Wheatstone Project

Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan

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ACRONYMS, ABBREVIATIONS AND TERMINOLOGY

ADCP	Acoustic Doppler Current Profiler
ALARP	As Low as Reasonably Practicable
AMSA	Australian Maritime Safety Authority
ANZECC	Australian and New Zealand Environment Conservation Council
Area of High Impact	Area of predicted irreversible impacts based on the outputs from the base case modelling and the tolerance limits developed for the Zones of Impact.
Area of Influence	Area of influence (changes to environmental quality but would not result in a detectible impact on benthic biota) based on the outputs from the base case modelling and the tolerance limits developed for the Zones of Impact.
Area of Moderate Impact	Area of reversible impacts based on the outputs from the base case modelling and the tolerance limits developed for the Zones of Impact.
ARMCANZ	Agricultural and Resource Management Council of Australia and New Zealand
AS/NZS	Australian/New Zealand Standard
BHD	Backhoe Dredge
BPP	Benthic Primary Producers; functional ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components.
BPPH	Benthic Primary Producer Habitat*; functional* ecological communities that inhabit the seabed within which algae (e.g. macroalgae, turf and benthic microalgae), seagrass, mangroves, corals or mixtures of these groups are prominent components. BPPH also include areas of seabed that can support these communities.
CAR	Compliance Assessment Report
CEO	Chief Executive Office of the Office of the Environmental Protection Authority
Channel facilities	Areas of the channel, including the access channel, turning basin and PLF.
Chevron Australia	Chevron Australia Pty Ltd
Clean-up dredging	Includes dredging activities associated with the channel facilities and any other areas in which the previously achieved design depth, during capital dredging, has reduced due to accumulation of sediments.
CLG	Cumulative Loss Guidelines as defined in EAG #3.
Coral EPO Assessment	An assessment of achievement of the coral EPOs described in Condition 6-1 (i), (iv) and (v) undertaken at the mid-term and post dredging works and in the event of a Level 3 water quality trigger exceedence.
CPCe	Coral Point Count with Excel Extensions
CSD	Cutter suction dredge
CSFM	Conservation Significant Marine Fauna; specifically marine mammals, marine turtles, whale sharks and sawfish
Cth	Commonwealth
CWR	Centre for Whale Research
DBNGP	Dampier-to-Bunbury Natural Gas Pipeline

DDSPEMMP	Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan
DEC	Department of Environment and Conservation (WA) – now split into DER and DPaW
DEH	Department of Environment and Heritage (Cth)
Designated Reef Formations	Defined as Paroo Shoals, Gorgon Patch, SW of Gorgon Patch and Hastings shoals as per MS 873.
DEWHA	Department for the Environment, Water, Heritage and the Arts (Cth) – formerly DEH
Domgas	Domestic gas
DOTE	Department of the Environment (Cth) – formerly SEWPaC
DPA	Dampier Port Authority – now Pilbara Port Authority
DPaW	Department of Parks and Wildlife
DPI	Department for Planning and Infrastructure (State)
Draft EIS/ERMP	The Environmental Impact Statement/Environmental Review and Management Programme
DSPS	Dredge Spoil Placement Site
Dredging	Includes all activities associated with the capital dredging and disposal of material including: the excavation or dredging of the material, the loading and carriage of dredge spoil for the purpose of dumping and the dumping of the material at the prescribed spoil grounds for the Nearshore and Offshore Facilities. See also clean-up dredging.
Dredging activity	For the purposes of this Plan, dredging activity has been defined as a combination of the type of dredging (e.g. CSD, placement of dredge spoil) and the location of the activity.
EMP	Environment Management Plan
eNGO	Environmental Non-Government Organisation
EP Act (WA)	*Environmental Protection Act 1986*
EPA	Environmental Protection Authority (WA)
EPBC Act (Cth)	*Environment Protection and Biodiversity Conservation Act 1999*
EPBC 2008/4469	The Commonwealth Primary Environmental Approval and conditional requirements for the Wheatstone Project. Commonwealth Government of Australia, Minister for Sustainability, Environment, Water, Populations and Communities, Hon. Tony Burke, 22 September 2011, as amended from time to time.
EPO	Environmental Protection Outcomes as defined in MS 873
EQO	Environmental Quality Objective
EQC	Environmental Quality Criteria
FCC	Fouling Control Coat
Final EIS/RTS	Final Environmental Impact Statement/Response to Submissions on the Environmental Review and Management Programme
GPS	Global Positioning System
ha	hectare(s)

HES	Health, Environment and Safety
Irreversible Loss	Loss refers to direct removal or destruction of benthic primary producer habitat. Benthic primary producer habitat is directly modified so significantly that the impacted benthic primary producer habitat would not be expected to recover to the pre-impact state and therefore the loss is considered irreversible. As defined in EAG #3.
km	kilometre(s)
KP	Kilometre Point
KPI	Key Performance Indicators
LAT	Lowest Astronomical Tide (Ashburton North)
LAU	Local Assessment Unit
LNG	Liquefied Natural Gas
m	metre(s)
Management triggers	Are management trigger indicators which are used to implement appropriate management actions in an adaptive management process. These are not used to as a compliance matter.
Marine Fauna	Whales, dolphins, dugongs and marine turtles
Marine mammals	Whales, dugongs and coastal dolphins
mAHD	Metres above Australian Height Datum (approximately the height above mean sea level)
MEB	Marine Ecosystem Branch
MFO	Marine Fauna Observer; A suitably trained and dedicated person engaged to be on duty on vessels actively engaged in dredging during all daylight hours when dredging is conducted
Mm^3	Million cubic metres
MODIS	Moderate Resolution Imaging Spectroradiometer
MOF	Materials Offloading Facility
MO	Management Objectives as defined in MS 873.
Monitored Reef formations	Reef formations within the Onslow area adjacent to which water quality data will be collected for the Responsive Monitoring Programme, and upon which BPPH data will be collected for the Verification Monitoring Programme (includes both impact monitored reef formations and reference reefs). Note: also includes Designated Reef Formations, as illustrated in Figure 6.7
MS 873	Ministerial Statement No. 873: The State (WA) Primary Environmental Approval, and conditional requirements for the Wheatstone Project. Government of Western Australia, Minister for the Environment; Water, Hon. Bill Marmion MLA, 30 August 2011 as amended by MS903 and amended from time to time.
MTPA	Million tonnes per annum
NADG	National Assessment Guidelines for Dredging
Nearshore	Marine habitat from the 20 m contour to the shoreline
Nearshore facilities	Includes the shipping channel, product loading facility, materials offloading facility, Dredge Spoil Disposal Site A and discharge lines.
NES	National Environmental Significance (see Table 3-1)

NTU	Nephelometric Turbidity Units
OE	Operational Excellence
OEPA	Office of the Environmental Protection Authority
Offshore	Marine habitat beyond the 20 m contour to the shoreline
Offshore facilities	Includes the shipping channel, dredge spoil disposal sites B, C, D and E and produced water outfall.
PAR	Photosynthetically Active Radiation
PAM	Proactive Adaptive Management
PIN	Pilbara Inshore bioregion
PIO	Pilbara Offshore bioregion
(The) Plan	Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan
PLF	Product Loading Facility
PPA	Pilbara Port Authority – formerly Dampier Port Authority
Practicable	Means reasonably practicable having regard to, among other things, local conditions and circumstances (including costs) and to the current state of technical knowledge (taken from the EP Act)
Project	The Wheatstone Project as assessed and approved under MS 873 and EPBC 2008/4469.
Proponent	Chevron Australia Pty Ltd
PSD	Particle Size Distribution
Responsive Management	Management undertaken for adaptive management and includes corrective actions as detailed in Section 6.2.3.
Responsive Monitoring	Monitoring undertaken to inform adaptive environmental management as detailed in Section 6.3.1.
ROW	Right of Way
Serious Damage	'Serious damage' is intended to apply to damage to benthic primary producer habitat that is effectively irreversible or where recovery, if that can be reasonably predicted at all, would not occur for at least 5 years. As defined in EAG #3
SEWPaC	Department of Sustainability, Environment, Water, Population and Communities (Cth) – now DOTE
SDP	Sea Dumping Permit
SIA	Strategic Industrial Area
SIC	Shared Infrastructure Corridor
SMFG	Size Management Fish Grounds
SSC	Suspended Sediment Concentration
Suitably trained and dedicated person	The person has demonstrated knowledge (detailed in MS 873 Condition 10-1) in marine fauna observation, distance estimation and reporting and must not have any other duties while engaging in visual observations of marine fauna
SME	Subject Matter Experts
SoW	Scope of Works

TIEMMP	Trunkline Installation Environmental Monitoring and Management Plan
TSHD	Trailing suction hopper dredge
Turbidity–generating activities which are part of the construction of the nearshore and offshore marine facilities	Capital dredging and dredge spoil disposal required for the construction of nearshore or offshore marine facilities, and construction activities for the offshore produced water outfall pipeline which generate and/or release sediment into marine waters. Throughout this Plan referred to as dredging – see *Dredging.*
Verification Monitoring	Monitoring undertaken to assess the effectiveness of the water quality triggers in affording protection to BPPH from increased turbidity during dredging, as detailed in Section 6.3.3. *Note: Verification Monitoring will not be used to assess achievement of the EPOs*.
WA	Western Australia
Zone 1	Overflow control zone as defined in MS 873
Zone 2	Overflow control zone as defined in MS 873
ZoHI	Zone of High Impact. Defined in Figure 3 and 4 of Schedule 1 in MS 873
ZoI	Zone of Influence
ZoMI	Zone of Moderate Impact. As illustrated in Figure 3 and 4 of Schedule 1 in MS 873. The Zone of Moderate Impact as defined in EPBC 2008/4469 applies to the seagrass sampling under the Dugong Research Plan and is not relevant to this Plan.

1.0 BACKGROUND

1.1 Project Overview

Chevron Australia Pty Ltd (Chevron Australia) will construct and operate a multi-train Liquefied Natural Gas (LNG) facility and domestic gas (Domgas) plant near Onslow on the Pilbara Coast, Western Australia. The Wheatstone Project (the Project) will process gas from various offshore in the West Carnarvon Basin. Ashburton North Strategic Industrial Area (ANSIA) is the approved site for the LNG and Domgas plants.

The Project requires installation of gas gathering, export and processing facilities in Commonwealth and State waters and on land. The initial Project will produce gas from Production Licences WA-46-L, WA-47-L and WA-48-L, 145 km offshore from the mainland, approximately 100 km north of Barrow Island and 225 km north of Onslow, and will also process gas from Production Licence WA-49-L operated by Woodside Petroleum Limited. Figure **1.1** shows the location of the Project.

The ANSIA site is located approximately 12 km south-west of Onslow along the Pilbara coast within the Shire of Ashburton. The initial (or foundation) Project will consist of two LNG processing trains, each with a capacity of approximately 4.45 million tonnes per annum (MTPA). Environmental approval was granted for a 25 MTPA plant to allow for the expected further expansions. The Domgas plant will be a separate but co-located facility and will form part of the Project. The Domgas plant will tie-in to the existing Dampier-to-Bunbury Natural Gas Pipeline infrastructure via third party DBP Development Group Pty Ltd Domgas pipeline. Figure 1.2 shows the onshore and nearshore project footprint.

1.2 Proponent

Chevron Australia is the proponent and the company taking the action for the Project on behalf of its joint venture participants Woodside Petroleum Limited, PE Wheatstone Pty Ltd a company part-owned by Tokyo Electric Power Company, Kuwait Foreign Petroleum Exploration Company and Kyushu Electric Power Company.

1.3 Objectives

The objectives of the Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan (the Plan) are to:

- Manage the impacts to matters of national environment significance (Table 3-1), associated with dredging required for the Project; and
- Ensure that turbidity–generating activities, referred to as dredging, which are part of the construction of the nearshore and offshore marine facilities:
  i. Achieve the environmental protection outcomes (EPOs) set in Condition 6-1 or any approved revised EPOs *(*WA Ministerial Statement No. 873 [MS 873]; Table 1-1)
  ii. Are managed with the aim of achieving the management objectives (MOs) set out in Condition 6-2 (MS 873; Table 1-1).

Table 1-1: Environmental Protection Outcomes and Management Objectives as required by WA Ministerial Statement No. 873

No.	Condition
6.1	The Proponent shall ensure the construction of nearshore and offshore marine facilities achieves the following environmental protection outcomes:
i	no irreversible loss of, or serious damage to, coral habitats outside of the Zone of High Impact shown in Figure 3 of Schedule 1;
ii	no irreversible loss of, or serious damage to, filter feeder habitats outside of the Zone of High Impact shown in Figure 3 of Schedule 1;
iii	no irreversible loss of, or serious damage to, seagrass, macroalgal and other benthic habitats outside of the Zone of High Impact shown in Figure 4 of Schedule 1;
iv	protection of at least 70% of baseline live coral cover on each designated reef formation (see Figure 2 of Schedule 1) within the Zone of Moderate Impact shown in Figure 3 of Schedule 1;
v	no detectable reduction of net live coral cover within the Zone of Influence shown in Figure 5 of Schedule 1; and
vi	no detectible net negative change from the baseline state of filter feeder, seagrass, macroalgal and other benthic habitats determined by implementing Condition 7, outside of the Zones of High and Moderate Impact, shown in Figures 3 and 4 of Schedule 1, whichever figure is relevant to the habitats above,
	unless and until, at a specified site(s) outside the Zones of Moderate Impact or specified designated reef formation(s) or site(s) in the Zones of Moderate Impact, a revised environmental protection outcome has been approved by the Minister in accordance with Condition 6-10 to have effect for that specified site(s) or specified designated reef formation(s), in which case the approved revised environmental protection outcome for the specified site(s) or designated reef formation(s) shall be achieved in the construction of the nearshore and offshore marine facilities.
6.2	Notwithstanding the Environment Protection Outcomes specified in Condition 6-1 which the Proponent must achieve, the Proponent shall design and execute turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities with the aim of meeting the following management objectives:
i	Within the Zone of High Impact shown in Figure 3 of Schedule 1: protection of at least 50% of baseline live coral cover on each of the following two reef formations: a) End of Channel Shoal and b) Saladin Shoal, which are shown in Figure 2 of Schedule 1;
ii	Within the Zone of Moderate Impact shown in Figure 3 of Schedule 1: no detectible reduction of net live coral cover at any designated reef formation in this zone; and
iii	Within the Zone of Influence shown in Figure 5 of Schedule 1: no detectable reduction of net live coral cover within this zone.

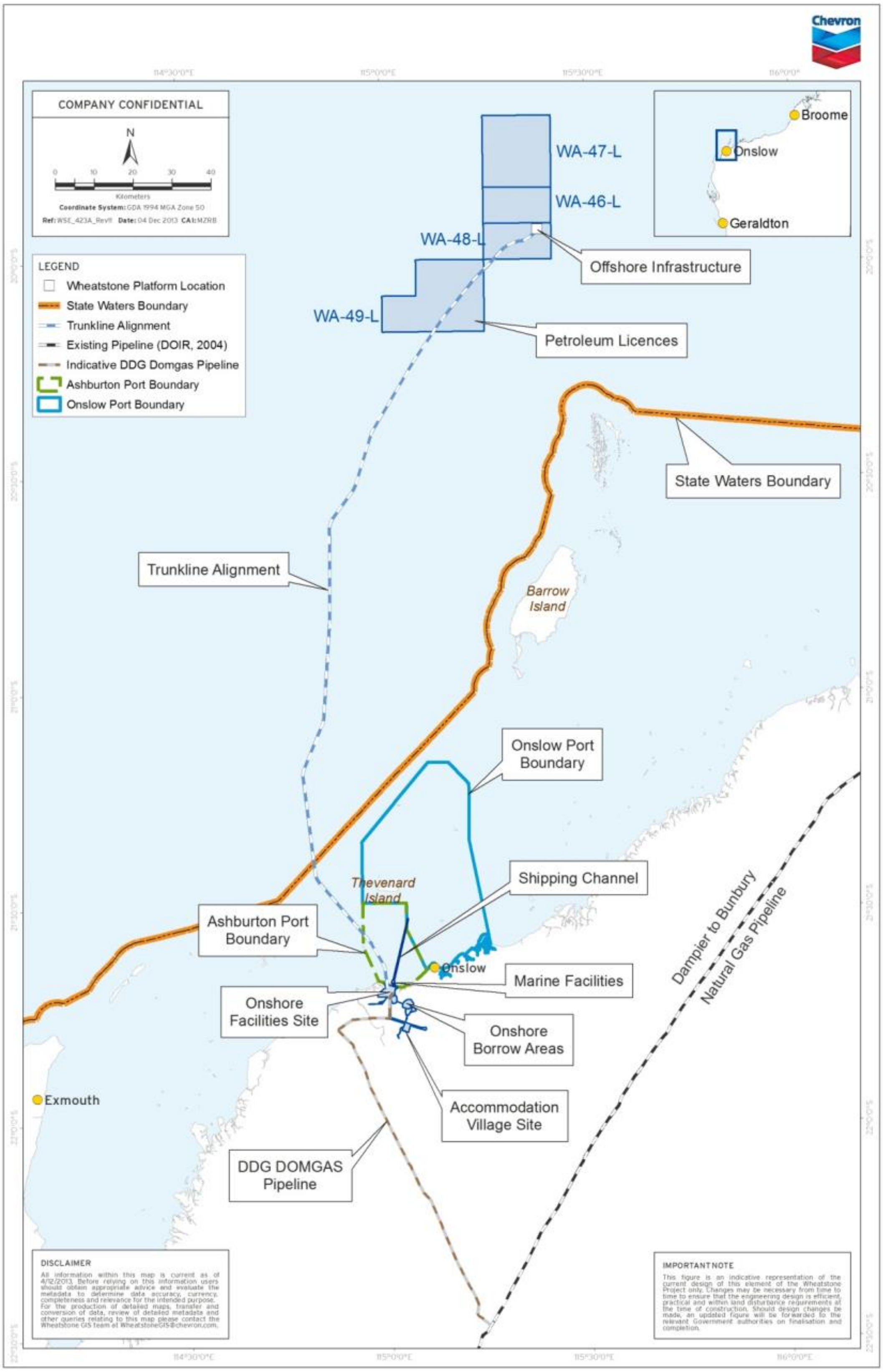


Figure 1.1: Location of Wheatstone Project Infrastructure

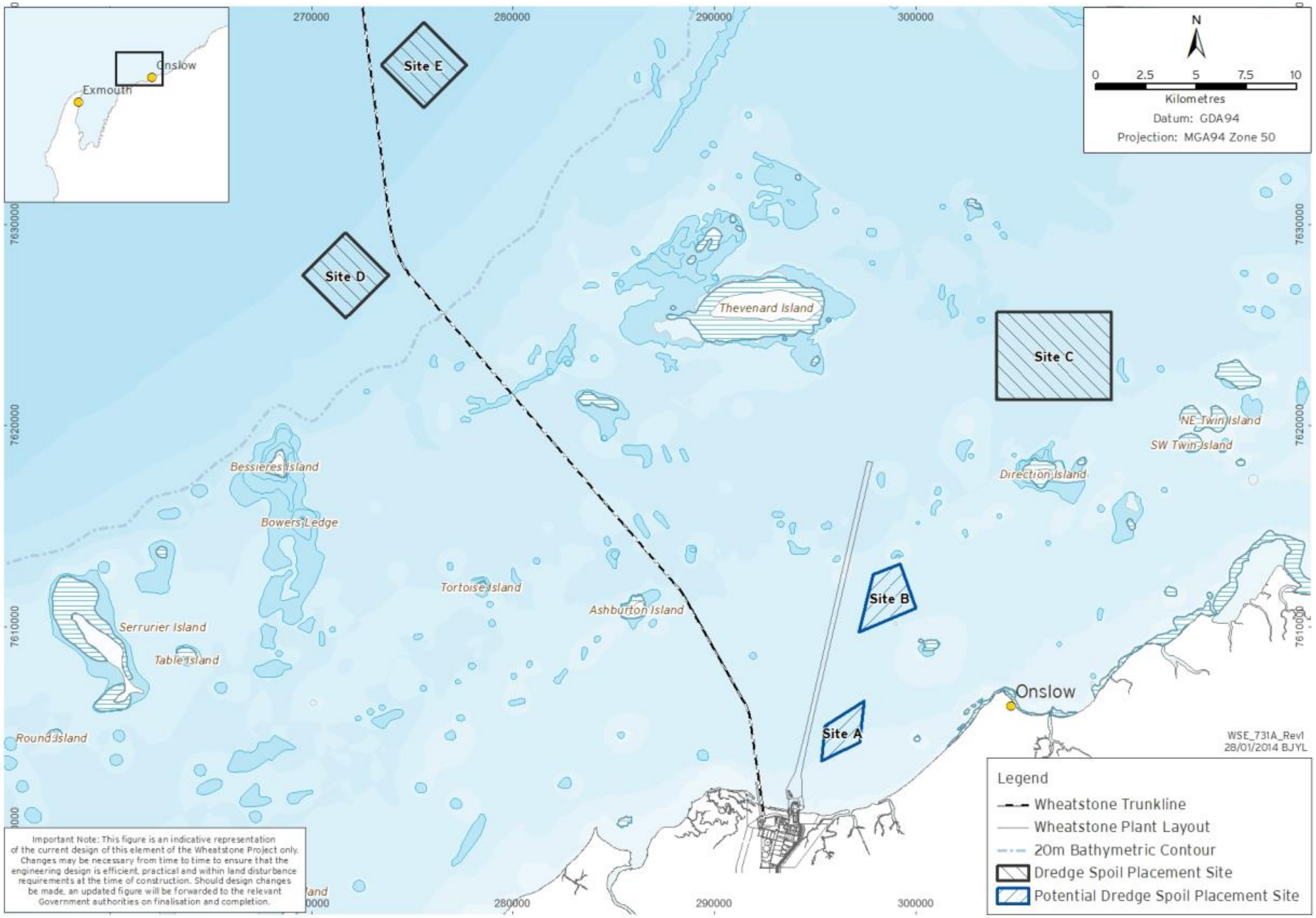


Figure 1.2: Nearshore Project Infrastructure

1.4 Scope

The Plan has been prepared to address the potential impacts associated with dredging activities which are part of the construction of nearshore and offshore marine facilities in accordance with Condition's 6-3, 6-4 and 6-5 of MS 873 and Condition 10 and 11 of EPBC 2008/4469 (Table 1-2; Table 1-3) of the Wheatstone Project.

Chevron Australia will meet Condition 10 and 11 of EPBC 2008/4469 through the submission of two environmental monitoring and management plans, to better align with requirements under MS 873:

1. This Plan to manage turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities.
2. The Trunkline Installation Environmental Monitoring and Management Plan (TIEMMP) to manage turbidity-generating activities associated with trunkline installation.

The separation of the dredging activities into two separate environmental monitoring and management plan's does not affect the objectives of the Plans or the EPOs as they are directly related to distinct dredging activities, being those turbidity generating activities which are part of the construction of nearshore and offshore marine facilities and, separately, those that are part of the trunkline installation. Cumulative impacts from the dredging for the nearshore marine facilities, offshore marine facilities and the trunkline installation are dealt with in Section 11.0. The Minister has approved the submission of this Plan and the TIEMMP to meet Condition's 10 and 11 of EPBC 2008/4469, as per the letter dated 19 October 2012.

The following construction activities which are relevant to this plan are the dredging of the shipping channel (referred to as the approach channel), PLF, MOF, and spoil placement activities at dredge spoil placement sites (A to E). The following activities are excluded from this Plan:

- Dredging for the secondary stabilisation of the trunkline which is dealt with in the TIEMMP
- Construction of the produced water outfall as it is currently not required for the foundation project.

This plan covers both Commonwealth and State waters however the only management measures required in Commonwealth waters are marine fauna management measures associated with dredge spoil placement at dredge spoil placement site (DSPS) E which is discussed in Section 9.0. This is because the only dredging activity in Commonwealth waters is placement of dredge spoil at DSPS E. No additional management measures are required when placing dredging spoil at DSPS E due to the lack of Benthic Primary Producers (BPPs) at those depths and therefore there are no predicted impacts to BPP or Benthic Primary Producer Habitat (BPPH).

1.5 Environmental Approvals

The Project was assessed through an Environmental Impact Statement / Environmental Review and Management Programme (EIS/ERMP) assessment process under the WA *Environmental Protection Act 1986* (EP Act) and the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act).

The Wheatstone Project was approved by the WA Minister for Environment; Water on 30 August 2011 by way of MS 873 and as amended by Ministerial Statement No. 903

(MS 903), Ministerial Statement No. 922 (MS 922), Ministerial Statement No. 931 (MS 931) and Attachments 1 to 4. Revised Environmental Protection Outcomes under Condition 8-7 to allow for trunkline installation were approved by the Minister by way of letter dated 30 January 2013.

The Commonwealth Minister for Sustainability, Environment, Water, Population and Communities (SEWPaC), now the Department of the Environment (DOTE), approved the Project on 22 September 2011 (EPBC 2008/4469) with variations to EPBC 2008/4469 Conditions 44, 45, 55, 56 and 66 made pursuant to section 143 of the EPBC Act. Other amendments may be made from time to time and if so will be reflected in the next revision of this Plan.

The Project involves the placement of dredge spoil at sea within both Commonwealth and State waters and therefore requires a Sea Dumping Permit (SDP) under the *Environmental Protection (Sea Dumping) Act 1981*. The identified environmental impacts related to the SDP for the management of dredge spoil management were assessed as part of the EIS/ERMP under the EPBC Act (Commonwealth), as agreed with DOTE. Approval to undertake sea dumping was granted through SDP 2011/2102.

This Plan has been prepared to meet the following requirements for both MS 873 and EPBC 2008/4469, as per the Note[1] in EPBC 2008/4469:

- Prior to the commencement of turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities, unless otherwise approved by the CEO, the Proponent shall prepare a Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan that meets the objectives set out in Condition 6-4 to be approved by the CEO (Condition 6-3 of MS 873).
- The person taking the action must submit a DDSPEMMP to the Minister (Condition 10 of EPBC 2008/4469)[2].

The sections in this Plan which are noted (Table 1-3) to meet the conditions of EPBC 2008/4469 shall be read and interpreted as only requiring implementation of EPBC 2008/4469 for managing the impacts of the dredging on, or protecting, the EPBC Act matters listed in (Table 3-1). The implementation of matters required only to meet the requirements of MS 873 are not the subject of EPBC 2008/4469. Similarly, the implementation of matters required only to meet the requirements of EPBC 2008/4469 are not the subject of MS 873.

This Plan has been developed to meet the environmental conditions within MS 873 (Table 1-2) and Commonwealth conditions (EPBC 2008/4469) (Table 1-3).

[1] If a condition of another approval held by the proponent requires submission of a plan that meets the requirements of Condition 10, the proponent may simultaneously meet the relevant requirements of both conditions by submitting a single plan.

[2] This Plan along with the Trunkline Installation Environmental Monitoring and Management Plan, prepared to manage turbidity-generating activities associated with trunkline installation, together meet Condition 10 of EPBC 2008/4469.

Table 1-2: WA Ministerial Statement No. 873 Requirements for this Plan

No.	MS 873 Conditions	Section
6-4	The objectives of the Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan are to ensure that turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities: i. Achieve the environmental protection outcomes set in Condition 6-1 (or any approved revised environmental protection outcome): and ii. Are managed with the aim of achieving the management objectives set out in Condition 6-2.	Section 6.1.2
6.5	The Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan shall include:	
i.	descriptions of monitoring sites, including key physical attributes, geographic locations and measures of the baseline condition of benthic communities to be monitored;	Figure 6.7 Table 6-6 Table 6-7
ii.	descriptions of the environmental variables to be monitored for determining achievement of the environmental protection outcomes set in Condition 6-1(i), (iv) and (v), (or any approved revised environmental protection outcome), and the management objectives in Condition 6-2;	Section 6.3.1
iii.	the monitoring and data evaluation procedures to be applied so as to assess achievement of the environmental protection outcomes set in Condition 6-1(i), (iv) and (v), (or any approved revised environmental protection outcome) and the management objectives in Condition 6-2;	Section 6.3.1
iv.	the monitoring methodologies to be applied to, unless otherwise approved in writing by the CEO:	
a.	measure relevant physical indicators (e.g. water currents, water quality conditions including turbidity, photosynthetic radiation and light attenuation coefficient, and sediment production and deposition rates) at a frequency to allow near-real time dredge and dredge overflow management and the validation and calibration of numerical models that may be used to assist in the management of dredging activities; and	Section 6.3.1
b.	measure relevant biological indicators with intervals between monitoring occasions of approximately 14 days (depending on weather conditions and the biological indicators) to inform adaptive environmental management (e.g. measures of live coral cover/coral mortality);	Section 6.1.1
v.	management trigger indicators and values for relevant physical and biological indicators to be applied in a risk-based tiered approach for the management of the environmental impacts of turbidity generating activities which are part of the construction of nearshore and offshore marine facilities;	Section 6.2.3

No.	MS 873 Conditions	Section
vi.	evidence demonstrating that the monitoring required to assess achievement of environmental protection outcomes set in Condition 6-1, (or any approved revised environmental protection outcome) and management objectives in Condition 6-2, is based on tests using appropriate effect size(s) and has statistical power values of at least 0.8 (or alternative value(s) or methods as approved by the CEO);	Section 6.3.1
vii.	management actions that will be implemented in the event that the management triggers values set in Condition 6-5(v) are not met;	Section 6.2.3 Table 6-1
viii.	methods and procedures that will be implemented to regularly characterise, spatially-define and report the realised Zone of Influence caused by turbidity-generating activities which are part of the nearshore and offshore marine facilities;	Section 6.3.1.2 and Table 12-1
ix.	procedures for coral reproductive status monitoring to assist with predicting the timing and duration of coral spawning events;	Section 8.3
a.	the following with respect to dredge spoil placement site C: a. calculations of predicted incremental loss of dredge spoil under metocean conditions typical of the location (i.e. inter-cyclone periods taking account of seasonal variations) following completion of marine works; and b. predictions of fate and environmental impact of dredge spoil calculated to be lost following completion of marine works;	Section 10.0
b.	a. management actions measures to be undertaken during dredge spoil placement activities to minimise the environmental impact of those activities and any material incremental losses of dredge spoil which may occur following completion of dredge spoil placement at sites in State waters; b. monitoring to be undertaken of retention, stability and fate of dredge spoil placed at dredge spoil placement sites during and following the completion of dredge spoil placement at sites in State waters to verify the efficacy of the measures referred to in 6(xi)(a) above; c. contingency measures to be implemented should monitoring required by Condition 6-5(xi)(b) indicate management actions measures referred to in Condition 6(xi)(a) are not effective; and	Section 10.0
xii.	requirements for timely reporting of monitoring data, management responses and contingency measures.	Section 11.0

No.	MS 873 Conditions	Section
6-6A	The Proponent shall provide relevant stakeholders with a draft copy of the Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan required under Conditions 6-3, and provide those stakeholders a reasonable opportunity to comment on the plan before it is submitted to the CEO for approval under Condition 6-3.	Section 1.7
10-12 i	a description of the environmental stressors relating to the construction….of nearshore and offshore marine facilities…which are likely to impact on marine fauna (environmental stressors may include, but are not limited to….dredge entrainment…)	Section 9.0
10-12 ii	a description of design features and management actions which the Proponent will implement to avoid, or where this is not practicable, mitigate impacts of the environmental stressors relating to the construction and operation of nearshore and offshore marine facilities, trunkline and Onshore Facility on conservation significant marine fauna (for example, darkness strategies that avoid, or where this is not practicable, the impact of lights or light glow from the construction and operations of the Proposal, vessels and offshore accommodation vessel, interfering with female turtles and hatchlings);	
10-12 iii	environmental performance standards to determine whether the design features and management actions are achieving the plan objectives referred to in Condition 10-11; and	
10-12 iv	a process (including a monitoring programme) to determine that the environmental performance standards are being achieved	

Table 1-3: Commonwealth Ministerial Conditions EPBC 2008/4469 Requirement for this Plan

No.	EPBC 2008/4469 Conditions	Section
11	The DDSPEMMP must include the following:	
a	Consideration and analysis of different dredging mitigation measures, which have the potential to reduce the impact on coral reefs, mapped seagrass beds or other dugong (*Dugong dugon*) habitat	Section 2.2
b	Consideration of any data collected through the Dugong Research Plan, referred to at Condition 37, and implementation of adaptive management measures, if applicable	Section 9.0
c	A monitoring program, management triggers and corrective actions to manage impacts to coral reefs, seagrass and dugongs, taking into consideration the revised modelling referred to at Condition 9, any data collected through the Dugong Research Plan referred to at Condition 37 and any seagrass surveys that are undertaken. *Note: For the purposes of clarification, Condition 11 (c) does not require that seagrass presence or health is used as a specific management trigger.*	Section 6.0 Section 7.2.1 and 7.3.1 Section 9.0
d	A commitment to cease dredging activities at least 3 days prior to the predicted commencement of mass coral-spawning, or as soon as mass coral spawning is detected, if prior to the predicted time, and to only recommence dredging activities after at least 7 days have passed since the commencement of mass coral spawning unless 11 e. applies.	Section 8.0
e	The Minister may approve in writing, a reduction in the period over which dredging must cease (refer Condition 11 d), if the person taking the action provides peer-reviewed scientific evidence that demonstrates that if dredging activities were to continue during mass coral spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.	Section 8.0
f	Adaptive management processes	Section 6.0
g	Operating procedures to minimise injury to, or mortality of, EPBC Act listed threatened or migratory species from dredging or nearshore facilities construction	Section 9.0
h	Reporting within one business day to the Minister when injury to, or mortality of, an EPBC Act listed threatened or migratory species occurs from dredging activities	Section 9.0

Note: The modelling has been re-run and the relevant results have been incorporated into this plan to meet Condition 9 (EPBC 2008/4469)

1.6 Relationship between Ministerial Requirements

This Plan details the methods to assess achievement of EPOs 6-1 (i), (iv) and (v). The results from these assessments will be used to responsively manage the dredging activities associated with the nearshore and offshore marine facilities. The data collected under this plan will be used to assess achievement of the EPOs 6-1 (i), (iv) and (v) for Condition 6-7. To the extent of any differences or inconsistencies between this Plan and the State of the Marine Environment Scope of Works (SoW), with respect to the assessment of achievement of Condition's 6-1 (i), (iv) and (v) this Plan will take precedence.

The survey data collected under the State of the Marine Environment SoW (Chevron 2012) will be used to assess the achievement of the EPOs in Conditions 6-1 (ii), (iii), (vi) at the mid-term, post development and potentially 2nd post development survey. To the extent of any differences or inconsistencies between this Plan and the State of the Marine Environment SoW, with respect to the assessment of achievement of Condition's 6-1 (ii), (iii), (vi), the State of the Marine Environment SoW will take precedence. The survey data collected under this Plan may be used to assist in the interpretation of achievement of the EPOs assessed through the State of the Marine Environment SoW (Table 1-4).

Table 1-4: Relationship between Variables and the Assessment of the Achievement of EPOs in Conditions 6-1

Variable (Section)	Condition	Timing of Assessment
Coral		
	6-1 i. no irreversible loss of, or serious damage to, coral habitats outside of the Zone of High Impact shown in Figure 3 of Schedule 1;	1. During Dredging (Interim assessment; Condition 6-3 DDSPEMMP) * 2. Mid term/Post Development and potentially 2nd Post Development (Condition 7)
	6-1 iv. protection of at least 70% of baseline live coral cover on each designated reef formation (see Figure 2 of Schedule 1) within the Zone of Moderate Impact shown in Figure 3 of Schedule 1;	1. During Dredging (Condition 6-3 DDSPEMMP) 2. Mid term/Post Development and potentially 2nd Post Development (Condition 7)
	6-1 v. no detectable reduction of net live coral cover within the Zone of Influence shown in Figure 5 of Schedule 1; and	1. During Dredging (Condition 6-3 DDSPEMMP) 2. Mid term/Post Development and potentially 2nd Post Development (Condition 7)
Seagrass, macroalgae and filter feeders		
	6-1 ii. no irreversible loss of, or serious damage to, filter feeder habitats outside of the Zone of High Impact shown in Figure 3 of Schedule 1;	1. Mid term (interim assessment)/Post Development and potentially 2nd Post Development (Condition 7)*
	6-1 iii. no irreversible loss of, or serious damage to, seagrass, macroalgal and other benthic habitats outside of the Zone of High Impact shown in Figure 4 of Schedule 1;	1. Mid-term (interim assessment)/Post Development and potentially 2nd Post Development (Condition 7)*
	6-1 vi. no detectible net negative change from the baseline state of filter feeder, seagrass, macroalgal and other benthic habitats determined by implementing Condition 7, outside of the Zones of High and Moderate Impact, shown in Figures 3 and 4 of Schedule 1, whichever figure is relevant to the habitats above,	1. Midterm/Post Development and potentially 2nd Post Development (Condition 7)

** NOTE: Interim assessments can only provide an indication of achievement due to the definition of 'irreversible loss of, or serious damage' as achievement cannot be determined until recovery is understood.*

Management actions for Conservation Significant Marine Fauna (CSMF) from potential impacts from the physical presence of the DSPSs, due to dredge spoil placement activities associated with the nearshore and offshore marine facilities, are dealt with in this Plan. Management actions for potential impacts to CSMF from dredging activities, including entrainment and disturbance are also dealt with in this plan. Other potential impacts from the construction and operations of the Project are dealt with in the Conservation Significant Marine Fauna Interaction Management Plan (CSMFIMP). To the extent of any differences or inconsistencies between this Plan and the CSMFIMP, with respect to management measures associated with dredging and dredge spoil placement activities this Plan will take precedence.

1.7 Stakeholder Consultation and Public Availability

In accordance with Condition 6-6A of MS 873 (Table 1-2) Chevron Australia has provided a reasonable opportunity for the following relevant stakeholders, as agreed with the Office of the Environmental Protection Authority (OEPA), to comment on the initial draft of this Plan before submission to the CEO for approval:

- OEPA
- Department of Environment and Conservation (DEC) – now Department of Parks and Wildlife (DPaW)
- The Wilderness Society
- Cape Conservation Group
- Dampier Port Authority (DPA) – now the Pilbara Port Authority (PPA).

The comments received from these stakeholders have been taken into consideration in the preparation of this Plan. In accordance with Condition 12 (EPBC 2008/4469) the Plan has been reviewed and endorsed by the Dredging Technical Advice Panel (DTAP) prior to submission to the Minister for approval. A copy of all the recommendations made by DTAP and an explanation of how these recommendations have been implemented, or an explanation of why Chevron Australia does not propose to implement certain recommendations has been provided to the Minister.

The approved Plan will be made publicly available in a manner approved by the CEO (MS 873 Condition 6-6) and will be published on Chevron Australia's website after approval in accordance with EPBC 2008/4469 Condition 8. In accordance with Condition 20 of MS 873, Chevron Australia is required to make publicly available, in a manner approved by the CEO validated environmental data relevant to the implementation of the MS 873.

1.8 Plan Structure

This Plan adopts an adaptive approach for the environmental management of dredging and dredge spoil to achieve the EPOs and Management Objectives (MOs) detailed in MS 873 Condition 6-1 and 6-2 or any approved revised EPOs.

The Plan is structured as follows:

- Section 2.0 of this plan provides an overview of the applicable activities.
- Section 3.0 provides a high-level overview of the existing environment and the key studies that have been completed.
- Section 4.0 of this plan details the methods and results of the Environmental Risk Assessment (ERA) that has been undertaken.
- Section 5.0 details the results of the sediment plume modelling and the development of the relevant impact zones.
- Sections 6.0 to 11.0 present the specific management strategies that will be adopted for each parameter and the monitoring programme that informs any necessary management. The management strategies provide the outcomes and management triggers against which environmental performance will be measured.
- Section 12.0 details the reporting requirements for this Plan.

2.0 WORKS OVERVIEW

The Project elements description which follows describes the construction of the nearshore and offshore marine facilities. These may be amended from time to time, for example under Section 45C of the EP Act. The project elements which are detailed in this Plan should therefore be read as subject to any project amendments which are made from time to time.

2.1 Introduction

Up to 45 million cubic metres (Mm^3) of dredge spoil may be generated during the dredge works for the key marine infrastructure[3] (Figure 2.1) as follows:

- Temporary right of way (ROW) channels to support construction activities
- Material Offloading Facility (MOF) including Approach Channel, Turning Circle, Berth Pocket and Tug Harbour Area
- Project Loading Facility (PLF) including turning basins and berth pockets
- Approach channel.

Clean-up dredging of fine material that settles in the dredging area will also be required to finalise the dredging works. Dredge spoil will be disposed of at the proposed nearshore and offshore DSPSs (Figure 1.2). The dredging and dredge spoil management works are expected to be undertaken over approximately a three-year period commencing early 2013.

[3] This volume is the amount approved in the Environmental Approvals (MS 873 and EPBC 2008/4469) and does not include dredging volumes that may be generated from the installation of the trunkline. These are detailed in a separate management plan, the TIEMMP, specific to the trunkline (Chevron, 2012).

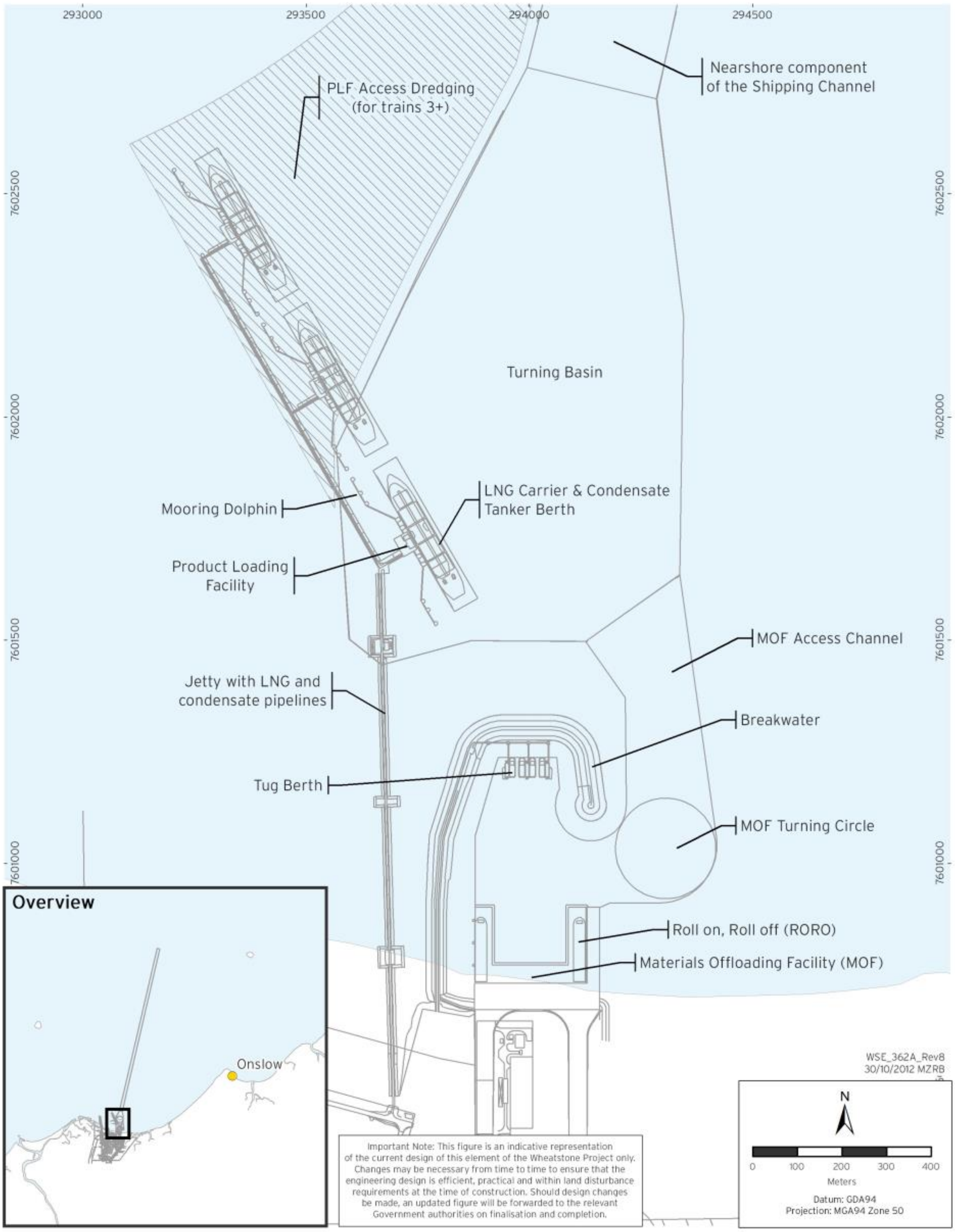


Figure 2.1: Entrance Channel, Turning Basin and Berth Alignment

2.2 Optimisation of Dredge Programme

Since submission of the EIS/ERMP (Chevron 2010), the dredge programme has been refined and optimised with the aim to achieve the EPOs and the MOs (Conditions 6-1 and 6-2 respectively of MS 873). The length of the approach channel, ~16 km, and the seasonal drift of the currents provides opportunities for adaptive management to achieve the EPOs and MOs. The following sections describe the optimised base case dredge programme designed since submission of the EIS/ERMP and include:

- Environmental basis of design and environmental benefits (Section 2.2.1)
- Overview of the base case (Section 2.2.2)
- Detailed dredging methods (including equipment) and sequencing (Section 2.2.2.1).

This optimised 'base case' dredging program is the basis of the modelling detailed in Section 5.0.

2.2.1 Optimised Dredge Programme (Base Case)

Following submission of the EIS/ERMP (Chevron 2010), additional scenarios have been considered by the Proponent and have been supported through additional modelling in order to consider different dredging mitigation measures to reduce the impact on coral reefs, mapped seagrass beds or other dugong habitat[4]. The mitigation measures considered included the use of different dredge plant (e.g. backhoe dredge (BHD) which has no overflow), location of dredging activities and climatic scenarios. Modelling was undertaken based on the different dredge plant—BHD, Cutter Suction Dredge (CSD) and Trailing Suction Hopper Dredge (TSHD)—during different seasonal water movement patterns (summer, transitional, winter) along the length of the approach channel. The modelled outputs identified different areas over the footprint of the dredging works, under different climatic scenarios, that would result in unlikely, possible or likely impact to corals[5].

Based on these predictions (illustrated in Figure 2.2 to Figure 2.4), a new *optimised dredge programme base case* ('base case') was developed with the aim to achieve the EPOs and MO's (Condition 6-1 and 6-2 respectively of MS 873). The base case methods are the most suitable options to meet the technical and economic requirements while achieving the EPOs. In terms of environmental suitability, the methods present a number of benefits including:

- Use of BHD in Zone 2[6], CSD in Zone 1[6] only during winter or transition periods, and TSHD at the end of the approach channel outside of Zone 2 reduces the turbidity generation and risk to nearby habitats.
- Where operational restrictions allow, medium to large sized TSHD and CSD may be used as opposed to smaller vessels, to reduce the duration of the works and thus reduce the temporal extent of any environmental impacts.

[4] No 'other dugong habitat' has been identified in the vicinity of the dredging activities.

[5] Reducing impacts to corals was considered as an indicator to reducing impacts to mapped seagrass habitats as coral reefs/shoals are located between dredging activities and mapped seagrass habitats (Figure 3.1).

[6] Zone 1 and Zone 2 are based on the overflow control zones as defined in MS 873.

- The methods will reduce the double-handling (side casting and re-dredging) of material and will utilise direct placement to DSPSs via barges or a spreader pontoon with diffuser.

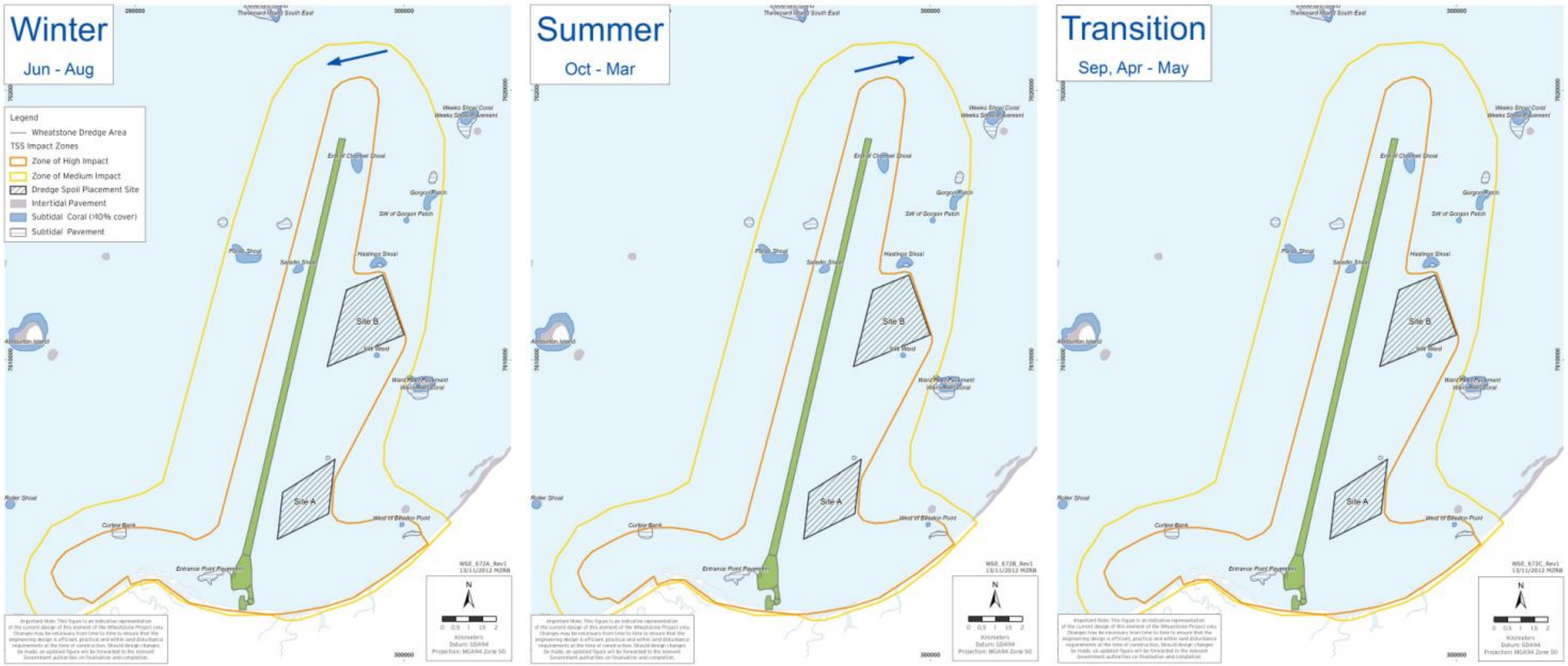


Figure 2.2: Modelling Outputs of BHD and Seasonal Conditions that will result in Unlikely (green), Possible (orange) or Likely (red) Impacts to Coral

Note: The blue arrow indicates the net currents which are partly seasonally controlled therefore the plumes predominantly extend eastward during summer and westward during winter with more variable conditions during transitional periods.

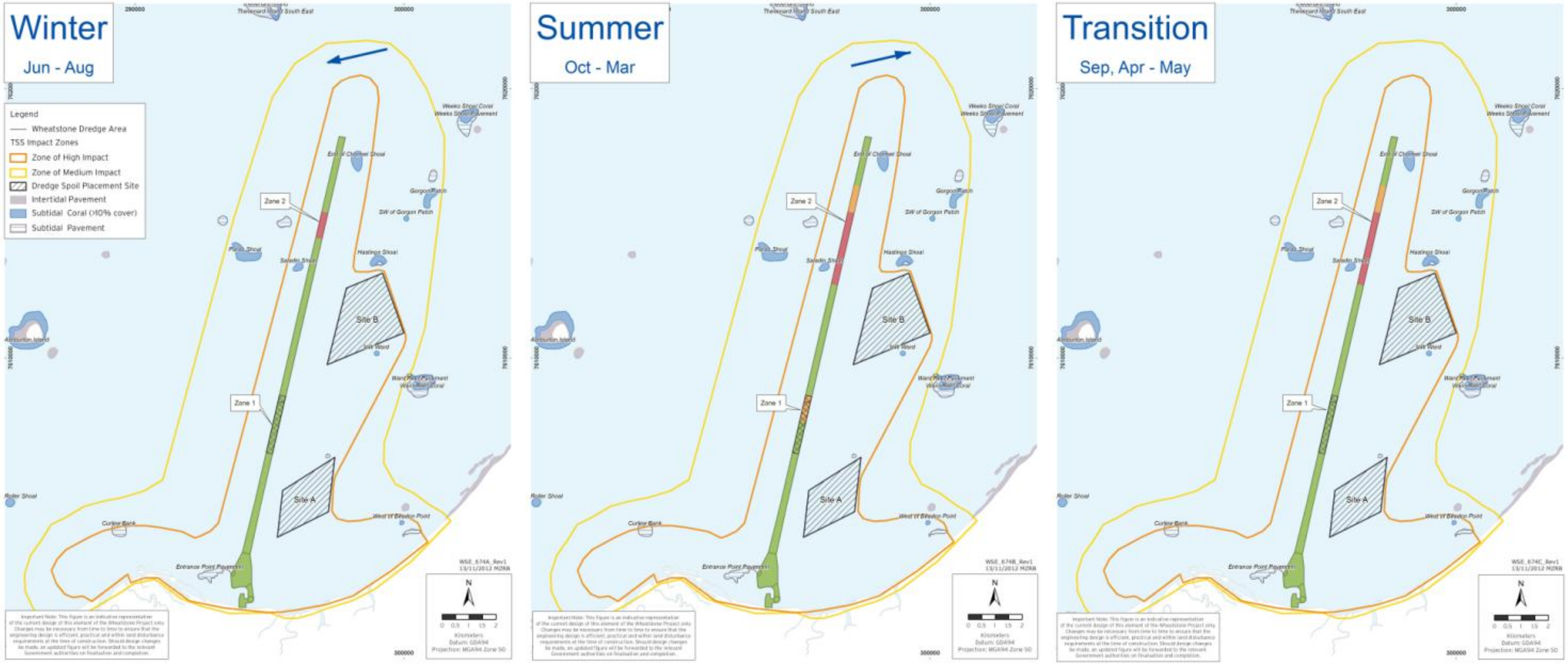


Figure 2.3: Modelling Outputs of CSD and Seasonal Combinations that will result in Unlikely (green), Possible (orange) or Likely (red) Impact to Coral

Note: The blue arrow indicates the net currents which are partly seasonally controlled therefore the plumes predominantly extend eastward during summer and westward during winter with more variable conditions during transitional periods.

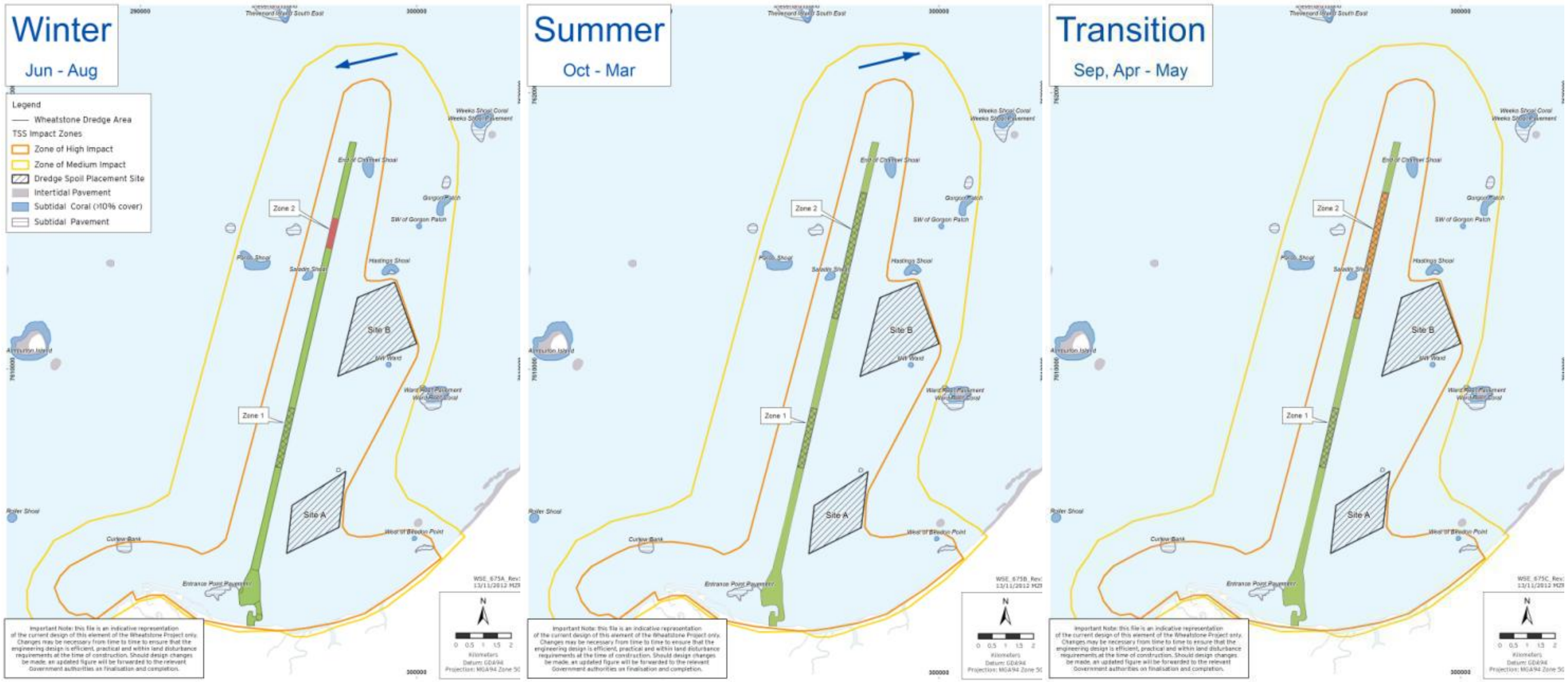


Figure 2.4: Modelling Outputs of TSHD and Seasonal Combinations that will result in Unlikely (green), Possible (orange) or Likely (red) Impact to Coral

Note: The blue arrow indicates the net currents which are partly seasonally controlled therefore the plumes predominantly extend eastward during summer and westward during winter with more variable conditions during transitional periods.

2.2.2 Base Case Overview

The base case for dredging includes the use of a BHD, CSD and a TSHD as illustrated in Figure 2.5. Zone 1 and Zone 2 in Figure 2.5 are based on the overflow control zones as defined in MS 873. The zones were based on modelling which indicated that restricting overflow in Zone 1 during summer would reduce the level of elevated turbidity at Ward Reef (due to the net currents) and restricting overflow in Zone 2 would reduce the level of elevated turbidity at the designated reef formations (Paroo Shoal, Gorgon Patch, SW Gorgon Patch and Hastings Shoal).

The BHD will be deployed to dredge part of the MOF manoeuvring area, berth pockets and tug harbour area; the restricted overflow area Zone 2 and its surroundings (500 m on the south side) in the PLF approach channel (Figure 2.5). Dredged material will be loaded into self-propelled and towed split-hopper barges and disposed at dredged spoil placement site (DSPS) C.

A CSD will be deployed to dredge all other areas including the restricted overflow area Zone 1 in the PLF approach channel under certain climatic conditions. The CSD can transport and dispose of the dredge spoil in the following manners:

- Via an on board barge loading installation through which it can load split-hopper barges or hoppers for disposal at DSPS C.
- Pumping of dredged material through a closed pipeline connected to a spider barge into a split-hopper barge or hopper for disposal at DSPS C. This method allows the CSD to dredge at another location while the loading operation is performed.
- Pumping of the dredged material through a closed piping system connected to a spreader pontoon for disposal directly into DSPS A and/or B[7] by means of a near bed diffuser mounted on the pontoon[8].

A TSHD will dredge the northern part of the PLF approach channel and will undertake clean-up dredging. The bulk material will be disposed at DSPS C while the clean-up material will be placed at DSPS C or E.

[7] Sites A and B will only be considered in the event of an emergency situation and will require the approval of the Dampier Port Authority prior to use.

[8] The near bed diffuser is a head connected at the underwater outlet of the pipeline to reduce the material outflow velocity and potential for resuspension. For near bed disposal, the pontoon will be positioned inside the DSPS site by anchors and shifted by means of hydraulic winches. This position will be determined based on optimising equal distribution of the disposed material within a pattern of dump cells and taking into account environmental conditions.

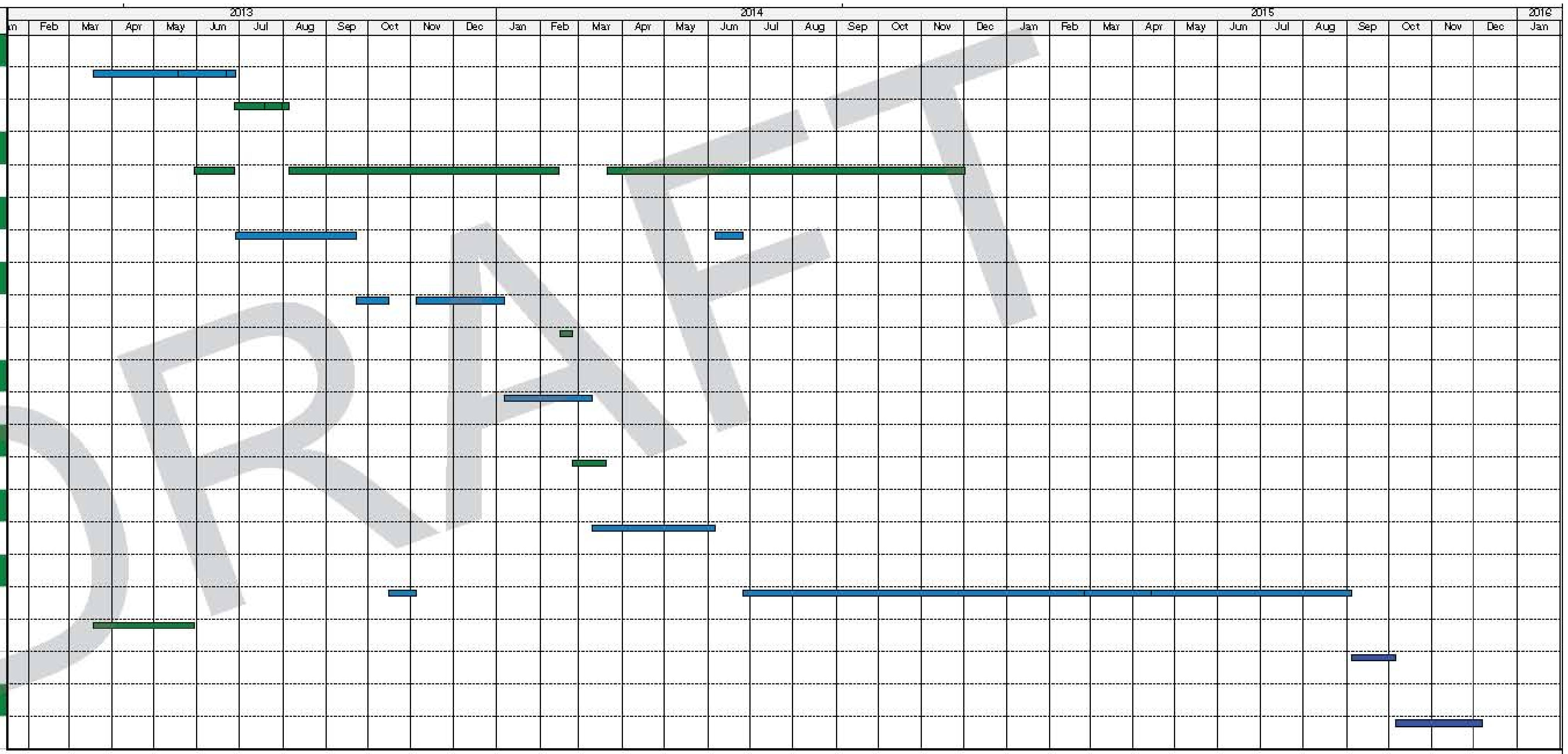
Figure 2.5: Base Case of Dredging Areas and Dredging Equipment

The base case has been divided into ten dredge activities that will be undertaken to complete the SoW, described in chronological order in Section 2.2.2.1 with a timeline summary provided in Table 2-1. The dredge volumes, depth and equipment to be used for each activity are summarised in Table 2-2.

In Table 2-2, the net volume consists of the total volume of in-situ material to be removed to achieve design depth while the gross volume also includes over dredging (below design depth) due to operability of equipment. The difference in dredge volumes from the EIS/ERMP (Chevron 2010), 45 Mm^3, is due to the refinement of the dredge program and the detailed design. The in-situ dredge volumes will be re-assessed based on the bathymetric data of the Pre-Dredge Survey carried out prior to commencement of the dredging works.

Table 2-1: Conceptual Wheatstone Downstream Dredging Schedule

Activity ID	Activity Name	At Completion	Start	Finish
MOF and ROW Dredged Area		140	18-Mar-13	05-Aug-13
CSD Amazone		102	18-Mar-13	28-Jun-13
BHD New York		39	27-Jun-13	05-Aug-13
Zone 2 of the Access Channel		551	29-May-13	01-Dec-14
BHD New York		551	29-May-13	01-Dec-14
Zone 1 of the Access Channel		363	28-Jun-13	26-Jun-14
CSD Amazone		363	28-Jun-13	26-Jun-14
Access Channel and MOF Dredged Area		155	22-Sep-13	24-Feb-14
CSD Amazone		109	22-Sep-13	09-Jan-14
BHD New York		9	15-Feb-14	24-Feb-14
PLF Berthing Pocket Dredged Area		63	09-Jan-14	10-Mar-14
CSD Amazone		63	09-Jan-14	10-Mar-14
Removal of Breakwater Material		25	24-Feb-14	20-Mar-14
BHD New York		25	24-Feb-14	20-Mar-14
PLF Dredged Area		88	10-Mar-14	09-Jun-14
CSD Amazone		88	10-Mar-14	09-Jun-14
Remaining Dredged Areas		931	18-Mar-13	05-Oct-15
CSD Amazone		689	15-Oct-13	04-Sep-15
BHD New York		72	18-Mar-13	29-May-13
TSHD Pallieter		31	04-Sep-15	05-Oct-15
Clean-up Dredging		63	05-Oct-15	07-Dec-15
TSHD Pallieter		63	05-Oct-15	07-Dec-15



**Excludes any downtime e.g. cyclones*

Note: Dates provided are indicative and subject to change. Clean-up dredging may occur at anytime during the period following the completion of capital dredging but prior to Pilbara Port Authority assuming operational control of facilities.

Table 2-2: Proposed Dredge Volumes[1] for Each Stage of Dredging

Sequence	Dredge Activity	Dredge Equipment	Net[2] Volume (m^3)	Gross[3] Volume (m^3)	Depth (m-LAT)
1 / 4	MOF and ROW dredged area	BHD, CSD	2 309 967	2 703 222	-8 / -7
2	Zone 2	BHD	2 561 337	3 002 763	-13.5
3	Zone 1	CSD (restricted periods)	2 718 522	3 002 193	-13.5
5	Access Channel and MOF Dredge Area	CSD	870 564	1 148 488	-7/ -8
6	PLF Berth Pocket	CSD	2 053 295	2 195 080	-13.5
6	PLF Turning Basin/dredged area	CSD	2 673 361	2 854 223	-13.5
7	Breakwater /Bund material	CSD BHD	350 000[4]	350 000[4]	NA
8 / 9	Remaining Areas	CSD TSHD	12 766 578	13 900 786	-13.5
10	Clean-up Dredging	TSHD	NA	NA	Required depth
N/A	Berth 3	TBC		**5 645 000**	
		Total	**26 303 624**	**34 801 755**	

[1]Volumes are calculated based on a bathymetric survey performed at project inception and may have changed due to natural variability. The in-situ dredge volumes will be re-assessed based on the bathymetric data of the Pre-Dredge Survey carried out prior to commencement of the dredging works.

[2]The net volume consists of the total volume of in-situ material to be removed to design depth.

[3]The gross volume also includes over dredging (below design depth) due to operability of equipment.

[4]The total volume of the material to be removed will be established by joint in-surveys prior to dumping and joint out-surveys upon completion of dumping.

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2.2.2.1 Base Case Dredging Sequence

1. <u>CSD dredging Right of Way and Material Offloading Facility area</u>

Dredging works are proposed to commence with dredging of a temporary ROW (up to -7 m LAT) to provide access for the CSD and BHD to the MOF area to allow commencement of dredging in this area (as illustrated in Figure 2.6). The MOF area will be dredged up to -7 m LAT.

The material dredged by the CSD will be loaded onto split-hopper barges or hoppers for disposal at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

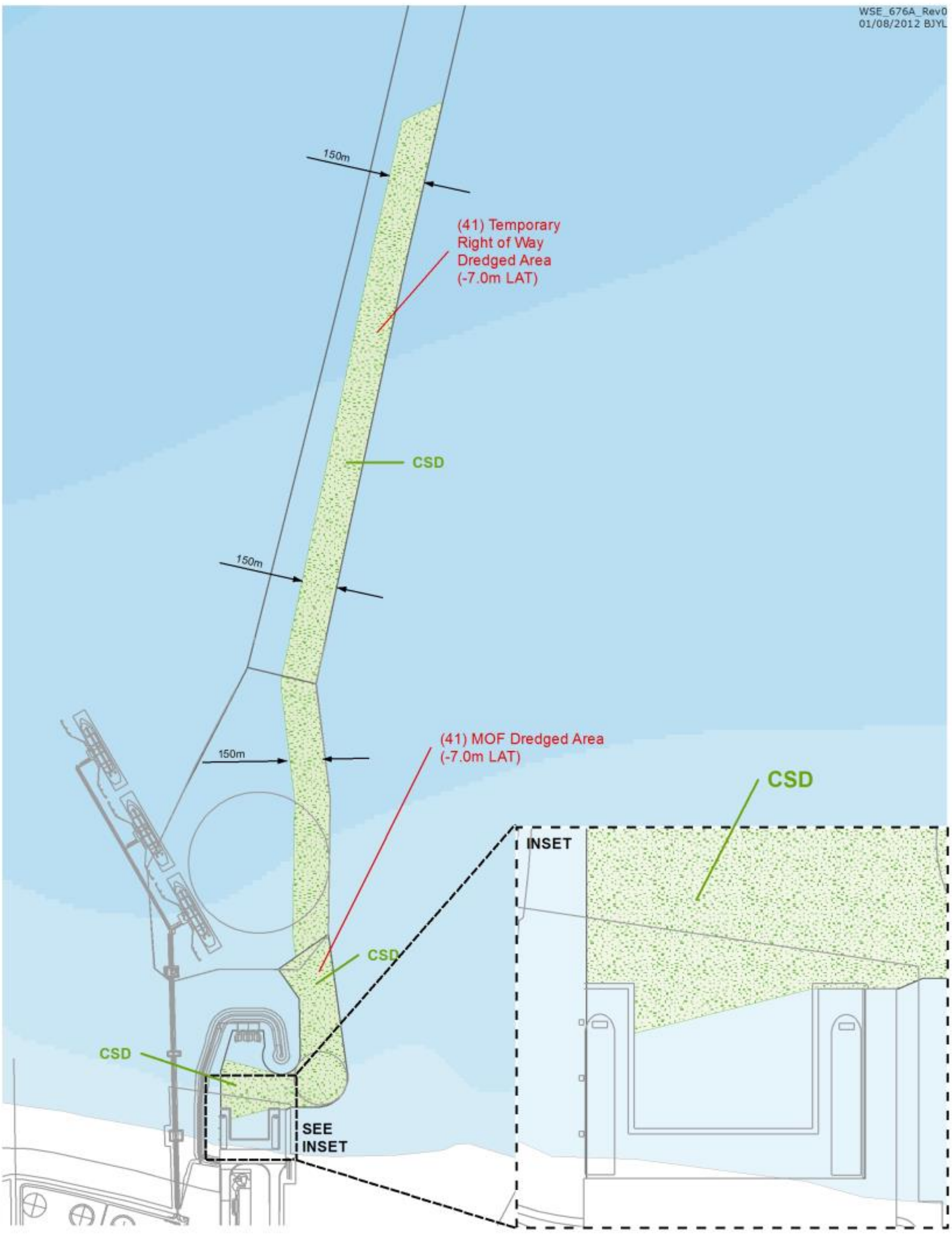

Figure 2.6: CSD Dredging ROW and Part of MOF

2. BHD dredging Zone 2 (up to -13.5 m LAT)

Dredging works may also commence with a BHD dredging within Zone 2 (as defined in MS 873) of the approach channel. Initial modelling had indicated a potential environmental risk to the reef formations within the vicinity of the approach channel (Figure 2.3 and Figure 2.4).

The dredge spoil will be loaded into barges and placed at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

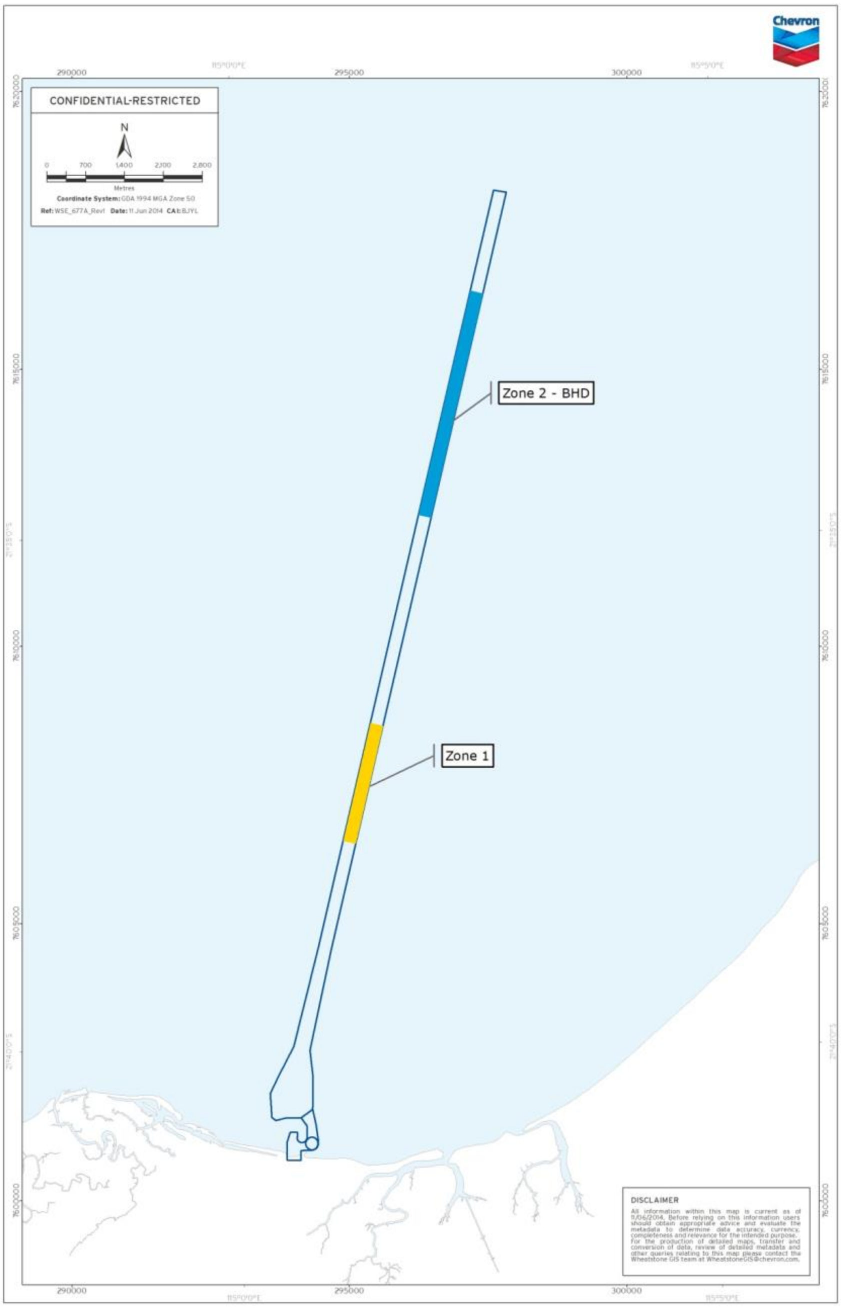

Figure 2.7: BHD Dredging Extended Zone 2

3. CSD dredging Zone 1 (up to -13.5 m LAT)

Following completion of works in the ROW and MOF area the CSD will move to Zone 1 (as defined by MS 873) of the approach channel to commence dredging, as shown in Figure 2.8. Numerical modelling has shown that dredging during the winter and transitional periods with a CSD is unlikely to result in impacts to corals and therefore the EPO can be achieved. This is shown by the summary numerical modelling maps presented in Figure 2.9. This is based on the fact that Zone 1 was established to reduce elevated levels of turbidity at Ward Reef, which is to the east of the approach channel, and that net currents predominantly extend eastward during summer. Based on these results the base case includes dredging of Zone 1 with a CSD in the winter and/or in the transition season.

The material dredged by the CSD will be disposed of via a barge loading installation through which it can load split-hopper barges or hoppers for disposal at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

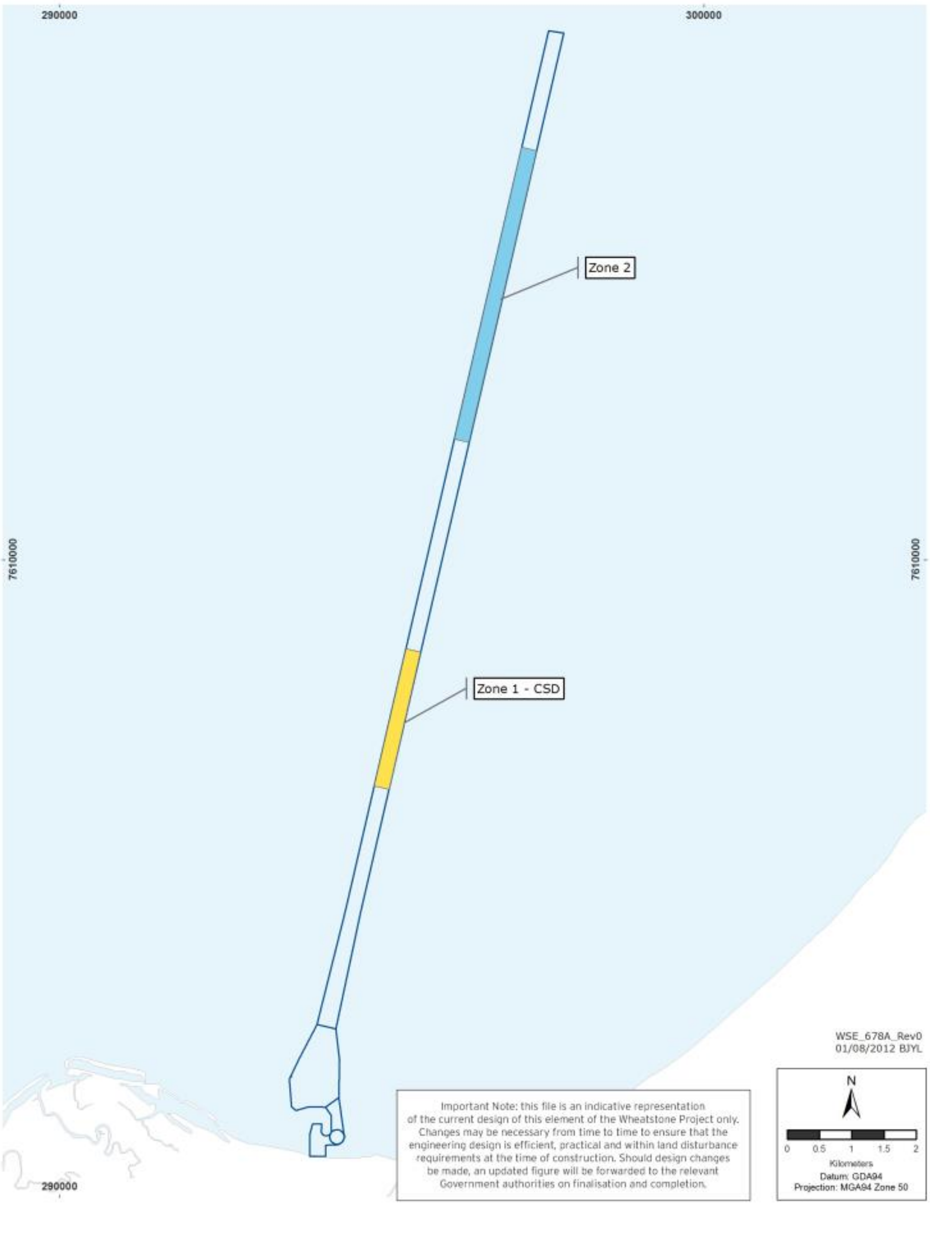

Figure 2.8: CSD Dredging Zone 1

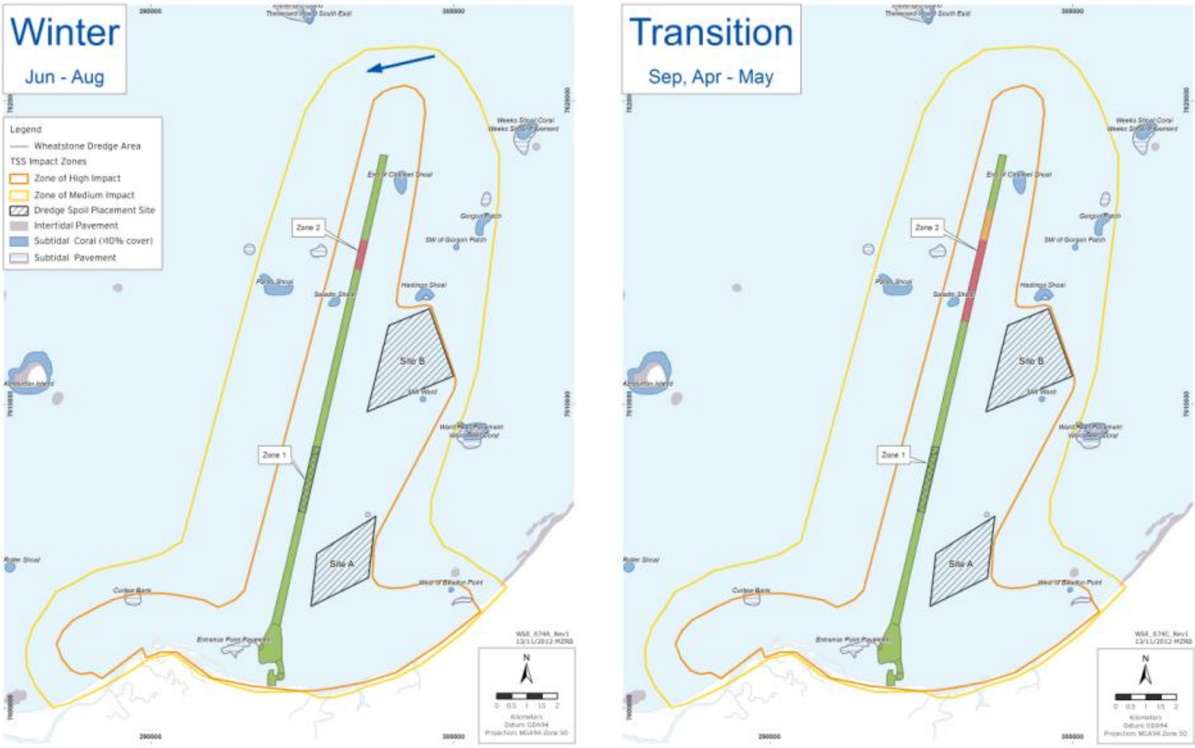

Figure 2.9: Modelling Results for CSD Dredging in Winter and Transition Season

Note: The blue arrow indicates the net currents which are partly seasonally controlled therefore the plumes predominantly extend westward during winter with more variable conditions during transitional periods.

4. BHD dredging in MOF area (-7 m LAT) and MOF berth pocket (-8 m LAT)

Once the CSD has finished dredging the area described in (1), or as soon as sufficient operational footprint is available, the BHD will move from Zone 2 to the MOF area. The BHD will dredge the MOF area and MOF berth pockets (Figure 2.10) up to -7 m LAT and up to -8.0 m LAT respectively.

The dredge spoil will be loaded into barges and placed at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia. Once the BHD has completed dredging these areas it will be returned to the approach channel and continue dredging Zone 2.

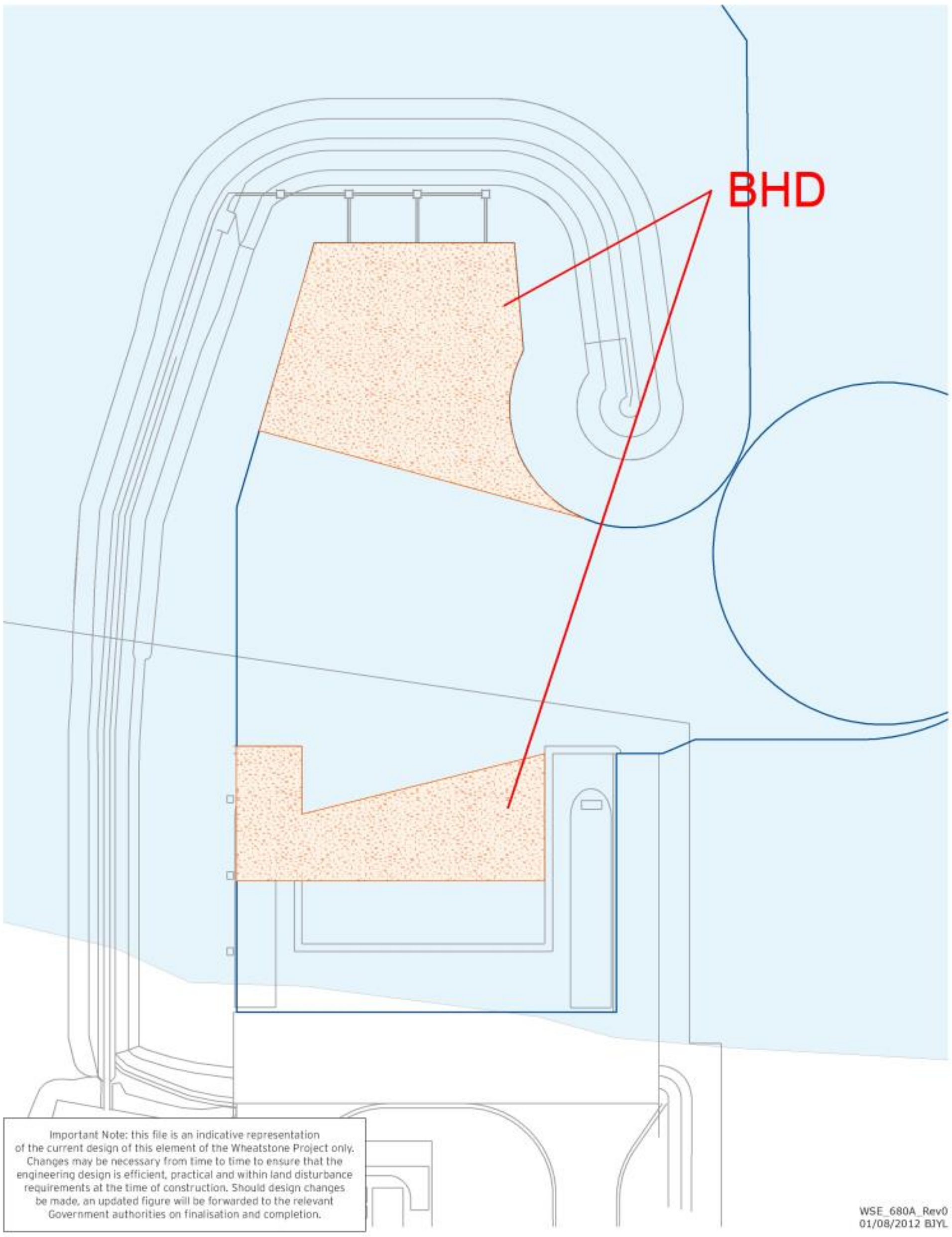

Figure 2.10: BHD Dredging in MOF Area and MOF Berth Pocket

5. CSD dredging Access Channel (-7 m LAT), MOF area (-7 m LAT), MOF berth pocket (-8 m LAT) and removal of bund material

Once the CSD has completed dredging in Zone 1, the CSD will be moved and commence dredging of the temporary access channel (up to -7 m LAT). This will also include CSD dredging to finish the MOF area (up to -7 m LAT) and the MOF berth pocket (up to -8 m LAT), including the removal of bund material placed in the MOF area during the construction of the MOF (Figure 2.11).

The dredge spoil will be loaded into barges and placed at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

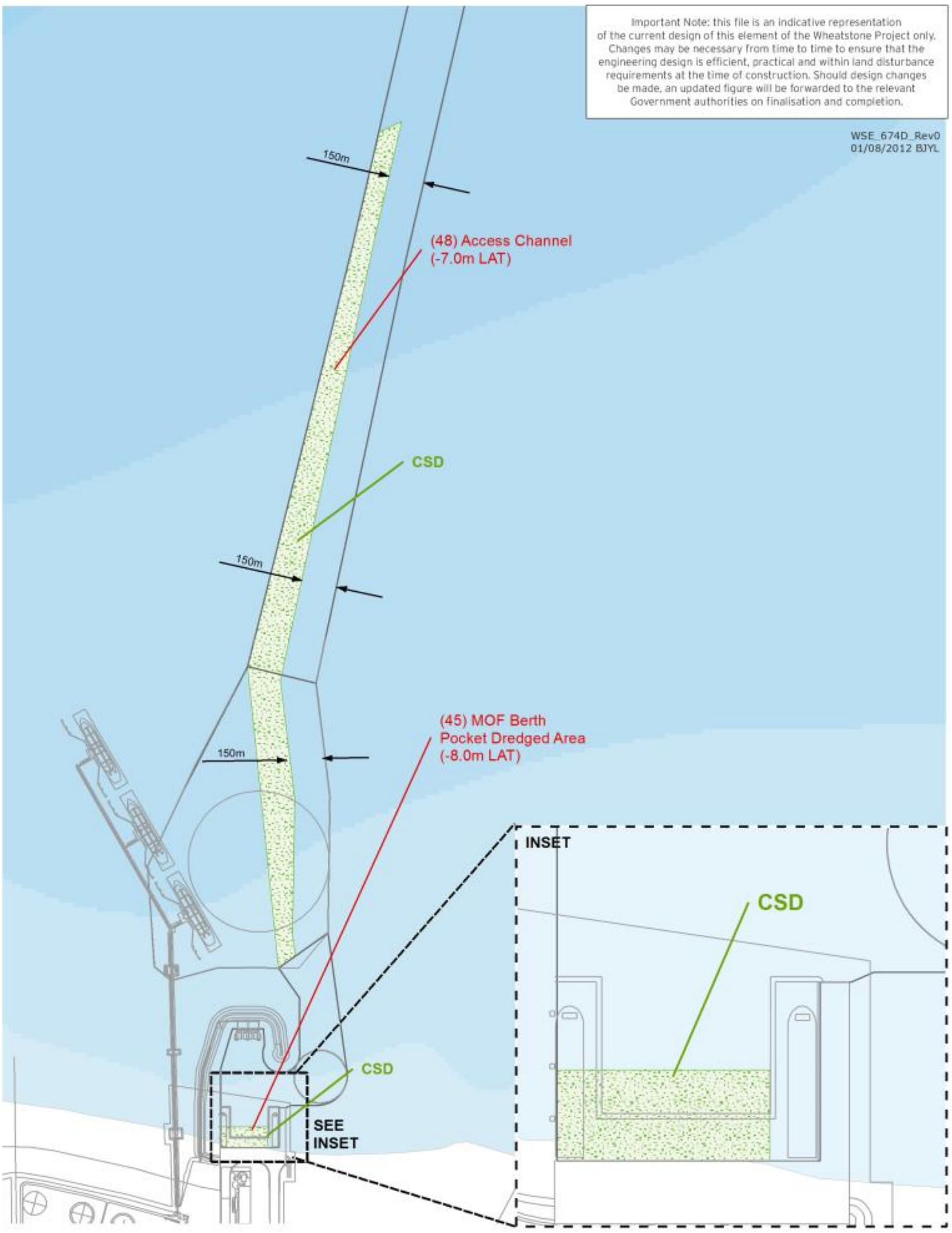

Figure 2.11: CSD Dredging Access Channel, MOF Area, MOF Berth Pocket and Bund Material

6. CSD dredging PLF berth and PLF (-13.5 m LAT)

Upon completion of the MOF area the CSD will dredge the PLF berth and PLF dredged areas (both up to -13.5 m LAT) as shown in Figure 2.12. The dredge spoil will be loaded into barges and placed at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

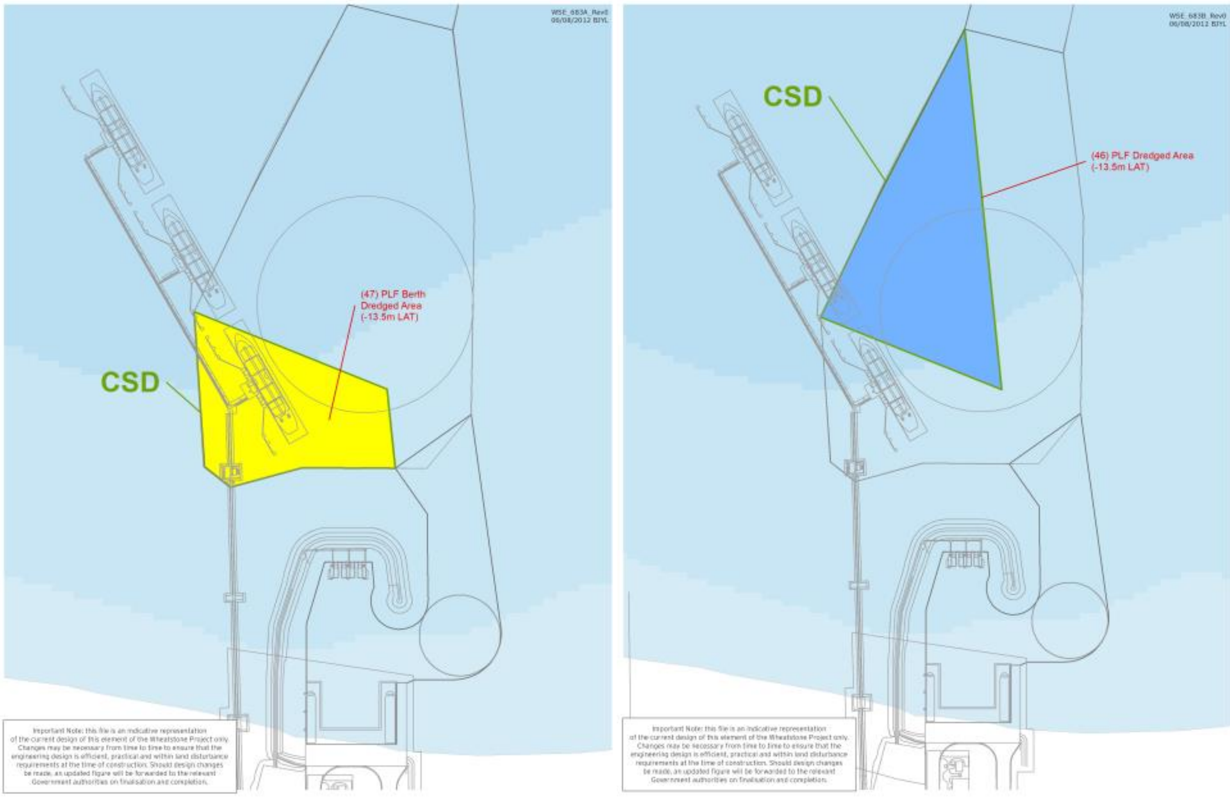

Figure 2.12: CSD dredging PLF berth and PLF area

7. BHD dredging MOF berth pocket (Eastern Quay wall) (-8 m LAT) and removal of breakwater material

While dredging in Zone 2 of the approach channel the BHD will be moved to dredge the MOF berth pocket next to the eastern part of the quay wall (Figure 2.13; up to -8 m LAT) and to remove the material from the breakwater foundation which will be placed into the MOF basin. The dredged material will be loaded into barges and placed at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

Once the BHD has completed dredging this area it will be returned to the approach channel and continue dredging Zone 2.

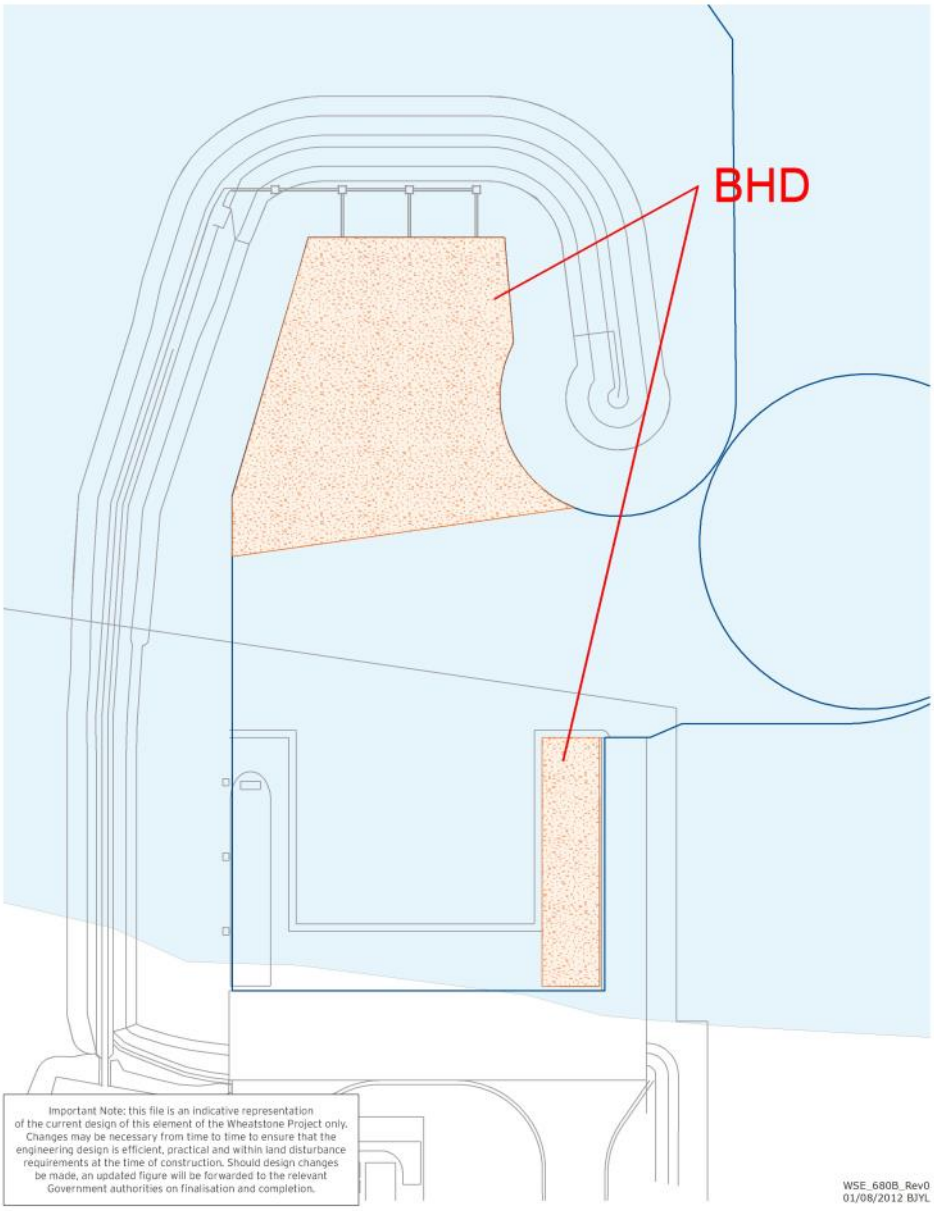

Figure 2.13: BHD dredging MOF berth pocket (next to eastern part of quay wall) and removing breakwater material

8. CSD dredging part of the Approach Channel

Once the CSD has completed works in the PLF it will be used to dredge the remainder of the approach channel, as marked by the green areas in Figure 2.14, to -13.5 m LAT.

The CSD dredging works dredge spoil will be loaded into barges, via a CSD barge loading system or via an extended pipeline coupled to a spider barge loading system, for disposal at DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

Figure 2.14: CSD Dredging Approach Channel

9. TSHD dredging part of the Approach Channel

The TSHD will be used to complete the dredging of the approach channel. The use of the TSHD has been assessed based on modelling, soil characterisation and metocean analysis. Modelling has demonstrated that a THSD can be used to dredge the northern section of the approach channel, north of Zone 2, as marked by the yellow area in Figure 2.15, at any time of year.

The TSHD will dispose the material in DSPS C. DSPS D and E may be used for the placement of dredge spoil if considered appropriate by Chevron Australia.

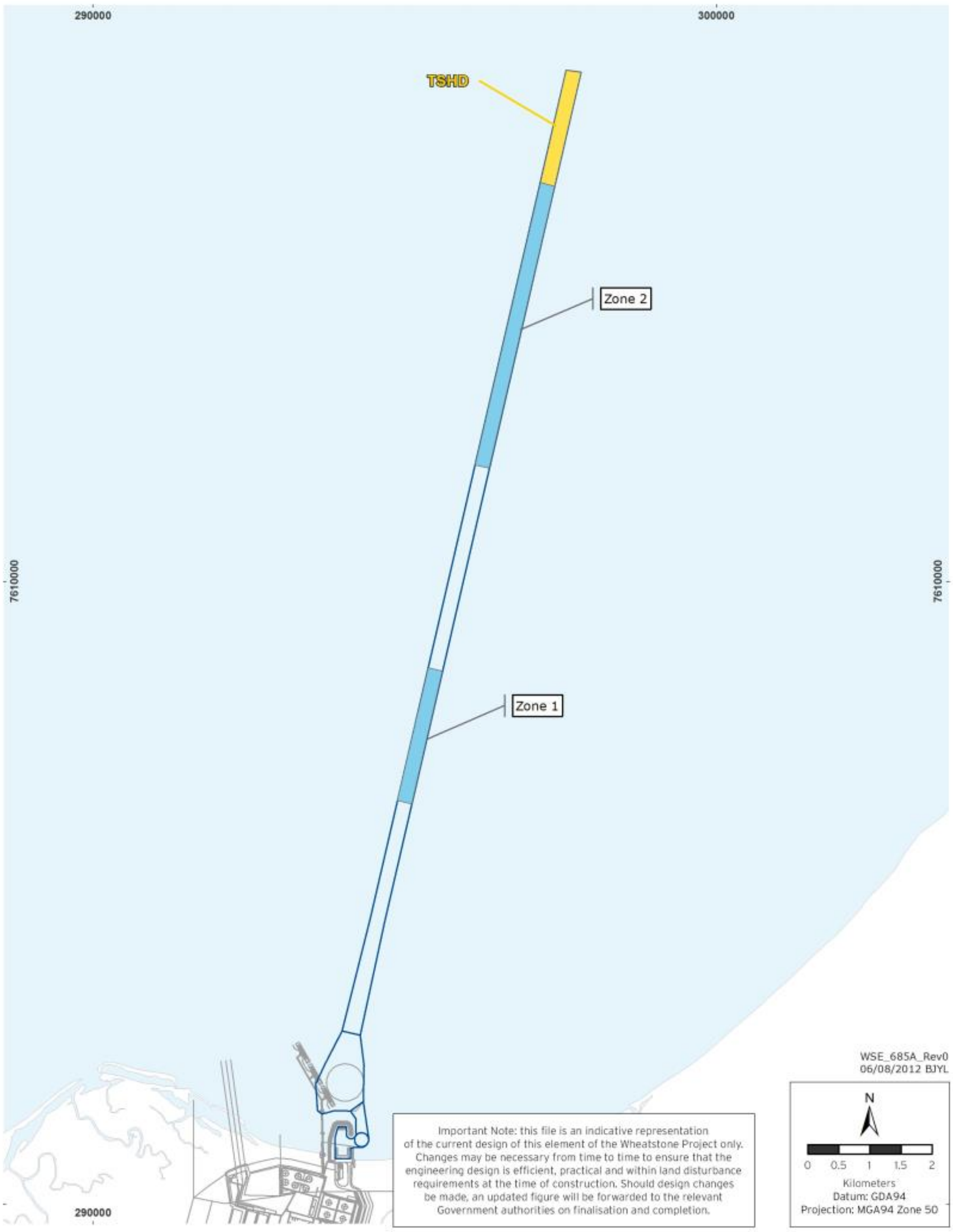

Figure 2.15: TSHD Dredging northern part of Approach Channel

10. Clean-Up Dredging

At the end of the capital dredge works, and prior to handover of the channel to operations, clean-up dredging may be required in areas in which the previously achieved design depth has reduced due to the accumulation of sedimentation. Fines resulting from clean-up operations will be placed at DSPS C, D or E.

If the layer of sedimentation caused by the work method, within 250 m outside of the toe line, is more than 20 cm, it will also be removed. The accretion of sediment will be monitored by means of the interim bathymetric surveys and compared to the pre-dredge bathymetric survey. Prior to provisional acceptance of the dredging works, or during the execution of the works if required, a tug or multicat will use a sweep beam or plough (Figure 2.16; Figure 2.17) to drag this material downslope into the channel where it will be removed by the TSHD, CSD or BHD under the base case or alternative dredging scenario (see Section 2.2.3). Part of the original seabed may also be removed. Alternatively, the sedimentation will be removed directly by the THSD, CSD or BHD. The clean-up material will be disposed in DSPS C, D or E.

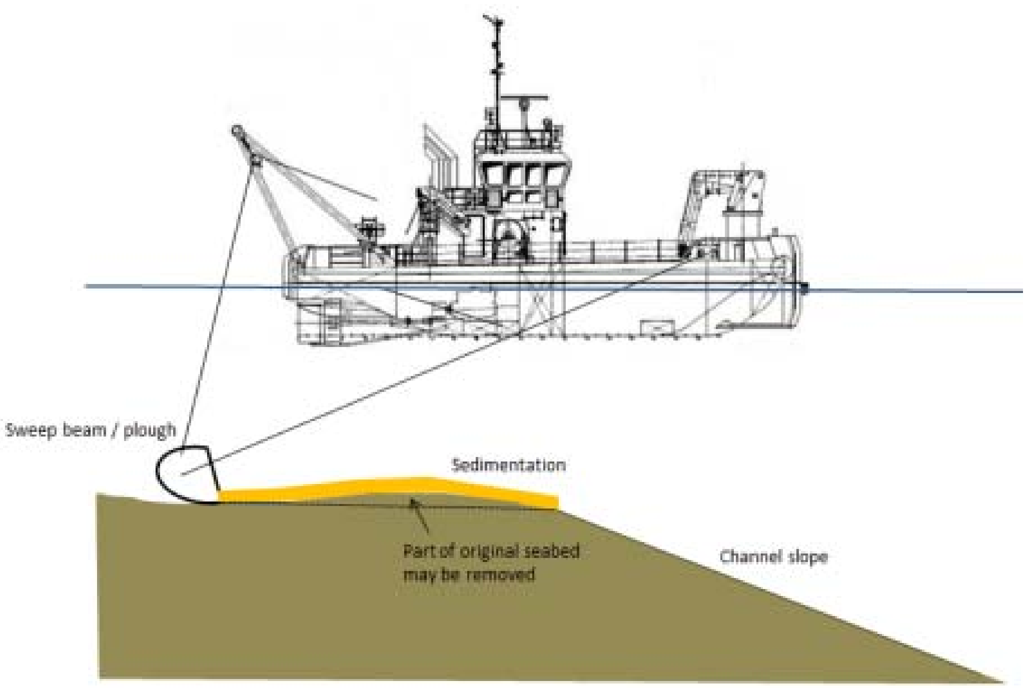

Figure 2.16: Ploughing Sedimentation into the Channel

Two components of clean-up dredging activities may be required prior to channel handover to PPA:

- Clean-up dredging in the MOF and MOF channel may be required due to unforeseen infill of these areas (such as following a direct hit from a cyclone) which poses navigational hazards to vessels through the MOF, with subsequent delays in construction of the Wheatstone LNG plant. Dredging associated with the MOF and MOF channel is predicted to be short in duration, but may be needed more than once prior to handover to PPA. Dredging may be needed of infill volumes of approximately 250 000 m^3 annually within the MOF and MOF channel; and
- Clean-up dredging of the channel facilities (channel, turning basin, and PLF) may be required prior to handover to PPA to ensure the facilities are at design depth, depending on rates of infill. Dredging may be needed of infill volumes of up to 1 500

000 m^3 (maximum volume of clean-up dredging within a 12 month period, including clean-up dredging in the MOF and MOF channel) within the channel facilities (a worst-case estimate of infill and dredge volumes).

Through modelling, it was determined that the risk from clean-up dredging is negligible (i.e. very low risk of plumes from clean-up dredging contacting coral and non-coral receptor sites[9], and if contact occurs it will be of insufficient magnitude or duration to pose a risk to receptors). Due to the negligible environmental risk from clean-up dredging activities, the comprehensive monitoring programmes associated with the capital dredge programme are not considered necessary nor deemed useful for management purposes. Therefore, a revised monitoring programme will be implemented for clean-up dredging, and the proposed monitoring programme for clean-up dredging is presented in Table 2-3.

The primary monitoring for clean-up dredging will be the assessment of water quality by examining satellite imagery on a daily basis. This monitoring programme would be implemented for all clean-up dredging scopes, however, trigger assessment using satellite imagery would only occur for dredging programmes that last for 20 days or more10; satellite imagery will be collected for all dredging scopes, regardless of duration.

In the event of satellite imagery showing plumes interacting with receptor sites for an equivalent number of days to a Level 2 chronic water quality trigger (20 in 40 days; see Section 6.2.3.4), then an inference assessment will be done to determine if plumes were attributed to dredging. Where a Level 2 water quality criteria has been attributed to dredging, then management responses outlined in Section 6.2.3.4 would be considered. In the event that satellite imagery is unavailable (due to cloud cover etc) but a plume was observed to contact a receptor site on the previous day, it will be assumed that on all days following, daily elevations have occurred and will contribute towards a trigger assessment, until such time as satellite imagery or other data is available to suggest otherwise.

Aspects of monitoring programmes associated with water quality, coral, seagrasses, macroalgae and filter feeders outlined in Sections 6.3 and 7.0 will not be implemented during clean-up dredging (see Table 2-3). Specifically, there will be no in-situ water quality monitoring at sites within ZoI, ZoMI, ZOHI and Reference zone, no verification monitoring during clean-up dredging, and no EPO assessments after clean-up dredging. Coral monitoring during coral spawning windows will be removed for clean-up dredging (Section 8.0), and management of dredging will occur in accordance with Section 8.2 and approved coral spawning exemptions.

Reporting requirements for clean-up dredging are summarised in Section 12.0.

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[9] Coral and non-coral sites where water quality was monitored during capital dredging (see Table 6-5)

[10] 20 days was chosen to align with a Level 2 chronic water quality criteria (20 days out of a 40 day rolling assessment period). If a coral or non-coral site experiences less than 20 days elevated turbidity (as per Section 6.2.3.4 of DDSPEMMP), then it suggests all EPOs and Management Objectives (MOs) for the ZoI of “no net detectable reduction in live coral cover” are being achieved, and no management response is required. Modelling has predicted that no receptor reefs will reach a Level 2 water quality criteria.

Table 2-3: Overview of aspects of the monitoring programme for clean-up dredge scopes

Clean-up Dredge Monitoring Programme	Aspects of the Capital Dredge Monitoring Programme Not Implemented
Water quality monitoring using satellite imagery on a daily basis to verify the predicted extent of plumes	*in-situ* water quality monitoring at sites within Reference Zone and also ZoI, ZoMI and ZoHI, as prescribed in the DDSPEMMP
If dredging for ≥20 days, then trigger assessment using satellite imagery to ensure water quality remains at or below a Level 2 chronic water quality trigger	Verification monitoring before, during or after clean-up dredging
If a satellite imagery Level 2 or 3 trigger is reached, then implementation of controls to reduce the extent of plumes as per DDSPEMMP	EPO assessments after clean-up dredging
Regular (three weekly) reporting of dredging and satellite imagery during clean-up dredging, and a final summary report on activities provided to DTAP. If dredging less than three weeks, then a combined regular and final report will be provided to DTAP	Monitoring of corals while dredging during a coral spawning window; management of dredge activities during predicted coral-spawning windows will be done in alignment with coral spawning exemptions

2.2.2.2 Potential Alternate Dredge Scenarios

To provide flexibility in the optimised base case dredging program a number of alternative scenarios were identified which could be implemented to allow for further optimisation of the dredge programme. These alternatives were modelled (see Section 5.0 for the outputs) which has indicated that they will achieve the EPOs and MOs. These scenarios allow adaptation and optimisation of the dredging programme in an informed manner from an environmental perspective.

The alternate scenarios have covered the following key options:

1. CSD pumping to DSPSs A and B[11] via spreader pontoon rather than overflowing barges.
2. TSHD capital dredging at various locations and configurations.
3. Simultaneous BHD dredging at Zones 1 and 2
4. CSD dredging in Area above Zone 2.

[11] Sites A and B will only be considered in the event of an emergency situation and will require the approval of the Dampier Port Authority prior to use.

As these alternative scenarios have been assessed to achieve the EPOs and MOs (and the modelling is presented in Section 5.0), the alternative scenarios may be implemented if considered appropriate by Chevron Australia.

2.2.3 Deviations from Base Case Dredge Programme

During the dredge programme there may be situations where deviations from the base case or alternate scenarios (see Section 2.2.2) are required to be able to further optimise the dredge plan and manage unforeseen circumstances. Prior to implementing deviations from the base case or alternate scenarios, predictive plume modelling will be undertaken to investigate the potential impacts from changes to dredge methodology at different parts of the channel / area. A collection of scenarios can be generated, by combining source terms, to investigate alternative scenarios to the base case. Only those dredging activities which modelling indicates will not exceed the EPOs will be implemented. Please refer to Section 5.0 for details on the process to be implemented in the selection and implementation of other dredging scenarios.

2.2.4 Dredging Equipment

The dredging and dredge spoil placement works will be undertaken by a combination of dredges and support vessels. It is envisaged that the following dredging equipment will be utilised:

- One TSHD
- One large CSD
- Two large BHDs
- Hopper barges (self and tug propelled)
- Tug equipped with sweep bar/plough
- A range of ancillary equipment including large powerful support tugs, one or more multicats and/or supply vessels, a workshop/crane barge and various support launches to provide emergency response, crew transfers, fuel, water and goods supply, hydrographic and environmental surveys, and assistance with installation of navigational aids.

Examples of the envisaged dredge vessels are shown in Figure 2.17. The final decision on the selection of the dredging equipment type will be made based on a number of factors including:

- Anticipated vessel availability
- Vessel operability (including vessel draft, cutting strength, pumping distance capability)
- Soil strength
- Transport distances
- Required dredging accuracy
- Required environmental performance.

A

B

C

D

E

A – Trailing Suction Hopper Dredge
B – Cutter Suction Dredge
C – Back Hoe Dredge
D – Split-hopper Barge
E – Tug with Sweep Bar

Figure 2.17: Examples of Dredge Plant

2.3 Dredged Material Management

2.3.1 Nearshore Dredge Spoil Placement Sites

Three nearshore (< 30 m water depth) DSPSs have been approved under MS 873, EPBC 2008/4469, and SDP2011/2012 for the placement of dredged material (Figure 2.18). Within each of the DSPS the target placement areas will be the naturally deeper waters within each site.

Proposed DSPS A has a capacity of approximately 1.5 Mm^3. Coarse material will be placed here using CSD and a near bed diffuser. DSPS B has a capacity of approximately 2–3 Mm^3. Site B may be used as an alternate site to Site C for dumping of material that is removed from the channel by a BHD or for coarse material discharged via a spreader pontoon by a CSD, but may include finer material from clean-up dredging. Approval by the PPA will be required prior to the use of DSPS A and B and will only be considered in an emergency situation.

DSPS C is the primary placement site for coarse material and has a capacity of up to 40 Mm^3. If necessary, bed levelling (e.g. via the use of an underwater plough) may be undertaken to reduce the localised raising of sea bed levels. A summary of the characteristics of nearshore DSPSs is provided in Table 2-4.

2.3.2 Offshore Dredge Spoil Placement Sites

In addition to the approved identified inshore material placement sites, two offshore DSPSs (Site D and E) in approximately 40 m to 70 m water depth to the west of Thevenard Island will be used as alternative sites for placement of dredge material, including placement of the finer material from clean-up operations (Figure 2.18). These offshore DSPSs (> 30 m water depth) have been approved under MS 873, EPBC 2008/4469, and SDP2011/2012 for the placement of dredged material. Each of these offshore sites is anticipated to have a capacity of up to 40 Mm^3.

While Site E was initially identified as a potential contingency site for placement of dredge spoil, subsequent refinements of the dredge programme identified Site E as the potential placement site for fine material from the clean-up dredging operations and as a contingency site for coarse material in the event that Site C can’t be used (see Section 10.3). The use of Site E was preferred to Site D due to the following:

- Shorter sailing distance reduces the sailing time and fuel usage
- The sailing route would not traverse the trunkline reducing potential simultaneous operations issues.

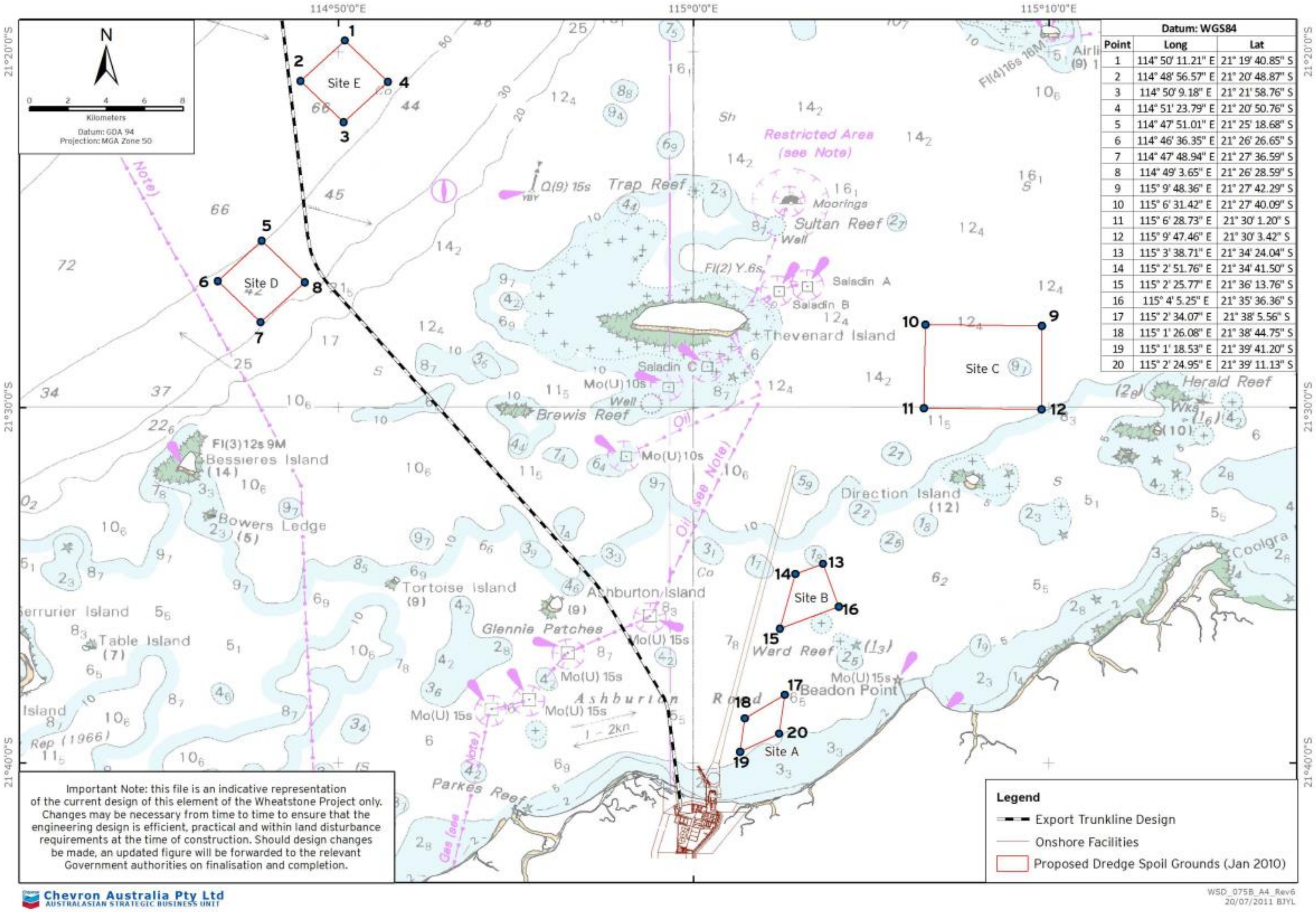
Site D may be used for the placement of dredge spoil if considered appropriate by Chevron Australia. A summary of the characteristics of offshore DSPSs is provided in Table 2-4.

Table 2-4: Summary Characteristics of Dredge Spoil Placement Site

Placement	Proposed Use	Water Depth	Capacity (Mm^3)	Area (km^2)
Site A[1]	To establish access channel. (Placement with spreader pontoon 1.5 m coarse material disposal layer)	<7	1.5	4
Site B[1]	Site B may be used as an alternative to Site C as a closer alternative for placing coarse or BHD dredged material (Placement of dump layer 3.5 m) OR for direct disposal from PLF approach channel with CSD and spreader pontoon (layer 1.5 m coarse material)	10-12	3	5
Site C[2]	The primary placement site	12-15	40	24
Site D	Alternate placement site	38-48	40	9
Site E[2]	Alternate placement site	63-71	40	

[1]Sites A and B will only be considered in the event of an emergency situation and will require the approval of the PPA.

[2]Dredge Spoil Placement Sites currently modelled in the optimised base case.



Datum: WGS84		
Point	Long	Lat
1	114° 50' 11.21" E	21° 19' 40.85" S
2	114° 48' 56.57" E	21° 20' 48.87" S
3	114° 50' 9.18" E	21° 21' 58.76" S
4	114° 51' 23.79" E	21° 20' 50.76" S
5	114° 47' 51.01" E	21° 25' 18.68" S
6	114° 46' 36.35" E	21° 26' 26.65" S
7	114° 47' 48.94" E	21° 27' 36.59" S
8	114° 49' 3.65" E	21° 26' 28.59" S
9	115° 9' 48.36" E	21° 27' 42.29" S
10	115° 6' 31.42" E	21° 27' 40.09" S
11	115° 6' 28.73" E	21° 30' 1.20" S
12	115° 9' 47.46" E	21° 30' 3.42" S
13	115° 3' 38.71" E	21° 34' 24.04" S
14	115° 2' 51.76" E	21° 34' 41.50" S
15	115° 2' 25.77" E	21° 36' 13.76" S
16	115° 4' 5.25" E	21° 35' 36.36" S
17	115° 2' 34.07" E	21° 38' 5.56" S
18	115° 1' 26.08" E	21° 38' 44.75" S
19	115° 1' 18.53" E	21° 39' 41.20" S
20	115° 2' 24.95" E	21° 39' 11.13" S

Figure 2.18: Wheatstone Dredge Spoil Placement Sites

3.0 EXISTING ENVIRONMENT

3.1 Overview

The characterisation of the marine environment within the region has been undertaken as part of the environmental impact assessment which underpins the environmental approvals process. This information provides context for determining the management strategies and monitoring programmes detailed in later sections. Full details of the existing marine environment can be found in Section 6.0 of the Draft EIS/ERMP (Chevron 2010).

3.2 Key Environmental Receptors

The key environmental receptors that could potentially be impacted by the proposed dredging and dredge spoil placement management activities include:

- Hard corals
- Seagrasses
- Macroalgae
- Filter feeders
- Marine turtles
- Humpback whales
- Dugongs.

3.3 Marine Reserves and Conservation Areas

There are no protected areas in the immediate vicinity of the Ashburton North Site, although a number of marine parks and reserves occur within the Pilbara Nearshore and Pilbara Offshore bioregions. There is no evidence that the dredging and dredge spoil placement management activities are likely to impact on any of these marine parks and reserves.

The Ashburton North Site does not contain any World Heritage Properties or Ramsar Wetlands of International Significance.

3.4 Existing Physical Environment

3.4.1 Water Quality

A review of studies in the Onslow region (MScience 2009) indicate that the regional median turbidity was usually <1 Nephelometric Turbidity Units (NTU) and the 80th percentile was <3 NTU during non-cyclonic periods.

Across 30 sites daily median turbidity ranged from <1 NTU during winter up to 6 NTU during non-cyclonic periods in summer. Discharge from the Ashburton River during inland rainfall is the primary source for input of terrestrial sediments to the nearshore waters. These events can cause large-scale turbidity elevations in nearshore waters over a period of months. Spring and summer are times of the year when there are persistent westerly winds and increased runoff from rainfall as well as periodic cyclones.

The influence of cyclonic activity on turbidity is strong. During the passage of Tropical Cyclone (TC) Dominic in January 2009, daily median turbidity increased to approximately 80 NTU and remained above 20 NTU for at least ten days. Offshore waters in general tend to have lower turbidity levels.

More recently, turbidity results from the period January to March 2012 show the influence of TC Iggy. Site medians across all sites ranged from 0–3.4 NTU apart from a period of about one week in late January that coincided with the passing of TC Iggy (SKM 2012). Turbidity levels in the week following TC Iggy peaked at approximately 100 NTU at inshore and some eastern mid-shore sites; and 80 and 60 NTU at western mid-shore and offshore sites, respectively.

During the January – March 2012 monitoring period, median daily photosynthetically active radiation (PAR)—a measure of light available to BPP—showed a general pattern of greater PAR at offshore sites than inshore and mid-shore sites. PAR also varies seasonally in waters off Onslow. The median total daily PAR across sites ranged from 1.8 to 16 mole/m^2/day in summer and 3.0 to 11.4 mole/m^2/day in winter (SKM 2012). Daily PAR decreased to 0.0 mole/m^2/day after the passing of TC Iggy. The return to normal PAR levels following this event was quicker at offshore sites (SKM 2012). Most monitoring sites showed a response to spring tides, with the added water depth resulting in reduced PAR.

Sediment re-suspension, mainly due to wind-driven waves, is common in the area immediately seaward of the intertidal zone and can lead to considerable turbidity (Forde 1985). This was evident in the January to March 2012 monitoring period and may be related to the generally smaller particle sizes that were found at the inshore sites (SKM 2012). Re-suspension further offshore is mainly due to internal or subsurface waves (Heywood et al. 2006).

Water temperature and salinity were similar across all sites during January to March 2012, indicating that the waters were well mixed.

Contaminant levels within the water column are expected to be near background and representative of uncontaminated coastal and marine areas along the Pilbara coast (EIS/ERMP 2010).

3.4.2 Marine Sediments

The marine sediments in the region mainly consist of silt and sand sheets of varying thickness overlying Pleistocene limestone. Near the Ashburton Delta, sediments are generally fine silts and clays with high silica content.

Broadly, two types of soils are to be dredged: sands intermixed with variable fractions of clays, silts and or gravels, and; rock (siltstone, claystone and sandstone) that is generally weathered and weak. The proportion of the two soil types changes with increasing distance from the shore. In the MOF and PLF basin the material to be dredged consists of 75% sand and 25% weak rock. In the PLF approach channel the material will be 60% sand and 40% weak rock. In both cases, sand is assumed to overlay the rock. Sediments become increasingly coarse and increase in calcium carbonate content with distance offshore, due to decreasing input of terrigenous silts and clays from river runoff and coastal erosion (Coffey 2009).

The chemical characteristics of marine sediments in the vicinity of the Ashburton North Site has been assessed on two previous occasions; once in 2005 by the DEC (2006) and more recently by URS in the Wheatstone dredging area (URS 2009).

The DEC (2006) study recorded no discernible anthropogenic enrichment of contaminants (e.g. organotins, hydrocarbons, organochlorine pesticides and polychlorinated biphenyls) in sediments offshore of the Ashburton River mouth. The study also measured natural background concentrations of trace metals in the marine sediments, noting that, with the exception of arsenic, natural background concentrations of all metals were below the relevant Australia and New Zealand Environment and Conservation Council/Agricultural and

Resource Management Council of Australia and New Zealand (ANZECC/ARMCANZ) (2000) screening levels (DEC 2006).

During the URS (2009) survey, marine surface sediments and deep cores were sampled within and near the proposed dredging area and grab samples from the proposed nearshore DSPSs. Detailed results of this study are provided within the EIS/ERMP. The study recorded concentrations of all contaminants and trace metals as being below the laboratory limit-of-recording (LOR) or below the relevant National Assessment Guidelines for Dredging (NAGD) (Commonwealth of Australia 2009d) screening levels, with the exception of arsenic and nickel (URS 2009).

The results of the sampling and analysis programme determined that the sediments to be dredged are suitable for unconfined ocean placement in accordance with the NAGD.

3.4.3 Metocean Conditions

3.4.3.1 Waves

The coast around Onslow is sheltered from prevailing south-west swells (i.e. from the Indian Ocean) by the continental landmass of the North West Cape. Similarly, Barrow Island and the shoals of the Lowendal and Montebello Islands provide shelter from Timor Sea swells. Consequently, the nearshore wave climate is mainly influenced by locally-generated wind waves and occasional tropical cyclones (Damara 2009).

These effects were evident in wave conditions recorded via acoustic Doppler current profilers (ADCPs) and a directional wave rider in the nearshore area, by RPS Metocean (RPS Metocean Engineers 2009). Wave conditions from January to April 2009 were generally mild, with a median wave height of 0.2 m and wave period of four seconds. However, tropical cyclones and other low pressure systems generated elevated wave conditions. Other energetic conditions similarly occurred due to low pressure systems to the west of Onslow, producing onshore winds.

3.4.3.2 Winds

The region experiences dominant summer and winter conditions. The climatic conditions are governed by interaction between the south-east trade winds and monsoonal flows. Tropical cyclones affect the area, particularly during the summer and autumn months. During the summer months) interaction between a low pressure system induced by heating of the continental land mass and the Asian monsoon tends to draw air toward the Australian continent. This leads to predominantly westerly and south-westerly winds at the site. During the winter months), the south-east trade winds bring cool dry air from over the Australian continent, leading to easterly to south-easterly winds in the region.

3.4.3.3 Currents

In the nearshore, the local topography directs the tidal currents along the coastline with easterly flow on flood tide and westerly flow on ebb tide. This pattern can be interrupted by wind-driven currents during neap tides when tidal currents are weakest. West of the Ashburton Delta, the tidal current directions are controlled by the flow in and out of Exmouth Gulf with southerly flow into the gulf on flood tide and northerly flow out of the gulf on ebb tide.

Induced by wind stress and, to a lesser extent, gradients in pressure, net currents generally propagate along the coastline and can generate significant alongshore flow, particularly in shallower water. The net currents in shallower water are primarily driven by local winds. Magnitudes of simulated net currents are in the order of half the spring tidal current speeds in many areas. Field measurements (RPS Metocean Engineers 2009) confirm the simulations, including the wind-driven net currents, dominating over tidal currents during both neap and spring tidal conditions.

3.4.3.4 Tides

Tides in the nearshore are semi-diurnal with a spring tidal range of 1.9 m (mean high and low water spring tides of 2.5 m and 0.6 m, respectively). Tidal peaks occur near the equinoxes in March and September. The highest astronomical tide is 2.9 m. The tidal signal changes progressively along the North West Shelf (NWS) coastline with increasing tidal ranges from Exmouth to Broome.

Modelling of extreme cyclonic water levels for the Onslow town site and Onslow Salt (GEMS 2000, Nott & Hubbert 2005) has estimated the 100-year Average Recurrence Intervals (ARI) water level as 4.7 m Australian Height Datum (mAHD) (6.2 m Chart Datum - CD), including allowance for wave setup.

3.5 Existing Biological Environment

3.5.1 Marine Habitats

A marine habitat map has been developed and is shown in Figure 3.1. The majority of the seafloor mapped (between the mainland shore and Thevenard Island) is comprised of unvegetated sand and silts.

The Benthic Primary Producers Habitat (BPPH) types are sparsely distributed. The Benthic Primary Producers (BPP) present includes sparse macroalgae, hard coral, seagrasses and mangroves.

On the basis of field surveys, URS (2009a) concluded that the most significant locations with respect to nature conservation value are the shallow fringing coral reefs and macroalgal platforms surrounding Serrurier, Ashburton, Thevenard, Direction, Mangrove, and the Mary Anne Group of Islands (Figure 3.1). However, please refer to Section 3.5.1.1 for recent changes to coral communities. The Mangrove and Mary Anne Group of Islands are considered the largest and most important nature conservation resource in the vicinity of the Project and are important foraging areas for marine turtles and dugongs.

Ward Reef is an unusual patch of reef located 4.5 km from the proposed PLF approach channel. Until early 2011, the reef was almost completely composed of the genus Montipora and characterised by high coral cover. Ward Reef is a locally important recreational fishing area and due to its uniqueness may have some conservation value. However, during 2011, coral bleaching and impacts from a tropical cyclone have drastically reduced the percentage cover of coral on this reef and throughout the region in general (see SKM 2012 for a detailed description).

Four major ecosystem units (ECU) were derived from the Integrated Marine and Coastal Regionalisation of Australia (IMCRA) hierarchical ecosystem classification framework and further development by Lyne et al. (2006) for the North West Shelf and these units are detailed within the EIS/ERMP:

- ECU0 – Onslow Onshore encompassing intertidal habitats.
- ECU1 – Onslow Nearshore encompassing waters between LAT and up to 10 m depth in relatively complex bathymetry, covering mainly soft substrates but including a ridge of scattered patch shoals which support corals and sponges.
- ECU2 – Onslow Offshore encompassing waters between 10–20 m depth and including most offshore islands and coral reefs and algal-dominated shoals.

- ECU3 – Onslow Inner Shelf incorporating the relatively steep gradient shelf break from 20–70 m depth.

These ECUs are shown in Figure 3.2. Subsequently, Local Assessment Units (LAUs) were identified within the ECUs based on bio-geomorphic attributes and the distribution of various types of BPPH. These LAUs were the basis of the BPPH loss assessment described in Section 5.3.

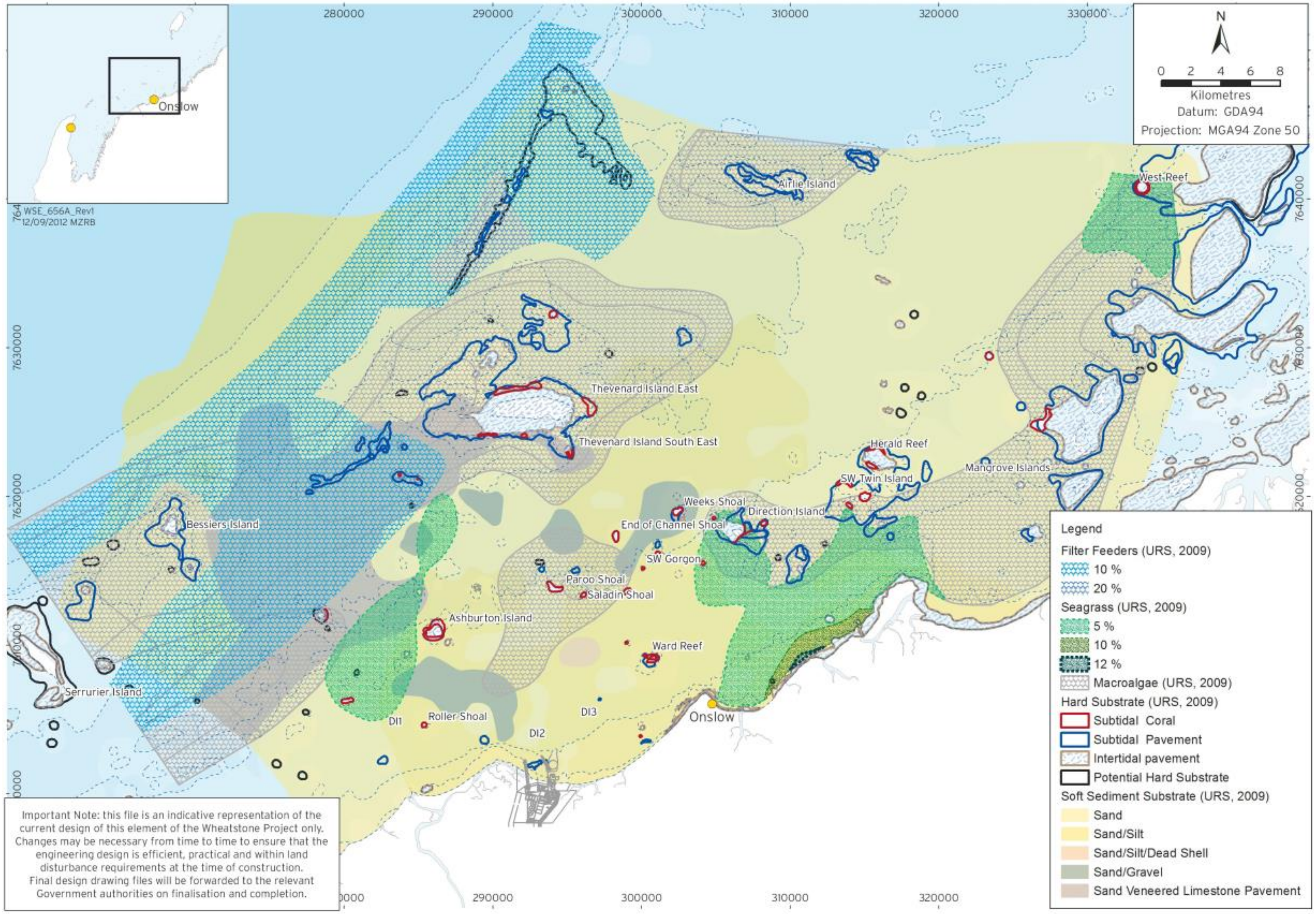


Figure 3.1: Marine Habitat Map

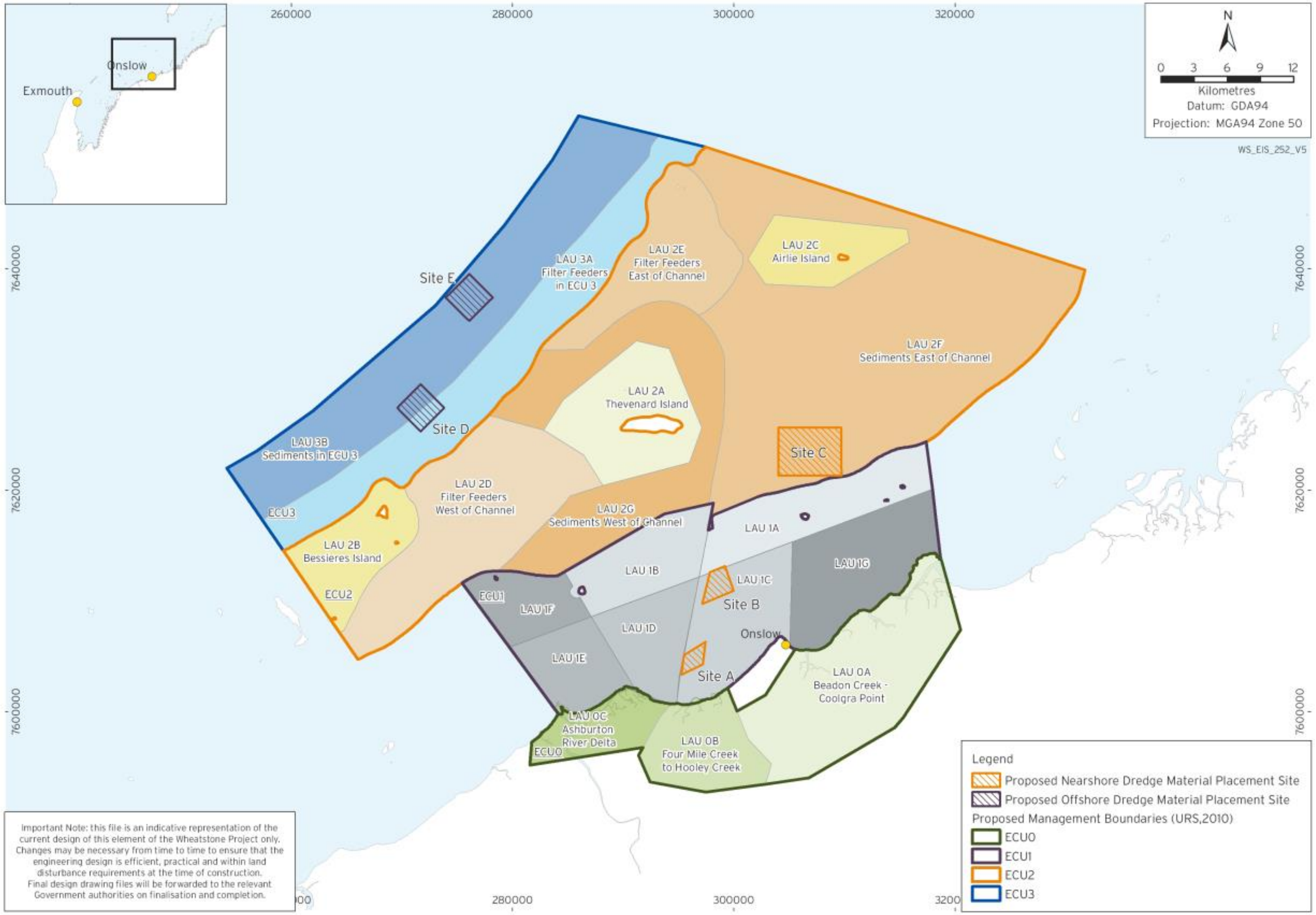


Figure 3.2: Ecosystem Units Defined for the Wheatstone Project

3.5.1.1 Hard Coral

The coral-health based EPOs in MS 873 were based on the status of coral communities prior to April 2011 when coral cover ranged from 29 – 68% (mean 45%) across reefs in the region. Dominant hard coral genera included Montipora and Acropora, with Porites and various Favidae genera as sub-dominant groups. Subsequent surveys indicated that hard coral cover in the vicinity of the dredging area has declined considerably, linked to thermal mass bleaching and the impact of TC Carlos in February 2011 (Figure 3.3; SKM 2012a). Mean coral cover across monitored reef formations in June 2012 was reported to be ~5%, and is < 10% at > 90% of those reefs monitored during the baseline surveys (Figure 3.4).

Recovery of coral communities may be affected by numerous factors. Corals remaining, or new corals settling, must compete with turf algae and other biota for substrate. Bare available substrate is less than 1% at most sites. Corals may also be subject to further natural disturbances, such as thermal bleaching and cyclones that may also inhibit recovery. January 2012 water temperatures were relatively high and indicate potential further stress and bleaching in February or March 2012. In addition, the passing of TC Iggy in January 2012 and TC Lua significantly affected metocean conditions in the region and may have caused further damage to the remaining corals. Further baseline monitoring will continue prior to the commencement of dredging will be able to ascertain whether any changes have occurred in coral communities since November 2011.

Based on studies of recovery elsewhere, it is likely that recovery of coral communities will be slow in the short-medium term In other regions where coral cover has been reduced significantly due to bleaching events and other stressors, recovery has taken up to ten years, or in some cases, reefs have still not fully recovered (Baker et al. 2008, Graham et al. 2011). On the Great Barrier Reef, while one reef was reported to recover within a year following the 2006 bleaching event (Diaz-Pulido et al. 2009), the resulting community was dominated by one species and was not representative of the community that existed prior to the bleaching event (Diaz-Pulido et al. 2009).

Continued monitoring prior to commencement of dredging is critical to document surviving hard coral and to determine whether and when the system has shifted from one of decline to recovery. However, there is no historical evidence to indicate whether corals present pre-2011 were a ‘stable’ community type or whether these were high-cover, Acropora-dominated communities due to an unusually quiet period of limited cyclone activity (2008-2010). Therefore, there is no way of predicting what the recovery trajectory might be for corals and whether recovery to levels observed in 2010 will even occur.

Coral communities are unlikely to recover prior to the commencement of dredging. When and if recovery does commence, it is likely to be slow (Graham et al. 2011) and corals are unlikely to reach moderate levels, such as those observed in 2010, prior to the commencement of dredging.

3.5.1.2 Seagrass

Temporal variability in distribution, density and biomass of seagrass can occur as a result of seasonal cycles and inter-annual change due to sporadic environmental events and natural variation. The abundance and distribution of tropical seagrass species can vary greatly in response to seasonal changes in water quality (turbidity, light penetration) and conditions (wave action, temperature) (Lanyon and Marsh 1995; Short et al. 2001; Loneragan et al. 2003; Duarte et al. 2006). Inter-annual differences in seagrass biomass, distribution and abundance can be attributed to regional-scale changes in climate (Collier and Waycott 2009) and also to smaller scale disturbances (Rasheed 2004).

Paling (1990) surveyed subtidal areas off Onslow and found seagrass was absent from most sites. He noted only ‘rare’ patches of *Halophila decipiens*. More recent surveys, conducted in 2011, show that *Halophila minor and Halophila spinulosa* are the most abundant species in subtidal environments of the Project area (RPS 2012). In September and December 2011, towed video data was captured along 60 transects within 12 potential seagrass zones, ranging in depth from 4–13 m (RPS 2012). Seagrass habitat accounted for approximately 5% of towed video observation points, with 76% of points designated ‘un-vegetated’. Compared to results from September 2011, seagrass cover had increased in deeper water and declined in shallower water near the coastline, likely due to light availability linked to nearshore turbidity (RPS 2012).

Additionally, grabs and drop camera images were gathered from 37 locations to inform the relationship between above and below ground biomass; and percent cover. Seagrass represented < 0.4% as analysed from drop camera images. Above and below ground biomass was strongly correlated (R^2 = 0.93) and there appeared to be a linear relationship between percent cover and total biomass, although this was based on a small sample size. Seagrass seed stock was assessed from a subsample of each grab; only three seeds were found.

Around the islands offshore from Onslow, species of a number of genera (e.g. *Halophila*, *Halodule* and *Syringodium*) have been reported from intertidal platforms and in the lee of small reefs, while *Thalassodendron* was reported from shallow macroalgal meadows west of Thevenard Island (URS 2009a). The only recent report of intertidal seagrasses in the Project area was sparse seagrass (taxa not described) from Beadon Point (URS 2010).

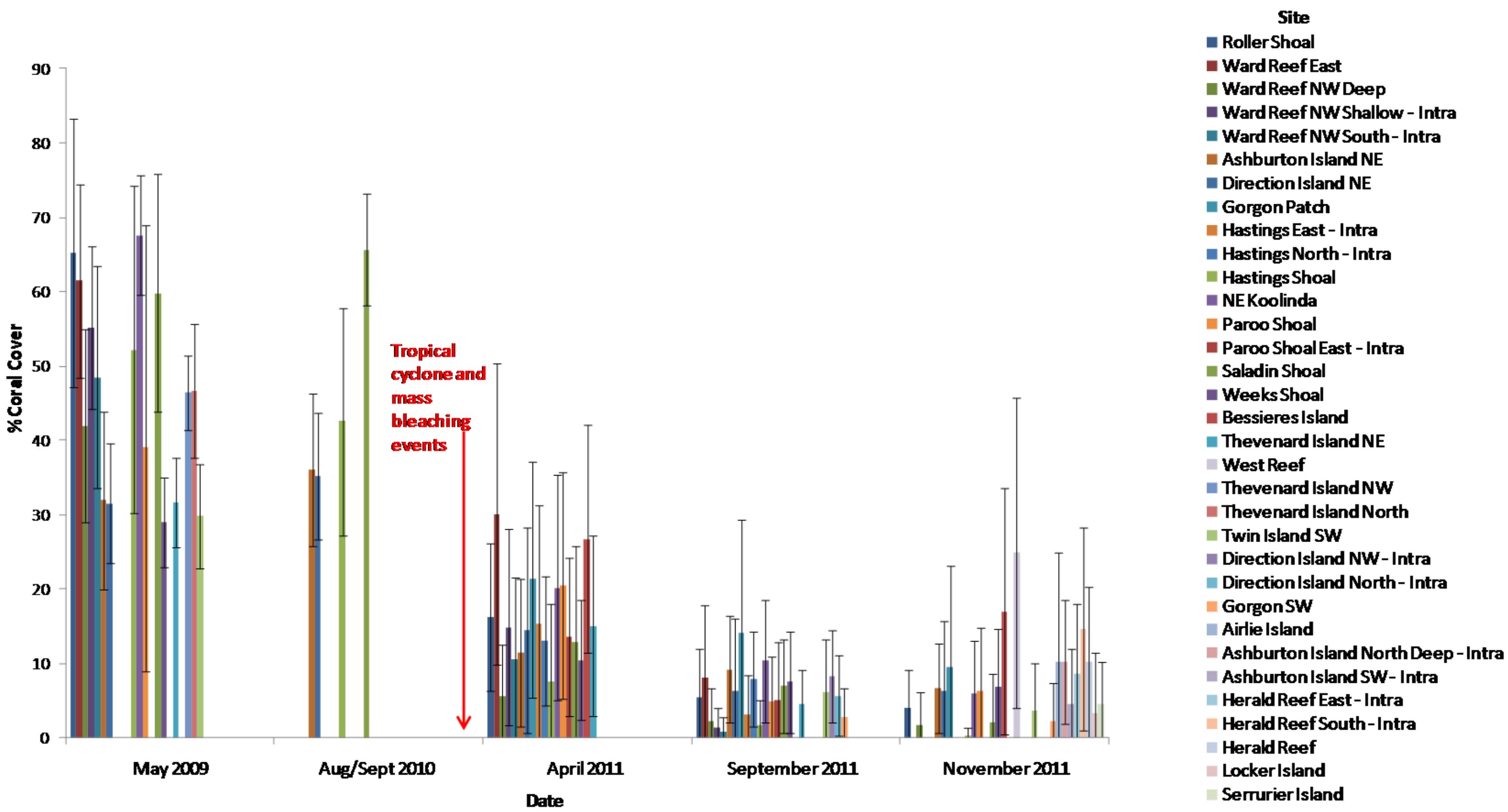


Figure 3.3: Mean Percent Live Hard Coral Cover (+95%CI) at Wheatstone monitored reef formations prior to and following 2011 bleaching and cyclone events

Note: Some reefs include established intra-sites and hence multiple sites per reef are shown in the figure.

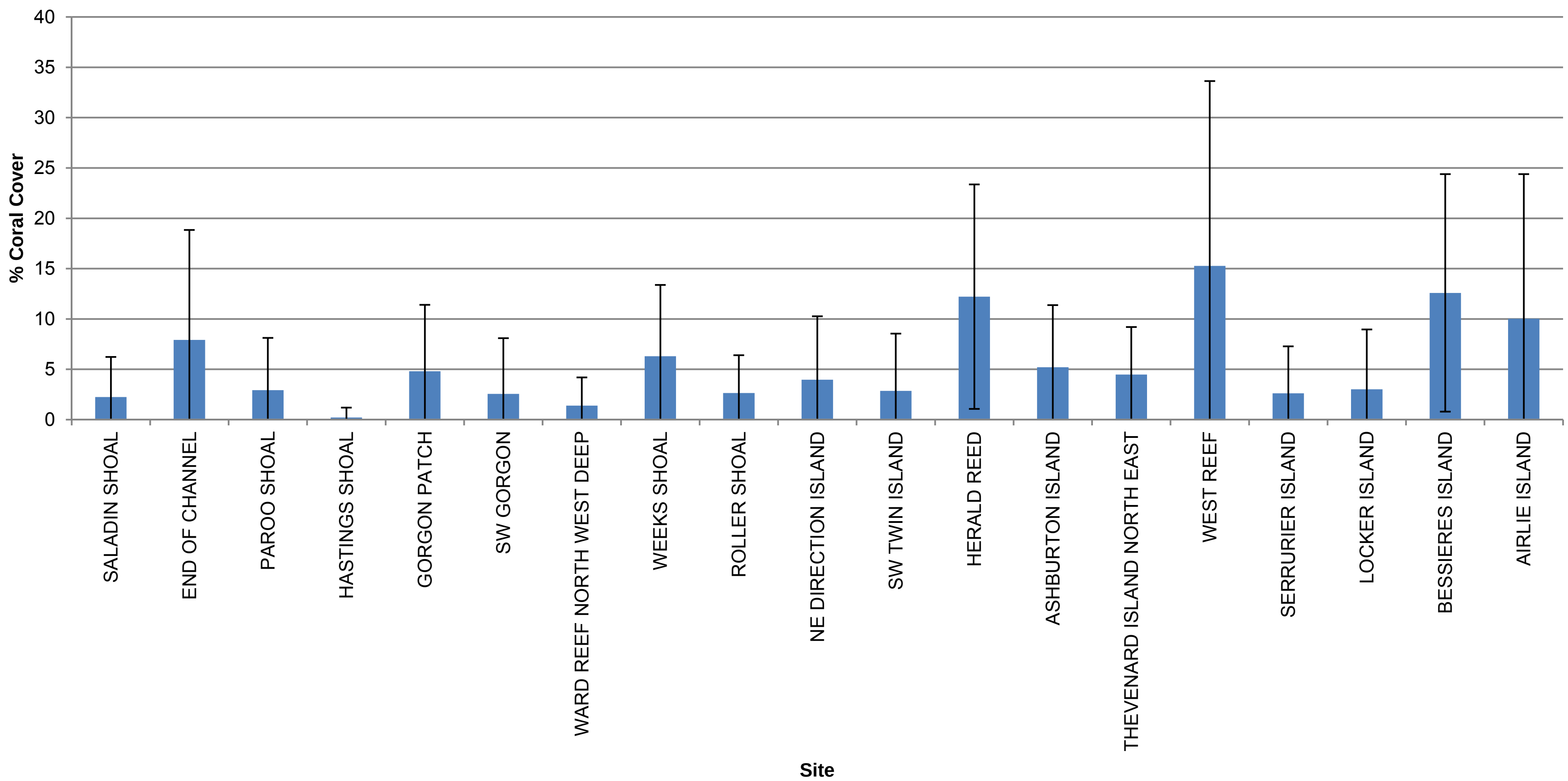


Figure 3.4: Mean Percent Live Hard Coral Cover (± 95% CI) at Wheatstone monitored reef formations during June 2012 (post-bleaching and cyclones)

3.5.1.3 Macroalgae

For the most part, macroalgae in Western Australia do not exhibit a pronounced seasonality. However the brown algal genus, *Sargassum*, is reported to undergo annual growth and reproductive cycles and based on observations in nearby Pilbara locations, it is likely that intertidal and shallow subtidal *Sargassum* species undergo a seasonal succession with peak growth and reproduction over summer (URS 2009).

Macroalgae are present on many shallow shoals and platforms that surround the offshore islands (e.g. Thevenard, Twin Islands). Macroalgae in the region includes large brown algae of the genera *Sargassum*, *Padina* and *Dictyopteris*, and red algae of the genera *Gracilaria* and *Laurencia*. Less common are green algae of the genera *Halimeda* and *Caulerpa* (URS 2009a).

In December 2011, towed video footage was captured to depths of 32 m along 99 transects considered likely to support macroalgae. Macroalgae was present in 28% of the approximately real time 6600 observations, with unvegetated substrate accounting for 58% of the observations. Analysis of still images from the towed video footage using CPCe determined macroalgae cover to be 11% and bare substrate 83% (RPS 2012). Macroalgae cover and distribution was highly variable across water depth and proximity to the coastline.

3.5.1.4 Sessile Filter Feeders

During a December 2011 survey, sessile filter feeders (including soft corals, sponges and ascidians) were recorded from 12% of approximately 1000 observations from towed video footage along 15 transects (RPS 2012). Analysis of still images determined the percent cover of sessile filter feeders along theses transects ranged from 0–12%, with soft corals the dominant class.

3.5.1.5 Intertidal Habitats

Two major types of marine habitats are recognised in the intertidal marine areas, namely mangroves (and associated high tidal mudflats) and algal mats. Within the nearshore area, mangroves occupy the mainland intertidal zone between mean sea level (MSL) and an elevation of 2.2 m CD, which is between high neap- and spring-tide levels. Mangroves in the area occur mostly within river mouth and tidal creek systems, where they form nearly continuous ribbons of vegetation fringing the channels. These mangroves are protected and partially isolated from the sea by barrier dune systems. Areas of mangroves also occur along the outer, coastal shoreline on the western and northern sides of Coolgra Point (URS 2009b).

Landward of the mangroves, large areas of high tidal mudflats commonly extend to the hinterland margin or merge with supra-tidal salt flats. These mudflat areas are not inundated by daily tides. Two habitat types were recorded on the high tidal mudflats:

- Bioturbated mudflats, devoid of macro-vegetation

  and

- Samphire flats, dominated by halophytic shrubs but with some crab burrows.

3.5.2 Marine Fauna

3.5.2.1 Overview

Fifteen EPBC listed marine fauna species occur, or could occur, in the nearshore or offshore area. These include one bird, five marine mammals, six reptiles and three sharks/rays as shown in Table 3-1. These species are the relevant matters of NES to which this Plan applies. Of these, 13 species are afforded protection status under the Western Australian *Wildlife Conservation Act (1950).*

In addition to these species, a number of migratory marine mammals and birds that are also protected under the EPBC Act may occur in the nearshore and offshore areas including cetacean species (whales and dolphins), dugongs, migratory seabirds and wetland birds.

3.5.2.2 Marine Mammals

The Pilbara region supports migratory, transient and resident marine mammals such as whales, dolphins and dugongs, all of which are EPBC listed. Many of these are protected under Commonwealth law because they are listed on international treaties to which Australia is a signatory.

Baleen Whales

Four species of cetaceans, including humpback whales (*Megaptera novaeangliae*), pygmy blue whales (*Balaenoptera musculus brevicauda*), Bryde's whales (*Balaenoptera edeni*) and minke whales (*Balaenoptera acutorostrata*) are known to occur in the region.

Humpback whales are known to move through the region on their northern and southern migrations to and from the Kimberley between June and October. Aerial surveys beginning in May 2009 found northbound humpback whales were concentrated seaward of Thevenard Island and over the continental slope, on average 49 km offshore (CWR 2009). The southbound migration found whales on average 36 km offshore; around the 50 m depth contour. Cow and calf pods were found predominantly inshore of the 50 m depth contour resting in areas nearshore. Although the data indicate that the area does not have the same importance for resting as Exmouth Gulf, or for calving as Camden Sound, the humpback population transiting through the area (Southern Hemisphere Breeding Stock D) has increased. A recent population estimate concluded that the Breeding Stock D humpback whale population has been increasing as much as 10-12% annually (Salgado et al 2012).

Noise loggers identified pygmy blue whales, dwarf minke whales and Bryde's whales in the offshore waters although none of the species were recorded in the shallow waters in the region. Antarctic minke whales, blue whales and southern right whales were not recorded during the field surveys and are unlikely to be present within the region due to their preference for colder waters.

Dolphins and Toothed Whales

Coastal dolphin species that could occur in the region include the Indo-Pacific humpback dolphin (*Sousa chinensis*) and bottlenose dolphins (*Tursiops* sp.). Little is known of the population structure, movement patterns or ecology of these species within the region. Recent aerial surveys recorded dolphin species within the region although positive identification of dolphins to species level was not possible. However, it is inferred that the Indo-Pacific humpback dolphin and bottlenose dolphins were present (CWR 2009). It can be expected that these coastal dolphin species may be present in shallow and nearshore waters of the region at any time. All coastal species typically occur in low numbers and are widely dispersed, which is in accordance with previous documentation of these species in the Pilbara region (Prince 2001). It is likely that the Indo-Pacific humpback dolphin will move between different shallow water estuaries and inlets along the coast.

Dugongs

Dugongs (*Dugong dugon*) are found within the region. Dugongs tend to occur in wide shallow bays, mangrove channels and in the lee of large inshore islands. Shallow waters such as tidal banks and estuaries have also been reported as sites for calving (Oceanwise 2005).

From the available aerial survey data, it is expected that at least some dugongs are resident in the area year-round but with seasonal variation in densities (CWR 2010, RPS 2010, Murdoch 2012 and Murdoch 2012a). Low numbers of dugongs were sighted offshore from Onslow, predominantly near inshore islands including Ashburton, Direction and Thevenard Island. To the north east of the Project site, in waters between Barrow Island and the Mangrove Passage, larger numbers of dugongs have been sighted. Dugongs were also sighted in areas within and near Exmouth Gulf including close to Serrurier and Muiron Islands. Predominantly dugongs were sighted in water depths less than 10 m and often over or near to known areas of seagrass and macroalgae, as identified during benthic surveys of the area (URS 2009a).

3.5.2.3 Marine Turtles

Green (*Chelonia mydas*) and flatback turtles (*Natator depressus*) are known to occur in the region during sensitive life-history phases (e.g. mating, nesting and inter-nesting) and may be present in the area year-round (RPS 2010a). Loggerhead (*Caretta caretta*) and hawksbill turtles (*Eretmochelys imbricata*) are less abundant and their distribution in the area is not well known. Leatherback turtles (*Dermochelys coriacea*) have not been recorded in the region, nor are they known to nest in the general area.

Surveys have recorded nesting activity by a combination of flatback and green turtles on the large (Serrurier and Thevenard) and moderate sized (Bessieres, Locker and Ashburton) islands. Smaller islands such as Tortoise Island have very small areas of suitable nesting habitat, and very low density nesting activity. Other smaller islands such as Flat, Table, Direction and the Twin Islands have small areas of suitable habitat, with moderate levels of nesting activity (Pendoley Environmental 2009). There was low density of nesting activity observed on the mainland beaches, with large sections of beach presenting no evidence of nesting activity at all (Pendoley Environmental 2009; RPS 2010a).

Juvenile green turtles were observed around the islands. These animals are likely to be residents at their foraging grounds. Foraging green turtles are likely to be found in seagrass and algal habitats and may also utilise coastal mangrove habitats (Pendoley Environmental 2009). A total of 1091 turtles were sighted during the aerial surveys from mid-May to late December off the west Pilbara conducted by the Centre for Whale Research (CWR 2009).

3.5.2.4 Sawfish

The green sawfish (*Pristis zijsron*) and freshwater sawfish (*Pristis microdon*) are found within the region. Survey work was conducted during 2011 to gain a better understanding of the distribution of sawfish populations in the Onslow area. Passive tracking of sawfish was carried out to study movement patterns (Murdoch University, 2011). A total of 12 individuals were captured comprising 10 green sawfish and 2 freshwater sawfish. The area appears to be a nursery area for the green sawfish and provides habitat for adult freshwater sawfish which were found near the mouth of the Ashburton River. Nursery habitat for green sawfish appears to be widespread along the Western Australian coast.

Table 3-1: Conservation Status of Marine Fauna Which Occur or May Occur in the Region

Scientific Name	Common Name	EPBC Act *(Cth)* Conservation Status	*Wildlife Conservation Act* Status
Birds			
Macronectes giganteus	Southern giant petrel	Endangered	Rare or likely to go extinct
Mammals			
Balaenoptera musculus	Blue whale	Endangered	Rare or likely to go extinct
Balaenoptera musculus brevicauda	Pygmy blue whale	Endangered	
Eubalaena australis	Southern right whale	Endangered	Rare or likely to go extinct
Megaptera novaeangliae	Humpback whale	Vulnerable	Rare or likely to go extinct
Dugong dugon	Dugong	Listed marine and listed migratory species	Specially Protected
Reptiles			
Caretta caretta	Loggerhead turtle	Endangered	Rare or likely to go extinct
Chelonia mydas	Green turtle	Vulnerable	Rare or likely to go extinct
Dermochelys coriacea	Leatherback turtle	Vulnerable	Rare or likely to go extinct
Eretmochelys imbricata	Hawksbill turtle	Vulnerable	Rare or likely to go extinct
Natator depressus	Flatback turtle	Vulnerable	Rare or likely to go extinct
Crocodylus porosus	Saltwater crocodile	Protected	Specially Protected
Sharks			
Rhincodon typus	Whale shark	Vulnerable	
Pristis zijsron	Green sawfish	Vulnerable	Rare or likely to go extinct
Pristis microdon	Freshwater sawfish	Vulnerable	Rare or likely to go extinct

3.5.2.5 Migratory Waterbirds

Review of Faunabase (now Fauna Map - WA Museum), the Birds Australia Atlas Database, the DEC Threatened and Priority Fauna Database, and the EPBC Protected Matters Search Tool indicate that up to 38 migratory waterbird species may be found within the Onslow locality. Bamford Consulting Ecologists (2009) has recorded 26 of these species in the Onslow locality, and those not observed are likely to only occur as infrequent visitors to the area. Of these 26 species, the counts for numbers of waterbird species are all well below any criterion of international significance, except for the common tern (*Sterna hirundo*). The subspecies *Sterna hirundo* ssp. *longipennis* breeds in northern Asia and spends the non-breeding period in south-eastern Asia and northern Australia, and has a minimum population estimate of 25,000 (Scott and Delaney 2002). Three migratory species, the whimbrel (*Numenius phaeopus*), eastern curlew (*Numenius madagascariensis*) and sanderling (*Calidris alba*), may be present in regionally important numbers at the Ashburton River delta, Beadon Creek and Town Beach. However, these are again based on uncertain and conservative estimates of regional populations (Bamford et al. 2008).

3.6 Social and Economic Environment

The land and sea area surrounding the Project has a number of uses and values, including commercial, heritage, environmental conservation, and recreational. The following section provides a brief overview of the sea use and recreational values.

3.6.1 Sea Use Values

3.6.1.1 Commercial Fisheries

The waters off the Pilbara coast are home to many managed commercial fisheries including prawn, demersal scalefish, demersal finfish, mackerel, oyster and several types of tuna. The fisheries in closest proximity to Onslow are managed by the Department of Fisheries (DoF), and include:

- Onslow and Nickol Bay Prawn Managed Fisheries (ONPMF)
- Pilbara Managed Trap Fishery
- North Coast Blue Swimmer Fishery
- Pearl Oyster Managed Fishery
- Pilbara Line Fishery
- Mackerel Managed Fishery
- Specimen Shell Managed Fishery
- Marine Aquarium Fish Managed Fishery.

The ONPMF is a combination of three areas and four associated Size Management Fish Grounds (SMFG) totalling 39 748 km^2. Construction of the proposed Project, including dredging a MOF and construction of an LNG and condensate jetty, would most directly affect the Zone ‘Area 1’ of the ONPMF, which is near the mouth of the Ashburton River, which also includes the Ashburton SMFG.

3.6.1.2 Pearling

Onslow was one of the earliest commercial pearling centres in WA since the commencement of the State’s commercial pearling industry during the nineteenth century. Since 1992, the health of wild oyster stock (the basis for pearl farm production) and the market price of WA pearls have been controlled by a production (output) quota. Quota units are allocated to licence holders (572 units existed in 2006) with one quota unit normally allowing 1000 shells (though there may be annual variations). Social impact studies and consultation with commercial fishermen has determined that there are no pearling leases that will be impacted by the proposed dredging and disposal activities.

3.6.1.3 Oil and Gas Production Facilities

Oil is produced from a number of small fields in shallow waters offshore from Onslow. Further offshore, are the BHP Billiton operated Griffin oilfield, the Chevron Australia operated Barrow Island facility and the Gorgon gas field development, as well as Apache's Varanus Island operations.

Key island facilities for oil and gas processing, storage and shipping facilities are located on Barrow, Thevenard, Airlie and Varanus Islands. Gas gathering pipelines from the Griffin and Roller fields come ashore west of Onslow, near Urala Station. A new structure plan is being developed for Onslow to complement the proposed Ashburton North Hydrocarbon Precinct, i.e. ANSIA as it is currently known as, which was endorsed in December 2008 to support further opportunities for gas processing plant development in the area. The Ashburton North Hydrocarbon Precinct would cover approximately 8000 ha and include the Project, the BHP Billiton/Apache Macedon Domgas plant, and the ExxonMobil/BHP Billiton Scarborough LNG plant. The Ashburton North Hydrocarbon Precinct would have optimal access to the coast, a buffer of about 12 km from the Onslow town site and would accommodate various gas-related industrial land uses.

3.6.1.4 Shipping

Onslow and the surrounding area is currently not a high density shipping channel. Greater shipping activities occur in neighbouring locations including Exmouth, Dampier and Port Hedland (AMSA 2008).

3.6.2 Recreational Values

Coastal recreational value, within and adjacent to the area, has been determined by a values and land use assessment study. The areas of highest value and/or use identified in this study included the Ashburton River, Four Mile Creek, Hooley Creek, Sunset Beach, Sunrise Beach, Onslow Town Beach and Beadon Creek. The high value areas that may be affected by changed coastal processes include the Hooley to Four Mile Creek complex (fishing, boating and crabbing); Sunset Beach (four-wheel driving); and Onslow Town Beach (walking). It is important to note that not all of the values identified in the high value areas by the values and land use study would be adversely affected.

4.0 ENVIRONMENTAL RISK ASSESSMENT AND PERFORMANCE MEASUREMENTS

4.1 Overview

A series of environmental risk assessments have been completed to identify the most significant risks. These risk assessments along with the EPOs and MOs will be the focus of environmental management and monitoring. The risk assessments have addressed each aspect of the Project including the dredging and dredge spoil management activities. The risk assessments have been undertaken in two phases:

- Phase 1 – An environmental risk assessment was conducted during the scoping phase of the Project to identify key areas of environmental risk requiring detailed assessment.
- Phase 2 – A detailed environmental risk assessment was conducted during the preparation of the EIS/ERMP and this PLAN. This assessment reviewed the environmental acceptability of the Project, identified key areas of risk and developed potential monitoring and management strategies.

4.2 Risk Assessment Method

The risk assessment completed for the EIS/ERMP was undertaken in accordance with the principles and guidelines contained in the AS/NZS 4360:2004 – Risk Management and the Environmental Protection Authority (EPA) draft guidelines 'Application of risk-based assessment in EIA' (EPA 2008). The process evaluates the likelihood and consequence of environmental impacts occurring as a result of a factor's (receptor) exposure to one or more aspects (project activities) to assess the environmental risk levels.

'Consequence' has been defined by the EPA as an indication of the magnitude of an environmental impact resulting from an environmental change. The 'likelihood' is defined as the probability or frequency of the defined consequence occurring and takes into consideration the probability and frequency of the following:

- The environmental change occurring
- The environmental factor being exposed to the environmental impact
- The environmental factor being affected.

Subsequent investigations and sediment plume modelling provided additional data upon which the previous risk assessments conducted in the scoping phase (phase 1) could be refined. The risks have been assessed assuming the application of mitigation and management measures and therefore indicate the residual risk levels posed to each key environmental factor.

4.3 Risk Assessment Outcomes

The results of the environmental risk assessment of the dredging and dredge spoil placement management activities are provided in Chapter 8 of the EIS/ERMP.

Environmental risks that have been assessed as posing either a medium or high residual risk include impacts to BPPH and changes to marine water quality and sediment, as detailed in the following sections. Additionally impacts to marine fauna have been included due to being matters of NES.

4.3.1 Benthic Primary Producer Habitat

Impacts to subtidal BPPH is predicted to occur through direct removal and indirect impacts.

- The direct loss of subtidal BPPH is predicted through the removal of subtidal habitat within the dredge footprint and loss of structural function of BPPH at the DSPSs
- Indirect impacts on BPP and habitats are predicted due to increased turbidity, sedimentation and light attenuation, associated with construction (capital) dredging of the approach channel and berthing area and placement of dredge spoil, leading to temporary loss of habitat in excess of acceptable levels as defined in EPA Guidelines No 7.

4.3.2 Marine Water Quality and Sediments

Impacts to marine water quality and sediments are predicted from increased turbidity and light attenuation due to predicted exceedance's of agreed water quality targets (which were defined in the EIS/ERMP as the ANZECC/ARMCANZ water quality guidelines) as a result of the dredging for the approach channel and berthing area and placement of dredge spoil.

4.3.3 Marine Fauna

All residual impacts to protected marine fauna, including entrainment, loss of critical habitat, vessel collisions and changes to behaviour, were assessed as a low to very low risk.

4.4 Management, Monitoring and Reporting

The environmental risk assessment detailed in Chapter 8 of the Draft EIS/ERMP (Chevron 2010) has been used to assist the development of the monitoring, management and reporting described in Sections 6.0 to 11.0.

5.0 SEDIMENT PLUME MODELLING AND IMPACT ASSESSMENT

A detailed investigation into the potential impacts to BPPH has been undertaken based on the infrastructure footprint and through sediment plume dispersion modelling which provides predictions of the potential sediment plume concentrations and sedimentation associated with the dredging and dredge spoil placement activities. The modelling outputs were then used in order to give an indication of the size and distribution of each impact zone arising from the modelled dredge programme.

Since submission of the EIS/ERMP the dredge programme has been refined and optimised with the aim to achieve the EPOs (Condition 6-1) and MOs (Condition 6-2) (MS 873). Therefore the dredge plume modelling has been re-run based on the finalised dredge programme to satisfy EPBC 2008/4469 Condition 9 and allow the recalculation of impacts. Details of optimised base case dredge programme and the amended inputs used to re-run the plume model are presented in Section 2.2 and Section 2.3, respectively. It is important to note that modifications to the dredge programme have not resulted in increases to the predicted extent of receptor based impacts caused by dredging activities (Section 5.2).

Impact Zones and allowable impacts (EPOs and MOs) have been defined in MS 873. These zones, EPOs and MOs define the requirements and management aims for the dredging programme. This section presents the results of new modelling as an indicator of likely turbidity and sedimentation due to the dredging program. The matters in this section are only for the purpose of modelling and impact prediction, and cannot and do not replace the legal requirements.

5.1 Sediment Plume Modelling (Base Case)

5.1.1 Overview

The modelling provides a prediction of turbidity and sedimentation patterns associated with the base case dredging programme. Sediment plume modelling has considered two climatic conditions (strong and representative) and three seasons (summer, winter and transitional) for the dredging of the nearshore and offshore marine facilities, covering the full range of dredging equipment and DSPSs. The base case, as described in Section 2.2 has been used to model the turbidity plume and represents the most realistic and an optimised dredging programme.

5.1.2 Dredging Scenarios

The scenarios were developed on the basis of the proposed dredging activities from the dredging contractor. The execution plan was originally established with considerable emphasis on environmental performance, and additional optimisation of the execution plan was carried out to arrive at the final plan which has been simulated.

The scenarios are based on the following (dredge locations as illustrated in Figure 5.1):

1. A CSD dredging a temporary ROW from -7 m LAT to and including part of the MOF.
2. A BHD deployed for “environmental” dredging in the critical restricted overflow Zone 2. As part of the environmental programme optimisation, the BHD dredging has been extended beyond the boundaries of the defined Zone 2.
3. CSD dredging of Zone 1, avoiding summer conditions with net easterly currents.
4. BHD dredging within the MOF
5. CSD dredging of the MOF access channel, the PLF, the approach channel up to Zone 1 and between Zone 1 and the extended Zone 2.

6. TSHD is primarily deployed for clean-up dredging of fines left in the channel from the CSD and BHD dredging and a smaller bulk dredging role for the outer part of the approach channel above Zone 2.
7. The CSD and BHD will be loading barges for transport to DSPS C.
8. The TSHD will dispose the material at DSPS C for the bulk dredging and DSPS E and C for the clean-up dredging.

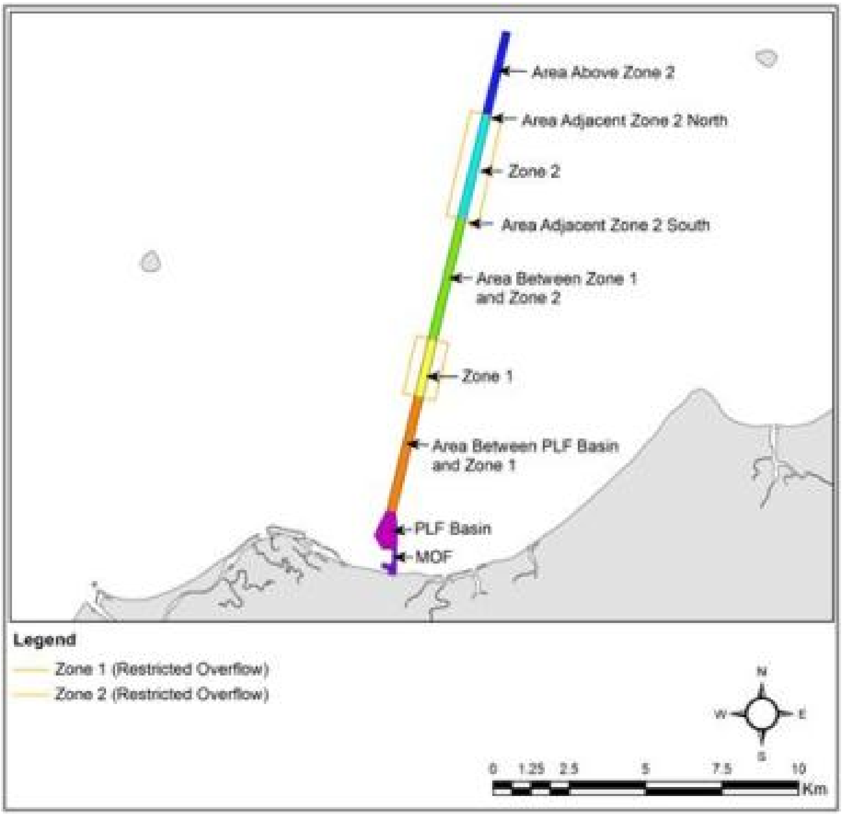


Figure 5.1: Dredge area definitions

5.1.2.1 Base Case Dredging Scenarios

An overview of the scenarios is provided in Table 5-1 (reference to dredge areas are those illustrated in Figure 5.1). The total of 21 scenarios for the base case dredging programme provides coverage of the entire dredge area. It is noted that the scenarios include BHD dredging as well as CSD dredging during winter and transitional climatic scenarios for Zone 1. These are considered inter-changeable scenarios (as the impacts are similar).

Table 5-1: Overview of 21 Modelling Scenarios representing the Base Case Dredging Programme

Scenario	Description
1, 1a	CSD dredges in the PLF basin (part of RoW) with overflow; BHD dredges the MOF
3	CSD dredges the area between Zone1 and PLF Basin, BHD dredges Zone 1 or Zone 2
4, 4a, 4b, 4e, 4f, 4g, 4h	CSD dredges the area between Zone1 and PLF Basin, BHD dredges Zone 1
5, 5a, 5c, 28, 28a	CSD dredges the area between Zone 1 and Zone 2, BHD dredges Zone 2
7a	TSHD dredges above Zone 2; CSD dredges between Zone 1 & 2, BHD dredges Zone 1
8, 8a, 8b, 8c	CSD dredging Zone 1 (winter & transitional climate scenarios), BHD dredges Zone 2
25	CSD dredges in the MOF, BHD dredges the MOF

5.1.2.2 Alternate Dredge Scenarios

In order to maintain flexibility in the base case dredging programme to enable further optimisation of the dredge plan and manage unforeseen circumstances a large number of alternative dredge scenarios have been modelled. These scenarios, which all achieve the EPOs and MOs, are considered to create a range of alternate scenarios, but not limited to the list below, that could be implemented to allow adaption and optimisation of the dredging programme in an informed manner from an environmental perspective.

The alternate scenarios have covered the key options detailed in Table 5-2.

Table 5-2: Overview of alternate Dredging Scenarios

Scenarios	Description
2	BHD dredging Zone 1, BHD dredging Zone 2
6, 6a, 6c	CSD dredges the area above Zone 2, BHD dredges Zone 2
12	Large TSHD dredges PLF, BHD dredges Zone 1
13	Large TSHD dredges area between PLF and Zone 1, BHD dredges Zone 1
14	Large TSHD dredges between Zones 1 & 2, BHD dredges Zone 2
18	CSD dredges between PLF & Zone 1 with pumping to Disposal Site A, BHD dredges Zone 1
19	CSD dredges between Zones 1 & 2 with pumping to Disposal Site B, BHD dredges Zone 2
20	TSHD dredges between Zones 1 & 2, BHD dredges Zone 1, BHD dredges Zone 2
21	CSD dredges area above Zone 2, BHD dredges Zone 1, BHD dredges Zone 2
23	Medium TSHD dredges Zone 2 without overflow extending alternately into area above Zone 2 and area between Zones 1 & 2 with overflow (similar to Scenario 7a of the EIS), CSD dredges between PLF and Zone 1, BHD dredges Zone 1

Scenarios	Description
24	Medium TSHD makes long passes from above Zone 2 to Zone 1, CSD dredges PLF, BHD dredges MOF
26	Medium TSHD dredges Zone 1

5.1.3 Climatic Scenarios

The climatic scenarios from the draft EIS/ERMP have been maintained for the re-modelling of optimised base case dredging programme. This includes three two month simulation periods representing Summer, Transitional and Winter conditions.

The modelling for the draft EIS/ERMP included two full sets of modelling applying Onslow winds and MesoLAPS winds, respectively. The draft EIS/ERMP modelling demonstrated that the MesoLAPS winds tend to slightly underestimate the wind for the near-shore area during summer, while the Onslow winds tend to slightly underestimate the wind during winter. During the transitional period the winds are generally weaker and more variable. This generally seems to be captured fairly well by the MesoLAPS winds which can account for the spatial variability.

To maintain consistency with the draft EIS/ERMP approach of adopting the worst case of the two wind fields, the MesoLAPS winds have been applied for the winter and transitional climatic scenarios, while the Onslow wind has been applied for the summer climatic scenarios.

5.1.4 Source Terms

With the base case dredging program now planned in detail, the spill source terms input into the model have been based on the dredging schedule, cycle times and spill rates provided by the dredging contractor. These source terms are equipment, production and site specific, taking into consideration a detailed analysis of the geotechnical data. These source terms are considered best available estimates prior to validation of the dredge modelling which will be undertaken once dredging commences.

5.1.5 Modelling Results

Combining the scenarios discussed in Section 5.1.2.1, illustrates the mean excess suspended sediment concentration (SSC) across the scenarios for each given location. These combined plots are presented in Figure 5.2. Note that these represent the maximum areas of impact arising for the modelled dredge scenario during all seasons. Figure 5.2 also illustrates the predicted sediment plume if the alternative scenarios (described as ‘playbook’ in Figure 5.2) were to be implemented.

A general finding for the applied climatic scenarios is that the plumes and impact zones predominantly extend eastward during summer and westward during winter, while transitional climatic conditions lead to more localised plumes with occasional further extension in either direction. Whereas this is a predominant trend, it should be recognised that the net drift is driven by the wind fields, and there are periods where the predominant net drift directions are changed, i.e. westerly transport during summer and easterly transport during winter.

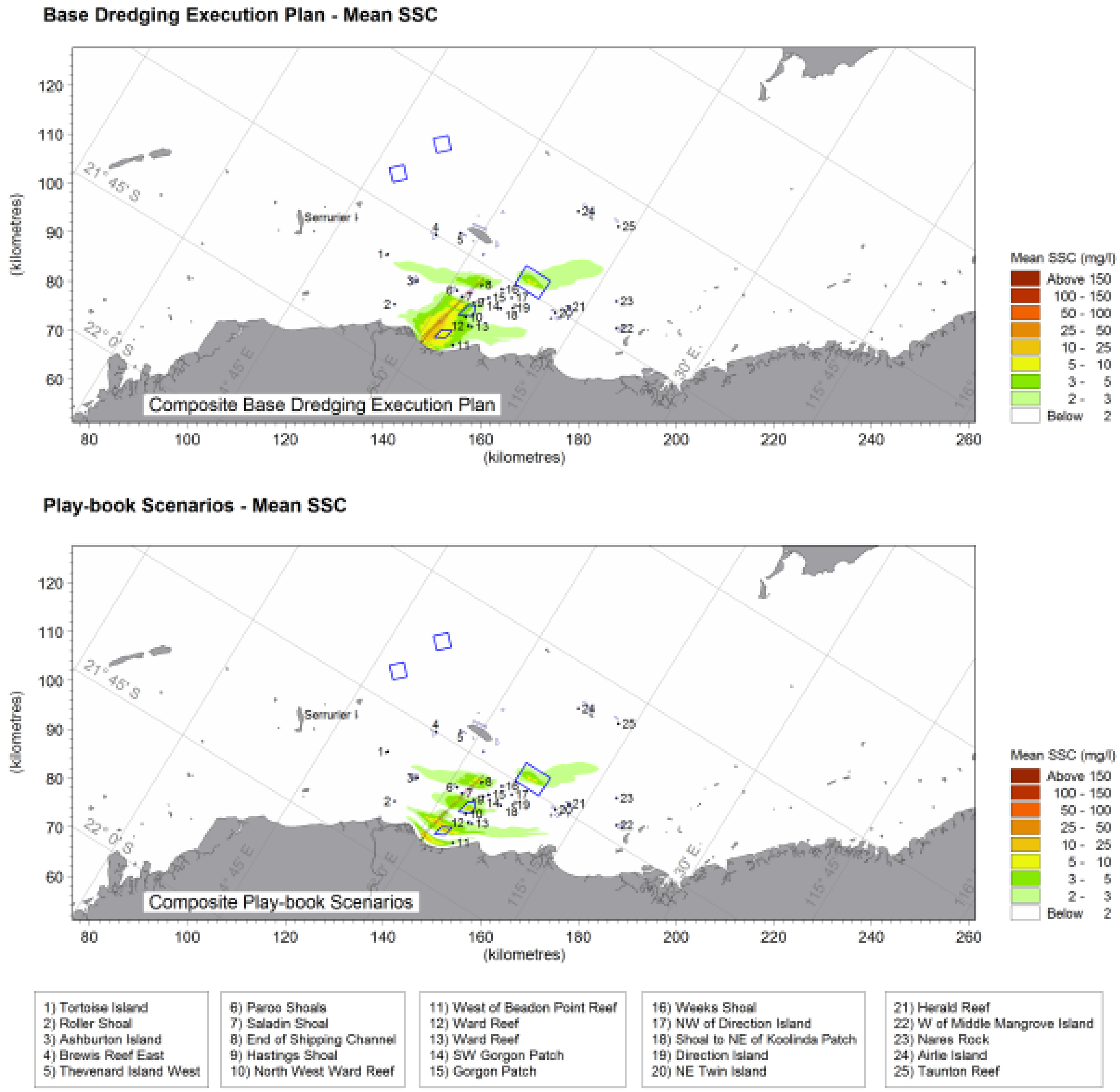


Figure 5.2: Mean excess concentration for the Full Dredge Base Case Programme and the Alternate Scenarios

5.2 Potential Impacts

5.2.1 Development of Impact Zones

Impact zones were initially developed based on the recommended approach of the OEPA Marine Ecosystem Branch (MEB), which uses four categories of classification. A description of the impact zones initially developed is provided in Table 5-3 (columns 1 and 2 identified as EIS/ERMP definitions). Refer to the draft EIS/ERMP document prepared for the Project for further details on the establishment of these zones (Chevron 2010).

There are slight differences between the zones presented in the draft EIS/ERMP (columns 1 and 2 of Table 5-3) and the zones used in the Final EIS/RTS, which are the basis for the zones in MS 873, (columns 3 and 4 of Table 5-3) due to differences in definitions contained within new versus superseded Guidance Statement, however, generally the Zone of Total Mortality and Partial Mortality correspond to the Zone of High Impact (ZoHI) and the Zone of Moderate Impact (ZoMI). The Zone of Influence (ZoI) and Zone of No Impact have not changed and correspond exactly between definitions used in the draft EIS/ERMP and those used in this Plan.

Table 5-3: Definition of Impact Zones

Draft EIS/ERMP Definitions (as per GS29)		Revised Definitions in Final EIS/RTS (as per EAG3 and EAG7)	
Zone	**Definition**	**Zone**	**Definition**
Zone of Total Mortality	An area within which key receptors are predicted to suffer total or substantial mortality (>50%), and where loss of structural function is predicted to occur.	Zone of High Impact	An area within which BPPH or the BPP communities that they support are predicted to suffer permanent impacts (not recoverable within 5yrs) as a result of direct or indirect impacts attributable to dredging or placement activities.
Zone of Partial Mortality	An area within which key receptors are predicted to suffer partial mortality (up to 50% loss close to the channel and <1% loss at the extremes). Mortality will occur within the area, but will not include all individuals. The outer border will be drawn so that no mortality will be predicted to occur immediately outside of this zone.	Zone of Moderate Impact	An area within which non-permanent impacts (recoverable within 5 yrs) are predicted to occur as a result of dredging or placement activities. To provide a quantifiable impact for corals/filter feeders this has been defined as an area within which 70% of hard corals will remain unimpacted (up to 30% mortality of corals may occur). For seagrass/macroalgae the original definition of the Zone of Partial Mortality has been used to provide a quantifiable level of impact.
Zone of Influence	Outside the outer boundary of the Zone of Partial Mortality there may be influence from the dredge plume at low levels (for example sub-lethal impacts on key receptors, turbidity may be visible or very light sedimentation may occur) but this is predicted to be unlikely to have any material and/or measurable impact on the key receptors.	Zone of Influence	Outside the outer boundary of the ZoMI there may be influence from the dredge plume at low levels (for example sub-lethal impacts on key receptors, turbidity may be visible or very light sedimentation may occur) but this is predicted to be unlikely to have any material and/or measurable impact on the key receptors.
No Impact	Beyond the outer boundary of the ZoI, there will be an unbounded area where there is no detectable influence on turbidity and sedimentation rates from the dredging. This area would be suitable for locating reference reefs.	No Impact	Beyond the outer boundary of the ZoI, there will be an unbounded area where there is no detectable influence on turbidity and sedimentation rates from the dredging. This area would be suitable for locating reference reefs.

5.2.1.1 BPP Tolerance Limits

Tolerance limits for both turbidity (suspended sediment within the water column) and sedimentation rates (sediment deposited on the seafloor) have been established for hard coral, seagrass and macroalgae. Tolerance limits have been established for both the nearshore (ECU1) and offshore waters (ECU2) to reflect the different natural turbidity climate of these areas (refer to Section 3.5.1 for description of the four major Ecosystem Units ECUs) (DHI, 2010).

The initial tolerance limits for corals were developed based on the definition of Impact Zones for the draft EIS/ERMP and thus the tolerance limits for the ZoHI were based on substantial mortality (defined as >50% mortality) and the tolerance limits for the ZoMI were based on partial mortality (defined as up to 50% mortality close to the channel and <1% mortality at the extremes). These tolerances limits were refined to achieve the revised definitions of impact zones and to achieve the EPOs in Condition 6-1 (MS 873) which defined substantial mortality as >70% mortality (ZoHI) and partial mortality as <30% mortality (ZoMI). These new tolerance limits are detailed in the following Tables (Table 5-4 to Table 5-6); refer to the draft EIS/ERMP for the original tolerance limits. These same tolerances limits were applied to filter feeders as per the logic described in the draft EIS/ERMP (Chevron 2010). There were no refinements following changes to the definition of the impact zones for the seagrass and macroalgae tolerance limits since the draft EIS/ERMP (Chevron 2010) which are presented in Table 5-8 to Table 5-11.

Table 5-4: Definition of Impact Zones for Suspended Sediment Impacts on Corals Applicable for Nearshore Waters (within 5 m isobath) in ECU1 during Summer and Winter Only

Zone	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC > 25 mg/l for more than 14% of the time OR ♦ Excess SSC > 10 mg/l for more than 38% of the time OR ♦ Excess SSC > 5 mg/l for more than 63% of the time
Zone of Moderate Impact *EPO: <30% mortality*	♦ Excess SSC > 25 mg/l for 5-14% of the time OR ♦ Excess SSC > 10 mg/l for 20-38% of the time OR ♦ Excess SSC > 5 mg/l for 50-63% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC > 25 mg/l for 1-5% of the time OR ♦ Excess SSC > 10 mg/l for 1-20% of the time OR ♦ Excess SSC > 5 mg/l for 5-50% of the time
No Impact	♦ Excess SSC > 25 mg/l for less than 1% of the time OR ♦ Excess SSC > 10 mg/l for less than 1% of the time OR ♦ Excess SSC > 5 mg/l for less than 5% of the time

Table 5-5: Definition of Impact Zones for Suspended Sediment Impacts on Corals Applicable for Offshore Waters (beyond 5 m isobath) for All seasons and for Nearshore Waters (within 5 m isobath) during Transitional Periods Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC > 25 mg/l for more than 7% of the time OR ♦ Excess SSC > 10 mg/l for more than 19% of the time OR ♦ Excess SSC > 5 mg/l for more than 40% of the time
Zone of Moderate Impact *EPO: <30% mortality*	♦ Excess SSC > 25 mg/l for 2.5-7% of the time OR ♦ Excess SSC > 10 mg/l for 10-19% of the time OR ♦ Excess SSC > 5 mg/l for 25-40% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC > 25 mg/l for 0.5-2.5% of the time OR ♦ Excess SSC > 10 mg/l for 0.5-10% of the time OR ♦ Excess SSC > 5 mg/l for 2.5-25% of the time
No Impact	♦ Excess SSC > 25 mg/l for less than 0.5% of the time OR ♦ Excess SSC > 10 mg/l for less than 0.5% of the time OR ♦ Excess SSC > 5 mg/l for less than 2.5% of the time

Table 5-6: Definition of Impact Zones for Sedimentation Impact on Corals Applicable for Nearshore Waters (within 5 m isobath) in ECU1 during Summer and Winter Only

Zones	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation more than 34 mg/cm^2/day (more than 11.9 mm/14 days)
Zone of Moderate Impact *EPO: <30% mortality*	Sedimentation 10-34 mg/cm^2/day (3.5-11.9 mm/14 days)
Zone of Influence *EPO: 0% mortality*	Sedimentation 2.5-10 mg/cm^2/day (0.9-3.5 mm/14 days)
No Impact	Sedimentation less than 2.5 mg/cm^2/day (less than 0.9 mm/14 days)

Table 5-7: Definition of Impact Zones for Sedimentation Impact on Corals Applicable for Offshore Waters (beyond 5 m isobath) for All Seasons and for Nearshore Waters (within 5 m isobath) during Transitional Periods Only

Zones	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation more than 14 mg/cm^2/day (more than 4.9 mm/14 days)
Zone of Moderate Impact *EPO: <30% mortality*	Sedimentation 5-14 mg/cm^2/day (1.7-4.9 mm/14 days)
Zone of Influence *EPO: 0% mortality*	Sedimentation 1-5 mg/cm^2/day (0.3-1.7 mm/14 days)
No Impact	Sedimentation less than 1 mg/cm^2/day (less than 0.3 mm/14 days)

Table 5-8: Suspended Sediment Impact on Seagrass for Offshore Waters (beyond 5m isobath), and for Nearshore Waters (within 5 m isobath) during Transitional Periods Only

Zone of Impact	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC > 25 mg/l for more than 25% of the time OR ♦ Excess SSC > 10 mg/l for more than 50% of the time
Zone of Moderate Impact *EPO: <50% mortality*	♦ Excess SSC > 25 mg/l for 2.5 – 25% of the time OR ♦ Excess SSC > 10 mg/l for 10 – 55% of the time OR ♦ Excess SSC > 5 mg/l for more than 25% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC > 25 mg/l for 0.5 – 2.5% of the time OR ♦ Excess SSC > 10 mg/l for 0.5 – 10% of the time OR ♦ Excess SSC > 5 mg/l for 2.5 – 25% of the time
No Impact	♦ Excess SSC > 25 mg/l for less than 0.5% of the time OR ♦ Excess SSC > 10 mg/l for less than 0.5% of the time OR ♦ Excess SSC > 5 mg/l for less than 2.5% of the time

Table 5-9: Suspended sediment impact on seagrass for nearshore waters (within 5 m isobath) during summer and winter only

Zone	Definitions
Zone of High Impact *EPO: total mortality allowed*	♦ Excess SSC > 25 mg/l for more than 50% of the time
Zone of Moderate Impact *EPO: <50% mortality*	♦ Excess SSC > 25 mg/l for 5 – 50% of the time OR ♦ Excess SSC > 10 mg/l for 20% of the time
Zone of Influence *EPO: 0% mortality*	♦ Excess SSC > 25 mg/l for 1 – 5% of the time OR ♦ Excess SSC > 10 mg/l for 1 – 20% of the time OR ♦ Excess SSC > 5 mg/l for more than 5% of the time
No Impact	♦ Excess SSC > 25 mg/l for less than 1% of the time OR ♦ Excess SSC > 10 mg/l for less than 1% of the time OR ♦ Excess SSC > 5 mg/l for less than 5% of the time

Table 5-10: Net sedimentation impact on seagrass for offshore waters (beyond 5 m isobath), and for nearshore waters (within 5 m isobath) during transitional periods only

Zones	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation > 70 mg/cm^2/day (> 17 mm/14day)
Zone of Moderate Impact *EPO: <50% mortality*	Sedimentation 20 – 70 mg/cm^2/day (7 – 17 mm/14day)
Zone of Influence *EPO: 0% mortality*	Sedimentation 3 – 20 mg/cm^2/day (1 – 7 mm/14day)
No Impact	Sedimentation < 3 mg/cm^2/day (< 1 mm/14day)

Table 5-11: Net sedimentation impact on seagrass for nearshore waters (within 5 m isobath) during summer and winter only

Zones	Definitions
Zone of High Impact *EPO: total mortality allowed*	Sedimentation > 100 mg/cm^2/day (> 24.5 mm/14day)
Zone of Moderate Impact *EPO: <50% mortality*	Sedimentation 30 – 100 mg/cm^2/day (10 – 24.5 mm/14day)
Zone of Influence *EPO: 0% mortality*	Sedimentation 4 – 30 mg/cm^2/day (1.5 – 10 mm/14day)
No Impact	Sedimentation < 4 mg/cm^2/day (< 1.5 mm/14day)

5.2.2 Modelled Impact Areas for the Optimised Base Case Dredging Scenarios

The modelled outputs for the base case dredging programme were then interrogated with the developed tolerance limits (detailed in the previous section) to illustrate the predicted Areas of High Impact, Moderate Impact and Influence (Figure 5.3) and allow a comparison with the approved Zones of Impact defined in MS 873 (see Section 5.2.3).

The optimised (combined) base case dredging program illustrates the following key components:

1. BHD and CSD dredging of the MOF and PLF Basin (Scenarios 1, 1a and 25) results in a plume that predominantly extends parallel to the coastline and remains in the near-shore area. These plumes follow the seasonal trends, extending predominantly eastward during summer and predominantly westward during winter. While the simulation indicates that the predicted Area of Moderate Impact extending towards the West of Beadon Point reef, no BPP are within the Area of High or Moderate Impact.

2. CSD dredging of the area between the PLF basin and Zone 1 with simultaneous BHD dredging of Zone 1 or Zone 2 (Scenarios 3, 4, 4a, 4b, 4e, 4f, 4g and 4h) results in the predicted Area of Moderate impact extending in the order of 5 km from the approach channel, following the general seasonal trends. No BPP fall within the predicted impact areas.

3. CSD dredging of Zone 1 (during winter and transitional climate scenarios) combined with BHD dredging of Zone 2 (Scenario 8, 8a, 8b, and 8c) results in a plume extending westward during winter season and symmetrically west- and eastward during the transitional season. No designated BPP fall within the predicted impact areas

4. TSHD dredging within the area above (north of) Zone 2 with simultaneous CSD dredging between Zones 1 & 2 and BHD dredging of Zone 1 (Scenario 7a) results in the predicted Area of Moderate Impact to extend up to ~ 3 km from the channel. End of Channel Shoal falls within the predicted Area of Moderate Impact.

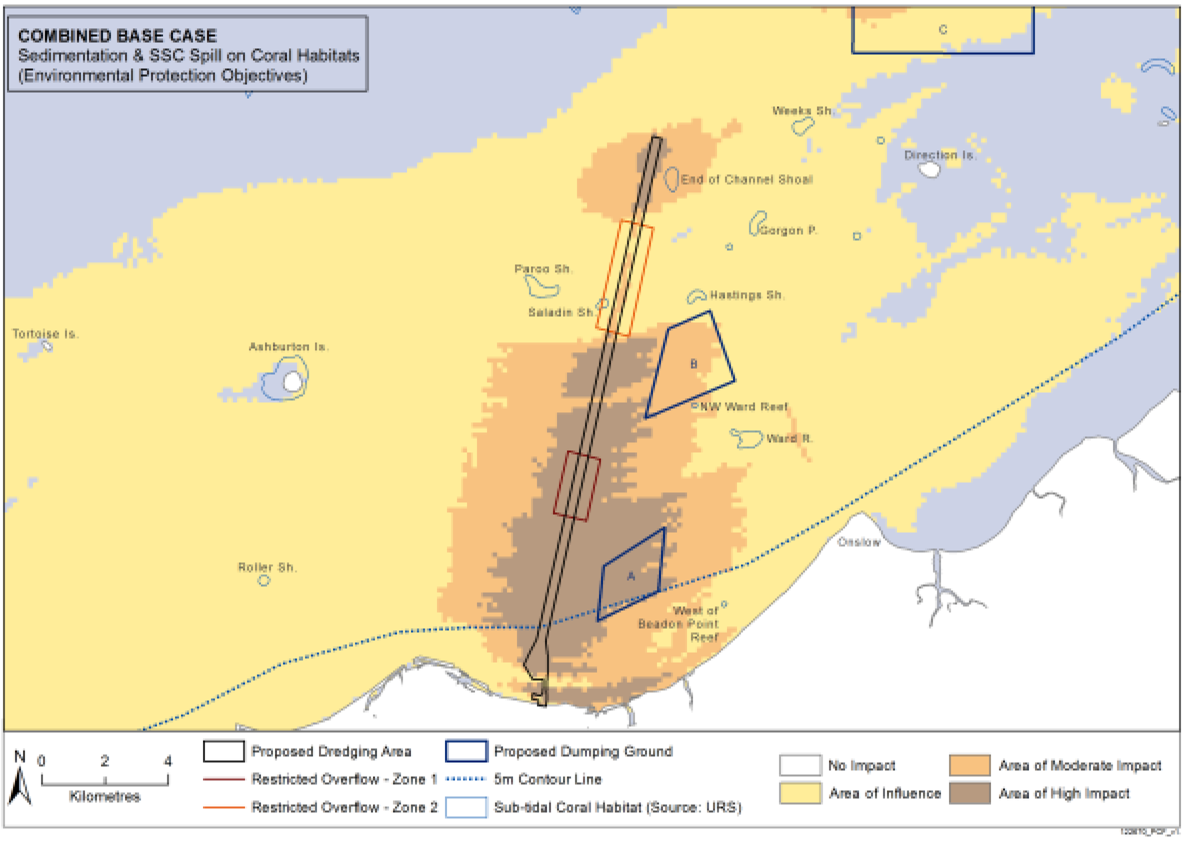


Figure 5.3: Details of Predicted Impact Areas close to Site for Combined Base Case Scenarios.

5.2.3 Final EIS/RTS Model Outputs vs. Optimised Impact Areas (base case)

5.2.3.1 Dredging Scenarios

The optimised impact areas are based on the modelling of the scenarios from the base case dredging programme (Section 2.2) which has been optimised to limit impacts to corals, seagrass, macroalgae and filter feeders. A comparison of the modelled scenarios in the Final EIS/RTS (Chevron 2011) and the optimised base case dredging programme, presented here, is provided in Table 5-12.

Table 5-12: Summary of Dredging Scenarios used in the Modelling included within the Final EIS/RTS (Chevron 2011) and the Dredging Scenarios for the Optimised Base Case

<table>
<tr><th>Scenarios Modelled within the Final EIS/RTS</th><th>Optimised Base Case Dredging Programme</th><th>Rationale for Optimised Base Case</th><th>Deviations from the Optimised Base Case Dredge Programme</th></tr>
<tr><td>Nearshore dredging in the temporary access channel by CSD pumping to placement Site A.</td><td>CSD is dredging the ROW and the MOF area while the BHD is dredging in zone 2.
Transport to and disposal at site C is done with barges where the 6700 m^3 barges will be allocated to the CSD and the 2700 m^3 barges will be allocated to the BHD. Note that these are interchangeable.</td><td rowspan="3">The use of a BHD loading barges in Zone 2 reduces the environmental risk extensively compared to TSHD:
♦ BHD is loading barges without overflow
♦ BHD reduces the amount of water in barge
♦ BHD reduces loss at the head while it has the ability of selective excavation if required
♦ BHD can dredge spoil without dissemination of the soil matrix keeping fines within the soil matrix, by greatly reducing the diffusion of fines into the water column
♦ BHD has a lower production hence lower generation of spill due to disturbance of smaller area.
The use of CSD loading barges in Zone 1 during winter or transition period creates opportunity for the BHD to dredge more material around Zone 2 near benthic communities.
The CSD creates a more confined plume as compared to a TSHD due to the larger area disturbed during dredging. Hence the CSD</td><td rowspan="3">There may be situations where Chevron Australia is required to deviate from the base case, to be able to further optimise the dredge plan, manage unforeseen circumstances and take advantage of opportunities as they arise. Prior to implementing deviations from the base case, predictive plume modelling will be undertaken to investigate the potential impacts from changes to dredge methodology at different parts of the channel / area. Only those dredging activities which do not exceed the EPOs and MOs will be implemented (see Section 2.2.3).</td></tr>
<tr><td>Nearshore dredging in the PLF basin by CSD and pumping dredged material to hopper barges located at the -3 m LAT contour for placement at Site C.</td><td>CSD is dredging the Access Channel while BHD is dredging the MOF area. Transport to and disposal at site C is done with barges where the 6000 m^3 barges will be allocated to the CSD and the 2700 m^3 barges will be allocated to the BHD. Note that these are interchangeable.</td></tr>
<tr><td>Nearshore dredging in the MOF basin by CSD and pumping dredged material to hopper barges located at the -3 m LAT contour for placement at Site C.
Offshore dredging by the 5000 m^3 capacity TSHD in section 4 of the PLF approach channel and placement of dredge spoil at site C.</td><td>CSD is dredging the PLF and loading barges while BHD is dredging in Zone 2. Transport to and disposal at site C is done with barges where the 6700 m^3 barges will be allocated to the CSD and the 2700 m^3 barges will be allocated to the BHD. Note that these are interchangeable.</td></tr>
</table>

<table>
<thead>
<tr><th>Scenarios Modelled within the Final EIS/RTS</th><th>Optimised Base Case Dredging Programme</th><th>Rationale for Optimised Base Case</th><th>Deviations from the Optimised Base Case Dredge Programme</th></tr>
</thead>
<tbody>
<tr><td>Nearshore dredging in the PLF basin, of weak rock, by 10 000 m^3 capacity TSHD, with placement to Site C.
Offshore dredging in the PLF approach channel, of sand, by 10 000 m^3 capacity TSHD with placement at Site C.</td><td>CSD is dredging the PLF dredge area and the BHD is dredging zone 2. Transport to and disposal at site C is done with barges where the 6700 m^3 barges will be allocated to the CSD and the 2700 m^3 barges will be allocated to the BHD. Note that these are interchangeable.</td><td rowspan="4">ZoI is expected to be smaller over time due to less plume to propagate.
Working with the CSD is more localised and enables a better assessment of plume behaviour, influence of soil characteristics and use of nearby sentinel instruments. This information will feed into the modelling as part of the Proactive Adaptive Management System to manage possible risk towards the marine environment.
The use of CSD provides more workability and certainty when harder material is encountered and no blasting or drilling is needed. It is also expected that a TSHD will create more additional fines when dredging a hard clay layer by scratching the surface due to less penetration of the draghead. Natural preferential dredging lanes will be formed when dredging hard clays with a TSHD requiring more clean-up dredging and additional release of fines. This will be avoided when using the CSD.
The use of the TSHD at the end of the channel is introduced as the dredging layer depth becomes minimal in this area resulting in a more suitable dredging method for the TSHD. In addition the material encountered at the end of the channel is predominantly sand as opposed to gravel which makes it suitable to be dredged with a TSHD.</td><td rowspan="4"></td></tr>
<tr><td>Nearshore dredging of sand in the PLF basin by 10 000 m^3 capacity TSHD with placement at Site C.
Offshore dredging in the PLF approach channel in weak rock by 10 000 m^3 capacity TSHD with placement at Site C.</td><td>CSD is dredging the Access channel while BHD is dredging Zone 2 or just adjacent to Zone 2. Transport to and disposal at site C is done with barges where the 6700 m^3 barges will be allocated to the CSD and the 2700 m^3 barges will be allocated to the BHD. Note that these are interchangeable.</td></tr>
<tr><td>Offshore dredging of sand and weak rock in the PLF approach channel by 10 000 m^3 capacity TSHD with placement of dredged material at Site C.</td><td>CSD is dredging Zone 1 during Winter or Transition period while BHD is dredging Zone 2 or just adjacent to Zone 2. Transport to and disposal at site C is done with barges where the 6700 m^3 barges will be allocated to the CSD and the 2700 m^3 barges will be allocated to the BHD. Note that these are interchangeable.</td></tr>
<tr><td>10 000 m^3 capacity TSHD dredging sand with placement of dredged material at Site C.
Dredging along Section 2 and parts of Sections 1 and 3 with operational mitigation to avoid overflow in “no overflow” zone.</td><td>CSD is dredging between Zone 1 and Zone 2 while the BHD is dredging zone 2 or just adjacent to zone 2.
A TSHD capacity around 5000 m^3 will be deployed to dredge the area north of Zone 2 to the end of approach Channel.</td></tr>
</tbody>
</table>

5.2.3.2 Optimised Modelled Impact Areas

Modelling outputs indicate:

- All the designated reef formations lying within the ZoMI (Paroo Shoal, Hastings Shoal, Gorgon Patch) per the Final EIS/RTS definition fall outside the predicted Area of Moderate Impact based on the modelling for the optimised base case dredging programme. This indicates that no mortality is predicted for these reefs, which is consistent with the MOs of zero percent coral mortality within the ZoMI.
- The End of Channel Shoal, NW Ward Reef, West of Beadon Point Reef and Saladin Shoal, which lie within the defined ZoHI per the Final EIS/RTS definition fall within the predicted Area of Moderate Impact or within the Area of Influence based on the modelling for the optimised base case dredging programme. This indicates that less than 30% mortality (based on the tolerance limit for the ZoMI) which is consistent with the MO of 50% for the ZoHI.
- The predicted Areas of Influence and Zones of Moderate Impact for the optimised base case dredging programme (Figure 5.4) are generally smaller than the corresponding zones from the Final EIS/RTS (Figure 5.5). This has mainly been achieved through the use of BHD at critical areas, which lowers the overall spill.
- The predicted Area of High Impact for the base case dredging programme is larger than the ZoHI from the Final EIS/RTS, which is expected per the re-definition of the zones as detailed in Section 5.2.1. However there are no reefs or seagrass located within the predicted Area of High Impact for the base case dredging programme.
- The predicted Area of Moderate Impact (Figure 5.6), based on the base case dredging programme, for seagrass and macroalgae is now concentrated around the channel and does not extend into any seagrass beds (Figure 5.7).

Overall, the optimised base case dredging programme and the inclusion of different dredging mitigation measures, e.g. use of the BHD, has resulted in a significant reduction to potential impacts to corals and seagrass, as compared to the Final EIS/RTS dredge scenarios.

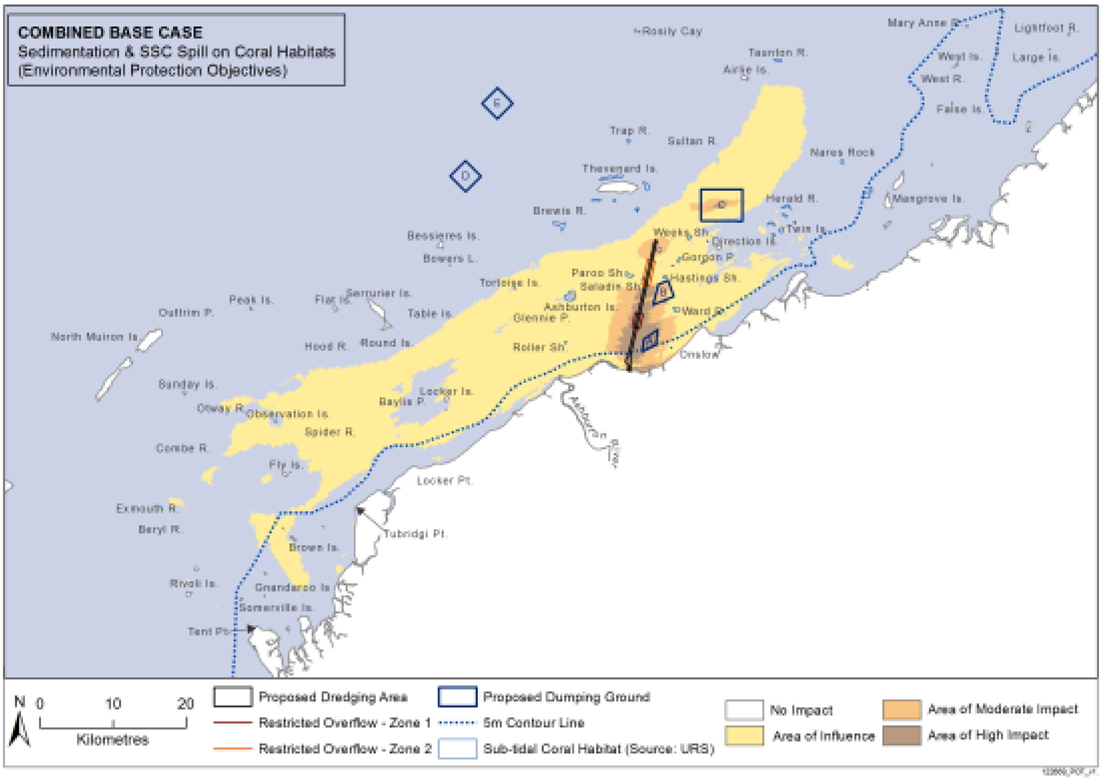


Figure 5.4: Envelope plot of predicted impact areas from suspended sediment concentrations (SSC) and sedimentation on coral habitats for all climatic scenarios for the optimised base case dredge scenarios

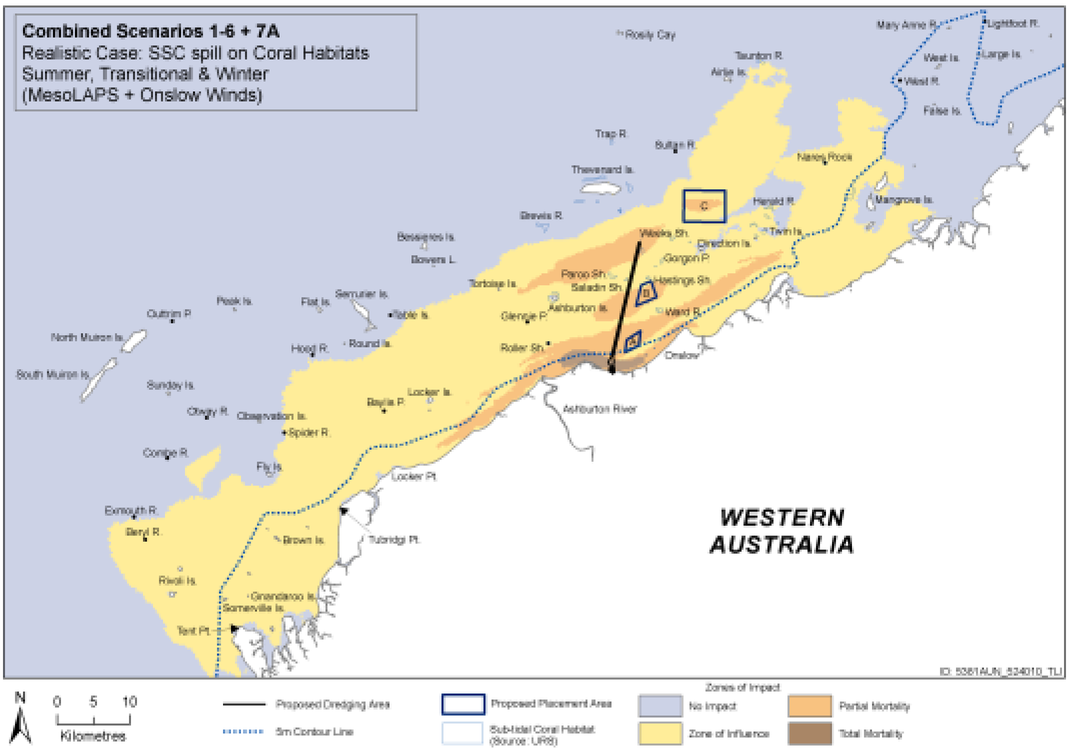


Figure 5.5: Envelope plot of predicted impact zones from suspended sediment concentrations (SSC) and sedimentation on coral habitats for all climatic scenarios for the EIS/ERMP dredge scenarios

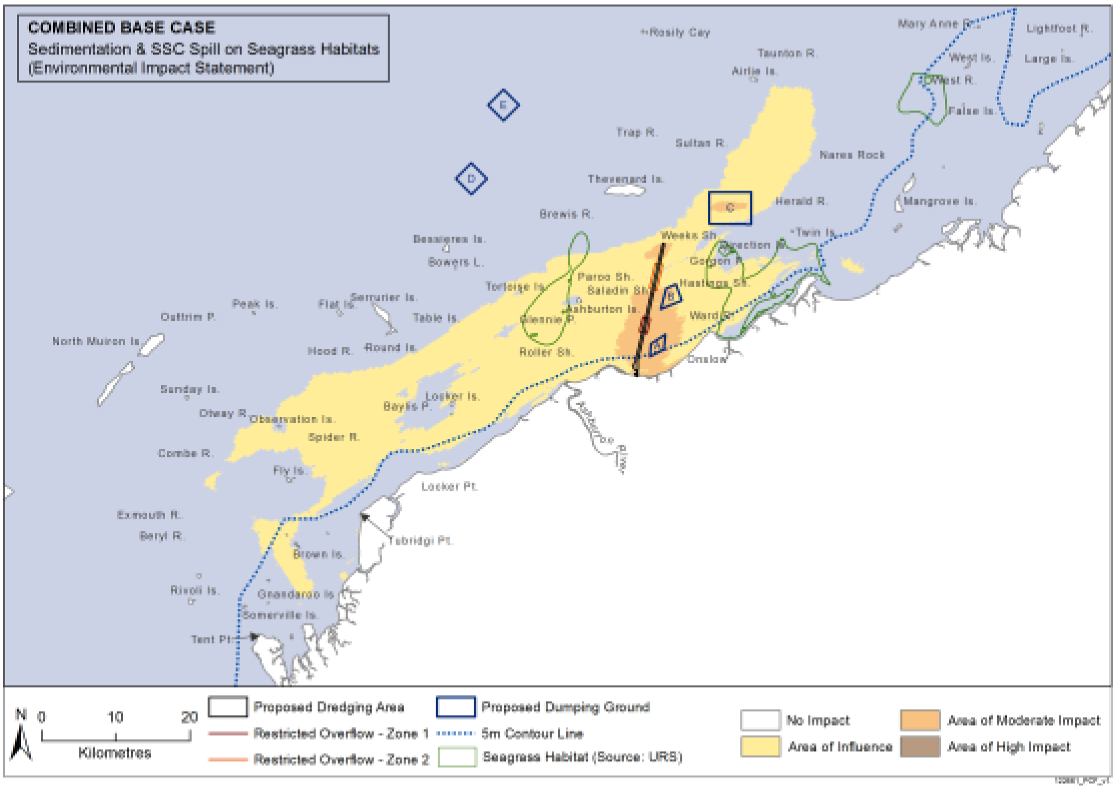


Figure 5.6: Envelope plot of predicted impact areas from Suspended Sediment Concentrations (SSC) and sedimentation on seagrass for all climatic scenarios for base case dredge Scenarios

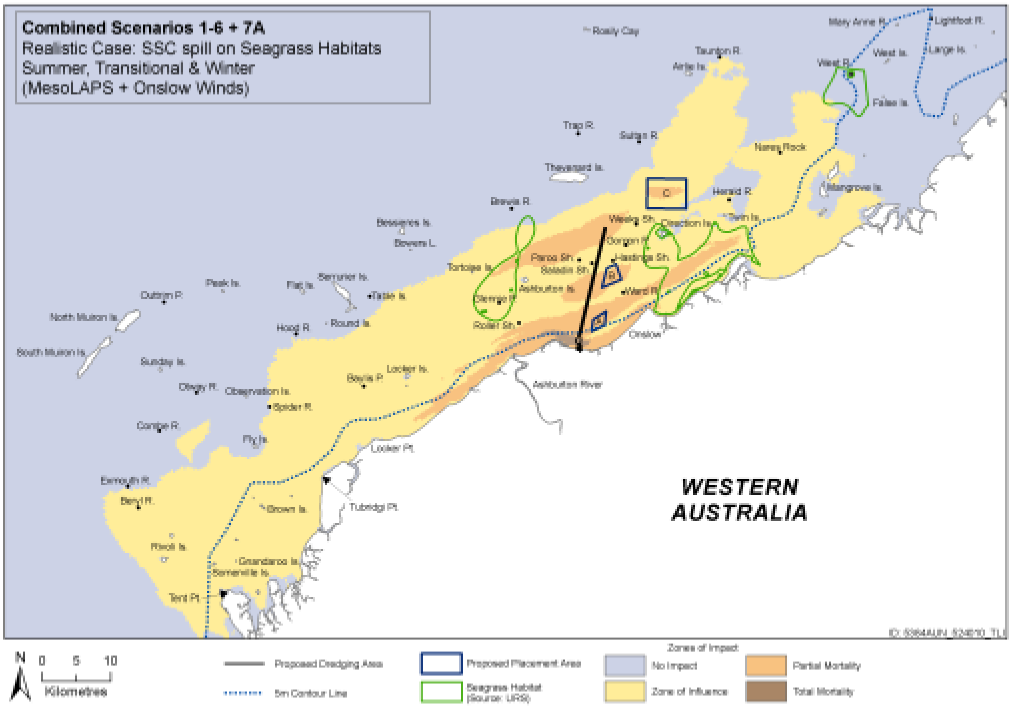


Figure 5.7: Envelope plot of predicted impact zones from Suspended Sediment Concentrations (SSC) and sedimentation on seagrass for all climatic scenarios for the EIS/ERMP dredge scenarios

5.3 BPPH Loss Assessment

The monitoring and management programmes described within this Plan have been based on both EAG No. 3 (EPA 2009) and Environmental Assessment Guideline No. 7: Marine Dredging Proposals (EPA 2011).

EAG Number 7 defines the key potential impacts to BPPH from dredging as:

- Direct loss of benthic communities and habitats by removal or burial and which are generally coincident with the footprint of infrastructure and the areas immediately around the infrastructure
- Indirect impacts on benthic communities and habitats from the effects of sediments introduced to the water column by the dredging and disposal.

The BPPH loss assessments are presented within this Plan to provide context for the management strategies presented in Section 6.0. The BPPH loss assessment within this Plan is based on the approved Impact Zones within MS 873 (Figure 5.8) and consistent with Appendix FN of the Final EIS/RTS (Chevron 2011).

5.3.1 Direct BPPH Loss

Direct impacts are limited to the footprint of the proposed infrastructure and the area immediately adjacent to the footprint. Therefore the only direct removal of BPPH due to the capital dredging programme will occur within the approach channel and result in the loss of approximately 250 ha of macroalgae.

Various calculations are possible depending on which LAU boundary is used for example:

- The percentage loss in LAU 1B alone is 6.2% (based on an area of 4022 ha of macroalgae within LAU 1B)
- The percentage loss in LAU 1B and the western portion of LAU 1A is 5.4% (based on an area of macroalgae within LAU 1B and LAU 1A of 638 ha)
- The percentage loss in the total macroalgae meadow (6185) is 4%.

These loss estimates are all close to the applicable Cumulative Loss Guideline (CLG) of 5%.

5.3.2 Indirect BPPH Loss

The indirect impacts anticipated from the capital dredging activities relate to the generation of water turbidity and sedimentation. Excessive turbidity and sedimentation can degrade BPPH (coral reefs and seagrass meadows in particular) at large scales (Chevron 2010). The main potential impact pathways are light reduction and/or abrasion due to elevated suspended sediment concentrations in the water column and smothering due to increased sedimentation rates. Indirect impacts from the dredging activities are predicted to impact on coral, seagrass and macroalgae. All predicted indirect impacts have not been classified as serious damage, i.e. contained within the ZoMI, and are therefore considered recoverable within 5 years, with the exception of corals. Four coral shoals are predicted to be within the ZoHI and suffer irreversible and serious damage due to the dredging and the ongoing chronic effects of vessel movements along the channel.

Table 5-13 details the predicted cumulative losses of BPPH due to the dredging and ongoing activities for the Project based on the impacts zones illustrated in Figure 5.8 and Figure 5.9.

Table 5-13: Predicted Losses of BPPH within each Management Unit

LAU	Descriptor	BPPH	~Area (ha)	BPPH Area (ha)	Permanent Loss		Reversible Loss	
					BPPH Loss (ha)	Percentage Loss (%)	BPPH Loss (ha)	Percentage Loss[12] (%)
1A	Offshore corals (and other BPPH) to the east of channel and within port limits	Coral	9600	244	23.4	9.6	11.2	4.6
1B	Offshore corals (and other BPPH) to the west of channel and within port limits	Coral	7300	123.2	8.6	6.9	12.3	10
		Macroalgae		4023	250	6.2	949	23.6
1C	Nearshore corals within inner port area between navigation channel and Beadon Point	Coral	9500	35	5	14	None	None
1D	Nearshore BPPH (primarily macroalgae) within inner port area between channel and western port limits	Macroalgae	6175	1511	None	None	352	23.3
1F	Offshore corals and seagrasses west of port limits	Seagrass	4969	2882	None	None	51	1.8
1G	Sediments and Seagrasses to east of Onslow	Seagrass	13311	8511	None	None	1284	15.1

[1212] The percentages for seagrass varies slightly from those presented in the EPA report, this because the percentages in the EPA report were based on the LAUs in the Draft EIS/ERMP and not the Final EIS/ERMP however the total seagrass reversible loss is the same in the Draft and Final EIS/ERMP.

2G	Sediments west of channel: all sand/gravel substrates supporting low abundance ephemeral seagrasses and/or ephemeral foliose brown algae	Macroalgae	19200	9311	None	None	2328	25
		Seagrass		1420	None	None	145	10

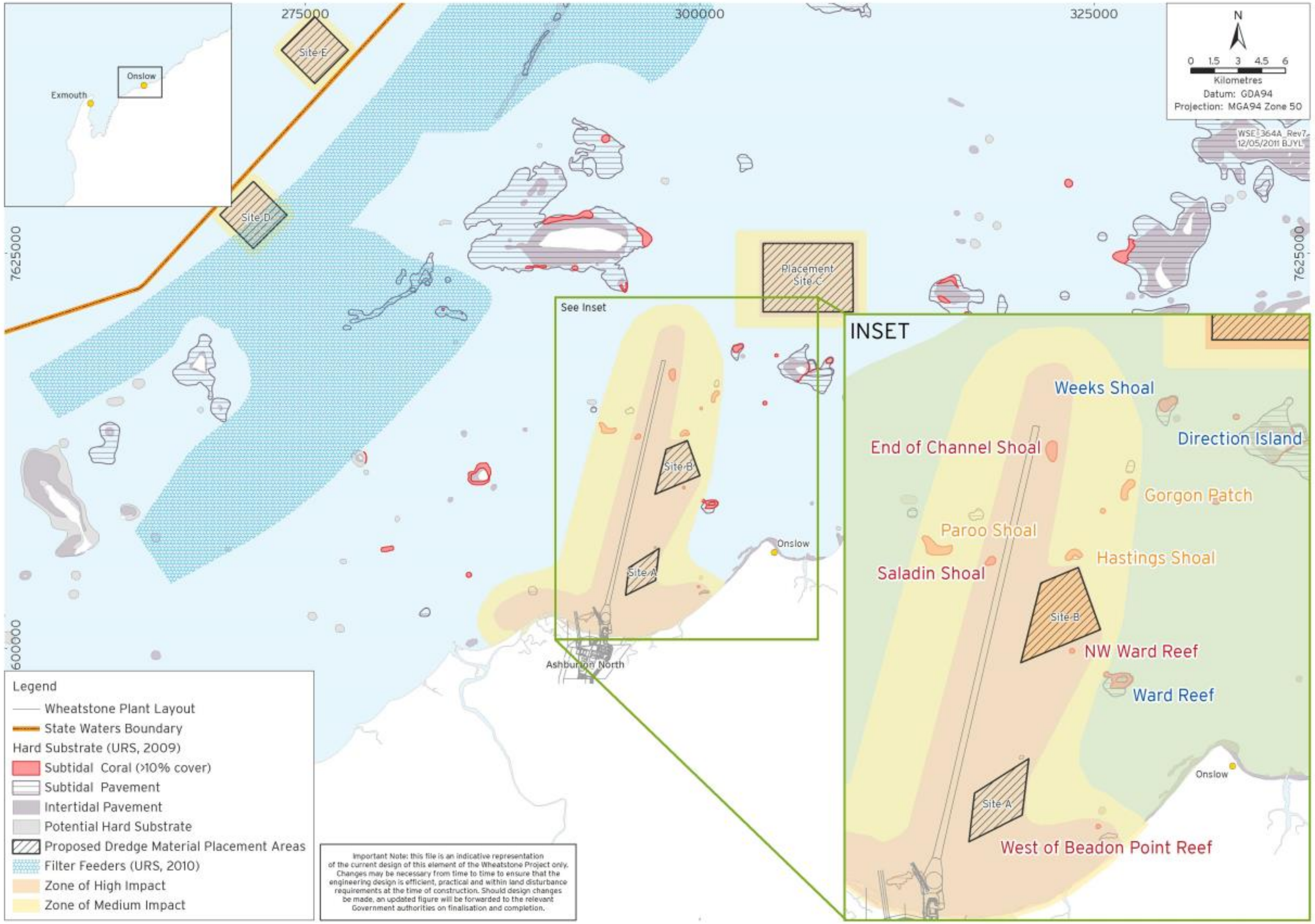


Figure 5.8: Zones of High and Moderate Impact, as defined in MS 873, for Hard Coral and Filter Feeder BPPH

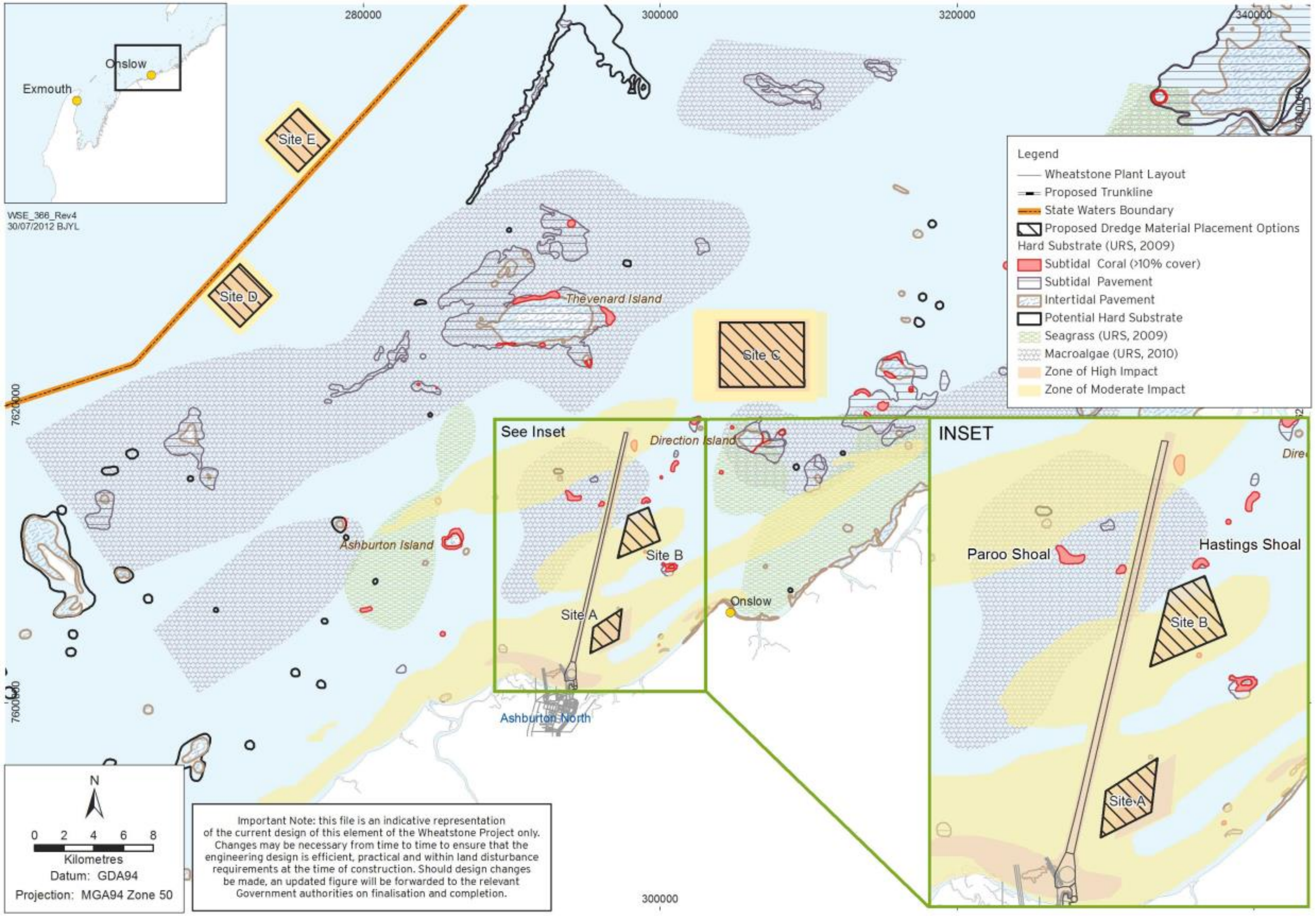


Figure 5.9: Zones of High and Moderate Impact, as defined in MS 873, for Seagrass and Macroalgae BPPH

6.0 WATER QUALITY AND CORAL MONITORING AND MANAGEMENT

6.1 Background

Dredging and dredge spoil placement activities have the potential to affect marine benthic communities through the direct removal of habitat (such as the removal of habitat within the dredging footprint). There is also the potential for indirect impacts as a result of a reduction in light availability, caused by elevated turbidity, and smothering due to the subsequent deposition of the sediments suspended by dredging and the placement of dredge spoil. Condition 6.2 (MS 873; as detailed in Section 1.5) requires that the turbidity-generating activities that are part of the construction of nearshore and offshore marine facilities are designed and executed with the aim of achieving the MOs and Condition 6-1 (MS 873; as detailed in Section 1.5) stipulates EPOs that need to be achieved that relate to levels of protection of these communities.

This monitoring and management section details the water quality management strategy which will be implemented during capital dredging to aim to achieve the MOs and EPOs and has been based on the revised modelling as detailed in Section 5.0. Monitoring associated with clean-up dredging is included in Section 2.2.2.1(10). This Chapter is structured under the following four broad components:

- The EPOs and MOs
- The water quality-based adaptive management and monitoring approach undertaken to achieve the EPOs and MOs
- The coral monitoring programme designed to assess if the EPOs and MOs are being achieved
- Verification and sedimentation monitoring programmes designed to support the above two tasks by providing data to assist with interpretation and to verify the water quality criteria are appropriate.

Although the emphasis here is on achieving the EPOs and MOs that relate to corals, the water quality management approach and verification monitoring described here are also designed to afford protection to non-coral benthic communities (discussed further in Section 7.0).

6.1.1 Environmental Protection Outcomes

As per the requirements of MS 873, Ministerial Condition 6-1, the EPOs for hard corals are:

- No irreversible loss of, or serious damage to, coral habitats outside of the ZoHI
- Protection of at least 70% of baseline live coral cover on each designated reef formation within the ZoMI
- No detectable reduction of net live coral cover within the ZoI.

Given the recent natural changes in coral cover (see Section 3.5.1 and Section 6.1.3) a management and monitoring programme based on water quality (turbidity) is considered the best approach to ensure that the EPOs are achieved and to facilitate adaptive management of the dredging activities (Table 6-1). In addition to the water quality monitoring to inform adaptive environmental management, the EPOs will be directly measured by monitoring coral in the following way[13]:

1) At the mid-term of marine works and post-development activities[14], by which time, a long time-series of data will be available to provide supporting evidence to coral EPO assessments through an examination of temporal trends in coral cover; and
2) In the event of a Level 3 water quality trigger being exceeded during dredging, which would provide evidence to support the notion that a detected change in coral cover was more likely to be the result of an increase in turbidity resulting from dredging activities, rather than a natural event or anomalous change.

In both instances, multiple lines of evidence, based on examination of additional parameters and information on recent conditions and activities, will be used to assist in determining whether the detected change was 'real' and attributable to dredging (see Section 6.3.1.3).

6.1.2 Management Objectives

In addition to the prescribed coral EPOs, as per the requirements of Ministerial Condition 6-2, turbidity generating activities which are part of the construction of nearshore and offshore marine facilities are to be designed and executed with the aim of achieving the following MOs:

- Within the ZoHI shown in Figure 3 of Schedule 1: protection of at least 50% of baseline live coral cover on each of the following two reef formations: a) End of Channel Shoal; and b) Saladin Shoal, which are shown in Figure 2 of Schedule 1.
- Within the ZoMI shown in Figure 3 of Schedule 1: no detectible reduction of net live coral cover at any designated reef formation in this zone.
- Within the ZoI shown in Figure 5 of Schedule 1: no detectable reduction of net live coral cover within this zone.

Turbidity-generating activities which are part of the construction of nearshore and offshore marine facilities will be designed and executed with the aim of achieving these MOs through the use of water quality criteria that aim to achieve the prescribed level of protection of coral communities. The recent changes in coral communities, as detailed in Section 3.5.1, has implications for the monitoring methods to assess whether the MOs associated with coral cover, stipulated by Condition 6-2, are being achieved. Therefore, monitoring of water quality and assessment against management triggers is also considered the most appropriate way of assessing whether the MOs are being achieved to allow adaptive management of dredging activities.

The water quality criteria which were developed with the aim of achieving the MOs equate to the Level 2 management triggers as described in Section 6.2.3. If these triggers are exceeded, a management response would be required (set out in Table 6-1) that would reduce pressure on BPP communities and allow Chevron Australia achieve the MOs and to avoid reaching EPOs. In addition to the water quality monitoring to inform adaptive

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[13] Due to the definition of 'no irreversible loss of, or serious damage to' condition 6-1 (i) will only be assessed at the post-development surveys.

[14] This has been defined under the SoW and will be undertaken under the SoW as detailed in Section 1.6.

environmental management, the MOs will be directly measured by monitoring coral at the mid-term of marine works and post-development, by which time, a long time-series of data will be available to provide supporting evidence to coral MO assessments through an examination of temporal trends in coral cover.

6.1.3 Management of Water Quality

Since the release of MS 873 a major reduction in the mean percent cover of corals in the area, due to thermal mass bleaching and the effects of cyclones between January and March 2011, has been reported. Reefs that were once dominated by hard coral (average coral cover 45%) are now dominated by turf algae which averages about 70% cover per reef, while coral cover is now <10% on most reefs (average coral cover ~5%).

Since coral communities are in a low and unstable condition within the Wheatstone Project area, detecting a change in coral cover and inferring the cause of this change at any single point in time during dredging may be problematic. As such, it is proposed that water quality (turbidity) criteria are used to manage the dredging programme (Section 6.2.3). Water quality criteria have been developed to afford protection to corals and are also predicted to afford protection to other BPPH and to filter feeders (described in Section 7.0).

Water quality criteria have been derived from the most recent and relevant information available, including outcomes from the Chevron Australia Gorgon Marine Monitoring Programme and data from other dredging projects and experimental studies. The Gorgon Marine Monitoring Programme provides one of the most comprehensive datasets known on the relationship between water quality and coral health during a dredging programme, and is the first dredge monitoring programme in the Pilbara where net mortality of corals (all of which were within limits of allowable loss prescribed within Gorgon Ministerial Conditions) attributable to dredging-related elevations in turbidity were recorded. For a discussion of how these criteria are predicted to afford protection to other benthic habitats, see Section 7.0. The use of the Gorgon data set to derive water quality criteria is consistent with best practice to continually derive improved dredging management measures.

Relationships between water quality and coral health data were derived from Gorgon data where net mortality in corals was detected and attributable to decreases in water quality resulting from dredging. Observed relationships between water quality and coral health were, therefore, used to develop criteria that would prevent no net detectable mortality of corals (directed towards achieving condition 6-1 (v), Condition 6-2 (ii) and Condition 6-2 (iii)) or would result in the protection of at least 70% of baseline live coral cover (directed towards achieving Condition 6-1 (iv)) or protection of at least 50% of baseline coral cover (directed towards achieving Condition 6-2 (i)).

Water quality criteria are based on the observed frequency of elevations of turbidity above background conditions (measured against concurrent water quality measurements at reference sites) and the duration over which these elevations occurred.

These criteria capture any potential long-term (chronic) elevations above the 50^{th} percentile of background conditions that may result in impacts to corals, any medium-term (moderate) elevations above the 80^{th} percentile of background conditions or the potential cumulative impact of several short events of elevated turbidity. There was no evidence in Gorgon data of any single, short-term elevation in turbidity that resulted in a subsequent response in corals and such a response is not expected during Wheatstone if dredging programmes are similar.

Due to similarities in coral communities and water quality environments, the water quality criteria derived from Gorgon data were considered appropriate for use as management triggers for Wheatstone corals, with only minor modifications required. Relevant information from other dredging programmes and laboratory experiments also supported the application of Gorgon-derived water quality criteria to Wheatstone. Gorgon-derived water quality criteria are considered conservative when applied to Wheatstone, since net mortality was only detected at Gorgon reefs deeper than 7.5 m, and the criteria were derived from a Gorgon site that was at 8.9 m depth. In contrast, the majority of Wheatstone reefs are shallower than 7 m. Therefore, less stress would be expected for corals within the Wheatstone Project area if water quality is managed using Gorgon-derived criteria, since the shallower reefs at Wheatstone are less likely to be affected by elevated turbidity and subsequent light reduction. Further, any settled sediments from dredging are more likely to be naturally resuspended at shallow Wheatstone reefs than the deeper Gorgon reefs.

Table 6-1: Management and Monitoring of Water Quality and Coral

Management Area:	**Management of water quality and coral**
Performance Objective:	To manage impacts from turbidity-generating activities, associated with the construction of nearshore and offshore marine facilities, to within water quality criteria to achieve the coral EPOs described in Condition 6-1 and that aim to achieve the MOs described in Condition 6.2.
Management:	The water quality management framework is described below. Figure 6.1 provides a summary of the monitoring and management components of the water quality management framework for Conditions 6-1 (iv) and (v). See Section 6.2.3 and Section 6.3.1 for details. **Overview** The management of water quality and associated potential impacts on monitored reef formations will be managed via: ♦ Preventative management including, where practicable: ▪ management measures to be applied where practicable during the dredging and dredge spoil management activities ♦ The use of modelling and sentinel reefs to allow proactive adaptive management and optimisation of the dredging execution scenarios ♦ Responsive monitoring and management, including: ▪ Water quality monitoring data collected approximately every 30 minutes at monitored reef formations along with an associated tiered management response ▪ Coral EPO assessment following an exceedence of the Level 3 water quality trigger ♦ Verification of the water quality criteria through quarterly benthic community monitoring and refinement of the water quality criteria, if required (Section 6.3.3). ♦ Implementation of an approved Turbid Water Overflow Adaptive Monitoring and Management Strategy (TWOAMMS; Chevron, in prep) when overflowing in Zone 1 or Zone 2, if turbidity at the designated reef formations exceeds >2.0 x background turbidity which is attributable to turbidity associated with the turbid water overflow from dredging equipment. If TWOAMMS has not been approved and turbidity at the designated reef formations exceeds >2.0 x background turbidity which is attributable to turbidity associated with the turbid water overflow from dredging equipment, overflow of turbid water will cease.
Preventative Management	**Preventative Management** *The following management measures may be applied to reduce excessive levels of suspended sediment reaching benthic communities. These measures will be applied during turbidity-generating activities covered by this Plan where relevant and practicable, and may be applied even where additional responsive*

	*management measures (see the following description on responsive management) might apply.* ♦ GPS, monitoring and automation systems on specified equipment ♦ Well-maintained, repaired and properly calibrated equipment ♦ TSHDs will be fitted with a turbidity reducing valve within the overflow pipe. ♦ Flexibility within the dredge execution plan and well prepared and studied alternative plans ♦ Route selection to minimise turbidity caused by vessel props, where practicable. ♦ Proactive adaptive management (PAM) strategy **TSHD and Split-Hopper Barges** ♦ Optimising under-keel clearance to reduce sediment re-suspension caused by propeller wash, where practicable ♦ Raising the overflow pipe to avoid spillage during transit ♦ Ensure TSHD bottom doors and split-hopper barges hull seals inspected prior to mobilisation and operated appropriately to prevent and reduce sediment loss during transit ♦ Transiting via designated corridors to Dredge Spoil Placement Site C and avoiding no-transit and no-anchoring areas ♦ Confining hopper dewatering to areas away from monitored reef formations where practicable ♦ Limiting overflow in sensitive areas based on implementation of the PAMS ♦ Maintaining an ~0.5 nautical mile buffer zone around coral reefs to the east of the approach channel to limit stress associated with sediment re-suspension from propeller wash **CSD** ♦ Employing optimised cutter heads for differences in soil types to reduce spillage and suspended solids ♦ Utilising a diffuser head on the spreader barge connected at the underwater outlet of the pipeline during near bed dredge spoil placement in Dredge Spoil Placement Sites A and B[15] to reduce material outflow velocity and potential for re-suspension
Responsive Monitoring	**Responsive Monitoring and Management Procedures** Responsive water quality monitoring and associated tiered responsive management and coral EPO assessment monitoring will be implemented to manage any potential impacts that increased turbidity may have on monitored reef formations. _Water Quality Monitoring_ Water quality measurements will be logged at approximately 30 minute intervals at monitored reef formations throughout the duration of the dredging and dredge spoil placement works. Water quality monitoring will be achieved through the use of *in-situ* water quality data logging instruments. Refer to Section 6.3 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.2.3

[15] Sites A and B will only be considered in the event of an emergency situation and will require the approval of the PPA prior to use.

	♦ Used to assist in inferring the cause of any observed impacts to benthic communities *<u>Coral EPO Assessment Monitoring</u>* Coral cover will be surveyed at the ‘affected reef formation’ following an exceedence of a Level 3 management trigger. Refer to Section 6.3.1.3 for further details of the EPO assessment monitoring programme. The results of this monitoring will be used to assess if net live coral cover at the affected reef had declined as a result of dredging and if this decline was greater than the EPOs defined in MS 873 Condition 6-1. *<u>Verification Monitoring</u>* Monitoring will consists of: ♦ Quarterly routine monitoring of benthic communities at the monitored reef formations (Figure 6.7) to provide verification of the appropriateness of water quality criteria ♦ Verification monitoring which will be triggered by an exceedence of the Level 2 management trigger. Monitoring of benthic communities will be at the monitored reef formations (Figure 6.7) at which triggers were exceeded, and at associated reference reefs *Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs.*
Responsive Management	**<u>Potential Responsive Management Measures</u>** ***<u>Exceedence of a Level 2 management trigger</u>*** Management measures will be implemented once a Level 2 management trigger is exceeded (see Section 6.2.3), dependent on the applicability of the measure and the potential for severity of environmental impact. Notably, no change in dredging or disposal operations may be required to reduce potential environmental impacts attributed to the trigger if, for instance, metocean conditions change and water quality returns to a level which does not lend itself to concern, especially if below the trigger intensity. The chosen measure(s) will take into account current and forecast metocean conditions, proximity of monitored reef formations, flexibility in the dredge execution plan and the PAM strategy. While the optimal measures will be employed given the specific situation, additional measures will still be available in case the initial measures are found to be ineffective. Management measures that may be considered and implemented include: ♦ Optimising the monitoring programme including the monitoring frequency, parameters, and area to more closely scrutinise the cause and possibility of recurrence of the exceedence ♦ Conducting bathymetric surveys for more comprehensive understanding of environment and allow optimisation of dredge operations ♦ Refining dredging and/or disposal operations based on sediment plume model results, current and forecasted metocean conditions, and the soil model. These refined operations include modifying: • Scale of operations and resulting potential area of influence • Location of dredging, type of dredging technique, overflow, and/or dredge spoil placement activities • Dredging practice including overflow operations and production rate and/or volume • Disposal technique including discharge rate and/or volume • Redefining transit routes

	• Reduce dredging and/or material placement activities ♦ Implementing the refined dredging and/or disposal operations based on sediment plume model results, current and forecasted metocean conditions, and the soil model until the exceedence resolves. ***Exceedence of a Level 3 management trigger*** (only applicable in the ZoMI and ZoI) If a Level 3 management trigger is exceeded, dredging activities which could reasonably be expected to have caused or contributed to the exceedence will cease and, the Level 3 Exceedence Procedure (detailed in Section 6.2.3 and Figure 6.2) is required to be followed for the site where the exceedence was reported.

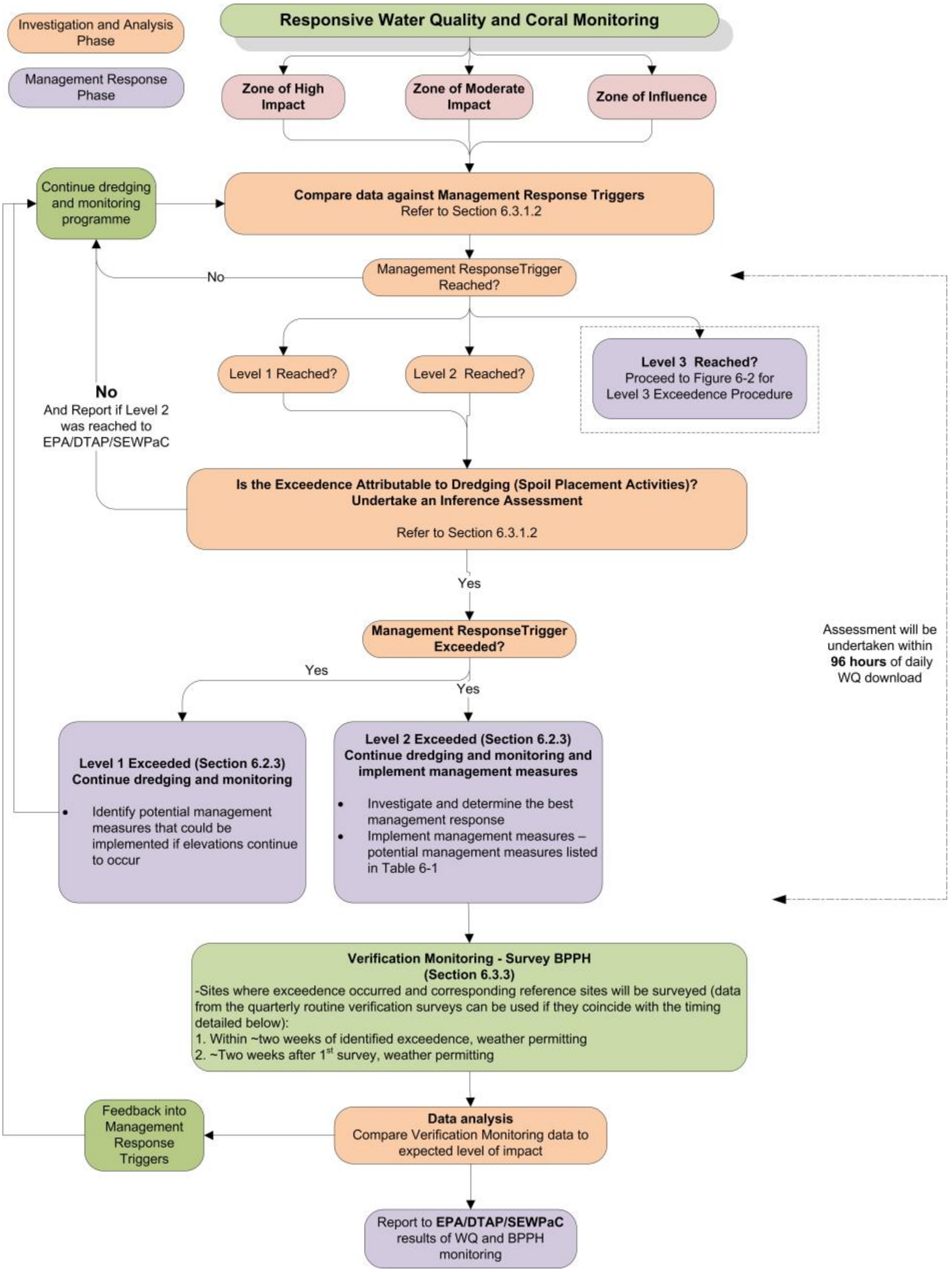


Figure 6.1: Water Quality Management Procedure

Note: This figure presents a summary of the relevant monitoring and management required by the conditions that will be applied during dredging operations.

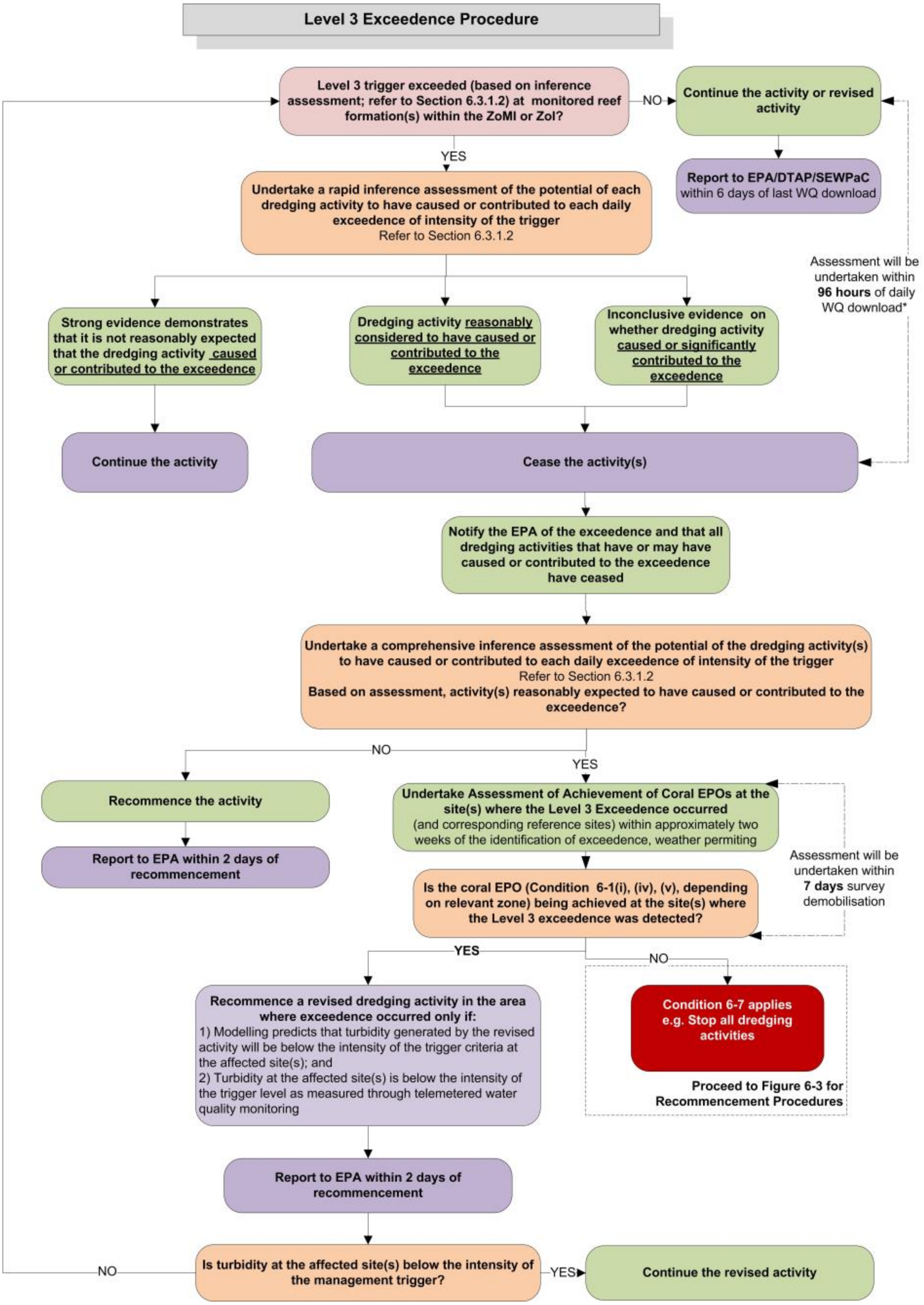


Figure 6.2: Level 3 Exceedence Procedure

** This 96 hour timeframe is the maximum timeframe in which the inference assessment must be completed and relevant management measures implemented. This timeframe will be reviewed following the completion of a Level 3 exceedence procedure to determine if the 96 hours can be reduced.*

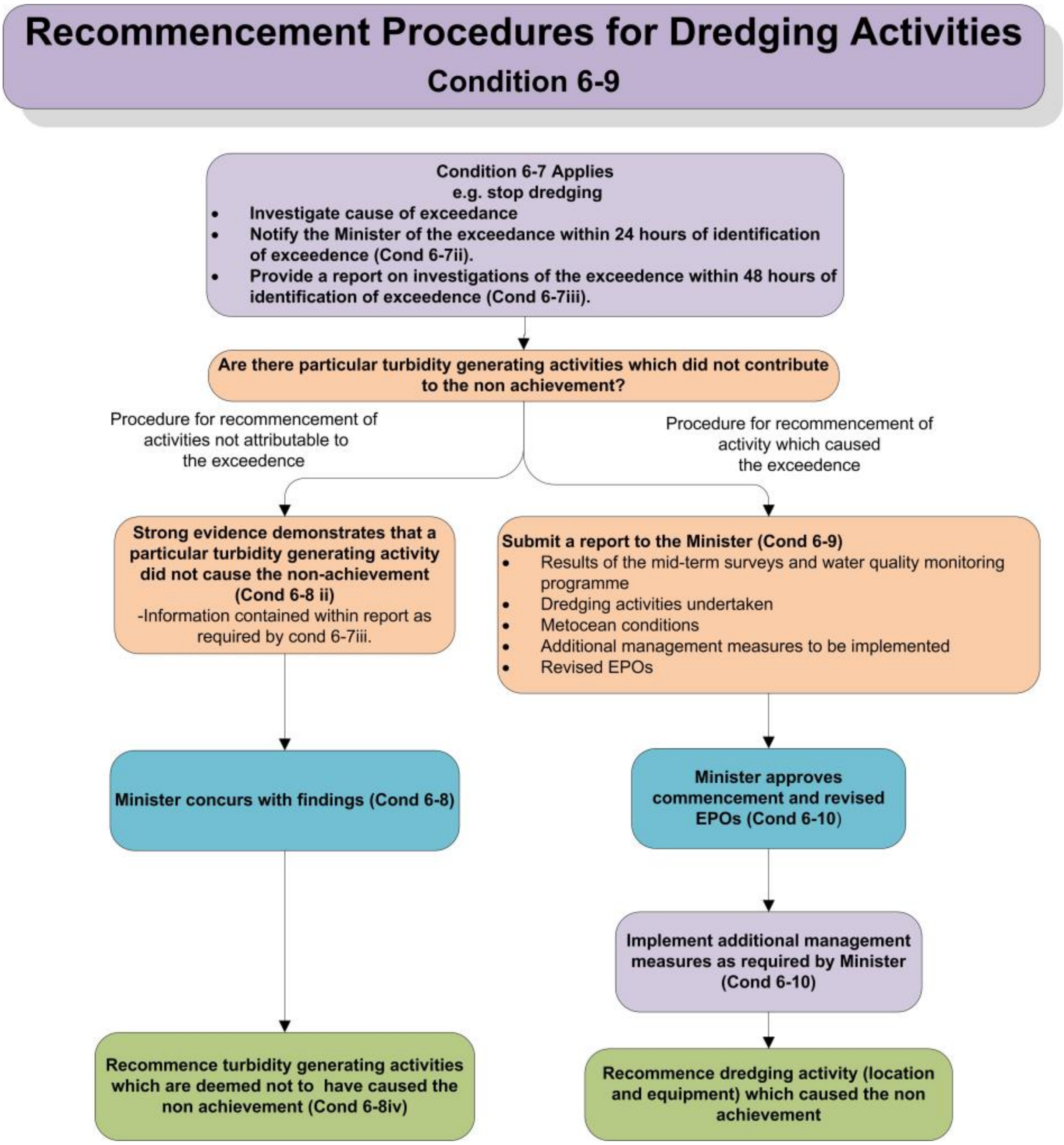


Figure 6.3: Recommencement Procedure in the event that Condition 6-7 applies

6.2 Management Strategy for Water Quality and Coral

6.2.1 General Approach

A PAM approach will be implemented for the Wheatstone capital dredging programme; clean-up dredging, which is of lower risk to receptors due to volume and duration of dredging material, will not use a PAM approach. The PAM approach provides a tool based on the latest dredge environmental practice where modelling is used to predict environmental effects and steer the dredging operations. The use of the model during execution enables the dredge contractor to use field measurements and the most updated hydrodynamic conditions to manage dredging operations. This PAM will be supported by a responsive management programme which is based on water quality (turbidity levels) at identified monitored reef formations and a tiered approach to management of the dredging operations.

The water quality management approach for the dredging programme is composed of:

1) **PAM and Monitoring** consisting of:
    a. Proactive modelling (Programme 1a as illustrated in Figure 6.4): the complementary proactive use of predictive sediment transport models, based on upcoming dredge execution plans (scenarios) and predicted metocean conditions to avoid exceeding triggers of Programme 1 during dredging execution

       and

    b. Mobile sentinel monitoring (Programme 1b as illustrated in Figure 6.4): a detailed system of rapid feedback monitoring designed to inform dredge managers of any trend towards exceeding formal triggers of Programme (2). The monitoring in Programme 1b will link to modelling predictions and refinement of Programme (1a)
2) **Responsive Management and Monitoring** at the monitored reef formations (Programme 2 as illustrated in Figure 6.4): A formal field monitoring and management programme including a hierarchy of three trigger levels with linked responses, directed towards achieving the MOs and EPOs.

The relationship between the PAM approach and the responsive management components (including formal management triggers) is illustrated in Figure 6.4.

The benefits of this overall adaptive proactive and responsive approach may include, but is not limited to, the following:

- The sediment transport model can be optimised before and during the dredging process and will as such become a reliable tool to predict impact and act accordingly before the dredging is done.
- Modelling as part of the PAM will be used to manage overflow of the dredge equipment to reduce environmental impact.
- Breakdowns, changing metocean circumstances and observations/experience during dredging operations can occur necessitating a plan ‘B’, which will be model tested upfront.
- It creates flexibility and continuity towards the execution while at the same time safeguarding the environmental guidelines. This is due to the fact that the dredging can continually be optimised, through modelling, to ensure that the EPOs will be met.

- A data bank of water quality (turbidity) at the monitored reef formations will be used when implementing scenarios so the water quality history on the monitored reef formations is taken into account evaluating possible adapted dredging scenarios.

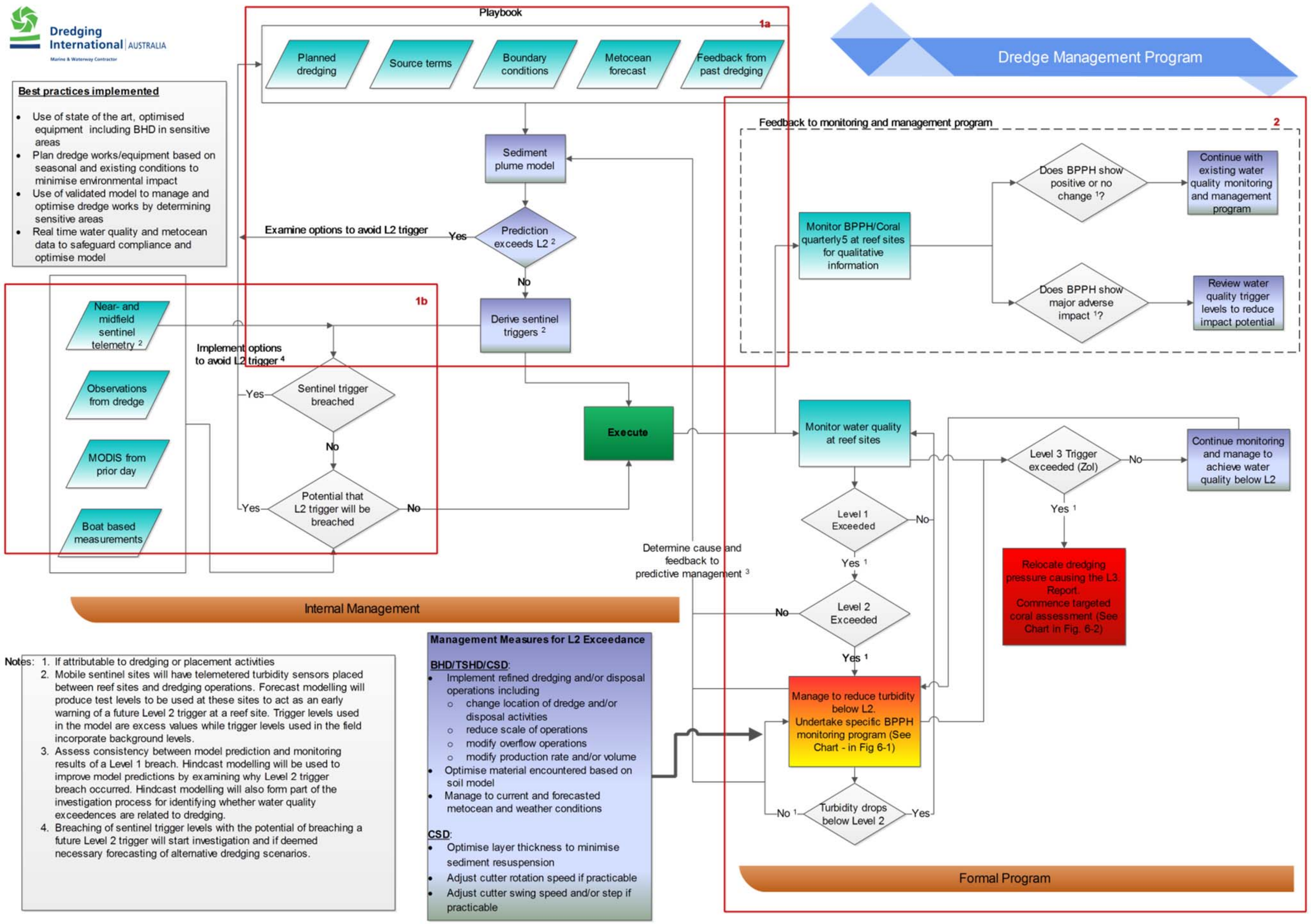


Figure 6.4: Linkages between Proactive Adaptive Management and Responsive Management

6.2.2 Proactive Adaptive Management

PAM will be used during the preparation phase, e.g. to optimise the base case (Section 5.2), and during dredging execution to allow adjustments of the dredge programme to achieve the MOs and EPOs. The PAM approach encompasses modelling activities and examination of water quality data collected from an array of sentinel water quality loggers positioned near-field to the dredging operations (as described in detail in Section 6.3.2). The PAM approach is illustrated in Figure 6.5 and summarised below.

The first step in the PAM approach is to undertake modelling of the potential dredge scenarios, to be implemented during dredging, to be undertaken at least fortnightly (Figure 6.5; Step1) and in the event of an exceedence of a Level 2 management trigger, every three days. The applied model that has been used for the EIS/ERMP and this Plan will continue to be used during dredging and is a 2D hydrodynamic and sediment transport model developed by Danish Hydraulic Institute (DHI) (Chevron 2010). The sediment transport model makes use of the output of the hydrodynamic model and the sediment releases due to the dredging and dredge spoil placement activities to calculate the predicted sediment dispersion and sedimentation. Available telemetered data such as near/midfield, responsive monitoring water quality data, measurement from intensive boat based surveys (ADCP and vertical profiling turbidity sensors) and metocean data will be used to evaluate the settling velocities, particle size distributions and source term verification. These results will allow the verification of model.

The model outputs will be compared (evaluated) to the management triggers developed for the responsive monitoring programme (see Section 6.2.3 for details). If the predicted values are above the Level 2 management triggers (Table 6-2; Table 6-3; Table 6-4) then the dredge scenario will be adapted and remodelled until the model outputs predict the achievement of the Level 2 management triggers for the relevant zones and therefore it is likely that the aim to achieve the MOs will be achieved (Figure 6.5; Step 2). This allows the dredging execution scenarios to be modelled based on the current, up to date and relevant, metocean forecast to receive a predicted water quality consequence. Only dredging scenarios which the modelling outputs indicate produces a plume which does not cause the turbidity levels at any monitored reef site to be above the Level 2 trigger will be implemented during dredging.

The model results are then used to derive early warning test levels for mobile sentinel loggers around dredging locations. The early warning test levels are turbidity levels at the mobile sentinel site which are consistent with water quality being below the MO at monitored reef formations (Figure 6.6). Once the early warning test levels are established the selected dredging execution scenario can be implemented during hydrodynamic conditions comparable to those modelled (Figure 6.5; Step 4). During dredging, monitoring will be undertaken to avoid water quality levels approaching Level 2 triggers (Figure 6.5; Step 5; Section 6.3.2). Monitoring for the early warning test levels will use telemetered instruments as specified in the monitoring section (Section 6.3.2).

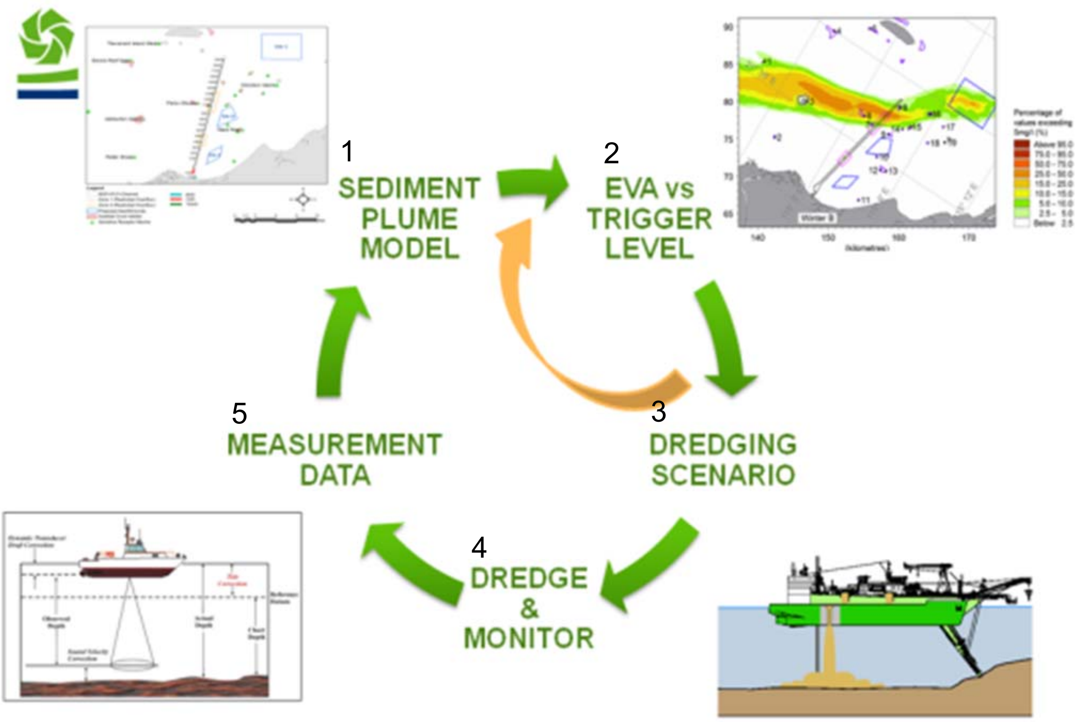


Figure 6.5: Proactive Adaptive Management System

EVA - evaluated

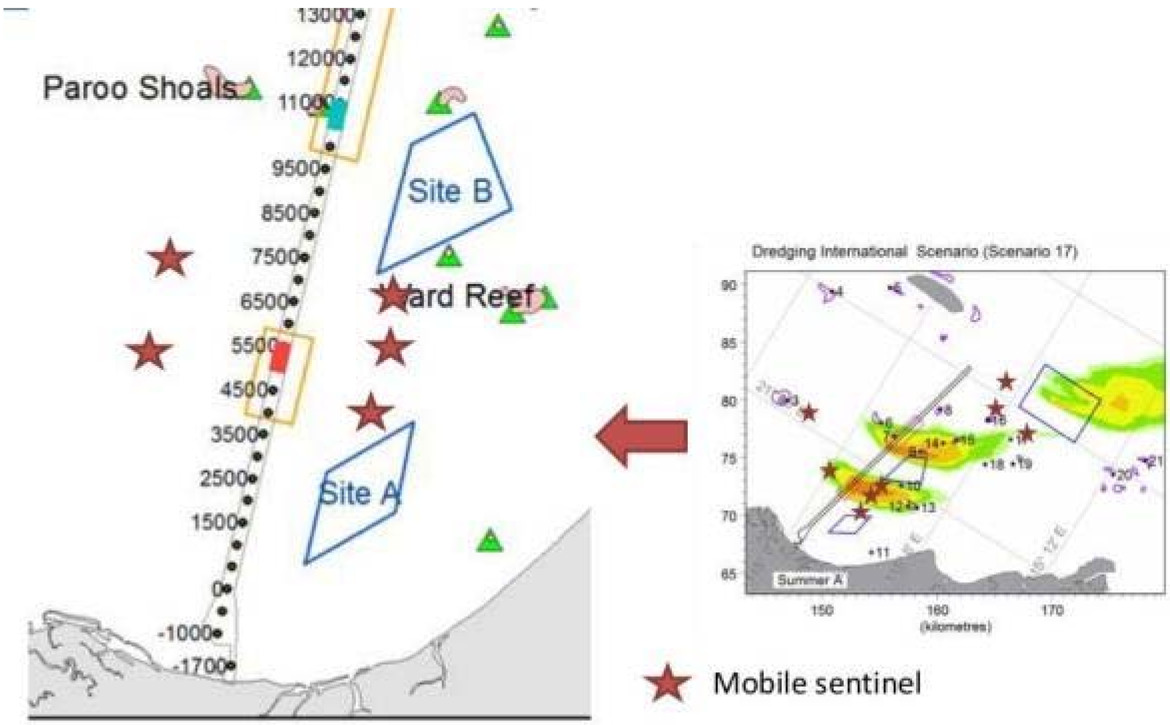


Figure 6.6: Mobile Sentinel Loggers at Targeted Locations

6.2.3 Responsive Management

Responsive management of the dredging activities will occur through the use of management triggers based on water quality criteria. These triggers have been designed to guide the management of dredging activities to achieve the coral EPOs and to manage the impacts of activities with the aim of achieving MOs.

A three-tiered management trigger system has been developed for the ZoMI and ZoI, while a two-tiered management trigger system has been developed for the ZoHI (no Level 3 trigger applies to the ZoHI since up to 100% of corals are predicted to be impacted within this zone). As described in Section 6.1, water quality criteria have been derived from the most recent and relevant information available, including outcomes from the Gorgon Marine Monitoring Programme and data from other dredging projects and experimental studies. The derivation of these criteria was summarised in Section 6.1.

Management triggers were developed from observed, dredging-related impacts to water quality (turbidity elevations) and decreases in coral health during Gorgon dredging. Observed relationships between water quality and coral health were used to develop criteria that would indicate that ongoing dredging pressure at that site is reasonably likely to result in the EPO not being achieved and therefore direct monitoring of coral would need to commence. These criteria were adopted for Level 3 triggers. Shorter-term Level 1 and 2 triggers were developed that, if exceeded, would prompt a management response to afford protection to coral well before reaching Level 3 triggers. Provided effective management is implemented at Level 2, it is anticipated that the Level 3 management trigger would not be exceeded and coral EPOs will be achieved.

The basis for setting durations for Level 1, 2, and 3 triggers is that if - over short durations - water quality can be kept consistently below either the levels of NTU or the increase above background NTU that were observed to be associated with a certain level of mortality at Gorgon during dredging, then cumulatively, water quality will remain below the levels above background that would lead to the appropriate level of protection being afforded to corals at Wheatstone.

Just as ‘background’ water quality conditions over the long term can be expressed as an average of percentiles across Reference reefs, background turbidity can also be calculated on a day to day basis as the (geometric) average of turbidity across Reference reefs. A geometric average is necessary here because NTU data are typically log-normally distributed (and so arithmetic averaging is not appropriate). Thus, the water quality criteria for Levels 1, 2, and 3 management triggers presented here are essentially increasingly longer duration tests of how frequently water quality at a monitoring site is elevated above the long-term difference between background and water quality that is predicted to result in a certain level of net mortality (as observed at Gorgon during dredging).

Essentially, the criteria assess how often a daily allowable level of turbidity above background (Reference reefs) has been reached during a rolling assessment period at the assessed reef formation. The aim of triggers is to keep turbidity at levels that did not lead to a certain level of mortality, based on the observations from Gorgon. Whenever the assessment shows that water quality exceeds *either* chronic *or* moderate criteria, the associated management responses are required.

Whilst these criteria have been derived from, and are applied to the protection of coral habitats, the criteria are also predicted to afford protection to other benthic habitats, including macroalgae, filter feeders and seagrasses but with less certainty (see Section 7.0).

6.2.3.1 Hierarchy of Trigger Levels

The assessment of water quality data against management triggers is comprised of two equally important parts:

1. The exceedence of a numeric value for water quality over a defined frequency within a set time period (following the procedure described in Section 6.3.1.2)
2. An inference assessment of a range of factors, for example, metocean conditions, dredging characteristics and satellite imagery to determine if dredging or spoil placement can reasonably be expected to have contributed to or caused each daily exceedence of the intensity of the trigger (Section 6.3.1.2).

Both parts of the assessment are required before it can be determined that an exceedence of a management trigger has occurred. For example, if the numeric value for water quality is exceeded but the inference assessment indicates that the exceedence is not attributable to dredging activities then the determination is the trigger level has not been exceeded.

Level 3 management triggers are based on water quality criteria directed towards achieving the coral EPOs in Statement 873 Condition 6-1. These triggers apply to all monitored reef formations within the ZoI and ZoMI. As there is no EPO for the ZoHI there is no Level 3 Management Trigger applicable to this zone.

If Level 3 management triggers are exceeded, this would indicate that ongoing dredging activity at a site may result in the coral EPOs not being achieved and would require the Level 3 Exceedence Procedure to be followed, as described below and illustrated in Figure 6.2.

Level 3 Exceedence Procedure

In the event that a Level 3 water quality trigger has been reached, a rapid inference assessment will be undertaken of dredging activity(s) [16] which are reasonably expected to have contributed to or caused the exceedence. Information used in this assessment could include: the location of the activity compared to the affected reef formation and examination of recent MODIS imagery illustrating the extent of dredge plumes. Any dredging activity which could reasonably be expected to have caused or contributed to the exceedence and any dredging activity where it cannot be determined will be required to cease. Notification is to be provided to the EPA, DTAP and DOTE that the Level 3 trigger has been exceeded and there has been a cessation of all dredging activities that have or could reasonably be expected to, cause or contribute to the exceedence.

Where there is strong evidence which demonstrates that it is reasonably expected that the dredging activity has not caused or contributed to the exceedence the dredging activity(s) can continue. Since the activity is defined as the ‘dredge/disposal vessel and the location’ it is also possible for dredge/disposal vessels that were required to cease operations to commence activities in other locations, provided there is strong evidence that these activities are not reasonably expected to cause or further contribute to an exceedence at the affected reef formation(s). For example if the Level 3 exceedence occurs at a monitored reef formation located inshore, there might be strong evidence that if the vessel was moved to an offshore dredging location, it would not contribute to an exceedence at the affected site.

[16] For the purposes of this Plan, dredging activity has been defined as a combination of the type of dredging (e.g. CSD, placement of dredge spoil) and the location of the activity.

Dredging activities that have been stopped but, based on a comprehensive inference assessment, are not reasonably expected to be causing or contributing to the exceedence may be recommenced. A report setting out the rationale for the assessment that those activities that did not contribute to or cause the exceedence must be provided to the EPA within two working days of the recommencement.

In the event that a Level 3 water quality trigger is exceeded, a Coral EPO Assessment will be undertaken at the affected reef formation within approximately two weeks (weather permitting) to determine whether coral EPOs are being achieved at the affected reef formation. The monitoring and analysis procedures for the Coral EPO Assessment are detailed in Section 6.3.1.3.

If the Coral EPO Assessment reveals that the EPO is being achieved the turbidity generating activities that have been stopped can recommence if:

- Modelling of the revised activity predicts turbidity will be less than the trigger intensity at the affected reef formation; and
- Measured turbidity at the affected reef formation has dropped below the trigger intensity, as demonstrated by telemetered data.

If the revised activity is allowed to recommence and the turbidity generated by this activity at the affected site rises above the intensity of the trigger whilst a Level 3 exceedence is still in effect (i.e. while the cumulative number of days above the trigger intensity is still higher than the number of allowable days within a rolling period), the activity would again be required to stop and the Level 3 exceedence procedure would again be followed.

If the Coral EPO Assessment reveals that the EPO is not being achieved at the reef formation where the Level 3 Exceedence occurred, as a result of dredging activities, the Recommencement Procedure (Figure 6.3), is required to be followed in accordance with Condition 6.9 of MS 873.

Level 2 management triggers are based on water quality criteria designed with the aim to achieve the MO for each monitored reef formation within each management zone (ZoHI, ZoMI and ZoI). If Level 2 management triggers are exceeded, this would indicate that the MOs might not be being achieved, and a management response is required, where reasonably practicable, to reduce pressures (elevated turbidity) and to avoid a further escalation of impacts that might result in non-achievement of the MOs.

If a Level 2 trigger is exceeded, management of dredging activities is required, where reasonably practicable, to continue to be implemented to reduce pressure on the reef formation(s) where the exceedence occurred until water quality at that reef formation(s) is reduced to below the trigger intensity. Management actions would be assessed as effective if turbidity levels are reduced to below the magnitude of the management triggers (i.e. 3.9, 3.8, 3.3 or 3.2 times background depending on the zone and criteria).

If Level 2 management triggers are exceeded, monitoring of benthic communities (two surveys) is required at monitoring reef formations where the management trigger was exceeded to provide verification of whether the water quality criteria are effective in affording the required level of protection to receptors (Section 6.3.3). Two field surveys are planned following a Level 2 exceedence. One survey will occur within two weeks of the initial exceedence and another will occur within two weeks of the end of the first survey. Consequently, the field survey period following a Level 2 exceedence will be four weeks in total. During this four week period, should the Level 2 be exceeded again at the same affected reef formation, it will not trigger an additional two verification monitoring surveys, but will only instigate additional management measures. Verification monitoring can only commence again at that same affected reef formation once the current four week survey period has ended.

Level 1 management triggers provide an early warning that dredging activities are elevating turbidity at monitored reef formations and there is the potential for future impacts to coral should these elevations continue to occur. Level 1 management triggers are set at half the duration of time required to reach a Level 2 management trigger. If Level 1 management triggers are exceeded, this would prompt an investigation of events that led to the trigger being exceeded and identification of any potential management responses that could be implemented in the event that impacts to water quality continue to occur.

6.2.3.2 ZoHI Management Triggers

There is no EPO for the ZoHI since it is predicted that up to 100% of corals may potentially be impacted within this zone. Therefore, no Level 3 management trigger has been developed for this zone (that is directed at achieving the EPO). However, the MO for the ZoHI is to aim to achieve protection of 50% of live coral cover. Therefore, Level 1 and Level 2 management triggers have been developed with the aim to achieve the MO for this zone (Table 6-2). The procedure used to assess water quality data against these triggers is provided in Section 6.3.1.2.

The Level 1 trigger criteria for the ZoHI will be based on water quality conditions that, if exceeded, would be below coral tolerance limits but above predicted background levels. This would result in an investigation as to why this occurred and a check of the predictive model to see if changes to the dredging and/or placement activities are required.

The Level 2 management trigger for the ZoHI is based on water quality criteria that are directed towards the aim of achieving the MO for this zone of “protection of 50% of live coral cover”. If the Level 2 management trigger is exceeded at any monitored reef formation within the ZoHI as a result of dredging activities, management measures will be implemented to reduce pressure on these reef formation(s) and minimise the likelihood that further impacts will occur. Verification Monitoring will also be implemented at the monitored reef formation(s) where the Level 2 trigger was exceeded, as well as at associated reference reefs to verify whether the water quality criteria are affording the required level of protection for benthic communities (as described in Section 6.3.3). Monitoring will be undertaken ~2 weeks following identification of an exceedence and a second survey will be undertaken ~2 weeks following the first survey to examine potential lag-effects in the response of receptors to water quality impacts and to examine congruence (and hence improve confidence) in survey results.

Table 6-2: Management Triggers and Required Responses for monitored reef formations within the ZoHI

	Trigger Level		
	Level 1	**Level 2**	**Level 3**
Water Quality Criteria	**Chronic criteria** Daily median turbidity >3.9 x background turbidity and >3.09 NTU for no more than 20 days out of a 40 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.8 x background turbidity and >6.19 NTU for no more than 8 out of a 40 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.9 x background turbidity and >3.09 NTU for no more than 40 days out of an 80 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.8 x background turbidity and >6.19 NTU for no more than 16 out of an 80 day rolling assessment period.	Not applicable as no coral EPO applies to this zone that requires a Level 3 trigger, directed at achieving an EPO.
Management Measures	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Check predictive model for interpretation. Investigate potential management responses that could be implemented if elevations continue to occur.	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Implement management, where reasonably practicable, to reduce levels below the trigger value. Continue monitoring and assessing water quality to ensure the effectiveness of the measures applied. Alter management response if not effective e.g. continued elevated turbidity Two surveys of benthic communities at targeted monitored reef formations where exceedence was identified and related reference monitored reef formations to verify appropriateness of water quality criteria.	

6.2.3.3 ZoMI Management Triggers

The Level 1 trigger criteria for the ZoMI will be based on water quality conditions that are considerably less than durations that would result in net detectable mortality in corals but above predicted background levels. This would result in an investigation as to why this occurred and a check of the predictive model to see if changes to the dredging and/or placement activities are required (Table 6-3).

The Level 2 management trigger for the ZoMI is based on water quality criteria that have been derived with the aim of achieving the MO for this zone of “no detectible reduction of net live cover at any designated reef formations in this zone”. If the Level 2 management trigger is exceeded at any monitored reef formation within the ZoMI as a result of dredging activities it is reasonably likely that the MO may not be achieved therefore management measures will be implemented to reduce pressure on these reefs and minimise the likelihood that further impacts will occur. Verification monitoring will also be implemented at the monitored reef formation(s) where the Level 2 trigger was exceeded, to verify whether the water quality criteria are affording the required level of protection for benthic communities (as described in Section 6.3.3). Monitoring will be undertaken ~2 weeks following identification of an exceedence, weather permitting, and a second survey will be undertaken ~2 weeks (weather permitting) following the first survey to examine potential lag-effects in the response of receptors to water quality impacts and to examine congruence (and hence improve confidence) in survey results.

The Level 3 management trigger for the ZoMI are set at a level which indicates that ongoing pressure from elevated turbidity caused by dredging activities at the affect monitored reef formation may result in the EPOs not being achieved. The coral EPO for this zone prescribed in Condition 6.1 of MS 873 is no irreversible loss (Condition 6.1 (i)), or protection of 70% of baseline live coral cover (Condition 6.1 (iv)), at each monitored reef formation.

If the Level 3 trigger is exceeded, the Level 3 Exceedence Procedure (Section 6.2.3.1; Figure 6.2.) will be followed, which includes cessation of all dredging activities which are reasonably expected to be contributing to or causing the exceedence, and an assessment of achievement with the coral EPO at the affected reef formation.

Table 6-3: Management Triggers and Required Responses for designated reef formations within the Zone of Moderate Impact

	Trigger Level		
	Level 1	**Level 2**	**Level 3**
Water Quality Criteria	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 20 days out of a 40 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 8 days out of a 40 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 40 days out of an 80 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 16 days out of an 80 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 170 days out of a 340 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 68 days out of a 340 day rolling assessment period
Management Actions	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Check predictive model for interpretation. Investigate potential management responses that could be implemented if elevations continue to occur.	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Implement management, where reasonably practicable, to reduce levels below the trigger value. Continue monitoring and assessing water quality to ensure the effectiveness of the measures applied. Alter management response if not effective e.g. continued elevated turbidity. Two surveys of benthic communities at targeted monitored reef formations where exceedence was identified and related reference monitored reef formations to verify appropriateness of water quality criteria.	Follow the Level 3 Exceedence Procedure (Figure 6.2).

6.2.3.4 ZoI Management Triggers

The Level 1 trigger criteria for the ZoI are based on water quality criteria that are considerably less than durations that would result in net detectable mortality in corals, but are above predicted background levels. If a Level 1 management trigger is exceeded it would result in an investigation as to why this occurred and a check of the predictive model to see if changes to the dredging and/or placement activities are required, including potential management measures should turbidity levels remain elevated.

The Level 2 management trigger for the ZoI is based on water quality criteria that have been designed with the aim to achieve the MO for this zone of "no net detectable reduction in live coral cover". The MO and EPO for the ZoI are the same in Condition 6.1 and 6.2 of MS 873 (i.e. "no net detectable reduction in live coral cover"). However, water quality criteria associated with the Level 2 management trigger have been set more conservatively than for the Level 3 for the ZoI and are, therefore, unlikely to result in any net detectable reduction in live coral cover even if Level 2 management triggers are exceeded.

If the Level 2 management trigger is exceeded at any monitored reef formation within the ZoI as a result of dredging activities, management measures will be implemented, where reasonably practicable, to reduce pressure on these reefs and minimise the likelihood that further impacts will occur. Verification monitoring will also be implemented at the monitored reef formation (s) where the Level 2 trigger was exceeded, as well as at any associated reference reefs to verify whether the water quality criteria are affording the required level of protection for benthic communities (as described in Section 6.3.3). Monitoring will be undertaken ~2 weeks following identification of an exceedence, weather permitting, and a second survey will be undertaken ~2 weeks (weather permitting) following the first survey to examine potential lag-effects in the response of receptors to water quality impacts and to examine congruence (and hence improve confidence) in survey results.

The Level 3 management trigger for the ZoI Impact are set at a level which indicates that ongoing pressure from elevated turbidity caused by dredging activities at the affect monitored reef formation may result in the EPOs not being achieved which is "no net detectable reduction in live coral cover". If the Level 3 trigger is exceeded, the Level 3 Exceedence Procedure (Section 6.2.3.1; Figure 6.2) is required to be followed, this includes an assessment of achievement of the coral EPO at the affected reef formation.

Table 6-4: Management Triggers and Required Responses for monitored reef formations within the ZoI

	Trigger Level		
	Level 1	**Level 2**	**Level 3**
Water Quality Criteria	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 10 days out of a 20 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 4 days out of a 20 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 20 days out of a 40 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 8 days out of a 40 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 40 days out of an 80 day rolling assessment period. **OR** **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 16 days out of an 80 day rolling assessment period.
Management Actions	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Check predictive model for interpretation. Investigate potential management responses that could be implemented if elevations continue to occur.	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Implement management, where reasonably practicable, to reduce levels below the trigger value. Continue monitoring and assessing water quality to ensure the effectiveness of the measures applied. Alter management response if not effective e.g. continued elevated turbidity. Two surveys of benthic communities at targeted monitored reef formations where exceedence was identified and related reference monitored reef formations to verify appropriateness of water quality criteria.	Follow the Level 3 Exceedence Procedure (Figure 6.2).

As detailed above, in order to formally reach a management trigger, an inference assessment must conclude that is reasonably expected that dredging or placement activities have contributed to or caused each daily exceedence of intensity of the trigger (refer to Section 6.3.1.2).

6.3 Monitoring Strategy for Water Quality and Coral

1. **Responsive Water Quality Monitoring** at the monitored reef formations will be used to collect turbidity data to be assessed against Level 1, 2 and 3 management triggers.
2. **An Assessment of Achievement with Coral EPOs** will be undertaken if a Level 3 water quality trigger is exceeded.
3. **Proactive Monitoring** will be used to monitor the near-field plume using mobile sentinel water quality loggers to allow adaptive management of dredging activities.
4. **Verification Monitoring** will be used to verify the effectiveness of water quality management triggers in affording protection to corals.

These four monitoring programmes are detailed in the following sections, as well as sedimentation monitoring which will be used to assist in the interpretation of data collected under the water quality and benthic community monitoring programmes.

6.3.1 Responsive Monitoring Programme (to achieve EPOs and MOs)

6.3.1.1 Location of Monitoring Sites

Approximately twenty-two monitored reef formations will be used in the responsive monitoring programme. The water quality and sedimentation data will be collected adjacent to these reefs. Impact monitored reef formations and indicative reference reefs are listed in Table 6-5 and their locations are shown in Figure 6.7. A description of the physical attributes for the monitored reef formations (including both impact reefs and indicative reference reefs) is detailed in Table 6-6 and a description of the benthic communities at the monitored reef formations is provided in Table 6-7.

Table 6-5: Impact Monitored Reef Formations and Indicative Reference Reefs in the Responsive Water Quality Monitoring Programme

Zone/Type	Name	Variables	Monitoring Frequency
High Impact	Saladin Shoal	Turbidity, temperature, conductivity, benthic light availability, depth	Data collected every ~30 minutes
High Impact	End of Channel Shoal		Data collected every ~30 minutes
Moderate Impact	Paroo Shoal		Data collected every ~30 minutes
Moderate Impact	Hastings Shoal		Data collected every ~30 minutes
Moderate Impact	Gorgon Patch		Data collected every ~30 minutes
Moderate Impact	SW Gorgon		Data collected every ~30 minutes
Influence	Weeks Shoal		Data collected every ~30 minutes
Influence	Ward Reef		Data collected every ~30 minutes
Influence	Roller Shoal		Data collected every ~30 minutes
Influence	NE Direction Island		Data collected every ~30 minutes
Influence	SW Twin Island[#]		Data collected every ~30 minutes
Influence	Herald Reef[#]		Data collected every ~30 minutes
Influence	Ashburton Island		Data collected every ~30 minutes
Reference	Thevenard Island East		Data collected every ~30 minutes
Reference	Thevenard Island Southeast		Data collected every ~30 minutes
Reference	West Reef		Data collected every ~30 minutes
Reference	Serrurier Island		Data collected every ~30 minutes
Reference	Fly island		Data collected every ~30 minutes
Reference	Locker Island		Data collected every ~30 minutes
Reference	Mangrove Islands		Data collected every ~30 minutes
Reference	Bessieres Island		Data collected every ~30 minutes
Reference	Airlie Island[2]		Data collected every ~30 minutes

[#]These sites were originally located within the ZoI, following modelling of the revised base case scenario, they are now located outside the ZoI. Therefore, it may be possible to use these sites as 'reference' reefs provided the criteria defined within the section: "Initial choice of Water Quality Reference Reefs" are met.

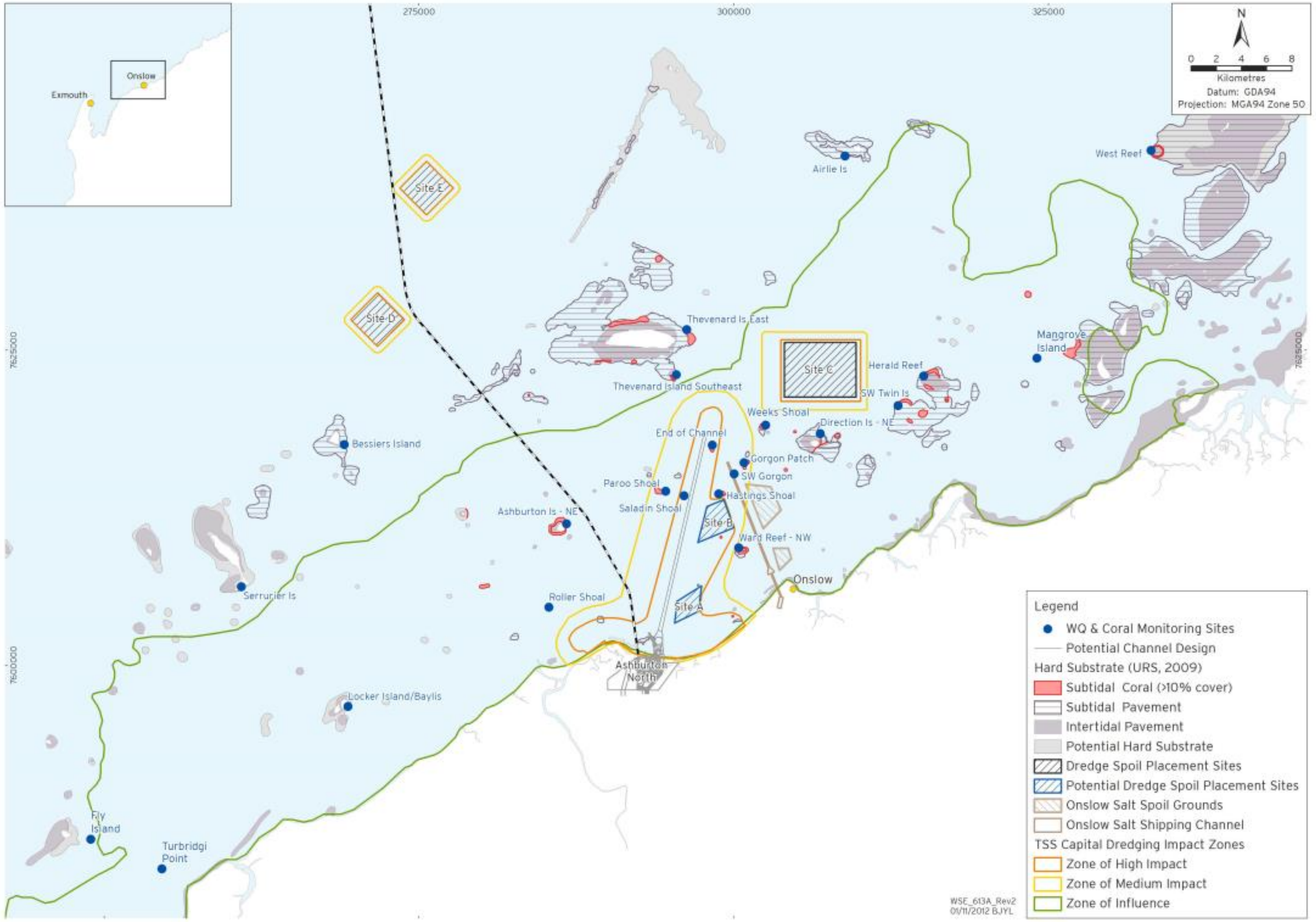


Figure 6.7: Impact Monitored Reef Formations and Indicative Reference Reefs in the Responsive Water Quality Monitoring Programme

Table 6-6: Description of Key Physical Attributes of Impact Monitored Reef Formations and Indicative Reference Reefs

Zone/Type	Name	Average water quality logger depth (m)	Physical Attributes										
			Reef Type	Water Quality Environment (May 2011 to August 2012)									
				Turbidity (NTU)					Light Climate (Total daily PAR- μmol photons/m²/day)			Sedimentation rate (mg/cm²/day)	
				Min	Max	Median	80th %ile	95th %ile	Min	Max	Median	Average	Average StDev
High Impact	Saladin Shoal	9.7	Patch reef	0.0	128.0	0.9	1.3	2. 9	1.4	5756	2588	17.0	2.3
High Impact	End of Channel Shoal	11.2		0.2	5.9	0.8	1.1	1.8	0	7061	1615	2.7	0.1
Moderate Impact	Paroo Shoal	10. 2	Patch reef	0.1	133.7	0.7	1.1	3.2	1.2	5773	3082	13.9	0.8
Moderate Impact	Hastings Shoal	7.5	Patch reef	0.0	108.2	0.8	1.4	3.8	1.2	8357	3787	14.3	0.7
Moderate Impact	Gorgon Patch	10.8	Patch reef	0.0	164.8	0.8	1.3	4.0	1.1	4846	1924	19.7	10.2
Moderate Impact	SW Gorgon	9.8	Reef slope	0.0	175.4	1.0	1.6	5.0	0	5651	2190	28.2	2.8
Influence	Weeks Shoal	11.3	Patch reef	0.0	86.5	0.9	1.3	2.0	0	4812	1720	11.3	0.8
Influence	Ward Reef	8.3	Reef slope	0.1	140.8	1.2	2.5	6.6	1.3	6500	2095	22.8	0.9
Influence	Roller Shoal	9.3	Patch reef	0.0	161.2	1.6	2.9	6.6	1.1	5011	1174	25.8	1.6
Influence	NE Direction Island	7.3	Reef slope	0.2	158.3	1.2	2.4	5.3	0	6253	3186	65.4	10.8
Influence	SW Twin Island#	6.7	Reef slope	0.1	162.2	1.0	1.9	5.2	1.3	8491	3514	38.7	4.1
Influence	Herald Reef#	7.2	Patch reef	0.0	112.4	0.9	1.7	4.7	1.3	8056	3898	46.1	3.9
Influence	Ashburton Island	9.3	Reef slope	0.1	245.1	0.7	1.1	2.2	0	5873	3210	10.7	0.5
Reference	Thevenard Island East	10.2	Reef slope	0.1	85.6	0.6	1.0	2.4	1	6513	3150	10.4	0.6
Reference	Thevenard Island Southeast	9.1		0.1	96.3	0.9	1.4	2.6	1.1	6587	3126	14.1	0.6
Reference	West Reef	9.6	Reef flat	0.1	79.9	0.9	2.1	4.7	1.2	7150	2355	24.1	2.9
Reference	Serrurier Island	6.5	Patch reef	0.0	169.4	0.5	0.8	2.3	4.4	14035	6907	21.1	0.7
Reference	Fly Island	To be determined											
Reference	Locker Island	5.7	Reef slope	0.0	152.2	2.1	3.8	8.1	0	7436	2768	26.3	2.8

Zone/Type	Name	Average water quality logger depth (m)	Physical Attributes										
			Reef Type	Water Quality Environment (May 2011 to August 2012)									
				Turbidity (NTU)					Light Climate (Total daily PAR- µmol photons/m^2/day)			Sedimentation rate (mg/cm^2/day)	
				Min	Max	Median	80th %ile	95th %ile	Min	Max	Median	Average	Average StDev
Reference	Mangrove Islands	To be determined											
Reference	Bessieres Island	7.5	Patch reef	0.0	68.0	0.3	0.4	1.5	1.4	13026	6481	32.9	11.8
Reference	Airlie Island	6.3	Patch reef	0.1	95.6	0.7	1.3	3.4	1.2	13022	5517	60.3	13.4

#These sites were originally located within the ZoI, following modelling of the revised base case scenario, they are now located outside the ZoI. Therefore, it may be possible to use these sites as ‘reference’ reefs provided the criteria defined within the section: “Initial choice of Water Quality Reference Reefs” are met.

Table 6-7: Description of Key Physical Attributes of Impact Monitored Reef Formations and Indicative Reference Reefs

Zone/Type	Name	Site Depth	Reef Type	Site/species Descriptor[17]	% Benthic Community Cover*
High Impact	Saladin Shoal	3-6 m	Patch reef	**Coral** - *Faviidae* dominated with occasional *Poritidae.*	2.2
				Filter Feeders – Limited to no soft corals and minimal sponges	Not available
				Macroalgae – limited to no macroalgae growth	0.0
High Impact	End of Channel Shoal	8 m	Isolated Patch Reef	**Coral** - Dominated by *Faviidae* with *Dendropyhlliidae and Pectiniidae* present and occasional *Agariciidae*, *Merulinidae*, *Mussidae* and *Poritidae.*	7.9
				Filter feeders - Numerous soft coral (Nephtheidae) and numerous sponges	Not available
				Macroalgae - Macroalgae - Limited to none macroalgae growth.	0.2
Moderate Impact	Paroo Shoal	4-8 m	Patch reef	**Corals** - *Poritidae, Merulindae, Mussidae* and *Pectiniidae* present, dominated by *Faviidae*	2.9
				Filter feeders - Numerous soft coral (Nephtheidae) and numerous sponges	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Moderate Impact	Hastings Shoal	4-6 m	Patch reef	**Coral** – Very limited coral cover with small patches of Faviidae.	0.2
				Filter feeders – limited to no soft corals and limited sponges	Not available
				Macroalgae – Minimal macroalgae growth	8.2
Moderate Impact	Gorgon Patch	1-6 m	Patch reef	*Faviidae* dominated. *Dendrophylliidae* and *Poritidae present. Occasional Acropidae, Merulinidae, Mussidae and Pectiniidae.*	4.8
				Filter feeders - Numerous soft coral (Nephtheidae), sponges, encrusting Zoanthids.	Not available

[17] Information gathered from baseline studies

Zone/Type	Name	Site Depth	Reef Type	Site/species Descriptor[17]	% Benthic Community Cover*
				Macroalgae - Limited to none macroalgae growth	1.8
				Coral - *Dendrophylliidae and Faviidae dominant* with occasional Mussidae and Poritidae.	2.6
				Filter feeders - Numerous soft coral (Nephtheidae) and sponges.	Not available
Moderate Impact	SW Gorgon	4-6 m	Reef slope	**Macroalgae -** Limited to none macroalgae growth.	0.0
				Coral - *Faviidae* dominant with *Acroporidae and Dendrophylliidae* present and the occasional *Agariciidae, Merulinidae, Mussidae and Poritidae.*	6.3
				Filter feeders - Minimal soft coral and sponges.	Not available
Influence	Weeks Shoal	4-6 m	Patch reef	**Macroalgae -** Limited to none macroalgae growth	0.1
				Coral - *Faviidae* dominant with occasional *Merulinidae* and *Poritidae.*	1.4
				Filter feeders - Limited to none soft corals and sponges.	Not available
Influence	Ward Reef	4-6 m	Reef slope	**Macroalgae -** Limited to none macroalgae growth.	0.0
				Coral - *Faviidae* dominant with occasional *Acroporidae, Pectiniidae,* and *Poritidae*.	2.6
				Filter feeders - Limited to none soft corals and minimal sponges.	Not available
Influence	Roller Shoal	4-6 m	Patch reef	**Macroalgae -** Limited to none macroalgae growth.	0.0
				Coral - *Poritidae* dominated with *Agariciidae* and *Merulinidae* present and the occasional *Dendrophylliidae, Faviidae, Montipora, Mussidae and Pectiniidae*.	4
				Filter feeders - Limited to none soft corals and sponges.	Not available
Influence	NE Direction Island	4-6 m	Reef slope	**Macroalgae -** Minimal macroalgae growth	8.3
				Coral - *Faviidae and Poritidae* dominant with the occasional *Dendropyhlliidae.*	2.9
				Filter feeders - Limited to none soft corals and sponges.	Not available
Influence	SW Twin Island#	1-2 m	Reef slope	**Macroalgae -** Significant macroalgae growth	34.3

Zone/Type	Name	Site Depth	Reef Type	Site/species Descriptor[17]	% Benthic Community Cover*
Influence	Herald Reef[#]	3-5 m	Patch reef	**Coral** - *Faviidae and Poritidae* dominant with *Acroporidae, Dendrophylliidae and Mussidae* present and the occasional *Merulindae.*	12.2
				Filter feeders - Limited to none soft coral and minimal sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	2.0
Influence	Ashburton Island	3-7 m	Reef slope	**Coral** - *Faviidae* and *Merulinidae* dominant with the occasional *Dendrophylliidae, Mussidae, Pectiniidae and Poritidae*	5.2
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.7
Reference	Thevenard Island North East	3-5 m	Reef slope	**Coral** - *Faviidae* dominant with *Poritidae* and *Merulinidae* present[1]	4.5
				Filter feeders - Minimal soft coral and limited to none sponges.	Not available
				Macroalgae - Minimal macroalgae growth.[1]	8.5
Reference	Thevenard Island Southeast	9-10 m	Not available	**Coral –** Very low level of coral cover; mainly Turbinaria.	<1.0
				Filter feeders – Low cover of soft coral.	<5.0
				Macroalgae – Moderate to low (depending on season) level of macroalgae cover .	10.0-30.0
Reference	West Reef	3-5 m	Reef flat	**Coral** - *Faviidae* dominant. *Poritidae present with occasional Mussidae, Pectiniidae* and *Pocilloporidae.*	15.3
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Reference	Serrurier Island	2-3 m	Patch reef	**Coral** - *Faviidae* and *Poritidae* dominant. Occasional *Acroporidae*, *Agariciidae*, *Dendrophylliidae.*	2.6
				Filter feeders - Minimal soft corals and limited to none sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Reference	Fly Island	10-11 m	Not available	**Coral –** *Porites* and *Faviidae* dominant genera in terms of cover. *Acropora* cover	15.0

Zone/Type	Name	Site Depth	Reef Type	Site/species Descriptor[17]	% Benthic Community Cover*
				high with most other reefs.	
				Filter feeders – Low cover for soft corals.	<5.0
				Macroalgae – Very low cover of macroalgae, but turf algae abundant.	Not available
Reference	Locker Island	2-3 m	Reef slope	**Coral** - *Poritidae* and *Faviidae* dominant. *Dendrophylliidae* present with occasional Acroporidae and *Merulinidae*.	3.0
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Minimal macroalgae growth.	6.9
Reference	Mangrove Islands	8-9 m	Not available	**Coral** - *Poritidae* and *Faviidae* dominant. Water Quality site predicted to support benthic communities similar to the closest benthic primary producer habitat sites at Herald and Twin Islands.	Not available
				Filter feeders – Predicted to have low cover of filter feeders.	Not available
				Macroalgae – Predicted to have low cover of macroalgae.	Not available
Reference	Bessieres Island	1-2 m	Patch reef	**Coral** - *Poritidae* dominated. *Faviidae*, *Montipora* and *Mussidae* present with occasional *Merulinidae*.	12.6
				Filter feeders - Numerous soft coral; *Lobophyton* sp. and *Sinularia* sp. Limited to none sponges.	Not available
				Macroalgae - Limited to none macroalgae growth.	0.0
Reference	Airlie Island	1-2 m	Patch reef	**Coral** - *Faviidae* and *Mussidae* dominated with *Merulinidae* present and the occasional *Poritidae*.	10.0
				Filter feeders - Limited to none soft corals and sponges.	Not available
				Macroalgae - Limited macroalgae growth.	0.2

[#] *These sites were originally located within the ZoI, following modelling of the revised base case scenario, they are now located outside the ZoI. Therefore, it may be possible to use these sites as 'reference' reefs provided the criteria defined within the section: "Initial choice of Water Quality Reference Reefs" are met.*

[1] *Based on winter 2011 data.*

Reference Reefs

Reference reefs will be used for three main purposes in Wheatstone monitoring programmes:

- In water quality trigger assessments, to provide an estimate of 'background' turbidity used in the calculation of trigger criteria (e.g. trigger criteria = 3.2 x geometric mean of associated reference site daily medians; see Section 6.2.3). The Reference site daily medians may be adjusted where baseline site comparisons have indicated that the accuracy in predicting impact site background can be improved by applying an adjustment factor. That factor would be based on the relationship between impact and reference reef baseline turbidity data, and relationships would be quantified (and provided to EPA and DTAP) prior to the start of dredging. The adjustment factors may be reviewed during the dredging program, provided they are still calculated based on baseline data. Any amendments, if required, will be provided to the EPA and DTAP prior to implementation.
- In Coral EPO Assessments, to provide an i) estimate of the natural level of change in coral communities, ii) to determine 'net' change in coral cover at impact reef formations (i.e. net change = change at impact reef formations minus average change at associated reference reefs), and iii) to assist in inferring the cause of any detected change.
- In Verification Monitoring, to interpret any potential change observed in monitored variables at impact reef formations and to assist in inferring the cause of that change.

In most cases, the same reference reefs will be used in each of the above assessments. This would also provide reference water quality data and reference data on coral, macroalgae and filter feeders from the same location to be able to infer the cause of changes. However, since water quality trigger assessments are based on calculations of 'background' turbidity, defined as the reference reef daily medians (or adjusted daily medians; Section 6.3.1.2), it is critical that the water quality characteristics of reference reefs resemble as closely as possible that of impact reef formations against which they are compared. Therefore, in some instances (e.g. in inshore environments) it may be necessary to include specific water quality reference reefs in water quality trigger calculations, but for which no significant benthic communities exist that would provide useful reference data for Coral EPO assessments or Verification Monitoring.

Initial choice of Water Quality Reference Reefs

Due to the requirement to understand baseline water quality environments of reference and impact reef formations to be able to match these reefs as best as possible for trigger assessments, the initial list of reference reefs associated with each impact site will be provided to the EPA and DTAP, for confirmation and transparency, prior to the commencement of dredging. Indicative-only reference reefs are provided in Table 6-5.

The initial list of reference reefs will be chosen to be as comparable as possible (during baseline conditions) to impact reef formations, both in environmental characteristics and trends in water quality conditions (i.e. similar behaviour/changes occur over similar timeframes). The initial choice of reference reefs associated with each 'impact' site will be based on the following criteria (see also Figure 6.8):

- For each 'impact' within the ZoHI, ZoMI and ZoI, there should be at least 3 Reference reefs and preferably a pool of reference reefs that account, as best as possible for any localised spatial and temporal variation.
- Reference reefs should be located outside the ZoI of turbidity-generating activities associated with the construction of the nearshore and offshore facilities as shown in

Figure 5.9, or towards the outer edge of this zone within the ZoI (see further discussion on reference reefs within the ZoI below.

- Sites should be readily accessible by a survey vessel.
- The turbidity at reference reefs has to be comparable to the turbidity of the impact reef formations it is used for in the trends in water quality conditions (i.e. changes occur over similar timeframes). Statistics such as correlation coefficients and cluster analyses will be used to examine baseline water quality data and determine the comparability of water quality environments of all reference and impact reefs.
- If reference and impact reefs have similar behaviors' in water quality environments (similar timing of fluctuations in turbidity), but differ in the magnitude of turbidity values (i.e. reference reefs are consistently higher or lower in turbidity than the associated impact reef formation), the accuracy in predicting impact reef formation background can be improved by applying an offset. This offset would be calculated (and provided to EPA and DTAP) prior to the start of dredging. The offset would be based on linear regressions of log-transformed data for each impact/reference site combination.
- A hierarchical list of possible reference reefs will be produced for each impact site, (based on comparability of water quality environments). From these, the best group of reference reefs (at least 3) will be defined and used for trigger assessments. If a malfunction at one reference site occurs, it will be possible, in most instances, to use the 'next best' reference site to calculate 'background' turbidity and maintain a minimum of 3 reference reefs in calculations.
- Where significant seasonal differences exist in correlations between reference and impact reefs, a different pool of reference reefs may be defined for each season.

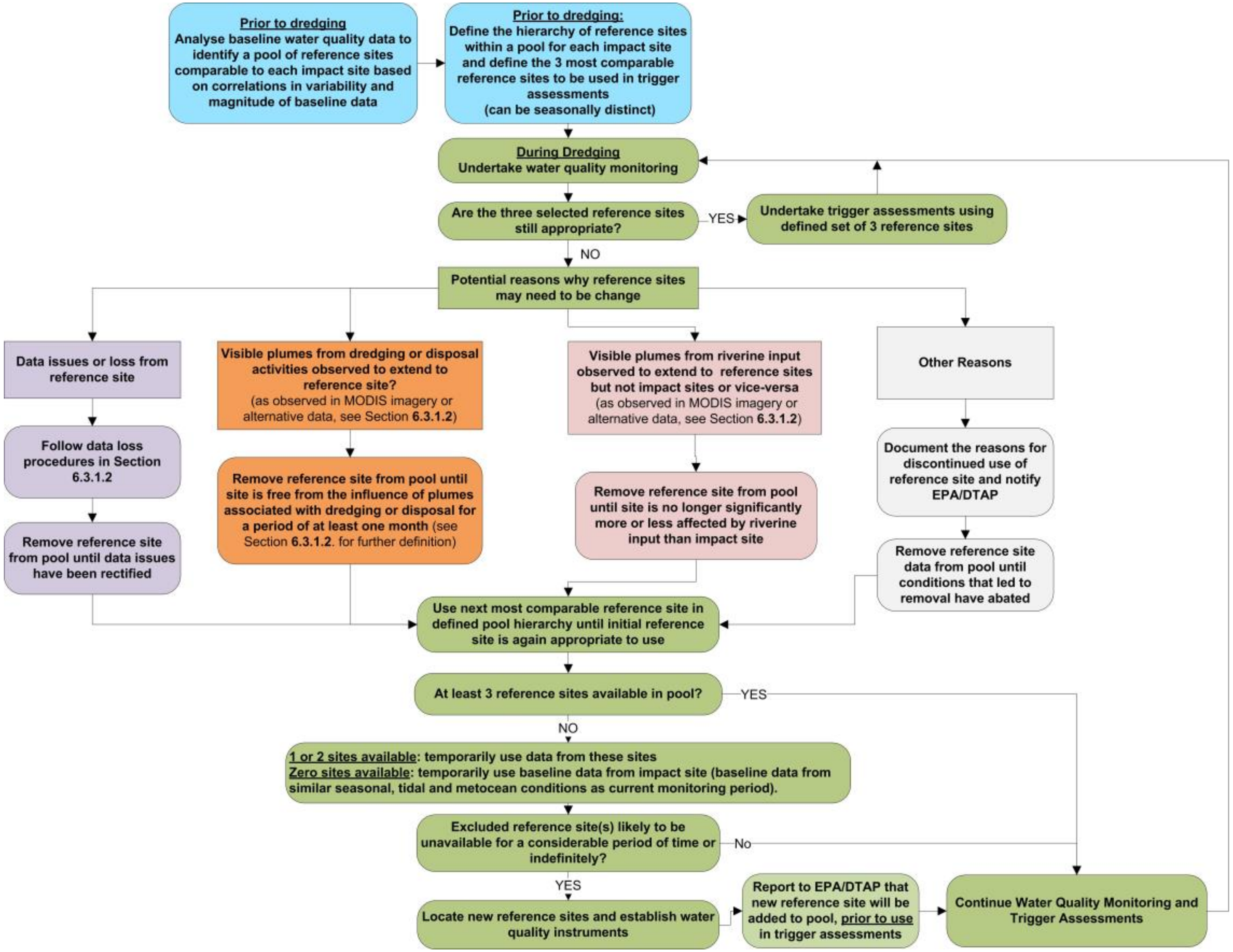


Figure 6.8: Procedure to Select and Modify choice Reference Reefs

While EPA guidance (EAG7; EPA 2011) recommends the location of reference reefs outside the predicted influence of development activities, it recognises that this is neither always possible nor practical, given the spatial extent of the plume associated with a large dredging campaign. The predicted Wheatstone ZoI extends a considerable distance west and east of the dredge and dredge material placement locations (see EIS Section 8.3 and Figure 5.9). To the west of the ZoI is the Exmouth Gulf, where depths and exposure to wind and wave action are distinctly different to those within the project area and no comparable reference reefs could be identified. To the east of the ZoI are the Mangrove Islands, within which conditions are generally shallower and more turbid than those within the project area, limiting the comparability of these areas with impact reef formations.

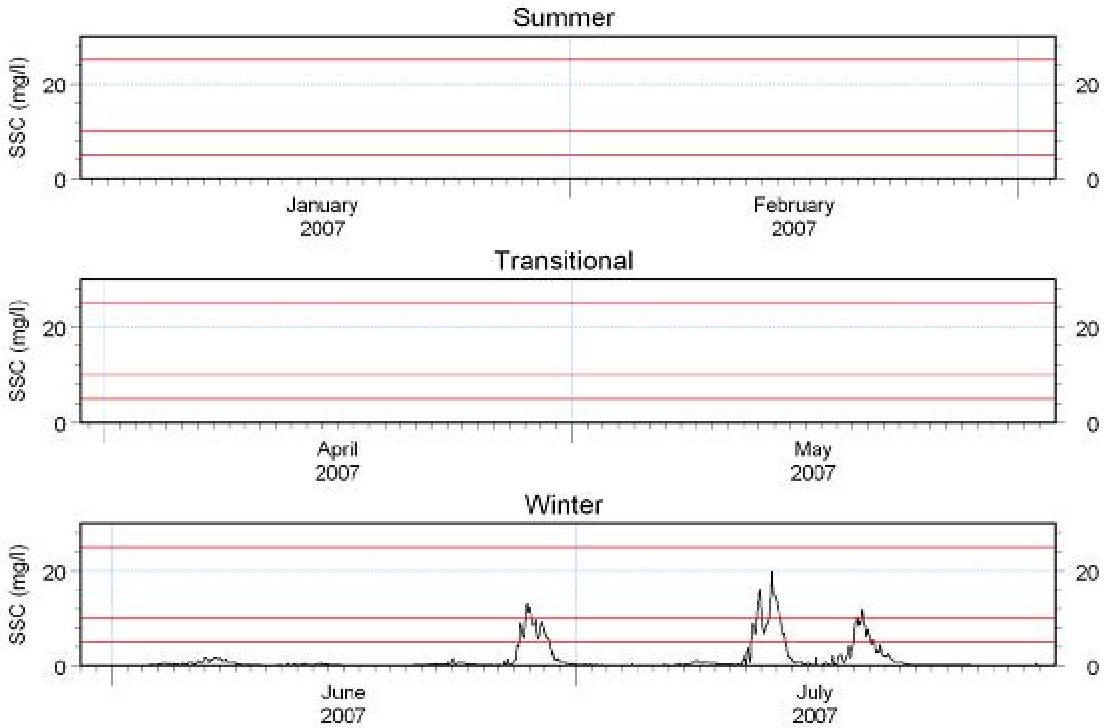
The proposed solution to the limited number of reference reefs that are comparable to impact reef formations is to establish some of the reference reefs in areas within the ZoI but towards the outer boundary of this zone. These reefs will be treated as appropriate reference reefs or controls provided there are no detected elevations in turbidity due to turbidity generating activities which are part of the construction of the nearshore and offshore marine facilities or turbidity generating activities associated with the trunkline installation at these reefs. This approach is consistent with the guidance of EAG7 (EPA 2011).

Since the main purpose of reference reefs is to provide an estimate of background turbidity, used to calculate water quality-based management trigger criteria on a daily basis [e.g. trigger criteria = 3.2 x geometric mean of associated reference site daily medians (or adjusted daily medians; Section 6.3.1.2)], provided the reference reefs are not being influenced by turbidity-generating activities at the time that reference data are used, nor have been influenced by dredge-related plumes to an extent that resuspension of dredged sediments at the reference reef might be reasonably expected, they are expected to perform as well as reference reefs located outside the ZoI in providing an estimate of background conditions. Some reefs within the ZoI are only expected to be influenced very briefly during dredging, in some cases only within one season (for example, see Figure 6.9). Additionally, the revised plume modeling suggests that some reefs that initially lay within the ZoI and are currently labeled as ZoI reefs (for example NW Twin and Herald Island) are now located outside the influence of dredging activities and may act as suitable controls.

Following the guidance of EAG7 (EPA 2011), conservative criteria have been established to define whether reference reefs are free from impacts of turbidity-generating activities. The following criteria have been established to determine whether reference reefs are suitable controls to indicate background levels of turbidity and coral condition:

- Visible plumes associated with dredging, spoil placement or trunkline installation are not observed to extend to reference reefs at the time the data are required for use in trigger calculations, based on an examination of MODIS satellite imagery. In the case that satellite imagery is obscured due to cloud cover, recent dredging activities, recent logged water quality data and the most recent history of MODIS satellite imagery will be used in an assessment to determine whether visible plumes are not reasonably expected to extend to reference reefs; and
- Visible plumes associated with dredging, spoil placement or trunkline installation have not been observed to extend to reference reefs within the last month. This will ensure that any small amounts of dredged sediments that may have been deposited within the vicinity of reference reefs (which is unlikely to be significant at the outer boundary of the ZoI) have had a chance to be removed from the area through wind, wave and tidal action, and that resuspension of dredged sediments is, therefore, not expected to elevate turbidity to detectable levels at reference reefs, nor to affect biota.

Where the above criteria are not met, reference reefs will be assessed as unsuitable for the purposes of calculating background turbidity in water quality trigger calculations. In this instance, sub-optimal reefs in the order of hierarchy would be used in the water quality trigger assessment in accordance with the procedure detailed below and illustrated in Figure 6.8.



Note: Red lines correspond to SSC levels of 5 mg/L, 10 mg/L and 25 mg/L above background. X-axis scale in days

Figure 6.9: Example of a site within the ZoI but close to the outer boundary of this zone (near Locker Island) where predicted excess SSC concentrations due to dredging activity (dredging scenario 5) are only detectable for brief periods during the dredging programme (winter) and hence, it may be possible to use this site as a reference site for part of the programme

Refining Water Quality Reference Reefs

It is foreseeable that, while Reference reefs will be chosen to match as closely as possible each impact site, based on available baseline data, during dredging, some Reference reefs may no longer be comparable to impact reef formations or may no longer fit the definition of a control in trigger assessments. For example:

- Reference reefs might be influenced by dredging activities and no longer be considered suitable ‘controls’ for a period of time during and after being affected. This is most likely to occur at reference reefs that lie within the ZoI.
- Data recovery issues, such as logger failure, may result in a loss of data from reference reefs for brief periods. This may result in a reference site not being used for a particular period of testing, after which it will be brought back into use.

The process described in Figure 6.8 will be followed during dredging to allow for reference reefs associated with each impact reef formation to be refined, if required, in response to scenarios, such as those described above. This process allows for Reference reefs to be changed objectively and transparently if and when required.

Initial Choice of Reference Reefs used for Coral EPO Assessment and Verification Monitoring

Reference reefs are also required to quantify natural spatial and temporal changes in i) coral cover, to allow net-change to be calculated at impact reefs in order to measure achievement of the coral EPOs; and ii) in coral cover and other variables, such as macroalgae and filter feeders, for the purposes of Verification Monitoring used to assess the appropriateness of water quality criteria. The principles for selecting and refining reference reefs for Coral EPO Assessments and Verification Monitoring are largely consistent with that described for Water Quality Reference Reefs. For example, reference reefs need to be environmentally similar to the impact reef formations, but sufficiently far from dredging activities so as not to be unduly affected, as described in EAG 7 (EPA 2011) and described above.

The initial choice of Coral EPO Assessment and Verification Monitoring reference reefs will be based on the following criteria:

- Where possible, coral reference reefs will be consistent with the water quality reference reefs
- Reference and impact reefs will be chosen to share as similar as possible, baseline coral abundance (percent cover) and genera composition
- For each ‘impact’ site within the ZoHI and ZoI, there should be at least three reference reefs
- For the ZoI there should be at least three reference reefs
- Reference reefs should be located outside the ZoI of Wheatstone dredging activities, or at the very least, or towards the outer boundary of the ZoI
- Reference reefs should be readily accessible by a survey vessel.

Refining Reference Reefs used for Coral EPO Assessment and Verification Monitoring

Although reference reefs will be chosen to match as closely as possible to impact reef formations, based on available baseline data, during the course of time some reference reefs may no longer be suitable and require replacement. For example:

- Reference reefs might be influenced by dredging activities (e.g. reference reefs that lie within the ZoI)
- Anomalous events, such as widespread bleaching or outbreaks of coral predators (e.g. *Drupella* snails or crown of thorns starfish), may affect some reference reefs but not impact reefs.

For these reasons some redundancy is required in the selection of reference reefs. Contingency reference reefs may be identified and used, if required, in the event that an existing reference site needs to be replaced.

6.3.1.2 Water Quality Monitoring

Objectives

There are two key objectives of the water quality monitoring component of the responsive monitoring programme:

1) To provide data that are assessed against management triggers to inform management of dredging or dredge spoil placement activities.
2) To provide data to assist in inferring the cause of any potential changes in coral health.

Variables

Water quality variables that will be measured at monitoring reefs via water quality loggers during the responsive monitoring programme include the following:

<u>Turbidity (measured in nephelometric turbidity units - NTU)</u>

Turbidity provides an indirect measure of the alteration of the light climate received by BPP communities that may be a result of the natural suspension and movement of sediments and/or the suspension and movement of sediments caused by dredging or dredge spoil placement. Due to the link between turbidity and sedimentation rates, turbidity data may also indirectly provide a relative measure of the level of sedimentation settling on the substrate or biota.

<u>Benthic light climate (measured in photosynthetically active radiation – PAR)</u>

The quanta of light received by BPP, measured in PAR, is a direct measure of potential impacts to BPP as a result of altered water quality. However, this measure must be combined with turbidity data to determine whether changes in light climate are a consequence of the suspension and movement of sediments caused by dredging or dredge spoil placement activities or just due to natural variation.

<u>Water Temperature</u>

Water temperature will not be significantly affected by dredging and offshore dredge spoil placement. However, there have been recorded instances in the Pilbara region of changes in coral health, including bleaching and partial morality, due to natural thermal anomalies (MScience 2008). Therefore, temperature will be recorded at all monitored reef formations to identify natural thermal anomalies to inform the differentiation of potential dredging and dredge spoil placement impacts on coral health from natural thermal anomaly events.

<u>Salinity</u>

Although salinity is unlikely be significantly altered by dredging activities, salinity data may be useful for inference assessments. The salinity data can provide supporting evidence on the cause of any detected changes to BPPH that may occur due to the natural variation in salinity (e.g. due to the input of freshwater from the Ashburton River).

In addition, information will be gathered on the following: <u>Metocean Conditions</u>

Measurements of metocean conditions (e.g. wave height, current speed, current direction) are being undertaken by metocean buoys at selected locations and resulting data will be used in the interpretation of changes in water quality and coral health. These measurements will identify important relationships between metocean conditions, dredging activity and location, and any subsequent impacts to water quality and coral health.

<u>Satellite Imagery (Characterisation of the ZoI)</u>

Satellite imagery will be used to satisfy the requirements of Condition 6.5 viii. which is "To regularly characterise, spatially-define and report the realised ZoI caused by dredging activities which are part of the nearshore and offshore marine facilities." MODIS satellite imagery will be used as an indicator to monitor the spatial extent of the ZoI during dredging, from which TSS concentrations in the near-surface waters will be calculated. TSS data derived from MODIS imagery will be correlated from water samples taken for the plume modelling verification, to determine the accuracy of the satellite imagery.

The realised extent of the ZoI during dredging operations, as derived from MODIS imagery, will then be compared with the predicted extent of the ZoI derived through modelling predictions.

Data Collection

In-situ loggers

Water quality data will be collected at approximately 30 min intervals through the use of *in-situ* water quality data logging instruments. The majority of the water quality loggers at the reefs will be telemetered providing real-time access to data which will be downloaded daily. The *in-situ* water quality data loggers have been deployed adjacent to the monitored reef formations rather than directly on them to prevent damage to the coral during deployment and retrieval.

It is anticipated that during dredging, there is likely to be some loss of data from water quality instruments due to equipment failure or loss. The parameters: light, temperature, depth and salinity are used primarily to assist with the inference assessment for relating water quality with any changes to coral health, and data loss is unlikely to present a significant problem provided it is minimised, where practicable, throughout the programme. However, since turbidity data are critical to the management of dredging and turbidity data are used on a daily basis in management trigger assessments, procedures have been developed to minimise turbidity data loss and to deal with turbidity data loss issues when they occur. These procedures are illustrated in Figure 6.10 and summarised below.

Minimising data loss

The vast majority of water quality loggers (including all reference reefs and impact reef formations assessed to be 'at risk' from dredging) will be telemetered. Therefore, malfunctions or instrument losses/damage can be picked up almost immediately. Once a malfunction or instrument loss/damage is identified, equipment will be repaired or replaced within a maximum of 48 hours (weather permitting) or sooner where possible. However, it should be noted that a maximum of only three water quality loggers can be replaced within 48 hours due to logistical constraints. Therefore, if circumstances arise where more than three loggers have malfunctioned (e.g. following an intense cyclone), replacement of all water quality loggers may take longer than 48 hours.

Dealing with data loss

The first step in the data loss procedure (illustrated in Figure 6.10) is to identify how much data is missing[18]. If the period of lost data is less than 12 hours (i.e. at least 12 hrs of data from the daily period of 0.01 am to midnight is still available), the daily median will be based on the remaining data. For locations with greater than 12 hrs of data loss within a daily assessment period (0.01 am to midnight), calculating the daily median will depend on one of three site categories:

- ‘At risk’ impact reef formations (defined as being previously exposed to a dredge plume or is one or more days above the daily trigger intensity within a rolling period)
- ‘Unaffected’ impact reef formations (impact reef formations that are not ‘at risk impact reef formations’)
- Reference reefs.

For a site ‘at risk’, calculating the daily median will be based on the average of three adjacent locations, if proxy sites are available, or based on the previous available daily median of the same site. For an ‘unaffected’ site, the daily median will be based on seasonally averaged baseline data from the same site. For a reference site, this will depend on the availability of other reference reefs. If another reference site is available the daily median will be based on data from that site. If a reference site is unavailable, the daily median will be based on a seasonally averaged baseline data from the impact site.

[18] Data is only considered to be lost if it cannot be retrieved either via telemetry or manually e.g. it may be that the telemetry unit malfunctions but the data can still be collected manually.

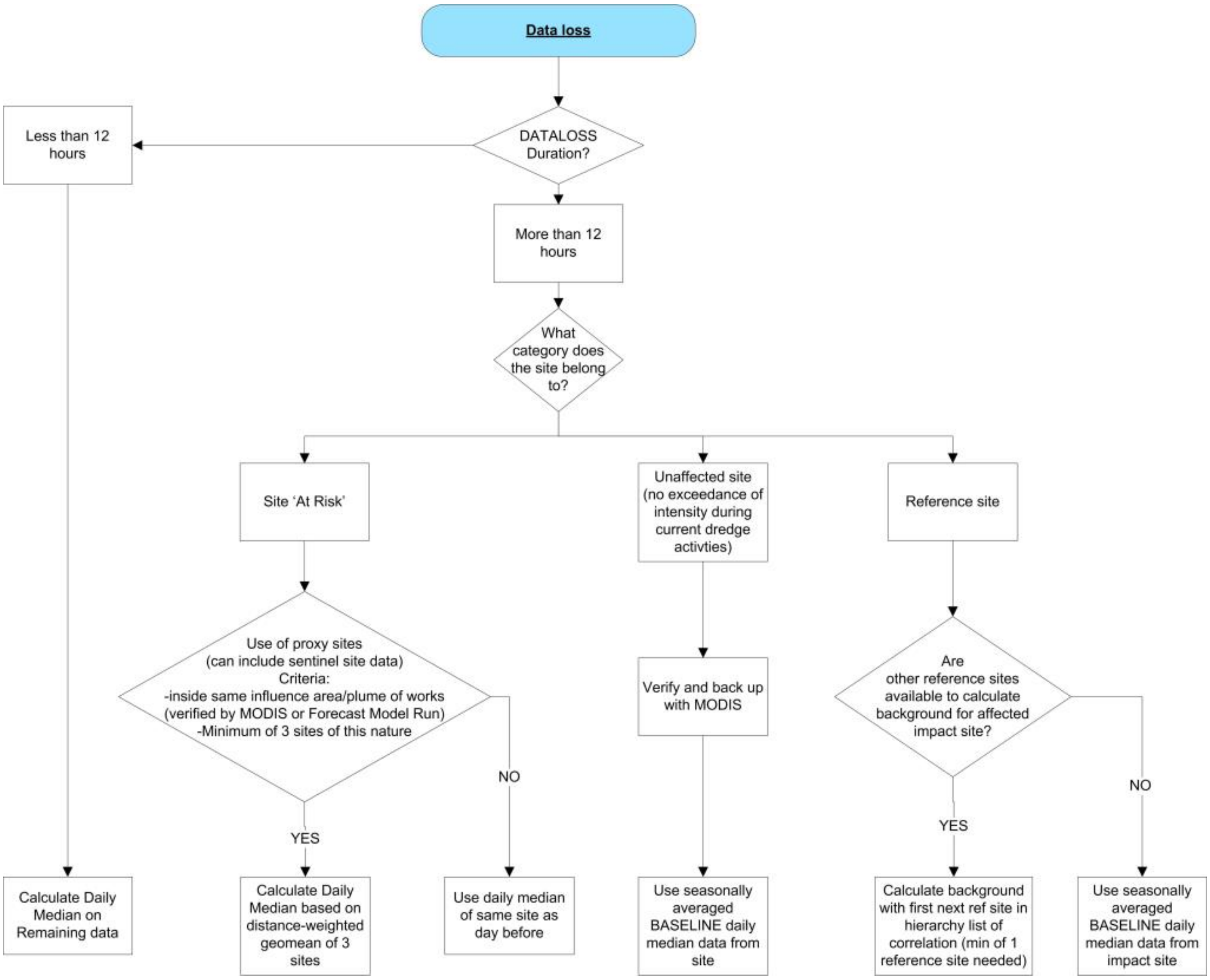


Figure 6.10: Procedure to deal with Water Quality Data Loss

<u>Metocean Buoys</u>

Measurements of metocean conditions are being undertaken by metocean buoys at selected locations (indicative locations are illustrated in Figure 6.11). The metocean buoys are separate to the in-situ water quality loggers at the monitored reef formations.

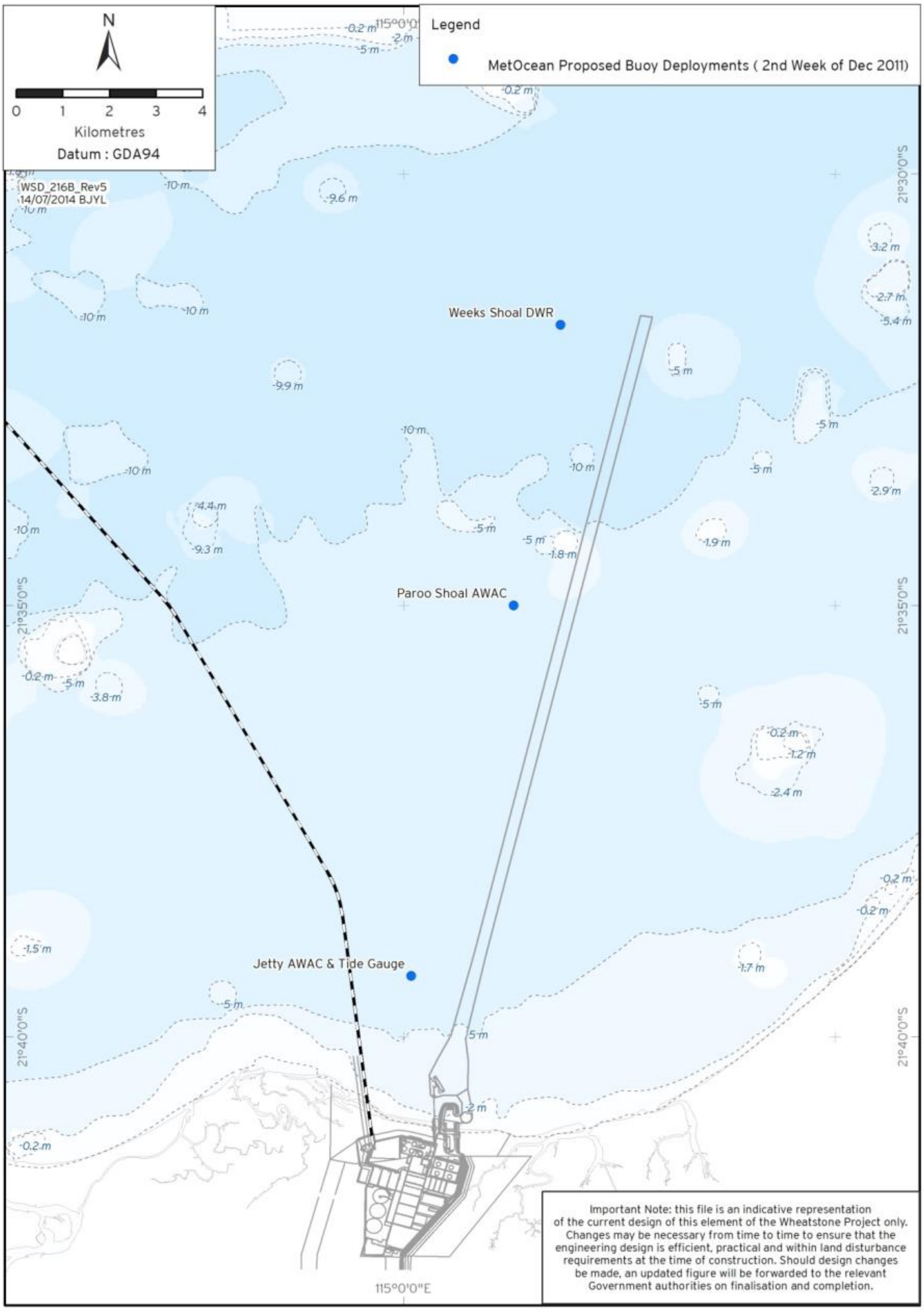


Figure 6.11: Indicative Location of the Metocean Buoys

Data Analysis

All data will be subject to rigorous quality assurance and quality control (QA/QC) procedures. Due to issues with bio-fouling of equipment, a regular maintenance schedule will be implemented and all loggers retrieved, downloaded, cleaned and redeployed or replaced as necessary to maintain the quality of data collected. Prior to the analysis of water quality data to assess whether management triggers have been exceeded, a preliminary check of data integrity will be undertaken and anomalous data removed using an objective function, following guidance outlined in ANZECC and ARMCANZ (2000).

Assessing Water Quality Data against Management Triggers

The following four main steps for assessing water quality criteria will be undertaken during dredging:

- Record the daily median turbidity at each of the monitoring and reference reefs, the median of all usable 30 min data (QA/QC data) measured within a 24 hour period, from in situ loggers at each site. This daily summary of turbidity at each site is the key variable in all subsequent calculations and assessment of exceedence against the management triggers.
- Determine daily background levels of turbidity associated with the assessed site, based on the (geometric) average of the measurements of (daily median) turbidity from each of the reference reefs.
- If reference reefs are found to have the same daily patterns in turbidity (i.e. good correlations), but consistently differing magnitude in turbidity (higher or lower) or consistently differing response to changes in metocean conditions than the associated impact reef formations, it may be necessary to use an adjusted daily median for reference reefs. Adjustment factors will be determined prior to commencement of dredging using baseline data, these may be reviewed during the dredging program based on baseline data and updated if required. These adjustments would be determined using a linear regression of log-transformed baseline data for each reference/impact site pair and using that linear regression to more accurately predict background turbidity at potential impact reef formations:

  $$\ln y = a.\ln x + b$$

  Where: y= impact site turbidity, x = reference site turbidity, a= slope and b= constant.

  For example, if a reference site and impact site during baseline show a good correlation in patterns of turbidity, but the reference site is always approximately 1NTU higher than the impact site, that reference site would be adjusted downward by 1 NTU before the geometric mean of all reference reefs in the group is calculated.

- Assess whether measurements of daily median turbidity at monitoring impact reef formations are elevated over daily background levels, as calculated on the same day from associated reference reefs. For example daily median turbidity from an ‘impact’ site will be compared against the background daily median turbidity calculated on the same day from the associated reference reefs. water quality criteria (specific for each impact zone, see Table 6-2, Table 6-3, and Table 6-4), will be used to determine whether daily elevations are significantly elevated above background levels and are at levels that, if continued over the long term, might lead to management triggers being exceeded.
- Determine the total number of days that elevations in turbidity at the assessed site have been above chronic or moderate water quality criteria for the associated zone (e.g. more than 3.2 x reference reefs and 5.08 NTU, Table 6-2, Table 6-3, and Table 6-4) within the

rolling assessment period defined within each set of criteria (e.g. 20, 40, 80 or 340 days; see, Table 6-2, Table 6-3, and Table 6-4). Each day, the latest water quality data from monitoring reef formations (including reference reefs) will be added to the data sets against which criteria are assessed and the oldest day of data from the rolling assessment period will move out of the assessment window. Thus each day the period of data assessed will move forward by one day, as a rolling window. Early in the dredging programme, baseline data from before dredging has commenced will need to be included in the window of assessment to begin assessing data against water quality criteria from day 1 of dredging. In this way, dredging related turbidity could only be above criteria for the allowable number of days within a rolling period before being required to be managed (e.g. 8 to 16 days), rather than having to wait for the duration of the entire rolling window before assessments could commence.

All four steps, detailed above, will be undertaken daily for monitored reef formations within the ZoI, ZoMI and ZoHI and will occur from the commencement of dredging until after dredging has been completed.

As an example, the procedure using water quality criteria for the ZoI would be:

1) For each site, record the daily median turbidity across the multiple measurements which will have been made with loggers; i.e. the daily median of turbidity measurements made at a site between 0:01am to midnight. The daily median for each site then becomes the variable of interest/ used as a measure of turbidity at a site in all of the subsequent calculations.

2) Determine daily background water quality (associated with each assessed site) which is defined as the geometric average of (daily median) measurements of NTU on a day, across the Reference reefs that correspond to the assessed site. This will be done for each of the days during the baseline and all of the days during dredging leading up until the current day of assessment.

3) Assess whether a significant elevation above background is recorded on a day by day basis, using the moderate and chronic water quality criteria in, Table 6-2, Table 6-3, and Table 6-4.

    a) Is the NTU more than **3.3** times the daily background (calculated in 2) and is the NTU at the site at least **2.62**? Record a daily elevation for the chronic water quality criteria at that site for each day where this occurred.

    b) Is the NTU more than **3.2** times the daily background (calculated in 2) and is the NTU at the site at least **5.08**? Record a daily elevation for the moderate water quality criteria at that site for each day where this occurred.

4) Determine whether triggers have been exceeded over the days leading up to present. Triggers based on the chronic and moderate water quality criteria are both assessed separately.

    a) For the chronic criteria

        (1) Level 1 – have there been at least 10 daily elevations (‘yes’ in 3.a.) in the preceding 20 days? If yes, a Level 1 trigger has been exceeded

        (2) Level 2 – have there been at least 20 daily elevations (‘yes’ in 3.a.) in the preceding 40 days? If yes, a Level 2 trigger has been exceeded

(3) Level 3 – have there been at least 40 daily elevations ('yes' in 3.a) in the preceding 80 days? If yes, a Level 3 trigger has been exceeded

b) For the moderate criteria

(1) Level 1 – have there been at least 4 daily elevations ('yes' in 3.b) in the preceding 20 days? If yes, a Level 1 trigger has been exceeded

(2) Level 2 – have there been at least 8 daily elevations ('yes' in 3.b) in the preceding 40 days? If yes, a Level 2 trigger has been exceeded

(3) Level 3 – have there been at least 16 daily elevations ('yes' in 3.b) in the preceding 80 days? If yes, a Level 3 trigger has been exceeded

The key differences between this example and the procedures for the ZoMI or ZoHI are in the last two steps that would be taken. For assessment in the ZoMI, criteria for significant daily elevation of turbidity above background are the same as used in the example above (step 3 is the same), but the windows over which triggers are assessed are different (step 4 is different); i.e. Level 1 triggers being assessed over the previous 40 days, Level 2 triggers over the previous 80 days and Level 3 triggers assessed over the previous 340 days (see Table 6-2 and Table 6-3). For assessment in the ZoHI, the criteria for determining significant daily elevation of turbidity above background (step 3) is different; in step 3.a above, the criteria for recording a daily (50^{th} percentile based) significant elevation would be whether the turbidity at a monitoring site on a day was more than 3.9 times the background levels and at least 3.09 NTU, and for step 3.b the criteria for recording a daily (80^{th} percentile based) significant elevation would be whether turbidity at a monitoring site on a day was more than 3.8 times the background levels and at least 6.19 NTU (Table 6-2). Step 4 would also be different in the ZoHI assessment from the example above; i.e. Level 1 triggers are assessed over the previous 40 days, Level 2 triggers over the previous 80 days and there is no Level 3 trigger.

If water quality is above the criteria for the allowable number of days out of a rolling period, Chevron Australia will undertake an inference assessment. The inference assessment may consider the following:

- MODIS satellite imagery (e.g. Does the imagery show an obvious potential reason for change which could be dredge related, natural or due to other factors);
- metocean conditions (e.g. What are the prevailing currents and recent meteorological conditions);
- records of dredging activity (e.g. Was dredging/placement activity occurring in the vicinity such that it could have caused the net change);
- modelling results (e.g. does modelling indicate that the dredging activity has contributed to the exceedence);
- sedimentation data and water quality data to examine the gradient effect away from the source of concern (e.g. Did water quality change show a change in intensity of effect with increasing distance from the dredging activity); and
- other relevant factors (e.g. riverine inputs).

The management trigger will only considered to have been exceeded if the results of the inference assessment indicate it is reasonably expected that dredging activities have contributed to or caused each daily exceedence of intensity of the trigger.

6.3.1.3 Coral EPO Assessment

This section includes the objective of the EPO assessment monitoring, description of the monitoring variables and details how data will be collected. It also provides an overview on the preferred statistical approaches to evaluate the monitoring data to help facilitate interpretation[19].

Objective

The objective of the Coral EPO Assessment is to provide data that will assist in determining whether the coral EPOs specified in Condition 6-1 (iv) and (v) are being achieved.

Timing

The Coral EPO Assessment will occur:

1) In the event that a Level 3 water quality trigger is exceeded as a result of dredging activities (detailed here); and
2) At the mid-term of dredging activities and post dredging activities (described in the State of the Marine Environment Baseline SoW document; Chevron 2012).

Variables

Since the coral EPOs described in Condition 6-1 (iv) and (v) are described in terms of a change in live coral cover, the primary variable that will be examined during the Coral EPO Assessment will be change in percent live coral cover. However, during image processing (refer to Image Processing Section below), a wide range of abiotic categories (such as sediment cover, bare substrate etc.) and biological stressors may also be scored to assist in inferring the cause of any detected change in live coral cover. Each of these parameters will be available for quantitative, semi-quantitative, or qualitative assessment. These data, along with the water quality data and MODIS satellite imagery, will assist with interpreting any potential change in coral cover that might be detected to determine if the change is ‘real’ or simply an artefact of sampling and low coral cover, and to infer the cause of any detected change.

Sampling approach and image processing

The Coral EPO Assessment will utilise the same data collection and image processing method as the baseline coral monitoring programme (detailed in Section 6.3.3).

Sampling design

Multiple reference and impact reefs will be monitored, both before and after the commencement of dredging. However, the statistical analysis for the ZoHI and ZoMI EPO assessment is characterised by a before versus after contrast at multiple reference reefs but only a single impact reef (i.e. an asymmetrical design). The reason for this is that there is a requirement to assess dredge impacts on a reef by reef basis stipulated in Condition 6-1 of MS 873. An asymmetrical design is sub-optimal for inferring causation because the impact effect at the putative impact reef could be confounded by a natural change specific to that reef (due to the lack of impact reef replication). For this reason, a structured decision making framework, using a number of approaches, will be required to rigorously assess whether the

[19] Please note that these same methods will be used to assess achievement of the MOs however they will be undertaken under the SoW at the mid-term and post development surveys and therefore is not detailed here.

detected change at an affected reef was due to dredging or simply the result of natural change.

Another important aspect of the sampling design is that one or more sites will be sub-sampled per impact reef, depending on its size. This is to reduce site level effects confounding reef level effects and to better understand the spatial scale of observed change. For the purposes of the Coral EPO Assessment, the reef is the biological unit of interest. Sites within reefs will be sub-sampled using replicate transects and then averaged to estimate the level of change within a reef.

Level of replication

During baseline, five transects were used per site per reef. Prior to the major decline in coral cover during 2011, this level of replication provided a high level of power for the proposed statistical test. Effect sizes of 10-15% change in baseline live coral cover could be detected with high certainty. Cover of coral in the Project area is now low and spatially variable, making it very difficult to obtain precise measurements of change based on this level of replication. For example, low levels of coral cover (e.g. <2%) is within error terms routinely associated with the monitoring and statistical analysis techniques (Stoddart et al. 2005). Thus, there is limited benefit in attempting to assess whether coral EPOs are being achieved based solely on the results of statistical tests. Tests of power conducted using coral cover estimates returned from recent surveys of targeted monitoring reefs at Wheatstone show that the baseline monitoring methods return a power of less than 0.4 to detect a 30% decline in coral cover for reefs with less than 5% cover (the majority of Wheatstone reefs had less than 5% coral cover as of June 2012) as seen in Table 6-7. Based on these results, a considerably greater effects size, possibly in the order of 80-100% change, would be required to achieve a test with a power of 0.8. As approved by the CEO on the 27 November 2012, the power will range from 0.05 to 0.8, subject to the additional analysis detailed in the following paragraphs. Nevertheless, during dredging the level of replication used to sample an affected reef following a Level 3 exceedence will be increased, where practicable. The major limitations to greatly increasing the level of replication to achieve greater power is the small size of many of the monitored reef formations present an elevated risk of transects overlapping and not being considered independent sources of data, which is an important assumption of inferential statistical approaches.

Table 6-8: Power calculations for two effect sizes: 30% and 10% declines, based on data collected during June 2012 (following the 2011 natural mass mortality event)

Site	Zone	Region	% coral cover	Power to detect 30% decline	Power to detect 10% decline
Gorgon	ZoHI	Mid Shelf - East	11.1	0.65	0.2
Saladin	ZoHI	Mid Shelf - West	4.1	0.34	0.13
Ashburton	ZoI	Mid Shelf - West	7.3	0.54	0.15
Direction	ZoI	Mid Shelf - East	5	0.41	0.14
Roller	ZoI	Inshore	5.8	0.41	0.14
Weeks	ZoI	Mid Shelf - East	5.9	0.42	0.12
Ward	ZoI	Inshore	1.9	0.22	0.09
Hastings	ZoMI	Mid Shelf - West	0.9	0.15	0.09
Paroo	ZoMI	Mid Shelf - West	4.7	0.37	0.12

Process for supporting or refuting the dredge impact hypothesis following an exceedence of a Level 3 water quality trigger

A comprehensive and transparent framework for decision-making is required to assess coral cover following a Level 3 water quality exceedence. This process includes two main steps:

Step 1: Accumulation and analysis of evidence; and

Step 2: Submit findings and conclusion to EPA, DOTE and DTAP.

Step 1 is summarised in Table 6-9. All six evidence types (A to F) will need to be examined and discussed in a formal reporting form (or proforma) to be submitted to the EPA, DOTE and DTAP. The proforma will also contain evidence supporting or rejecting the overall conclusion of whether the detected change was or was not the cause of an observed decline at the affected reef.

Figure 6.12 illustrates in chronological order the steps, as listed in Table 6-9, to provide a holistic assessment of the EPO at an affected reef following an exceedence of Level 3 trigger. The first step is a formal statistical test of gross decline in coral cover at the affected reef, followed by a similar test, but of net change (i.e. factoring in change in cover that occurred concurrently at reference reefs). The third step is an assessment of the magnitude of change (effect size +-CI) in coral cover between the affected reef and reference reefs, from before dredging to the current survey period (that is, whether the difference in coral cover between the affected reef and the reference reefs had increased or remained consistent since dredging). Following this is a comparison of trends in mean coral cover through time will be compared among the affected reef and reference reefs. The fifth step is an inference assessment which includes the collation and synthesis of all available circumstantial evidence supporting or refuting the conclusion that either dredging or a natural agent of disturbance resulted in an observed decline in coral cover at the affected reef. Data accumulated via the verification monitoring programme will also be used to support the inference assessment. The final step is the formulation of a conclusion of whether the EPO is being achieved or not achieved as a result of dredging based on a holistic assessment of all analyses and investigations. A report will then be submitted to the EPA, DOTE and DTAP containing the conclusion and all supporting evidence.

Table 6-9: Step 1: Accumulation and Analysis of Evidence

	Method to obtain evidence	Description and notes	Interpretation
A	T-test: Before versus after test of change at impact site.	Formal test of a null hypothesis (e.g. no difference between affected reef at time 'x' during dredging compared to baseline). If more than one test is required per assessment period, a correction factor will be applied to limit the risk of an inflated Type I error rate.	If not significant = unsupportive of impact hypothesis.
B	T-test: Test of net change at impact site (i.e. change at impact monitored reef formations versus changes at reference reefs).	As above, but this test factors in change measured at the reference reefs.	As above
C	Estimate effect size and its Confidence Interval (CI).	The purpose of this method is to compare the effect size (the difference between affected reef and the reference reefs) before dredging with the effect size after dredging. A CI approach, like this, provides important information for decision-making not gained from a test of a null hypothesis (Evidence Step A and B). A CI approach focuses on the magnitude of change, with some measure of uncertainty. Walshe et al. (2007) also stated that a CI approach has the advantage of communicating the key elements of statistical power without being constrained to a dichotomous decision making framework. For example the width of the CI is influenced by the sample size, variability of the variable being measured and the degree of confidence required. The other element of power analysis – the effect size – can be illustrated graphically.	Larger mean effect size (+-CI) following dredging map provide evidence supportive of the dredge impact hypothesis.
D	Trend analysis	The purpose of this approach is to compare temporal trends in coral cover estimates (mean +-CI) at the affected reef, from before to after the start of dredging. This is also compared with the average trends of the reference reefs.	Evidence supportive of the dredge impact hypothesis would be a decline in cover at the affected reef following dredging, but no decline at the reference reefs.

	Method to obtain evidence	Description and notes	Interpretation
E	Inference assessment	This approach is used to facilitate inference when the sampling design is sub-optimal (Downes et al. 2002). It uses multiple lines of evidence, based on causal criteria, to assess the impact hypothesis.	See Table 6-10
F	Verification monitoring (see Section 6.3.3)	This monitoring is carried out routinely (every three months) and in the event of a Level 2 trigger being exceeded. Data from this monitoring will be used to support the interpretation of results from the Coral EPO Assessment.	See Table 6-13 Increase levels of sediment accumulation on live corals at the impact monitored reef formation, relative to the reference reefs, would be supportive of the dredge impact hypothesis.

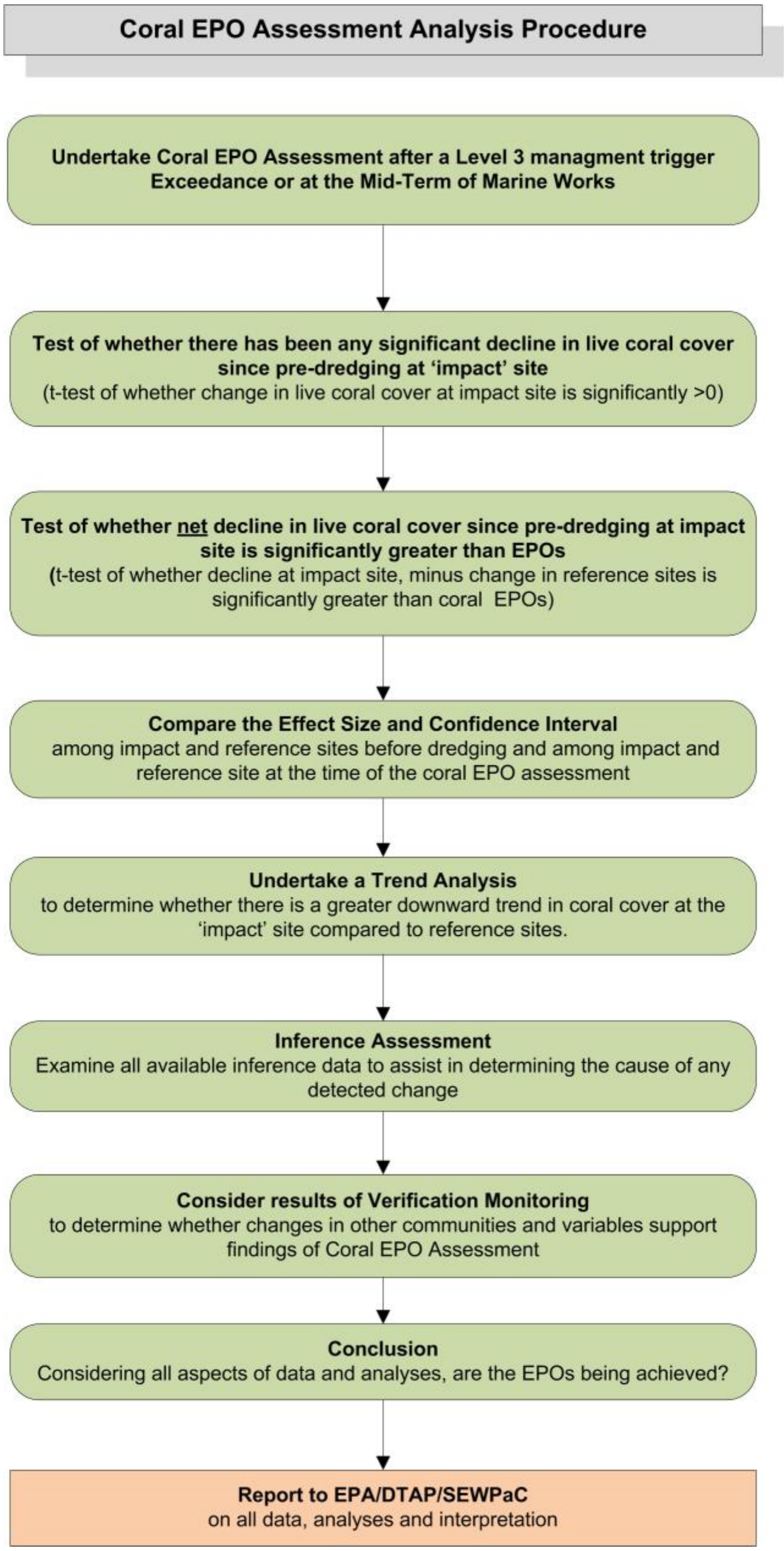


Figure 6.12: Coral EPO Assessment Analysis Procedure

Inferring the Cause of the Detected Change

The sampling design is the primary framework for inference in ecological monitoring (Underwood 1997). An optimal sampling design for impact assessment includes sampling before the start of a disturbance, at replicate impact and reference reefs, and at these same reefs after the start of disturbance. Reference reefs are used to separate dredging related impacts from those caused by natural disturbance (e.g. thermal stress, predation; freshwater discharge; cyclones). Unfortunately, sampling design in impact assessment is generally sub-optimal because there may be one impact site and limited baseline or few reference reefs that are ecologically comparable to the impact reef. Fortunately, when a sampling design is sub-optimal, other methods can be employed to facilitate inference such as lines of evidence.

With the lines of evidence (Downes et al., 2002; McArdle, 1996; Suter, 1996; Beyers, 1998; Fabricius and De'ath, 2004), inference is developed based on carefully structured arguments. This approach has been used successfully in disciplines where manipulative experimentation is unlikely for ethical reasons, such as assessing the effects of diseases on humans, or when impact sampling designs are sub-optimal (e.g. lack of suitable reference sites). Its formal use in ecological impact assessment is relatively recent (Beyers 1998; Downes et al. 2002; Fabricius and De'ath 2004). Hill (1965) categorised different types of causal argument into nine criteria for studies into the effects of diseases on humans. Table 6-10 lists each of Hill's causal criterions and how they relate to ecological impact assessment. With lines of evidence there is a need to seek evidence not only to support the impact prediction, but evidence to rule out plausible alternative predictions, such as that the observed difference was due to natural processes (Beyers 1998; Downes et al. 2002).

Table 6-10: Hill's causal criteria and description in the context of ecological impact assessment (sensu Hill 1965 and Downes et al. 2002)

Causal criterion	Description (as per Hill 1965)	Description (as per Downes et al. 2002)
Strength of association	A large proportion of individuals are effected in the exposed area relative to reference areas	A particularly large change in the response variable is observed
Consistency of association	The association has been observed by other investigators at other times and places	The expected effect on the response variable is observed (may be redundant with Strength of association)
Specificity of association	The effect is diagnostic of exposure	The data are observed
Temporality	Exposure must precede the effect in time	The expected change in the response variable occurs after the onset of human activity
Biological gradient	The risk of effect is a function of magnitude of exposure	A dose-response relationship is observed (if a gradient design is used)
Biological plausibility	A plausible mechanism of action links cause and effect	The study at hand meets any requirement for the hypothesised mechanism to apply
Experimental evidence	A valid experiment provides strong evidence of causation	The predicted effects from the experiments are observed to occur in the human impact study

Causal criterion	Description (as per Hill 1965)	Description (as per Downes et al. 2002)
Coherence	Similar stressors cause similar effects	
Analogy	The causal hypothesis does not conflict with existing knowledge of natural history and biology	The predicted effect is observed

A strength of the lines of evidence approach is that it provides a highly structured method of facilitating inference, particularly in situations when an optimum sampling design cannot be implemented (Beyers 1998; Downes et al. 2002). Fabricius and De'ath (2004) also argued that it is transparent and easy for decision makers to understand. A weakness of this method is that the evidence is circumstantial because it is based on correlations (Downes et al. 2002), which does not necessarily imply causation. Proponents acknowledge that each causal argument is weak independently, but argue that when combined may provide strong support for a conclusion (Downes et al. 2002). However, rarely will all criterion, listed in Table 6-10, be useful for any one monitoring programme. The criterion *specificity of association* will, for example, not apply unless the assessment relates to an activity that has a unique effect in the environment and the criterion *temporality* will be useful only if monitoring commenced prior to the start of a disturbance.

There are a number of potential causes for impact within the study area and the lines of evidence approach consider each of these and its likelihood of occurrence. Table 6-11 lists the potential causes of impact, their risks and likelihood and how each one will be considered. Each of these potential causes of impact is investigated to determine the likelihood that any observed change in coral health is due to the dredging activity or natural disturbance. This step in the process enables an approach to be taken which has multiple lines of evidence which complement each other to provide greater certainty of effect. By considering other potential sources of impact it enables greater confidence in the determination of causal effect.

A number of factors are relevant to the likelihood and level of severity of an impact occurring, including existing stress levels, age, size and health status of colonies, associated biota and adaptations to localised conditions. For example, during the inference assessment it is important to consider that in certain localised areas there may be stress causing factors acting on the corals which may not be at a sufficient level to cause mortality but could make the corals more susceptible to a lower level of TSS increases that otherwise may not have had an impact.

The inference assessment also needs to consider the difference in physical characteristics between reference reefs and impact reefs and how this could affect the scale of effect observed between the corals. For example, the depth of water that the coral are living in could affect the scale of impact, as shallower water is likely to increase the effects of thermal bleaching. All aspects of the causal effect should be considered to determine whether any exceedence is due to dredging or another factor.

Table 6-11: Potential Impacts to coral and their Risks and Likelihood

Potential Impact	Likelihood of Occurrence	Consequence of impact and scale of effect	Monitoring
Thermal Bleaching	High	Severe	Temperature recording via water quality loggers Evidence through surveys
Natural Mortality	High	Mild	Evidence through survey and type of impact evident at localised sites
Pollution Incidents (including nutrient enrichment)	Medium	Mild - Severe	Communication with other users and Port Authority
Localised predation (corals only)	High	Mild - Medium	Monitoring of percent cover of transects in coral reef monitoring sites to identify signs of predation
Cyclones – direct damage	High	Severe	Weather reports together with monitoring of transects
Cyclones – indirect smothering	High	Medium	As above plus water quality loggers
Salinity Change	Low in general area but medium close to Ashburton River	Mild	Salinity recording via water quality loggers
Ship propeller disturbance – increases in TSS	Low generally – but medium in shallower water	Medium	water quality logger information
Other dredging campaigns in the area – capital or maintenance	High for trunkline - possibility for maintenance of existing navigation channel	High	Awareness of other schemes - water quality loggers should record any cumulative plumes

During the inference assessment data on a number of variables will be considered to provide a weight of evidence as to whether or not dredging activities were reasonably considered to cause or contribute to the impact. The consideration would include whether the impact is strongly linked to dredging or dredge spoil placement activities, shows no link, or the assessment is inconclusive.

Table 6-12 shows the causal criteria that would be considered during the assessment of evidence approach to assess whether an impact is due to dredging or other activities.

Table 6-12: Causal criteria and assumptions

Causal Criterion	Criteria and assumptions	Evidence supportive of dredging impact	Evidence unsupportive of dredging impact or evidence is inconclusive
Timing of impact	Exposure must precede the effect in time Greatly elevated turbidity and sedimentation associated with dredging is a potential source of mortality	The abundance of bleached, dead and or smothered coral at the monitoring sites increased after exposure to increased levels of turbidity or sedimentation from the dredging activity (linked to water quality thresholds). Reference sites (if available) showed no similar effects.	The impacts on coral occurred prior to exposure to increased levels of change in water quality or sufficiently long after to reject any lag effects (relate to water quality thresholds). Thermal Stress Coral show a response linked to an increase in temperature shown on the temperature loggers. The impacts will be generally widespread but may be more prevalent in shallower water where temperatures and light intensity are likely to be higher. Freshwater Discharge Impacts occur (generally in nearshore areas only) soon after increased rainfall and storm conditions. Storm Event Physical damage and/or smothering to coral following storm event.
Biological Gradient	The risk of effect is a function of magnitude of exposure (i.e. there is a strong relationship between dose and effect) and distance	The proportion of stress or mortality observed at sites decreases with increasing distance from the dredge or disposal site. Impacts are not observed in the reference sites (if available).	The proportion of individual coral (e.g. colonies) exhibiting signs of stress or mortality did not show any pattern relating to proximity to the dredge site. Thermal Stress Stress and/or mortality occurred at random or widespread sites not linked to distance from the dredge, including at reference sites. Freshwater Discharge Coral show a greater impact close to the source of freshwater input (i.e. close to the Ashburton River mouth). Pollution Event/Disease/Predation/Grazing Highly localised impact within impact site or reference site. Signs of damage to surrounding habitats. Evidence of predators, including feeding scars. Storm Event Generally widespread impact but

Causal Criterion	Criteria and assumptions	Evidence supportive of dredging impact	Evidence unsupportive of dredging impact or evidence is inconclusive
			could show increased localised effect in exposed/shallower areas.
Duration, intensity and frequency of exposure	The length of time that coral is exposed to increased levels of TSS or sedimentation influences the level of response.	Sites which have been exposed to longer durations of high exposure (following analysis of water quality data) have suffered higher losses. Water quality thresholds have been exceeded at the site showing impacts but have not exceeded at sites where no impact is observed.	Sites exposed to longer durations of higher exposure show lower losses indicating that another causal factor could be responsible for the impact Water quality thresholds have not been exceeded at the site showing an impact to coral health.
Experimental Evidence		The observed effects were predicted at some level during the impact assessment phase. The impacts correspond with the results of modelling predictions. The sedimentation shown at the site through the monitoring relates to material that could have been moved to the site. This is verified using the hindcast modelling. MODIS imagery shows a clear evidence of a plume in the areas impacted.	The observed effects are not known to occur as a result of dredging during previous schemes. The modelling does not predict increases in TSS at the site experiencing stress and/or mortality. The sedimentation shown at the site through monitoring is coarse material that is unlikely to have been moved to the receptor site from the dredge location. The MODIS imagery does not show plumes reaching the impacted sites during or preceding the impact.
Strength of Association	A ‘particularly large’ change in the response variable is observed	An appreciably large amount of dead and smothered coral within the ‘active plume’ area. The proportion of dead to live coral is higher than would be expected following natural change. No unusual natural events occurring in the preceding period, i.e. cyclones.	No or very low level of dead or smothered coral. Impact severity and distribution could be linked to a periodic or unusual natural or anthropogenic event (i.e. pollution event).
Wider Habitat Change	Changes to corals relating to increases in TSS levels and sedimentation are likely to have similar impacts on	Impacts which could be attributed to dredging (i.e. smothering, light deprivation) can also be observed on habitats and species within the reef system.	There are no impacts on adjacent habitats within the reef system which would indicate dredging related changes.

Causal Criterion	Criteria and assumptions	Evidence supportive of dredging impact	Evidence unsupportive of dredging impact or evidence is inconclusive
	other corals in the surrounding area.		

6.3.2 Proactive Monitoring (mobile sentinels)

The proactive monitoring programme (a component of PAM described in Section 6.2.2) will incorporate a series of telemetered mobile sentinel instruments deployed around the dredge and DSPSs between areas of anticipated turbidity/plume activity and monitored reef formations. These sentinel sites would be mobile to allow monitoring flexibility and the location and early warning test levels would be dependent on proximity to the dredge and proximity to monitored reef formations. An example is illustrated in Figure 6.13.

Objectives

The proactive monitoring programme will provide data that are assessed against the early warning test levels to provide an early indication of the potential for water quality exceedance's at the monitored reef formations due to dredging or dredge spoil placement activities. Evaluation of the data will allow a rapid management response to locations with water quality levels of concern near dredging and dredge spoil placement activities as warranted by the data.

Variables

Turbidity (measured in nephelometric turbidity units - NTU) provides an indirect measure of the alteration of the light climate received by BPP communities that may be a result of the natural suspension and movement of sediments and/or the suspension and movement of sediments caused by dredging or dredge spoil placement.

Data Collection

The location and number of sentinel units deployed will vary throughout the project and depend on the number of active dredges, dredging and disposal technique(s) utilised, and proximity of dredging and disposal activities to monitored reef formations. For instance, during initiation of the dredging works, a more intensive sentinel monitoring campaign may utilise the total eight units to assist in conducting a more comprehensive validation of the sediment plume model.

These sentinel units will be placed at a safe distance from the dredge so as not to impede dredging activities but at an optimal distance from the monitored reef formation(s) of concern to allow enough time to capture fluctuations in water quality and permit management actions to be implemented, if necessary, prior to influence or impact at the monitored reef formation(s). This sentinel unit set up will progress and evolve along with dredging operations, as necessary, by maintaining an ideal number of sentinel units and optimal distances between dredging activities, monitored reef formation, and sentinel units. For instance, as dredging activities approach the vicinity of a monitored reef formation, a sentinel unit may be incorporated into the set up to serve as an early warning monitor for this reef and similarly, as dredging operations advance away from a reef site, a sentinel unit may be removed from the set up as plume progression is not anticipated to impact this reef.

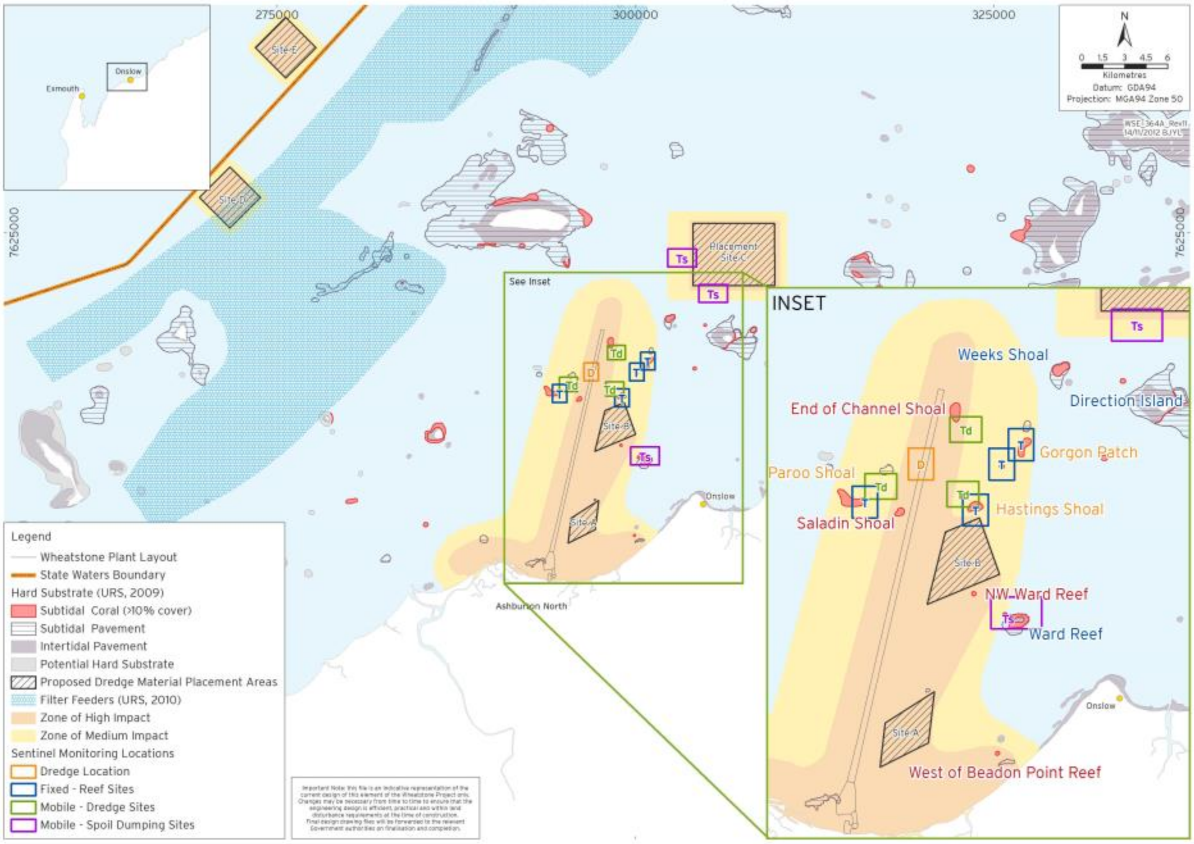


Figure 6.13: Example of Sentinel Monitoring Locations around Dredging and Dredge Spoil Placement Sites

6.3.3 Verification Monitoring Programme

Water quality criteria have been derived using the most recent and relevant information available, based largely on predictive relationships between water quality and coral health developed from the Gorgon Marine Monitoring Programme. To verify that derived water quality criteria afford the appropriate level of protection to benthic communities, a water quality criteria verification monitoring programme (hereafter 'Verification Monitoring Programme') will be utilised to investigate the appropriateness of water quality criteria and to adapt or revise, if appropriate, water quality criteria.

It should be noted that data from the Verification Monitoring Programme will not be used to assess achievement of the EPOs, for the following reasons:

- The benthic communities being investigated are very low in cover (e.g. corals, seagrass) or highly variable (e.g. seagrass, macroalgae) and prone to a high level of natural change. In order to be able to reliably infer the cause of any detected change requires either i) a long-term dataset to examine trends at the impact reef compared to that of reference reefs (i.e. EPO assessments will be undertaken at the mid-term of dredging and post-dredging when a long-term dataset is available to assist in interpreting any detected changes) or ii) a definitive pressure on benthic communities that would reasonably be considered to elicit a response (i.e. coral EPOs will also be assessed in the event of a Level 3 water quality trigger exceedence).
- Verification Monitoring focuses on a range of indicators including those designed to detect early signs of biological stress, such as partial coral mortality or sediment accumulation on corals and other sessile organisms. The EPO Assessment Monitoring focuses principally on measuring changes in live coral cover as described

in Condition 6.1. While indicator variables included in Verification Monitoring cannot be used to assess the EPOs directly, they will be helpful in interpreting change in coral cover during EPO assessments.

Objectives

The primary objectives of the verification monitoring programme are twofold:

- To provide a feedback mechanism to assess whether water quality criteria and management triggers are affording appropriate levels of protection to coral, filter feeders, macroalgae and seagrass; and
- To assist in revision of water quality criteria, if appropriate, by evaluating benthic communities and other available data sources when applicable.

Timing

As approved by the CEO on the 27 of November 2012, monitoring of biological indicators, to inform adaptive management, will occur at the following times:

1) Routine Verification Monitoring: Approximately quarterly at all monitored reef formations and at the non-reef formations (Figure 6.7; Figure 7.2) that are assessed to be ‘at risk’ from dredging activities as well as reference reefs; and
2) Responsive Verification Monitoring: Following a positive finding that dredging activities have caused a Level 2 management trigger to be exceeded, monitoring will be undertaken at the affected monitored reef formation(s) and associated reference reefs (Figure 6.7) and/or at the non-reef formations (Figure 7.2). The first survey will occur approximately 2 weeks, weather permitting, following the determination of the management trigger being exceeded and the 2nd survey will follow 2 weeks (weather permitting) after the first survey. A total of two surveys will be conducted following each set of events that led to Level 2 management triggers being exceeded.

Verification Indicator Variables

The verification monitoring programme focuses on the capture of images of benthic quadrats along transects at the monitored reef formations. Given the low and spatially variable cover of hard coral, seagrasses, and filter feeders, a single variable (e.g. percent cover) on its own may not be sufficient to adequately verify the effectiveness of water quality criteria. However, data on a range of variables, interpreted together, may collectively be useful to inform or validate criteria and determine whether water quality criteria are providing the required protection for benthic communities.

Currently, there is limited consensus on which coral, seagrass, filter feeder and macroalgal indicators are best placed to assess potential impacts from changes in water quality. There are few studies from which to make a robust choice as to the most reliable variables to indicate change in water quality (De’ath and Fabricius 2008), especially in relation to non-corals. To assist with interpretation, Cooper and Fabricius (2007) recommended that indicators have one or more of the following characteristics: the variable should provide some level of response specificity so that the change in the variable could be related to a dose/response relationship; and the change in the variable through time should be low in the absence of a disturbance. Other important considerations are that the indicators are easy to measure and are biologically relevant (Cooper and Fabricius 2007).

A list of coral, seagrass, filter feeders and macroalgae indicator variables to be used initially to verify the water quality criteria during the Wheatstone dredging programme are provided in Table 6-13. The indicators in Table 6-13 are to be used initially because additional variables may be included at a later stage, while other initially identified may be removed as new knowledge about their reliability is gained via the monitoring programme and the peer-reviewed literature or if they become too variable to describe meaningful changes.

The following two types of indicator variables were adopted:

- Those that will potentially indicate change during or soon after exposure to water quality levels predicted to cause a negative biological response in coral, seagrass, filter feeders and macroalgae; and
- Those that may measure cumulative effects over longer periods of time (Cooper and Fabricius 2007).

Table 6-13, column 2 provides justification for the choice of these indicators, while acknowledging that the utility of some of these variables as reliable predictors of water quality effects to coral, seagrass, filter feeders and macroalgae have not been conclusively demonstrated in the Pilbara. Table 6-13, column 3 briefly describes how change in each variable might be interpreted based on observations of trends through time. Given the uncertainty as to how some of these variables might change naturally through time in response to a range of biotic and abiotic factors, it is unlikely that any single variable can be used to make a decision in relation to the success or otherwise of the water quality criteria. Instead, this section describes how the changes in a range of indicator variables will be described to make a more holistic interpretation of the validity of water quality criteria.

Table 6-13: Coral, Seagrass, Filter Feeders and Macroalgae Indicators that will be used initially to verify water quality Criteria

Indicator variables	Justification	Change/trends that would contribute evidence of change attributable to dredging	Source
Corals			
Coral assemblage structure	Coral assemblage structure is known to respond to changes in water quality.	Shift in assemblage structure at impact reef relative to baseline and reference reefs	e.g. Brown et al. (2002)
Percent Cover	Percent cover is known to respond to changes in water quality. This variable is potentially useful for assessing change over the long term.	Negative (decreasing) trend in cover, relative to baseline and reference reefs	
Increase in level of partial mortality of randomly chosen colonies	Partial mortality is a known response to changes in water quality. This variable is potentially useful for assessing change over the medium to long term	Positive (increasing) trend in partial mortality, relative to baseline and reference reefs	e.g. Nugues and Roberts (2003) Gorgon data
Mucus production in *Porites*	*Porites* and other corals are known to shed sediment using mucus. Variable potentially useful for assessing change over the short to medium term.	Positive (increasing) trend in the proportion of *Porites* colonies showing evidence of significant mucus production relative to baseline and reference reefs	Gorgon data
Sediment on living corals	Corals can reject sedimentation, but sedimentation may accumulate on living corals if coral is overwhelmed. Variable potentially useful for assessing change over the short to medium term.	Positive (increasing) trend in the proportion of colonies showing evidence of sediment accumulation on living tissue relative to baseline and reference reefs	e.g. Gilmour et al. (2006)
Filter feeders			
Percent Cover	Percent cover is known to respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference location.	
Sediment on sponges	Sponges can potentially reject sedimentation, but sedimentation may accumulate on sponges if overwhelmed.	Positive (increasing) trend in the proportion of colonies showing evidence of sediment accumulation on living tissue relative to baseline and reference location.	

Indicator variables	Justification	Change/trends that would contribute evidence of change attributable to dredging	Source
Macroalgae			
Percent cover	Percent cover is known to respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference location (if available).	
Seagrasses			
Percent Cover	Percent cover is known to respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference locations (if available).	
Plant or leaf density	Plant density will potentially respond to changes in water quality.	Negative (decreasing) trend in cover, relative to baseline and reference locations (if available).	

In addition to percent cover and leaf density, additional seagrass variables that will be considered for inclusion in the assessment are C:N:P ratios and above-ground biomass. These will be considered in consultation with subject matter experts.

During image processing (see Image Processing Section below), a wide range of abiotic categories (such as sediment cover, bare substrate etc.) and biological stressors may also be scored. Each of these parameters will be available for quantitative, semi-quantitative, or qualitative assessment. These data, along with the water quality data and MODIS satellite imagery, will assist with interpreting change in coral condition to inform the verification assessment.

In addition to the above monitored parameters, light data (PAR) may also be utilised to provide information for inference assessments or as additional lines of evidence. PAR data recorded every 30 minutes at all monitored reef formations will be used to:

1. Compare with predicted minimum light requirements of seagrasses, macroalgae and filter feeders; and
2. Correlate with temporal changes in biota abundance to develop a better understanding of the relationship between light levels and abundances of biota.

Data Collection

Reef formations (coral, macroalgae and filter feeders)

The verification monitoring programme will utilise the same survey methodology as the baseline BPPH monitoring programme to provide consistent data over a long period of time to investigate temporal trends. The survey method has the following characteristics:

- Data are collected via a ROV
- 5 random transects are surveyed per site

- Length of transect is approximately 30–50 m
- Up to 300 images are taken at each site from which approximately 150 images are analysed (based on an objective list of criteria, such as sharpness of the image), i.e. 30 images per transect are retained for analysis
- Size of images collected is approximately 75 cm x 50 cm.

Image Processing

Each image is scored for a variety of habitat categories (such as seagrasses, sponges, soft corals, etc.) and abiotic categories (such as sediment cover), sub-lethal indicators of stress (such as mucus production, bleaching, and the pattern of mortality which includes partial versus total mortality of individual corals and other sessile organisms when applicable).

In relation to hard corals, partial mortality of a sub-sample of coral colonies within frames can be estimated. Differences in the level of partial mortality or partial sediment cover of colonies can be compared between potential impact reefs and reference reefs to determine whether any net change has occurred that may provide verification of the appropriateness of water quality criteria. Coral colonies will be chosen from images for partial mortality analyses using definitions modified from Nugues and Roberts (2003). Colonies chosen for analyses will be defined as an autonomous mass of skeleton with living tissue. As such, a colony divided by partial mortality or morphological characteristics into separate patches of living tissue, but located on the same mass of skeleton, will be considered to be one colony. Colonies with more than 50% of their surface area lying outside of frames will not be included in partial mortality analyses.

Partial mortality will be defined as areas of bare and algal-covered skeleton present on the colony surface or areas covered in other organisms (e.g. sponges) or a layer of sediment. It is important to distinguish however, between perceived and realised partial mortality when corals are overlain with sediment. It has been demonstrated in previous studies (e.g. the Gorgon Marine Monitoring Programme) that sediment overlying coral colonies may be subsequently removed through water movement (e.g. wave action), and providing this sediment has not overlain the coral for beyond a critical period of time (e.g. several weeks), the removal of sediment may reveal live tissue underneath, with no subsequent 'realised' mortality.

Non-reef formation (seagrass habitats)

Two sampling cells or grids (~500 m x~500 m) will be located in seagrass areas immediately adjacent to loggers shown in Figure 7.2. Within each cell, benthic habitat data were gathered along five randomly-oriented ~100 m transects. Towed video, based on oblique and downward-facing cameras, will be used to survey the transects. Transects as the smallest unit of measure will be used to record:

- Distribution of specific habitats along a transect (proportion of habitat type present) quantified from imagery
- Within habitat sections, approximately 10 downward still images will be selected randomly for point count scoring (% cover of habitat)
- Random points will be overlain on each still image selected and the substrate type classified beneath each point to estimate percent cover.

Inferring the cause of the change

Consistent with Verification Monitoring described for coral in Section 6.3.1.3 verification monitoring used to assess whether water quality criteria are affording protection to benthic communities will also use a lines of evidence approach to help infer the cause of any observed changes. Table 6-12 shows the causal criteria that would be considered during the assessment of evidence approach to assess whether an impact is due to dredging or other activities for all benthic communities. The impact inference criteria shown in Table 6-14 are used to help interpret change in non-coral benthic communities. For brevity, Table 6-11 is not repeated in this Section; however, in addition to those criteria shown in Table 6-11, localised grazing of seagrasses and macroalgae should also be considered when interpreting temporal changes in non-coral communities.

Table 6-14: Potential impacts to benthic communities and their risks and likelihood

Potential Impact	Likelihood of Occurrence	Consequence of impact and scale of effect	Monitoring
Localised grazing (seagrass and macroalgae)	High	Mild-High	Monitoring of seagrass and macroalgae percent cover to identify signs of predation
Refer to Table 6-11 for the full list of potential impacts to benthic communities			

6.3.3.1 Sedimentation Monitoring

The main objective of monitoring sedimentation rates is to assist in understanding potential impacts of dredging and dredge material placement activities on sedimentation regimes at monitoring reef formations, and to infer potential impacts on benthic communities. It is likely that permanent sedimentation impacts to benthic communities, if any, will only occur in areas within close proximity to dredging or dredge material placement activities where there is deposition of coarse sediments. Finer sediments may deposit on benthic species and habitats at greater distances from the dredging activity. However, much of this finer material is likely to resuspend during water movement associated with tides, wind and wave action, but some may remain in place for periods of time that could cause impacts on benthic species. Sedimentation monitoring is therefore required to provide evidence of whether potential impacts within these areas were caused by dredging or other factors (i.e. natural resuspension of sediments during storms).

Objectives

The sedimentation monitoring programme has been established to provide gross sedimentation data at the monitored reef formations. This extensive set of data will assist investigations into trends in sediment accumulation on a spatial and temporal scale on the seabed adjacent to the reefs. The specific objectives of the monitoring programme are:

1. To deduce potential dredge-related impact contribution to a exceedence of water quality triggers, by assessing sedimentation rates as well as other available data sources when applicable, and

2. To assess whether the water quality criteria are affording appropriate levels of protection to benthic communities from increases in sedimentation, and to assist in

revision of water quality criteria, if water quality criteria are found not to be affording protection from elevations in sedimentation.

Variables

Gross sedimentation will be measured at the monitored reef formations (outlined in Section 6.3.1.1) throughout dredging activities on a ~six-weekly basis.

Data Collection

Sediment traps will be deployed at the monitoring reef formations outlined in Section 6.3.1.1 utilising a frame assembly which consists of at least three sediment traps per site. Collection of the sediment trap assembly samples and re-deployment of the cleared traps will occur approximately every six weeks. Similar to the water quality monitoring assemblies, all sediment trap frame assemblies will be deployed adjacent to the monitored reef formations, rather than directly on the reef, to prevent damage to the coral during deployment and retrieval.

Each sediment trap will be constructed to the design criteria in Storlazzi et al. (2011) or other relevant approaches. The multiple trap assembly allows determination of inorganic weight from sediment within two of the traps and particle size distribution (PSD) from sediment within one of the traps for the duration of deployment. The additional trap also serves as a backup should data from one of the traps be erroneous.

Data Analysis

Sediment samples obtained from the sediment traps will be analysed to provide data on the following two variables:

1. Inorganic weight of the material trapped to determine:
   - The rate of sediment accumulation at each specific location over time
   - The spatial variability of sediment accumulation among the monitoring reef formations
   - The change in sediment accumulation both temporally and spatially during dredging activities as compared to the baseline monitoring period.
2. PSD of each sediment sample will be evaluated to determine the percentage of fines in the sample, especially coarse, medium, and fine sand as compared to silt and clay.

Analysis of the above parameters will be performed at an off-site laboratory. The inorganic weight of the sediment sample will be determined by drying/burning off organic material. The PSD of the sample will be ascertained via sieve analysis and. additional measurement techniques, such as laser diffraction, may be incorporated, where warranted and requested, to determine a more intensive fines assessment as needed.

6.3.3.2 Water Quality Criteria Refinement

These refinements serve to develop a better understanding of the relationship between benthic communities and water quality, especially turbidity, suspended sediment concentrations, and sedimentation. Water quality criteria will be reviewed after the first quarterly verification monitoring surveys or exceedence of a Level 2 management trigger, whichever occurs first. Additionally water quality criteria may be reviewed after the following:

- If a decline in benthic communities, from the most recent baseline, is discovered during a routine quarterly or Level 2 management trigger (in the ZoI and ZoMI) exceedence monitoring survey, and the initial investigation determines this exceedence is due to dredging-related activity, it may be necessary to assess the need to revise water quality criteria.
- If no decline in coral is determined during a coral EPO assessment following an exceedence of the Level 3 management trigger, it may be appropriate to assess the need to revise water quality criteria.
- If verification monitoring or other assessments indicate that chronic and moderate triggers are not affording the required level of protection for benthic communities from acute elevations in turbidity, the requirement for inclusion of an acute trigger will be reviewed.

7.0 SEAGRASS, MACROALGAE AND FILTER FEEDERS MANAGEMENT AND MONITORING

7.1 Background

As described in Section 6.1, subtidal benthic communities that may potentially be affected by the dredging and dredge spoil management activities include hard corals, seagrass, filter feeders and macroalgae. This section describes benthic community monitoring, associated to capital dredging, to assess EPOs related to seagrass, filter feeders and macroalgae (note that the benthic community monitoring described in Section 6.3.3 relates specifically to verifying the effectiveness of the water quality criteria). Monitoring associated with clean-up dredging is included in Section 2.2.2.1(10).

Dredging impacts to seagrasses and macroalgae are predicted to be temporary (EAG No.3 definition: recoverable within 5 years; EPA 2009) given the habitat is expected to remain unaltered by the turbidity plume and their life history strategies are conducive to rapid recolonisation or regrowth following disturbance. In addition, the abundance of *Halophila* (the dominant seagrass) and *Sargassum* (the dominant algae) in the region are known to be highly variable in space and time independent of human activities. Filter feeders occur, but are predominantly located to the north of the impacted area in the ZoI. As such, most filter feeders are predicted to remain unaffected by dredging.

Table 7-1 outlines the approach to managing water quality to achieve the EPOs related to seagrass, filter feeders and macroalgae. These EPOs will be assessed based on the data collected for the Marine State of Environment: SoW.

Table 7-1: Management and Monitoring Measures to reduce Impacts to Seagrass, Macroalgae and Filter Feeders

Management Area:	**Management of Subtidal Benthic Communities (Seagrass, Macroalgae and Filter Feeder)**
Performance Objective:	To manage impacts from dredging to achieve the Environmental Protection Outcome as follows: *The Proponent shall ensure the construction of nearshore and offshore marine facilities achieves the following environmental protection outcomes:* *ii. no irreversible loss of, or serious damage to, filter feeder habitats outside of the Zone of High Impact shown in Figure 5.8;* *iii. no irreversible loss of, or serious damage to, seagrass, macroalgal and other benthic habitats outside of the Zone of High Impact shown in Figure 5.9* *vi. no detectible net negative change from the baseline state of filter feeder, seagrass, macroalgal and other benthic habitats determined by implementing Condition 7, outside of the Zones of High and Moderate Impact,* shown in Figure 5.8 and Figure 5.9*, whichever figure is relevant to the habitats above.*
Preventative Management:	There is no preventative specifically for seagrass, macroalgae or filter feeders however the management measures detailed in Section 6.0 for water quality are also predicted to afford protection to seagrass, filter feeders and macroalgae.
Monitoring	*Responsive Water Quality Monitoring* Responsive water quality monitoring and associated management triggers will be implemented to manage any potential impacts that increased turbidity may have on seagrass. Water quality measurements will be logged at approximately 30 minute intervals at seagrass communities throughout the duration of the turbidity-

	generating activities which are part of the construction of the nearshore and offshore facilities. Water quality monitoring will be achieved through the use of an *in-situ* water quality data logging instrument. Refer to Section 6.3 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.2.3. ♦ Used to assist in inferring the cause of any observed impacts to benthic communities. *Verification Monitoring* Monitoring will consists of: ♦ Quarterly routine monitoring of seagrass (Figure 7.2) to provide verification of the appropriateness of water quality criteria. ♦ Verification monitoring which will be triggered by an exceedence of the Level 2 management trigger at the seagrass location (Figure 7.2) at which the triggers were exceeded. Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs. *Habitat Monitoring* ♦ Pre/during/post surveys assessments of seagrass, macroalgae and filter feeders under the State of the Marine Environment: SoW.
Responsive Management	**Potential Management Actions** Management measures will be implemented once a Level 2 trigger is exceeded (see Section 6.2.3), dependent on the applicability of the measure and the potential for severity of environmental impact. Notably, no change in dredging or disposal operations may be required to reduce potential environmental impacts attributed to the trigger if, for instance, metocean conditions change and water quality returns to a level which does not lend itself to concern, especially if below the trigger intensity. The chosen measure(s) will take into account current and forecast metocean conditions, proximity of non-reef formations, flexibility in the dredge execution plan and the adaptive management strategy. While the optimal measures will be employed given the specific situation, additional measures will still be available in case the initial measures are found to be ineffective. Management measures that may be considered include: ♦ Optimising the monitoring programme including the monitoring frequency, parameters, and area to more closely scrutinise the cause and possibility of recurrence of the exceedence ♦ Refining dredging or placement operations based on sediment plume model results and current and forecasted metocean conditions. Implementing the refined dredging and/or disposal operations based on sediment plume model results, current and forecasted metocean conditions, and the soil model until the exceedence resolves. These refined operations may include modifying: ▪ Scale of operations and resulting potential area of influence ▪ Location of dredging, type of dredging technique, overflow, and/or dredge spoil placement activities ▪ Dredging practice including overflow operations and production rate and/or volume ▪ Disposal technique including discharge rate and/or volume ▪ Redefining transit routes

	▪ Reduce \ dredging and/or material placement activities.

7.2 Management Strategy for Seagrass, Macroalgae and Filter Feeders

EPOs have been developed for seagrass, macroalgae and filter feeders, to reduce impacts during the proposed dredging and spoil disposal programme (Condition 6.1). The EPOs relating to the management of relevant benthic communities are summarised below.

Within the ZoHI (as per Figure 4 of Schedule 1 of MS 873; Figure 5.9), only macroalgae are present. The loss of macroalgae in the ZoHI is due to direct removal within the shipping channel. Therefore these impacts are irreversible and as such there is no management within this zone.

Within the ZoMI, modelling interrogations predict that some seagrass and macroalgae may suffer partial mortality which is likely to recover within five years. EPOs described within Condition 6.1 require that no permanent losses of the filter feeders, macroalgae and seagrasses occur within this Zone as per EAG No.7 (EPA 2011).

Within the ZoI, modelling interrogations predict that no detectable impacts to benthic communities will occur. The EPOs described within Condition 6-1 for the ZoI requires no net detectable impacts to filter feeder, seagrass or macroalgae.

The management triggers (based on water quality criteria) outlined in Section 6.0 are predicted to afford protection to seagrass, macroalgae and filter feeders. Justification for this assumption is discussed below.

The most common genus of seagrass in subtidal areas off Onslow is *Halophila* (mostly *H. minor* and *H. spinulosa*). However, cover of seagrass is low, with average cover only 1.3% across all transects sampled (RPS 2012). Seagrass within the Wheatstone Project area were most abundant in depths less than 10m (RPS 2012). The transect zones with the highest percent cover of seagrass were S4 (depth range 8-10 m) and S10 (depth 5-6 m). In areas at water depths ranging from 8-10 m, seagrasses are believed to peak in abundance in summer and senesce in winter (RPS 2012). This pattern differs from inshore areas where seagrass abundance is greatest in winter. In summer, seagrasses in inshore areas die-off naturally which is thought to be attributed to elevated turbidity levels caused by resuspension and river discharge.

As stated earlier, the water quality criteria prepared for the preservation of coral during the Wheatstone dredge programme (Section 6.2.3) should afford protection to seagrasses. This prediction was based on a comparison between the predicted light levels that the Level 3 water quality trigger would maintain at the seafloor and published minimum light requirements for *Halophila* (Duarte 1991; Schwartz et al. 2000). Based on Duarte (1991) and Schwartz et al. (2000) the light requirements for *Halophila* is estimated to range from 5–16% of surface irradiance over a range of temporal scales which equates to minimum light requirement of approximately 1.6–4.5 $E/m^2/d$. Some researchers have suggested that *Halophila* can tolerate even less light levels. Collier and Waycott (2009) reported minimum light requirement (expressed as % of surface irradiance) for *Halophila* ranging from 1-6%. Fourqurean et al. (2003) reported that *H. decipiens* in Florida Bay had a minimum light requirement ranging from <1-5%.

To relate minimum light requirements to seagrass resources in the Wheatstone area, the average light levels that would be afforded by the Gorgon derived water quality criteria for two depths and for two seasons were calculated (Table 7-2). These two depths (6 m and 9 m) were chosen because they encompass the depth range of a large proportion of mapped seagrasses in the Wheatstone area. The average light levels associated with the water quality criteria proposed for Wheatstone were predicted using light level data recorded by loggers at two Gorgon sites (6 m and 9 m depth) that experienced elevated turbidity during dredging at levels used to develop the water quality criteria proposed for Wheatstone.

Table 7-2: Predicted Average Light Levels to be afforded by the Water Quality Criteria for Two Depths and Two Seasons

Depth (m)	Summer Mean (min to max)	Winter Mean (min to max)
6	4.8 $E/m^2/d$ (0.04 to 13.11)	2.8 $E/m^2/d$ (0.09 to 9.03)
9	2.7 $E/m^2/d$ (0.13 to 6.73)	0.74 $E/m^2/d$ (0.001 to 3.76)

Compared with the light requirements for *Halophila* estimated from Duarte (1991) and Schwartz et al. (2000), the water quality criteria are predicted to afford seagrass protection in summer, since average light levels will be maintained above 1.6 $E/m^2/d$ at both shallow (6 m) and deeper (9 m) seagrass habitats. During winter, when surface irradiance is naturally lower, triggers are predicted to maintain average light levels above the minimum light requirements at shallow seagrass habitats. However, in the deeper seagrass habitats during winter, the range of available light will encompasses the minimum light requirement for *Halophila* as predicted by Duarte (1991) and Schwartz et al. (2000). Maintaining adequate light levels for deeper seagrasses during winter may be less critical because of a potential tendency for natural senescence of *Halophila* commencing late summer in response to a natural decline in light levels to below minimum requirements, as observed in Queensland (Chartland et al. 2008) and potentially in northern Western Australia (Straits Salt 2004; DEC 2009). In the Project area, RPS (2012) reported seagrass to be very low abundance in September compared with December, and thus, it is also likely that *Halophila* may undergo a natural period of senescence during winter. However, it is acknowledged that there is currently an incomplete understanding of the temporal dynamics of seagrasses within the Wheatstone Project area and this issue will be reviewed when further data is available. In addition, light monitoring and verification monitoring within seagrass habitat (Section 6.3.3) will assist in determining the effectiveness of the triggers in affording protection to seagrasses.

The minimum light requirement for macroalgal functional groups ranges from 0.13 to 1.95 $E/m^2/d$ (Browse 2010). In general the minimum light requirements for macroalgae are lower than those for seagrass, but are likely to be highly variable with season, species and morphology. However, the water quality criteria developed for the Level 3 management trigger within the ZoI will retain light above 2.7 $E/m^2/d$, which is above the minimum light requirement for macroalgae. This predicted light level is based on a corresponding depth of 8.9 m (the depth of the Gorgon site from which the criteria were derived). However, macroalgal beds within the Wheatstone Project area are relatively shallow and therefore, light levels will be far greater at these depths if water quality is managed to management trigger levels. Therefore, the water quality criteria should afford adequate protection for macroalgal communities.

Little is known of the response of filter feeders to dredging impacts. Until more data becomes available, the tolerance limits of filter feeders have been assumed to be similar to that of corals, upon which the water quality criteria are based. Providing this assumption is justified, the proposed water quality criteria derived for Wheatstone should also provide protection for filter feeders from turbidity impacts, since the turbidity water quality criteria will perform a dual role of managing impacts associated with light reduction and sedimentation (see Section 6.0). However, verification monitoring will assist in determining the effectiveness of management triggers in affording protection to filter feeders, and triggers may be refined based on the results of this monitoring if deemed appropriate.

7.2.1 Responsive Management

Responsive management of the dredging activities will occur through the use of management triggers based on the water quality criteria developed for the monitored reef formations, as described in Section 6.2.3. A non-reef (seagrass) formation site will also be used to responsively manage dredging activities and verification monitoring will occur in seagrass habitat when a Level 2 trigger is exceeded at Hastings Shoal or Ashburton Island. The relevant management triggers and management responses for seagrass are detailed in Table 7-3 and illustrated in Figure 7.1. Responsive management of seagrasses in inshore waters east of Ward Reef will be implemented between 01 May and 30 September, when abundances are predicted to peak, but not between 01 October and 30 April when seagrasses are predicted to die-off naturally due to high natural turbidity. These inshore seagrass communities frequently experience high elevations in turbidity from plumes emanating from the Ashburton River during summer as well as frequent elevations from natural resuspension in coastal waters that is greater during summer months. In response to this high natural turbidity during summer months, it appears that seagrasses naturally die-off in nearshore waters during this time (RPS 2012).

Table 7-3: Management Triggers and Required Responses for Seagrass Locations within the Zone of Influence

	Trigger Level	
	Level 1	**Level 2**
Water Quality Criteria	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 10 days out of a 20 day rolling assessment period. OR **Moderate criteria** Daily median turbidity >3.2 x background at turbidity and >5.08 NTU for no more than 4 days out of a 20 day rolling assessment period.	**Chronic criteria** Daily median turbidity >3.3 x background turbidity and >2.62 NTU for no more than 20 days out of a 40 day rolling assessment period. OR **Moderate criteria** Daily median turbidity >3.2 x background turbidity and >5.08 NTU for no more than 8 days out of a 40 day rolling assessment period.
Management Actions	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Check predictive model for interpretation. Investigate potential management responses that could be implemented if elevations continue to occur.	Identify the events that led to the trigger being exceeded and whether they are likely to continue to occur or reoccur. Implement management, where reasonably practicable, to reduce levels below the trigger value. Continue monitoring and assessing water quality to ensure the effectiveness of the measures applied. Alter management response if not effective.

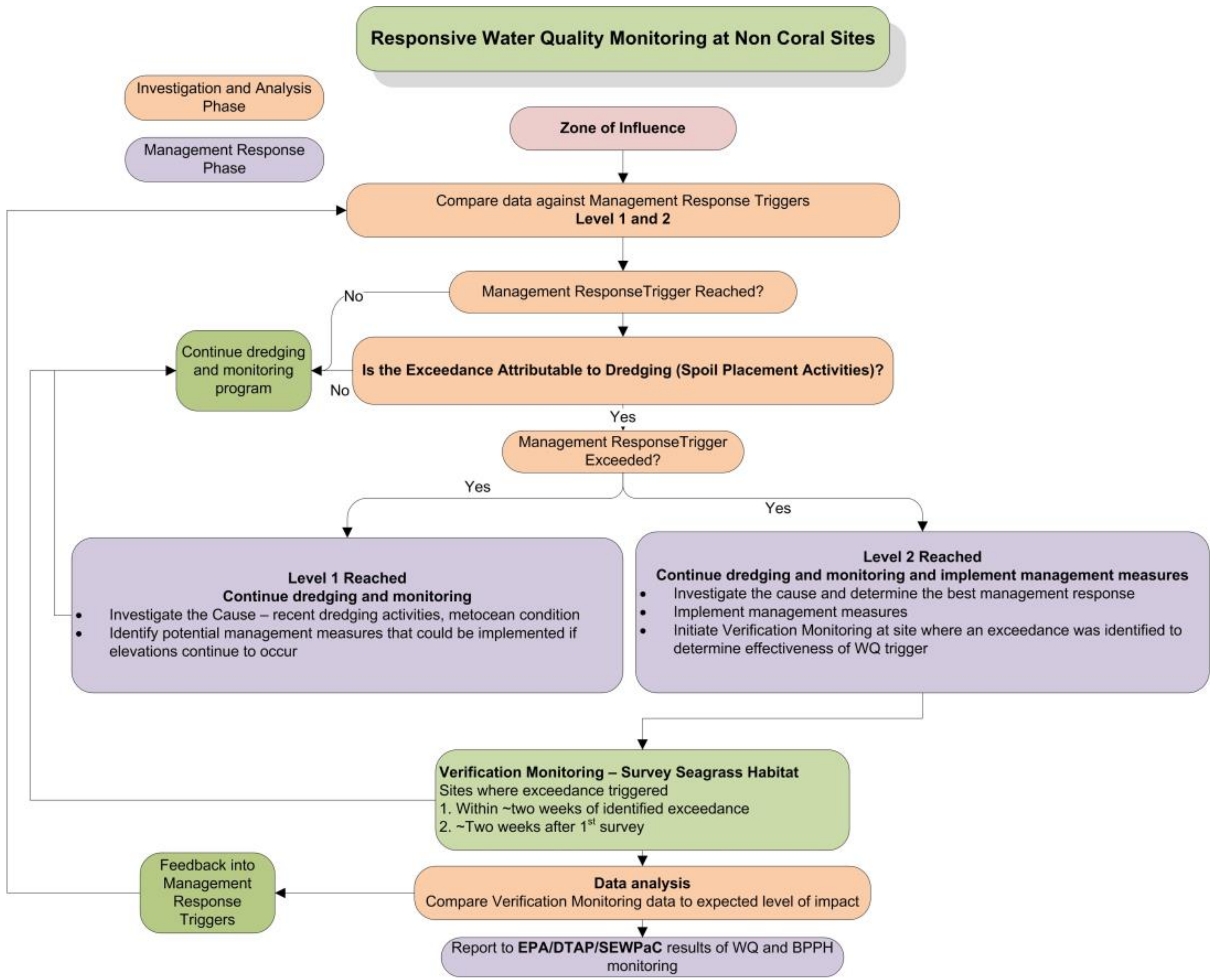


Figure 7.1: Seagrass Responsive Management and Monitoring Procedures

7.3 Monitoring Strategy for Seagrass, Macroalgae and Filter Feeders

7.3.1 Responsive Monitoring

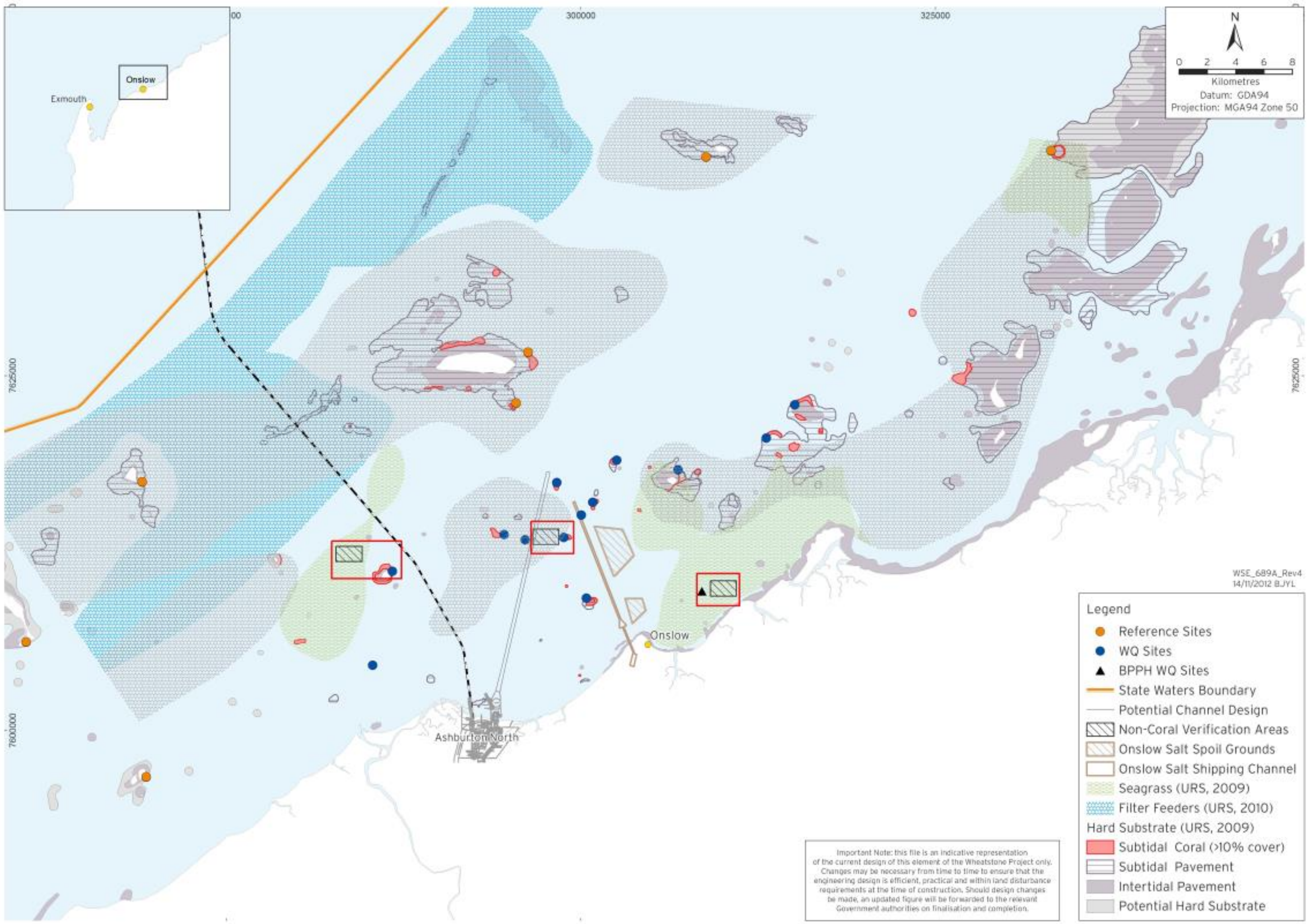
To allow responsive management (as detailed in Section 7.2.1) a responsive monitoring programme will be undertaken to allow adaptive management of the dredging and disposal activities.

Water quality will be collected from one non-reef (seagrass) monitoring site in mapped seagrass habitat and verification monitoring will occur at two additional seagrass habitat locations (see Figure 7.2) as per the following:

- **Seagrass site east of Ward Reef (dedicated water quality logger):** water quality at this site will be managed to the Level 1 and Level 2 management triggers. Seagrass habitat will be monitored when a Level 2 management trigger is exceeded and during the routine verification monitoring, which occurs quarterly (see Section 6.3.3). As described in Section 7.2.1, water quality at this site will not be required to be managed during 01 October to 30 April.
- **Seagrass site immediately west of Hastings Shoal (water quality logger adjacent to Hastings Shoal):** water quality at this site will be managed as detailed in Section 6.0, however the adjacent seagrass habitat will also be monitored when a Level 2 management trigger is exceeded and during the routine verification monitoring, which occurs quarterly (see Section 6.3.3).
- **Seagrass site north west of Ashburton Island (water quality logger adjacent to Ashburton Island):** water quality at this site will be managed as detailed in Section 6.0, however the nearby seagrass habitat will also be monitored when a Level 2 management trigger is exceeded and during the routine verification monitoring, which occurs quarterly (see Section 6.3.3).

The locations illustrated in Figure 7.2 are indicative only at this stage, and the final placement of the water quality logger and verification areas will be based on the final water quality and seagrass baseline surveys.

The variables, data collection, methods and data analysis will be the same as described in Section 6.3.1.



Note: Red outline indicates the potential location of water quality loggers which will be used to manage impacts to adjacent seagrass habitat

Figure 7.2: Indicative Location of Non-reef (seagrass) Monitoring Locations in the Responsive Water Quality Monitoring Programme

7.3.2 Habitat Monitoring

This section is intended to be a duplication of the seagrass, macroalgae and filter feeder monitoring as detailed in the SoW for the State of the Marine Environment Report and may be amended from time to time if the SoW for the State of the Marine Environment Report is amended, the same amendments will be taken to be made as part of the DDSPEMMP and an updated copy will be prepared and provided to EPA and DOTE as soon as practicable.

If the SoW for the State of the Marine Environment Report amendments also requires a review of the DDSPEMMP the review will be in accordance with Section 11.0. The data collected as part of the State of the Marine Environment Reports will be used to assess achievement of Conditions 6-1 (ii), (iii) and (iv). In the event of any inconsistencies or differences between the SoW for the State of the Marine Environment and this document, the SoW for the State of the Marine Environment takes precedence to the extent of any difference or inconsistency.

The potential for detection of permanent loss of BPP that might be attributed to the effects of dredging or material placement will be assessed through a monitoring programme. This monitoring programme is designed to detect changes in the abundance of BPP and changes in the underlying habitat using a before, during and after impact design and with controls if available. More specifically, BPP will be surveyed mid-way through the dredging programme and post-dredging to establish recovery of any affected biota. During each monitoring period, sampling will also be undertaken at increasing distances from the source of impact (gradient sampling approach) to help establish the spatial scale of impact and allow a cause-effect relationship to be investigated. A standard BACI (Before/After/Control/Impact) sampling design is not proposed because there are limited seagrass, macroalgae and filter feeder communities which are not expected to be influenced by dredging activities that could be used as ‘controls’ (references). Baseline data was collected to describe how the abundance and distribution of these BPP change naturally through time. Habitat monitoring, using PSD as an indicator, was also undertaken to assess if impacted BPP will be able to recover following cessation of dredging.

7.3.2.1 Location and Establishment of Survey Sites

During capital dredging, there will be two dredge programmes with the potential to cause indirect impacts to seagrass, macroalgae and filter feeders: the navigation channel (including the turning basin, MOF and tanker berths) and the trunkline dredge programmes. Elevated turbidity levels originating from these two programmes potentially threaten seagrasses and other benthic communities in adjacent areas. Modelling used to predict the trajectory and fate of the plume during dredging suggest that the plume could extend up to approximately 80 km west and 40 km east of the channel (Section 8.3 Draft EIS/ERMP). The locations for the seagrass, macroalgae and filter feeder surveys for the 2011 survey period are shown in Figure 7.3. Figure 7.4 illustrates the sampling locations undertaken in 2012 and will form the basis for the mid-term and post development surveys. An explanation for the survey designs in both years is given in Section 7.3.2.4.

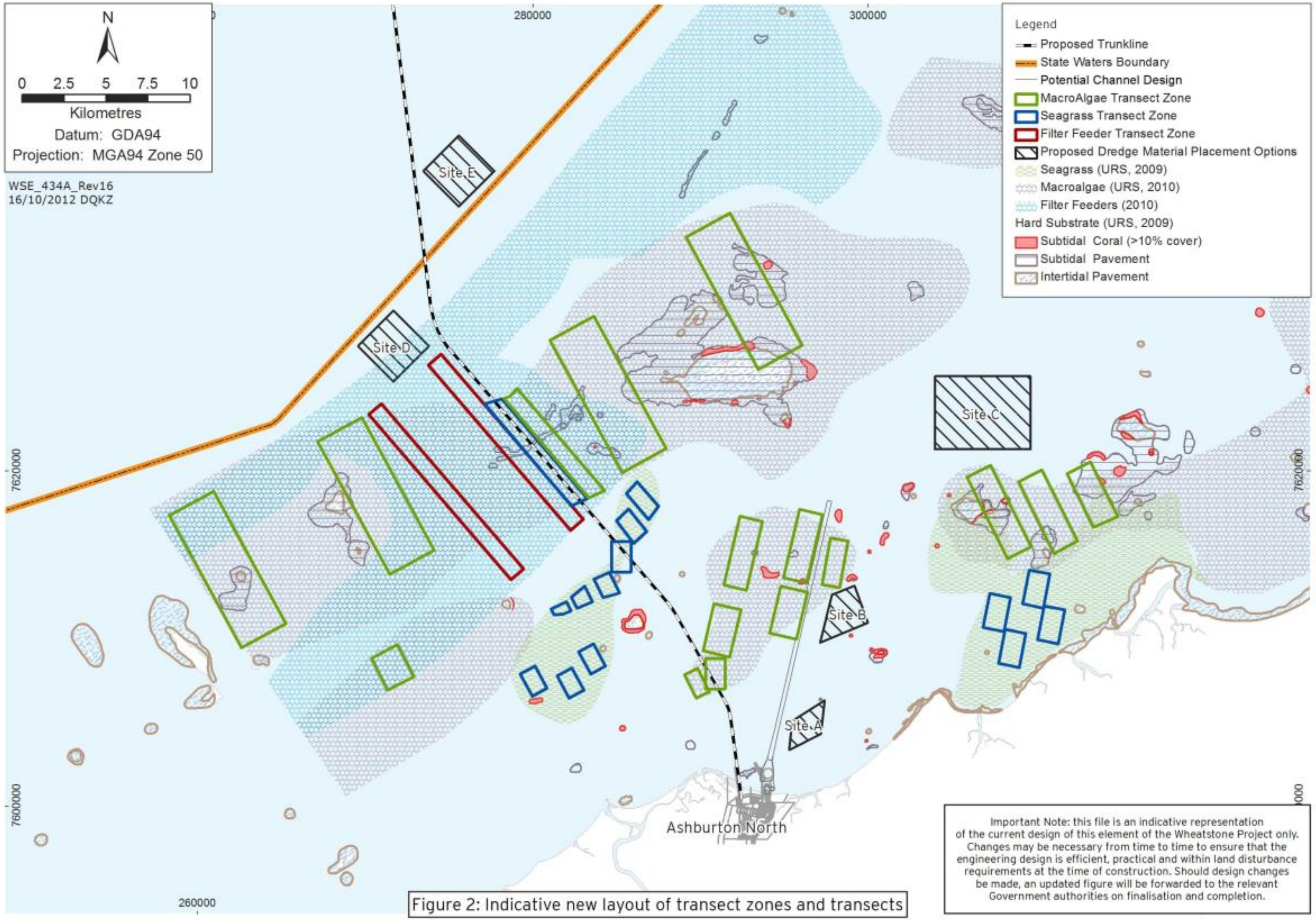


Figure 7.3: 2011 Survey Locations of the Seagrass, and Filter Feeders Transects

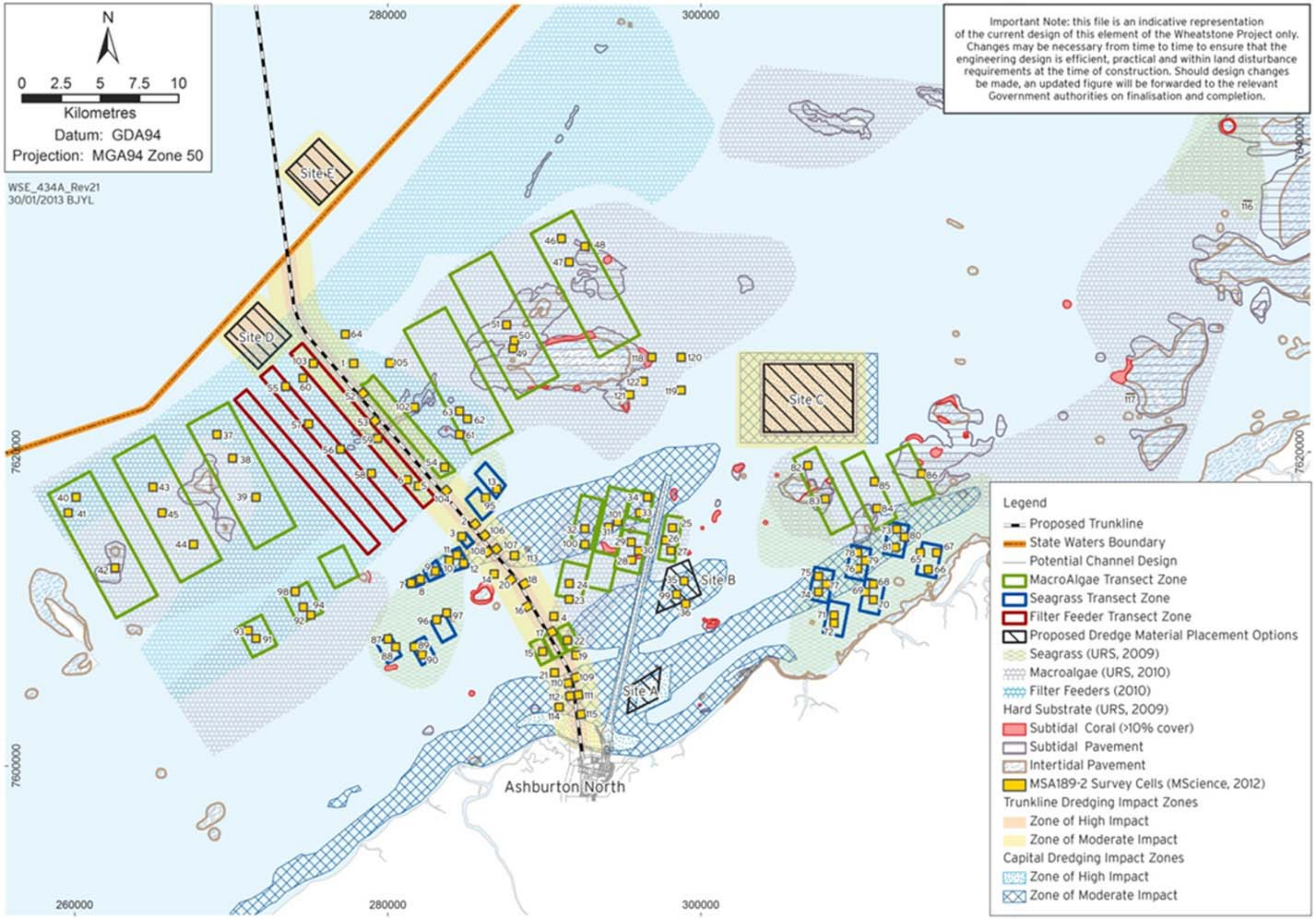


Figure 7.4: 2012 Survey Locations of the Seagrass, Macroalgae and Filter Feeders Transects

7.3.2.2 Variables

In order to monitor any changes over time, and differentiate between natural and dredging impacts, seagrass, macroalgae and filter feeders will be sampled with the following information recorded:

- Percentage cover
- Above ground biomass
- Below ground biomass
- Seed type

These variables have been selected to identify changes in seagrass, macroalgae and filter feeders. These habitats vary naturally and therefore the baseline should provide an understanding of the expected natural variability, both spatially and temporally. This is required as the BPP may be influenced by the dredge operations.

7.3.2.3 Sampling Design

A gradient approach based on distance from the channel and trunkline dredging footprints is proposed (at this stage) to allow an evaluation of the potential changes to seagrasses, macroalgae and filter feeders at increasing distances from the source(s) of disturbance. This sampling approach may be necessary, particularly for seagrasses, given the lack of appropriate control (reference) sites due to the modelling prediction that the turbidity plume could, at some stage during dredging, extend 80 km west and 40 km east of the dredge footprint. A traditional BACI sampling approach (Underwood 1994) relies on the fact that controls are close enough to the disturbance so that the control is comparable to the natural variability of the disturbed environment and yet far enough away that the control site is not affected by the disturbance (Ellis and Schneider 1997). Consequently, if ‘true’ control sites are required these need to be located > 80 km west and > 40 km east of the dredge foot print. Such distant sites are unlikely to share similar hydrodynamic conditions and community types to the putative impact sites, thus compromising their utility as control sites.

However, it may be possible for suitable reference sites for seagrass, filter feeders and macroalgae to be established immediately outside, or just within, the outer boundary of the ZoI. Recent guidance from the EPA (EPA, 2011) has assessed that it may be possible to use control sites from within the ZoI as long as these sites are infrequently influenced. If the communities at the control sites are found to share similar characteristics to those communities predicted to be impacted (e.g. similar taxa composition and structure), they might serve as suitable control sites, thus allowing a BACI design to be used for these BPP. This will be reviewed during the initial baseline surveys.

Gradient sampling approaches have been adopted previously by researchers (e.g. Ellis and Schneider 1997) where disturbances are reliably predicted to attenuate with distance from the point source of disturbance (e.g. drilling operations and sewage outfalls) and in situations where the aim is to measure precisely the spatial scale of impact. With the proposed gradient approach, inference is not based on a comparison between control and impact sites; rather it is based on the level of impact with increasing distance from the source of impact (Ellis and Schneider 1997) which, in this case, is the dredge footprint. The impact hypothesis would be supported if the level of impact to benthic primary producers decreased, on average, with increasing distance from the disturbance area. Ellis and Schneider (1997) tested the gradient approach against a randomised approach for detecting certain impacts in the marine environment and found that the gradient approach was more powerful at detecting changes in benthic abundance than the control impact design. An obvious weakness of a gradient approach is that inference is based on correlations, which do not necessarily infer causation. Abundances of many marine organisms are naturally correlated with environmental gradients which may make it difficult to separate out the effects of human disturbance from natural agents of disturbance. However, inferential uncertainty in these instances can be reduced by adopting approaches such as levels-of-evidence (Fabricius and De'ath 2004).

7.3.2.4 Sampling Approach

Three benthic communities will be investigated under this scope: seagrass; macroalgae and filter feeders. It should be noted that seagrass in the area is sparse and patchy and the dominant genus recorded, *Halophila*, is ephemeral and as such their abundance varies greatly over short-term temporal scales, making such biota types difficult to monitor. This SOW includes above and below ground monitoring for seagrasses which may, to some extent, counter this issue.

Macroalgae is also ephemeral and difficult to monitor due to the seasonal changes in cover and biomass. Filter feeders are relatively unknown and are problematic to monitor due to the lack of scientific knowledge on which variables can be reliably used as key indicators of the condition of filter feeder habitats. Given the lack of knowledge about the abundance and distribution of seagrass, filter feeder and macroalgae in the survey area, it was necessary to undertake a survey in 2011 to achieve two goals:

1. Obtain baseline (2011 combined with 2012 would provide baseline over two years).
2. Provide data to optimise the 2012 baseline survey design so that it will allow a rigorous assessment of the EPOs.

For these reasons, the sampling approached used in 2012 was slightly different from that used in 2011, and thus, both are described separately below. Importantly, the 2012 methods will form the primary basis for the mid-term and post development surveys.

7.3.2.5 2011 Surveys

The following description relates to the surveys in September and December 2011.

Transect zones

Transect zones were defined based on the described gradient approach for each biota type as shown in Figure 7.3. The transect zones covered seagrass, filter feeder and macroalgae habitat.

Transects and Sampling Method

Five transects, approximately 500m in length, were established within each of the Transect zones. Transects were fixed and recorded to return to the same locations to undertake repeat monitoring of each transect (the method used will depend on the level of accuracy required which will be appraised following the initial baseline survey).

The indicative transect zones were surveyed using a remotely operated towed video system consisting of a forward facing high definition video/stills camera with two light emitting diode (LED) arrays attached to an adjustable frame. The frame was deployed off the stern of the vessel using an A-frame and towed at a speed of approximately 1–1.5 knots and maintained at a target depth approximately 1 m above the seabed. Live towed video feed to the surface was used to undertake geo-referenced qualitative classification of benthic habitats types and substrates. This provided a qualitative record of the change in habitat and biota types over a longer distance to give broad scale coverage.

Over 22,000 still images were captured along the towed video transects during the survey. Images were of a standard size of approximately 3840 x 2160 pixels. A quality control process was used to ensure that only still images of suitable quality were used for analysis. After the quality control process was complete, a subset of 50 randomly selected images for each transect was used to estimate the percent cover of benthic habitats using Coral Point Count with Excel extensions (CPCe) 3.5 or similar. All images were analysed where less than 50 images were available.

Grab samples

Seagrass biomass within the seagrass transect zones was assessed using 34 sediment grabs. Sediment subsamples were taken from the grab sample (~300 mL each) for seed stock analysis. Each sediment sample was placed into a large graduated cylinder to calculate the total volume. Sediments were then wet sieved with a 125 µm sieve, as seeds of species in the region are >200 µm. All seagrass material was removed from the sample, identified to species and weighed onshore using a balance to obtain total biomass after being blot dried with tissue paper. Biomass samples were then frozen and transported to Perth where they were separated into above and below ground biomass and weighed.

7.3.2.6 2012 surveys

The 2012 September and December surveys were an extension of surveys conducted in September and December 2011. Whilst it was important to retain a similar design to the 2011 survey to allow for a comparison, there were some amendments made in the 2012 design. The 2012 design better targets habitats for survey, albeit in the same areas as the 2011 survey. Further, it incorporated a randomised design component to make it more conducive to assess achievement with the EPOs during the mid and post dredging surveys.

Transect Zone (hereafter Blocks)

Blocks for the 2012 survey were largely consistent with the 2011 survey. The terminology was changed to minimise confusion with the term ‘transects’ and ‘impact zones’ used in the Draft EIS/ERMP. Blocks in the 2011 survey were labelled according to the habitat target at each zone, based on the habitat mapping presented in the Draft EIS/ERMP (Chevron 2010).

Cells

Rather than use fixed transects within a block, each block was divided into 500 x 500 m grids (Figure 7.5). The Cells forming the grid then became potential sampling sites. One to three cells were selected from each block to be included in the survey, using a combination of randomised and targeted selection criteria. Firstly, a geospatial modelling environment was used to randomly select 40% of cells. From this selection, the cells to be sampled were finalised by querying habitat data to ensure that majority of cells had macroalgae, filter feeders and/or seagrass habitat present, based on past surveys.

The number of sample cells was then balanced over Zones of impact and depth. Consequently, additional cells were established outside of the blocks. All zones were designed to have 12 cells except the trunkline ZoMI, the Trunkline ZoHI and the area where channel and Trunkline ZoMI overlap (Table 7-4). These areas were too small so had a minimum of ten (10) cells. There are also cells in potential reference areas to meet the requirements of a BACI design. There was a bias to deeper transect areas as the large vessel used for surveys was unable to safely access areas shallower than -3 m. The design included 122 cells sampled during the baseline period, with the breakdown of the cells in the specific zones shown in Figure 7.5. The investigative cells (5 cells) will not be surveyed during the mid-term or post development surveys. The final number and location of cells surveyed during the mid-term and post development surveys may vary as a result of further knowledge gained from baseline studies.

Table 7-4: Number of Cells in each Zone of Influence/Impact, Depth Range and Habitat Class

Location / Zone	Number of cells
Channel	
Cells in Zone of Moderate Impact	12
Cells in Zone of Influence	12
Trunkline	
Cells in Zone of High Impact	10
Cells of Zone of Moderate Impact	10
Cells in Zone of Influence	12
Channel and Trunkline	
Cells in both Zone of Influence	12
Cells in Channel Zone of Moderate Impact and Trunkline Zone of Influence	12
Cells in Channel and Trunkline Zone of Moderate Impacts	10
Reference	
Cells in seagrass habitat (but inside Channel Zone of Influence)	10
Cells in macroalgae and filter feeder habitat	15
Cells Potential seagrass (outside channel Zone of Influence)	2
Investigative cells*	5
Total	**122****

*These cells will not be surveyed during the mid-term or post development surveys

**The final number and location of cells surveyed during the mid-term and post development surveys may vary as a result of further knowledge from baseline studies.

Transects and sampling method

Within each cell, benthic habitat data was recorded along five randomly placed (start and orientation randomised) 100 m transects (Figure 7.5). Randomising the transect orientation minimised the potential for transects to be aligned with, or across, any linear trends in the underlying habitat. Data was gathered along transects using a towed camera system, comprising a forward-facing video and a downward-looking still camera mounted on a frame. The frame was towed behind the boat, approximately 50 cm above the seafloor, while the boat was driven along the transect lines. The still camera was fixed on the underside of the sled, facing downward and recorded images approximately every three seconds. At the tow speeds of approximately 1.5–2 knots, a three second interval corresponds to approximately 2–3 m spacing between images.

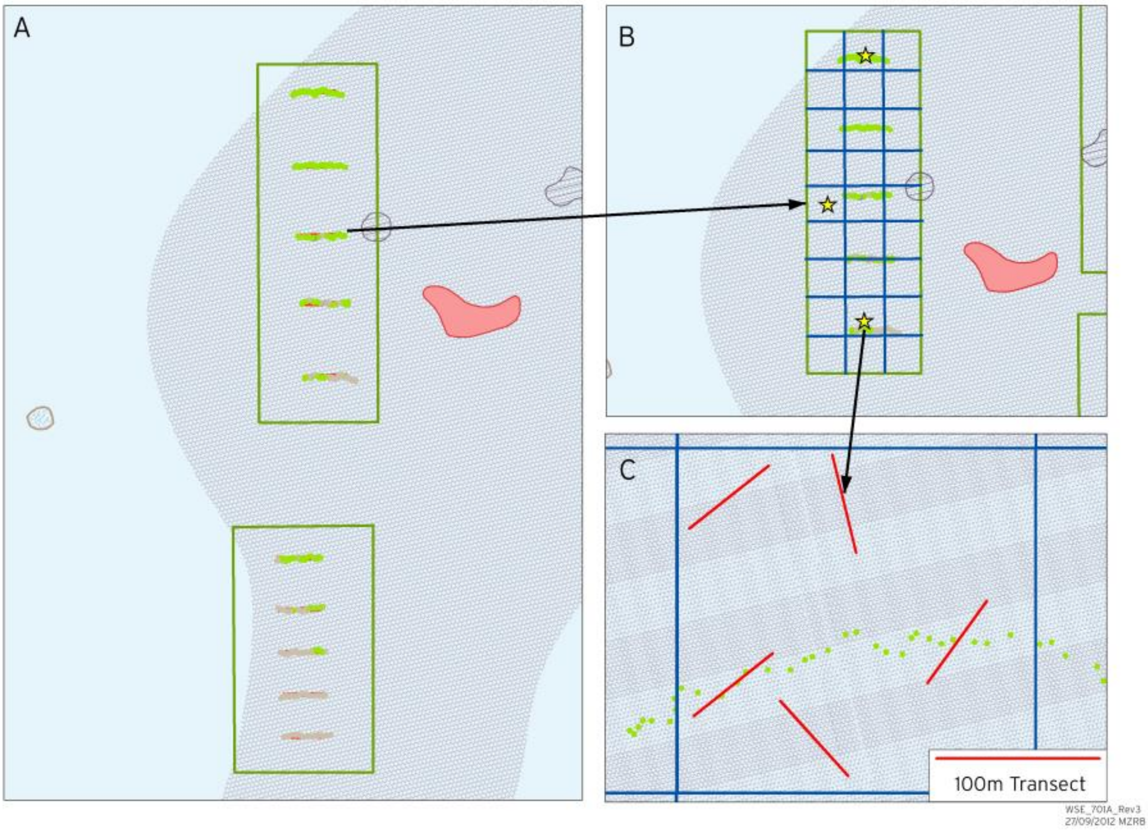


Figure 7.5: Conceptual Diagram Illustrating Division of Blocks into Cells and the Random Orientation of Transects within Cells

Grab samples

Sediment grab sampling for seeds were obtained from a range of locations (includes QA samples). Sampling was undertaken using covers on the grab and careful handling to minimise the loss of fines during sampling. On return from the survey, samples for seagrass seed samples were sent for analysis.

Seeds were quantified based on the method developed by Hammerstrom and Kenworthy (2003). Firstly, sediment was fractionated based on grain size. The sizes of *H. decipiens* seeds are 0.4–0.6 mm (Hammerstrom and Kenworthy 2003). Consequently, sediment samples were wet sieved in order to separate the sediment fraction ranging between 0.25 to 1 mm, ensuring all seeds were present in sediment analysed. Seeds were then removed from this fractionated sediment using a density separation technique. Briefly, five replicate sub-samples (2 cm^3) of the sieved sediment from each sample were placed in centrifuge tubes. Where there was not enough sediment collected from some sites for five replicate sub-samples, the entire sediment sample was used and volume of sediment recorded. This was then standardised to the 2 cm^3 samples. For each sub-sample, 10 ml of chilled Ludox (colloidal silica 40%) was added to each tube as the extract solution. Tubes were capped, shaken vigorously for 20 seconds and then centrifuged at 2500 revolutions per minute (rpm) for three minutes. Most inorganic sediment particles sink to the bottom, whilst organic matter (including seeds) floats at the top of the tube. The floating organic matter was then removed from the tube using a pipette, and transferred to a Petri dish, allowing the number of seeds to be counted under a dissecting microscope. The same or very similar approaches will be used for seed analysis during the mid-term and post development surveys to ensure consistency of results.

7.3.2.7 Timing and Frequency of Surveys

Sampling will be undertaken prior to commencement of dredging (baseline), mid-term of dredging and post development of dredging for all three biota types, but at different frequencies. Tropical seagrasses and macroalgae are known to vary in abundance seasonally (e.g. between dry and wet seasons in tropical Australia), but such patterns are not always predictable. The most likely period to detect these biota types is summer (December/January). Seagrasses and macroalgae are predicted to exhibit the greatest levels of natural variability warranting the greatest level of survey replication. Filter feeders are considered more stable in terms of their abundance and distribution and could therefore be sampled less frequently whilst still picking up any change in abundance due to natural disturbance events. Percentage cover will be sampled in all surveys. Biomass and PSD will be sampled on a less frequent basis.

7.3.2.8 Treatment of Survey Data

The approach to detect impacts involves the use of an appropriate statistical test (e.g. t-test, ANOVA or similar approach). The method for analysis will be dependent on the location of suitable reference sites for assessment of net changes. If reference sites are unavailable then a test for gross change will be carried out, using a t-test, or similar. Regression analysis can be applied to assess linear relationships, testing whether there is a change with increasing distance from the source of impact. If reference sites are available then net change can be established and an ANOVA approach can be used.

The detection of any changes with increasing distance from the source of impact will be used in an inference assessment, should any detectable change occur, which will also take into account any other potential sources of impact.

8.0 CORAL SPAWNING MANAGEMENT AND MONITORING

8.1 Background

Corals spawn through the release of gametes into the water column. Elevations in turbidity, such as those associated with dredge plumes, have the potential to reduce the fertilisation success of coral gametes and the survival of coral larvae (Gilmour 1999). As such, to manage the potential impacts of elevated turbidity on coral reproduction and therefore coral recruitment, Condition 6.11 (MS 873) requires that the proponent:

'*shall not conduct turbidity-generating activities which are part of the construction of nearshore and offshore marine facilities during the period 3 days prior to the predicted commencement of mass coral spawning, or as soon as mass coral spawning is detected if prior to the predicted time, and those turbidity-generating activities are to remain suspended for 7 days from the commencement of mass coral spawning unless it supplies peer-reviewed scientific evidence that if those turbidity-generated activities were to continue during coral mass spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs and the CEO provides a written exemption of those turbidity-generating activities from the requirement to cease over the period specified or alters the period that turbidity-generating activities must cease*.'

And Condition 11 (d) and (e) of EPBC 2008/4469 requires:

(d) A commitment to cease dredging activities at least 3 days prior to the predicted commencement of mass coral-spawning, or as soon as mass coral spawning is detected, if prior to the predicted time, and to only recommence dredging activities after at least 7 days have passed since the commencement of mass coral spawning unless 11 (e) applies.

(e) The Minister may approve in writing, a reduction in the period over which dredging must cease (refer Condition 11 d), if the person taking the action provides peer-reviewed scientific evidence that demonstrates that if dredging activities were to continue during mass coral spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.

Mass spawning events or synchronous spawning is when individual colonies of many different species release gametes simultaneously (Babcock et al. 1984). These events can vary in terms of how many species spawn at once (the extent of spawning) and also the proportion of individuals within populations of those species that spawn synchronously (the magnitude of spawning).

For the purposes of this Plan, an autumn mass spawning event is predicted to occur if at least 50% of females within the colonies sampled have mature eggs (or at least 40% in the event that a split spawning event is likely to occur; see Section 8.2). For hermaphroditic species this would mean that at least 50% of the colonies sampled were observed to have pigmented eggs. For gonochoristic species or genus-groups, the percentage of individuals showing pigmented eggs will need to be adjusted by the estimated sex ratio. For example, if 30% of gonochoristic species or genus groups were recorded as having pigmented eggs, and the sex ratio is assumed to be 50:50, then the percentage of females with mature eggs for gonochoristic species or genus groups within the sample would be adjusted to 60%. If histological assessments are undertaken, these can be used to determine the actual sex ratio by examining the number of males and females in the sample. In this case, the percentage of females with mature eggs would be adjusted by the actual sex ratio of the sample. However, for colonies where no eggs and no sperm were observed in histological assessments, a 50:50 sex ratio will be assumed for those colonies.

The above definitions are likely to capture the major spawning event for the year, assuming that most species spawn once per year, and increases the likelihood of actually detecting the defined spawning event, compared to a definition based on a lower proportion of species or colonies spawning (Styan and Rosser 2012).

A spring, dominant *Porites*, spawning event is predicted to occur if an assessment of *Porites* spp. corals indicates that >40% of samples contain mature gametes (stage IV or late stage III).

A summary of the management and monitoring measures associated with coral spawning is provided in Table 8-1.

Table 8-1: Summary of Management and Monitoring Measures to Manage Impacts to Coral Spawning

Management Area:	**Coral Spawning**
Performance Objective:	To achieve Condition 8-18 (MS 873) and Condition 11 (d) EPBC 2010/4469 *To not significantly impact the functional ecology of local and regional reefs by limiting interactions between dredging-related turbidity and a mass spawning event*
Management:	♦ Cessation of dredging operations during coral mass spawning events unless the CEO provides a written exemption under MS 873 Condition 6-11 and the Commonwealth Minister provides written approval under EPBC 2008/4469 Condition 11(e): ▪ If cessation of dredging is assessed as unnecessary (as approved by the CEO and Minister) management of dredging or disposal activity to ensure no significant effects on functional ecology of local and regional reefs will be undertaken by changing the dredging location
Monitoring:	♦ Coral Spawning Prediction Monitoring (Section 8.3)

8.2 Management Strategy for Coral Spawning

The first step in the management of dredging activities to minimise interaction with mass coral spawning is to identify potential mass coral spawning events that may occur throughout the proposed dredge programme. The identification of potential mass coral spawning events is based on an examination of historical records and an understanding of the environmental factors that produce the most conducive conditions for successful spawning of corals. Typically, corals in the Pilbara region have been observed to spawn 6 to 10 days after the full moon during autumn each year (Simpson 1985; Simpson et al. 1991; Rosser and Gilmour 2008; Gilmour et al. 2009). However, separate multi-species spawning events have also been reported in the region during spring to early summer (Rosser and Gilmour 2008).

Recent studies have been undertaken to investigate the seasonality of coral reproduction in the Dampier Archipelago (Baird *et al*, 2011). This research has confirmed that, as stated above, coral spawning predominantly occurs in the autumn with a small proportion of species (7%) (examined *in situ*) active in spring and summer. Species noted to spawn in spring included three *Acropora* species, *Favites flexuosa*, *Porites* spp. and possibly *Turbinaria mesenterina*. Spring spawning events were found to be much smaller than those previously documented in northern WA where up to 16 *Acropora* species spawn in spring. Studies have indicated that typically there is only one gametogenic cycle per colony in each year (Rosser & Gilmour, 2008; Baird *et al*, 2011). This suggests that typically the majority of corals will either spawn in autumn (with the exception of a few species) or not at all for that year. There is currently limited understanding of spring spawning on reefs within the Project area, although *Porites* spp. which are known to spawn in spring in the Pilbara region (Baird et al. 2011) are common on some reefs within the Project Area.

The sampling of corals for spawning predictions will target species or genus-groups known to predominantly spawn within the season sampled: autumn or spring, to increase the likelihood of detecting a spawning event. Within these groups known to spawn in a given season, a wide range of species will be sampled haphazardly, rather than targeting a few individual species, according to recommendations of Styan and Rosser (2012).

Table 8-2 lists potential coral spawning windows in the region during capital and clean-up dredging works, based on a knowledge of spawning periods for corals at similar locations, including Dampier (Simpson 1985), Barrow Island (Rosser and Baird 2009), and Scott Reef (Gilmour et al. 2009). The actual likelihood of a mass spawning event occurring within these potential windows will not be known until pre-spawning surveys are undertaken to examine the stage of maturity of gametes in coral samples (see Section 8.3 for details of monitoring).

Once a mass coral spawning event is predicted to occur in an upcoming spawning window (Table 8-2) it will be assumed that corals will spawn during that window and no further coral spawning assessments are required for that season. If a mass spawning event is not predicted to occur during the upcoming window, further monitoring is required prior to upcoming spawning windows during that season.

However, in stating the above, if there is indication that a split mass spawning event is likely in autumn, and the sampling prior to the spawning window indicates that >40% to < 70% of colonies sampled during autumn contain mature gametes, the potential for a split mass coral spawning event in March and April will be predicted to occur, requiring management of dredging around the March spawning window. In this event, an assessment would again be required prior to the subsequent April spawning window and if >40% of colonies sampled contain mature gametes this would reaffirm the potential of a mass split coral spawning event between March and April, requiring management of dredging during April in addition to March. This approach would increase the likelihood that two smaller ‘mass’ spawning events would be captured.

However, if >70% of colonies sampled contain mature gametes it will be assumed that a single mass coral spawning event is likely to occur in the upcoming window, requiring management of dredging during that window (pending exemption), and no further assessments will be required for subsequent windows during that spawning season to avoid unnecessary damage to corals.

During the spring spawning season if sampling of *Porites* corals indicates that >40% of samples contain mature gametes (stage IV or late stage III), a dominant *Porites* spawning event will be predicted to occur in the next spawning window, requiring management of dredging. Once a dominant *Porites* spawning event has been predicted to occur in the next spawning window, it will be assumed that *Porites* will not exhibit another significant spawning event and no further assessments will be required for subsequent windows during that spawning season, to avoid unnecessary damage to corals.[20]

Any identified mass coral spawning period will result in the suspension of dredging activities during the 3 days prior to the predicted commencement of mass coral spawning and activities will remain suspended for 7 days (since the commencement of spawning is difficult to define, it will be considered here to be 7 days from the 1st day of the spawning window), unless the CEO provides a written exemption under MS 873 Condition 6-11 and the Commonwealth Minister provides written approval under EPBC 2008/4469 Condition 11(e).

However, Chevron Australia can seek an exemption from the requirement to cease dredging for 10 days based on peer-reviewed scientific evidence that if those turbidity-generating activities were to continue during mass spawning events, any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.

8.2.1 Approved Exemptions

Following provisions made within MS 873 Condition 6-11 and EPBC 2008/4469 Condition 11 (e), Chevron Australia submitted requests for approval from DOTE and the OEPA for specific dredging activities to continue during mass coral spawning, based on peer-reviewed scientific evidence that any effect, if it were to occur, would not significantly impact the functional ecology of local and regional reefs.

Autumn 2013

The CEO of the OEPA granted an exemption, on 1 March 2013, from the requirements of Condition 6-11 of MS 873, for turbidity-generating activities associated with the construction of nearshore marine facilities (as defined in Schedule 4 and shown in Figure 6 of MS 873) with disposal at offshore DSPS D and E to continue during the April and May predicted potential coral mass spawning periods (Table 8-3).

Spring 2013

The CEO of the OEPA granted an exemption, on 11 November 2013, from the requirements of Condition 6-11 of MS 873 and the Minister granted an exemption, on 23 October 2013, from the requirements of Condition 11d, in accordance Condition 11e, for turbidity generating activities to be undertaken during October and November 2013 at the following locations:

- Navigation Channel: Trailer Suction Hopper Dredge (TSHD), Cutter Suction Dredge (CSD) and/or Back-hoe Dredge (BHD) between the shoreline and Kilometre Point (KP) 1.5, with disposal at offshore DSPS D or E, including BHD disposal (only) at DSPS C
- Navigation Channel: BHD between KP 9.5 and KP 12.5, with disposal at DSPS C, D or E

[20] A decision will be made by Chevron to determine if assessments will continue for additional potential spawning windows should a dominant spawning event be triggered. In this decision, the benefit of improving our understanding of spawning in *Porites* will be weighed against avoiding unnecessary damage to *Porites* colonies through sampling.

Autumn 2014

In December 2013 Chevron Australia submitted a request to the OEPA and DOTE for a blanket exemption for turbidity-generating activities to occur in six individual proposed Dredge and Disposal Exemption Zones. The turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities proposed within Dredge and Disposal Exemption Zones and justification for the exemption requested are summarised in Table 8-2.

The CEO of the OEPA granted the blanket exemption, on 17 February 2014, from the requirements of Condition 6-11 of MS 873, for the activities and locations detailed in Table 8-2 during mass coral spawning events for the remainder of the dredging program.

The Minister granted an exemption, on 26 February 2014, from the requirements of Condition 11d, in accordance with Condition 11e of EPBC 2008/4469, for the dredging methods, activities and locations detailed in Table 8-2 during the autumn and spring mass coral spawning events in 2014.

Table 8-2: Turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities proposed to continue within Dredge and Disposal Exemption Zones

Wheatstone Project	Dredge Exemption Zones	Equipment	Disposal Exemption Zones
Navigation Channel	Nearshore Exemption Zone (shoreline to KP 1.5)	TSHD, CSD, BHD	Site D or E Site C (BHD only)
	BHD Navigation Channel Exemption Zone (KP 1.5 to the end of channel)	BHD	Site D, E or C

Spring 2014

The CEO of the OEPA granted an exemption for the dredging program, on 4 September 2014, from the requirements of Condition 6-11 of MS 873 and the Minister granted an exemption, on 22 September 2014, from the requirements of Condition 11d, in accordance with Condition 11e of EPBC 2008/4469. The exemptions provided the following relevant to spring spawning in 2014:

- No mass coral spawning prediction assessments are required to be undertaken
- Dredging may continue across the site during the October, November and December 2014 mass coral spawning events, with dredge disposal at DSPS D, E or C
- Dredge spoil disposal must be restricted to DSPS E during a ten day period during the December mass coral spawning event.

Table 8-3: Predicted Potential Coral Spawning Periods associated with the timing of Dredging

Dredging works estimated to occur from 2013 to 2018	
Full Moon	**Potential Spawning period**
2013	
April 26th	May 2nd to 6th
September 19th	September 25th to 29th
October 19th	October 25th to 29th
November 17th	November 23rd to 27th
2014	
March 17th	March 23rd to 27th
April 15th	April 21st to 25th
November 7th	November 9th to 12th
December 6th	December 8th to 11th
2015	
March 6th	March 12th to 16th
April 4th	April 10th to 14th
May 4th	May 10th to 14th
September 28th	September 30th to October 3rd
October 27th	October 29th to November 1st
November 26th	November 28nd to December 1st
2016	
February 22nd	February 28th to March 4th
March 23rd	March 29th to April 2nd
April 22nd	April 28th to May 2nd
September 16th (Effective Full Moon)	September 22nd to September 26th
October 16th	October 22nd to October 26th
November 14th	November 20th to November 24th
December 14th	December 20th to December 24th

2017	
March 12th	March 18th to March 22nd
April 11th	April 17th to April 21st
May 11th	May 17th to May 21st
October 5th (Effective Full Moon)	October 12th to October 16th
November 4th	November 10th to November 14th
December 3rd	December 9th to December 13th
2018	
March 2nd	March 8th to March 12th
March 31st	April 6th to April 10th
April 30th	May 6th to May 10th
September 25th	October 1st to October 5th
October 24th (Effective Full Moon)	October 31st to November 4th
November 23rd	November 29th to December 3rd

8.3 Monitoring Approach

The overall objective of Mass Coral Spawning Prediction Assessments are to predict, with a high level of confidence, whether a mass spawning event is likely to occur during upcoming predicted spawning windows. A pre-spawning survey is required prior to each identified potential mass coral spawning window to predict when a mass coral spawning event will occur. However, in the case where monitoring predicts corals will undergo a mass spawning event in the upcoming spawning window, it will be assumed that corals are unlikely to exhibit a mass spawning event again within that season (i.e. autumn or spring) and no further spawning prediction monitoring will be undertaken within that season.

8.3.1 Data Collection

8.3.1.1 Sampling Sites

At least three coral spawning assessment sites (depending on the potential area of vulnerability from sediment plumes at the predicted times of spawning and range of dominant and sub-dominant genera at those sites) will be selected adjacent to a subset of established reef formation monitoring sites within the ZoI and reference sites (as corals close to dredging operations may be stressed and have reduced participation in mass spawning events). It is expected that if a mass spawning event takes place, it will occur at a regional level and sampling of a subset of sites will sufficiently enable prediction of a mass spawning event. Additionally given that coral spawning monitoring requires the collection of coral samples, using a subset of sites for predictive monitoring will reduce the extent of impacts to coral communities.

Since coral cover is very low in the project area and still on a downward trajectory, it is not possible to identify which monitoring sites will be chosen for a given spawning assessment at this stage, and indeed, sites may need to be changed during dredging if low coral cover precludes sampling. Sites will be chosen prior to spawning assessments based on the coral communities present and their representation of coral communities that occur throughout the region. Sites will also be chosen based on whether they contain sufficient representative colonies of species that are likely to spawn in a given predicted spawning window.

8.3.1.2 Collection of samples

Species will be sampled haphazardly (following recommendations of Styan and Rosser 2012) from within genus-groups known to spawn in the given season within which sampling is to occur. One nubbin per colony (pieces of coral approx. 1–4 cm in length) will be taken from 60 to 100 colonies throughout the selected sample sites. Where possible, large colonies will be chosen to ensure the colony has reached sexual maturity. Coral corers or chisels will be used to collect samples from massive and plating corals, whereas branching coral samples will be removed by hand.

Coral colonies sampled will, where possible, be situated away from areas where routine monitoring is undertaken (e.g. away from reef areas in the water quality Monitoring Programme) to avoid interference and confoundment of datasets collected for other purposes.

Coral samples will be obtained up to two weeks prior to the predicted mass spawning window.

8.3.2 Data Analysis and Mass Spawning Prediction

Collected samples will be examined under a dissecting microscope in the field to assess reproductive status, as per Table 8-4. For most species, microscopic assessments can be used to assess the presence of mature eggs. However, for certain species, samples may be required to be histologically staged where the results from field dissecting microscope examination are inconclusive (for example, results that are within 10% of the spawning cut-off value, or where species are sampled that have very small eggs which cannot be adequately assessed using a dissecting microscope [e.g. *Porites*]). Additionally, some samples may require histological analysis in order to assess the sex of gonochoristic species.

Results will be pooled among sites and the percentage of females containing mature eggs (or adjusted percentage of females containing mature eggs for gonochoristic species; see Section 8.1) will be determined for the whole sample. This percentage will be compared to the definition described in Section 8.1 to determine whether management of dredging is required during the upcoming spawning window.

Table 8-4: Coral Reproductive Status Scoring Criteria

Egg Development Status Microscope	Egg Development Status Histology	Interpretation
Eggs present, pigmented (e.g. pink, purple, green) and irregular in shape	Stage IV, late Stage III	Spawning likely to occur in the upcoming spawning window
Eggs present, un-pigmented (white or opaque) and regular in shape	Stage III, late Stage II	Spawning unlikely to occur in upcoming spawning window but is likely to occur in the following spawning window
No eggs present	No gametes, Stage I or Stage II	Spawning will not occur in upcoming spawning window

In the case where monitoring predicts that corals will undergo a mass spawning event in the next spawning window, it will be assumed that spawning will commence at the beginning of the predicted spawning window and no monitoring will be undertaken during the spawning window (this reduces impacts to coral communities through over sampling).

8.3.3 Refinement of Coral Spawning Assessment Procedures

Since coral spawning assessments are within an emerging field, there are likely to be advances in methods and new information on timing of spawning at hand during the course of the Wheatstone dredging programme. Additionally, data collected during the Wheatstone coral spawning assessments may help to improve knowledge of the timing of spawning in certain genera. New information will be considered and may be used to refine coral spawning assessment procedures where the information improves confidence in the prediction of mass spawning events and management of dredging activities around these events. In particular, considering the known variability in the timing of spawning of *Porites* in the Pilbara region, information gathered on the reproductive activity (including, but not limited, to the timing of spawning and the proportion of colonies spawning each month during split spawning events) in this genus during Wheatstone dredging will feed into the refinement of coral spawning assessment procedures and management of dredging where confidence is improved. Following the collection of each year of field data the OEPA will be consulted in a review of those results and the applicability of existing management in the identification and management of ecologically significant spawning events in this genus.

9.0 MARINE FAUNA MANAGEMENT AND MONITORING

9.1 Background

Potential impacts on marine fauna as a result of the dredging activity include disturbance, entrainment, vessel strike and potential impacts on habitat. These are discussed in detail in the Conservation Significant Marine Fauna Interaction Management Plan. Management actions for Conservation Significant Marine Fauna (CSMF) from potential impacts from the physical presence of the DSPSs, due to dredge spoil placement activities associated with the nearshore and offshore marine facilities, are dealt with in this Plan. Management actions for potential impacts to CSMF from dredging activities, including entrainment and disturbance are also dealt with in this plan. Other potential impacts from the construction and operations of the Project are dealt with in the Conservation Significant Marine Fauna Interaction Management Plan.

Table 9-1 provides a set of the management measures to be applied to minimise impacts on marine fauna from dredging and placement activities in State and Commonwealth waters. Management and reduction of potential impacts to habitats likely to be used by marine mammals and turtles is covered under the sections on hard coral and seagrass, macroalgae and filter feeders.

Table 9-1: Management: Whales, Dolphins, Dugongs and Marine Turtles

Management Area:	**Marine Fauna (Whales, Dolphins, Dugongs and Marine Turtles)**
Performance Objective:	*To manage dredging activities during the construction phase of the Project to reduce, as far as reasonably practicable, Project-attributable impacts on marine fauna."*
Management Triggers (Environmental Performance Standard):	♦ No project-attributable deaths of marine fauna due to dredging activities for the construction of the nearshore and offshore facilities.
Management:	The following measures will be employed to monitor any sightings or interactions with marine fauna: ♦ Condition 10-1 of MS 873 requires at least one dedicated Marine Fauna Observer (MFO), to be on active duty on vessels actively engaged in dredging[21] during all daylight hours when dredging is conducted. ♦ Condition 10-3 requires at least one member of the vessel crew (on vessels other than those with an MFO on active duty), trained in marine fauna observation and mitigation measures, to be on active duty during daylight hours during vessel movement. The trained crew member may have other vessel duties. ♦ Prior to commencement of dredging and dredge spoil placement, selected crew will receive training in marine fauna observations, including procedures in the event of injury or death.

[21] For the purposes of this plan 'actively engaged in dredging' only refers to CSDs and TSHDs and therefore a BHD does not require an MFO. This is due the low risk to marine fauna posed by the stationary BHD or grab dredge. Note though that a BHD/ grab dredge will have a trained crew member to monitor and ensure management is implemented as required, including recording observed marine fauna.

	Striking impact on Whales, Dolphins and Dugongs ♦ Whale and dugong observations and response procedures including application of ~300 m observation zone and ~100 m exclusion zone will be implemented during dredging and dredge spoil placement works as outlined in Figure 9.1. If calves are present the exclusion zone will be extended to ~300 m. ♦ Dolphin observations and response procedures including application of ~150 m observation zone will be implemented during dredging and dredge spoil placement works (Figure 9.1). ♦ The presence of whales, dolphins or dugongs in or near exclusion zones established for key dredging activities will be recorded. ♦ All sightings of whales, dolphins or dugongs that result in any management measures being implemented will be recorded. ♦ A trained crew member will maintain a watch, during daylight hours, for whales, dolphins and dugongs while any dredge is on route to and from the dredge area to DSPSs. If sighted, direction/speed will be adjusted to avoid impact (within the safety constraints of the vessel). ♦ A MFO will maintain watch, during daylight hours, for whales, dolphins and dugongs during dredge operations. ♦ Designated transit corridors have been established for dredge vessels transiting to Site C to minimise the disturbance to marine fauna (Figure 9.2), these may be reviewed if required. Entrainment impacts on Marine Turtles (TSHD) ♦ When operating with less than 5 m under-keel clearance, the dredge will initially move slowly through the area before commencing dredging so that the noise and vibration alerts marine turtles in the vicinity and encourages them to leave. This will only be applied on dredging in new areas and not once the work area has been established. ♦ Dredge pumps will be stopped as soon as practically possible after completion of dredging and where practical the draghead will remain as close as practicable to the seabed until the dredge pump is stopped. ♦ When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to drag heads engaging the seabed. ♦ Tickler chains and/or deflector devices on the draghead of the THSD will be used as a management mitigation approach to reduce turtle entrainment, where safety and logistical constraints permit. ♦ Overflow screens will be used on TSHDs to visually assess for turtles and turtle remains associated with entrainment during dredging after each load.
Monitoring:	♦ The following monitoring programmes will provide an indication of potential impacts to marine fauna habitat: • Water quality monitoring (Section 6.3); • Benthic community verification monitoring (Section 6.3); • Seagrass, macroalgae and filter feeder monitoring for impact on habitat (Section 7.3.2); ♦ MFO or trained crew members (as applicable) observations of whale, dolphin, dugong and marine turtle throughout dredging; ♦ Results from the Dugong Research Plan; and ♦ Monitoring of draghead and overflow screens to identify turtle fatalities

9.2 Management Strategy

Impacts to marine fauna (whales, dolphins, dugongs and marine turtles) from increased turbidity and sedimentation (e.g. direct behavioural impacts or indirect impacts through alteration of foraging habitats) are managed by application of management actions, if necessary, following visual observations during the works and through the water quality monitoring undertaken at monitored reef formations. Section 3.5 provides details on marine fauna species that may be present, their distribution and abundance is detailed in the Conservation Significant Marine Fauna Interaction Management Plan.

Marine Mammals

The management of marine mammals will focus on the species most likely to be sighted (whales, particularly humpback whales, and dugongs) and will primarily involve observation and avoidance measures to minimise the risk of dredge vessel interaction with both whales and dugongs (as illustrated in Figure 9.1) and management measures implemented to protect marine fauna habitat. With respect to dolphins, while their mobility and intelligence means the risk of impact is negligible, interactions will be managed in accordance with the requirements for cetacean interactions specified under Part 8 of the EPBC Regulations 2000 (Cth).

Data from the Dugong Research Plan (as detailed in EPBC Reference 2008/4469 Condition 37) will be assessed to identify any impacts that could be associated with the dredging activity, and adaptive management will be developed and applied as necessary during the dredging activity (EPBC Reference 2008/4469 Condition 11 b).

Marine Turtles

The management of marine turtles will primarily involve measures to minimise the risk of entrapment/entrainment of the marine turtles within the draghead of the TSHD including the following management actions:

- Dredge pumps will be stopped as soon as reasonably practicable after completion of dredging and where reasonably practicable the drag head will remain as close as practicable to the seabed until the dredge pump is stopped.
- When operating with less than 5 m under-keel clearance, the TSHD will initially move slowly through the area before commencing dredging so that associated noise and vibration will alert marine turtles in close proximity and encourage them to leave. This will only be applied to dredging in new areas and not once the work area has been established.
- When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to drag heads engaging the seabed
- Tickler chains and/or deflector devices will be used on the drag head of the TSHD.

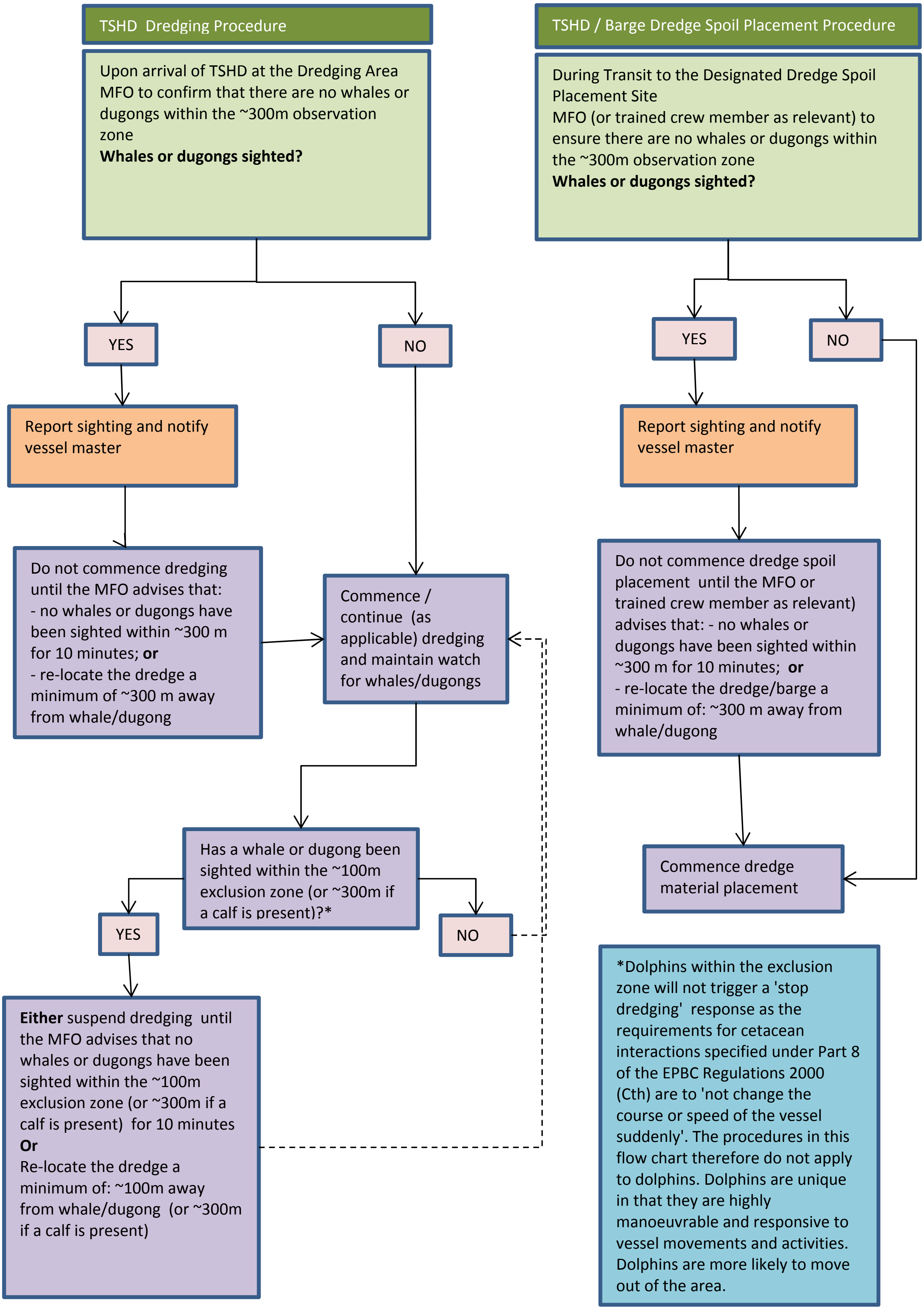


Figure 9.1: Whale, Dolphin and Dugong Interaction Procedures

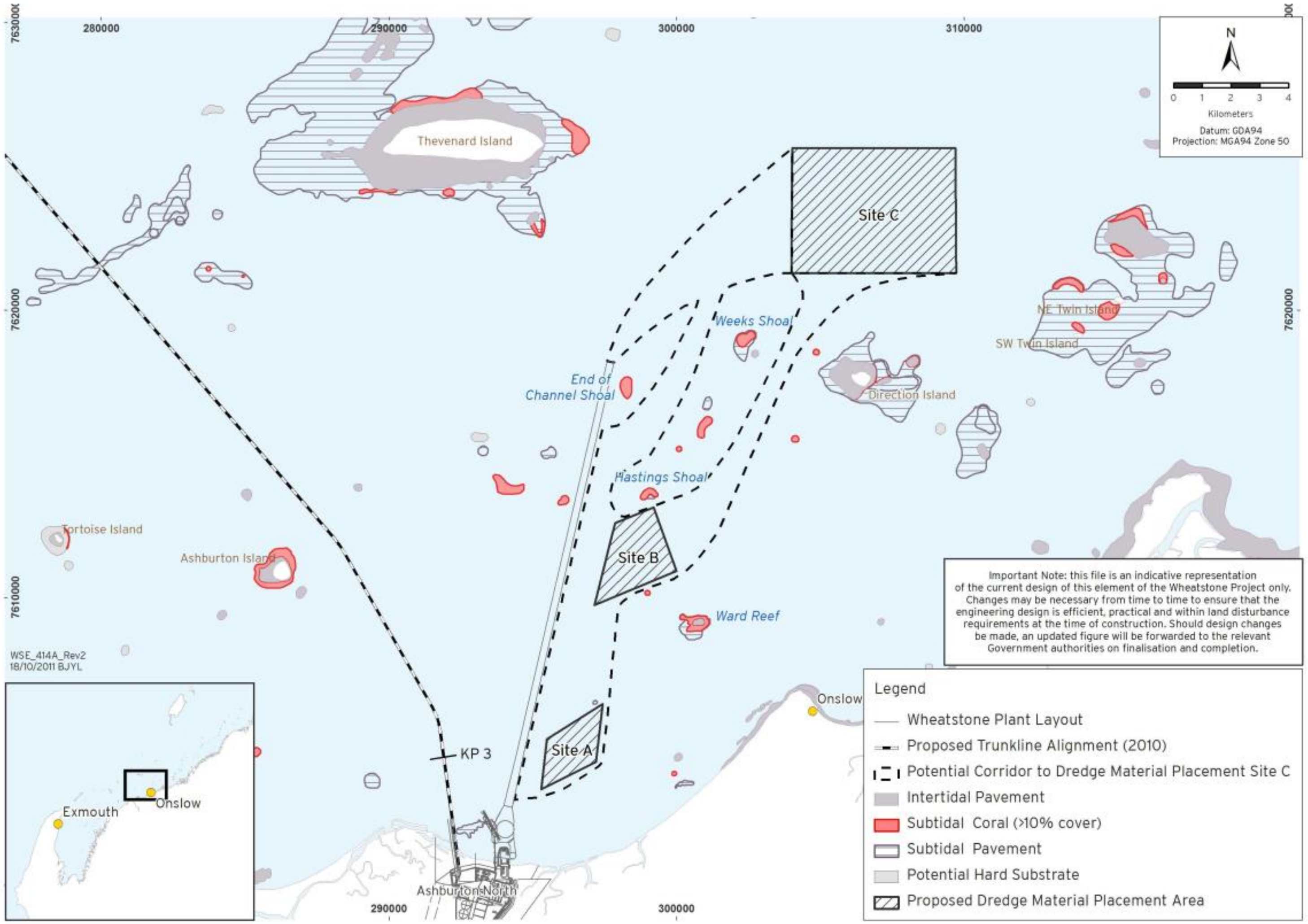


Figure 9.2: Designated Transit Routes to Dredge Spoil Placement Site C

9.3 Monitoring Strategy

The monitoring strategy for marine fauna focuses on the habitat monitoring as outlined in Section 7.3.2 and the benthic community verification monitoring as outlined in Section 6.3.3. Sedimentation monitoring is also undertaken at the seagrass and macroalgae sites to detect impacts on habitats potentially used by marine fauna (Section 7.3.2). Specific monitoring of dugongs is dealt with in the Dugong Research Plan.

Monitoring of marine fauna during dredging and disposal activities for the Project include:

- Monitoring of draghead and overflow screens to determine any fatalities of turtles
- As required by Condition 10-1 of MS 873, CSD and TSHD will have at least one MFO on active duty during daylight hours. The MFO will have no other vessel duties during on shift time.
- As required by Condition 10-3 of MS 873 vessels, other than CSDs and TSHDs, will have at least one member of the vessel crew, trained in marine fauna observation and mitigation measures, on active duty during daylight hours. The trained crew member may have other vessel duties.
- The MFO, and the trained crew members, on active duty will maintain a log of marine fauna observations (as detailed in MS 873 Condition 10-1 and 10-3).

10.0 DREDGE SPOIL PLACEMENT MANAGEMENT AND MONITORING

10.1 Background

The following dredging material placement management procedures will be implemented to minimise impacts from elevated turbidity and sedimentation, due to material placement at DSPS A, B[12], and C, to BPP and BPPH (Table 10-1). These management measures are not relevant to:

- DSPS D, which is dealt with in the TIEMMP (as this site is unlikely to be used for the turbidity-generating activities associated with the construction of nearshore and offshore marine facilities, though may be used for clean-up dredging)
- DSPS E as there are no predicted impacts to corals, seagrass and dugongs from dredge spoil placement activities at this site due to the lack of corals and seagrass at those depths.

The nearshore and offshore dredge spoil placement areas that will be utilised are shown in Figure 10.1.

Table 10-1: Summary of Management and Monitoring Measures to Reduce Impacts from Dredge Spoil Placement

Management Area:	**Dredge Spoil Placement Area Management**
Performance Objective:	To undertake the dredging and dredge spoil management activities in accordance with the requirements of EPBC 2008/4469 and MS 873. *to minimise the environmental impact of dredge spoil placement activities and any material incremental losses of dredge spoil which may occur following completion of dredge spoil placement at sites in State waters*
Management:	Management of DSPS A, B[22] and C in State waters only (DSPS D is dealt with in the TIEMMP as dredge spoil placement site D is unlikely to be used for the turbidity-generating activities associated with the construction of nearshore and offshore marine facilities) : ♦ Division of placement sites to determine the schedule for placement of dredge spoil based on seasonal and metocean conditions and dredge spoil; ♦ The use of buffer zones within the perimeter of the placement sites provides a zone to reduce any movement of sediment outside the site boundary following placement or risk of placement of material outside the site; Conditions of the SD2011/2102 required the following measures: ♦ Establish by Differential Global Positioning System (DGPS) that the vessel is within the approved dredge spoil placement area immediately prior to dredge spoil placement.

[22] Sites A and B will only be considered in the event of an emergency situation and will require the approval of the Dampier Port Authority prior to use. Therefore these management and monitoring measures will only be implemented if DSPS A and B are used.

	♦ Marine mammal management procedures as detailed in Section 9.0 will be followed during dredge spoil placement activities. ♦ Records comprising either weekly plotting sheets or a certified extract of the ship's log will be retained (for verification and auditing purpose), which detail: ▪ The times and dates of when each dredge spoil placement run is commenced and finished. ▪ The position (as determined by DGPS) of the vessel at the beginning and end of each dredge spoil placement run, with the inclusion of the path of each dredge spoil placement run. ▪ The volume of dredge spoil (in cubic metres) moved to the placement area and quantity in dry tonnes for the specified operational period. These quantities will be compared with the total amount permitted under the SDP. Contingency measures for management of DSPS A[14], B and C in State waters only: ♦ Review the division of placement sites and the schedule for placement of dredge spoil based on seasonal and metocean conditions, buffer zones, dredge spoil update to take account any impacts that have been observed. ♦ Move dredge spoil placement to other spoil placement sites.
Monitoring:	1. A bathymetric survey of the dredge spoil placement areas will be undertaken of DSPS A, B[23] and C during dredging: a) Prior to the commencement of dredging; b) Quarterly surveys; c) Within one month of the completion of all dredge spoil placement activities authorised under the SDP. 2. Water quality Monitoring (See Section 6.3 and Section 10.4.2) for DSPS A, B and C only.

[23] Sites A and B will only be considered in the event of an emergency situation and will require the approval of the Dampier Port Authority prior to use. Therefore bathymetric surveys of DSPSs A and B will only be undertaken if used.

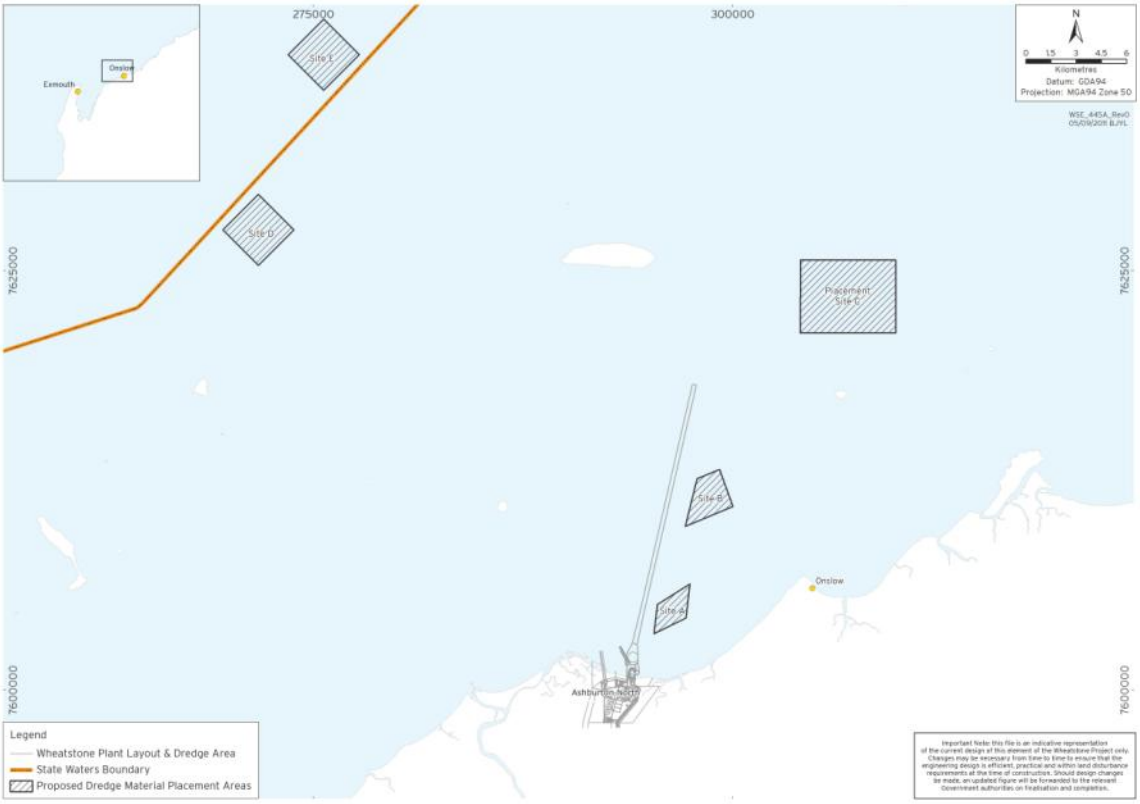


Figure 10.1: Dredge Spoil Placement Areas

10.2 Predicted Incremental Loss of Dredge Spoil

To assess the potential loss of sediment from the DSPS C it is required to understand both transport patterns under existing conditions and with the soil material in place, which again requires understanding of the differences in sediment composition between the existing surfaces of DSPS C and the likely spoil material.

The predicted losses were derived based on an assumption that the sediment presently found on the seabed at the DSPSs is in a ‘dynamic balance’ between erosion and deposition and fines will be lost from the dredge spoil placed there to eventually achieve a similar particle size distribution as found in the existing surface material. The conditions at the placement site C, indicates a predominance of sand or coarser material (~80%) with only a small amount of fines. Two representative classes were defined for the dredge spoil based on the degree of consolidation:

- ‘Sand’ consisting of predominantly granular, non-consolidated material
- ‘Weak rock’ consisting of weakly consolidated clay- silt- and sand-stone.

Therefore the placed material is expected to contain a higher percentage of fines on average than the parent material at the DSPSs. The existing surface sediments at DSPS C has an average fines (silt and mud) content of about 20% which is on average 10% less than predicted for the dredge spoil. Table 10-2 shows the results of the incremental losses predicted from DSPS C. The reworking and loss of fines from the upper 20 cm is considered a reasonable estimate while reworking and loss of fines from the maximum capacity of the DSPS (40 Mm^3) is considered very conservative, ignoring any effects of self-armouring and consolidation over the extended time period the loss of fines would take.

Table 10-2: Estimated loss from Dredge Spoil Placement Site C to achieve similar grain size distribution as found in existing surface layers

Parameter	Dredge Spoil Placement Site C
Maximum Volume (million m^3)	40
Mean bed level change for max volume (m)	1.70
Loss from 20 cm top layer (thousands m^3)	470
Loss from entire spoil volume (thousands m^3)	4000

On completion of the placement of dredge spoil at DSPS C a bathymetric survey will be undertaken, the results of this survey, modelling and analysis of collected data during the dredge programme will allow the fate of lost dredge spoil to be assessed.

10.2.1 Potential Impacts from loss of Sediments

In considering the potential incremental transport rates of sediments from the DSPSs (the potential for introducing contaminants through the spoil is treated separately in the EIS/ERMP), the following potential impacts are identified:

1. The impacts to the surrounding areas from fines emitted from the DSPSs during and after “construction”, i.e. during and after the entire dredging programme.

2. The impacts to the surrounding areas by increased transport rates out of the DSPSs after completion of the project and placement activities.

Modelling has indicated that (DHI 2011):

- Re-suspension from the DSPSs showed insignificant contribution to the overall dredge plume during dredging
- Mobility under “normal” conditions is limited, and the fines in the top layer will relatively quickly adjust to the “base” conditions, such that the incremental addition to total suspended solids under normal conditions is insignificant after the initial “weening” period; and
- During cyclonic conditions, the high bottom shear stresses will lead to high levels of total suspended solids, irrespective of the DSPSs, throughout the area from the coastline and out to deeper water (> ~50 m). Whereas cyclones will lead to additional smothering and reworking of the top layers of the DSPSs, incremental resuspension from the DSPSs will be insignificant compared to the sediment suspended throughout the area and discharged from rivers. It is estimated that Ashburton alone can discharge in excess of a million m^3 in a single event.

The main potential environmental impacts from an incremental transport of sand out of the DSPSs include:

- Potential impacts on surrounding habitats through smothering
- Potential impacts to the coastline and river entrances.

Loss of sand out of the DSPSs will primarily occur under cyclonic conditions. Model results for Cyclone Vance illustrate a predominantly westerly dispersion of the sediment from the DSPS. This is a general pattern for most cyclones due to the clockwise rotation of the cyclones in the southern hemisphere, which causes predominant north-easterly wind and wave directions when a cyclone is making landfall at the site. The modelled resulting average sedimentation rates outside the dredged areas are less than a millimetre. The influence of this thin veneer of sediment mixing with the transport from the surrounding areas is negligible, and incremental impacts to surrounding habitats due to increased mobility are considered negligible.

The contribution from the DSPSs to the littoral transport system will be very slow and insignificant compared to the existing littoral transport rates. No impacts to the coastal morphological balance are predicted from the DSPSs (DHI 2011).

10.3 Management Approach

To reduce the incremental loss of spoil from the placement site, a number of management measures will be implemented during disposal activities at the placement sites within State waters only (DSPS A, B and C). Management measures will focus on the division of the placement sites into specified areas as illustrated in Figure 10.2. These may include, but is not limited, to the following:

- Buffer zones where no material can be placed to reduce the potential for placement outside of the designated boundary as seen in Figure 10.2
- Specified cells which will be the basis:
    - for a schedule of placement of dredge spoil based on seasonal and metocean conditions to reduce plume exposure outside of the placement sites and the potential for environmental impact to nearby receptors; and
    - for placement of different dredge loads (i.e. material with higher fines content will be placed selectively and armoured with coarser material where possible).

Disposal tracking of each load will be undertaken to ensure accuracy of placement—established by Differential Global Positioning System (DGPS)—that the vessel is within each placement site. Feedback from the bathymetry surveys and water quality monitoring data (Section 10.4) will be used to adjust the management measures to reduce potential environmental impacts.

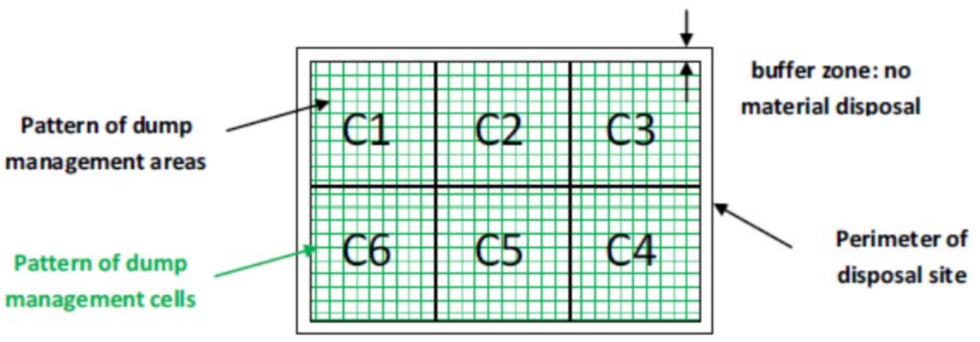


Figure 10.2: Example of Division of a Placement Site for Dredge Spoil

10.3.1 Contingency Measures

As a contingency measure, following any unexpected impacts resulting from placement activities, there will be a review of the division of placement sites and the schedule for placement of dredge spoil. Changes will be made to the schedule as necessary to reduce the potential for any further impacts.

If it is determined that changes to the division of the placement sites and the schedule for placement of dredge spoil will not mitigate impacts dredge spoil placement will be moved to another DSPS.

10.4 Monitoring Approach

Monitoring of the retention, stability and fate of the dredge spoil at the at the placement sites within State waters only (DSPS A, B and C) will involve both bathymetric surveys and a water quality monitoring programme.

10.4.1 Bathymetric Surveys

Surveys will be undertaken prior to placement (to establish a baseline) and then at a minimum frequency of three monthly during dredging and placement activities and within one month following the last placement at the site. Multi-beam bathymetric surveys will reveal seabed features such as sand waves and mounding, including potential navigation hazards. Comparison of subsequent surveys and consideration of disposal records will depict the movement of material within and surrounding these sites.

10.4.2 Water Quality Programme

Additional monitoring of the fate of the dredge spoil would involve the analysis of data from water quality loggers placed at coral monitoring receptor sites and sentinel sites located between the placement sites and coral monitoring sites described in Section 6.3 and shown in Figure 10.3. Note water quality logger data will not be available during clean-up dredging as described in Section 2.2.2.1 (10).

Sentinel Sites

The modelling indicated that following the initial release of fines during placement, sediment release would be insignificant. This would be validated at each placement site through the monitoring of water quality at sentinel sites. Sentinel(s) will be placed around the DSPS C in locations where sediment will be predicted to transport as identified from modelling.

Water quality loggers, sediment traps at the coral monitoring sites, metocean data and potentially MODIS data (if surface plumes are observed) will also be used to provide inference assessment information for any plumes that may reach these areas. Although the modelling has shown it is very unlikely that material will reach these sites, the use of the loggers at the receptor sites, and the interim loggers at the sentinel sites, will show any increases in turbidity approaching and/or reaching the receptor sites that may be linked to placement activity.

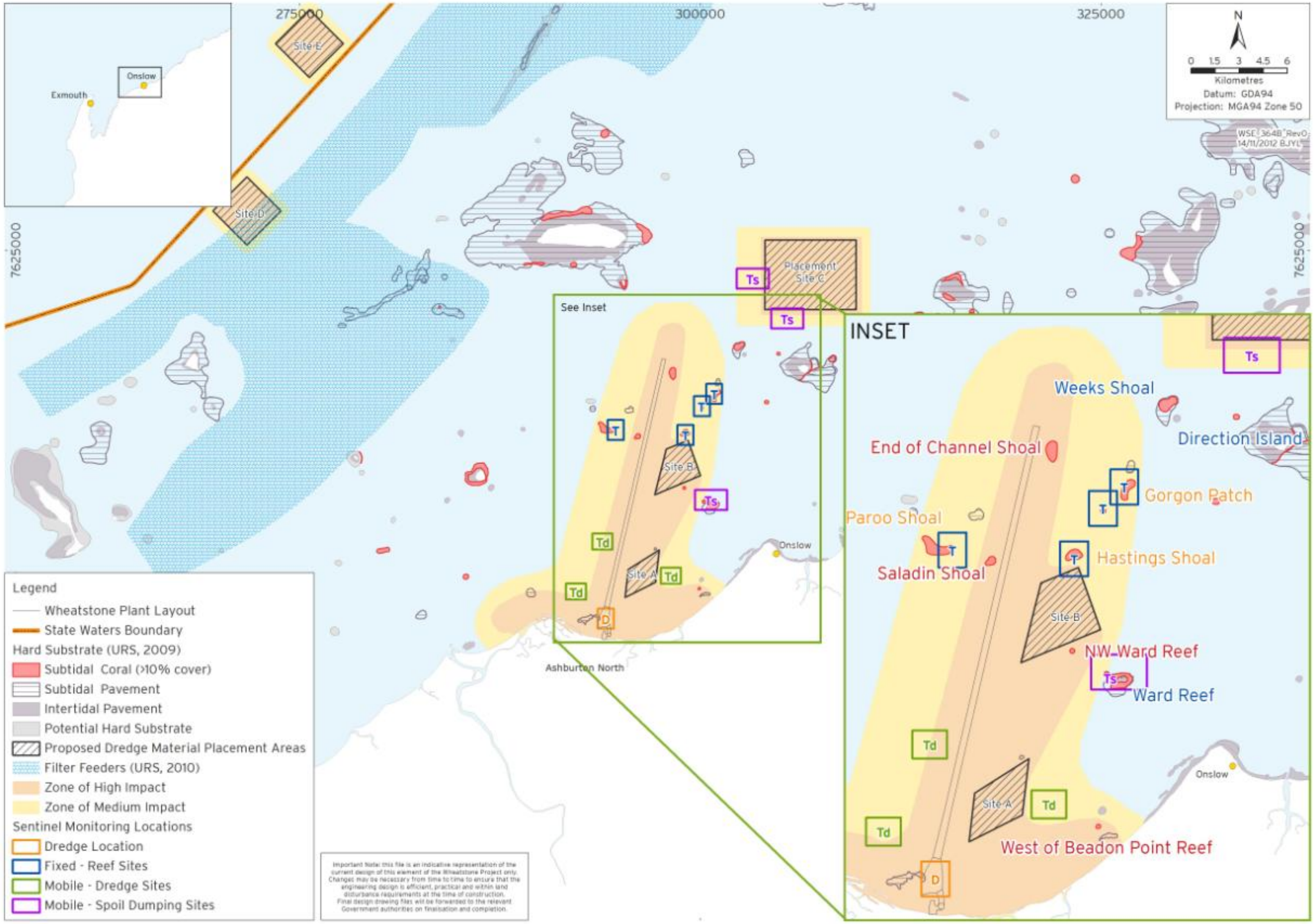


Figure 10.3: Dredge Spoil Placement Sites and Indicative Location of Telemetered Water Quality Loggers including Sentinel (mobile) Instruments

11.0 CUMULATIVE IMPACTS MANAGEMENT AND MONITORING

11.1 Background

It is likely that the turbidity-generating activities for trunkline installation, trenching and sand backfill, will occur simultaneously with the turbidity generating activities for the nearshore and offshore marine facilities, dredging of the MOF, PLF and PLF approach channel. If these operations occur simultaneously there is risk of cumulative impacts if the sediment plumes from the two programmes overlap. Chevron Australia will manage potential cumulative impacts from overlapping plumes through the following procedures (Table 11-1).

Table 11-1: Summary of Management and Monitoring Measures to Manage Cumulative Impacts from Turbidity-generating Activities associated with Trunkline Installation and Construction of Nearshore and Offshore Marine Facilities

Management Area:	**Cumulative Impacts from turbidity-generating activities associated with trunkline installation and construction of nearshore and offshore marine facilities**
Performance Objective:	*Cumulative impacts from turbidity generating activities associated with the trunkline installation undertaken simultaneously with turbidity generating activities associated with the construction of the nearshore and offshore marine facilities are managed to achieve the environmental protection outcomes set in Condition 8-7 and Condition 6-1 (MS 873) (or any revised environmental protection outcomes) as required by Condition 8-8 (iii) (MS 873).*
Management:	The cumulative impacts management framework by Chevron Australia is described below and Figure 11.1 provides an overview of the management and monitoring components of the cumulative impacts management framework. Preventative management of the potential impacts on monitored reef formations will be determined via the following prior to and during dredging activities: ♦ Prior to turbidity generating activities model combined turbidity-generating activities associated with both trunkline installation and the construction of nearshore and offshore marine facilities to identify likely critical scenarios of combinations of climatic conditions and dredging and dredge spoil placement activities that could lead to overlapping plumes.. ♦ Assessment of model outputs against management triggers at all monitoring reefs to assess risk of Level 2 exceedance's from cumulative effects. Responsive management actions will be based on the monitoring results (as detailed below) and will follow the management actions described in Section 6.2.3.
Management Actions	♦ Turbidity-generating activities will be scheduled, where practicable, to avoid the risk of overlapping plumes that may result in an Level 2 exceedence based on the outcomes from the modelling of the combined operations or where not practicable, implement adaptive management measures. ♦ Adaptive management measures that may be considered and implemented, prior to and during dredging include:

	▪ Refining dredging and/or disposal operations based on sediment plume model results, current and forecasted metocean conditions, and the soil model. These refined operations include modifying: - Scale of operations and resulting potential area of influence - Location of dredging, type of dredging technique, overflow, and/or dredge spoil placement activities - Dredging practice including overflow operations and production rate and/or volume - Disposal technique including discharge rate and/or volume - Redefining transit routes - Reduce dredging and/or material placement activities - Stop dredging at a particular location
Monitoring:	♦ Use of daily MODIS imagery to determine location of dredge plumes from the turbidity-generating activities associated with trunkline installation and the construction of nearshore and offshore marine facilities. ♦ Hindcast/Forecast modelling of turbidity-generating activities associated with trunkline and the turbidity-generating activities associated with the construction of the nearshore and offshore marine facilities. ♦ Water quality monitoring at monitored reef formations at risk of cumulative impacts

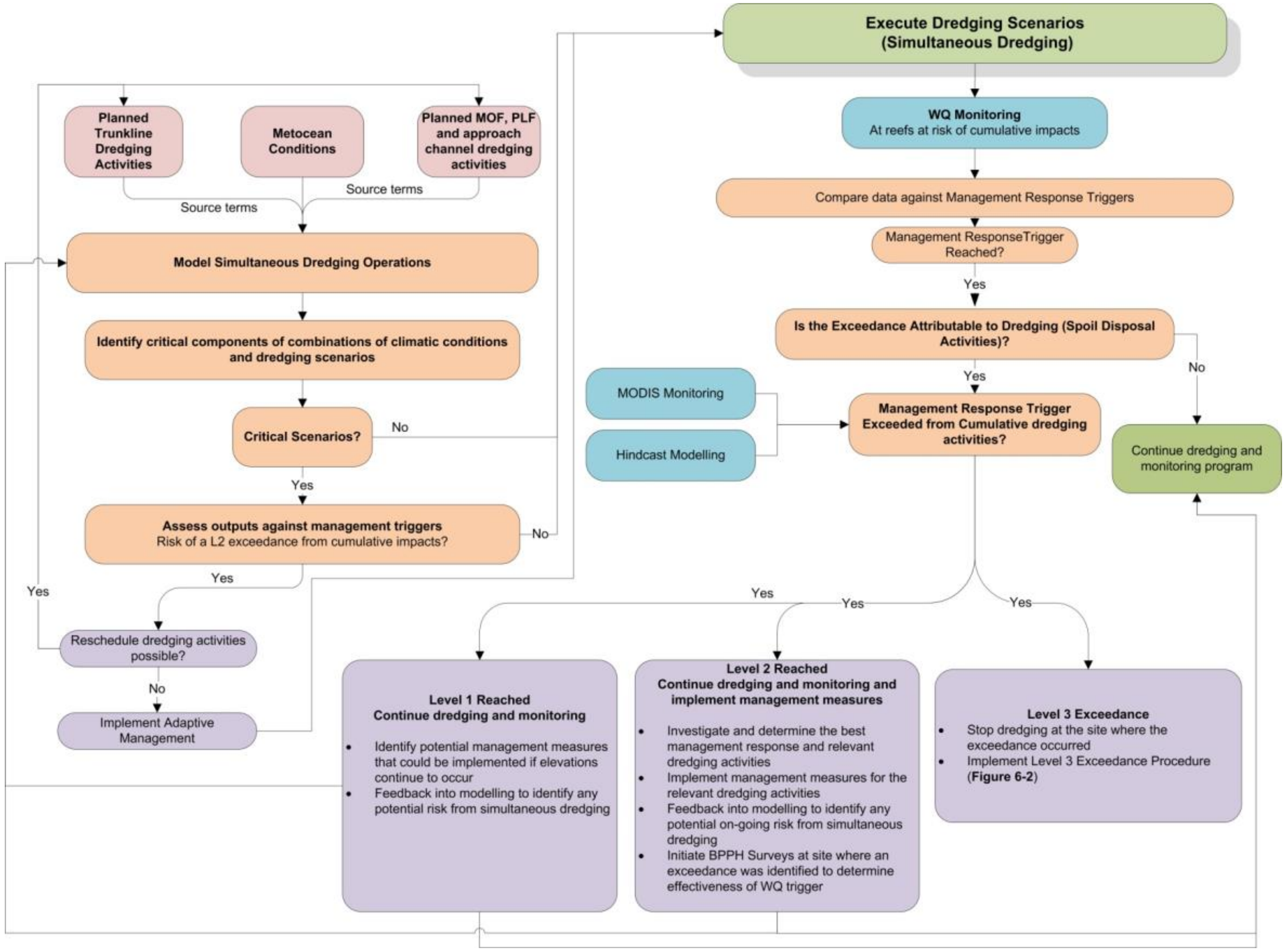


Figure 11.1: Cumulative Impacts Management Framework

11.2 Management Strategy for Cumulative Impacts

Prior to the commencement of simultaneous dredge operations an assessment of turbidity generating activities will be undertaken by Chevron Australia to minimise the risk of cumulative impacts (Figure 11.1). Modelling will be undertaken of the combined turbidity-generating programmes to identify dredging scenarios that have high risk of resulting in cumulative impacts. The modelling will assist in the identification of likely critical scenarios, due to schedule, taking into account combinations of climatic conditions, dredging and dredge spoil placement activities (including both dredging equipment and location) that could result in cumulative impacts. The modelling outputs will also be interrogated with the BPPH tolerance limits to provide cumulative impact maps and compare against management triggers to assess the risk of a Level 2 exceedance’s from cumulative effects.

It is also recognised that the execution programmes of the turbidity generating activities may change through the works And for this reason, modelling will be undertaken based on look-ahead schedules, as required, and forecast winds and production data (from both the trunkline installation activities and the construction of nearshore and offshore marine facilities). This modelling will allow an assessment of risk of cumulative impacts. If a risk of an impact or Level 2 exceedence is predicted, this will be identified and, where possible, the rescheduling of activities may occur or adaptive management process may be implemented with a project-wide perspective.

11.3 Monitoring Strategy for Cumulative Impacts

To ensure that the management of turbidity generating activities has been effective in avoiding impacts from overlapping plumes, the following four monitoring programmes will be undertaken:

1. Water quality monitoring at monitored reef formations at-risk of cumulative impacts;
2. MODIS imagery acquisition and analysis;
3. Hindcast modelling of turbidity-generating activities; and
4. Regular review of production results from the two programmes to assess location of equipment, performance and quantities of dredged material.

11.3.1 Water Quality Monitoring

Water quality at monitored reefs at risk of cumulative impacts (see Section 11.2) will be assessed on a daily basis to determine whether the management triggers (Level 1, Level 2 and Level 3; see Section 6.2.3) have been reached due to simultaneous turbidity generating activities. The variables, data collection, methods and data analysis will be the same as described in Section 6.3.1. If it is determined that a management trigger or EPO has been reached the appropriate monitoring and management measures will be implemented (see Figure 11.1).

11.3.2 MODIS Imagery

MODIS imagery will be collected on a daily basis, weather permitting. Both light attenuation algorithms and TSS algorithms will be developed to allow near real time delivery of TSS and light attenuation maps. These maps will allow the identification of the sediment plumes from turbidity-generating activities and determine whether additional management measures are required to reduce the risk of impacts from overlapping plumes e.g. move location of the dredging activities.

11.3.3 Review of Production Data

Dredging data collected by all equipment in the field for both programmes will be reviewed regularly, to assess dredging and disposal activities, and to develop an accurate model of the dredging campaigns.

11.3.4 Hindcast Modelling

Modelling will be undertaken using measured metocean conditions and production data from both programmes. This modelling will allow an assessment of risk of cumulative impacts. If a risk of an impact is predicted, this will be identified and incorporated into the adaptive management process.

These plots will allow the identification of the sediment plume from turbidity-generating activities and determine whether additional management measures are required to reduce the risk of cumulative impacts from overlapping plumes.

12.0 REPORTING AND REVIEW PROCEDURES

This section provides a framework for external reporting to regulatory authorities relevant to this Plan, including scheduled and unplanned reporting.

12.1 Annual Compliance Reporting

Both a state and Commonwealth annual Compliance Assessment Report (CAR) are required by MS 873 and EPBC 2008/4469 respectively. Both reports assess compliance against Ministerial Conditions within the compliance reporting period being 31st August to 30 August of each compliance year, with each CAR due by 30 November. As part of the preparation of the annual CARs, Chevron Australia will assess its compliance status against this Plan, which will be guided by the action table provided in Appendix A.

12.2 Incident and Other Reporting

Table 12-1 and Figure 12.1 summarises the regulatory reporting requirements associated with capital dredging and dredge spoil placement activities. Table 12-2 summarises the regulatory reporting requirements associated with clean-up dredging and dredge spoil placement activities.

Table 12-1: Reporting Requirements for Capital Dredging and Dredge Spoil Placement Activities

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Dredge Spoil Placement Site Monitoring			
Quarterly report	Data to present: ♦ Bathymetric survey & dump plot results ♦ Management measures Data to incorporate as needed: ♦ Water quality data of nearby reef sites + sentinels as applicable ♦ Sediment trap results of nearby reef sites ♦ Metocean conditions ♦ MODIS data Conclusion	Quarterly (within 35 business days following survey finalisation)	EPA
Final report	Data to present: ♦ Bathymetric & dump plot survey results ♦ Management measures ♦ Data to incorporate as needed: ♦ Water quality data ♦ Sediment trap results ♦ Metocean conditions ♦ MODIS data Conclusion	Three months following completion of dredging	EPA
Water Quality Monitoring			
Zone of Influence			

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Characterised Zone of Influence	Will detail the spatial extent of the Zone of Influence and compare with the predicted extent of the Zone of Influence derived through modelling predictions	Annually – First report to be submitted 15 months after dredging commences (with first 12 months of data)	EPA
Level 2 exceedence (refer to Figure 6.1; Figure 12.1)			
a) Formal report (proforma)	Results of investigation including the inference assessment (water quality results at selected sites, metocean conditions, dredging activities, MODIS data, management measures)	Within 5 days following identification and confirmation of a trigger exceedence	EPA/DTAP/ DOTE
b) Close out report (proforma)	Water quality results at selected sites, metocean conditions, dredging activities, MODIS data, management implemented and effectiveness	5 days following reduction of water quality to below Level 2 trigger intensity levels (Table 6-2; Table 6-3; Table 6-4)	EPA/DTAP/ DOTE
Level 3 exceedence (refer to Figure 6.2; Figure 12.1)			
a) Notification of Exceedence	Notification of exceedence and that all dredging activities that can reasonably be expected to have caused or contributed to the exceedence have ceased	Within 48 hours cessation of relevant dredging activities	EPA/DTAP/ DOTE
b) Recommence-ment report of dredging activities found to have not contributed to the exceedence	Results of investigation including the inference assessment (water quality results at selected sites, metocean conditions, dredging activities (MODIS data, modelling)	Within 2 days of recommence-ment of relevant dredging activities	EPA/DTAP/ DOTE
Confirmation of non exceedence of the level 2 or level 3 management triggers			
Water quality trigger assessments (non exceedence)	Results of the water quality trigger assessment, associated inference assessments and conclusions on non exceedence.	6 business days after the last daily water quality download	EPA/DTAP/ DOTE
Regular Reporting			
Water quality triggers	Results of the water quality trigger assessment, any associated inference	On a 6-weekly	DTAP/DOTE

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
assessments	assessments and conclusions.	basis	
		When a Level 1 Management Trigger has been exceeded	EPA
Coral EPO Assessments (refer to Figure 6.3; Figure 12.2)			
Achievement of EPOs			
1. Recommence ment of all dredging activities	Results of investigation including the inference assessment (water quality results at selected sites, metocean conditions, dredging activities, MODIS data, management measures, latest BPPH data and coral EPO assessments and modelling)	Within 2 days of recommence-ment of relevant dredging activities	EPA/DOTE
Non Achievement of EPOs			
2. (a) Notification of Exceedence	Notification that all turbidity-generating activities which are part of the construction of the nearshore and offshore marine facilities have been suspended	Within 24 hours of the suspension	EPA/DOTE
2. (b) Report to minister (cond. 6-7)	Results of investigation (water quality results at selected sites, metocean conditions, dredging activities , MODIS data, management measures)	Within 48 hours after implementation of Condition 6-7	EPA/DTAP/ DOTE
2. (c) Recommence ment report (cond. 6-9)	Results of investigation (water quality results at selected sites, metocean conditions, dredging activities , MODIS data, management measures, latest BPPH data, modelling, revision EPOs if required)		EPA/DOTE/ DTAP
Reporting Achievement of EPOs based on Mid-term Surveys will be undertaken under the SoW			
BPPH Monitoring			
Level 2 Exceedence feedback monitoring			
a) Close out report after 2nd survey	BPPH results, conclusion on effectiveness	Within 10 days following the completion of field survey	EPA/DTAP/ DOTE
Verification Monitoring			
b) Verification that water quality Criteria are affording appropriate protection	Results of BPPH surveys and water quality verification investigations including light and sediment deposition	Annually – First report to be submitted 15 months after dredging commences (with first 12 months of data)	EPA/DTAP/ DOTE

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Marine Fauna			
Injury to, or mortality of an EPBC listed threatened or migratory species from dredging activities	NA	Within 24 hours of observation	DOTE/DPaW

Condition 4-5 (MS 873) requires reporting of any potential non-compliance.

Condition 3 requires reporting of any non-compliance with the conditions of EPBC Approval 2008/4469.

Table 12-2: Reporting Requirements for Clean-up Dredging and Dredge Spoil Placement Activities

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Dredge Spoil Placement Site Monitoring			
Final report	Data to present: ♦ Bathymetric & dump plot survey results ♦ Management measures ♦ MODIS data (where applicable) Conclusion	Three months following completion of clean-up dredging	EPA
Water Quality Monitoring			
Level 2 exceedence (refer to Figure 6.1; Figure 12.1)			
c) Formal report (proforma)	Results of investigation including the inference assessment (water quality results at selected sites, metocean conditions, dredging activities, MODIS data, management measures)	Within 5 days following identification and confirmation of a trigger exceedence	EPA/DTAP/ DOTE
d) Close out report (proforma)	Water quality results at selected sites, metocean conditions, dredging activities, MODIS data, management implemented and effectiveness	5 days following reduction of water quality to below Level 2 trigger intensity levels (Table 6-2; Table 6-3; Table 6-4)	EPA/DTAP/ DOTE

Report	Content (content will be provided where available, relevant, after QA/QC verification)	Timeframe	Recipient
Level 3 exceedence (refer to Figure 6.2; Figure 12.1)			
c) Notification of Exceedence	Notification of exceedence and that all dredging activities that can reasonably be expected to have caused or contributed to the exceedence have ceased	Within 48 hours cessation of relevant dredging activities	EPA/DTAP/ DOTE
d) Recommence-ment report of dredging activities found to have not contributed to the exceedence	Results of investigation including the inference assessment (water quality results at selected sites, metocean conditions, dredging activities (MODIS data, modelling)	Within 2 days of recommence-ment of relevant dredging activities	EPA/DTAP/ DOTE
Confirmation of non exceedence of the level 2 or level 3 management triggers			
Trigger assessments (non exceedence)	Results of the trigger assessment, associated inference assessments and conclusions on non exceedence.	6 business days after the last elevation that resulted in a trigger	EPA/DTAP/ DOTE
Regular and Final Reporting			
Satellite imagery triggers assessments	Regular (3-weekly) reporting of dredging and satellite imagery during clean-up dredging, and a final summary report on activities. If dredging less than three weeks, then a combined regular and final report will be provided.	On a 3-weekly basis/Final report	EPA/DTAP/ DOTE
Notification of dredging	Notify DTAP of dredging activities prior to commencement, and on completion of clean-up dredging.	Within 5 business days of commencement or completion	EPA/DTAP/ DOTE
Marine Fauna			
Injury to, or mortality of an EPBC listed threatened or migratory species from dredging activities	NA	Within 24 hours of observation	DOTE/DPaW

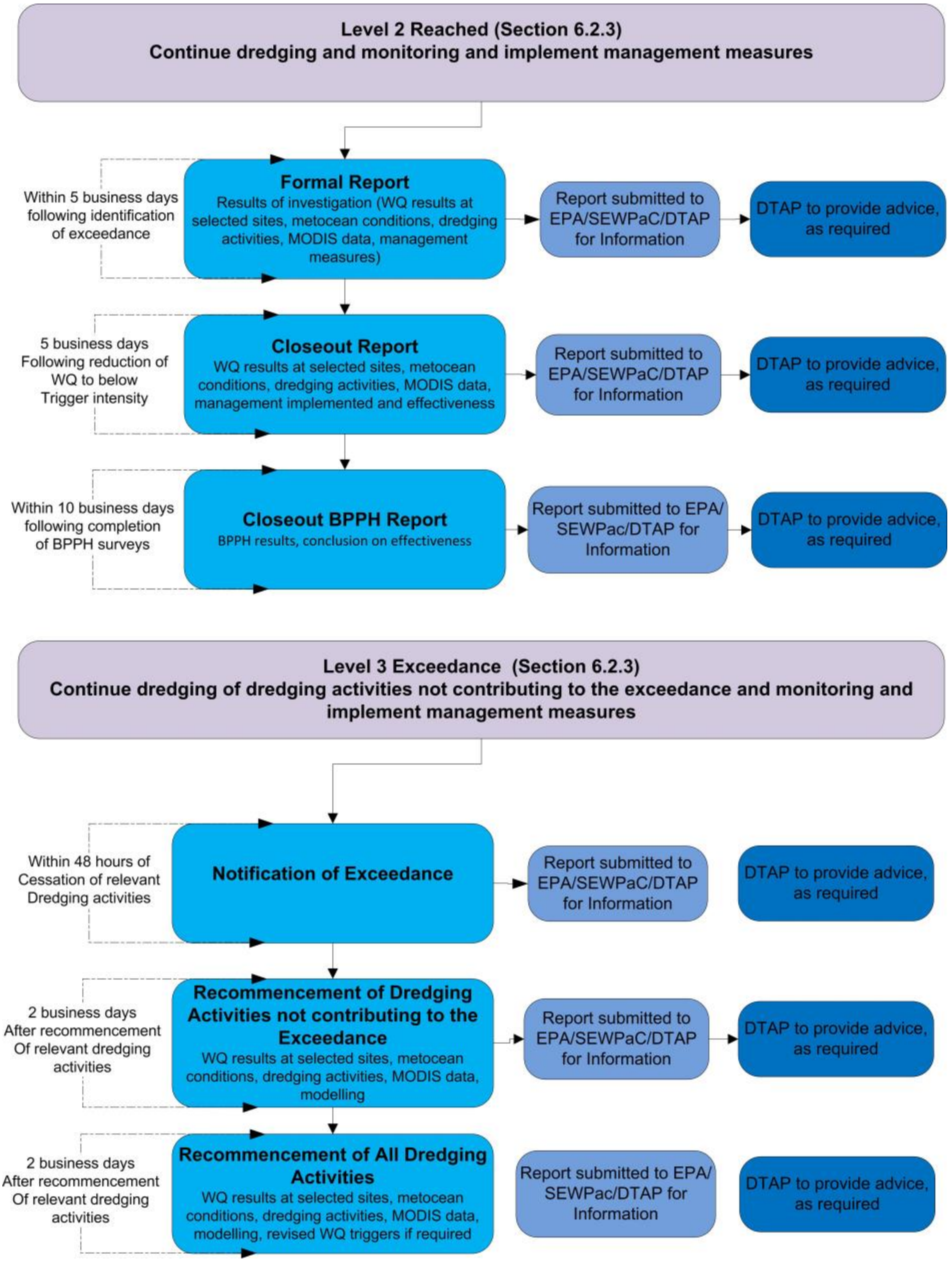


Figure 12.1: Reporting Requirements if a Level 2 Trigger and/or a Level 3 Trigger is Exceeded

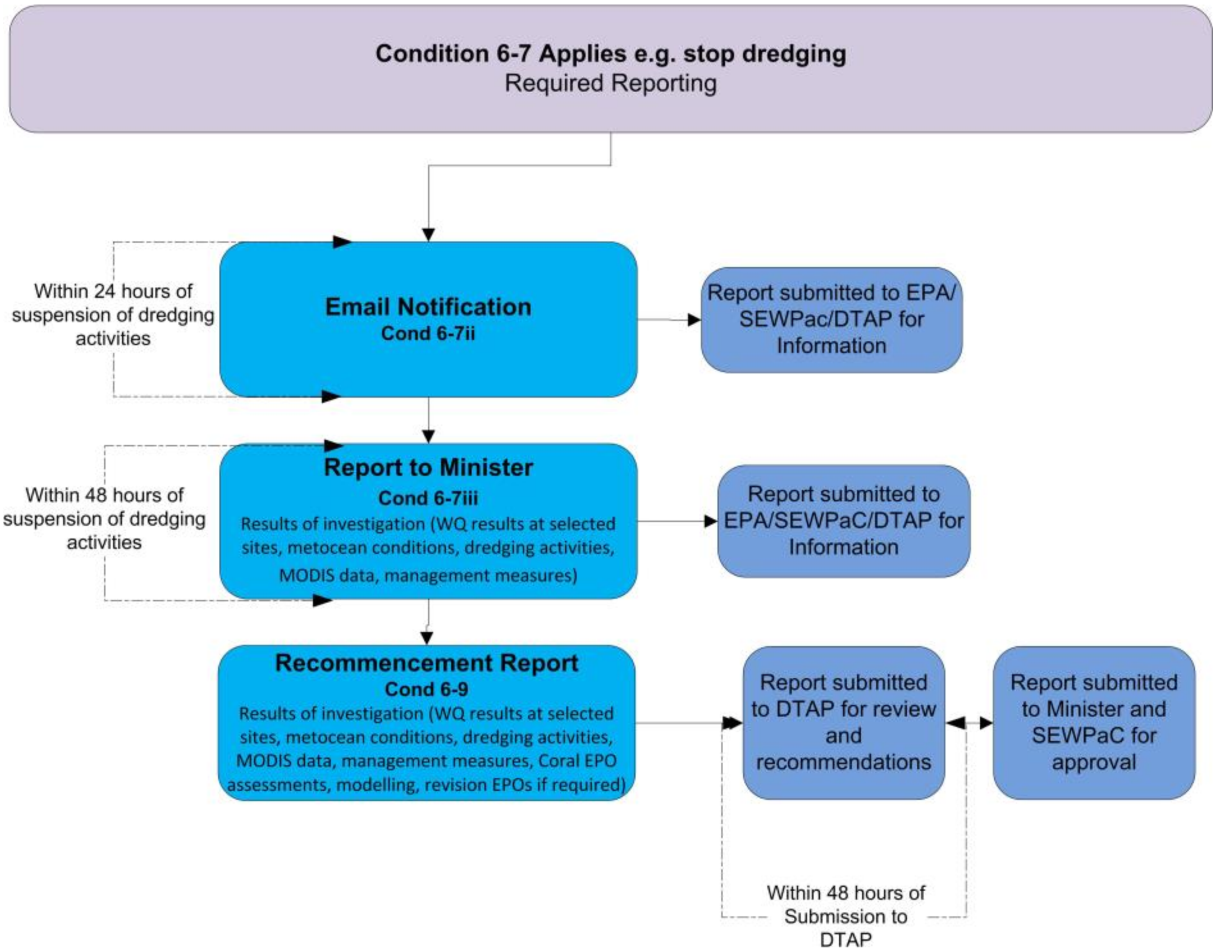


Figure 12.2: Reporting Required to recommence Dredging Activities following a Non-achievement of the Coral EPOs

12.3 Reviews of the Plan

Chevron Australia is committed to conducting activities in an environmentally responsible manner and aims to implement reviews of its environmental management actions as part of a programme of continuous improvement. This commitment to continuous improvement means that the Proponent will review the Plan to address matters such as the overall effectiveness, environmental performance, changes in environmental risks and changes in business conditions on an as needed basis (e.g. in response to new information).

In accordance with Condition 24-1 of MS 873, Chevron Australia will implement an amendment to this Plan from the date of the amendment. Significant amendments may only be implemented from the date of approval of the amendment by the CEO.

Significant amendments are those amendments which alter the obligations of Chevron Australia, that is, are not minor or administrative.

If new EPOs and additional management measures are approved by the Minister under Condition 6-10, Condition 6-13 provides that these are taken to have effect as if they were part of the approved Plan. An updated Plan will be provided to the CEO and made publicly available when practicable after the changes take effect.

In accordance with Conditions 5 and 6 of EPBC 2008/4469, Chevron Australia may only implement the Wheatstone Project otherwise than in accordance with the provisions of this

Plan which regulate the matters of NES relevant to this Plan from the date of approval of any variation to this Plan by the Commonwealth Minister. Any new EPOs and any additional management measures approved by the State Minister in accordance with Conditions 6-10 and 6-13 of MS 873 that regulate matters of NES relevant to this Plan require an update to the Plan.

12.3.1 Dredging Technical Advice Panel Reviews

EPBC Reference 2008/4469 requires the establishment, funding and management of a DTAP prior to and for the duration of the dredging programme. In accordance with Condition 17 and 21 of EPBC Reference 2008/4469 the role of the DTAP is to undertake reviews for adaptive management purposes. The timing, frequency, scope and objective of DTAP reviews of this Plan are outlined within the DTAP Terms of Reference (ToR) as amended from time to time.

12.3.1.1 Additional Reviews

At the time of the DTAP reviews (as detailed in Section 12.3.1) any results from the Dugong Research Plan and any seagrass surveys undertaken will be considered and any changes to the adaptive management processes, if applicable.

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Appendix A Action Table

No	Reference	Action	Timing
Water Quality and Benthic Primary Producer Habitat Management			
1	Table 6-1	TSHDs will be fitted with a turbidity-reducing valve within the overflow pipe.	Prior to commencement of TSHD operations
2	Table 6-1	CSD utilising a diffuser head on the spreader barge connected at the underwater outlet of the pipeline during near bed dredge spoil placement in DSPS A and B [if the sites are used] to reduce material outflow velocity and potential for re-suspension.	During offshore placement with CSD activities
3	Table 6-1	Optimising under-keel clearance of the TSHD to reduce sediment re-suspension caused by propeller wash where practicable	When practicable
4	Table 6-1	Raising the overflow pipe to avoid spillage during transit of the TSHD.	During all sediment transport by TSHD
5	Table 6-1	TSHD bottom doors and split-hopper barges hull seals inspected prior to mobilisation and operated appropriately to prevent and reduce sediment loss during transit	Prior to commencement of TSHD operations
6	Table 6-1	Well-maintained and properly calibrated dredging equipment will be utilised.	Prior to commencement of dredge
7	Table 6-1	Confining hopper dewatering to areas away from monitored reef formations where practicable.	Throughout TSHD/barges operations
8	Table 6-1	Limiting overflow in sensitive areas based on implementation of the PAMS	Throughout TSHD/barges operations
9	Table 6-1	Ensure TSHD transiting via designated corridors to DSPS C and avoiding no-transit and no-anchoring areas	Throughout TSHD/barges operations
10	Table 6-1	Employing optimised cutter heads for differences in soil types to reduce spillage and suspended solids	Throughout CSD operations
11	Table 6-1	Maintaining a 0.5 nautical mile buffer zone around coral reefs to the east of the approach channel to limit stress associated with sediment re-suspension from propeller wash	Throughout TSHD/barges operations
12	Table 6-1	GPS, monitoring and automation systems on equipment	Throughout dredging

No	Reference	Action	Timing
13	Table 6-1	Flexibility within the dredge execution plan and well prepared and studied alternative plans	Throughout dredging
14	Table 6-1	Route selection to minimise turbidity caused by vessel props, where practicable	Throughout dredging
15	Table 6-1	Proactive adaptive management (PAM) strategy	Throughout capital dredging
Water Quality and Benthic Primary Producer Habitat (Hard Coral) Management			
15	Section 6.0	Responsive water quality monitoring and associated tiered responsive management and coral EPO assessment monitoring will be implemented to manage any potential impacts that increased turbidity may have on monitored reef formations. *Water Quality Monitoring* Water quality measurements will be logged at approximately 30 minute intervals at monitored reef formations throughout the duration of the dredging and dredge spoil placement works. Water quality monitoring will be achieved through the use of *in-situ* water quality data logging instruments. Refer to Section 6.3 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.2.3. ♦ Used to assist in inferring the cause of any observed impacts to benthic communities. *Coral EPO Assessment Monitoring* Coral cover will be surveyed at the 'affected reef formation' following an exceedence of a Level 3 management trigger. Refer to Section 6.3.1.3 for further details of the EPO assessment monitoring programme. The results of this monitoring will be used to assess if net live coral cover at the affected reef had declined as a result of dredging and if this decline was greater than the EPOs defined in MS 873 Condition 6-1. *Verification Monitoring* Monitoring will consists of: ♦ Quarterly routine monitoring of benthic communities at the monitored reef formations (Figure 6.7) to provide verification of the appropriateness of water quality criteria.	Throughout capital dredging

No	Reference	Action	Timing
		♦ Verification monitoring which will be triggered by an exceedence of the Level 2 management trigger. Monitoring of benthic communities will be at the monitored reef formations (Figure 6.7) at which triggers were exceeded, and at associated reference reefs. Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs.	
Subtidal Benthic Primary Producer Habitat Management (Seagrass, macroalgae and filter communities)			
14	Section 7.0	*Responsive Water Quality Monitoring* Responsive water quality monitoring and associated management triggers will be implemented to manage any potential impacts that increased turbidity may have on seagrass. Water quality measurements will be logged at approximately 30 minute intervals at seagrass communities throughout the duration of the turbidity-generating activities which are part of the construction of the nearshore and offshore facilities. Water quality monitoring will be achieved through the use of an *in-situ* water quality data logging instrument. Refer to Section 6.3 for further details of the water quality monitoring programme. The results of the water quality monitoring will be: ♦ Assessed against management triggers, as detailed in Section 6.2.3. ♦ Used to assist in inferring the cause of any observed impacts to benthic communities. *Verification Monitoring* Monitoring will consists of: ♦ Quarterly routine monitoring of seagrass (Figure 7.2) to provide verification of the appropriateness of water quality criteria. ♦ Verification monitoring which will be triggered by an exceedence of the Level 2 management trigger at the seagrass location (Figure 7.2) at which the triggers were exceeded. Note: Data collected under this monitoring programme will not be used to assess achievement of the EPOs or MOs.	Pre, during and post capital dredging

No	Reference	Action	Timing
		Habitat Monitoring Pre/during/post surveys assessments of seagrass, macroalgae and filter feeders under the State of the Marine Environment SoW.	
Marine Fauna Management			
15	Table 9-1	Condition 10-1 of MS 873 requires at least one dedicated Marine Fauna Observer (MFO), to be on active duty on vessels actively engaged in dredging during all daylight hours when dredging is conducted.	Throughout TSHD and CSD operations
16	Table 9-1	Condition 10-3 requires at least one member of the vessel crew (on vessels other than those with an MFO on active duty), trained in marine fauna observation and mitigation measures, to be on active duty during daylight hours during vessel movement. The trained crew member may have other vessel duties.	Throughout dredging
17	Table 9-1	Whale and dugong observations and response procedures including application of ~300 m observation zone and ~100 m exclusion zone will be implemented during dredging and dredge spoil placement works as outlined in Figure 9.1. If calves are present the exclusion zone will be extended to ~300 m.	Throughout dredging
18	Table 9-1	Dolphin observations and response procedures including application of ~150 m observation zone will be implemented during dredging and dredge spoil placement works (Figure 9.1).	Throughout dredging
19	Table 9-1	A trained crew member will maintain a watch, during daylight hours, for whales and dugongs while any dredge is en route to and from the dredge area to DSPSs. If sighted, direction/speed will be adjusted to avoid potential impact (within the safety constraints of the vessel) to marine mammals.	Throughout dredging
20	Table 9-1	Designated transit corridors have been established for dredge vessels transiting to Placement Site C to minimise the disturbance to marine fauna (Figure 9.2) these may be reviewed if required.	Throughout dredging
22	Table 9-1	The presence of cetaceans/dugongs in or near exclusion zones established for key dredging and construction activities will be recorded.	Throughout dredging
23	Table 9-1	All sightings of whales, dolphins or dugongs that result in any management measures being implemented will be recorded.	Throughout dredging

No	Reference	Action	Timing
24	Table 9-1	Details of at risk conservation significant marine fauna (CSMF) sighting within vessel work areas and/or corridors of vessel movement between work areas will be communicated to the coordinator of Project vessel movements (or equivalent) to warn other vessels operating in the area, as soon as it is safe to do so.	Throughout dredging
25	Table 9-1	Vessels engaged in construction of the Project (excluding any vessels engaged in emergency response) will adhere to speed limits presented in the Conservation Significant Marine Fauna Interaction Management Plan (CSMFIMP) or any speed limit designated by the Department of Transport or relevant Port Authority; whichever is lesser (MS 873 Condition 10-4).	Throughout dredging
26	Table 9-1	Dredge pumps on TSHD will be stopped as soon as practical possible after completion of dredging and where practical the drag head will remain as close as practicable to the seabed until the dredge pump is stopped.	Throughout TSHD operations
27	Table 9-1	When operating with less than 5 m under-keel clearance, the TSHD will initially move slowly through the area before commencing dredging so that associated noise and vibration will alert marine turtles in close proximity and encourage them to leave. This will only be applied to dredging in new areas and not once the work area has been established.	Throughout TSHD operations
28	Table 9-1	When initiating dredging, suction through dragheads will be initiated just long enough to prime the pumps, prior to drag heads engaging the seabed.	Throughout TSHD operations
29	Table 9-1	Tickler chains and/or deflector devices on the drag head of the TSHD will be used as a management mitigation approach to reduce turtle entrainment.	Throughout TSHD operations
30	Table 9-1	Overflow screens will be used on TSHD to visually assess for turtles and turtle remains associated with entrainment during dredging after each load.	Throughout TSHD operations
32	Table 9-1	A MFO will maintain watch, during daylight hours, for whales, dolphins and dugongs during dredge operations	Throughout TSHD and CSD operations
33	Table 9-1	All observations of marine fauna will be recorded by the MFO, or trained crew member (as appropriate), and submitted to DPaW and DOTE annually.	Throughout dredging
34	Table 9-1	All CSMF incidents will be reported to the Department of Environment and Conservation (now DPaW) within 24 hours of the observation as per MS 873 Condition 10-16ii.	Throughout dredging
35	Table 9-1	All CSMF and EPBC Listed Threatened or Migratory species incidents will be reported to	Throughout dredging

No	Reference	Action	Timing
		the Minister responsible for administering the EPBC Act within one business day of observation as required by EPBC 2008/4469 Condition 26(e).	
36	Table 9-1	Observations of any at risk marine fauna will be reported to the vessel master (or their delegate) as soon as practicable	Throughout dredging
37	Table 9-1	Prior to commencement of dredging and dredge spoil placement, selected crew will receive training in marine fauna observations, including procedures in the event of injury or death	Prior to dredging
Dredge Spoil Placement Area Management			
33	Table 10-1	At the offshore sites the placement of dredge spoil will comply with the requirements of the Sea Dumping Permit (SDP), including: ♦ Establish by Differential Global Positioning System (DGPS) that, immediately prior to dredge spoil placement, the vessel is within the approved dredge spoil placement area ♦ Any dredge used in connection with the dredge spoil placement activities and any associated towing vessels must be capable of disposing dredged material at the DSPSs in accordance with the SDP ♦ Marine mammal management procedures as detailed in Section 9.2 will be followed during dredge spoil placement activities ♦ Records comprising either weekly plotting sheets or a certified extract of the ship's log will be retained (for verification and auditing purpose), which detail: ▪ the times and dates of when each dredge spoil placement run is commenced and finished ▪ the position (as determined by DGPS) of the vessel at the beginning and end of each dredge spoil placement run, with the inclusion of the path of each dredge spoil placement run ▪ the volume of dredge spoil (in cubic metres) dumped and quantity (in dry tonnes) for the specified operational period and compare these quantities with the total amount permitted under the SDP.	Throughout dredge spoil placement activities
34	Table 10-1	Division of placement sites to determine the schedule for placement of dredge spoil based on seasonal and metocean conditions and dredge spoil;	Throughout dredge spoil placement activities

No	Reference	Action	Timing
35	Table 10-1	The use of buffer zones within the perimeter of the placement sites provides a buffer zone to reduce any movement of sediment outside the site boundary following placement or risk of placement of material outside the site;	Throughout dredge spoil placement activities
36	Table 10-1	A bathymetric survey of the dredge spoil placement areas will be undertaken: ♦ Prior to the commencement of dredging ♦ Quarterly during dredging ♦ Within one months of the completion of all dredge spoil placement activities authorised under the SDP.	Pre-dredging, quarterly during dredging and one month post-dredging

Wheatstone Project

Addendum 1: Revised Designated Transit Routes to Dredge Spoil Placement Site C

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Chevron

Wheatstone Project

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22 December 2016

Monica Collins
Director
Department of the Environment and Energy
51 Allara Street
CANBERRA ACT 2601

Dear Monica,

Wheatstone Project (EPBC 2008/4469) – Revised Designated Transit Routes to Dredge Spoil Placement Site C

The Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan (DDSPEMMP) [WS0-0000-HES-RPT-CVX-000-00086-000 Rev 4] required by Conditions 10 and 11 was approved by way of letter on 7 March 2016.

A revision to Figure 9.2 of the DDSPEMMP has been made to incorporate the completed shipping channel as a designated transit route to Dredge Spoil Placement Site C. Chevron Australia Pty Ltd intend to utilise the shipping channel during dredge clean up activities scheduled for early 2017. Incorporation of the shipping channel is not considered to pose any additional or different environmental risks to those already assessed under the DDSPEMMP.

We respectfully request your approval of this letter as an addendum to the DDSPEMMP by 10 January 2017. Once approved by your Department the addendum will be implemented, and the revised figure will be incorporated in the next revision of the Plan. For the purpose of Condition 14, Chevron considers these changes minor in nature.

If you require any further information in relation to this matter, please do not hesitate to contact Ms Alex Cargo on tel. 08 6145 7264 or email acargo@chevron.com.

Yours sincerely

Joe Sanderson
HES Supervisor – Environment
Wheatstone Project

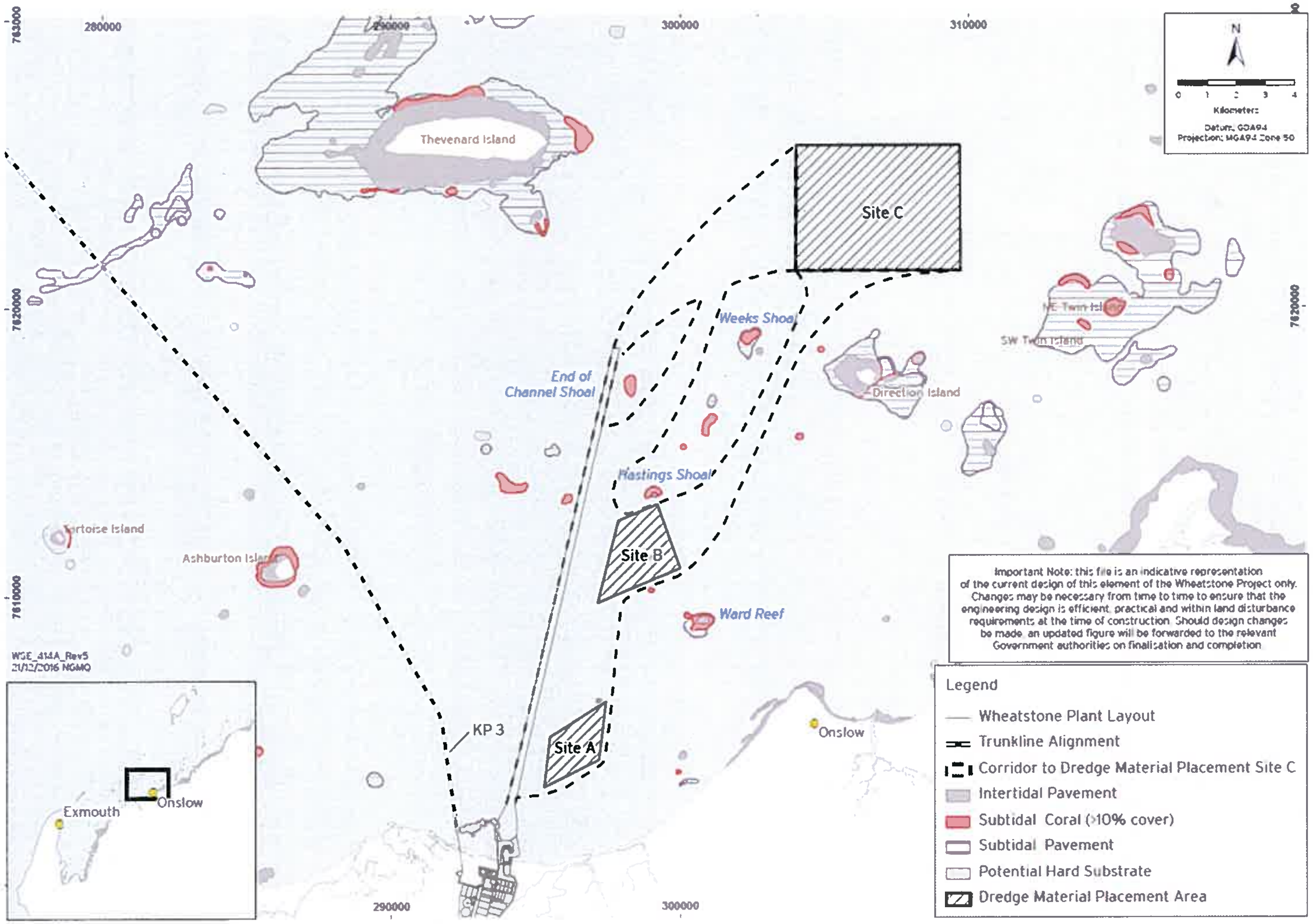

Figure 9.2: Designated Transit Routes to Dredge Spoil Placement Site C

Australian Government
Department of the Environment and Energy

Mr Joe Sanderson
Environmental Manager Wheatstone Project
Chevron Australia Pty Ltd
GPO Box S1580
Perth WA 6845

Wheatstone LNG Project, Western Australia (EPBC 2008/4469)

Dear Mr Sanderson,

Thank you for your letter of 22 December 2016 requesting approval of Addendum 1 to the Dredging and Dredge Spoil Placement Environmental Monitoring and Management Plan (DDSPEMMP) (Revision 4).

Officers of the Department have reviewed your request and advised me that Addendum 1 meets the requirements of condition 11 of EPBC Act approval 2008/4469. On this basis, and as a delegate of the Minister for the Environment and Energy, I have decided to approve Addendum 1 to the DDSPEMMP (Revision 4) in accordance with condition 5 of that approval. The Addendum must now be implemented.

Should you require any further information please contact Heather Cross, Project Officer, on (02) 6274 1432 or by email: post.approval@environment.gov.au.

Yours sincerely

Monica Collins
Assistant Secretary
Compliance & Enforcement Branch
Environment Standards Division

24 Jan 2017