
Appendix F Multi Criteria Analysis of Proposed Disposal Sites

Mandorah Marine Facilities: Supplementary Environmental Report

Prepared for **DEPARTMENT OF INFRASTRUCTURE, PLANNING AND LOGISTICS**

February 2023



Multi Criteria Assessment

		DEPWS - Neil Smitt, Site 1 (West of Dredge area)	DEPWS - Neil Smitt, Site 2 (North of Dredge area)	Mandorah Marine Facilities Referral	Onshore Disposal - Dedicated Disposal Site	Onshore Disposal - Shoal Bay Waste Management Facility (SBWMF)	Inpex Offshore Designated Disposal Site	Cullen Bay Maintenance Dredging	Darwin Port - Harbour Disposal
Location		Pipe discharge point 12°26'23.69"S, 130°46'22.09"E	Pipe discharge point 12°26'0.80"S, 130°45'46.10"E	Pipe discharge point 12°25'51.87"S, 130°46'9.21"E	Onshore Disposal Area 12°26'29.81"S, 130°45'56.14"E	Shoal Bay Waste Management Facility 12°23'18.91"S, 130°55'30.30"E	Inpex Disposal Site 12°13'10.68"S, 130°48'50.09"E	Pipe discharge point 12°26.931"S, 130°48.728"E	East Arm Wharf - 12°29'29.53"S, 130°52'32.77"E Marine Supply Base - 12°29'39.86"S, 130°53'37.97"E Fort Hill Wharf - 12°28'35.98"S, 130°50'48.09"E
Environmental Risk Factors	Landforms	N/A	N/A	N/A	> Designated for In situ stockpiling to allow for contamination characterisation and any necessary ASS Pass treatment prior to reuse of disposal. > Stockpiled material is temporarily not impacting landforms long term.	> Established Waste receiving facility operating in accordance with relevant environmental protection licenses administered by the NT EPA to avoid adverse impacts to terrestrial landforms.	N/A	N/A	N/A
	Terrestrial Environmental Quality	N/A	N/A	N/A	> Negative impacts to soil quality, stability and fertility from acidic runoff discharging into Darwin Harbour. Loss of topsoil during overland flows, eroded topsoil resulting in sedimentation in Darwin Harbour. > CEMP to include Hazardous Material Management to ensure stockpiles of bulk materials are well contained/separated from exposed soils.	> Roughly 115km material transport distance, large tipping trucks have the potential to pollute through noise and dust during transfer > ASS and PASS known to exist in dredge spoil, ASS management plan required in line with DSDMP > Appropriate mitigation administered by contractors CEMP would negate adverse environmental affects	N/A	N/A	N/A
	Terrestrial Ecosystems	N/A	N/A	N/A	> Potential indirect impacts considered negligible where appropriately endorsed DSDMP, ASSMP and CEMPs are administered	> Potential indirect impacts considered negligible where appropriately endorsed DSDMP, ASSMP and CEMPs are administered	N/A	N/A	N/A
	Hydrological Processes	N/A	N/A	N/A	N/A	> SBWMF operating in accordance with relevant environmental	N/A	N/A	N/A



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Inland Water Environmental Quality	N/A	N/A	N/A	N/A	protection licenses administered by the NT EPA to avoid adverse impacts to environmental factors affecting water > Robust water sampling and response management in place as part of SBWMF operating and environmental protection license	N/A	N/A	N/A
Aquatic Ecosystems	N/A	N/A	N/A	N/A		N/A	N/A	N/A
Coastal Processes	> Disposal of nominated dredge volumes would not affect coastal processes	> Disposal of nominated dredge volume's potential to affect coastal process given shallow depth and low tidal velocities is unknown	> Disposal of nominated dredge volumes would not affect coastal processes	N/A	N/A	> Disposal of nominated dredge volumes at deep, offshore and high-energy area would not affect coastal processes	> Disposal of nominated dredge volumes would not affect coastal processes	> Disposal of nominated dredge volumes would not affect coastal processes
Marine Environmental Quality	<p>> <u>Physical</u></p> <ul style="list-style-type: none"> - BCH identified as sponges. No significant coral or seagrass communities identified within or adjacent to disposal area - Indirect impacts of turbid plumes may result in increasing sedimentation on sponge communities facilitated through high dispersion. Mitigation practices through live monitoring data and informing contingency management practices. <p>> <u>Chemical</u></p> <ul style="list-style-type: none"> - Toxic contaminants exposed to marine ecosystem for biological uptake and bioaccumulation - Management through isolation, removal and confine areas where contamination is potentially toxic to the marine environment. 	<p>> <u>Physical</u></p> <ul style="list-style-type: none"> - BCH identified as macroalgae. No significant coral communities identified within or adjacent to the disposal area. - Live monitoring of SCC trigger values detailed in DSDMP which is crucial in areas of lower dispersion outside of high energy tidal currents. <p>> <u>Chemical</u></p> <ul style="list-style-type: none"> - Toxic contaminants exposed to marine ecosystem for biological uptake and bioaccumulation - Management through isolation, removal and confine areas where contamination is potentially toxic to the marine environment. 	<p>> <u>Physical</u></p> <ul style="list-style-type: none"> - BCH identified as sponges - No significant coral or seagrass communities identified within or adjacent to disposal area <p>> <u>Chemical</u></p> <ul style="list-style-type: none"> - Toxic contaminants made available to marine ecosystem for biological uptake and bioaccumulation. - Management through isolation, removal and confine areas where contamination is potentially toxic to the marine environment 	N/A	N/A	<p>> <u>Physical</u></p> <ul style="list-style-type: none"> - Indirect impacts of turbid plumes reducing light availability and associated sedimentation negated through live monitoring data informing contingency management practices. - No significant coral or seagrass communities identified within or adjacent to disposal area <p>> <u>Chemical</u></p> <ul style="list-style-type: none"> - Toxic contaminants exposed to marine ecosystem for biological uptake and bioaccumulation - Management through isolation, removal and confine areas where contamination is potentially toxic to the marine environment 	<p>> <u>Physical</u></p> <ul style="list-style-type: none"> - No significant coral or seagrass communities identified within or adjacent to disposal area <p>> <u>Chemical</u></p> <ul style="list-style-type: none"> - Toxic contaminants exposed to marine ecosystem for biological uptake and bioaccumulation - Management through isolation, removal and confine areas where contamination is potentially toxic to the marine environment 	<p>> <u>Physical</u></p> <ul style="list-style-type: none"> - Indirect impacts of turbid plumes on hard coral and filter feeder communities identified adjacent to Darwin Port disposal areas - Turbidity tolerance limits for benthic communities (Williams, 2017) and associated management practices incorporated into DSDMP <p>> <u>Chemical</u></p> <ul style="list-style-type: none"> - Toxic contaminants exposed to marine ecosystem for biological uptake and bioaccumulation - Management through isolation, removal and confine areas where contamination is potentially toxic to the marine environment



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Marine Ecosystems	>No significant corals and seagrasses were identified within the disposal area. Monitoring and management practices for SSC tolerance levels for sponge communities. > Vessel collision causing injury or mortality to protected marine megafauna.	> Light dependent macroalgae identified within disposal area (INPEX, 2018) - Determination of macroalgae SCC thresholds to inform live monitoring trigger values > Vessel collision causing injury or mortality to protected marine megafauna	> Soft Bottom Benthos / silty sediments, sponges, no corals and seagrasses identified within disposal area (INPEX, 2018) > Vessel collision causing injury or mortality to protected marine megafauna	N/A	N/A	> Soft Bottom Benthos / silty sediments, no light dependent communities such as corals and seagrasses identified within disposal area (INPEX, 2018). > Low percentage cover of epifauna within and adjacent to the disposal area accounting for less than 1% of the total mean cover (Cardno 2013c). > Vessel collision causing injury or mortality to protected marine megafauna	> Seagrass communities in Fannie Bay, some 1-6 km to the north-east of the spoil discharge point. > Hard coral communities in the East Point Aquatic Life Reserve, about 5 km north of the spoil discharge point; and at Weed Reef, Plater Rock and Kurumba Shoal about 5 km south-west of the spoil discharge point, URS 2010). > Sedimentation tolerance limits for hard corals and seagrasses modelled for Cullen Bay operations would be applied > Vessel collision causing injury or mortality to protected marine megafauna	> Light dependent benthic communities have been identified in disposal areas however are well represented in Darwin Harbour. Precedent for benthic community tolerance limits to turbidity which can inform management practices and avoid mortality > No benthic communities of critical importance to protected marine species have been identified during previous investigations
Air Quality	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions and contaminated dust > Dust mitigation facilitated through implementation of CEMP	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions and contaminated dust > Dust mitigation facilitated through implementation of CEMP	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions	> Decrease in local air quality via CO2 emissions. > Impacts to local fauna and human health through inhalation of emissions
Atmospheric Processes	> Direct emissions from the dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from the dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from the dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from excavation plant and support vehicles. > Cumulative impact of carbon emissions to global climate change	> Direct emissions from trucks transporting dredge spoil ~115km to SBWMF > Cumulative impact of carbon emissions to global climate change	> Direct emissions from the dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from the dredger > Cumulative impact of carbon emissions to global climate change	> Direct emissions from the dredger > Cumulative impact of carbon emissions to global climate change



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	Community and Economy	> Near proximity to shipping lane and Inpex Pipeline exclusion zone > Exclusions zones required to prevent collision with sediment piping > Community consultation and complaints handling procedures will be governed by the CEMP	> Closer proximity to beaches used by local community > Valuable benthic communities > Community consultation and complaints handling procedures will be governed by the CEMP	> Near proximity to shipping lane and Inpex Pipeline exclusion zone > Exclusions zones required to prevent collision with sediment piping > Community consultation and complaints handling procedures will be governed by the CEMP	> Decrease in utilisation for stakeholders of existing natural open areas, carparks and roads. > Stakeholder engagement with current uses of facilities to inform access issues during construction	> Increased localised traffic affecting Cox peninsula road (single lane) and Mandorah ferry carpark > Decrease in livability for users of existing boat ramp or carpark > Stakeholder engagement with current uses of facilities to inform of access issues during construction	> No high value benthic communities to recreational fishing, commercial fishing or tourism Industries	> High value coral and seagrass communities occurring within zones of influence however potential sedimentation and turbidity impacts considered low > Spoil transiting would occur across designated shipping channels	> Highly productive industrial import/export ports also servicing cruise ships and navy ships > Potential to interrupt agriculture, tourism and trade industries
	Culture & Heritage	> No native title or indigenous land use agreements affected	> Onshore sacred site that could be influenced through changes in coastal processes	> No native title or indigenous land use agreements affected	> No native title or indigenous land use agreements affected > Response and reporting procedures in case a site or object be encountered > Strict avoidance of the restricted work areas (RWA) captured in the Aboriginal Areas Protection Authority (AAPA) Certificate	> No native title or indigenous land use agreements affected > Response and reporting procedures in case a site or object be encountered > Strict avoidance of the restricted work areas (RWA) captured in the Aboriginal Areas Protection Authority (AAPA) Certificate	> No native title or indigenous land use agreements affected	> No native title or indigenous land use agreements affected	> Culturally significant sites within Darwin harbour
	Human Health and Safety	> High energy currents perpendicular to the direction of sediment pipeline creating potential operational risk > Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Adverse health impacts to site workers and users of the facility through dermal contact, ingestion/inhalation of contaminated dust > CEMP to include Hazardous Material Management to ensure stockpiles of bulk materials are well contained/separated from exposed soils	> Adverse health impacts to site workers and users of the facility through dermal contact, ingestion/inhalation of contaminated dust > CEMP to include Hazardous Material Management to ensure stockpiles of bulk materials are well contained/separated from exposed soils	> Offshore location and high-energy hydrodynamic conditions result in equipment requiring anchoring causing unnecessary safety and operational risk > Potentially restricted to stable placement options i.e. hopper bottom door placement	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines	> Navigational hazards, exclusion zones for recreational and commercial traffic > Emergency Management Plans to be developed by the contractor in accordance with industry standards and guidelines
Technical Feasibility	Distance from dredge footprint	0.6km NE	1km NW	1.2km NE	0km (adjacent to dredge area)	> In situ stock piling of material adjacent to dredge footprint within terrestrial footprint of project > ~ 115km from site to SBWMF via Cox Peninsula Road, Charles Point Road and Stuart highway	> ~29km from dredge footprint > North of Darwin Harbour, within the Beagle Gulf, approximately 12 km north-west of Lee Point	> 5 km from dredge footprint > Areas around 500 m from Northwest of Cullen Bay	> Ranging from 9 to 15 km from dredge footprint > Areas around 500 m from East Arm Wharf/Marine Supply Base and Fort Hill Wharf
	Cross Currents	> Predicted to reach up to 1.2 m/s during a spring tide and flood currents approach 0.5 m/s perpendicular direction of pipeline	> Sediment piping in approximate same orientation as tidal currents	> Predicted to reach up to 1.1 m/s during a spring tide and flood currents approach 0.4 m/s perpendicular direction of pipeline	N/A	N/A	> Unanchored disposal methods and shipping navigation hazards resulting from accidental disposal of spoil outside of the DSDA	> Strong alignment of tidal flows along an approximate north-north-west to south-south-east axis at the spoil discharge point.	> Unanchored disposal methods shipping navigation hazards resulting from accidental disposal of spoil outside of the DSDA



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	Required Equipment Assessment	> 0.6km sediment pipeline with no booster pumps are required whilst anchoring and access to navigation exclusions zones are required for the pipeline. > Dispersal from surface during high energy spring tides would negate sedimentation on benthic communities > Stable placement of material on seafloor (sunken sediment pipeline) reducing navigational hazards but increase sedimentation poses a risk to benthic communities and may cause damage to the pipeline.	> 1km sediment pipeline with no booster pumps are required whilst anchoring and access to navigation exclusions zones are required for the pipeline. > Dispersal from surface during high energy spring tides would negate sedimentation on sponge communities > Stable placement of material on seafloor (sunken sediment pipeline) reducing navigational hazards but increase sedimentation poses a risk to benthic communities and may cause damage to the pipeline.	> 1.2km sediment pipeline with no booster pumps are required whilst anchoring and access to navigation exclusions zones are required for the pipeline. > Dispersal from surface during high energy spring tides would negate sedimentation on benthic communities > Stable placement of material on seafloor (sunken sediment pipeline) reducing navigational hazards but increase sedimentation poses a risk to benthic communities and may cause damage to the pipeline.	> In situ ASS treatment > Excavators and large side tip trucks are required to transport the material from dredge site to SBWMF	> Excavators and large side tip trucks are required to transport the material from dredge site to SBWMF	> TSHD or CSD/hopper barge to allow easy disposal in deeper high energy waters > Unconfined ocean disposal of dredged sediment in high-energy environments via TSHD or hopper barge bottom doors > Alternative disposal methods such as hydraulic placement of materials unfeasible due to the distance from the dredge footprint	> TSHD or CSD/hopper barge to allow easy disposal in deeper high energy waters > Unconfined ocean disposal of dredged sediment via TSHD or hopper barge bottom doors > Alternative disposal methods such as hydraulic placement of materials unfeasible due to existing maritime industry activities and exclusion zones throughout Darwin harbour i.e pipes crossing shipping channel to reach spoil ground	> TSHD or CSD/hopper barge to allow easy disposal in deeper high energy waters > Unconfined ocean disposal of dredged sediment via TSHD or hopper barge bottom doors > Alternative disposal methods such as hydraulic placement of materials unfeasible due to existing maritime industry activities and exclusion zones throughout Darwin harbour
	Financial Feasibility				> Land placement of PASS 1 is likely to require management and monitoring to avoid impacts from acidic water discharges. This can be a major logistical and extremely expensive undertaking.	> Cost of disposal determined following special waste disposal application to SBWMF	> Implications to transporting costs of spoil large distances both capital and maintenance to be considered > Intermittent dredging/disposal activities due to spoil transport and inclement weather delays	> Located near the dredge area reducing spoil transit times compared to other sites which also can't adopt hydraulic pumping methods	> Intermittent dredging/disposal activities due to spoil transport, inclement weather delays and larger vessels taking way



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Dispersion performance	Current and Wave Assessment	> Swell waves typically approach the site from the north to northeast, however wind sea waves approach the site from different directions, ranging from north-north-west to south-east (Cardno 2021d) > Disposal site occurs within northerly ebb and southerly flood direction in excess of 1 m/s during spring ebb tide (Cardno 2021d)	> Disposal site fully exposed to longer period oceanic swell waves from the Beagle Gulf up to 0.9 m and sea waves approaching from north-north-east to southeast during dry season, and from the north-north-west to north-north-east during the wet season (Cardno 2021d) > Disposal site experiences low energy currents and eddies up to 0.2 m/s though sediment piping operations could experience current velocities up to 1.4 m/s between the dredge and disposal areas	> Current speeds at the site are relatively high, reaching 1.5 m/s in a spring tide ebb flow and ~0.5 m/s in a spring tide flood flow > Dry Season - average easterly direction wave height below 0.5 m, increases in the sea state and peak wave heights (up to 0.9 m) in the afternoon before declining again overnight (Cardno 2014b) > Wet Season - average wave heights in the Beagle Gulf are 0.8 to 0.9 m, roughly twice the height of the dry season, arriving from a westerly direction	N/A	N/A	> Dry Season - average easterly direction wave height below 0.5 m, increases in the sea state and peak wave heights (up to 0.9 m) in the afternoon before declining again overnight (Cardno 2014b) > Wet Season - average wave heights in the Beagle Gulf are 0.8 to 0.9 m, roughly twice the height of the dry season, arriving from a westerly direction > Tidal currents occur generally north-south direction towards East point and Fannie Bay up to 1.1 m/s	> Swell waves typically approach the site from the north to northeast. > Wind sea waves approach the site from different directions from north-north-west to south-east directions > Tidal currents occur generally north-south direction towards East point and Fannie Bay up to 1.3 m/s	> Large tidal ranges in the harbour produce peak current speeds of up to 2–2.5 m/s. > Tidal flows are also large; peak spring-tide flows have been measured along a line from East Point to Mandorah and are in the order of 120 000 m ³ > Waves within Darwin harbour are wind driven requiring SE directional winds to achieve considerable fetch as they enter the harbour mouth.
	Depth	> Between 5 m and 10 m LAT	> Between 10 m and 15 m LAT	> ~13.5m AHD	N/A	N/A	> Between 15 m and 20 m below LAT	> These waters are within Port Limits, in a depth of 18m LAT and is clear of existing anchorages	> East Arm Wharf - 10-13 m LAT > Marine Supply Base - 5-8 m LAT > Fort Hill Wharf - 13-15 m LAT
	Sedimentation Assessment	> Specific area not modelled, although has very similar physical conditions as the MMF referral sediment transport modelling suggesting similar disposal site dispersion	> Area of low tidal energy > Magnitude and extent of excess (above background) SSC is dominated by oceanic swell and sea waves	> Plume modelling indicates full dispersion of spoil through the water column > No sedimentation deposition greater than 1 mm occurs nears the dredge disposal site	N/A	N/A	> Magnitude and extent of excess (above background) SSC is dominated by the tidal flow patterns > Excess SCC range of 3 - 5 mg/L with greater spatial extent during wet season due to increased wave action	> Assessment of the dredge volume similar to MMF (90,000m ²) volumes adopted tolerance limits from INPEX Ichthy's project for hard coral, filter-feeder and macroalgae communities, seagrass beds and mangrove communities > Modelled sediment deposition (Williams 2016) indicated sedimentation did not pose a significant risk to benthic communities in the vicinity of the Project.	> Assessment of ~8,000m ³ dredge spoil found no net sedimentation of >2.5 mm within the hard coral and filter-feeder communities in East Arm. Posing negligible risk of significant impacts towards these communities. > Further understanding of sedimentation from larger quantities is required



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	Background Suspended Sediment Conc. (SSC)	> SSC (turbidity) corresponds to tidal current speed – increased turbidity in spring tides, and seasonality – higher background turbidity during the wet season. > Expected to be consistent with Darwin Harbour Background TSS: - Spring tides - between 10 - 15 mg/L - Neap tides - Between 2 - 5 mg/L	> SSC (turbidity) corresponds to tidal current speed – increased turbidity in spring tides, and seasonality – higher background turbidity during the wet season. > Expected to be consistent with Darwin Harbour Background TSS: - Spring tides - between 10 - 15 mg/L - Neap tides - Between 2 - 5 mg/L	> Median (50th percentile) concentrations: - Wet season 7 mg/L - Dry season 3 mg/L	N/A	N/A	> Spring tides - between 10 - 15 mg/L > Neap tides - Between 2 - 5 mg/L	> 9.7 mg/L Dry Season > 12.5 mg/L Wet Season	> 5 mg/L Dry Season > 10-15 mg/L Wet Season
	Legislative Implications	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Proximity to INPEX gas pipeline and shipping channel	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit.	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit.	> National Environment Protection Measure (soil screening criteria) for contaminated sites must be adhered to. > Appropriately endorsed ASS management plan > Waste classification of dredge spoil material provided to SBWMF prior to disposal	> National Environment Protection Measure (soil screening criteria) for contaminated sites must be adhered to. > Waste classification of dredge spoil material provided to SBWMF prior to disposal	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Remaining capacity for INPEX's NT EPA endorsed disposal activities is calculated to be approximately 7 Mm3 within the nominated disposal area. Therefore, unlikely to accommodate Mandorah disposal material	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Cumulative impact assessment required for additional spoil adding to Darwin Port's NT EPA endorsed disposal volumes	> Located within Northern Territory waters and consequently the Environment Protection (Sea Dumping) Act 1981 (Cwlth) does not apply, negating the need for a sea dumping permit. > Cumulative impact assessment required for additional spoil adding to Darwin Port's NT EPA endorsed disposal volumes

