Port of Melbourne Corporation

Turbidity – Detailed Design

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Revision history

Date	Version	Name	Reason
9/11/2007	Draft	David Provis	Peer Review
27/11/2007	Draft	PoMC	Internal Review
7/12/2007	Draft	EPA, DSE, DOI, DPI	Victorian Government Agency Review
11/1/2008		Dept of Environment, Water, Heritage and the Arts	Commonwealth Government Review

Contents

1 Document Intent

This document is one of a series of detailed design reports to inform the process of Environmental Monitoring and Baywide Monitoring programs associated with the Channel Deepening Project (CDP). This document relates specifically to the monitoring of turbidity occurring during and following dredging and details management measures, environmental performance monitoring and contingency plans as formalised in the Project Delivery Standards (PDS) of the Environmental Management Plan (EMP). This document details:

- The process of risk identification, analysis and evaluation undertaken in relation to the impacts of turbidity on identified assets
- Response levels and environmental limits for turbidity and how these levels and limits inform the implementation of management responses to minimise identified risks
- Justification for the selection of each monitoring site and distinguishes between monitoring sites subject to numerical environmental limits and those serving to provide additional information to the program
- The process of data collection, interpretation and validation and details how results will be reported, communicated and reviewed

It is important to note whilst every effort has been made to include necessary details in the document so as to adequately describe the Turbidity Monitoring Program there will be other operating procedures (e.g. equipment maintenance and database management) that provide further detail to inform the monitoring program.

The development of statistical means to identify and process data related to data gaps, turbidity probe fouling, faults and background turbidity have been established and will be continue to be refined during the project.

2 Background

Dredging and the disposal of dredged material will result in the temporary suspension of sediment in the water column, creating a "plume" in an area surrounding the dredge and the disposal site. This plume has the potential to affect surrounding assets, beneficial uses and values while sediments remain in the water column via the impacts of reduced light, reduced visibility and the clogging of gills and membranes of marine biota. In addition, there is the potential for settled sediments to impact on the epibenthic communities in Port Phillip Bay (the Bay). More information on these impact pathways is provided in Section 2.1.

The CDP Risk Assessment (URS, 2007) as part of the Supplementary Environment Effects Statement (SEES) assessed the impacts of the CDP on the key assets, beneficial uses and values of the Bay. Increased suspended sediments were identified as a major pathway by which the CDP could impact the environment.

The Risk Assessment analysed and evaluated the identified risks and distinguished between those assets at risk during CDP and those unlikely to be affected. In accordance with desired environmental outcomes identified in the evaluation objectives of the SEES Assessment

Guidelines (DSE, 2005) for Bay assets most at risk, Project Delivery Standards have been developed using environmental limits in accordance with relevant legislation.

The environmental limits set for the management of the plume and suspended sediments must ensure that short term adverse impacts are minimised and there are no long-term adverse impacts to the beneficial uses of the Bay.

The CDP Turbidity Monitoring Program has been designed to confirm the turbidity levels at key locations predicted in the SEES, and to confirm compliance with designated environmental limits. Environmental limits are detailed in Section 6.

The EMP identifies management commitments and contingency actions for varying levels of turbidity. Management commitments are detailed in Section 11.

2.1 Impact Pathways

Suspended sediments have the potential to affect Bay assets, beneficial uses and values via four pathways (URS, 2007):

- Clogging of gills and membranes of aquatic organisms
- Reduced visibility within the water column
- Reduced light within the water column
- Smothering of organisms via settled sediments.

High concentrations of suspended sediment in the water column has the ability to clog the gills of fish and the membranes of filter feeding organisms such as anchovies, mussels and sea squirts. Consequences to fish, particularly anchovies, will have indirect consequences on organisms such as seabirds and penguins that utilise these filter feeders as a primary food source. In addition, any consequences to fish populations could have indirect effects on recreational and commercial fishing and effects to mussels may have economic consequences for the aquaculture industry (Figure A1- 1).

Direct consequences of reduced visibility include the disruption to migratory routes of freshwater fish (eg mudfish, grayling) that move from the Bay into the Yarra during spring (PIRVic, 2006). Reduced visibility also has the potential to affect visual feeders such as predatory fish, penguins and marine mammals. However, these predators are highly mobile and are likely to avoid areas of the plume that hamper their feeding ability (PIRVic, 2006). Reduced visibility may also affect recreational diving and have indirect effects on tourism and commercial abalone divers (Figure A1- 2).

Reduced light will result in decreased primary production in photosynthetic organisms, particularly benthic plants such as seagrass, macroalgae and microphytobenthos, as well as phytoplankton in the water column. This reduction in productivity and biomass has the potential for flow on effects to other biological components in the Bay ecosystem, such as a reduction in food availability for grazers and decreased habitat for organisms such as juvenile fish, which rely on seagrass or macroalgae for structural habitat (Figure A1- 3).

Finally, settled sediments have the potential to smother epibenthic communities (both faunal components and microphytobenthos). Coatings of sediments on photosynthetic tissues of benthic plants can also result in decreases in productivity due to shading. (Figure A1- 4).

2.2 Key Assets, Beneficial Uses and Values at Risk

The turbidity monitoring program will inform PoMC management and aims to ensure that these pathways do not lead to impacts beyond that predicted in the SEES. At specific locations/sites where the risk & impact assessments predicted effects on assets with at least moderate consequence levels and/or at least medium risk levels, turbidity will be monitored. All relevant assets in the risk assessment which meet this criteria are listed in Table 1.

Table 1 Key assets beneficial uses and values assigned significant predicted effects or risk events as a result of increased suspended sediments (URS, 2007).

IMPACT	ASSET	RISK LEVEL (risk events)	CONSEQUENCE LEVEL (predicted effects)
Project Area 1 – Yarra & Williamstown			
Suspended sediments affects organisms / fauna (clogging)	Fish (anchovies, mudfish, grayling)	Medium	
	Fish eggs and larvae (bream)	Medium	
Project Area 3 – South of the Bay			
Reduced visibility affects humans (eg diving, swimming, snorkelling)	Commercial abalone divers		Moderate
	Recreational divers		Moderate
Reduced visibility affects fauna breeding and feeding	Seabirds	Medium	
Reduced visibility affects fauna migration	Fish migration (pilchards, snapper, whiting)	Medium	
Reduced visibility affects fauna migration	Commercial fishing	Medium	
Reduced light affects photosynthesis	Seagrass		Moderate
	Fish – from MPB and seagrass impacts		Moderate

IMPACT	ASSET	RISK LEVEL (risk events)	CONSEQUENCE LEVEL (predicted effects)
	Dolphins – from fish impacts		Moderate
Suspended sediments affects organisms / fauna (clogging)	Shallow habitat - Seapens		Moderate

Sedimentation (smothering via settled sediments) was considered by the risk assessment process, however it was assessed as not a significant risk to assets, beneficial uses and values (URS, 2007).

Assets and beneficial uses that may be indirectly influenced by increased suspended sediments such as penguins and marine mammals due to the effects on their food source will be protected through the protection of the primary assets at risk.

Whilst visibility impacts to recreational and commercial divers have been identified at risk from elevated suspended sediments, protection of the asset will be managed via a monitoring location where data received informs a community consultation process rather than being subject to an environmental limit.

2.3 Legislation

CDP works will be undertaken in accordance with all relevant state and federal legislation. The *Environment Protection Act 1970* (Vic) (*EP Act*) is the primary overarching legislation in regards to the impacts of suspended sediments from dredging operations. State Environment Protection Policies (SEPPs) and management guidelines developed under the *EP Act* will guide dredging operations with respect to the release of suspended sediments into the aquatic environment.

Dredging operations and disposal of dredged material within Port Phillip Bay are covered under Clause 13 of the State Environment Protection Policy (Waters of Victoria) Schedule F6 Waters of Port Phillip Bay (1997). With respect to the management of suspended sediment the following clauses are relevant.

Protection agencies or bodies undertaking dredging or spoil disposal must ensure that:

- *These activities are conducted in accordance with the current best practice or any code of best practice approved by the Authority*
- *These activities are conducted and managed to ensure local exceedances of the prescribed environmental objectives are confined to the smallest practicable area and over the shortest practicable time in the vicinity of the dredging and disposal operation*
- *These activities do not re-suspend and/or disperse sediments or accumulated contaminants that will be detrimental to the long term protection of beneficial uses.*

The Best Practice Environmental Management Guidelines for Dredging (2001) and the Framework for Applying "Best Practice" to Dredging in Port Phillip Bay (2006) have been developed to advise government agencies and industry on the application of "best practice" for

dredging in Victorian Waters and Port Phillip Bay. Essentially legislation in regards to suspended sediments for dredging operations requires minimising short term impacts and ensuring there are no long term impacts from dredging and disposal operations. Project Delivery Standards detailed in the EMP have been developed in accordance with this legislation.

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), the *Flora and Fauna Guarantee Act 1988* (Vic) (FFG Act) and *the Fisheries Act 1995* (Vic) provide lists of various species requiring protection. The potential impacts to all listed species have been assessed during the EES and risk assessment process. Dredging and monitoring programs detailed in the EMP have been tailored to provide protection to the following species where risks were identified –

- Humpback whale – Observers will be employed during the dredging program and if a whale is encountered, works will cease temporarily
- Australian grayling, Australian Mudfish – Dredging will not occur in Hobsons Bay or the Yarra River with the TSHD between 15 October – 30 November. This will avoid potential disruption to migration patterns
- Pipefishes and seahorses - A monitoring approach has been specifically developed to provide adequate light for seagrass. See details of the 2 week moving average methodology in Section 8.

Other listed species including the Australian sea-lion, Great white and Grey nurse shark, Sea cucumber, Southern hooded shrimp, Ghost Shrimp, Chiton and Leatherback turtle were found to either rarely frequent the Bay or exist in areas where impacts are unlikely.

The implementation of the EMP (the turbidity monitoring program is formalised in the Project Delivery Standards of the EMP) is also a requirement under the *Coastal Management Act 1995* (Vic).

3 Institutional & Community Communication

PoMC is responsible for implementing the turbidity monitoring program. PoMC has formed a partnership with Boskalis Australia who has formed the Alliance and will be undertaking required CDP field works which include the deployment and maintenance of turbidity monitoring equipment. Data analysis/interpretation, program reporting and internal auditing of this program will be undertaken by PoMC in conjunction with the Alliance and facilitated by an online database that receives a data transmission from turbidity meters every 2 hours.

PoMC Managers and Project Managers will maintain ongoing communication with Alliance throughout CDP works. The PoMC Executive General Manager Channel Deepening will undertake all communications with the Alliance in regards to any required alteration of operations or suspension of works due to turbidity level exceedances.

Alliance field operators and Project Managers will maintain an ongoing reporting and communication commitment as detailed in the Monitoring Procedure: Turbidity Buoy Maintenance (currently under development). Regular meetings will be scheduled during works and will also occur as required.

A key component of the turbidity monitoring program will be the ongoing communication with State Government agencies such as the Department of Sustainability and Environment (DSE), Environment Protection Authority (EPA) and the Department of Primary Industries (DPI). This

communication will occur formally through the generation of a quarterly report presented to the agencies. PoMC will maintain ongoing communication with dedicated representatives from each of the agencies during monitoring and will undertake notification and approval requirements in accordance with the turbidity contingency procedures detailed in the EMP.

Two key groups will be established by PoMC for the duration of the project including a Community Consultation Group (CCG) and Dive Industry Liaison Group (DILG). Both groups will be involved in quarterly meetings where information on CDP works are provided and will be asked to provide their own feedback as key stakeholder representatives. The CCG will comprise key stakeholders and community members from around the bay.

4 Objective / Key Aspects

The objectives of the CDP environmental monitoring programs are to:

- Facilitate management and mitigation of the project's significant predicted effects and risk events
- Enable compliance assessment of the project's implementation
- Enable improvement of the project's environmental performance.

Environmental monitoring programs have been established where the predicted effect or risk event is assessed as significant, or there is an established environmental limit for an identified risk event or predicted effect that has been identified as being relevant to the project and, under certain circumstances, could be exceeded.

The objective of the turbidity monitoring program is to protect key assets of Port Phillip Bay from the impacts of turbidity caused by the CDP. This will be undertaken through:

- Monitoring of the dredge plume to inform compliance to numerical limits and response levels
- Monitoring to separate dredge related elevations in turbidity from those of external processes.

The main aspects of the turbidity monitoring program as detailed in the EMP are:

- Continuous monitoring of turbidity at conformance locations
- Monitoring during dredging activities and for the period after dredging has ceased that turbidity remains above background concentrations (likely to be in the order of days after completion of dredging)
- Monitoring of turbidity at key sites between assets and dredge operations to provide additional data on the turbidity plume
- Monitoring of major inputs of turbidity not related to the project (e.g. upstream of the project in the Yarra River).

Eleven 'conformance' turbidity monitoring locations have been established at locations where assets are predicted to be significantly and directly influenced by the plume (see Section 2 and Table 1). Environmental limits are applicable to these locations only.

Nine 'other' turbidity monitoring locations have been established. These are not subject to an environmental limit. These monitoring locations are divided into those between assets and dredge operations to provide additional data on the turbidity plume and those monitoring major inputs of turbidity not related to the project.

5 Applicability

Turbidity monitoring is required at 20 (11 'conformance' and 9 'other') locations encompassing the Yarra River, Hobsons Bay, north of the Bay and south of the Bay.

Environmental limits are applicable during the construction phase and post construction for the period that dredge-related turbidity remains above background concentrations (likely to be in the order of weeks). The environmental limit is only applicable to the use of the trailing suction hopper dredge and the disposal of dredged material at the DMGs.

Environmental limits are applicable in the following project areas:

- Project Area 1: Yarra River and Hobsons Bay
- Project Area 3: South of the Bay

Assets and beneficial uses that may be indirectly influenced by increased suspended sediments (eg penguins and marine mammals due to the effects on their food source) will be protected through the protection of the primary assets at risk, consistent with the pathways identified in the environmental impact and risk assessment process.

Environmental limits do not apply to Project Area 2 (North of the Bay). Three 'other' monitoring locations will provide information on the plume extent in this Project Area.

For the purposes of environmental limits, Project Area 4 (the Entrance) has not been addressed separately. There were no identified risks from increased suspended sediments from dredging at the entrance (URS, 2007), and impacts to the assets located around the entrance and outside the heads are addressed within Project Area 3 (South of the Bay). Similarly, effects of dredged material disposal at the Dredged Material Grounds (DMG) are incorporated into the corresponding Project Area. Figure 2 shows locations of all 'conformance' and 'other' monitoring locations.

6 Response Levels & Environmental Limits

A process of management with respect to turbidity is provided through the use of both response levels and an environmental limit.

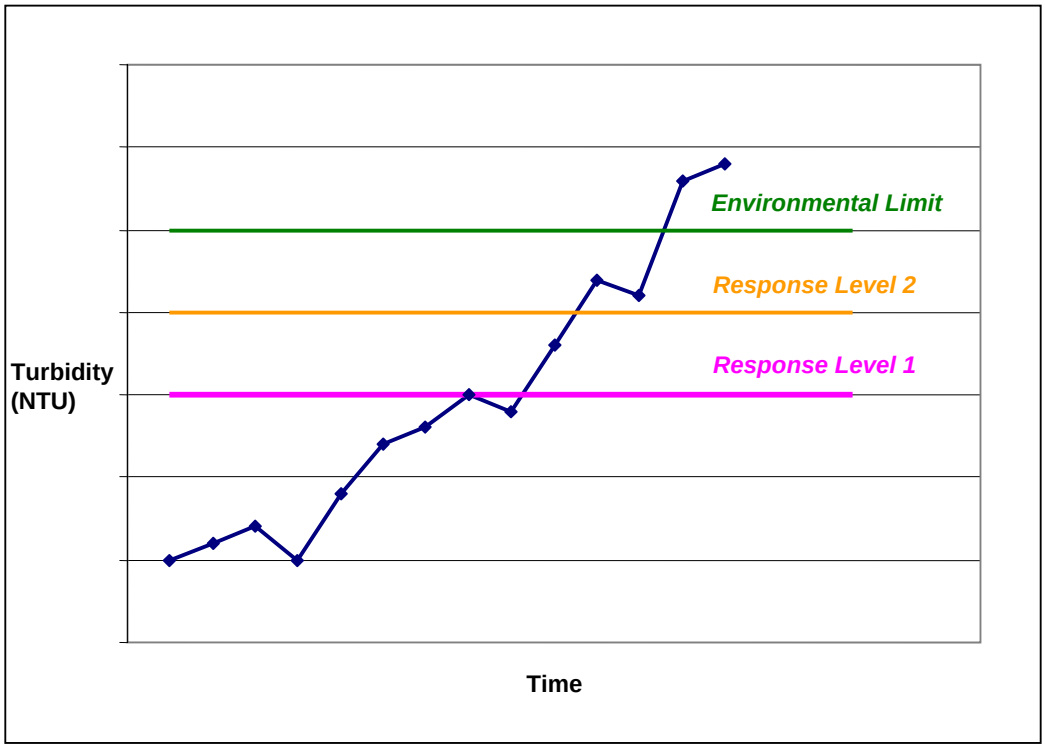
Environmental limits are defined levels of maximum tolerance to an environmental condition, beyond which the potential for long-term negative impact is considered unacceptable.

Where possible and appropriate, environmental limits have been developed to protect assets, beneficial uses and values within the Bay from long-term impacts resulting from the CDP. These levels are numerical performance standards and based on the biological requirements of the asset.

Response levels provide an early warning that conditions may be trending towards the environmental limit, enabling timely management action to be taken in order to avoid unacceptable adverse impacts. For the turbidity program, two tiers of response levels will be used.

Environmental limits and response levels will be based on a 6-hourly Exponentially Weighted Moving Average (EWMA) or a 2 week moving average (See Section 8). The environmental limit and response levels are conceptualised in Figure 1.

Figure 1 Conceptual order of Response Levels for management and the upper Environmental Limit



All environmental limits and response levels are expressed in nepholometric turbidity units NTUs (turbidity).

6.1 Environmental Limits

The environmental limits are based on the known impacts of increased suspended sediments and known concentrations that marine organisms can tolerate without severe or lasting impacts. The limits will help ensure that impacts do not exceed the tolerable levels predicted in the risk and impact assessment process. The assets identified in the risk and impact assessments as being directly influenced, and their associated environmental limits, are shown in Table 2.

For evidence behind the derivation of these environmental limits see Appendix 2. Details of the sites where these environmental limits apply are provided in Table 3. Note that only the environmental limit for the Australian grayling and mudfish depends on the background

turbidity (in Spring). The environmental limit for all other assets does not depend on background turbidity.

Table 2 Environmental Limits for Turbidity

IMPACT	ASSET	RATIONALE	ENVIRONMENTAL LIMIT
Increased suspended sediments → Reduced visibility affects fauna migration	Fish (Australian grayling and mudfish)	Similar species to the listed freshwater fish in the Yarra River have been shown to avoid conditions where turbidity is 25 NTU above background.	25 NTU above background during Spring (to a maximum of 45 NTU including background). (Limit only applicable 15 October to 30 November). Background is derived from a buoy upstream of the planned works.
	Seabirds (crested terns and Australasian gannets)	25 mg/L based on observations of cormorants.	17 NTU
Increased suspended sediments → Reduced light → Impacts Photosynthesis	Shallow habitats (seagrass)	The environmental limit has been developed using multiple lines of evidence regarding the light requirements of H. nigricaulis, including literature and a local shading experiment. In general, these studies suggest there is a biological requirement for average benthic light ≥ 15 percent surface irradiance.	25 NTU
Increased suspended sediments → Suspended sediments affect organisms / fauna (clogging)	Fish	Suspended sediment concentrations of greater than approximately 100 mg/L have been shown to increase fish egg hatching times, reduce hatching success and decrease larval fish survival.	70 NTU
	Shallow habitats (benthic invertebrates)	Based on the tolerance of Pyura stolonnifera (sea squirt) of 50 mg/L for more than 8 hours.	35 NTU

6.2 Response Levels

Response levels will inform dredge management by providing an early warning system so that management action can be taken if necessary to ensure that the environmental limit is not breached. As a guide, and consistent with ANZECC/ARMCANZ (2000), the level 1 response is typically an investigation or follow-up into the nature and causes for the trigger. A triggering of response level 2 requires management actions that will result in decreases in suspended sediment concentrations (turbidity). Management actions that may be implemented include moving the location of the dredge, dredging with no overflow, or dredging at a reduced speed. More information on these management responses/contingencies is provided in Section 11.

In assessing the suitability of proposed response levels, Environmetrics (October 2007) highlight the need to consider non-statistical issues, recognising that often there will be insufficient information to establish an ecologically based response levels. Environmetrics (October 2007) comment that modelled turbidity data and background turbidity concentrations should be used where possible. The process of establishing response levels attempts to balance the degree of forewarning and level of false-triggering. There are a number of design limitations that will affect the feasibility of a response level:

- The time frame for management response (ie response level 1 needs to be sufficiently lower than response level 2 to allow time for management response prior to the triggering of the second response level)
- False triggering can result in cost and time impacts to the project and as such need to be kept to a minimum. Therefore, response levels need to be sufficiently high to prevent large numbers of false triggers
- All background turbidity data collected for the CDP has occurred during times of drought. This has resulted in lower discharges from the catchment and a potentially biased sample of natural turbidity in Port Phillip Bay. In the event that the CDP occurs during a period of higher than average rainfall, higher background levels of turbidity could be expected. This impact would need to be identified when assessing reasons for exceedances

PoMC notes that:

- Different response levels at different areas or monitoring locations around the bay will be required as background/historical conditions vary
- In order to enable the operational response to be effective, in most cases the response levels need to be at lease approximately 3- 5 NTU away from the next response level or the environmental limit
- Both response levels will be able to be refined during CDP through the change management process
- PoMC is currently in the process of collecting additional background data at conformance locations. Data collected prior to and during dredging works will be used to assess and if appropriate adjust response levels throughout the project.

Response levels are applicable to the 6 hr EWMA calculations. Response levels have been developed with the understanding that the levels need to be operational and designed to invoke a management response to an undesirable trend in water column turbidity. Whilst the focus of

setting response levels have been to provide both sufficient time for management actions between levels and to minimise the occurrences of false triggering, modelled and background data has been used to guide the setting of response levels.

South of the Bay

Sorrento Bank (2006), Swan Bay – Coles Channel (2413), Mud Islands East C (2506), Camerons Bight (2601), Lonsdale Bight North (1308) - Environmental Limit 25 NTU.

Response Level 1 12 NTU

Guidance in establishing the level was provided by consideration of modelled 99th percentile concentrations and background concentrations.

Response Level 2 17 NTU

Guidance in establishing the level was provided by including a suitable buffer from response level 1 and consideration of modelled greater than 99th percentile concentrations and background concentrations.

Capel Sound (2704), Portsea Hole D (2106) - Environmental Limit 35 NTU.

Response Level 1 19 NTU

Guidance in establishing the level was provided by consideration of modelled 99th percentile concentrations and background concentrations.

Response Level 2 24 NTU

Guidance in establishing the level was provided by including a suitable buffer from response level 1 and consideration of modelled greater than 99th percentile concentrations and background concentrations.

Rye Jetty (2602), South of SE DMG (2948) - Environmental Limit 17 NTU.

Response Level 1 9 NTU

Guidance in establishing the level was provided by consideration of modelled 99th percentile concentrations and background concentrations.

Response Level 2 14 NTU

Guidance in establishing the level was provided by including a suitable buffer from response level 1 and consideration of modelled greater than 99th percentile concentrations and background concentrations.

Yarra River and Hobsons Bay

Hobson Bay Mud (7005) - Environmental Limit 70NTU

Response Level 1 35 NTU

Response Level 2 50 NTU

Modelled concentrations and background data were significantly lower than the less sensitive Environmental Limit for this site and did not provide any guidance in the setting of the response levels. Response levels were set purely at levels expected to enable practical management.

Mouth of Yarra River (8016) - Environmental Limit 25NTU above background to a maximum of 45 NTU. The limit applies from the 15 October to 30 November.

Response levels have not been specified for this site as there is currently no intention for dredging to occur during the times that the Environmental Limit applies.

The review of turbidity background concentrations prior to and during CDP works and plume turbidity concentrations during will provide an ongoing review of the effectiveness of the levels. It is recognised that where the response levels are currently either close to the environmental limit or significantly divergent from the environmental limit the occurrences of false triggering or inadequate forewarning may result a revision of these levels. The response levels will serve as an adaptive management tool and be subject to ongoing review and possible alteration throughout the project duration.

7 Data Collection

At each monitoring location, two turbidity meters will each take one reading of turbidity (NTU) every 12 seconds, giving 5 readings per minute for each sensor. For this one minute, the median of the 5 values will be calculated and stored by the logger. In the following minute another 5 readings are taken and the median of this value is then also stored. This provides a near continuous dataset, whilst avoiding storage of erroneous data due to transient spikes unrelated to turbidity itself (eg. instrument error or seaweed drifting past the sensor etc).

The turbidity meters are both attached to a single data logger, and this equipment is housed in a buoy with one shared battery supply charged by solar panels. This system is linked to a GSM modem which is interrogated by a GSM base station at the PoMC office every two hours. As noted in section 3 the database will receive transmission of data every 2 hours.

This monitoring regime will occur continuously at all monitoring sites once equipment is installed. Monitoring will occur prior to the commencement of CDP to provide baseline data collection, during dredging activities and for the period after dredging has ceased that turbidity remains above background levels (likely to be in the order of two weeks).

Planned equipment maintenance/cleaning and calibration events result in data gaps periodically. It is likely that these outages will not be more than around 1hr per week in the Yarra or 1hr per fortnight in Port Phillip Bay.

7.1 Monitoring Locations

There are two types of monitoring sites:

- Conformance locations – these are locations where an asset requires protection based on the criteria used in Section 2.1, and turbidity is assessed against response levels and environmental limits ("Conformance Sites")

POMC Code	Location Name	MGA		Approx Depth (m)	Asset Monitored
		Easting	Northing		
2006	Sorrento Bank	304446	5754974	3	Seagrass, Fish, Benthic Inv
2106	Portsea Hole D	299730	5757300	20	Fish, Benthic Inv
2413	Swan Bay (Coles Channel)	299480	5766480	4	Seagrass
2506	Mud Islands East C	307250	5761200	6	Seagrass, Fish, Benthic Inv
2601	Camerons Bight	305036	5752687	6	Seagrass
2602	Rye Jetty	309606	5752025	12	Seabirds, Seagrass
2704	Capel Sound	314026	5754171	12	Benthic Invertebrates
2948	South of SE DMG	321600	5761590	19	Seabirds
7005	Hobsons Bay Mud	319374	5807938	4	Fish
8016	Mouth of Yarra River	316400	5808390	8	Grayling, Mudfish
1308	Lonsdale Bight North	294500	5761075	3	Seagrass - Amphibolis

- Other locations ("External Input Sites") to characterise other major inputs of turbidity not related to the project (e.g. upstream of the project in the Yarra River)

POMC Code	Location Name	MGA		Approx Depth (m)
		Easting	Northing	
8011*	Yarra D	317910	5812200	11
8015	Yarra E	315440	5811410	6

* Site 8011 will provide the background readings to site 8016 for the calculation of the Spring based limit of 25 NTU above background.

- Other locations ("Plume Tracking Sites") between assets and dredge operations to provide additional data on the behaviour/characteristics of the turbidity plume.

POMC Code	Location Name	MGA		Approx Depth (m)
		Easting	Northing	
2710	Middle Ground Shelf	313660	5757305	12
2949	Mornington	324720	5765550	17
4506	PoM DMG South	313240	5785700	22
6003	East Fawkner	320757	5796641	16
6026	PMC West	314290	5802260	16
7017	Hobsons Bay	317600	5806900	10
8012	NPS Intake	314995	5809630	6

Additional information relating to how these sites have been selected is provided in the following sections. The assets associated with each site and the corresponding environmental limits are shown in Table 3.

Figure 2 Turbidity monitoring program indicative monitoring locations

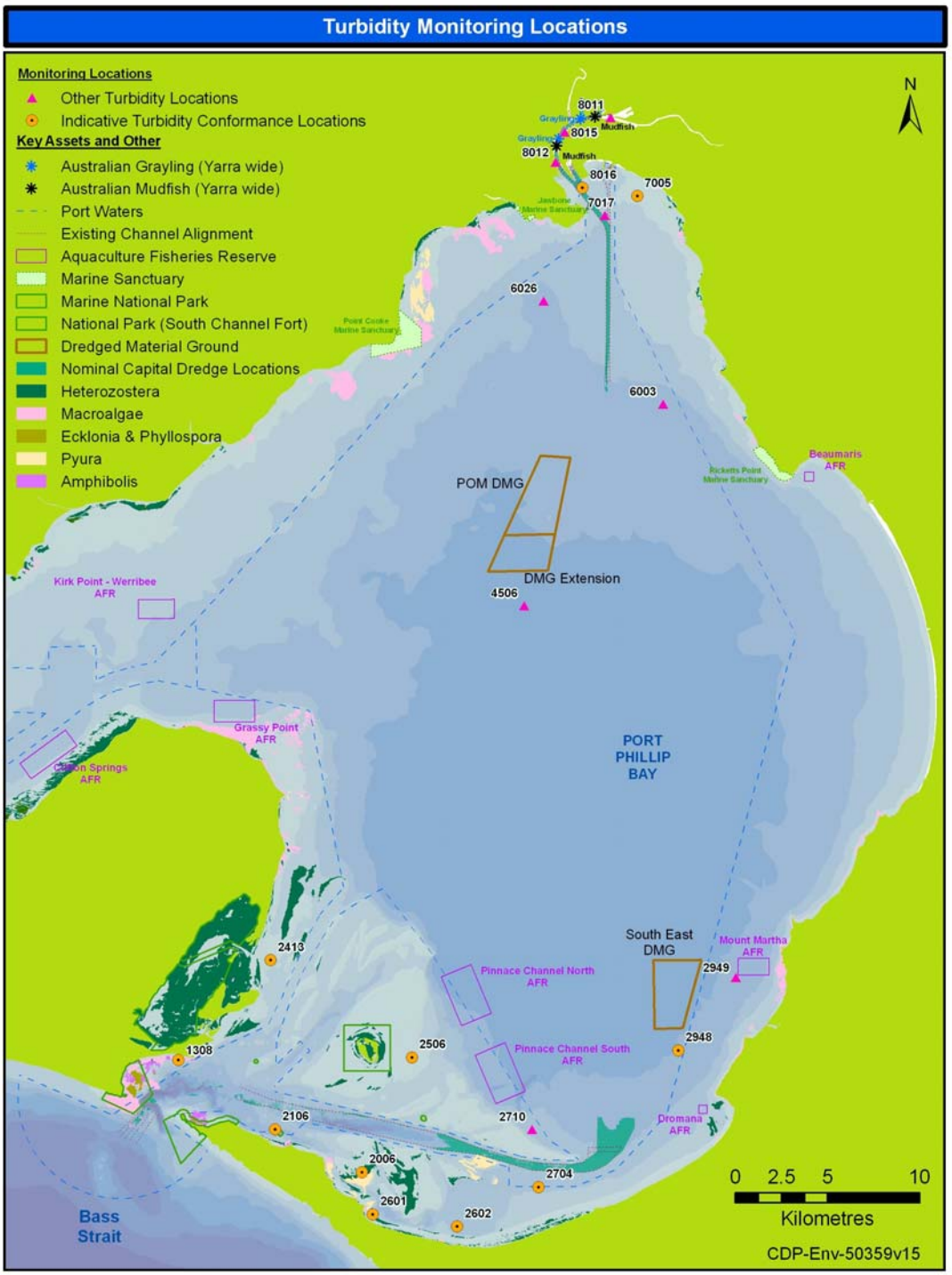


Table 3 Locations, assets and associated Enviornmental Limits

CODE	NAME	SITE TYPE	ASSET	RESPONSE LEVEL 1	RESPONSE LEVEL 2	ENVIRONMENTAL LIMIT
Project Area 1 – Yarra River and Hobsons Bay						
7005	Hobsons Bay Mud	Conformance	Fish	35 NTU	50 NTU	6 HR EWMA 70 NTU
8016	Mouth of Yarra River	Conformance	Migratory fish	N/A	N/A	6 HR EWMA 25 NTU above background during spring to max of 6 HR EWMA 45 NTU including background. (Applicable 15 Oct – 30 Nov only.
8015	Yarra E	External inputs	N/A	N/A	N/A	N/A
8011	Yarra D	External inputs	N/A	N/A	N/A	N/A
8012	NPS Intake	Plume Tracking	N/A	N/A	N/A	N/A
7017	Hobsons Bay D	Plume tracking	N/A	N/A	N/A	N/A
Project Area 2 – North of the Bay						
6026	PMC West	Plume tracking	N/A	N/A	N/A	N/A
6003	East Fawkner	Plume tracking	N/A	N/A	N/A	N/A
4506	PoM DMG South	Plume tracking	N/A	N/A	N/A	N/A
Project Area 3 – South of the Bay						
2006	Sorrento Bank	Conformance	Seagrass (also benthic invertebrates & fish) *	12 NTU	17 NTU	2week moving average of 15 NTU and 6 HR EWMA 25 NTU

CODE	NAME	SITE TYPE	ASSET	RESPONSE LEVEL 1	RESPONSE LEVEL 2	ENVIRONMENTAL LIMIT
2106	Portsea Hole D	Conformance	Benthic Invertebrates (also fish) *	19 NTU	24 NTU	6 HR EWMA 35 NTU
2413	Swan Bay – Coles Channel	Conformance	Seagrass	12 NTU	17 NTU	2week moving average of 15 NTU and 6 HR EWMA 25 NTU
2506	Mud Islands East C	Conformance	Seagrass (also benthic invertebrates & fish) *	12 NTU	17 NTU	2week moving average of 15 NTU and 6 HR EWMA 25 NTU
2601	Camerons Bight	Conformance	Seagrass	12 NTU	17 NTU	2week moving average of 15 NTU and 6 HR EWMA 25 NTU
2602	Rye Jetty	Conformance	Seabirds (also seagrass)*	9 NTU	14 NTU	2week moving average of 15 NTU and 6 HR EWMA 17 NTU
2704	Capel Sound	Conformance	Benthic Invertebrates	19 NTU	24 NTU	6 HR EWMA 35 NTU
2949	Mornington	Plume Tracking	N/A	N/A	N/A	N/A
2710	Middle Ground Shelf	Plume tracking	N/A	N/A	N/A	N/A
2948	South of SE DMG	Conformance	Seabirds	9 NTU	14 NTU	6 HR EWMA 17 NTU
1308	Lonsdale Bight North	Conformance	Seagrass - Amphibolis	12 NTU	17 NTU	2week moving average of 15 NTU and 6 HR EWMA 25 NTU

Note - For sites where multiple assets occur in the area, the most sensitive asset at each site is noted first. Other assets at this site are then noted in (brackets). Note that environmental limit is based on the biological requirements of most sensitive species.

7.1.1 Conformance Locations

Of the eleven conformance locations:

- Nine are located in Project Area 3 (South of the Bay); and
- Two are located in Project Area 1 (Yarra River and Hobsons Bay).

The program adopts an asset based approach and as such, numerical environmental limits and response levels have been set for key asset locations. Asset locations have been selected on the basis of the risk assessments (see Section 2.1 and 6.1). Whilst the locations of some assets and beneficial uses can be determined with a reasonable degree of accuracy (eg seagrass beds); other assets are mobile (eg fish, seabirds) and less easily located. In these instances conformance locations have been selected in consultation with relevant scientific experts to adequately capture habitat range and likely impact zones.

In addition, consideration has been given to statistical sample design. Environmetrics (2007b) determined that spatial replication at less than a 5km scale was not required. As such, the asset based conformance locations have been selected to provide adequate coverage for the purposes of monitoring against conformance criteria.

Consistent with the framework contained in the ANZECC and ARMCANZZ (2000a) guidelines, where more than one asset may occur at a site, the recommended concentration limit for the most sensitive asset has been used to set the numerical limit. The conformance sites are asset specific and therefore the numerical limit varies across sites and, in the case of the protection of migratory fish, is seasonally based.

Note that conformance location 1308 - Lonsdale Bight North is located specifically to protect *Amphibolis* seagrass beds. Other conformance locations for seagrass are specifically protecting *Zostera* seagrass. The risk assessment did not suggest a unique environmental limit for *Amphibolis* and so the environmental limits adopted for location 1308 are identical to those adopted for *Zostera*.

7.1.2 Other Locations

External Inputs

Of the nine other locations two will monitor external inputs and are located in Project Area 1 (Yarra River and Hobsons Bay).

The Yarra River has been identified as a significant source of turbidity (SKM, 2007) with plumes being detected extending into Hobsons Bay, particularly following rainfall events. Therefore to help identify the sources of elevated turbidity recorded in Hobsons Bay (ie. dredging-related or Yarra inflows), turbidity will be monitored in the Yarra River. Turbidity modelling (CLT, 2007) indicates the plume from dredging in the

Yarra River with the TSHD may at times extend more than 1km upstream of the dredging activities. To understand background Yarra River conditions during this period, turbidity will be monitored at site 8011 located several kilometres upstream. When there is no dredging in the Yarra River, the river can be monitored further downstream using site 8015, which has the benefit of better characterising the condition of Yarra River water upon entry to Hobsons Bay as it is downstream of the Maribyrnong River and Moonee Ponds Ck junctions.

There are other point sources of turbidity inputs into Port Phillip Bay, for example the outflow from the Western Treatment Plant, the Patterson River and the Mordialloc Drain discharge are both capable of resulting in visible "plumes" in the Bay. However these are not sufficiently close to the predicted plume (CLT, 2007) to be likely to impact conformance locations. In addition, there are many smaller drains that discharge stormwater into the Bay, but the impact of these is likely to be small. Accordingly it is proposed to monitor only the Yarra River as an alternative source of turbidity during the CDP.

Numerical limits and response levels do not apply to these monitoring locations.

Plume Tracking

Of the nine other locations seven will perform a plume tracking function and are located in:

- Project Area 1 (Yarra River and Hobsons Bay) – two sites
- Project Area 2 (North of the Bay) – three sites
- Project area 3 (South of the Bay) – two sites

These sites will inform dredge management and provide information on the location, direction of movement and turbidity concentrations within the plume. Monitoring locations have been placed between the operating dredge and conformance or asset locations.

Given the area of the predicted plume there is a large number of possibilities for the location of these sites that would meet the above objectives. A number of factors contributed to site selection, in addition to the prerequisite that they be located between the dredge and conformance locations. These included:

- Proximity to existing EPA fixed position water quality monitoring locations (sites 7017, 4506, 2710);
- Statistical advice (Environmetrics August 2007a);
- Monitoring of the plumes in the vicinity of the Dredge Material Grounds (sites 2949, 4506);
- Tracking the plume between dredging and recreational beaches or Marine Sanctuaries (2949, 6003).
- Proximity to the water intake point for Newport Power Station (8012). Elevated turbidity could affect the quality of water being used by the power station.

Dredging in the South Channel will be informed by site 2710. Works associated with the PoMC Dredged Material Ground and South East Dredged Material Ground will be informed by sites 4506 and 2949 respectively. Dredging in the Port Melbourne Channel will be informed by sites 6026, 6003 and 7017. Dredging in the Yarra River and Hobsons Bay will be informed by sites 8012 and 7017. The data analyst will be responsible for monitoring relevant non-conformance site data. The level of change in turbidity at non-conformance sites may provide indication of likely changes in turbidity at conformance sites. This will be a developing process based on actual learning throughout program.

Numerical limits and response levels do not apply to these monitoring locations.

7.2 Plume Behaviour

In isolation this program does not provide guidance on the behaviour of the turbid plumes during dredging. The primary focus of the design procedure is based on monitoring to inform compliance to numerical limits and protect assets. However, information on plume behaviour will be important in achieving improvement in environmental performance. Data from non-conformance sites will inform this process as described above and will be enhanced by monitoring results from the "Plume Intensity and Extent Program". The program is part of the baywide monitoring and will collect field (turbidity transects from a monitoring vessel) and satellite data to compare the plume intensity and extent during dredging against plume model outputs used in the SEES impact assessment at designated times during the project. Differences in modelled and actual plume characteristics demonstrated by the program will be monitored and assessed as to whether there is an increased or decreased risk to assets from turbidity.

7.3 Light Monitoring

Modelling was undertaken by Environmetrics to define the relationship between light attenuation and increased suspended sediments during dredging. This relationship was established using various assumptions regarding the homogenous nature of sediments within the dredge plume and was used to established the environmental limits. There is a commitment in the EMP to test the accuracy of this relationship during the project and assess any implications for the environmental limits if significant differences are evident.

Photosynthetically Available Radiation (PAR) sensors will be located at Mud Islands (2506), Camerons Bight (2601) and Sorrento Bank (2006) for the purpose of checking the turbidity environmental limits against ecological objectives of environmental limits. This data will be reviewed monthly for the first year of dredging.

8 Data Assessment & Interpretation

Data from the data loggers will be relayed to a secure server at the PoMC offices every two (2) hours. The following steps are then taken:

1. The quality of the data will be checked. The nature of the data collection process described in Section 7 ensures that significant erroneous data due to transient spikes unrelated to turbidity is removed from the data set. The analyst will undertake several daily data checks using graphical displays through the database to identify significant variations between the two meters at each monitoring location (See Section 8.2 for further details). Where significant variations indicate erroneous data, calculated data will defer to the operational meter and maintenance activities triggered for the faulty meter. Where significant variations do not exist the data transformation process will continue unchanged.
2. Suitable data will then be transformed as required into the 6-hourly EWMA and 2 week moving average. There may still be data incoming that does not reflect real changes in turbidity and therefore the nature of the two calculations provides further treatment to the data by using averages over current and previous time periods. Raw data values are stored in the database and calculated averages are graphed for each monitoring location.
3. Environmental limits and response levels for conformance locations are shown graphically in conjunction with calculated moving averages. Graphed moving averages for all monitoring locations are available to view on the database dashboard.

8.1 Data Transformation

Some amount of short term variability in turbidity, such as that caused by random instrument spikes or the transitory presence of an obstruction to the sensor, will be filtered out by setting the logger to record only the median value out of the 5 individual samples measured per minute.

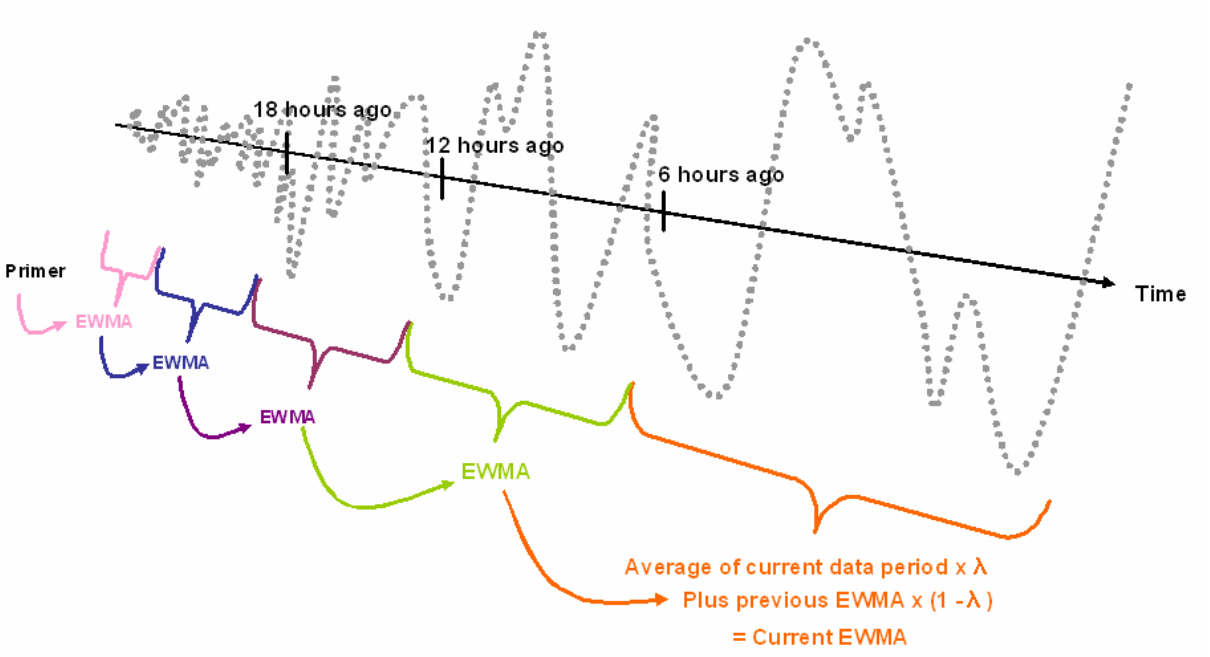
Once data is accepted into the database it may undergo further transformation to avoid further erroneous data and enable assessment against numerical limits. The relevant transformation differs between sites (as per Table 3). The types of data transformation required for assessment against Response Levels and Environmental Limits involve the calculation of:

- 6-hourly Exponentially Weighted Moving Average (EWMA) (Section 8.1.1);
- Combined site and background turbidity as a 6-hourly EWMA (Section 8.1.2);
- 2-week moving average (Section 8.1.3).

8.1.1 The 6-hourly EWMA

The Exponentially Weighted Moving Average (EWMA) control charting technique will be used to integrate data over 6 hour time periods. The EWMA is a weighted composite of the current observations and past history. An average of all of the data points logged in the past 6 hours (ie. the 'current observations') is calculated once every six hours. This value is then weighted by multiplying by Lambda 'λ'. This parameter λ is a value between 0 and 1 that represents the relative weighting given to this recent data – the higher the value, the larger the influence that recent data will have on the calculated EWMA. The previous EWMA (from the last 6-hour period) is multiplied by $(1 - \lambda)$ and added to the weighted average of the recent data. In this way, each EWMA contains a small fraction of every previous EWMA that has been calculated. This is shown in Figure 3:

Figure 3 Conceptual summary of how each sequentioal EWMA is calculated



One of the advantages of the EWMA over other control charting techniques is the ability to adjust the weighting given to current versus past results to suit the particular circumstances (ie. adjust λ). In addition, the EWMA was deemed to be the most appropriate control charting technique for this environmental limit due to:

- the fact that it makes use of all the available data;
- its ability to detect both large and small shifts in a process;
- its ability to track variability as well as changes in mean; and
- its insensitivity to non-normal data.

The benefit of using the EWMA also lies in the resistance to isolated aberrations in the data which are a common feature in field monitoring. As such, isolated high data readings will not result in false triggering of the environmental limit (evaluated using the EWMA). Consistently elevated turbidity readings, or a rapid change in the magnitude of a series of data readings will however result in an elevated EWMA and

will trigger the relevant response level or environmental limit (depending on the magnitude of the readings). The EWMA is therefore sensitive to turbidity levels, providing environmental protection, without reacting to transient spikes in the data

An important consideration in the design of the EWMA control chart is the choice of λ. It is suggested that the final choice be influenced by the nature of the environmental asset being protected and the required level of chart responsiveness to current conditions. Greater responsiveness to current conditions might be appropriate for seagrasses rather than fish (given the latter have an ability to avoid unfavourable conditions) in which case $\lambda = 0.6$ would be preferred over $\lambda = 0.2$. Such considerations need to undertaken on a site-by-site basis in which case it is entirely possible that a common λ would not be appropriate. With this in mind, PoMC will adopt a conservative λ of 0.6 at the beginning of the dredging program with the option of review and modification if necessary.

8.1.2 Incorporation of Background Turbidity as 6-hourly EWMA

At one conformance site, 8016 Mouth of Yarra River, the environmental limit is based on a consideration of site turbidity relative to 'background' turbidity. Background turbidity is considered to be the 'natural' turbidity likely in that area in the absence of dredging activities. For this site, the background conditions will be determined based on turbidity measured at site 8011 in the Yarra, located upstream of any dredging plumes. The database includes a time off-set function to enable turbidity at site 8011 to be incorporated in the EWMA calculation for conformance site 8016. This function will be set based on modelling activities yet to be undertaken. Data received from the sites prior to dredging in the Yarra River will determine whether an appropriate relationship between the naturally occurring turbidity at the two sites will need to be established to cater for processes such as sedimentation and dilution.

8.1.3 The 2-week Moving Average

In natural conditions, seagrass receives a certain amount of surface radiance at different depths. Increased turbidity will result in a reduced percentage of surface irradiance reaching the seagrass.

Environmetrics (August, 2007a) have undertaken a series of thorough and statistically rigorous analyses into modelling prediction and assessment of turbidity and benthic light conditions in the southern regions of Port Phillip Bay. It was concluded that the EWMA procedure be augmented with a fortnightly moving average chart of daily compliance with the minimum light criteria.

In order to provide additional assurance that the ecological requirement for seagrass will be met, an NTU/turbidity limit averaged over a 2 week period will be applied. Multiple lines of evidence exist to support the numerical guideline (including expert ecological assessment) that a minimum light requirement for seagrass maintenance can be expressed by 15% of surface irradiance, at 3 metres depth, 50% of the time. However, the maintenance of this light climate over relatively long time periods does

not in itself ensure the absence of episodic occurrences of severely degraded light climates on much shorter time-scales. Using 'worst case scenario data' from the trial dredging program, Environmetrics has demonstrated that these conditions are maintained where the two week moving average remains below 15 NTU. This level will be adopted as an environmental limit to ensure that adequate benthic light climate is maintained over all two-week periods for seagrass conformance sites and will also function effectively as an 'early-warning' trigger to the 25 NTU limit as calculated by the EWMA.

8.1.4 Environmental Monitoring Database Dashboard

The 'dashboard' is the visual interface between data stored in the Environmental Database and near real time viewing of the data. The dashboard serves as both the day to day viewing port and can be configured to present a graphed time series of the imported turbidity data, plus any treated time series (ie. 6-hourly EWMA or 2-week moving average). Response levels and environmental limits are represented graphically for easy visual assessment. An example of the dashboard interface is shown in Figure 4. Note that the example is provided as an indication of the presentation of information and does not provide a real example of data received.

8.2 Data Quality Check

Dual Meter / Data Source

Two identical turbidity meters will be deployed with each monitoring buoy. The calibration of meter 0 will be to 0-100 NTU and calibration of meter 1 will be to 0-400 NTU. This difference in calibration will provide the ability to record higher turbidity levels (above 100 NTU) which may occur over short time periods during Yarra River dredging and will provide required sensitivity at lower turbidity levels (below 100 NTU). The database will switch to the meter 1 if the turbidity goes above the calibration range of meter 0, ie 100 NTU. This function will occur automatically within the database. Turbidity levels below 100 NTU will exist during the majority of dredging works and therefore data from meter 0 will be maintained as the primary data source for calculation throughout the dredging program. Meter 1 will only become the calculation source of data in the event that data from meter 0 is above 100 NTU or indicates consistent erroneous readings above its calibrated range.

The identification of erroneous data will be undertaken by a dedicated data analyst. Graphical displays of the data from each meter will be available for each monitoring location. The analyst will be able to view a difference plot and correlation plot of raw data for the two probes from each monitoring site. The level of difference and correlation of data between the two meters will be interpreted at dedicated times throughout the day to identify times when data is significantly divergent. The data

analyst will be able to switch the calculations to the alternate meter if a fault is identified and trigger maintenance/repair procedures as required. This change will be highlighted in the database. The response levels and environmental limits may be enforced unless it is shown that the measured turbidity data is erroneous. Fouling of and faulty probes will be minimised by regular maintenance activities.

Data Gaps

Data collected that is associated with short periods of regular maintenance/cleaning and calibration activities will be recognised as invalid in the database to allow the continued calculation of the EWMAs and MAs with the reduced available data. Each maintenance event is estimated to be no more than one hour per week.

Data loss may occur during the dredging program due to failure of buoy electronic components or damage to both meters. With a download interval of two hours, the maximum amount of time before system users will recognise a loss of data transmission from a buoy is expected to be in the order of two hours. This situation may trigger the mobilisation of a maintenance crew to repair or replace the buoy. In daylight hours and in suitable conditions it is envisaged the crew can complete this process within a 3-5 hour period. The data gap in this instance is expected to be a maximum of 5-7 hours and if this time frame crosses two EWMA time periods then it is possible that two consecutive EWMA calculations would be missed.

In the event that turbidity data is unavailable at night or in unsafe/unfavourable conditions, a maintenance crew may not be able to perform required maintenance for up to 12 hours or potentially longer if unfavourable conditions persist. Maintenance crews may, depending on the severity of conditions, have the option of deploying an additional buoy adjacent to the faulty one and leaving the faulty buoy until calmer conditions allow for a safe retrieval and repair. In such an instance it is possible that three consecutive EWMA calculations would be missed.

There is potential for turbidity levels to exceed response levels and environmental limits during times where no turbidity data is available. An examination of previous, current and expected conditions is required to determine if a period of data loss at that location is likely to correspond with turbidity levels above response levels or environmental limits.

Certain conditions will provide sufficient confidence that a period of no data will not correspond with turbidity levels above response levels or environmental limits. These conditions include:

- If the buoy is located in the north of the bay and dredging is occurring in the south of the bay;
- If the buoy is located in the south of the bay and dredging is occurring in the north of the bay;
- If the location of the buoy is deemed to be significantly distanced from the location of dredge works and will not be affected by a plume given current climatic conditions;

- If other nearby functional buoys can provide data that can represent the faulty buoy and indicate that turbidity levels are acceptable;
- If turbidity data before the fault occurred is not exceeding the response levels or environmental limit for that location and the trend of data before the fault does not indicate an upward trend that could breach the response level within the time required for repair or replacement. This applies on the condition that dredging works have not altered in method or significantly in location.

Certain conditions will provide for a period where no turbidity data may correspond with turbidity levels above response levels or environmental limits. These conditions may include:

- If the buoy is located in close proximity to current or planned dredging works;
- If turbidity data before the fault occurred is exceeding the response level or environmental limit for that location;
- If the trend of data indicates an upward trend that could breach the response level within the time required for repair or replacement;

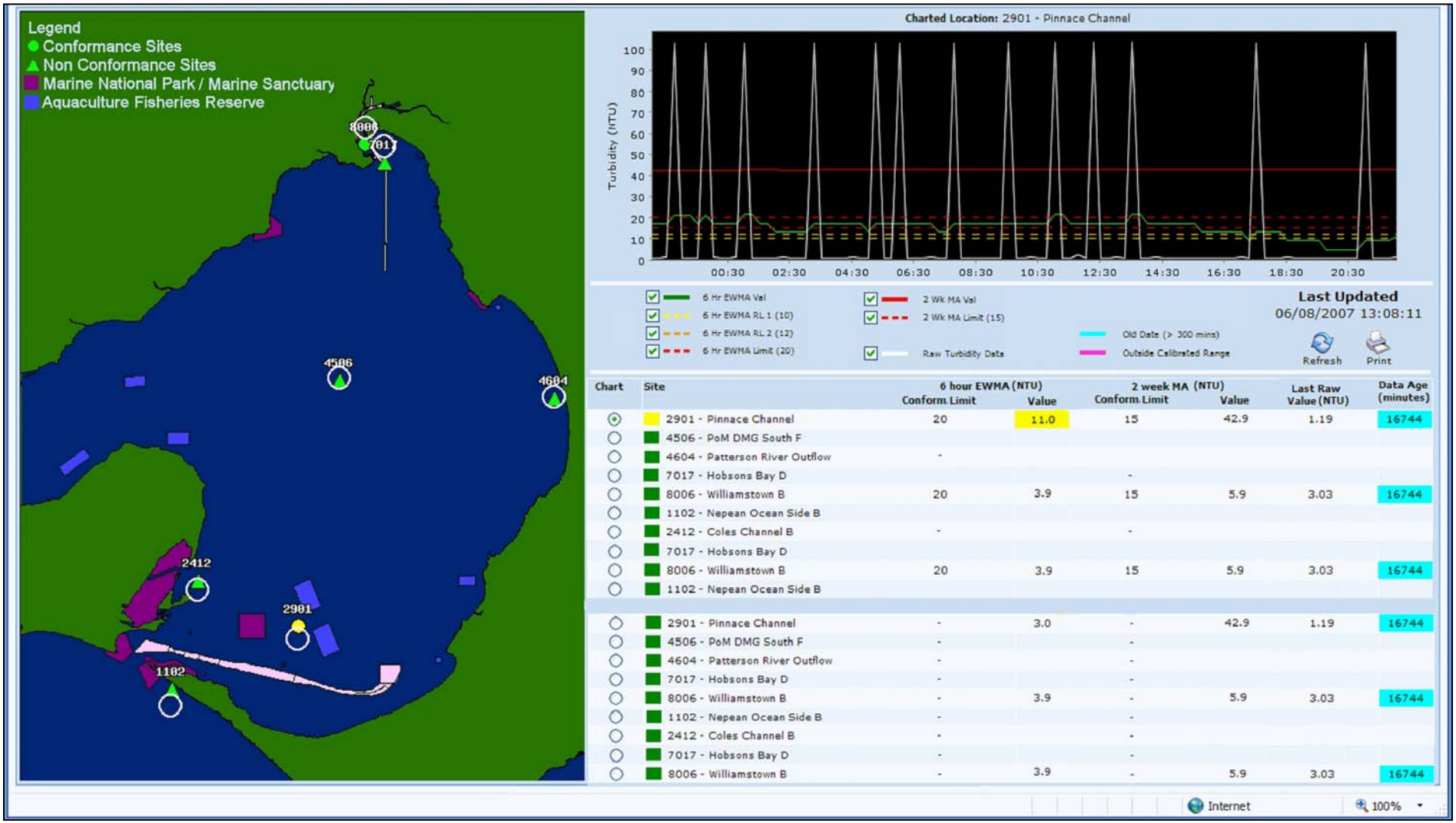
In regards to data treatment, as a guide, trending data will be assessed using interpolatory techniques when no more than 20% of the data is missing. The six hourly EWMA will be considered invalid when more than 20 % of data is absent. This level will be reviewed and refined as required during the project.

If the faulty monitoring buoy is in reasonable proximity to the dredging works and turbidity data is not restored within 24 hours, dredging works may be modified until turbidity data is restored.

Further statistical interpretation techniques may be employed during the daily viewing of data by the data analyst to ensure issues such as the fouling and faults of probes and background turbidity levels are sufficiently identified and accounted for in decision making processes.

It is important to note that such statistical tools will provide guidance in the decision making process. It is the experience of operators, in being able to consider all available information, who will progressively learn to apply the most appropriate responses to changing turbidity levels.

Figure 4 Example of dashboard configuration - the interface with the Environmental Database



8.3 Assessment against Response Levels & Environmental Limits

The primary method for assessing turbidity levels against response levels and environmental limits is undertaken by the Environmental Monitoring Database. The database will provide an automatic function where moving average calculations of the treated data for each monitoring site are compared against the corresponding response levels and environmental limits. The database provides alerts in the form of emails and text messages to responsible system users and provides clear graphical representation of these conditions on the dashboard interface.

Turbidity levels will also be monitored by staff on board the dredging vessels and in the office using the dashboard interface. Staff will be able to pay particular attention to the turbidity trends of monitoring locations in reasonable proximity to dredging works and will be able to see if levels are trending toward response levels or environmental limits. As shown in Figure 4, the dashboard provides a graph that plots both raw and processed turbidity data against the response levels and environmental limits at each site. The table on the dashboard colour-codes each site to highlight the status against these levels.

9 QA / QC

A variety of informal and formal QAQC measures are built into this program. These include:

- Two turbidity meters fixed at each monitoring location providing additional confidence to data accuracy with different calibration ranges to provide appropriate sensitivity;
- Data collection from turbidity meters taken as a median of five values over a minute ;
- Statistically developed moving averages (6 Hourly EWMA and 2 week moving average) where data calculation methods provide protection against inclusion of erroneous data;
- Statistically developed means to treat data in the event of missing raw data to ensure possible exceedances of response levels and environmental limits can be identified;
- A dedicated data analyst responsible for daily data checks ;
- Statistically developed means to identify a faulty meter or meter fouling and treatment of background data to assist the data analyst with interpretation;
- An automated alert system where any exceedance of response level or environmental limit triggers an SMS and email to the responsible PoMC staff;
- An automated alert system where the failure to download data from a buoy triggers an SMS alert to the responsible PoMC staff;

- Continuous viewing of data and trends via a visual 'dashboard' interface providing up to date graphical displays and raw data to be viewed by staff on-board dredging vessels and in the PoMC office;
- A dedicated contingency plan detailing the management actions in the event that response levels or environmental limits have been reached;
- A formal procedure of checking calibration and equipment maintenance and sensor drift (or biofouling) through frequent verification checks;
- A six-monthly management review process for further assurance that environmental performance is within assessed levels and to identify continuous improvement opportunities;
- A formal system of quarterly reporting monitoring results to relevant external agencies;
- A dedicated internal audit process providing an extensive review of the monitoring systems;
- A dedicated external annual audit process providing 3rd party review of systems to ensure systems conform with ISO 14001;

9.1 Equipment Servicing & Calibration

Calibration:

Calibration will be undertaken by the probe manufacturer prior to deployment in accordance with manufacturer's procedures.

Re-calibration will occur whenever equipment problems are identified or once every 12 months. Calibration logs will be maintained in the environmental database. Calibration is the responsibility of the Alliance Environmental Monitoring Manager and is undertaken by the Environmental Monitoring Field Engineers.

Maintenance:

The probes are housed in a brass and copper sleeve to reduce the amount of bioaccumulation and each is fitted with a wiper that wipes the sensor automatically every 15 minutes. A fortnightly maintenance program will include all buoys in the bay and specific maintenance and repairs will occur as required. Cleaning and maintenance events will occur weekly on buoys in the Yarra River area where more rapid bioaccumulation and fouling is likely to occur. Cleaning and maintenance events are undertaken fortnightly on other buoys in the Bay. This maintenance regime will be revised based on findings in the field prior to and during the project.

Verification of the sensor will be undertaken monthly. The sensor will be verified using 1 L of fresh turbidity standard from an accredited laboratory at the required NTU. Analysis of verification results will occur either by the database analyst or on the vessel and decisions on whether to replace the buoy or probe will rely on this analysis.

10 Reporting / Review Process

Formal reporting processes have been established to ensure ongoing comprehensive reviews of CDP environmental performance as well as providing comprehensive information to the community.

As part of the management review process a six-monthly assessment of the environmental monitoring program (including turbidity) will be undertaken. PoMC environment staff will prepare a report detailing all turbidity monitoring results at all monitoring locations for the preceding period. The report will detail the programs performance against the requirements of the EMP and will identify trends and all response level and environment level exceedances occurring during the relevant period. The report will provide information relevant to the objectives of the management review process, specifically:

- To identify changes to assets outside expectations
- To identify changes to the long-term beneficial uses of the bay
- To identify improvement opportunities to operations, environmental controls and limits and CDP environmental monitoring programs

The report will be provided as part of the publicly available reporting on a six monthly basis.

PoMC will provide a quarterly report to relevant agencies including relevant information on project activities and external factors. Details of turbidity monitoring as described above will be included as part of this reporting.

All requests for changes to the content of reports will be considered and implemented as agreed.

Monitoring results will form a part of the project close-out report following completion of construction activities.

11 Decision Framework for Management & Contingencies

A comprehensive decision framework for management has been developed to formalise the process of implementing contingency plans. Contingency plans have been identified for all environmental monitoring programs. The management actions identified in the contingency plans are not an exhaustive list but tangible responses that the project will implement if required. The most appropriate management action will be selected on a case by case basis. The contingency plans form part of the EMP.

The contingency process for turbidity monitoring is shown in Figure 5. If there is an exceedence of response level 1 or response level 2, appropriate management actions will be taken. Potential options for action include:

- Review of the forecast for the location and intensity of the plume and expected turbidity levels to inform management actions;

- Suspending dredging in the area impacted for a period of time;
- Relocation of the dredge (within the same project area or to a different project area);
- Interval dredging and;
- Operate in non-overflow mode, or combination of overflow and non-overflow modes.

Specific responses to an exceedance of response level 1 include:

- Data accuracy and equipment will be validated to verify exceedance within 24 hours of the exceedance. This process will include data checks as described in section 8.2 as well as a review of plume modelling, a review of any relevant information from the plume intensity and extent program, the cross reference of data from other buoys and physical checks of equipment.
- The collection of additional data that may impact on turbidity (e.g. rainfall, weather, tides) as well as increased monitoring of the plume including the mobilisation of a vessel to undertake specific plume transects to better understand plume behaviour.

Once the exceedance is verified Government Agencies will be notified (must occur within 1 working day of the exceedance) and the collection of additional data will commence.

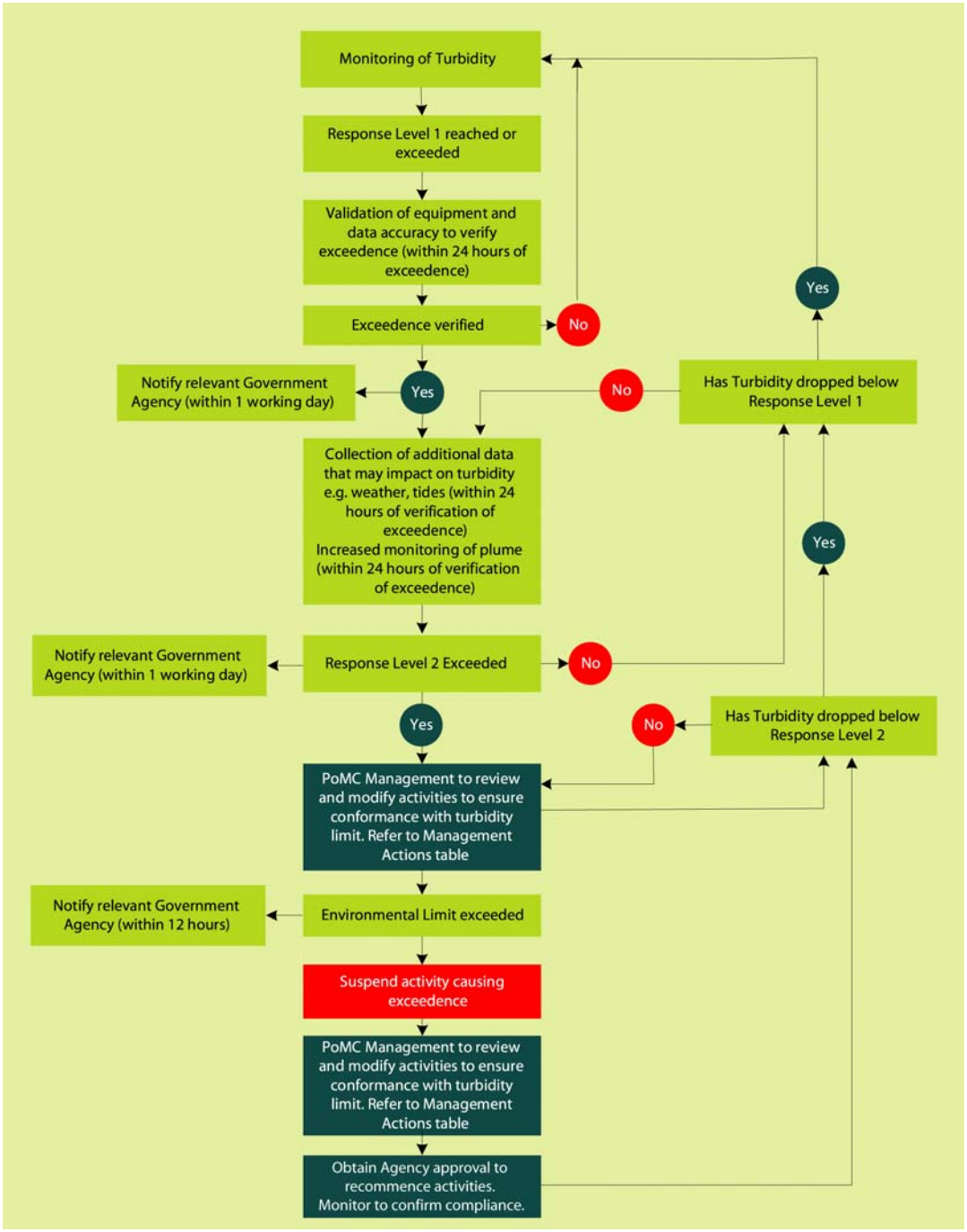
Responses to an exceedence of response level 2 include:

- Management actions to reduce turbidity levels will be initiated within 24 hours, or more promptly if exceedence of the environmental limit is imminent.
- Dredging will be modified so that turbidity falls below response level 2 within a five day timeframe.

Notification of the relevant Government Agencies (DSE, EPA, DPI) will occur within one working day following an exceedance of response level 1 or response level 2. Notification of Agencies will occur within 12 hours following an exceedance of an environmental limit.

Exceedance of an environmental limit will cause suspension of dredging operations unless it can be demonstrated that a given operation is not responsible for the exceedance. For instance, a review of the turbidity plume extent may indicate no impact on nearby assets when an environmental limit is triggered. The exceedance could be caused by an external turbidity input from the Yarra River for example. Dredging may continue if assessment of the plume extent demonstrates that dredging operations are not contributing to the turbidity levels at the asset. Suspension of dredging in this instance refers to a complete stop of dredging in the area where assets in question may be impacted. Dredging may move to an area where turbidity levels are within acceptable limits. The exceedance will trigger a review by PoMC Management and the subsequent modification of activities to ensure conformance with turbidity limits is achieved. Approval from Government Agencies will be required prior to recommencing dredging activities.

Figure 5 Turbidity contingency flowchart



12 Auditing

All CDP project components will be audited to ensure project activities are in accordance with the EMS, EMP and continued conformance with ISO14001. Conformance with the EMP will be assessed through observation of project activities, interviews and review of records.

Formal auditing processes have been established in order to ensure CDP environmental performance is in accordance with the EMP.

All aspects of the project will be subject to a dedicated external annual audit process providing 3rd party review of systems to ensure systems conform with ISO 14001.

Audits specific to the turbidity monitoring program will be undertaken by trained PoMC staff initially on a monthly basis and also to coincide with the commencement date of key activities and the use of key equipment. The CDP IMS Internal Audit Procedure details CDP internal audit requirements including the identification of appropriate management actions.

13 Timing

Key points in initial months of the delivery of this program are shown in Table 4.

Table 4 Approximate timing of key tasks and milestones

Approx. Timing	Description
Nov 2007	Peer review of this Detailed Design by an independent expert will be undertaken by David Provis of Cardno Lawson Treloar, agency representatives and the Independent Expert Group.
Nov 2007	Construction and deployment of all turbidity monitoring buoys.
Nov - Dec 2007	Commencement of background data collection from all turbidity monitoring buoys and transmission to database.
Feb 2008	Commence active monitoring of dredging works.
March 2008	Initial quarterly report to agencies
June 2008	Initial 6 monthly report for management review

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PoMC, (2007b) *Environmental Management Plan*, Port of Melbourne Channel Deepening Project (SEES Chapter 17, Attachment 4), Port of Melbourne Corporation, Melbourne, Victoria

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SKM, (2007) *Channel Deepening Project – Supplementary Environment Effects Statement: Social Impact Assessment,* Port of Melbourne Channel Deepening Project (SEES Technical Appendix 59), Sinclair Knight Merz, Armadale, Victoria

URS, (2007) Channel Deepening Project Risk Assessment for SEES (SEES Technical Appendix 6), URS, Southbank

Appendix 1 – Impact Pathways

Figure A1- 1 Clogging - Conceptual model of the effects of increased suspended sediment on assets, beneficial uses and values.

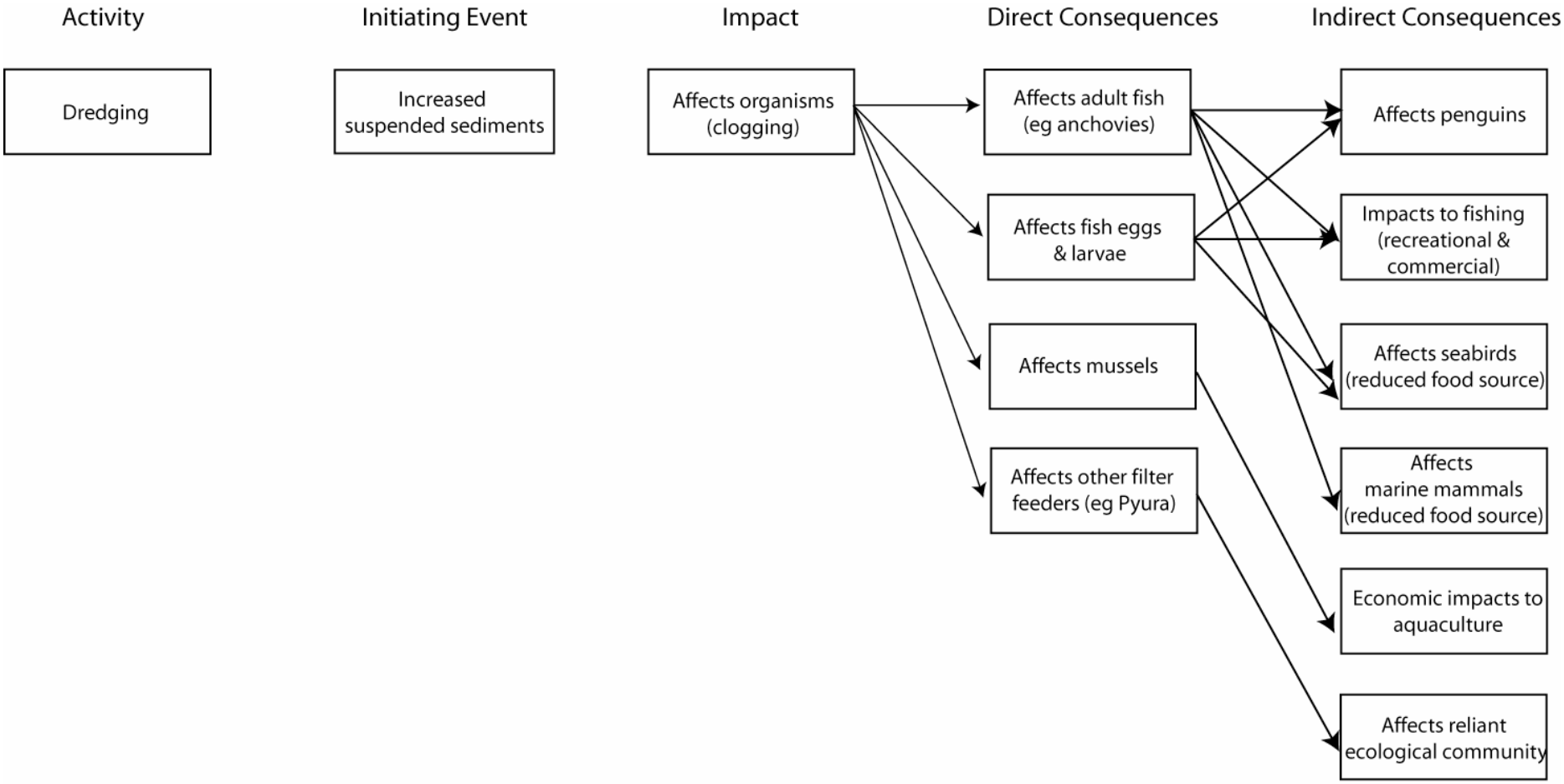


Figure A1- 2 Reduced visibility - Conceptual model of the effects of increased suspended sediment on assets, beneficial uses and values.

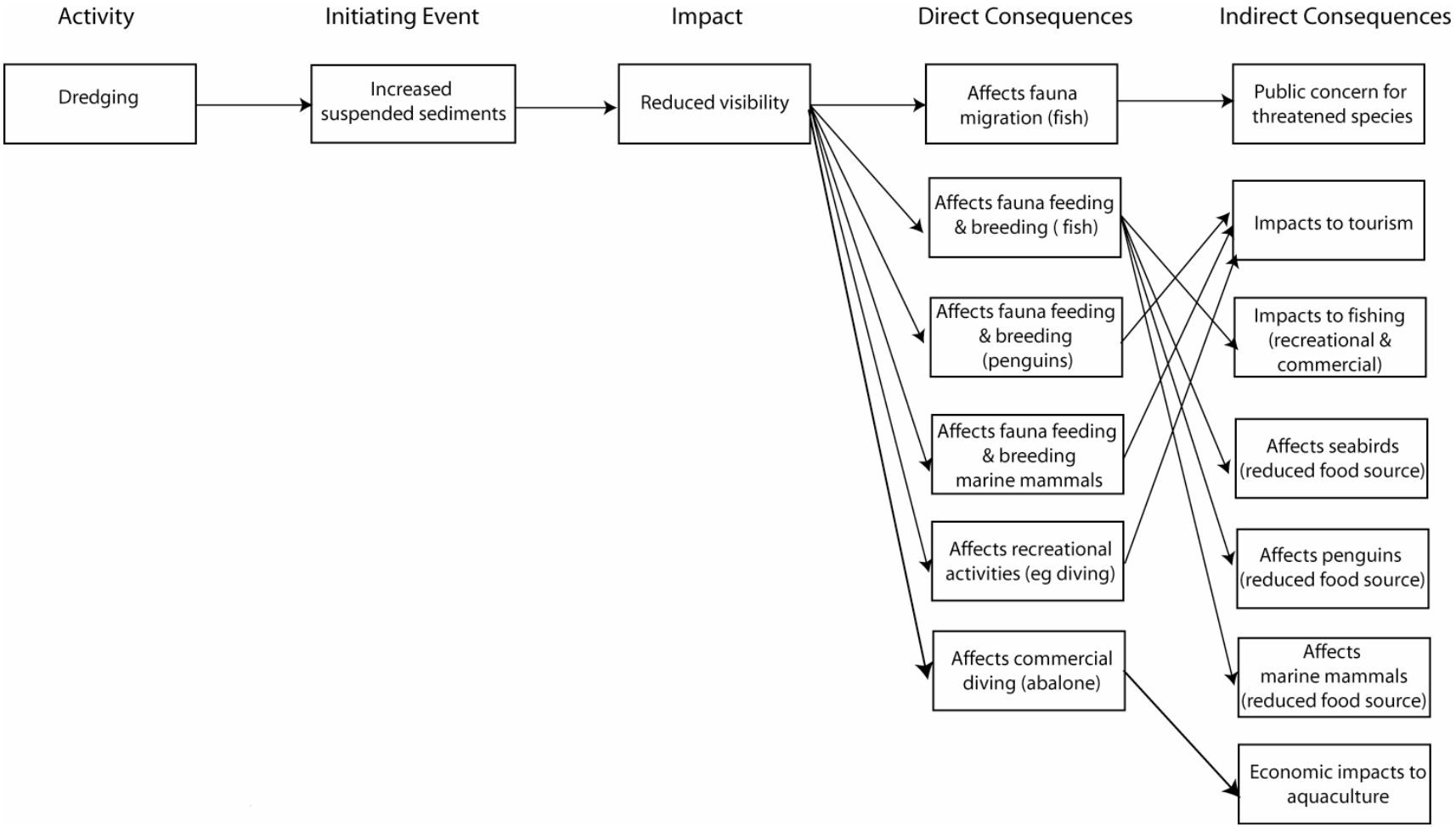


Figure A1- 3Reduced light - Conceptual model of the effects of increased suspended sediment on assets, beneficial uses and values.

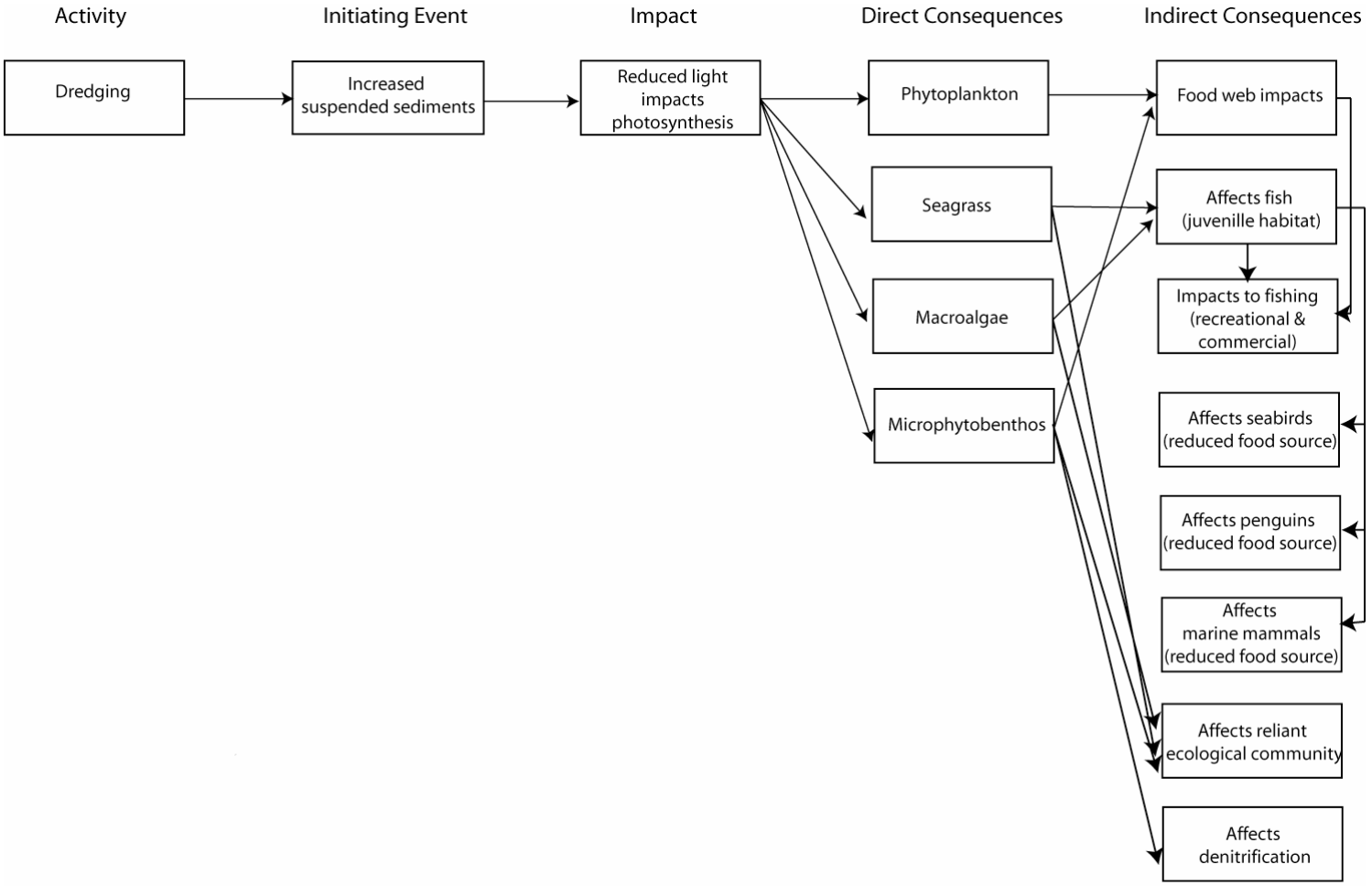
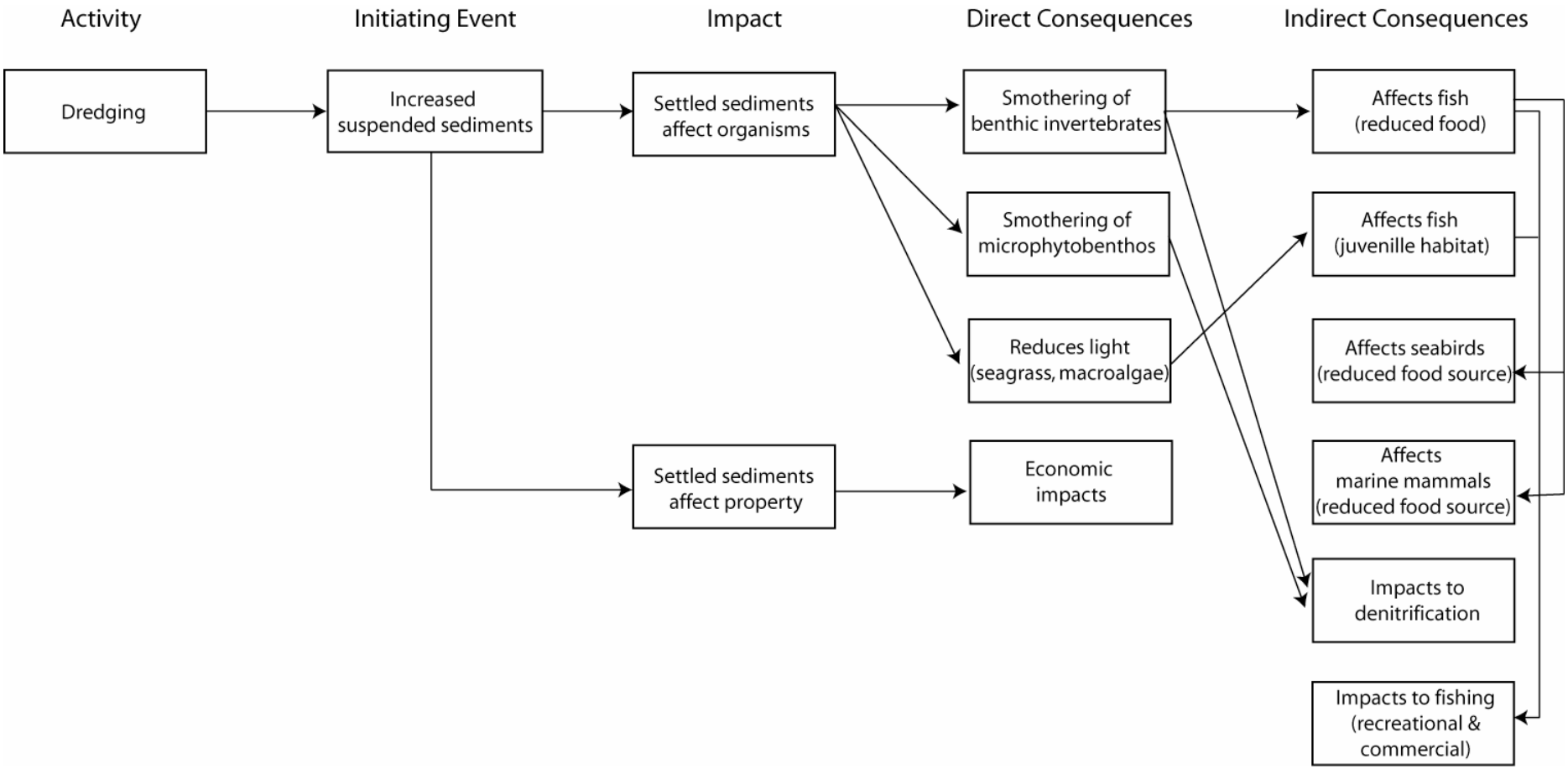


Figure A1- 4 Sedimentation - Conceptual model of the effects of increased suspended sediment on assets, beneficial uses and values.



Appendix 2 – Evidence used in the determination of Environmental Limits

Preface

All environmental limits are expressed in NTUs (turbidity). Turbidity can be monitored at short intervals (minutes) by the use of deployed meters, providing timely information to support management. Turbidity is a direct expression of the optical property that causes light to be scattered and absorbed rather than transmitted in straight lines through the water column. This is directly related to the amount of sediment in the water and provides an adequate surrogate for TSS and reduced light.

Where evidence for the biological requirements of assets is presented in TSS (mg/L) or units of light, this has been converted into NTU using relationship provided in Environmetrics (April 2007a; April 2007b). For TSS/NTU, this relationship is TSS= 1.4 x NTU.

Key points used in the development of environmental limits for suspended solids (turbidity):

Fish migration – Primary SEES Reference PIRVic 2006, Technical Appendix 57

Upstream migration of juveniles of the protected freshwater fish species (the Australian grayling and Australian mudfish) from Port Phillip Bay to the Yarra River occurs during spring (PIRVic, 2006; pages 44-45).

Protected freshwater fish species would interact with suspended sediments from dredging when drifting to the Bay as larvae and then returning to the Yarra as juveniles. (PIRVic, 2006; page 150).

Similar species to the protected freshwater fish in the Yarra River have been shown to avoid conditions where turbidity is 25 NTU (approximately 20 mg.l-1) above ambient. A performance standard is recommended of not greater than 25 NTU above ambient beyond 100 m of the dredging vessel in Project Area 1 (Yarra/Hobsons Bay) in spring. (PIRVic, 2006, page 212)

Fish gills and membranes- Primary SEES Reference PIRVic 2006, Technical Appendix 57)

Suspended sediment concentrations of greater than approximately 100 mg.l-1 have been shown to increase fish egg hatching times, reduce hatching success and decrease larval fish survival. (PIRVic, 2006, page 212)

Seabirds- Primary SEES Reference Brett Lane 2006, Technical Appendix 55

Turbidity can affect foraging efficiency of birds that take their food from underwater.

Crested Terns feed in shallow water from a few centimetres up to a metre and would therefore require visibility for at least this distance in order to forage successfully.

Cormorants have been found to successfully feed in levels of turbidity of 25 mg/L (Lane, 2006, page 195)

Feeding success of gannets and terns has been found to be positively influenced by decreasing water clarity over the light attenuation range < 0.05 to 0.25 (Hanney and Stone, 1988).

Feeding success of terns has been found to be influenced by water clarity, with optimum success at secchi depths of 50 – 89 cm and lower food intake at secchi depths < 30 cm and > 179 cm (Brenninkmeijer et al., 2002).

Benthic invertebrates - Primary SEES Reference CEE 2007a, Technical Appendix 49

Suspended sediments can cause physiological disturbance through damage to filter-feeding, reproductive and other structures. (CEE, 2007b, page 27)

Pyura stolonifera can survive short periods of increased sediment load (eg 8 hours) (CEE, 2007b, page 28)

Pyura stolonifera can tolerate 50 mg/L with low to zero retention of particles (CEE, 2007b Table 15)

Seagrass- Primary SEES Reference CEE 2007b, Technical Appendix 50& Environmetrics August 2007b

Based on evidence from the literature and investigations in Port Phillip Bay, a light requirement of 10 percent of surface light appears to be a realistic annual light requirement for Zostera in the south of the Bay. For the purposes of the SEES impact assessment, and to address uncertainty, an average value of 15 percent of surface light was used as a conservative minimum annual light requirement for Zostera in Port Phillip Bay. (CEE, 2007 a, page 22)

Seagrass can tolerate extended periods of severe shading. It is expected that short durations (days to weeks) of intermittent shading followed by adequate light conditions (at least 15 percent of surface) for a long period following exposure (months), are likely to have negligible effect on seagrass habitat. (CEE, 2007 a page 33). 80 percent to 85 percent of the Zostera in the south of the Bay is at depths < 3 m (CEE, 2007 a, page 65)

Providing the background and modelled data are both accurate and representative of expected conditions at site 2006, the minimum light requirement at 3m depth of 15% surface irradiance will be achieved more than 50% of the time (overall the entire dredging period) (Environmetrics, 2007b page 12).

It is recognised that the pattern of shading is also important. For example a few months of no shading followed by a few months of shading is a different scenario, with different results, to a few days of no shading followed by a few days of shading continually for a period of months. PoMC also therefore commissioned modelling looking at the most intense ("worst") periods of the proposed dredging campaign. The 'worst' period was described as the two week period of combined (modelled + background) NTU data that presented the most elevated turbidity. This modelling drew conclusions of the NTU required to meet a specified light requirement, as follows. In order to meet the light requirement at site 2006 of 15% surface irradiance at 3m depth for at least 50% of the time during the 'worst' periods of the dredging campaign, the NTU will need to be kept below 15 units. (Environmetrics, August 2007b, page 17).

The turbidity model (CLT, 2007) predicts that the seagrass at the most affected site (Sorrento Bank) will receive greater than 15 NTU on average, calculated over a 14 day period (Figure 10). Although this is considered a sufficient averaging time period to protect seagrass it is not sufficient for operational management of the dredge and as such is complimented by the more responsive 6 hourly EWMA.