programme. The collection and interpretation of these site-specific data (collected from within ML 170, primarily the target dredge site SP-1) has served to increase the robustness of the determinations by the specialists, where they now can confirm with a high degree of confidence their assessments made in 2012.

Within this section an effort has been made to provide an all-inclusive report, eliminating the need for the reader and reviewers to consult the 2012 EIA. However, that EIA was a significant report in its own right, and should not be overlooked.

The assessment of impacts is the primary component of an environmental impact assessment (EIA). Impacts are evaluated at the individual and at the project level. The Environmental Commissioner by issuing the Environmental Clearance Certificate (Record of Decision) becomes the final assessor of risk at both the individual and the project level. These risks / impacts (residual) are managed through the requirements listed in the Environmental Management Plan (EMP). The EMP is a dynamic document, containing performance criteria that may be adjusted as a result of findings of the monitoring programme detailed in the EMP. These adjustments require motivation both from the licence holder and approval by the regulatory authorities.

The potential primary project level risks (impacts) have been identified as:

1. Possible release of toxins (from the exposed sediments) into the water column from dredge overspill (tailings plume) or from a benthic plume generated from the engagement of the dredge suction and cutting head with the seabed sediments. The primary concerns here being: contamination of the water column, contamination of the fauna and flora that live within it, and the consequences to the ecosystem, to other users, i.e. the fishing industry, and the population that it serves;
2. The removal of marine sediments (dredging of the seabed) and the loss of the functions and services that this area of sediment provides to the ecosystem and consequently a loss of benefits to the users of these services. Primarily this is the fishing industry and the population that it serves;
3. The intrinsic loss of natural (undisturbed) ecosystem functions and services caused by the dredging project.

Project level risks (impacts) are evaluated by considering the individual level risks (impacts) and the determined significance of these risks (impacts). The individual risks (impacts) and their significance originally were assessed in the 2012 EIA. The significance of the impact was determined from the combined assessment of the following criteria: 1) Extent; 2) Duration; 3) Intensity; and 4) Probability. The criteria for assessment of 1 to 4 against which each of the impacts are evaluated is presented in Table 1.0.

The significance assessment of the risks (impacts) at the project and individual levels were collectively identified as being medium to low (risk). A criticism of these determinations was that there were

inadequate data collected from the Mining Licence Area (ML 170) and target dredge sites (SP-1, SP-2 and SP-3) to ensure confidence in the assessments provided. This criticism levelled at the impact assessments by external review parties and the authorities was shared in varying degrees (dependent on the individual impact assessed and the source of information for its determination) by the consultants who assessed the risks (impacts). This is reflected in the levels of confidence (in their assessment) that the consultants expressed for the particular impact assessed.

Overall the level of confidence in the original assessments has been raised from medium to high. Some of the original assessments are unchanged because they were deemed to be of low or no significance with the confidence level being high. A key change with respect to the assessment of fisheries impacts is that the reduction of the extent (area of influence) from that of the MLA (2233 km^2) to the specific site SP-1 dredge site (176 km^2).

The varying levels of confidence can be ascribed to the paucity of site-specific data on which the interpretations were made. Despite this the consultants determined that their assessments were robust. Steffani in her assessment of the benthic macrofauna comments *"In general, the confidence level in the assessments is medium, as most of the impact evaluations are based on assumptions that are derived from publicly available literature data, whereas data from ML 170 itself are very limited. A verification survey is therefore critical to confirm these assumptions."* This sentiment was similarly expressed by the rest of the consultant team.

The Verification Programme was undertaken to collect data from the target dredge area (SP-1), in order that the specialist consultants could re-evaluate (improve the level of confidence) their findings as detailed in the 2012 EIA. Not only did these data allow for the improvement of the levels of confidence in the assessed work but importantly will allow the authorities, external review parties, and I&APs to re-assess their criticisms of the original 2012 EIA.

In the following sections the impact tables from the 2012 EIA are reproduced in their original format, with the findings of 2012 listed against those of the 2013 – 2014 verification assessment.

Impact Criteria

In order that the reader is not required to consult the original EIA (2012), the criteria for the assessment of significance is replicated in this section.

The Assessment Procedure and the Determination of Significance

To ensure consistency in the evaluation of the impacts the specialists were provided with a set of definitions to apply for their determination of the significance of the impacts. In consultation with the specialists the set of definitions was revised from that detailed in the scoping report. This was done so as to accommodate for the extreme scales of potential impacts as identified during their investigations. The specialists in their evaluation of the impacts applied the revised definitions. The impact assessments are based on the professional opinions of the specialists, fieldwork and desk top analysis (available information). The definitions are identified as robust and in line with commonly applied impact criteria used in Southern Africa and recognised internationally.

The following methods have been used to determine the significance rating of impacts identified in this specialist study:

1. Description of impact - reviews the type of effect that a proposed activity will have on the environment;
2. What will be affected; and
3. How will it be affected.

Points 1 to 3 above are to be considered / evaluated in the context of the following impact criteria:

- *Extent*;
- *Duration*;
- *Probability*; and
- *Intensity / magnitude*.

These impact criteria are to be applied as prescribed in the table below:

Table 1.0: Impact Criteria

Impact Criteria:						
Extent	**Dredge Area** Per vessel cycle i.e. ~66,000 m^2 or 6.6 ha	**Annual Mining Area** Up to 3 km^2	**Specific Mine Site** (SP1 or SP2) each is 22x8 km or 176 km^2	**Local** 25-50 km or 2,000 km^2- 8,000 km^2	**Regional** 50-100 km or 8,000 km^2 – 30,000 km^2	**National** 100 km to EEZ (200 nautical miles)[1] 100 to 370 km, or >30,000 km^2

Duration	**Very Short Term** 3 days	**Short term** 3 days – 1 year	**Medium term** 1 - 5 years	**Long term** 5 – 20 years	**Permanent** > 20 years (life of mine)

Intensity/ Magnitude	**No lasting effect** No environmental functions and processes are affected	**Minor effects** The environment functions, but in a modified manner	**Moderate effects** Environmental functions and processes are altered to such extent that they temporarily cease	**Serious effects** Environmental functions and processes are altered to such extent that they permanently cease
Probability	**Improbable**	**Possible**	**Probable**	**Highly Probable/ Definite**

The status of the impacts and degree of confidence with respect to the assessment of the significance are stated as follows:

Status of the impact: A description as to whether the impact is positive (a benefit), negative (a cost), or neutral.

Degree of confidence in predictions: The degree of confidence in the predictions, based on the availability of information and specialist knowledge. This has been assessed as high, medium or low.

Based on the above considerations, the specialist provides an overall evaluation of the significance of the potential impact, which is described as follows:

[1] 1 nautical mile = 1,85 kilometres

	None	Low	Medium	High
Impact Significance	A concern or potential impact that, upon evaluation, is found to have no significant impact at all.	Any magnitude, impacts will be localised and temporary Accordingly the impact is not expected to require amendment to the project design	Impacts of moderate magnitude locally to regionally in the short term Accordingly the impact is expected to require modification of the project design or alternative mitigation	Impacts of high magnitude locally and in the long term and/or regionally and beyond Accordingly the impact could have a 'no go' implication for the project unless mitigation or re-design is practically achievable

Furthermore, the following are being considered:

- Impacts are described both **before** and **after** the proposed **mitigation** and management measures have been implemented;
- Where possible the impact evaluation takes into consideration the **cumulative effects** associated with this project. Cumulative impacts can occur from the collective impacts of individual minor actions over a period of time and can include both direct and indirect impacts;
- **Mitigation / management actions:** Where negative impacts were identified, the specialists specified practical mitigation measures (i.e. ways of avoiding or reducing negative impacts); and
- **Monitoring (forms part of mitigation):** Specialists recommend monitoring requirements to assess the effectiveness of mitigation actions, indicating what actions are required, the timing and frequency thereof.

B1.1 VERIFIED ASSESSMENT OF IMPACTS: SEDIMENTS AND WATER COLUMN

The verification programme addresses the impacts associated with dredging within the target dredge site SP-1.

INTRODUCTION

The Sediments and Water Column Specialist Study (Carter in Midgely, 2012) conducted within the framework of the 2012 EIA identified impacts to the water column and sediments that can be expected from the proposed Sandpiper Phosphate Project and assessed their significance. For seven of the impacts assessed, the confidence levels were only rated medium since data directly from the target area (SP-1) were lacking. The verification survey was specifically designed to tackle this issue, and to verify whether the assessment rating will remain unchanged in view of the newly acquired empirical data. These data were primarily of a biogeochemical nature and are dealt with in the Verification Survey Programme Report (Section C, Chapter C2.0). A series of eleven impact tables which present the impacts as they were assessed in original 2012 EIA and as re-evaluated using site-specific information gathered during 2013 are presented below.

A total of eleven negative impacts were identified in the original assessment study with six impacts having medium significance, and the remainder high. In sum, all changes to the original assessments centre on the level of confidence, increasing the level from medium to high as the verification survey largely confirmed the assumptions on which the assessments were based. This applied to six of the impact assessments while four remained unchanged.

Table 1.1: Water Column and Sediments. Summary of impact assessment determinations: Re-evaluated following the verification assessment. Reference table number refers to the individual impact table number found in the specialists section.

Ref. Tbl No.	1.1.1	1.1.2	1.1.3	1.1.4	1.1.5	1.1.6	1.1.7	1.1.8	1.1.9	1.1.10	1.1.11
Risk Area	**Vessel Operation**		**Overspill discharge**					**Seabed dredging**			
Impact	**Pollution from wastes**	**Alien spp. In ballast water**	**Turbid plume**	**H_2S toxicity at surface**	**Oxygen deficient water at surface**	**Nutrients added at surface**	**Trace/heavy-metal toxicity at surface**	**Trace-metal toxicity on seabed**	**H_2S toxicity on seabed**	**Lowered oxygen levels on seabed**	**Increase of H_2S flux.**
Extent	Dredge area	National	Dredge area	Dredge area	Dredge area	Dredge area	Dredge area	Annual Mining Area	Dredge area	Annual Mining Area	Dredge area
Duration	Very short term	Short term to permanent	Very short term	Short term	Very short term	Short term	Short term	Short term	Medium term	Medium term	Medium term.
Intensity	No lasting effect	None to serious	No lasting effect	Minor effects	No lasting effect	No lasting effect	Minor effects	Minor effects	Minor effects	Minor effects	Minor effects
Probability	Possible	Possible	Possible	Possible	Improbable	Possible	Possible	Possible	Possible	Possible	Improbable
Status	Negative	Negative	Negative	Negative	Negative	Neutral	Negative	Negative	Negative	Negative	Negative
Significance (no mitigation)	None	Can be high	Low	Low	Low	None	Low	Low	Low	Low	Low
Mitigation	System maintenance	IMP guidelines	Built in	None possible	Non	None possible	None possible	None possible	None possible	Not possible	n/a
Significance (with mitigation)	None	None	Low	Low	Low	None	Low	Low	Low	Low	Low
Confidence level 2012	High	High	High	Medium	High	Medium	Medium	Medium	Medium	High	Medium
Re-evaluated 2014 confidence level	High	High	High	High	High	High	High	High	High	High	High
Reason	MARPOL discharge standards apply	IMO guidelines for ballast water apply	Dredge area >20 mg/ℓ suspended sediment concentration. Plume disperses 1 to 2 days	Mine site sediment property data indicate low H_2S presence, pyrite sulphide will have low solubility	Mixing factors are therefore <1%; and dissolved oxygen concentration reductions will be negligible (<0.1 ml/ℓ).	Mine site sediment pore water volumes are low	Mine area Heavy metals have low solubility and bioavailability, trophic transfers are attenuated at primary consumer level	Mine area Heavy metals have low solubility and bioavailability, dredging should not increase exposures	Mine site sediment property data indicate low H_2S presence	POM in sediments is relatively refractory	Mine site sediment property data indicate low H_2S presence and release from iron pyrites should be low.

Table 1.1.1 Impact 1: Discharge to Sea of Ships Wastes: Potential impact of releasing vessel wastes into the sea.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment.

Nature of the impact	**1: Potential deterioration in water quality from discharges to sea of wastes such as oily water, sewage, food, grey water, from the dredger.**
Extent	Within the actual **dredge area** per event (~6.6 ha)
Duration	The effects of the event are "**very short**" because normal mixing would rapidly dilute the discharge material
Intensity	**No lasting effect**, because effects will not be measurable.
Probability (of pollution)	**Possible**
Status	**Negative**
Significance (no mitigation)	**None**
Mitigation	Ensure vessel discharge systems are in good working order and do not malfunction.
Significance (with mitigation)	**None**
Confidence level	**High**

Explanation: (Table 1.1.1: Impact 1)

Original EIA – Impact assessment
Discharges to sea from the dredger of wastes such as oily water, sewage, food and grey water occur under normal ship operations. These wastes are controlled in terms of MARPOL, to which convention Namibia is a signatory. This limits what can be disposed of to sea, and specifies monitoring and record keeping required. Therefore compliance with these regulations will, under normal operating conditions, limit *pollution* effects in the water column.

Post Verification Programme – Re-evaluated impact assessment
A re-evaluated assessment of this impact was not required in terms of the scope of the verification programme. The original assessment stands.

Table 1.1.2 Impact 2: Exchange of Ballast Water: Alien marine species may displace indigenous species and reduce indigenous biodiversity.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment.

Nature of the impact	**2: Alien marine species may displace indigenous species and reduce indigenous biodiversity and/or affect aquaculture and/or aquaculture products.**
Extent	**National**: introduced aliens can spread throughout central and northern Namibia (from the Lüderitz upwelling cell to the Angola Benguela front).
Duration	**Unknown**, depends on the introduced organisms but likely to be very long term or permanent when an introduced alien becomes invasive
Intensity	**None to serious.** Unknown, depends on behaviour of the introduced organisms.
Probability	**Possible** (i.e. it can occur)
Status	**Negative**
Significance (no mitigation)	Can be high – ecosystem changing
Mitigation	Follow IMO guidelines on ballast water management
Significance (with mitigation)	**None.** (Alien introductions would become "improbable" but if introductions were to occur the consequences (significance) would still be high).
Confidence level	**High**

Explanation: (Table 1.1.2: Impact 2)

Original EIA – Impact assessment

The dredger to be used will probably be travelling unladen into the mining area from a foreign port. For safe navigation it will have taken on ballast water which will be gradually discharged during the initial dredging cycle. Uncontrolled ballast water discharges have been identified as important vectors for alien and/or noxious species (IMO, http://www.imo.org).

Post Verification Programme – Re-evaluated impact assessment
A re-evaluated assessment of this impact was not required in terms of the scope of the verification programme. The original assessment stands.

Table 1.1.3 Impact 3: Increased Suspended Sediment Concentrations: Dredging generates plumes of suspended sediments that adversely affect organisms in the water column.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment.

Nature of the impact	**3: Dredging generates plumes of suspended sediments that adversely affect organisms in the water column**
Extent	**Dredge Area** - > 20 mg/ℓ suspended sediment concentration
Duration	**Very short term** – plume disperses within 1-2 days
Intensity	**No lasting effect** – within water quality guidelines for suspended sediment (chronic effects ensue after 3 days exposure to > 20 mg/ℓ)
Probability	**Possible**
Status	**Negative**
Significance (no mitigation)	**Low**
Mitigation	Built in, with discharge below dredger's hull (10-15 m below sea surface)
Significance (with mitigation)	**Low**
Confidence level	**High**

Explanation: (Table 1.1.3: Impact 3)

Post Verification Programme – Re-evaluated impact assessment
A re-evaluated assessment of this impact was not required in terms of the scope of the verification programme. The original assessment stands.

Table 1.1.4 Impact 4: Changed Biogeochemical Properties of near Surface Waters: Sulphidic sediment pore-water entrained in the dredged sediment is discharged with the over-spill water.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment after the verification programme (right column).

Nature of the impact	**4: Sulphidic sediment pore-water entrained in the dredged sediment is discharged with the over-spill water thereby affecting organisms in the water column**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area** – the amount of H_2S entrained will be minimal due to predicted low concentrations in the target dredge sediments.	b – the amount of H_2S entrained will be minimal due to apparent low concentrations in the target dredge sediments evident from proxy measurements.
Duration	**Short term** – because entrained H_2S will de-gas in the dredger hopper (turbulence) and rapidly dilute if released to the upper water column; however if toxicity effects do occur recovery periods can be longer than 3 days but definitely less than 1 year.	
Intensity	**Minor effects** – there may be short term toxicity effects on plankton (regeneration rates for plankton are days to weeks)	
Probability	**Possible**	
Status	**Negative**	
Significance (no mitigation)	**Low**	
Mitigation	None possible	
Significance (with mitigation)	**Low**	
Confidence level	**Medium** – the assessment relies on a prediction of a low H_2S concentration in the target dredge area sediments.	
Confidence level Post Verification Assessment		**High**: Mine site sediment property data indicate low H_2S presence, pyrite sulphide will have low solubility

Explanation: (Table 1.1.4: Impact 4)

Post Verification Programme – Re-evaluated impact assessment

Measurements of mine site sediment properties indicate that the probability of the presence of appreciable concentrations of H_2S in the sediments is low. This empirical data for the site supports the conclusions initially reached in the 2012 EIA assessment. Evaluations of potential sulphide generation from oxidation of iron pyrite following translocation of seabed sediments to the upper water column in the dredging process indicate that negligible amounts will be liberated and that associated effects on dissolved oxygen concentrations will be minimal. The latter is due to elemental sulphur being the end-point of the oxidation of sulphide as opposed to sulphate.

Table 1.1.5 Impact 5: Changed Biogeochemical Properties of Surface Waters: Potential impact of lower oxygen levels in overflow water.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment.

Nature of the impact	**5: Hypoxic/ anoxic bottom water is entrained in the discharged overflow water so reducing dissolved oxygen concentrations in the upper water column where it can affect organisms.**
Extent	**Dredge area**
Duration	**Very short – as mixing will reduce the oxygen debt.**
Intensity	**No lasting effect** – in a worst case scenario approximately 31 680 m^3 of anoxic water may be discharged along a 4 km long dredge path during dredging. This will be mixed into approximately $5x10^6$ m^3 of normal oxic water. Mixing factors are therefore <1%; and dissolved oxygen concentration reductions will be negligible (< 0.1 ml/ℓ). Such levels are not generally measurable at sea.
Probability	**Improbable**
Status	**Negative**
Significance (no mitigation)	**None**
Mitigation	N/a
Significance (with mitigation)	**None**
Confidence level	**High**

Explanation: (Table 1.1.5: Impact 5)

Original EIA – Impact assessment
In a worst case scenario approximately 31 680 m^3 of anoxic water may be discharged along a 4 km long dredge path during dredging. This will be mixed into approximately $5x10^6$ m^3 of normal oxic water. Mixing factors are therefore <1%; and dissolved oxygen concentration reductions will be negligible (< 0.1 ml/ℓ).

Post Verification Programme – Re-evaluated impact assessment
A re-evaluated assessment of this impact was not required in terms of the scope of the verification programme. The original assessment stands.

Table 1.1.6 Impact 6: Changed Biogeochemical Properties of Surface Waters: Potential impact of higher nutrient levels in overflow water.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment of the verification programme (right column).

Nature of the impact	**6: Increased availability of nutrients (ammonium and phosphorus) promote phytoplankton growth. Following senescence, the phytoplankton will add to the POM flux to the seabed eventually further reducing dissolved oxygen concentrations through remineralisation**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area**	
Duration	**Short term**	
Intensity	**No lasting effect** (silicate is probably the limiting nutrient for diatoms)	**No lasting effect (**silicate is probably the limiting nutrient for diatoms) and amounts of nutrients transferred to the euphotic zone will be low due to low pore water volumes
Probability	**Possible**	
Status	**Neutral**	
Significance (no mitigation)	**None**	
Mitigation	None possible	
Significance (with mitigation)	**None**	
Confidence level	**Medium** – due to there being no nutrient data specific to the proposed dredging areas	
Confidence level Post Verification Assessment		**High**: Mine site sediment pore water volumes are low

Explanation: (Table 1.1.6: Impact 6)

Post Verification Programme – Re-evaluated impact assessment

Measurements of sediment properties in the proposed dredge site show that the subsurface sediment pore water contained moderate nitrate-nitrogen concentrations but high phosphate-phosphorus concentrations and that the pore waters showed a considerable departure from the water column Redfield ratio observed in the survey area (8.2 vs 17.7) The measured moisture content of the sediment was low, however, indicating that the affected pore water volume is also low (~35 litres/m^3 sediment). Dilution in the dredged sediment slurry and with surface waters after discharge from the dredger will limit nutrient enrichment and consequent elevated phytoplankton production.

Table 1.1.7 Impact 7: Changed Biogeochemical Properties of Surface Waters: Potential impact of higher levels of heavy metals in overflow water.

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment after verification programme (right column).

Nature of the impact	**7: Heavy metals (cadmium and nickel) bound in the dredged sediment are discharged with the over spill water thereby affecting organisms in the water column.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area** – the affected area would be that of the suspended sediment plume.	
Duration	**Short term** – equivalent to the life of the plume.	
Intensity	**Minor effects** – there may be short term toxicity effects on plankton specifically from cadmium (240 hr EC_{50} equals >1000 µg/ℓ). Regeneration rates for plankton are days to weeks.	
Probability	**Possible** but unlikely due to required exposure periods being much longer than the predicted plume durations (< 40 hours) as the 240 hr EC_{50} concentration is >1000 µg/l).	**Possible** but direct toxicity effects are unlikely due to required exposure periods being much longer than the predicted plume durations (< 40 hours) as the 240 hr EC_{50} concentration is >1000 µg/l) and measurements indicate that metal solubilities are low. Toxicity effects due to ingestion would be limited to the primary consumer level (zooplankton) as trophic transfers are constrained by low absorption efficiencies in fish..
Status	**Negative**	
Significance (no mitigation)	**Low**	
Mitigation	None possible	
Significance (with mitigation)	**Low**	
Confidence level	**Medium** – due to there being no trace metal data specific to the proposed dredging areas	
Confidence level Post Verification Assessment		**High**: Mine area Heavy metals have low solubility and bioavailability, trophic transfers are attenuated at primary consumer level

Explanation: (Table 1.1.7: Impact 7)

Post Verification Programme – Re-evaluated impact assessment

Heavy metal elutriation measurements conducted on sediment samples retrieved from the proposed dredge site confirm that solubilities are low. Assessment of trophic uptake by particle ingestion and trophic transfers in the pelagic ecosystem (primarily zooplankton to fish) shows that these are inefficient due to the combined effects of low effective heavy metal assimilation in copepods (the dominant zooplankton group) and low assimilation efficiency in fish.

Table 1.1.8 Impact 8: Changes to Biogeochemical Properties of Bottom Waters: Potential impact of exposing heavy metals on the seabed

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment after the verification programme (right column).

Nature of the impact	**8: Heavy metals held within the target dredge area sediments are remobilized; they become bio-available through exposure to the overlying water during dredging with deleterious effects on filter and/or deposit feeding benthos.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Annual dredging area**	
Duration	**Short term** – bio-availability will reduce with time as heavy metals become bound into the sediments again.	
Intensity	**Minor effect** - the toxicity risk is from cadmium and /or nickel. Concentrations are below the probable effects level and therefore the risks of toxicity effects are considered to be low as is the potential for bio-magnification in the food chain.	
Probability	**Possible**	
Status	**Negative**	
Significance (no mitigation)	**Low**	
Mitigation	None possible	
Significance (with mitigation)	**Low**	
Confidence level	**Medium** – due to there being no trace metal data specific to the proposed dredging areas	
Confidence level Post Verification Assessment		**High**: Mine area Heavy metals have low solubility and bioavailability, dredging should not increase exposures

Explanation: (Table 1.1.8: Impact 8)

Post Verification Programme – Re-evaluated impact assessment

- Demersal fish inhabiting sedimentary areas with relatively high authigenic cadmium can have elevated concentrations of cadmium in their livers compared with the same species from areas with lower authigenic cadmium levels with take-up probably via predation on benthic invertebrates.
- Trophic transfers of heavy metals in pelagic food chains, phytoplankton/zooplankton (mainly copepods)/fish, show bio-diminution, as opposed to bio-magnification, due to the efflux of metals by copepods and low assimilation efficiencies in fish. In contrast benthic food chains comprising deposit feeders and predatory whelks show bio-magnification of metal concentrations primarily due to effective sequestration of dietary metals by whelks.

- As Namibian continental shelf sediments are characterized by naturally elevated cadmium concentrations and, although empirical data are apparently lacking, it is probable that resident demersal fish such as hake and monkfish would naturally have elevated cadmium concentrations in their livers. If present these patterns should extend across the region and the proposed NMP mining operations would not affect them. Trophic transfers of heavy metals associated with sediment plumes generated in the water column by the proposed mining would include ingestion/take-up by planktonic copepods and be interrupted at this stage. Note that the diminution would be partly due to rates of digestion of food particles being longer than gut passage leading to loss of metals in fecal pellets. Sinking rates of these are high and metals would be returned rapidly (hours to days) to the seafloor.

Hence although the process would probably occur through the dredging activities trophic transfers into especially fish are considered to be limited in extent and intensity.

Table 1.1.9 Impact 9: Changes to Biogeochemical Properties of Bottom Waters: Potential impact of releasing hydrogen sulphide from the seabed

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment after the verification programme (right column).

Nature of the impact	**9: Sulphidic sediment pore-water is exposed by dredging, and the flux of dissolved H_2S into the lower water column is increased, so affecting benthos.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area** – the amount of H_2S released will be minimal due to predicted low concentrations in the target dredge sediments.	**Dredge area** –the amount of H_2S released will be minimal due to low concentrations estimated from proxy measurements and measured low volumes of pore water present in the mine target area sediments.
Duration	**Medium term** –pulses of H_2S escaping from the trench walls will be extremely short term with toxicity effects on benthos being experienced over benthos life cycles.	
Intensity	**Moderate effects**	**Minor effects**
Probability	**Possible**	
Status	**Negative**	
Significance (no mitigation)	**Low**	
Mitigation	None possible	
Significance (with mitigation)	**Low**	
Confidence level	**Medium** – the assessment relies on a prediction of low H_2S in the target dredge area sediments.	
Confidence level Post Verification Assessment		**High**: Mine site sediment property data indicate low H_2S presence

Explanation: (Table 1.1.9: Impact 9)

Post Verification Programme – Re-evaluated impact assessment

Measurements of proxy variables indicative of presence or absence of H_2S, AVS, POM C/N, sediment pore water nitrate-nitrogen and sediment oxidation/reduction potential (ORP) all show that, at the time of measurement, H_2S concentrations in the pore water were low. Measured pore water volumes were also low, a variable likely to be stable over time in the subsurface sediments, and therefore even if H_2S concentrations were relatively high mass flux to the adjacent water body would be low. Consequently effects on resident biota would also be low.

Table 1.1.10 Impact 10: Changes to Biogeochemical Properties of Bottom Waters: Potential impact of exposing anoxic sediment surfaces on the seabed

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment after the verification programme (right column).

Nature of the impact	**10: Exposure of anoxic sediments by dredging reduces the already low concentrations of oxygen that occur in the lower water column so affecting resident biota, primarily benthos.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Annual dredging area** – it is expected that oxygen distributions that existed prior to dredging would re-establish themselves with time, and the effects on benthos will diminish.	
Duration	**Medium term**	
Intensity	**Minor effects** – The area is already identified as being hypoxic and therefore any additional effects from dredging will be relatively small.	**Negligible effects** – measurement of sediment properties in the target mine area indicate that they are severely hypoxic as opposed to being anoxic.
Probability	**Possible**	
Status	**Negative**	
Significance (no mitigation)	**Low**	
Mitigation	Not possible	
Significance (with mitigation)	**Low**	
Confidence level	**High** - the supporting evidence about sediment properties in the target dredge areas is robust.	
Confidence level Post Verification Assessment		**High**: POM in sediments is relatively refractory

Explanation: (Table 1.1.10: Impact 10)

Post Verification Programme – Re-evaluated impact assessment

The presence of anoxic sediments in the dredge area at the time of the verification survey was not apparent from the physical appearance of the grab (surficial) and gravity core (subsurface) layers nor was it indicated by measurements of sediment properties. The presence of large epibenthic organisms revealed by demersal fish trawls in and adjacent to the target mine site are also indicative of the absence of anoxic sediments. Thus risks of severe disruptions to lower water column dissolved oxygen concentrations and effects on biota are considered to be unlikely.

Table 1.1.11 Impact 11: Changes to Biogeochemical Properties of Bottom Waters: Potential impact of removing the thio-bacteria mat

Note: Original assessment table (Carter in Midgley 2012) for the impact assessment (left column) and the re-evaluated impact assessment after the verification programme (right column).

Nature of the impact	**11: Removal of thio-bacteria mats by dredging increases the flux of H_2S to the lower water column.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area** – the footprint of physical disturbance.	
Duration	**Long term** – the overall amount of H_2S in the dredge furrow sediments has been reduced and requires significant POM flux re-establish itself; only then could the thiobacteria return.	**Long term** – the overall amount of H_2S in the dredge furrow sediments is estimated to be low from measured proxies. The establishment of a significant H2S flux would require significant POM flux; only then could the thiobacteria return.
Intensity	**Minor effects**	**Negligible effects**
Probability	Possible – Thiobacterial mats have been observed at depth ranges similar to the proposed dredging areas so despite predicted low H_2S flux rates there can be a net supply of this compound to the lower water column until re-establishment of these thiobacterial mats.	
Status	**Negative**	
Significance (no mitigation)	**None**	
Mitigation	n/a	
Significance (with mitigation)	**None**	
Confidence level	**Medium** – the assessment relies on a prediction of low H_2S in the target dredge area sediments.	
Confidence level Post Verification Assessment		**High**: Mine site sediment property data indicate low H_2S presence and release from iron pyrites should be low.

Explanation: (Table 1.1.11: Impact 11)

Post Verification Programme – Re-evaluated impact assessment

Concentrations and thus possible fluxes of H_2S in sediment pore water are estimated to be low from measurements of proxy variables within the sediments in the target dredge area. Circumstantial evidence in support of this is the absence the large sulphate oxidising bacteria from the survey area during the period of the thiobacteria survey July/August 2014. Further, evaluation of pyrite-S mobilisation from sediments indicate that this is low. Consequently H_2S fluxes to the lower water column are considered to be negligible and the absence of large sulphur oxidising bacteria, due to either natural causes or disruption from dredging, would have little effect on these.