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**

B1.3 VERIFIED ASSESSMENT OF IMPACTS: MACROFAUNA

INTRODUCTION

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

The Benthos Specialist Study (Steffani 2012) conducted within the framework of the EIA (Midgley 2012) identified impacts on the benthic communities that can be expected from the proposed Sandpiper Phosphate Project, and assessed their significance. For many of these impact assessments, the confidence levels were only medium as data directly from the target area were lacking. The verification survey was specifically designed to tackle this issue, and to verify whether the assessments will remain in view of the newly acquired empirical data. These data were primarily of biogeochemical nature and are dealt with in the Verification Survey Programme Report (Section C, Chapter 2.0). A series of nine impact tables which present the impacts as they were assessed in original benthic impact study in the 2012 EIA and as re-evaluated using site information gathered during 2013 are presented below.

A total of nine negative impacts were identified in the original assessment study with one impact having medium significance, one low to medium, and seven low significance. 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 five of the impact assessments while four remained unchanged.

Table 1.3: 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 I*	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	None	None	None	None	None	None
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

Table 1.3.1 Impact 1: The removal of the upper 1 to 2.5 m of sediment by dredging will result in the loss of the benthic biota.

Note: Original assessment table (Steffani 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	**1: The removal of the upper 1 to 2.5 m (possibly up to 3 m) of sediment by dredging will result in the loss of the benthic biota associated with the sediment. The exposed sediments are likely to be different to the original superficial deposits, and sediment refill rates at this depth are likely to be very slow. Colonising assemblages are likely to differ to those present prior to the dredging activity.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area** - the loss of the benthic community is restricted to the dredged-out areas. Target areas are 22 x 8 km (176 km^2) in size but only a maximum of 3 km^2 per annum will mined, which amounts to a total of 60 km^2 after 20 years of mining (the period for which the mining licence is issued). **No change of assessment**	
Duration	**Permanent** (>20 years life of mine) - the recovery to the original community is likely to take longer than the life of mine or may even not be achieved in a meaningful time-scale. Recovery to functionally similar communities that provide similar ecosystem services as the original communities might, however, occur sooner (Long term). **No change of assessment**	
Intensity	**Moderate to serious effects** - recovery to the original community is likely to take very long (several decades, whereby beyond life of mine is classified as permanent), but recovery to a community providing similar ecosystem functioning is likely to occur sooner, e.g. environmental functions and processes are altered to such an extent that they temporarily cease. **No change of assessment**	
Probability	**Definite. No change of assessment**	
Status (+ or -)	**Negative. No change of assessment**	
Significance (no mitigation)	**Medium** - the duration of the impact is permanent in view of recovery to original community but recovery to a different community but providing similar ecosystem services may occur sooner, and the intensity is moderate to serious but the extent is confined to the mine site, maximum of 60 km^2 after 20 years of dredging. **No change of assessment**	
Mitigation	Leave behind a residual sediment layer of at least 30 cm of the original deposit thickness to cover the clay footwall. Leave behind undredged trenches to enable migration of mobile organisms from these areas. **No change of assessment**	
Significance (with mitigation)	**Medium** - the residual sediment layer will provide a substrate to be colonised by benthic organisms. Nonetheless, the recovering communities will be very different to those prior to dredging. **No change of assessment**	
Confidence level	**Medium** - the assessment is based on assumptions that are arrived from publicly available data, while data directly from the target areas are limited. A monitoring programme is needed to confirm the assumptions.	
Confidence level Post Verification Assessment		**High** - the verification survey confirms the assumptions on which the assessment was based, i.e. low dissolved bottom water conditions but not anoxic conditions nor significant amounts of HS^- flux from the sediments based on conditions measured.

Explanation: (Table 1.3.1: Impact 1)

Original EIA – Impact assessment

TSHD trial dredging that was undertaken near the mud belt in Atlantic 1 MLA in 105 m water depth is in terms of operational procedure comparable to the Sandpiper project as all of the dredged sediment was transported to shore. The dredged area was 200 x 500 m in size with an estimated average dredged depth of 5.28 m (Steffani 2010c). Monitoring surveys revealed that three years after mining the re-colonisation by macrofauna was relatively advanced, although abundance, biomass, species number, and species diversity were still lower than before the dredging and also when compared with a nearby unmined control site (Steffani 2010c). Differences in community structure were related primarily to a shift in the relative abundance of common species, and not due to a change in species composition. Interpretation of the data in terms of natural temporal variability was, however, compromised due to limited sampling of the control site. Although recovery was not fully accomplished three years after dredging, the recovery process was much faster than has been anticipated for such depths

Post Verification Programme – Re-evaluated impact assessment

The characteristics of the water masses present in the survey area over the period of measurement are those of the oxygen depleted, saline SACW flowing south in the poleward undercurrent from the Angola gyre, and the less saline, relatively oxic ESACW from the Cape Basin. The influence of the latter on ventilation of bottom water in the area is clearly evident from the temperature, salinity and dissolved oxygen time series measurements that were made. This is consistent with the findings in the EIA.

Table 1.3.2 Impact 2: Further exploration and environmental work will be conducted in the larger ML 170 that will remove benthic biota.

Note: Original assessment table (Steffani 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	**2: Further exploration and environmental work will be conducted in the larger ML 170 that will remove benthic biota.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge Area** – Gravity cores are ~2 inch in diameter, van Veen grab samples an area of max. 0.2 m^2 and larger grabs sample 3 m^2 bite. The total area disturbed by these tools even after extensive exploration campaigns will be very small. **No change of assessment**	
Duration	**Short term** – it is expected that slumping from the side of the holes will quickly fill in the disturbed area and migration from the adjacent area is fast. **No change of assessment**	
Intensity	**No lasting effects** – recovery will be very rapid as many animals will be transported into the disturbed area with the material slumping from the sides. **No change of assessment**	
Probability	**Probable**. **No change of assessment**	
Status (+ or -)	**Negative**. **No change of assessment**	
Significance (no mitigation)	**None** – recovery will be very rapid and effects on the system will not be measurable. **No change of assessment**	
Mitigation	No mitigation necessary	
Significance (with mitigation)	**None** – recovery will be very rapid and effects on the system will not be measurable. **No change of assessment**	
Confidence level	**High**. N**o change of assessment**	

Explanation: (Table 1.3.2: Impact 2)

Original EIA – Impact assessment
The footprint of exploration activity is minuscule, causing no discernable impact.

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 1.3.3 <u>Impact 3</u>: The depth of the dredged area might change local near bottom hydrographical conditions and thus act as trap for very fine material.

Note: Original assessment table (Steffani 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	**3: The depth of the dredged area might change local near bottom hydrographical conditions and thus act as trap for very fine material. This could lead to high decomposition rates and consequently anoxic conditions and H_2S concentrations in the sediments.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**<u>Specific mine site</u>** - Target areas are 22 x 8 km (176 km^2) in size but only a maximum of 3 km^2 per annum will be mined, which amounts to a total of 60 km^2 after 20 years of mining (the period for which the mining licence is issued). **No change of assessment**	
Duration	**<u>Permanent</u>** - sediment refill rates are expected to be very low at the water depth of the target areas. **No change of assessment**	
Intensity	**<u>Moderate to Serious effects</u>** - anoxic conditions are deadly for most benthic communities but large sulphur-oxidising bacteria can thrive under these conditions. **No change of assessment**	
Probability	**<u>Probable</u>** – localised anoxic conditions may occur in the deeper trenches and pits. **No change of assessment**	
Status (+ or -)	**<u>Negative</u>**. **No change of assessment**	
Significance (no mitigation)	**<u>Medium</u>** - duration is permanent and intensity moderate to serious, but extent is restricted to the mine area and large areas of the inner shelf are naturally subjected to anoxic conditions. **No change of assessment**	
Mitigation	Leave behind a residual sediment layer of at least 30 cm, which will reduce the depth of the dredged-out area. **No change of assessment**	
Significance (with mitigation)	**<u>Low to medium</u>** - a dredged depth of an average of 1.7 m (possibly up to 3 m) over a relatively large area is unlikely to reduce bottom current speeds to such an extent that very fine material will significantly accumulate in the dredge area. **No change of assessment**	
Confidence level	**<u>Medium</u>** - the assessment is based on assumptions that are arrived from publicly available data, while data directly from the target areas are limited. A recovery survey is needed to confirm the assumptions.	
Confidence level Post Verification Assessment		**<u>High</u>** - the verification survey confirms the assumptions on which the assessment was based, i.e. high natural near bottom current speeds sufficient enough to exert shear stress forces that prevent accumulation of sedimenting fine particulate matter.

Explanation: (Table 1.3.3: Impact 3)

Original EIA – Impact assessment

The total removal of the phosphate deposits in the Sandpiper target areas would expose the footwall, which consists of firm clay, compared with the sandy/shelly deposits of the original surface layer. Hard consolidated clay is less than ideal for small burrowing fauna, and the clay may function more like a hard bottom substrate. This would lead to the area being colonised by a very different suite of animals. Dredging of the clay footwall, however, is undesirable from a technical perspective and it is proposed to leave behind a residual layer of phosphate sand to avoid direct contact of the draghead with the footwall. Mitigation recommendations will also include leaving behind a minimum layer of approximately 30 cm of sediments. New sediment in the dredged out area can accumulate through bedload transport of mobile sand, by natural deposition of fines from the water column, through slumping from the undredged pit walls (and potentially undredged corridors between trenches), and/or by deposition of outwash fines from the dredger

Post Verification Programme – Re-evaluated impact assessment

- The measured currents reflected consistent NW (equatorward) flow in the near surface depths, switching between NW and S (poleward) flow at mid-depth and near the seabed a period of sustained poleward flow followed by switching between poleward and equatorward flows. The near surface and seabed currents are consistent with those predicted in the EIA. Time series measurements at mid-depth were not available to the EIA and the verification measurements represent new detail for the region.
- Current flow velocities were variable temporally and with depth. In general surface flows averaged 17 cm/s, mid-depth flows ~10 cm/s and near seabed flows 18 cm/s for poleward flow but were lower at 9 cm/s in oscillating pole/equatorward flows. These are in general agreement with the information in the EIA. Seabed current velocities are higher than the <10 cm/s predicted by Shillington et al (2006) as quoted in the EIA. In the short term velocities ~30 cm/s were recorded at the mooring implying considerable turbulence at the seafloor.
- The characteristics of the water masses present in the survey area over the period of measurement are those of the oxygen depleted, saline SACW flowing south in the poleward undercurrent from the Angola gyre, and the less saline, relatively oxic ESACW from the Cape Basin. The influence of the latter on ventilation of bottom water in the area is clearly evident from the temperature, salinity and dissolved oxygen time series measurements that were made. This is consistent with the findings in the EIA.

Table 1.3.4 Impact 4: Dredging removes mats of large sulphur-oxidising bacteria from the sediment surface and from the upper layer.

Note: Original assessment table (Steffani 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: Dredging removes mats of large sulphur-oxidising bacteria from the sediment surface and from the upper layer.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Specific mine site** - Target areas are 22 x 8 km (176 km^2) in size but only a maximum of 3 km^2 per annum will mined, which amounts to a total of 60 km^2 after 20 years of mining (the period for which the mining licence is issued). **No change of assessment**	
Duration	**Medium to long term** – the recovery of bacterial mats depends on the development of sufficient H_2S concentrations. This requires anoxic conditions that can only develop when high concentrations of organic matter accumulate in the dredge area. Although higher organic loading might be a possibility as the dredge area may act as trap, it will take a long time to build up enough material for anoxic conditions and high H_2S concentrations. **No change of assessment**	
Intensity	**Moderate to minor effects** – the large sulphur bacteria are important in oxidising the toxic H_2S thereby reducing its diffusion into the water column. Their removal will disrupt this, on the other hand, the removal of the sediments will also remove any H_2S contained in the sediments, and H_2S fluxes from the dredge area are thus not expected unless the system turns anoxic. If this happens, the bacterial mats are likely to return. **No change of assessment**	
Probability	**Improbable** – evidence from published data strongly suggests that offshore the mud belt at 24°S and beyond the 200-m isobaths concentrations of large sulphur bacteria are low or absent.	**Improbable**: the verification survey (Section C, Chapter 2.3) has confirmed the absence of large sulphur bacteria in SP-1 as neither *Thiomargarita, Beggiatoa*, nor *Thioploca* were found in the investigated samples, these species being typically associated with the formation of bacterial mats
Status (+ or -)	**Negative. No change of assessment**	
Significance (no mitigation)	**Low** – concentrations of large sulphur bacteria is assumed to be low or absent.	**Low**: Confirmed from the verification survey (Section C, Chapter 2.3)
Mitigation	No mitigation necessary	
Significance (with mitigation)	**Low** – concentrations of large sulphur bacteria is assumed to be low or absent.	**Low**: Confirmed from the verification survey (Section C, Chapter 2.3)
Confidence level	**Medium** - the assessment is based on assumptions that are arrived from publicly available data, while data directly from the target areas are limited. An initial survey is needed to confirm the assumptions.	
Confidence level Post Verification Assessment		**High** – the verification surveys has confirmed the assumption of absence of large sulphur bacteria in SP-1 as neither *Thiomargarita, Beggiatoa*, nor *Thioploca* were found in the investigated samples (Section C , Chapter 2.3).

Explanation: (Table 1.3.4: Impact 4)

Post Verification Programme – Re-evaluated impact assessment

The investigation into sulphur bacteria indicated that, at the time of sampling, sulphide fluxes were probably low as the large sulphate bacteria, namely from the genera *Thiomargarita*, *Beggiatoa* and *Thioploca*, which play a significant roles in the oxidisation of H_2S, were absent from the bacterial assemblage. Smaller forms including *Thiobacillus* spp. with relatively lower growth yields were present; however, indicating that although the concentration was estimated to be low (hydrogen) sulphide was present in the sediments.

Table 1.3.5 Impact 5: The anaerobic bacterium Clostridium botulinum type E might proliferate in the dredged area, and may pose a health risk to humans and wildlife when entering the food chain.

Note: Original assessment table (Steffani 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	**5 The anaerobic bacterium Clostridium botulinum type E might proliferate in the dredged area if the system turns anoxic, and may pose a health risk to humans and wildlife when entering the food chain.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Specific mine site** - Target areas are 22 x 8 km (176 km^2) in size but only a maximum of 3 km^2 per annum will mined, which amounts to a total of 60 km^2 after 20 years of mining (the period for which the mining licence is issued). **No change of assessment**	
Duration	**Short term** – if the system turns anoxic this will be of long term or permanent duration, but *C. botulinum* proliferation is linked to periodic massive die-offs of fish and other aquatic life that might occur during extreme events such as H_2S eruptions. Once these bacteria proliferate they may enter the food chain by ingestion of contaminated sediments from the dredge area. **No change of assessment**	
Intensity	**Serious effects** – botulism caused by the bacteria can be lethal to humans and wildlife. **No change of assessment**	
Probability	**Improbable** – no in situ contamination of fish populations by the bacterium has been reported for southern African fish populations. Literature data suggest that the distribution of the bacteria is limited in deeper saline waters. If the bacteria are a problem in Namibian waters, it is unlikely that the addition of 60 km^2 of anoxic seafloor will add any measurable risk of bacteria proliferation to the already large areas of anoxic zone. **No change of assessment**	
Status (+ or -)	**Negative – No change of assessment**	
Significance (no mitigation)	**Low** – proliferation of bacteria is assumed to be a rare probability. **No change of assessment**	
Mitigation	No mitigation necessary but this should not indemnify the fishing industry from complying with any regulations regarding *C. botulinum* contamination. **No change of assessment**	
Significance (with mitigation)	**Low** – proliferation of bacteria is assumed to be a rare probability. **No change of assessment**	
Confidence level	**Medium** – very little is known about the natural life-cycle of the bacteria and this assessment is based on data from the northern hemisphere	
Confidence level Post Verification Assessment		No assessment undertaken during the verification programme. Based on existing risk (impact) determination there is no justifiable cause for further evaluations of the possible impacts of *Clostridium botulinum* type E. **No change of assessment**

Explanation: (Table 1.3.5: Impact 5)

Original EIA – Impact assessment

In the worst case scenario, changes in the small-scale near bottom hydrographical conditions as a result of dredging might create an anaerobic environment over an area of 60 km^2 after 20 years of dredging. Put into a regional context, the addition of 60 km^2 anaerobic environment where the bacterium could occur to the naturally occurring vast area of the azoic zone, is negligible. If proliferation of *C. botulinum* in anaerobic zones was a problem in Namibian waters it is unlikely that it would be aggravated by this spatial addition, and the impact is thus regarded as negligible.

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 1.3.6 Impact 6: High suspended sediment concentrations near the sea bottom generated by the drag head and subsequent re-deposition of the material causes smothering effects.

Note: Original assessment table (Steffani 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	**6: High suspended sediment concentrations near the sea bottom generated by the drag head and subsequent re-deposition of the material causes smothering effects.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Dredge area** – sedimentation effects will only be relevant along a narrow strip around the dredge site as any re-depositions inside the dredge area will have no impact since the animals are removed. **No change of assessment**	
Duration	**Very short term** – smothering of a particular area occurs only during the dredging activity, maximum dredging activity per area is assumed to be < 10 days for intermittent (16 hour-cycle) dredging. **No change of assessment**	
Intensity	**Minor effects** – some organisms in the immediate vicinity of the dredge site may be impacted on a lethal level but the majority of impacts can be expected on a sub lethal level as many animals can cope with relatively high short-term suspended material concentrations. **No change of assessment**	
Probability	**Highly probable**. **No change of assessment**	
Status (+ or -)	**Negative**. **No change of assessment**	
Significance (no mitigation)	**Low** – very small extent, very short duration and low intensity. **No change of assessment**	
Mitigation	No mitigation necessary. **No change of assessment**	
Significance (with mitigation)	**Low** – very small extent, very short duration and low intensity. **No change of assessment**	
Confidence level	**High** – studies on draghead plumes have shown that the affected area is very small.	
Confidence level Post Verification Assessment		No assessment undertaken during the verification programme. Based on existing risk (impact) determination there is no justifiable cause for further evaluations. **No change of assessment**

Explanation: (Table 1.3.6: Impact 6)

Original EIA – Impact assessment

Sediment re-suspension from the draghead increases with hopper filling speed and travel speed of the dredger, but is mainly dependent on the properties of the sediments (Johnson and Parchure 1999). Suspended sediment concentrations generated at the point of dredging tend to decline as the sediments become coarser. The size fractions of greatest consequence are the silts, muds and clays (<63 µm) as these create the highest level of turbidity (Johnson and Parchure 1999). Near-bottom dredge plumes usually decrease rapidly with distance from the dredger. Kirby and Land (1991), for example, recorded suspended sediment concentrations decreasing from a maximum of 1,100 mg/ℓ at the cutter head of a cutter suction dredger to 20-90 mg/ℓ only 50 m away. The overburden in the target areas is described as silty sand with significant gravel component and will thus have relatively rapid settlement rates, and the re-suspended sediment should disperse only over short distances.

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 1.3.7 Impact 7: Re-deposition of particles in the overflow plume causes smothering of benthic organisms, particularly in the depo-center on the continental slope.

Note: Original assessment table (Steffani 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	**7: Re-deposition of particles in the overflow plume causes smothering of benthic organisms, particularly in the depo-center on the continental slope**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Local to regional** – the fines (<63 micron) in the plumes may be transported for several kilometres but upon entering the nepheloid layer, material may be transported to the depo-center ~100 km south-west of the licence area. Significant deposition-thicknesses are, however, expected to occur only in the immediate vicinity of the dredge area. **No change of assessment**	
Duration	**Very short term** – the overflow plumes will only be generated during dredging which occurs for approximately 16 hrs within a 37-hour dredge cycle for approx. 16 hours. **No change of assessment**	
Intensity	**Minor effects** – animals in the immediate vicinity of the dredge area may be affected by smothering, elsewhere sedimentation rates are expected to be very low. **No change of assessment**	
Probability	**Probable**. **No change of assessment**	
Status (+ or -)	**Negative. No change of assessment**	
Significance (no mitigation)	**Low.** – although widespread, re-deposition rates are expected to be low, and higher rates are limited to the immediate vicinity of the dredge area. Communities in the depo-center where higher settling rates may occur, are also likely to be adapted to sedimentation as this is a naturally high sedimentation area. **No change of assessment**	
Mitigation	No mitigation necessary.	
Significance (with mitigation)	**Low** – although widespread, re-deposition rates are expected to be low, and higher rates are limited to the immediate vicinity of the dredge area. Communities in the depo-center where higher settling rates may occur, are adapted to sedimentation as this is a naturally high sedimentation area. **No change of assessment**	
Confidence level	**Medium** – assumed low sedimentation rates are based on a study conducted in shallower waters (105-130 m) of southern Namibia with different hydrographical conditions. **No change of assessment**	

Explanation: (Table 1.3.7: Impact 7)

Post Verification Programme – Re-evaluated impact assessment

This review indicates that it is possible (but not certain) that the actual plume dimensions may exceed the dimensions assumed in the 2012 EIA assessment (i.e. plume dimensions may be 2 to 5 times larger than indicated). However, the implication of these potentially increased plume dimensions for the overall impact assessment and subsequent environmental decision-making is limited. Should the plume dimensions exceed those estimated in the 2012 EIA study, the extent of the plume reported in the impact assessment tables of this study may increase from being limited to the "Immediate Dredge Area" to affecting possibly the "Annual Mining Area". It is not expected that this change in the extent of the impact would be such that it affected the "Specific Mining Site". Therefore it is not expected that these possible, but modest, changes in the impacted area will materially affect the environmental decision-making surrounding this project.

Table 1.3.8 Impact 8: Dredging may mobilise dissolved nutrients from the sediments which could be released into the water column with the overflow from the dredger.

Note: Original assessment table (Steffani 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: Dredging may mobilise dissolved nutrients from the sediments which could be released into the water column with the overflow from the dredger. The increased nutrient level may result in extensive phytoplankton blooms, which upon death cause aggravated decomposition rates leading to anoxic conditions at the seafloor.**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Local** – the released nutrients will spread with the overflow plume. **No change of assessment**	
Duration	**Very short term** – the overflow plumes will only be generated during dredging which occurs for approximately 16 hrs within a 37-hour dredge cycle for approx. 16 hours. **No change of assessment**	
Intensity	**Minor effects** – literature data suggest that dissolved nutrient concentrations in the target areas are relatively low, which means that only low amounts of nutrients will be mobilised. **No change of assessment**	
Probability	**Possible** – it is likely that some nutrients will be mobilised but it is unlikely that this will result in massive dying phytoplankton-blooms reaching the sea bottom in such locally dense concentrations that this will cause anoxic seafloor conditions. **No change of assessment**	
Status (+ or -)	**Negative**. **No change of assessment**	
Significance (no mitigation)	**Low** – due to potentially low dissolved nutrient concentrations in the target areas. **No change of assessment**	
Mitigation	No mitigation necessary.	
Significance (with mitigation)	**Low** – due to potentially low dissolved nutrient concentrations in the target areas. **No change of assessment**	
Confidence level	**Medium** - the assessment is based on assumptions that are arrived from publicly available data, while data directly from the target areas are limited. An initial survey is needed to confirm the assumptions.	
Confidence level Post Verification Assessment		**High** - the verification survey confirms the assumptions on which the assessment was based, i.e. moderately high nutrient levels in the sediments but generally low pore water volumes that could release nutrients when disturbed. Therefore nutrient loading to the euphotic zone through dredging will be unlikely.

Explanation: (Table 1.3.8: Impact 8)

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 1.3.9 Impact 9: Release of hydrogen sulphide from the sediments affects benthic communities.

Note: Original assessment table (Steffani 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: Release of hydrogen sulphide from the sediments affects benthic communities**	
Report	***Impacts assessed EIA (2012)***	***Impacts re-evaluated: Verification programme***
Extent	**Local** – released hydrogen sulphide may spread along the sea bottom affecting undredged areas and the associated biotic life. **No change of assessment**	
Duration	**Short term** – the spread of hydrogen sulphide across the seafloor will be very short term and the gas will eventually mix with the seawater. The gas is, however, very toxic and will kill many animals in its path. Recovery of the benthic communities will be relatively rapid if hydrogen sulphide conditions are only temporary. **No change of assessment**	
Intensity	**Moderate effects** – hydrogen sulphide is very toxic and will kill many animals but its presence is temporary. **No change of assessment**	
Probability	**Probable** – literature data suggest that hydrogen sulphide concentrations in the near-bottom waters, pore waters and in the upper sediment layers in the target areas are very low. It can, however, not be excluded that deeper sediment layers may contain hydrogen sulphide. If hydrogen sulphide is present, it is presumably sucked up with the sediments and residual hydrogen sulphide at the seafloor will be minimal. **No change of assessment**	
Status (+ or -)	**Negative**	
Significance (no mitigation)	**Low** – hydrogen sulphide concentrations are assumed to be low, and the dredging process will also remove any gas contained in the sediments. **No change of assessment**	
Mitigation	No mitigation necessary	
Significance (with mitigation)	**Low** – hydrogen sulphide concentrations are assumed to be low, and the dredging process will also remove any gas contained in the sediments. **No change of assessment**	
Confidence level	**Medium** - the assessment is based on assumptions that are arrived from publicly available data, while data directly from the target areas are limited. An initial survey is needed to confirm the assumptions.	
Confidence level Post Verification Assessment		**High** - the verification survey confirms the assumptions on which the assessment was based, i.e. low dissolved bottom water conditions but not anoxic conditions nor significant amounts of HS^- flux from the sediments based on conditions measured.

Explanation: (Table 1.3.9: Impact 9)

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 at least 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.