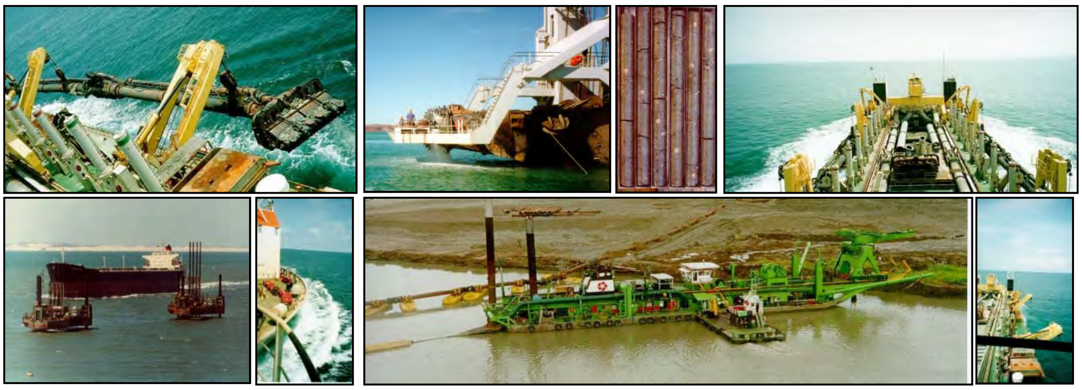
Baggerman Associates Pty Ltd
Marine & Dredging Consultants
Sydney, Melbourne and Perth. Australia.
ABN 21 002 99 310
Melbourne Office:
P.O. Box 545 Kilsyth Victoria. 3137
Telephone: 0408 608 995
Email: Hadyn_Pike@msn.com.au

INFRASTRUCTURE VICTORIA

PORTS PLANNING ADVICE
ENGINEERING SERVICES

DREDGING & RECLAMATION



Report No.: BA1701
Date: 28 April 2017

Prepared for:
GHD Pty Ltd

Document History and Status

Issue	Revision No.	Issued To	No.	Date	Reviewed	Approved
Draft Report	A	Mr. Richard Hill	1	23-December 2016		
Final Draft Report	A	Mr. Richard Hill	1	15-February-2017		
Final Draft Report	B2	Mr. Richard Hill	1	27-February-2017	Hadyn Pike	Hadyn Pike
Final Report	0	Mr. Richard Hill	1	28-April-2017	Hadyn Pike	Hadyn Pike

Printed: Saturday, 29 April 2017
Last Saved: 28/04/2017 6:24:00 PM
File Name: 2017.04.28 [iv_port planning advice_dredging and reclamation] rev 0.docx
Project Manager: Mr. Richard Hill. GHD Pty Ltd
Name of Organisation: Infrastructure Victoria
Name of Project: Ports Planning Advice -- Engineering Services
Name of Document: Dredging and Reclamation
Document Version: Final Report
Document Number: BA1701

Table of Contents

LIST OF FIGURES

LIST OF TABLES

Executive Summary

For the Bay West port development project, there are a number of dredging and reclamation work methods considered to be viable.

Notwithstanding there is a paucity of geotechnical information available for the preferred location at this time.

Consequently, should the wide-sweeping presumptions that have been made with respect of the type and nature of the material required to be dredged prove to be completely inaccurate the preferred dredging work method may be seriously hampered.

The preferred work method for dredging the channel, turning basin and berths is a mechanical work method using backhoe dredgers and or grab dredgers. This is based upon the assumption that the material to be dredged is predominantly clay.

With the use of a mechanical work method it is possible that most, if not all of the dredged material can be utilised in creating the necessary reclamation for the land required for the port.

Sand will also be required to construct part of and or to complete the reclamation area. The preferred work method for this part of the work is to use a trailing suction hopper dredger, winning sand sourced either from the South Channel in Port Phillip or from deep water in Bass Strait.

There may also be a small amount of very soft, very silty recent marine materials on the seabed surface, which will require careful consideration to minimise the impact of water turbidity generation on the surrounding environment. However, if it is present, typically it would be excavated coincidentally with the main body of material to be dredged.

A comprehensive site investigation programme will be required to move into a feasibility stage for the Bay West port option.

There is some recent seismic survey data available for the preferred port location, which confirms the upper level of basalt flows in the area with a reasonable degree of confidence, and the preferred site location has been selected based upon this information. Notwithstanding, should igneous or metamorphic rock be unexpectedly encountered the equipment proposed for the dredging can dredge rock, following its pre-treatment.

1 SCOPE OF REPORT

1.1 Background

Baggerman Associates Pty Ltd, in conjunction with Evers Consult, have been engaged by GHD Pty Ltd to provide an evaluation of the dredging and reclamation requirements which will be necessary for the development of a second container port for the State Government of Victoria. In doing so, some comparisons are also to be drawn against a recent study undertaken for the proposed development of a container port at Hastings, situated in Western Port, for which Baggerman Associates also carried out an assessment of the dredging and reclamation opportunities for that site.

1.2 Key Objectives

The engineering task includes consideration of dredging and reclamation issues. The key fundamentals to be considered will include but not be limited to:

1. dredging volume and reclamation volume synergy;
2. environmental risk management;
3. spoil disposal strategy and beneficial use of the dredged materials;
4. feasible dredging methodology and their cost and execution time estimates;
5. phasing of the works and interface management with other port development activities;
6. sourcing of environmentally sustainable engineering quality fill for reclamation purposes;
7. safety during dredging operations;
8. potential for collaboration with Port of Melbourne's routine maintenance dredging works.

The dredging and reclamation evaluations will be carried out in concert with the environmental, geotechnical, port planning, navigation and hydrodynamic engineers to ensure the dredging and reclamation methodologies are feasible and sustainable.

1.3 Deliverables of Interim Report

The deliverables from this evaluation will be:

1. a comparison between developing a port in Western Port and Port Phillip on the basis of:
    a. sustainable environmental risk management strategy;
    b. cost of dredging and reclamation based upon proposed phased development
    c. safety;
2. the feasibility of constructing a port in Port Phillip considering:
    a. basis of design;
    b. port development phasing strategy;
    c. interface management between civil construction and dredging and reclamation works;
    d. assumptions regarding geotechnical data and associated risk;
    e. bathymetry;
    f. site parameters (tides, currents, sea state and the like);

g. availability of suitable engineering quality material for the reclamation;
h. constructive and beneficial use of dredged materials;
i. sustainable environmental risk management;
j. safety;
k. decisive execution programme drivers;
l. R.O.M. Budget Costs;
m. perceived risks and opportunities;
n. long term planning strategies.

1.4 Project Approvals

The likely status of project approvals with respect to dredging and reclamation has not been reviewed or considered for the purposes of this report.

Notwithstanding, consideration has been given to similar, historical projects within Australia generally and Victoria particularly and these have been used as a guide in considering which dredging and reclamation work methods may be considered as being suitable.

1.5 Glossary

The following terms commonly used in the dredging industry to describe the size or capacity of a dredger.

It is to be noted that these terms may be simplistic and may not refer to all the capabilities of a particular dredger. Typically, dredgers are unique in their production characteristics, being designed and constructed to the owner's individual requirements.

Term	Description
TRAILING SUCTION HOPPER DREDGER	**HOPPER CAPACITY**
Mega	30,000 m3 and greater
Jumbo	15,000 m3 to 30,000 m3
Large	8,000 m3 to 15,000 m3
Mid-Size	4,000 m3 to 8,000 m3
Small	Less than 4,000 m3
CUTTER SUCTION DREDGER	**TOTAL INSTALLED POWER**
Mega	23,000 kW and greater
Heavy Duty	13,000 kW to 23,000 kW
Large	9,000 kW to 13,000 kW
Mid-Size	3,000 kW to 9,000 kW
Small	Less than 3,000 kW
BACKHOE DREDGER	**TOTAL INSTALLED POWER**
Mega	2,000 kW and greater
Large	1,000 kW to 2,000 kW
Medium	500 kW to 1,000 kW
Small	Less than 500 kW

Source: IHS International Dredging Directory - 2014

Table 1 Glossary

1.6 Abbreviations

The following abbreviations may be used throughout this report.

Abbreviation	Detail
BHD	Backhoe Dredger
BKA	Boskalis Australia Pty Ltd
BOD	Basis of Design
Boka	Royal Boskalis Westminster N.V.
CHEC	China Harbour Engineering Company
CASS	Coastal Acid Sulphate Soil
CD	Chart Datum
CSD	Cutter Suction Dredger
Cutter	Cutter Suction Dredger
D50	Material median grain size (sand)
DEE	Department of the Environment and Energy. Australian Federal Government
DELWP	Victorian State Government Department of Environment, Land, Water and Planning
DEME	Dredging, Environmental and Marine Engineering N.V.
DI	Dredging International N.V.
DMG	Dredged Material Ground (offshore)
DMM	Dredged Material Management
DMP	Dredge Management Plan
EMP	Environmental Management Plan
EMS	Environmental Management System
EPA	Victorian State Government Environmental Protection Authority
FEED	Front End Engineering Design
GD	Grab Dredger
GLD	Great Lakes Dredge & Dock Company
HAZID	Hazard Identification
HAZOP	Hazard and Operability Study
HMCM	High Moisture Content Material (saturated silt and clay particles mix)
HSE	Health, Safety and Environment
HSES	Health, Safety, Environment and Security
HSMP	Health and Safety Management Plan

Abbreviation	Detail
JDN	Jan De Nul N.V.
KPI	Key Performance Indicator
km	Kilometre
Mm3	Million cubic metres
LOA	Length Overall
MOF	Material Offloading Facility
MTF	Materials Transfer Facility
MUFF	Multi-User Functional Facility
nm	Nautical mile
Penta	Penta Ocean Construction Co., Ltd.
PASS	Potential Acid Sulphate Soil
PoM	Port of Melbourne Corporation (formally)
R.L.	Reduced Level
SEP	Self Elevating Platform
SOW	Scope of Work
TEU	The twenty-foot equivalent unit is an inexact unit of cargo capacity often used to describe the capacity of container ships and container terminals.
TDS	Tonnes Dry Solids
Trailer	Trailing Suction Hopper Dredger
TSHD	Trailing Suction Hopper Dredger
VO	Van Oord N.V.
VRCA	Victorian Regional Channels Authority

Table 2 Abbreviations

2 DELIBERATIONS TO DATE

2.1 Location

The Victorian Government had identified the Port of Hastings as being a suitable site for additional international container trade capability as and when the Port of Melbourne reaches container handling capacity.

The Victorian Government established the Port of Hastings Development Authority on the 1st January 2012 as the first key step in the development of Hastings as a future container port.

Subsequently in early 2015 the Victorian Government directed that detailed planning to develop such a port at Hastings be curtailed, and are now reviewing all appropriate locations for an additional, future container port.

This study is also tempered by the recent sale of the Port of Melbourne to private interest, and re-evaluation of the future capacity of the Port of Melbourne.

2.2 Shortlisted Port Locations

2.2.1 Hastings

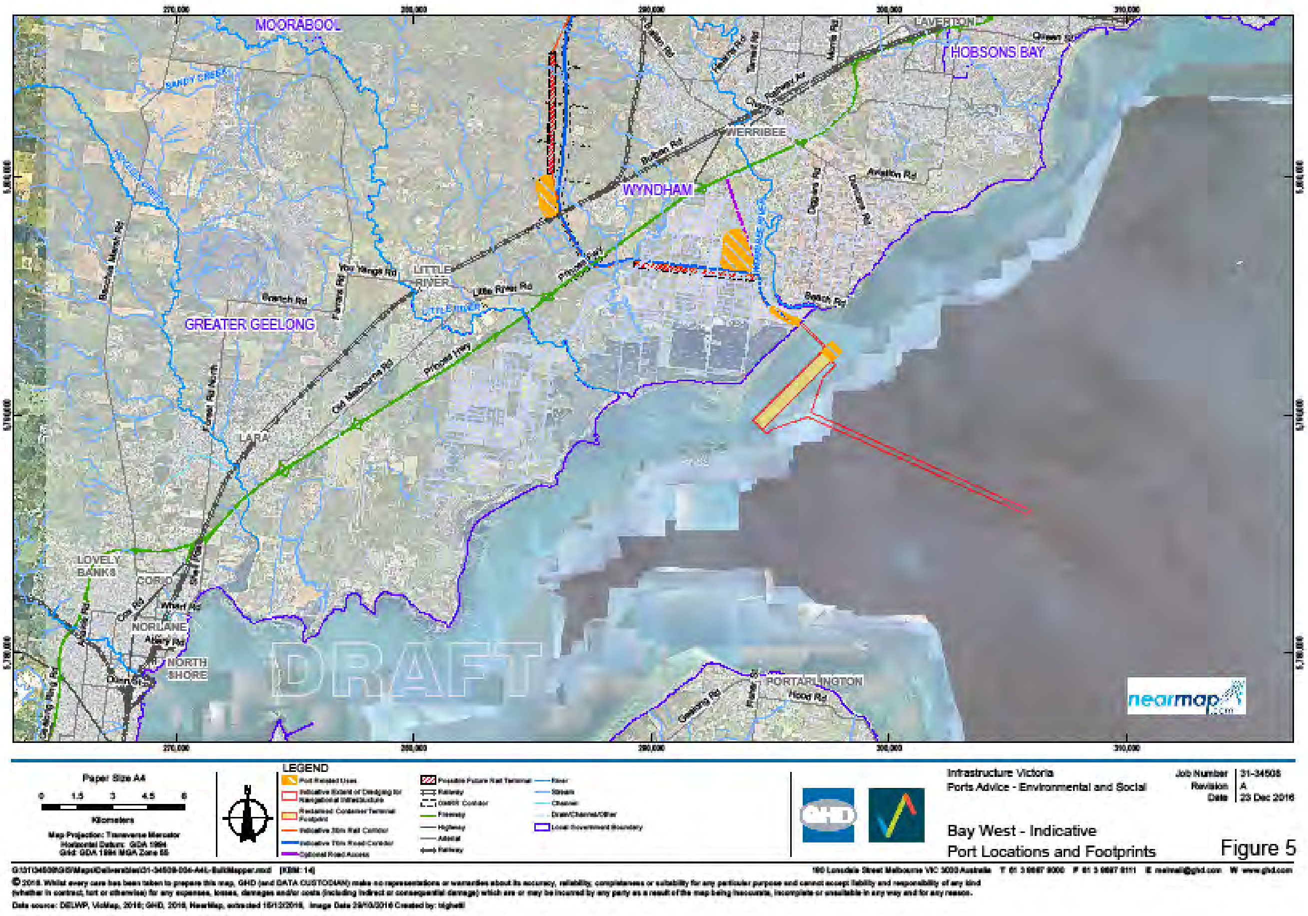
It was planned that the Hastings port be located near Hastings in Western Port, immediately north of the existing OneSteel port facility in Western Port, thereby taking some advantage of the existing shipping channel.

Sketch courtesy of Haskoning Australia Pty Ltd

Figure 1 Proposed Hastings Port Location

2.2.2 Bay West

The proposed location for Bay West port development is on the western shoreline of Port Phillip, some 3 to 4 kilometres offshore from the mouth of the Werribee River.



Sketch courtesy of GHD Pty Ltd

Figure 2 Proposed Port Phillip Bay West Port Location

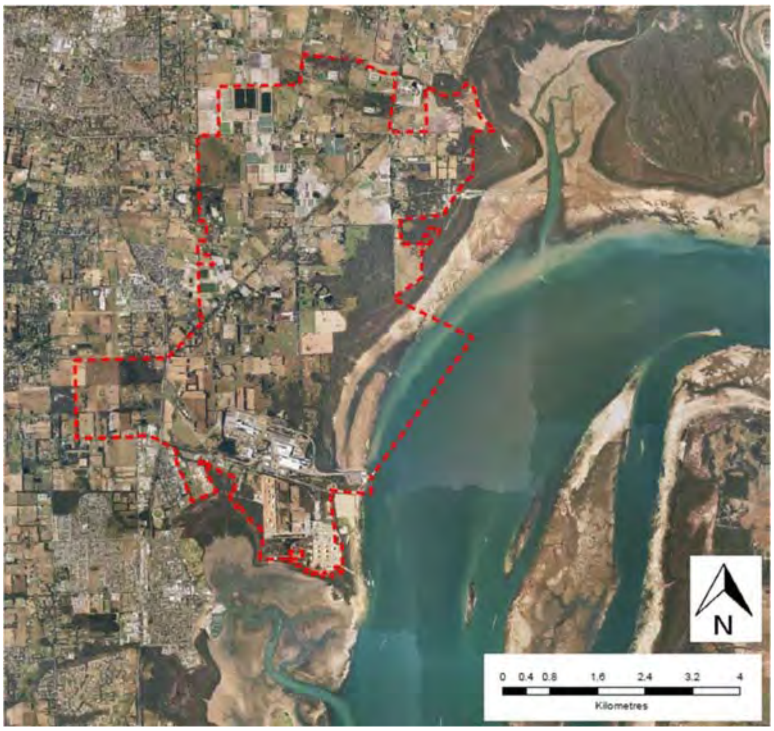
2.3 Port Development Staging

2.3.1 Hastings Port Development

The development considered for Hastings is a three-stage development.

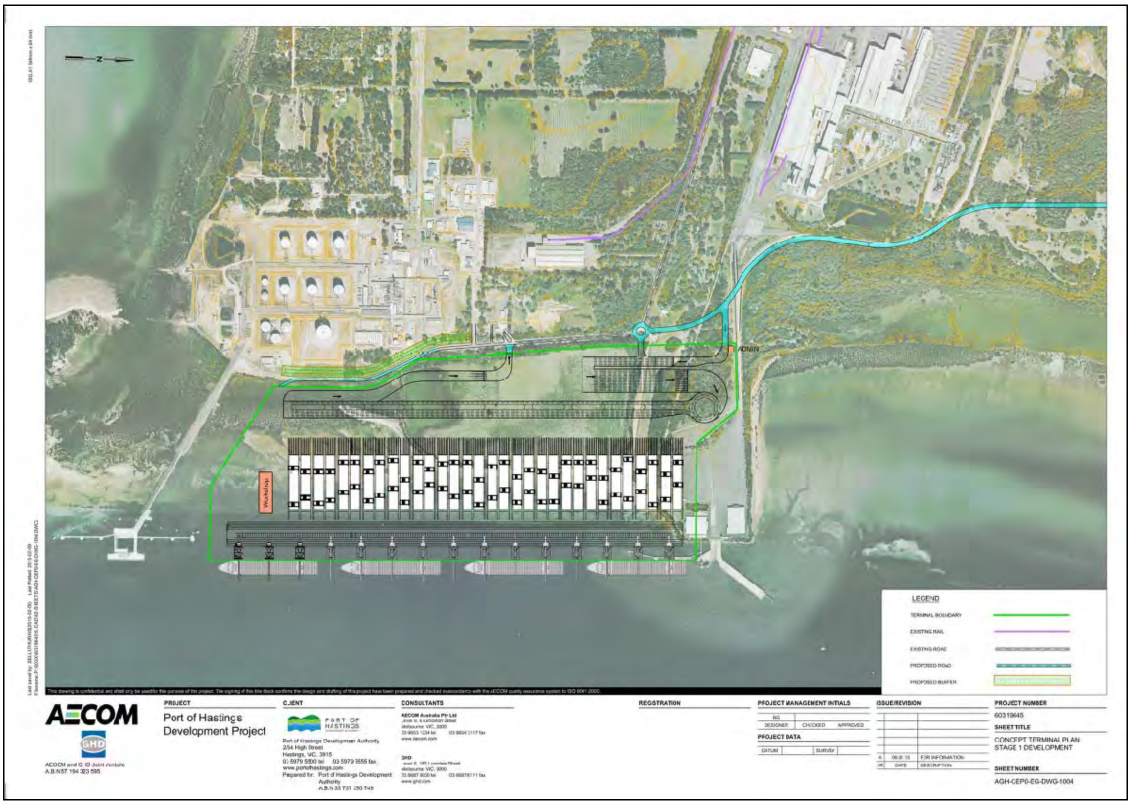
Notwithstanding, it may be cost beneficial to undertake all of the dredging works during the first stage for the following reasons:

1. mobilisation and demobilisation costs are significant;
2. once the port is operational, commercial vessels will have priority over dredging equipment, thereby adding to the capital cost of the dredging by shipping delays;
3. creation of required reclamation using sand will create solid land necessary to support other construction activities, as well as road and rail access developments.



Sketch courtesy of Haskoning Australia Pty Ltd

Figure 3 Hastings Port Precinct



Sketch courtesy of AECOM and GHD Joint Venture

Figure 4 Phase 1 Hastings Port Development

2.3.2 Hastings Phase 1 Work Scope:

Phase 1 is planned to provide 2,200 m of quay wall.

The dredging works required for this conceptual design are:

a) Navigable waters net volume: 10.3 Mm3;

b) Estimated gross dredge volume: 11.5 Mm3 (including over dredging);

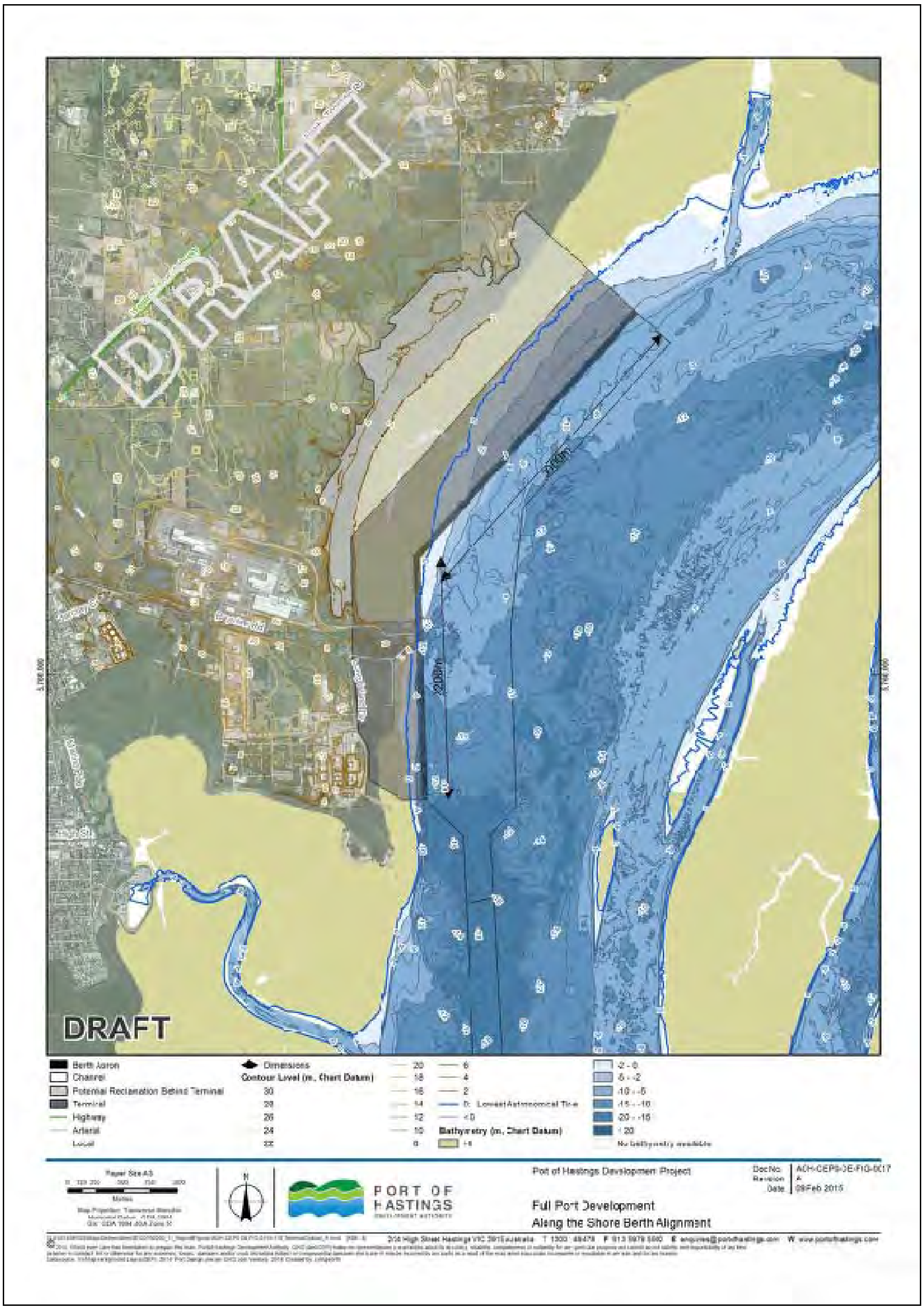
c) Land area generated: 120 hectares;

d) Reclamation fill volume required: 6.8 Mm3 (engineering quality fill);

e) Materials to be dredged: Predominantly stiff to hard clayey silty sand, stiff to hard silty clayey sand and soft fine silty sand. A relatively thin layer of recent marine sediments and sand may initially be removed and taken to an offshore, deep water DMG by selective dredging, depending upon the dredging work method finally adopted;

f) Spoil disposal: Various options were considered. The most cost effective and environmentally sustainable is to place all the dredged material into an offshore, deep water DMG.

The above volumes do not include the creation of a berm to facilitate the construction of the quay wall. This volume is estimated to be 1.2 Mm3, and may be constructed by land fill or by winning sand offshore and placing it direct into the required location using a TSHD.



***Sketch courtesy of AECOM and GHD Joint Venture

Figure 5 Phase 2 Hastings Port (Preferred) Development

2.3.3 Hastings Phase 2 Work Scope:

Phase 2 is planned to provide an additional 2,000m of quay wall.

The dredging works required for this conceptual design are:

g) Navigable waters net volume: 19.8 Mm3;

h)	Estimated gross dredge volume:	21.7 Mm3 (including over dredging);
i)	Land area generated:	178 hectares;
j)	Reclamation fill volume required:	11.1 Mm3 (engineering quality fill);
k)	Materials to be dredged:	Predominantly stiff to hard clayey silty sand, stiff to hard silty clayey sand and soft fine silty sand;
l)	Spoil Disposal:	Various options were considered. The most cost effective and environmentally sustainable is the place all the dredged material into an offshore, deep water DMG.

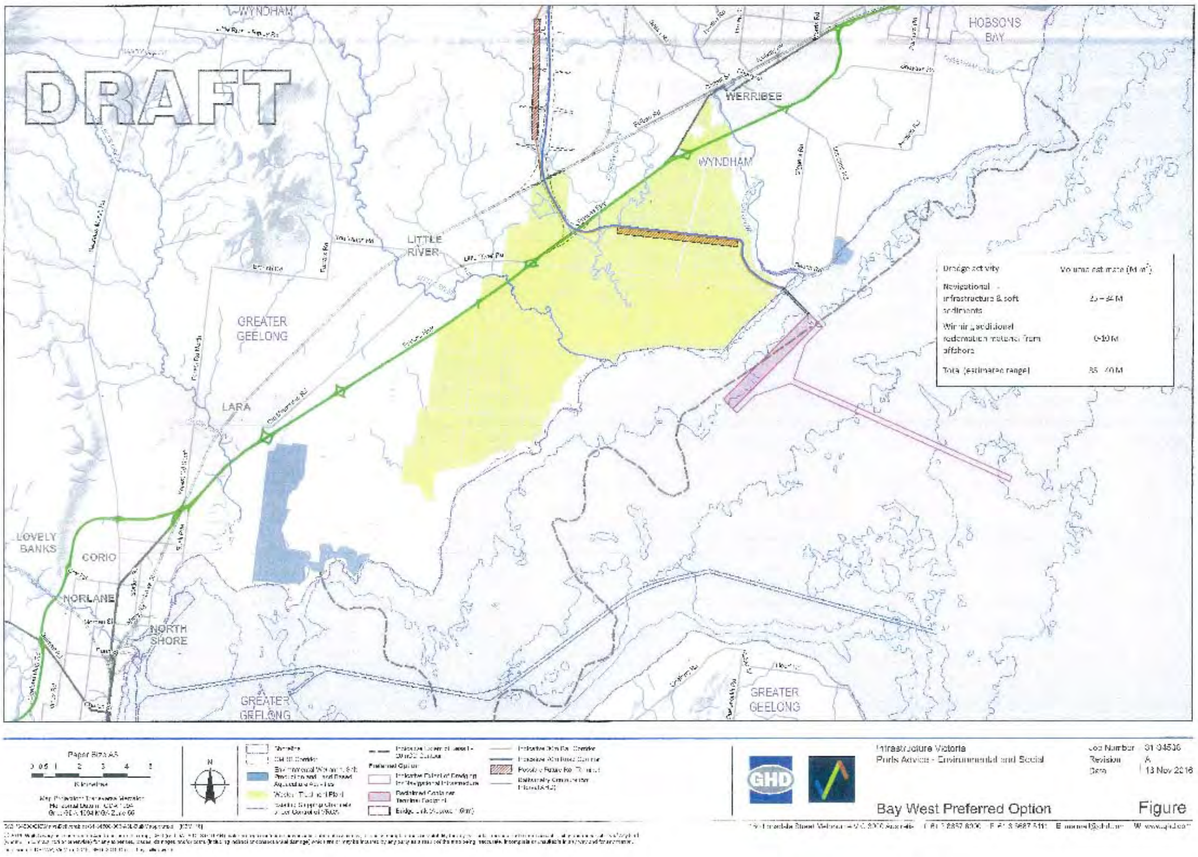
2.3.4 Bay West Port Development

The development considered for the Port Phillip Bay West port is a staged development.

Notwithstanding, it may be cost beneficial to undertake all of the dredging works during the first stage for the following reasons:

1. mobilisation and demobilisation costs are significant;
2. once the port is operational, commercial vessels will have priority over dredging equipment, thereby adding to the capital cost of the dredging by shipping delays;
3. approximately 50% of the total volume required to be dredged will be from the Channel, and further a significant volume will also be dredged from the Turning Basin for phase 1, with all dredged material proposed to be placed into the reclamation area.
4. due to the existing shallow water at the berth location, a jumbo or mega trailer dredger, planned to be deployed in stage 1 for the construction of the quay wall bund, will require the Channel and Turning Basin to be dredged to full design depth to enable it to get close enough to pump out and place the material for the quay wall bund construction.

Notwithstanding, the sequencing of the dredging, reclamation and port construction activities are not seen to pose any significant interface management problems.



Sketch courtesy of GHD Pty Ltd

Figure 6 Bay West Port Precinct

2.4 Comparative Outlook

Following is a brief overview of comparing the dredging requirements between the Port of Hastings development and the Bay West port development.

In the first instance, there is no obvious glaring advantages that may give preference to one option over the other.

Both have similar quantities to be dredged, and in both options the bulk of the material can be considered to be similar so far as their dredging characteristics are concerned.

Therefore, the overall cost of the dredging and reclamation works for both options may be relatively similar, subject to the assumptions made concerning the geotechnical nature of the material to be dredged fore Bay West being appropriate.

In both cases the material to be dredged is far from ideal to be used to create reclamation, and for both options a significant quantity of sand will be required to complete the works.

However, for the Bay West option, because the reclamation is planned to be positioned offshore in some 4 to 5 metres of water, the possibility exists to place the dredged clay into the reclamation area using marine equipment, and then surcharge it and then finally cap it with sand, thereby utilising the clay, rather than dumping it at sea.

Further, a heavy-duty turbidity screen can be installed around the perimeter of the reclamation area, thereby limiting the spread of turbidity plumes from the placed clay.

This work method is not possible for the Hastings development as the clay would have to be placed onshore, and this would require significant temporary infrastructure outlay and triple handling of the dredged material, and sand capping would still be required.

Both the Hastings and Bay West locations have significant environmental risk management undertakings, and for both options many of the environmental values to be maintained will require a very long lead time for planning, developing and receiving the necessary approvals.

Similarly, the sourcing of engineering quality sand, which is essential for both options, will require planning to commence as soon as possible, not only for receiving environmental approvals but also for strategic planning to stockpile the inherent value of sand already being dredged as part of the ongoing maintenance dredging requirements of the VRCA navigation channels in Port Phillip for future use, for either option.

3 BAY WEST

The following local information has been gathered and considered when formulating the dredging and reclamation work methods adaptable for the Bay West development.

3.1 Access to the Bay West Site

The proposed location for the Bay West port option is located on the western shoreline of Port Phillip, offshore from Wyndham.

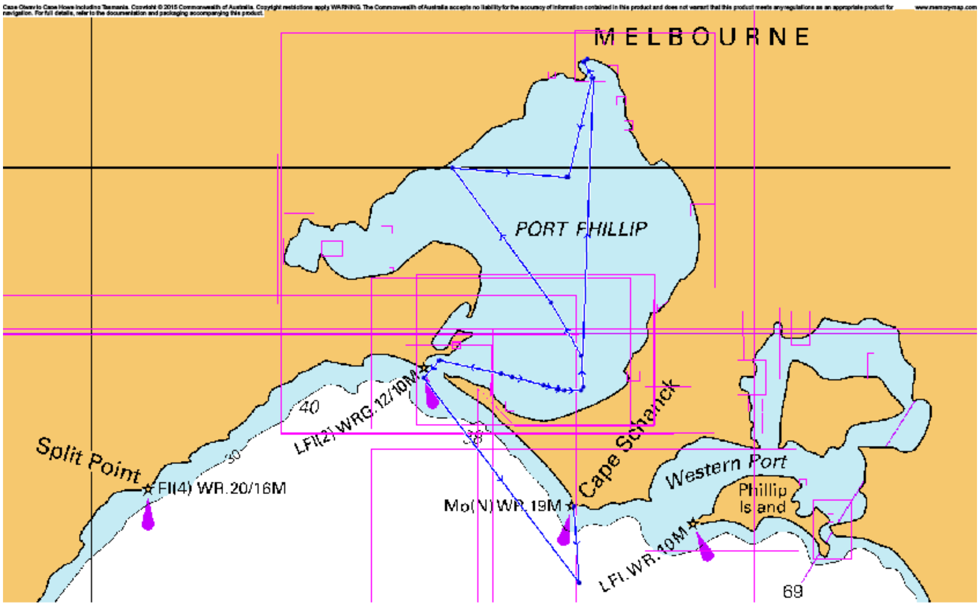


Figure 7 Port Phillip

There is no existing navigable water into this area, and access for the larger dredgers and marine ancillary equipment will have to be created.

Mega backhoe dredgers and mega grab dredger can create their own water, however trailer dredgers of a size necessary for this project would not be able to operate until sufficient water depth is first created. Typically, the jumbo trailer dredgers have a loaded draught in the range of 12 to 15 metres.

3.2 Supporting Infrastructure

The dredgers and ancillary equipment that would be deployed require service berths and landings for the safe transfer of personnel, taking on of stores, exchange of spare parts, bunkering and fresh water.

Some of the repair and maintenance activities will require crane lifts in the order of 30 to 40 tonnes.

Vessel draughts (light) could be in the order of 8 to 10 metres and LOA in the order of 180 to 230 metres.

3.2.1 Service Berths Available to Support Dredging Operations

All vessels will have to travel to either Geelong or Melbourne to undertake any major repair and maintenance activities

3.2.2 Bunkering and Fresh Water Facilities

Trailer dredgers and other self-propelled vessels will travel to either Geelong or Melbourne to take on fuel and fresh water.

Backhoe dredgers, and other non-propelled marine ancillary vessels will be bunkered on site by a multicat(s) or bunker barge. The multicat(s) will take fuel at either Melbourne or Geelong.

3.3 Tidal Regime

3.3.1 Port Phillip

The tides in Port Phillip are Semi Diurnal in nature.

MELBOURNE

Local Standard
Time Zone: 10:00 U.T.

37° 52' S 144° 55' E

Year 2016

Port 60780

HARMONIC CONSTANTS						TIDAL LEVELS	
	H ampl meters	g phase degrees		H ampl meters	g phase degrees	ref to Prediction Datum	meters
M2	0.236	60.7	P1	0.032	120.7	HAT	1.1
S2	0.055	197.0	N2	0.041	14.2	MHHW	1.0
K1	0.098	132.9	NU2	0.010	1.1	MLHW	0.7
O1	0.069	96.4	K2	0.011	187.0	MSL	0.6
Sa	0.039	98.6	L2	0.019	95.6	MHLW	0.5
Ssa	0.022	154.3	2N2	0.005	315.9	MLLW	0.2
Mm	0.003	72.3	MU2	0.014	74.3		
Msf	0.009	167.6	T2	0.001	201.9	ISLW	0.2
Mf	0.011	184.6	M4	0.005	77.8	Diurnal	
S1	0.007	134.7	MS4	0.002	144.4		
Q1	0.015	84.9	2MS6	0.004	329.2		

Figure 8 Port of Melbourne Tide Levels

All depths are in metres Chart Datum.

Strong tidal currents do not exist in Port Phillip in the region of the proposed location for Bay West port precinct. However tidal stream flow increase significantly closer to The Rip.

These currents may hamper the operations of cutter dredgers, floating pipeline, backhoe dredgers, grab dredgers and split hopper barges. They are not expected to hamper the operation of trailer dredgers except perhaps when they may be manoeuvring in shallow water.

3.3.2 The Rip

The Rip is one of the most dangerous stretches of water in the world, with very strong, eddying currents and significant tidal gradients present, with a chaotic nature.

The following information is sourced from the website of the Port Phillip Sea Pilots.

"Due to the restriction of the tidal range within Port Phillip caused by the relatively narrow entrance, the tidal stream in the vicinity of the Heads does not turn at high and low water.

The force of the tidal streams depends upon the relative water levels inside and outside Port Phillip. The greatest difference in levels occurs at about the time of high and low water at Port Phillip Heads. This is when the inward and outward streams run at their strongest, up to six knots under normal conditions and may exceed nine knots in extreme conditions.

Slack water at Port Phillip Heads occurs at about three hours before and three hours after high water, which is when the levels inside and outside are the same. The ingoing stream runs from about three hours before to about three hours after high water and the outgoing stream at other times. On the average, it is high water at the Port Phillip Heads three and a quarter hours before that at Williamstown and slack water at the Heads when it is high or low water at Williamstown".

PORT PHILLIP HEADS

Local Standard
Time Zone: -10:00 U.T.

38° 18' S 144° 37' E

Year 2016

Port 60730

HARMONIC CONSTANTS	H ampl meters	g phase degrees		H ampl meters	g phase degrees	TIDAL LEVELS ref to Prediction Datum	meters
M2	0.445	226.6	P1	0.048	64.6	HAT	1.9
S2	0.129	98.0	N2	0.086	281.1	MHWS	1.5
K1	0.147	71.0	NU2	0.015	281.0	MHWN	1.3
O1	0.103	39.0	K2	0.030	96.3	MSL	1.0
Sa	0.057	98.0	L2	0.025	353.4	MLWN	0.7
Ssa	0.025	161.2	2N2	0.011	223.1	MLWS	0.4
Mm	0.003	206.8	MU2	0.017	271.5		
Msf	0.004	163.0	T2	0.011	100.2	ISLW	0.2
Mf	0.009	180.4	M4	0.031	3.5	Semi Diurnal	
S1	0.006	144.2	MS4	0.001	245.1		
Q1	0.023	21.0	2MS6	0.004	161.2		

Figure 9 Port Phillip Heads Tide Levels

3.4 Sea state Conditions

Sea state conditions within Port Phillip will not pose any problem for large dredging equipment.

Sea state conditions in and near The Rip and in Bass Strait will hamper operations of split hopper barges, and may to a much lesser extent impinge on trailer dredger operations.

3.5 Weather Conditions

Heavy fog does occur in Port Phillip, and will hamper dredging operations from time to time.

3.6 Commercial Shipping Movements

For some of the dredging work methods costs will be incurred due to interruption to the dredging operations as commercial shipping movements always have right of way.

This will not occur at or around the Bay West port development site itself, but consequential delays to trailer dredgers and split hopper barges transiting through the South Channel and The Rip will occur.

3.7 Vessel Speed Restrictions

There are no speed restrictions gazetted for the Bay West port site location. However, speed restrictions do exist in the Yarra River, which may have a minimal impact on dredging operations if vessels have to transit the Yarra River for repair and or maintenance requirements.

3.8 Recreational Fishing

Recreational fishing is controlled under the Fisheries Act 1995 and the Fisheries Regulations 2009.

Port Phillip is a very active area for recreational fishing.

Recreational fishing takes place in all areas of Port Phillip, therefore safe operating procedures safeguarding recreational fishing will be required.

3.9 Commercial Fishing

The following is an extract from Victorian Bays and Inlets, Fisheries Association (VIBFA), Environmental Management System (EMS) 2013.

Fisheries Victoria, within the Department of Primary Industries (DPI) manages all commercial and recreational fishing activities in Victoria. The Fisheries Research Branch (FRB) is the scientific agency responsible for assessing the status of fish resources and essential fish habitats.

Bay and inlet fisheries have undergone significant changes over the years. Entry to the bay and inlet fisheries was capped in 1968 and in 1987 two-to-one restrictions were imposed on the transfer of licences (creating consolidated licences that then become transferable on a one-to-one basis). This consolidation stopped in 2009, and led to a reduction in the number of Fishery Access Licences, from 244 in 1989 to 214 in 1998 (bait and mussel-dive licences not included). Then, between 1999 and 2000, a voluntary buy-back scheme was implemented, further reducing the number of licences from 214 to 104 (see Table 1).

A series of spatial closures was also declared in the early 2000s. Commercial fishing was closed in Anderson Inlet, Shallow Inlet and Tamboon Inlet in 2000, followed in 2003 by the closure of Lake Tyers and Mallacoota Inlet in order to create recreational only areas. In 2002, Marine National Parks and Sanctuaries where commercial fishing is prohibited were declared in areas within Port Phillip Bay, Western Port and Corner Inlet. In December 2007 Western Port was closed to commercial net fishing. Today commercial operations are restricted to Port Phillip Bay, Western Port (although no commercial net fishing is allowed) Corner Inlet and Gippsland Lakes, with 71 licences remaining (Table 1 and Figures 1 -4).

Table1: Fishery access licences

Fishery	No. of licences in 1989*	No. of licences before buy-out (before 1999)**	No. of licences after buy-out (after 2000)**	No. of licences in 2004***	No. of licences in 2011****
Anderson Inlet	4	4	0	Closed	Closed
Corner Inlet	39	30	20	20	18
Gippsland Lakes	37	32	19	18	10
Lake Tyers	13	10	3	Closed	Closed
Mallacoota Inlet	8	8	4	Closed	Closed
Shallow Inlet	5	5	0	Closed	Closed

Tamboon Inlet	4	4	1	Closed	Closed
Port Phillip/Western Port *****	134	121	57	55	43
TOTAL	**244**	**214**	**104**	**93**	**71**

Bait and mussel-dive licences (18 in 2011) not included.

* Natural Resources and Environment Committee Report (NREC 1991).

** Adapted from Morison (2001).

*** Data from Fisheries Victoria – Commercial Fish Production Information Bulletin.

**** Data from Fisheries Victoria – Commercial Fish Production Information Bulletin.

***** Western Port closed to commercial net fishing in 2007.

Consequently, there are no perceived areas of conflict with commercial fishing in Port Phillip for the proposed dredging There is an abalone fishery located in Flinders Bight, between Flinders and Point Leo, however there is no perceived environmental management risk should sand winning operations be undertaken in deep water in Bass Strait, off Cape Schanck.

3.10 Recreational Sailing

Port Phillip is a very popular location for recreational sailing, with a number of marinas around the entire perimeter of the bay.

Notwithstanding no safety concerns are foreseen with the dredging operations when safety procedures are put in place by the dredging contractor.

It is noted however that at certain times of the year

3.11 Recreational Power Boating

Power boating and power water craft activities do take place in Port Phillip, however none near the proposed port development area.

4 GEOTECHNICAL INFORMATION

4.1 Port Phillip

Some limited knowledge is known of Port Phillip in general, and detailed knowledge of the existing shipping channels.

References:

1. Marine Geology of Port Phillip. G. R. Holgate, B. Geurin, M.W. Wallace and S.I. Gallagher. Australian Journal of Earth Sciences (2001) 48. 439 – 455.

See Appendix C for details

4.2 Bay West Locale

Very little geotechnical information is known about the preferred location of the Bay West port option, apart from some recent geophysical seismic survey run to generally observe the upper level of basalt flows known to occur along the western boundary of Port Philip. There is also some surface sampling available from this area.

See Appendix A for details

A very detailed site investigation programme will be required covering the proposed navigable waters to enable detailed appraisal of dredging work methods, cost and execution time estimates to be undertaken.

4.3 Bass Strait

Limited information is known about the availability of engineering quality sand in Bass Strait within an economical sailing distance from the Bay West preferred location.

However, there is sufficient information at this time to justify the inclusion of winning sand for the reclamation and land fill requirements of the Bay West port option and the Hastings port option.

See Appendix B, Seabed Map of Offshore Seabed Material prepared by Royal HaskoningDHV (Australia) for the Port of Hastings Development Project.

The location of NRE_1 has been selected as a likely sand source on the basis of water depth (55 metres). Sample report show only 2% mud and zero gravel.

Comprehensive sampling would be required to prove the extent of available sand.

4.4 Hastings

A marine geotechnical site investigation borehole programme was carried out with the field work running from the 14th December 2013 until the 24th July 2016.

The following reports from this programme are presently available:

1. Factual Report on Marine Geotechnical Investigations. Report No. 301010-01290-SS-REP-0001. Prepared by WorleyParsons Consulting. Revision 1 dated 10 October 2014;
2. Geotechnical Interpretive Report. Final Draft Report No. AGH-CEPO-EG-REP-0009. Prepared by AECOM + GHD Joint Venture. Revision 0 dated 13 March 2015.

4.5 Adequacy and Use of Geotechnical Information

4.5.1 Bay West

There is insufficient geotechnical information available at this time to undertake accurate production rate estimates and cost estimates.

The production and cost estimates set out in this report have been based upon the following suppositions:

1. the bulk of the material expected to be dredged from the channel, turning basin and berth pocket will be clay;
2. the volume of clay is assumed to consist of 50% of soft to firm (shear strength 12 – 50 kPa) and 50% of firm to very stiff (shear strength 50 kPa – 200 kPa);
3. there may be a thin layer of fine sand overlaying the clay, which could be selectively dredged more economically with a small trailer dredger, however shallow water depth may preclude this option. detailed site information is required.
4. the nature of the clay, when dredged by a backhoe dredger, is such that it can subsequently be re-handled and placed into the reclamation area using an unloader – spreader barge fitted with a conveyor arm. That is the clay is not too sticky.

4.5.2 Hastings

The marine geotechnical information available from these reports covering the dredge areas between Long Island Point and the Steel Works Jetty, and the port area further to the north are amply sufficient for determining suitable dredging and reclamation work methods and techniques, and for preparing R.O.M. dredging costs.

The geotechnical information is adequate for the purpose of deliberating on environmental management prerequisites associated with dredging and reclamation works for the preliminary determination of viable dredging work methods.

The data density between Crib Point and Long Island Point is sparse, but is sufficient for the purposes of this report.

The data density in the area of Stony Point to Sandy Point is very sparse, and care needs to be taken with respect to the possible presence of igneous and or metamorphic rock in the general area, but it is sufficient for the purposes of this report.

4.5.3 Terrestrial Data

Available information shows the possible existence of gravel and river beds in the general location of Bay West preferred location.

5 PORT CONCEPTUAL DESIGN

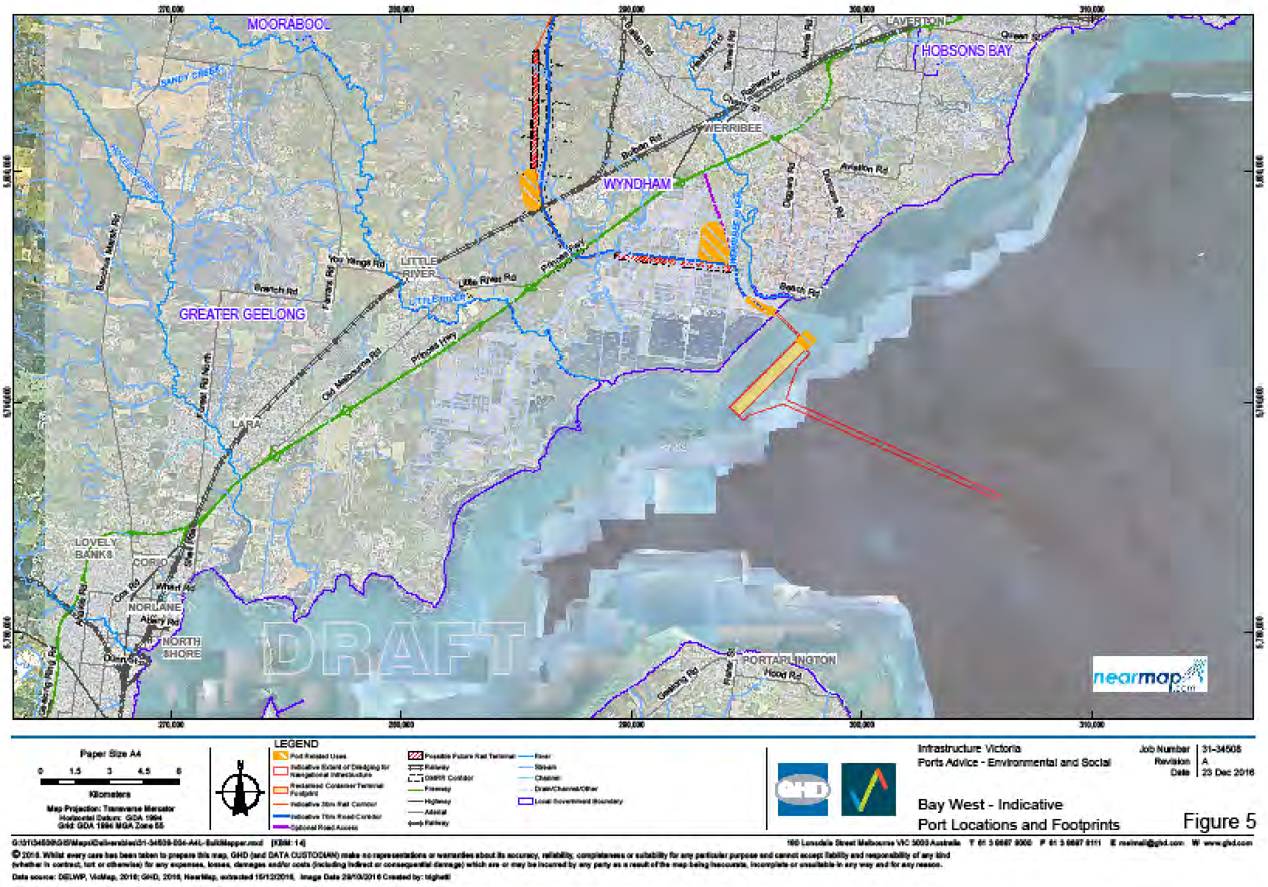
5.1 Overall Development

The new port is planned to be developed in stages.

This development concept is based on the engineering investigations and design work completed to the time of this report.

5.2 Bay West Conceptual Port Design

The conceptual position for the Bay west port is shown in the following sketch.



Sketch courtesy of GHD Pty Ltd

Figure 10 Bay West Conceptual Position

Estimated volumes for the dredging works required to develop this port design are:

a) Navigable waters gross volume: 37.83 Mm3;

b) Quay wall construction bund gross volume: 0.90 Mm3;

c) Fill required for land creation: 25.30 Mm3;

Notes:

1. Materials to be dredged: Assumed to be a mixture of soft to hard clay. See Section 4 for details;
2. Spoil Disposal: Based upon assumptions made concerning material to be dredged, all dredged material to be placed into the reclamation area.
3. All volumes and areas are best estimates at this time and may vary significantly as the port design matures.
4. Fill required for land creation (Item c) includes quay wall bund (Item b).
5. Gross volume allows a provision for estimated over dredging based upon material type and dredger type.

5.3 Project Milestones

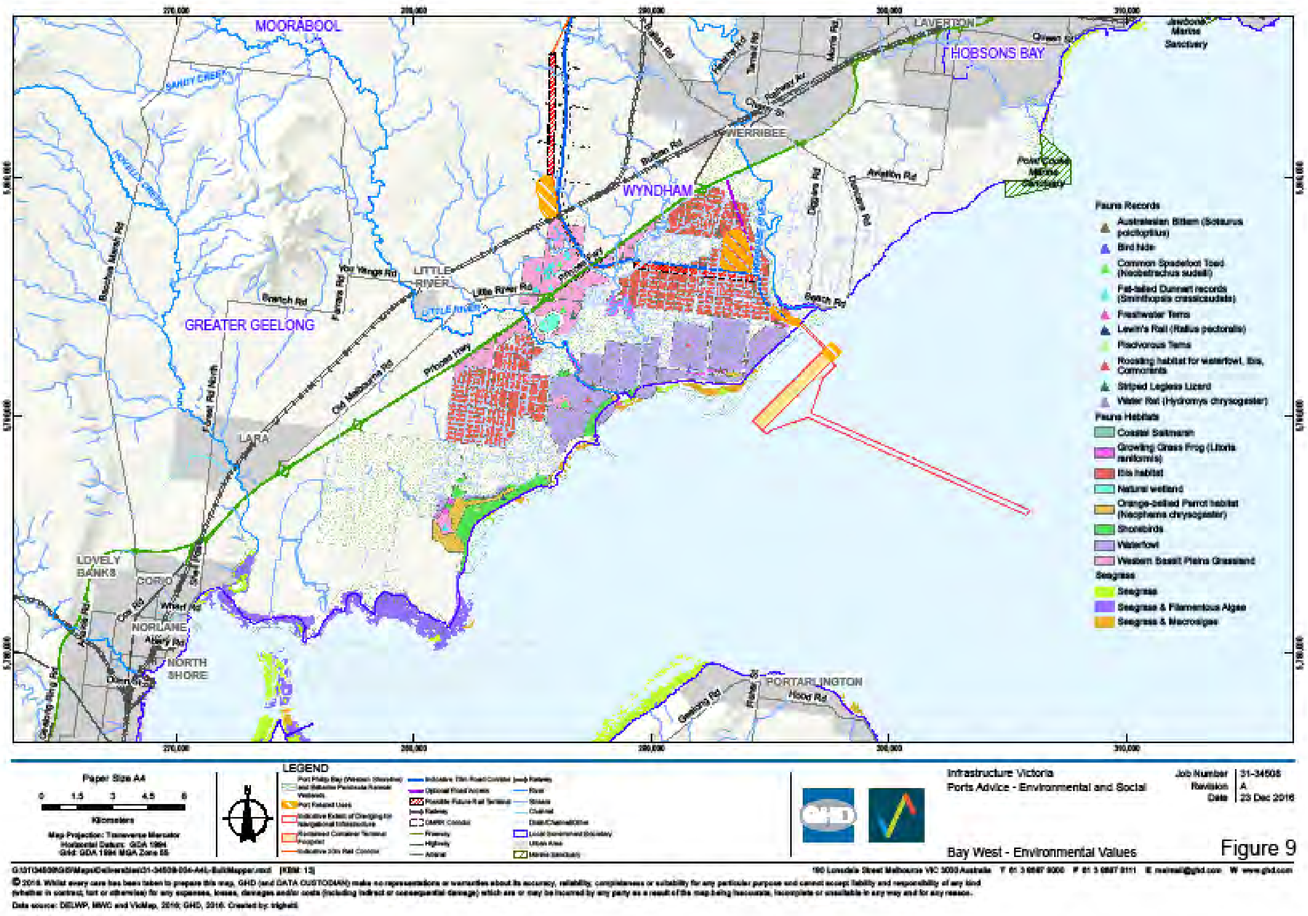
The completion date for the Stage 1 of the port development is mooted to be in the mid 2020's with a capacity of 3 million TEUs.

6 ENVIRONMENTAL RISK MANAGEMENT

Following are the perceived, guiding environmental criteria to be considered when developing the most appropriate dredging work method for the Bay West port option.

These matters mentioned are not exhaustive, and other key matters and constraints may be identified as the project develops. The purpose here is to create an expansive overview of the environmental qualities of Port Phillip in order to only select dredging work methods that will deliver the most holistic project management. The mentioned matters are however ones that will have to be taken into consideration when further short-listing the dredging work methods and undertaking further cost and programme estimates.

Further, some of the information referenced may not be the most current available on the given subject matter.



Sketch courtesy of GHD Pty Ltd

Figure 11 Key Environmental Values in Port Phillip

6.1 Key Environmental Consideration and Restraints

Port Phillip is also commonly referred to as Port Phillip Bay or locally just The Bay. Geographically, the bay covers 1,930 square kilometres and its shoreline stretches approximately 264 km. Although it is extremely shallow for its size, most of the bay is navigable. The deepest portion is only 24 metres and half the bay is shallower than 8 metres. The volume of the water in the bay is around 25 cubic kilometres.

Port Phillip waters and coast are home to seals, whales, dolphins, corals, and many kinds of seabirds and migratory waders.

6.2 Dredging Related Values

The following matters are perceived to be of vital importance for this project when considering suitable dredging work methods.

1. Existing Port of Melbourne Operations Ltd Dredging Environmental Management Plan;
2. DEWLP requirements for vessel hull inspections for vessels transiting intra and trans Port Phillip;
3. Ramsar Wetland;
4. Recent environmental changes in Port Phillip;
5. Development of reclamation suitable for container handling;
6. Minimisation of dredging volume;
7. Hopper overflowing and water turbidity;
8. Dredged Material Management;
9. Access restrictions in South Channel area during summer;
10. Waste removal from vessels;
11. Seagrass;
12. Mangroves;
13. Little penguins;
14. Cetaceans and marine mammals.

6.3 Port Phillip Ramsar Site

In October 2000, the Port Phillip Bay Ramsar site was added to the East Asian-Australasian Shorebird Site Network. The establishment of a shorebird network is a key action of the Action Plan for the Conservation of Migratory Shorebirds in the East Asian-Australasian Flyway: 2001-2005, which in turn is a key component of the Asia- Pacific Migratory Waterbird Strategy: 2001-2005.

This plan includes strategies to conserve shorebirds and protect their habitat.

In Victoria, wetlands are classified into eight categories (Corrick and Norman, 1980). The Port Phillip Ramsar site is the only site that contains areas of each of the eight categories recognised under this system.

Within the Port Phillip Ramsar site a number of wetland types are present that are recognised under the classification system used by the Ramsar convention. These include: six types of marine and coastal wetlands (i.e. permanent shallow marine waters, rocky marine shores, sand shingle or pebble shores, estuarine waters, intertidal mud and sand flats, and intertidal marshes including saltmarsh); two types of inland wetlands (i.e. permanent river/streams/creeks, and permanent freshwater marshes/pools); and two types of artificial wetlands (i.e. irrigated land and sewage treatment ponds).

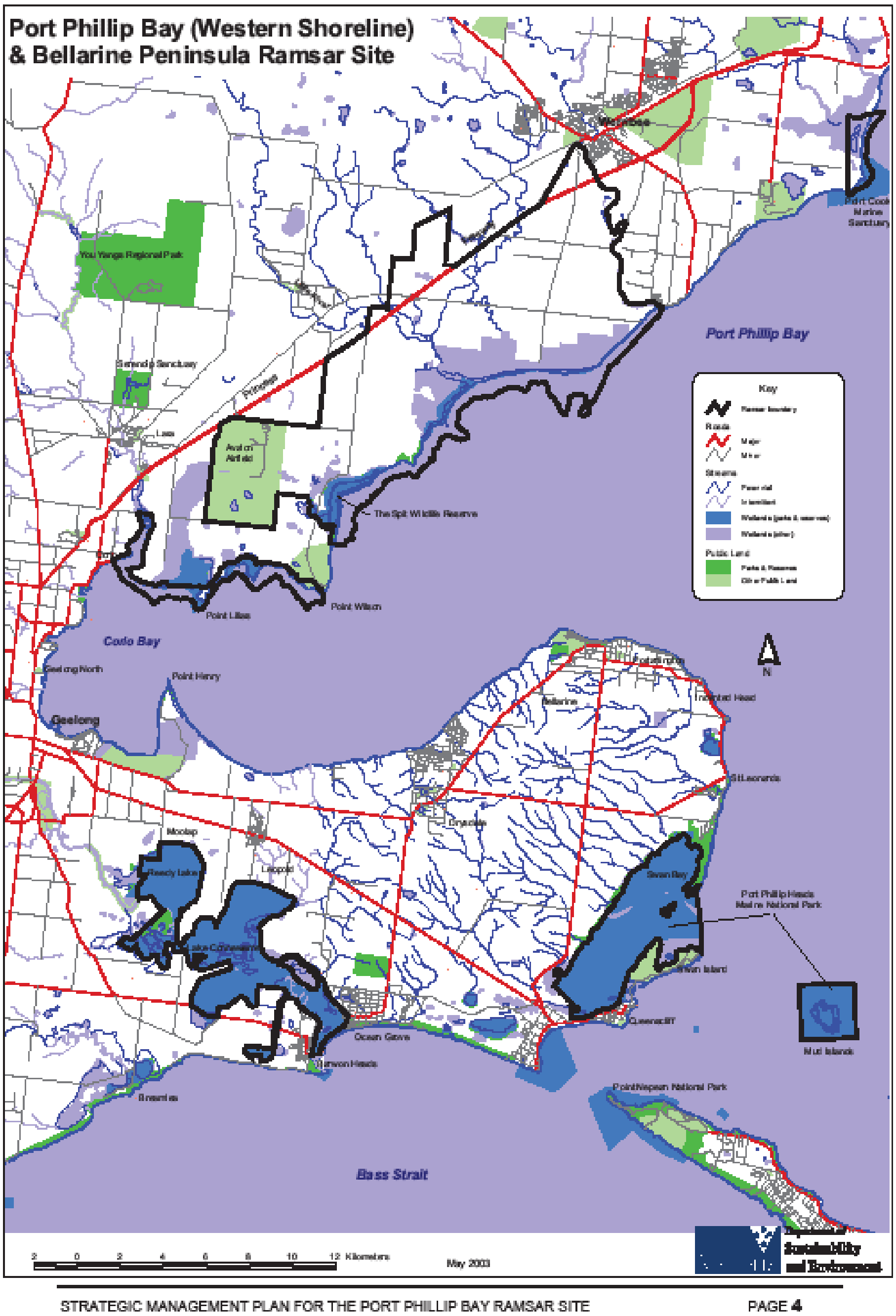
The Port Phillip Ramsar site consists of a number of component areas that include:

1. parts of the shoreline, intertidal zone and adjacent wetlands of western Port Phillip Bay, extending from Altona south to Limeburners Bay;
2. parts of the shoreline, intertidal zone and adjacent wetlands of the Bellarine Peninsula, extending from Edwards Point to Barwon Heads and including the lower Barwon River wetlands and Mud Islands.

The areas are:

1. Skeleton Creek to Point Cook;
2. Western Treatment Plant;
3. The Spit Nature Conservation Reserve;
4. Avalon Airfield;
5. Point Wilson to Limeburners Bay;
6. Swan Bay;
7. Mud Islands;
8. Lake Connewarre and Reedy Lake.

Whilst the proposed footprint of the dredging and reclamation required for the Bay West port option lies outside of the Port Phillip Ramsar area, the possibility of beneficial use of the dredged material to enhance any wetlands should be considered.



Source: DSE. Port Phillip (Western-Shoreline) & Bellarine Peninsula Ramsar Site Strategic Management Plan

Figure 12 Port Phillip Ramsar Area

6.4 Development of a Fit for Purpose Reclamation

The dredging work for this project has two prime objectives, namely:

1. create safe navigable water for port operations;
2. provide reclamation with an engineering competence so as to be able to provide the required area of land with the most sustainable qualities for handling containers.

Given that the material to be dredged to create the safe, navigable water is assumed to be predominantly clay brings about special challengers regarding the beneficial use of the material to be dredged.

In this circumstance, alternative sources of competent material to create and or complete the reclamation must be sought. Likely sources could be offshore in deeper water in Bass Strait, or from within Port Phillip where sand is routinely dredged in maintaining the South Channel shipping channel.

6.5 Minimisation of Dredging Volume

The net volume that is required to be dredged is primarily driven by the design vessel dimensions and its sailing and manoeuvring characteristics, tidal regime, dominant sea state conditions and the port operations regime.

The presence of rock is a very significant factor in the decision as to where to locate a new port, particularly igneous rock. Whilst the work methods that are used for the pre-treated of rock using explosive to fracture it to enable to be dredged are well proven over the past 50 years or so, and also the subsequent dredging methods, it is very expensive to blast and dredge fresh igneous rock. Further, the environmental risk is very low, and limited to the immediate area of the blasting.

Based upon the proposed location of Bay West options, there is fresh basalt present close inshore. See Appendix A for details of the extent of basalt in the area. Therefore, the positioning of the berth is an important decision. The cost difference between dredging a cubic metre of fresh basalt and stiff clay is in the order of 14 to 1.

The secondary consideration is the volume of over dredging that will occur. This varies depending upon the following factors:

1. the nature of the material being dredged;
2. the type of dredger being deployed;
3. the accuracy of the positioning system;
4. the accuracy and recording of tide measurement;
5. the sea state conditions at any given time;
6. the skill and experience of the dredge operator.

Typically, the accuracy of the dredging is monitored on a daily basis by the dredging contractor. This can be written in as a contractual requirement, subject to sea state and weather conditions.

6.6 Hopper Overflowing and Water Turbidity

Loading dredged material into any type of barge or hopper using a hydraulic work method (trailer dredger and cutter suction dredger) will result in fine grained material being carried back into the water column in the overflow water.

The only way to limit this is to limit the time of hopper overflowing. The time limit may be set as an interactive physical time interval, or it may be based upon recorded sediment load in the water surrounding the dredging work site, with a maximum sediment load budget specified for a prescribed time period.

A very recent example of this management approach is the Wheatstone LNG project off Onslow, Western Australia, where significant turtle population, sea grass and coral exist.

No hopper overflow limitations were imposed on the dredging operations itself. A tiered trigger level system for the designated project receptor (corals) was developed by the dredging contractor, Dredging International, and the proponent Chevron Australia.

The West Australian State Government EPA provided the determining criteria (via the dredging permit) for mortality in the different Zones (High-Moderate-Influence) and these were translated to Exposure Limits (using a tiered trigger level system) based on intensity, frequency and duration of exposure.

This system was managed with the Dredge Management Plan (DMP).

The other main component of the environmental management was the operational use of the water turbidity model developed for the project.

The EPA (W.A.) had confidence both in the water turbidity plume model and in the DMP to allow the implementation of a flexible management system, based upon forecast turbidity plume modelling, to manage the dredging works.

It is advised that this new and unique operational forecast system proved its value in the delivery of the project with zero coral mortality due to dredging.

6.7 Cetaceans and Marine Mammals

The following information is obtained from the Marine Mammals of Victoria Information Guide published by the then Victorian Government Department of Sustainability and Environment, September 2010.

Victorian waters are home to a large diversity of marine mammal species, including whales, dolphins and seals.

There is a substantial breeding colony of Australian Fur Seals at Phillip Island, and the New Zealand Fur Seal is plentiful along the entire Victorian coastline. Sub-Antarctic Fur Seals, Australian Sea Lions and Leopard Seals are also common.

Humpback whales are usually seen migrating through Victorian waters between autumn and spring, from their feeding grounds in Antarctica to their calving grounds in southern Queensland, and back to the Antarctica.

Southern Right whales can be seen in small numbers during winter along the whole of the Victorian coastline where they breed annually, with a known nursery aggregation area at Logan's Beach, Warrnambool.

Blue whales appear from November to May along the whole of the Victorian continental shelf, but are most common west of Cape Otway due to cold water upwelling, which sustains abundant krill. The Blue whales migrates to the north in winter.

Sperm whales can occasionally be seen in waters off the Victorian coastline

False Killer whales can occasionally be seen along the whole of the Victorian coastline.

Pilot Whales can be seen in the Victorian offshore waters.

Bottlenose dolphins can be seen along the whole of the Victorian coastline, including within Port Phillip, Western Port and the Gippsland Lakes

Killer Whales can be seen along the entire Victorian coastline.

Small numbers of common dolphins have become residents in eastern parts of Port Phillip since the late 2000s. In recent years, the numbers of southern humpback and southern right whales entering Port Phillip have shown increases. Unlike in Portland and on Great Ocean Road, Southern Rights in eastern Victorian waters are still critically endangered and in very small numbers. However, the presences of cow-calf pairs in Port Phillip in recent years indicate that Port Phillip was possibly once a wintering and or calving ground for these whales. They swim very close to shore to take rests in shallow, sheltered waters, sometimes just next to piers in Frankston

The bay is home to about 100 to 150 of the recently described species of bottlenose dolphin, the Burrunan dolphin (Tursiops australis). The other 50 or so of this rare species are to be found in the Gippsland Lakes

Subsequently, while this list is not exhaustive, it demonstrates that management systems for dredging vessels transiting Port Phillip and offshore waters will need to be rigorous and continually monitored for compliance.

6.8 Dredged Material Management

A comprehensive Dredge Management Plan will be required with prescribed practices to be followed and reported on by the dredging contractor.

This plan will detail dredging practise to be followed in the dredge areas, in the reclamation area and in the Dredged Material Ground(s).

6.9 Waste Removal from Vessels

No discharge of waste water, of any classification, is to be permitted from any vessel.

All waste, including domestic and hydrocarbons must be placed ashore and disposed of by a licenced waste disposal contractor.

6.10 Seagrass Meadows

The presence of seagrass will be taken into consideration when developing dredging work method strategies.

See Figure 11 for locations of seagrass meadows.

6.11 Mangroves

Water turbidity generated by dredging must be considered when developing dredging work methods. It is crucial that erosion and or sedimentation at or near stands of mangroves be avoided. Deposits of silt or sand may drown mangroves through the smothering of their pneumatophores.

Notwithstanding there is not any perceived concerns of risk to mangroves with the proposed siting of the Bay West port option.

6.12 Little Penguins

The following information was obtained from the Penguin Foundation Phillip Island web site.

The largest colony of little penguins in Victoria is located at Phillip Island, where the nightly 'parade' of penguins across Summerland Beach has been a major tourist destination, and more recently a major conservation effort, since the 1920s.

Phillip Island is home to an estimated 32,000 breeding pairs (70,000 birds).

Little penguin habitats also exist at a number of offshore locations, including London Arch and The Twelve Apostles along the Great Ocean Road, Wilson's Promontory and Gabo Island.

The little penguins travel considerable distances and significant procedures will have to be put in place to protect them from vessels transiting to and from any DMG, or offshore sand winning area. Depending on the season, a little penguin may spend between one day and one month at sea. When little penguins are breeding, they will regularly return to incubate the eggs and feed their chicks. During winter, little penguins spend more time at sea chasing fish and only return to rest and renovate their burrows.

6.13 Noise

Noise generated by the dredgers and ancillary vessels is not seen as an issue in Port Phillip due to the distance offshore the dredging and reclamation works are planned to be undertaken.

6.14 Light

Dredging operations will be conducted 24 hours per day, 7 days per week.

Light emanating from vessels is not seen to be a matter of concern in Port Phillip. Notwithstanding, vessel lighting impact must be checked.

6.15 Wind Blown Material

Depending upon the nature of the material being dredged and used to create the reclamation, windblown particles may be a problem once the material has dried out (except for any high moisture content materials of course).

If the problem is acute, stabilisation of the reclamation's surface will be required.

6.16 Recent Recorded Environmental Changes in Port Phillip

6.16.1 Port Phillip Tide Levels

A study was conducted to monitor the tide levels in Port Phillip following completion of the Port of Melbourne Corporation's Channel Deepening Project which was completed in 2008. The study commenced in October 2008 and concluded in September 2009.

6.16.1.1 Objective of Study

The Victorian State Government Office of the Environmental Monitor (OEM) commissioned the National Tidal Centre (NTC) of the Bureau of Meteorology (the Bureau) to undertake an independent assessment of the tide gauge data routinely collected by the then Port of Melbourne Corporation (PoMC). The purpose of this assessment is to identify any observed changes to tidal heights as a result of dredging activities associated with the Channel Deepening Project, and compare them to the predicted changes described in the Supplementary Environment Effects Statement (SEES).

Analysis and reporting of the tide gauge data collected by PoMC was undertaken on a monthly basis for a period of one year. The first monthly report, issued for October 2008, included an analysis to identify the level of accuracy by which the tide gauge data is able to detect changes due to dredging

6.16.1.2 Findings of Study

The report was prepared for the Office of the Environmental Monitor, The State Government of Victoria

The report was prepared by the National Tidal Centre, Bureau of Meteorology, Commonwealth of Australia

The findings of the study were summarised in the Executive Summary of the report "Tide Height Assessment Following Dredging in Port Phillip Bay. Report 12: September 2009 (Final)".

Quote
"Executive Summary

- *The predicted changes to high and low water tides within Port Phillip Bay were reported in the Supplementary Environment Effects Statement (SEES) to be in the order of 1cm. Following the completion of entrance dredging, twelve months of observed sea level data were analysed for changes in tide.*
- *The tide assessment confirms, within the limits of the precision available, that the observed changes to astronomical tide heights within Port Phillip Bay were consistent with the initial predictions reported in the SEES.*
- *Generally, the high tides and the low tides within Port Phillip Bay were 1cm higher and 1 cm lower, respectively, than those prior to dredging. The observed changes at Williamstown, West Channel Pile and Queenscliff were consistent with the changes predicted in the SEES.*
- *It was noted that the observed change in high tide at Hovell Pile, while lower than the changes at Williamstown and West Channel Pile, was higher than predicted in the SEES but in line with the overall pattern of observed change across the Bay.*
- *Tide height changes at locations without monitoring gauges (including Rip Bank, Pt Cook, Werribee, Mordialloc, Pt Wilson and Geelong) are estimated to be similar to the predicted changes given in the SEES. At Geelong, where the largest changes were predicted to occur, changes to Mean Higher High Water will likely be more than 1cm but less than 2.2cm.*
- *The uncertainty associated with the changes in high and low tide levels is in the order of 1cm, which is of similar magnitude to the predicted changes. Tidal levels observed at Lorne (Bass Strait) helped identify background regional changes and were used to refine calculations of the tide height changes within Port Phillip Bay.*
- *Extreme tides occur infrequently. Twelve months of observations limit the ability to accurately calculate the changes in extreme tide height. Therefore, the uncertainty associated with quantifying these changes are larger by an order of magnitude, than the actual predicted changes in the SEES. The actual change in extreme tide heights will emerge when the uncertainty decreases over a number of years.*
- *Vertical heights of the tide gauges have been verified against land-based reference marks. Small datum shifts have been identified in some of the sea level records but these shifts have not unduly compromised the astronomical tide height assessments."*

Unquote.

7 LESSONS LEARNT – PORT CHANNEL DEEPENING PROJECT

Following is a high-level summary of the most significant matters to come out of the Port Channel Deepening Project undertaken in 2008 – 2009 by the (then) Port of Melbourne Corporation, matters to be considered for both the Bay West and Port of Hastings proposed port developments.

7.1 Environmental Risk Management

7.1.1 General Needs

The environmental requirements specified were such that the whole of the works had to be postponed for at least a year, and further a trial dredge exercise costing more than $60 million had to be undertaken.

The environmental risk management hurdles that were faced by the PoMC were enormous.

Restrictions were mainly in respect of following criteria:

1. Dredging, transport and storage of contaminated dredged materials, including placement and timing of capping;
2. Creation of water turbidity plumes;
3. Detail of dredging in The Rip.

Real time turbidity monitoring was an EMP requirement.

7.1.2 Summer Time Restrictions on Dredging Activities

Some areas in the southern parts of Port Phillip, mainly the South Channel area and The Rip, were off-limits for dredging plant for certain periods of time during the summer season. This was mainly limited to the period from mid-December to the end of January each year.

7.1.3 Vessel Transits Intra and Ex Port Phillip

It is noted that prior to the commencement of the channel deepening project the DELWP had great concern and reservation in granting approval for the dredging equipment to sail from the southern part of Port Phillip to the north part of Port Phillip, and vice versa, without an underwater hull inspection for each transit.

It can be expected that this matter will be seriously raised again for the dredging required for the Bay West option. Given that the most likely port development construction programme will require the transportation of a large volume of sand from either or both the South Channel and from outside Port Phillip, off Cape Schanck, using a large trailer dredger.

Such an imposition of having to carry out a hull inspection of a rather large vessel at each and every transit will have very significant cost and programme consequences.

This is a major risk factor for the Bay West development and must not be treated as a trivial or an inconsequential requirement.

7.1.4 Tide Level Change

See Section 6.16.1.

A shown by the monitoring following completion of the CDP, tide level change as the result of any dredging in The Rip can be accurately forecast.

7.1.5 The Rip Canyon

The environmental impact on the condition of The Canyon was monitored following the completion of the Channel Deepening Project.

A study was undertaken two years after completion, and a second study undertaken six years post-dredging.

Both studies were undertaken by Cardno for the Port of Melbourne Corporation.

The key findings of these studies were as follows.

7.1.5.1 Two Year Post-Construction Survey

The following is an extract from the report prepared by Cardno Ecology Lab:

Two Year Post-Construction Survey of the Deep
Reef Habitat at the Entrance to Port Phillip Bay
J Job Number: EL1011047
Prepared for Port of Melbourne Corporation
November 2011

Executive Summary

Background

The Channel Deepening Project (CDP) was undertaken by Port of Melbourne Corporation (PoMC) from February 2008 to November 2009 to increase channels depths in Port Phillip Bay to accommodate 14 m draught vessels. The CDP included the removal of rock from the entrance to Port Phillip Bay ("The Entrance"), from Rip Bank and Nepean Bank (also known as the Plateau) (Figure ES1). A total of 461,000 m^3 of rock was removed from The Entrance from April 2008 to September 2008, comprising about 2% of the total volume of material dredged during CDP (22.97 million m^3).

As part of the regulatory approvals for the CDP, the Supplementary Environment Effects Statement (SEES) had predicted that loose rock and rubble would be generated from dredging activities in The Entrance, some of which was predicted to move across the top of the reef and fall down the deep canyon which meanders between Rip Bank and Nepean Bank. Much of the predicted impact was to occur in the two years following dredging, with pulses of rockfall occurring in decreasing magnitude over the following 30 years.

Recovery of marine habitats from biological and physical impacts from rockfall into the canyon were predicted to commence immediately following stabilisation of rockfall material. To meet the post-CDP Environmental

Management Plan (EMP) requirements, PoMC monitors the impact of rockfall and recovery of biota of the canyon walls which contain benthic fauna and flora (e.g. sponges, ascidians, kelp).

The objectives of the study are the following:

- To determine the extent that rockfall generated by dredging associated with the CDP affected the biota of the walls of the canyon at The Entrance; and
- Where biota have been affected by rockfall from the CDP, to determine whether there is evidence of recovery from these impacts.

To date, surveys of the canyon walls have been done up to and including pre-CDP in 2006, in 2009 (three to six months following completion of the CDP) and in 2011 representing the second post-CDP dredging survey. This report compares the results of all three survey periods.

Key Findings

1. Presence of sponge communities

a. Sponge communities were present in all depth strata sampled at Rip Bank and Nepean Bank. The photographic database compiled for the study provides a robust, historical record of these communities.

b. Biological diversity of The Entrance has shown some small-scale variation but has remained relatively stable over the period of the study before and after the CDP.

2. Before-after-control-impact study

a. Before-after changes in biota were measured at dredged and control locations within The Entrance, as well as the control sites at Portsea Hole and Wilsons Promontory.

b. Statistical comparisons of data from The Entrance to the regional controls were limited due to differences in habitat characteristics, such as the restricted depth range present at the regional control locations and the timing of baseline surveys. Notwithstanding this, spatial and temporal changes were evident in all deep reef communities at the locations sampled along the Victorian coastline, which indicates region wide variability that cannot be attributable to the CDP.

3. Physical disturbance at Rip Bank and Nepean Bank

a. Overall there was less physical disturbance observed in 2011 compared to 2009.Observations of cleared reef surfaces or the presence of rubble covering reef surfaces were interpreted as physical disturbances.

b. While smaller in magnitude that in 2009, physical disturbance in 2011 was more prevalent along Rip Bank, particularly adjacent to the area used for trial dredging and the subsequent CDP dredging, than at Nepean Bank.

c. There was evidence of rockfall along the northern edge of Nepean Bank between 2009 and 2011, primarily in the northern section of the bank.

d. The pre-dredging baseline survey in 2006 shows the presence of physical disturbance prior to the CDP. This is most evident within Rip Bank West and may have resulted from trial dredging, historical deepening activities, natural processes, or a combination of these three processes.

e. There is evidence of substantial recovery in the 2011 survey. The recovery is shown by a reduced frequency of photoquadrats showing impact categories within both Rip Bank and Nepean Bank.

f. There was very little evidence of rockfall occurring at the control locations.

g. Statistical analysis of impact categories confirmed that relatively more disturbance occurred at Rip

Bank than at Nepean Bank. However, there is clear evidence that disturbance was present prior to the CDP at Rip Bank. There was a trend to reduced disturbance at 27 m and 37 m from 2009 to 2011. No trend in impact categories was detected statistically at 47 m between 2009 and 2011. The 57 m stratum showed complex interactions between times and locations, with disturbance apparent in 2009 at Rip Bank and Plateaux D, E and F, that are all trending towards recovery in 2011.

4. Evidence of before-after changes in community structure of biota
a. Statistical analysis indicated some changes in community structure from before to after the CDP. In many cases these changes occurred at impact and control locations, indicating variation due to processes other than the CDP.

b. The patterns of change for individual taxa were highly variable. For example, one species of sponge has shown a decrease in cover at all locations from 2006 to 2011, indicating a larger-scale process within The Entrance independent of the CDP.

c. A species of ascidian that was not present at any location in 2006 was recorded at the impact and control locations in 2009 and 2011. The ascidian was more prevalent at the control locations in 2011.

d. There were no consistent changes in abundance over a broad range of taxa at The Entrance

5. Statistically significant biological change was detected for some taxa within the smaller patches of reef (~ 50 m) at all locations
a. Changes in the variance of cover by taxa within locations were apparent at some impact and control locations, indicating changes in the distribution of some taxa at smaller spatial scales. Changes occurring at larger spatial scales within the impact and control locations were not attributable to the CDP.

b. No statistically significant differences in the proportions of frames classified as “no visible disturbance” were detected between Period (Before vs. After CDP) and Treatment (Control vs. Dredged locations).

6. Rockfall impacts at Nepean Bank (the Plateau) were within expectations based on rockfall modelling
a. Small areas of rubble accumulation observed to 57 m in 2009 and 2011 were consistent with previous modelling predictions. However, predicted rockfall pathways between the reef top and 57 m shelf were not observed.

b. A single northward dispersal of material at Plateau E observed initially in 2009 was present in 2011. This appears to cover a relatively small area and would be expected to develop colonisation based on the analysis of impact categories.

7. Rockfall impacts at Rip Bank were broadly within expectations
a. The observed Rip Bank scree slope areas were generally consistent with the paths of rubble dispersal predicted by the modelling. Rockfall disturbances were observed to decrease from 2009 to 2011 which is also consistent with the modelling, although rubble accumulation appeared to cover a slightly greater area of the seabed than was predicted.

b. Rockfall originally observed in 2009 was still observed in 2011. However, a reduction in rockfall disturbance was apparent in 2011, as was predicted by the rockfall modelling.

c. The presence of fresh, angular rubble pieces indicates that scree slopes continue to be active in

the canyon adjacent to the Great Ship Channel.

8. Recovery at Nepean Bank was well advanced
a. Video footage taken by divers in 2011 at 19 m depth on the reef shelf above the canyon wall indicated a kelp community with some thinning consistent with rubble scouring. This contrasts with 2009 when there was little kelp regrowth. This suggests that, although there was rubble disturbance within this habitat in the period prior to the 2011 survey kelp regrowth appears to be more advanced.

b. At 27 m the substratum consisted of vertical walls, ledge edges, overhangs and steep slopes. There was no visual evidence of impacts on the walls or ledge faces and no evidence of scoured reef biota on steep slopes. Some large boulders and rock slabs, up to 6 m across, were observed just below this depth stratum at Plateau A with sponge regrowth on them.

c. In Plateau B the horizontal surfaces of some steps and ledges did not exhibit accumulations of rubble and/or signs of scouring in 2011, which was in contrast to 2009. At Plateaux C, D and F no rubble accumulations were observed. At Plateau E some vertical cracks and gullies were filled with gravel and rubble which was similar to the observations in 2009.

d. Deeper strata of Nepean Bank showed varying levels of disturbance attributed to rockfall, but with little evidence of new rockfall in 2011. At the foot of the Catacombs, opposite Plateau D, some disturbance observed in 2011 could be related to movement of pre-existing rubble or possibly new rubble.

9. Further recovery at Rip Bank was evident in 2011
a. The reef top and adjacent canyon wall habitats of Rip Bank West were the closest areas to the trial dredging and CDP dredging. Qualitative observations of video footage and stills indicated that this location had the greatest degree of disturbance after dredging activities, with scree slopes persisting from the trial dredging period observed in 2011. Fresh rockfall material was observed by divers on scree slopes in 2011, indicating some ongoing disturbance at Rip Bank West.

b. Notwithstanding the above, some sections of adjacent and/or nearby scree slopes at Rip Bank were relatively unaffected, with some patches of scouring and regrowth which were supporting sponge communities. Moreover, no disturbance was apparent on an overhang wall at the eastern end of this location. At 37 m boulder accumulations were similar in 2011 to 2009. At 47 m no exposed rockfall was observed, however stones were observed with encrusting sponges indicating that recolonisation was occurring.

c. Other locations at Rip Bank, not directly within or adjacent to the trial dredging area, generally showed less disturbance than Rip Bank West. There was evidence of ongoing rockfall disturbance, including reef scour, scree slopes and larger reef boulders up to 2 m across, particularly at 27 m at Rip Bank East. Some older rubble and scoured patches were present, with observed colonisation by encrusting biota. There was a dominance of fresh, bare rock at the eastern end of this depth stratum.

10. Continued monitoring is scheduled for further impact and recovery assessment
a. As many as possible of the individual reef patches surveyed in 2006, 2009 and 2011 should be resurveyed in the next scheduled monitoring program in 2015 to continue to allow a direct comparison of changes through time.

11. Overall conclusions
a. Although some new rockfall was observed in 2011, overall, there was less rockfall in 2011 than

2009, which is consistent with the SEES predictions.

b. Further recovery of the deep reefs since 2009 was evident in 2011, which is also consistent with the SEES predictions.

c. Assemblages and individual taxa varied in space and time at impact and control locations within The Entrance; little evidence of impact to biota that could be directly attributable to the CDP was detected statistically.

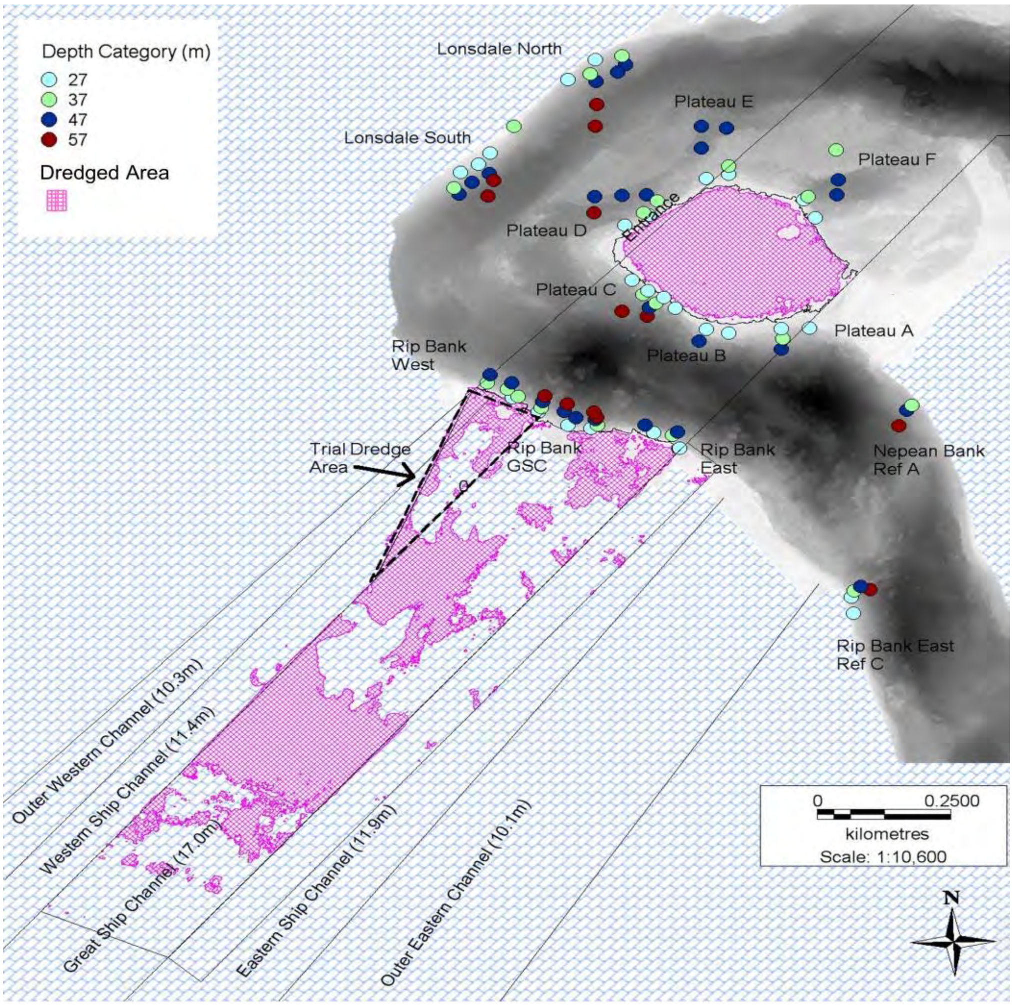


Figure ES1: Patches sampled at The Entrance during 2011 surveys of deep reefs including depth categories, study areas the Trial Dredge Area.

(Lines indicate the border of the shipping channels. Dashed line indicates the Trial Dredge Area.)

7.1.5.1 Six Year Post-Construction Survey

The following is an extract of the Executive Summary from the report prepared by Professional Marine Science Services (PMSS):

Six Year Post-Construction Survey of the Deep
Reef Habitat at the Entrance to Port Phillip Bay

J Job Number: PMSS-0136
Prepared for Port of Melbourne Corporation
July 2015

Key Findings

1. Presence of sponge assemblages

- Sponge dominated assemblages were present at all depth strata at Rip Bank and The Plateau. The photographic database compiled for the study provides a robust, historical record of these assemblages;
- Biological diversity (total list of taxa) of The Entrance at the potential impact locations has remained relatively similar over the period of the study before and after dredging for the CDP.

2. Before-After-Control-Impact Study

- Before-after changes in biota were measured at dredged and control locations within The Entrance, and regional control site Portsea Hole;
- Data collected at The Entrance and Portsea Hole were not compared statistically due to the differences in habitat characteristics, such as the restricted depth range present at Portsea Hole and different survey times for the baseline surveys. Notwithstanding this, spatial and temporal changes were evident at the regional control location Portsea Hole as well as at The Entrance locations, indicating the occurrence of a similar natural and region wide variability that cannot be attributable to the CDP.

3. Physical disturbance at The Entrance

- Overall, a large decrease in physical disturbance was observed in 2015 compared with 2011.
- Diver or ROV observations of cleared reef surfaces or the presence of rubble covering reef surfaces were interpreted as physical disturbances. The recovery is shown by a reduced frequency of frames showing impact categories within both Rip Bank and The Plateau;
- There was evidence of some further rock fall at Rip Bank and The Plateau since the previous survey in 2011, but at a reduced rate;
- Prior to the 2015 survey, there was evidence of a small amount of rock fall occurring at the control locations but no evidence of natural rock fall was recorded at the control locations in 2015;
- The pre-dredging baseline survey in 2006 shows the presence of physical disturbance prior to the CDP. This is most evident within Rip Bank West and may have resulted from the Trial

Dredge Program, historical deepening activities, natural processes, or a combination of these three processes;
- Statistical analysis of impact categories confirmed a recovery from 2009 to 2015 at Rip Bank and Nepean Bank Plateau D, E and F location group;
- There is evidence of disturbance prior to dredging for the CDP at Rip Bank at 27 m. There is also evidence of a decrease in physical disturbance at 27 m, 37 m and 47 m from 2009 to 2015, with minimal physical disturbance at 27 m in 2015;
- No statistically significant differences in the proportion of frames classified as ‘no visible disturbance’ were detected between the before and after dredging periods for either the control or dredged location groups.

4. Evidence of before-after changes in assemblage structure of biota

- Statistical analysis indicated some changes in assemblage structure from before to after the CDP. In many cases these changes occurred at both impact (dredging) and control locations but without any evident pattern, indicating variations are due to natural processes rather than from the CDP.

5. Statistically significant changes in the cover of some taxa were detected at the smaller spatial scale at all location groups
- The majority of taxa showed no changes in cover consistent over time and there were no patterns that may support the hypothesis of a CDP impact at dredged locations;
- The patterns of change for individual taxa were highly variable with no clear temporal or spatial patterns. For example, the sponge Nemertesia procumbens decreased in cover at all locations from 2006 to 2011 and increased from 2011 to 2015. The bryozoan Orthoscuticella ventricosa showed exactly the opposite trend. This may suggest that there are other regional processes within The Entrance that are independent of the CDP;
- Changes in the cover of taxa among location groups occurred generally at the smallest spatial scale and were unrelated to grouping of locations into dredged or control groups. The few statistically significant changes occurring at larger-spatial scales (i.e. between impact and control treatments or among location groups) are not attributable to the CDP because the patterns were consistent across the baseline and post-construction periods.

6. Rock fall impacts at Rip Bank showed further recovery and were broadly within expectations
- Rock fall disturbances were observed to further decrease between 2011 and 2015 which is consistent with the SEES predictions;
- Although rock fall originally observed in 2009 and 2011 at some locations was still observed in 2015, a reduction in rock fall disturbance was apparent in the 2015 survey;
- Small patches of angular rubble pieces at the base of scree slopes especially at Rip Bank East and Great Ship Channel indicates some continued physical disturbance in the canyon adjacent to Rip Bank;
- Qualitative surveys in 2009 showed the reef habitat of Rip Bank West having the greatest degree of disturbance post-CDP. Fresh rock fall material was observed by divers on scree slopes in 2011, indicating some ongoing disturbance. In contrast, the 2015 survey observed the most recent physical disturbance at Rip Bank East and to a lesser degree at Rip Bank West. Some patches of relatively fresh rubble were observed at the base of scree slopes and fresh scour marks at both sites were also observed. However, most rubble observed at Rip Bank remained stabilised with recolonisation growth including encrusting sponges.

7. Further recovery at Nepean Bank (The Plateau) was evident in 2015
- At the 27 m and in the majority of the 37 m depth contour at Nepean Bank the seafloor substratum mainly consisted of vertical canyon wall and step downs with varying degrees of shelving ledges. For these habitats, there was no visual evidence of physical impacts that could be attributable to CDP. As with 2011 some large boulders (5-6m) were observed at the base of vertical walls with advanced recolonisation including sponge and soft coral growth;
- For the 47 m and 57 m depth contours at Nepean Bank, there was less physical disturbance observed in 2015 when compared to the 2011 survey. There were some areas of rubble accumulation however, within these areas, there was little evidence suggesting new or recent rock fall. Existing rubble patches were again observed in 2015 to be predominantly within gullies or at the foot of reef slopes at Plateau D and Plateau E. To a lesser degree minor patches of rubble accumulation were observed at Plateau A, B, C and F;
- The deeper reefs of Nepean Bank showed varying levels of biota disturbance attributed to rock fall where impacts were observed. For the 2015 survey this was mostly evident with the presence of advanced recolonising biota such as encrusting form sponges and small hydroid species interspersed with occasional erect form sponges.

8. Overall conclusions
- Further recovery of the deep reefs since the 2011 survey was evident in 2015 which continues

the trajectory of observations from the 2009 survey, which is consistent with the SEES predictions;
- Although some new rockfall was observed in 2015, overall there was less rockfall than in 2011 which continues the trajectory of observations from the 2009 survey. This is also consistent with the SEES predictions;
- As was the case in 2011 the assemblages and individual taxa varied in space and time at impact (dredged) and control locations within The Entrance in the 2015 survey. Changes to biota assemblages occurred predominantly at small spatial and/or temporal scales with statistical analysis showing little or no evidence of these changes being directly attributable to the CDP;
- The findings from the 2015 survey have been shown to be consistent with the SEES predictions and the conclusions from the Minister for Planning's Assessment of the Project in 2007 under the Environment Effects Act 1978, as the evidence shows:
> Controls placed on the CDP have minimised short-term impacts on deep reef communities. Short term impacts with progressive habitat recovery have been observed
> Habitat recovery at impact locations was observed soon after dredging was completed and is well advanced as evidenced in the post-CDP surveys
> Full habitat recovery would take place over a period in excess of 5 years.

7.1.5.1 Closing Opinion

It is evident that the dredging work method practices put in place for dredging in The Rip obtained an acceptable environmental risk management outcome.

7.2 Technical Risks and Opportunities

7.2.1 Resource Preservation

Regular maintenance dredging takes place in the South Channel, with the material being dredged comprising engineering quality sand.

Areas for placement and storage within Port Phillip are seemingly at a premium, and there is a strong need for a detailed programme to be put in place with the DELWP to identify storage and subsequent beneficial use of tis sand. This will need to be followed with a detailed testing and prolonged monitoring programme.

At present this sand is placed into the South East DMG, located in Capel Sound off Rosebud. However, the water depth in this general area is such that a large trailer dredger cannot access this sand. If future beneficial use is to be made of this sand the maintenance dredging material needs to be placed into a deeper area.

Any clay dredged anywhere in Port Phillip, for example Webb Dock, is at a premium as a large quantity is still needed to enlarge the present VRCA DMG by way of creating additional underwater bunding for the storage of silts and clays removed during routine maintenance dredging campaigns.

7.2.2 Contaminated Materials

Contaminated silt placed in the VRCA DMG needs to be capped within a year after placement, but not before half a year after placement. Sand for this come from either the maintenance of the South Channel - or - if timing does not suit it will be extracted from the SEDMG.

7.2.3 Maintenance Dredging in The Rip

Regular maintenance of The Rip is still a requirement: rubble mounts tend to form against rock ridges. Monitoring is ongoing: actual dredging need to be carried out by a substantial TSHD, estimated one every three years. Last clean up maintenance was recently done in late 2016 by TSHD WD Gateway (12,000 m3 hopper capacity)

7.2.4 Possible Draught Limitations

It should be noted that navigation depths in existing navigation channels and DMGs may limit the loaded draft of jumbo and mega trailer dredgers.

7.2.5 Presence of Rock in the South Channel

A sandstone layer of limited strength is present just below the present depth level over most of the South Channel.

To date this rock has been able to be dredged by a jumbo trailer dredger, but only where patches have occurred above design depth at that time. Should further deepening of the South Channel be planned a cautionary approach should be taken as a cutter dredger may have to be deployed to crush this rock prior to removal by a TSHD. A cutter dredger operating in the South Channel will incur very significant lost time due to shipping movements, thereby potentially making any deepening very expensive.

Photograph: Baggerman Collection

Figure 13 Rock in the South Channel

8 WORK METHOD ACCEPTANCE CRITERIA

8.1 Dredging Work Method Drivers

For this project, given that the functionality of the reclamation is to be the primary focus for the dredging work method, the following facts have to be recognised:

1. the match between the volume of material to be dredged (cut) and the volume of material required to create the necessary reclamation (fill);
2. the nature of the material to be cut, in its entirety, is not ideally suited to create fill, unless dredged by a mechanical work method;
3. the dredging and reclamation areas is nearby the Port Phillip Ramsar Wetland.

The placement and distribution of the dredged material into the reclamation area, may be achieved either by using a mechanical dredging work method and rehandling of the spoil using a barge unloader fitted with a large conveyor arm.

Alternatively, the material to be dredged can be transported away from the project site and placed into offshore Dredged Material Grounds, and engineering quality sand won from either the South Channel or from deep water in Bass Strait used to create the required land.

8.2 Port Design Concepts

Some of the functional design elements of the Bay West Stage 1 development of the port will require that the dredging of the Channel and Turning Basin must commence well in advance of other construction activities on site.

Possibly the most critical element is the existing depth of water, which may limit the size of vessels that can work in the area.

At this time, the costings are based upon likely size dredgers required to be deployed, and hence production capabilities that may be achieved.

8.3 Dredged Material Grounds

The availability of a suitable offshore Dredged Material Grounds (DMG) has been assumed to exist for the purposes of this report.

An offshore DMG will be required in the event the materials to be dredged, either some or all, proves to be of little or no value in providing suitable engineering quality fill for the port land, has a low environmental benefit or high environmental demand outcome.

At this time, it is assumed that the existing Port of Melbourne DMG positioned in Port Phillip can be utilised, with the clays being used to further develop necessary under water containment bunds for the routine maintenance dredging undertaken in the Yarra River. Alternatively, it is assumed that a DMG can be developed for use in deep water Bass Straight.

8.4 Reclamation Objectives

The objective in determining the most cost and environmentally effective dredging and reclamation work method is to minimise so far as is practical the total volume of material to be dredged.

For this project, the critical driver is the nature of the material to be dredged, which is not ideally suited to creating land for engineering purposes.

8.5 Navigable Waters Objectives

The dredging equipment to be deployed must be capable of dredging all materials expected to be encountered to design depths.

8.6 Dredging and Reclamation Realisation

The material to be dredged, whilst not specifically challenging for experienced contractors, nevertheless will require dredging equipment with considerable power and production capabilities.

Further, the sea sate and tidal conditions are well defined, as are port traffic and operational requirements.

Therefore, work methods examined for use on this project are those commonly in use.

8.7 Alternative Sources of Material

In considering suitable dredging and reclamation work methods, the possibility of obtained suitable engineering quality material from offshore sources is also considered with respect to suitable types of dredgers and the potential environmental impacts.

This is seen to be a possible necessity given the nature of material to be dredged.

8.8 Environmental Considerations

In the consideration of short listing viable dredging work methods, the prime objective is the technical suitability of each work method. Notwithstanding, consideration is also given to their potential environmental risk management, which are provisionally dealt with when preparing the cost estimates.

As desired environmental outcomes will be driven primarily by other considerations, the short-listed work methods are not ranked in any order of environmental or cost impacts at this time.

8.9 Conceptual Execution Programme

The dredging works for the Bay West port option would have to commence well in advance of other construction activities as safe water depth for a large or jumbo trailer dredger will be necessary for the supply of sand for the construction of the quay wall bund.

8.10 Availability of Suitable Equipment

8.10.1 Availability

No dredgers of any type suited to undertake this project are permanently based in Australia.

For the purposes of this report it has been assumed that dredging and major ancillary equipment will be available from the Middle East and Japan, and demobilised to Singapore upon completion of the dredging work.

8.10.2 Market Competitiveness

The international contract dredging business is market driven.

The availability of suitable dredgers will be subject to world-wide market demand at the time the dredging works are tendered.

Notwithstanding for a project of this planned size, the availability of suitable equipment will not be a concern.

8.11 Technical Risks

The perceived technical risks for the dredging equipment proposed, which would be common for all stages of the development are as follows:

8.11.1 Trailer Dredgers

The following risks are present for trailer dredgers:

1. offshore sea state conditions can create programme risk;
2. fog, for personnel transfers and operational safety;
3. presence of rock;
4. differences in the nature of the clay can create programme risk with respect to loading production rate and discharging the spoil from the hopper.

8.11.2 Backhoe Dredgers and Grab Dredgers

The following risks are present for backhoe dredgers and grab dredgers alike:

1. tidal currents, for split hopper barges coming alongside and relocation of the dredger between dredging work areas;
2. fog, for personnel transfers and operational safety with split hoppers coming alongside;
3. presence of igneous or metamorphic rock;
4. differences in the nature of the clay. Should it stick in the bucket it can create programme risk.

8.11.3 Split Hopper Barges and Box Barges

The following risks are present for split hopper barges and box barges:

1. offshore sea state conditions will be a programme risk;
2. tidal currents, when coming alongside a cutter dredger or a backhoe dredger;
3. fog, for personnel transfers and operational safety;
4. differences in the nature of the clay may cause difficulty in discharging the spoil, which can create programme risk.

8.11.4 Barge Unloader

The following risks are present for a barge unloader:

1. tidal currents, for box barges coming alongside and relocation of the barge unloader within the work areas;
2. fog, for personnel transfers and operational safety with box barges coming alongside;
3. differences in the nature of the clay, should it be sticky it can create programme risk.

8.12 Health, Safety and Security

The overarching project health, safety and security risks are at this time seen to encompass the following areas of concern:

1. Vessel to vessel transfers;
2. Offshore sea state conditions.

9 DREDGING WORK METHODS IN GENERAL

9.1 Controlling Factors

Modern day dredging and reclamation work methods are driven by but not limited to the following parameters:

A. Types of materials to be dredged;
B. Beneficial use of the dredged material where possible;
C. Required execution time frame;
D. Volume of material to be dredged;
E. Area of reclamation required;
F. Pumping distance to reclamation area;
G. Sailing distance to DMG;
H. Sailing distance from offshore sand borrow area;
I. Site Parameters;
    1) existing water depth;
    2) design project depth;
    3) prevailing weather and sea state conditions;
    4) extreme weather conditions;
    5) tidal currents;
    6) strength of materials to be dredged;
    7) marine traffic;
    8) vessel speed restrictions;
J. Mobilisation and demobilisation costs;
K. Unit rate (dredging cost) per cubic metre versus the volume to be removed in consideration of equipment deployed on site versus the cost of mobilising and deploying additional equipment.

Work methods considered to be viable for Bay West are described in general in the following sections.

All work methods have initially been appraised. Details of discarded work methods and reasons for them being discarded can be provided upon request.

9.2 Trailing Suction Hopper Dredger

Trailing Suction Hopper Dredgers are used extensively for transporting large quantities of material over short and long distances.

They are designed to dredge unconsolidated materials such as sands and silt; however large modern trailer dredgers are capable of economically dredging materials with strength up to stiff to very stiff clays.

Photograph 2 shows a small trailer dredger of approximately 1,000 cubic metres hopper capacity compared to a trailer dredger with a hopper capacity of approximately 24,000 cubic metres.

Photograph Courtesy of Royal Boskalis Westminster

Figure 14 Trailer Dredger Size Comparison

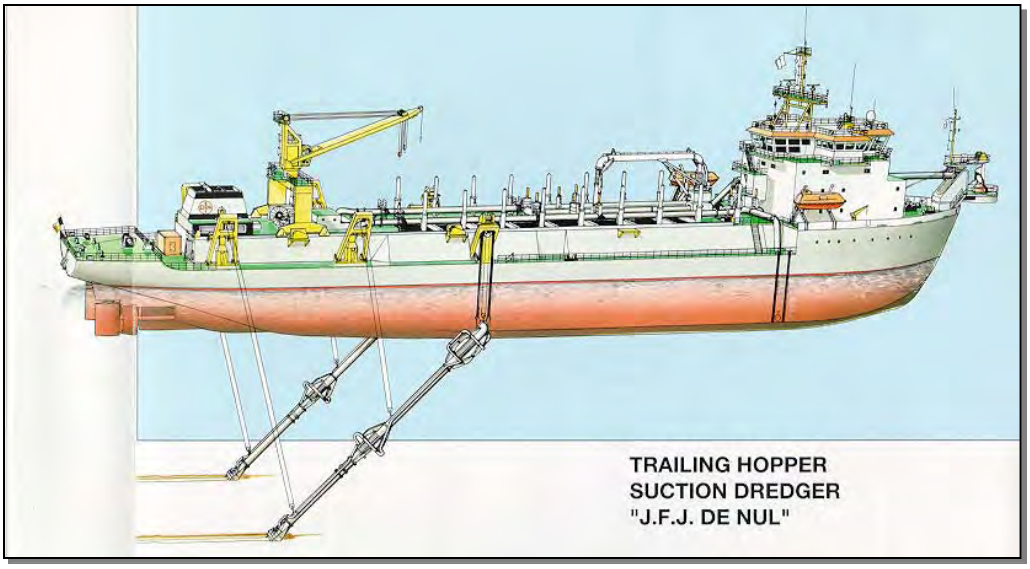
9.2.1 Trailer Dredger Work Methods

Trailing suction hopper dredgers are ocean going vessels and navigate and operate like any other cargo ship.

When dredging, they deploy a suction pipe(s) fitted with a draghead. The suction pipe is lowered over the side (not unlike using a vacuum cleaner at home) and then the dredger traverses in a controlled manner over the dredging area at a speed of 2 to 3 knots, as shown at Figure 4. The seabed material is dredged by the suction created by the dredge pump(s), which draws the material into the draghead in the form of slurry, which then passes into the suction pipe from where it is discharged into the vessel's hopper located (typically) in the central section of the vessel.

The volume of material being economically loaded into the hopper is completely dependent upon the settling characteristics of the material in the hopper, which in turn is dependent upon its median grain size.

Water used in the dredging process is discharged back into the sea through an adjustable hopper overflow or weir system, which discharges the run-off at keel level of the dredger. On completion of loading the suction pipe(s) are recovered back onboard and the dredger then can either sail to the DMG, or alternatively discharge the material ashore. Typically, a trailer dredger sails at speeds ranging from 8 to 18 knots, depending on its design, available under keel clearance, port speed restrictions and the sea room available for safe navigation.



Schematic Courtesy of Jan De Nul Group

Figure 15 Schematic of Trailing Suction Hopper Dredger at Work

Baggerman note that this vessel shown in Figure 15 has since been renamed "James Cook".

Video courtesy of Royal Boskalis Westminster
Click to activate

Figure 16 Trailer Dredger Operation Video

9.2.2 Trailer Dredger Discharging Methods

At the required dredged material release position the vessels can unload in one of the following ways:

1. by bottom dumping into an offshore DMG;
2. by rainbowing over the bow;
3. by pumping ashore via floating pipeline and shore line direct into reclamation;
4. by bottom dumping into a rehandling pit for subsequent rehandling by a cutter dredger;
5. by pumping out and discharging through a spreader pontoon for accurate underwater placement.

The method adopted depends on the project work requirements.

9.2.2.1 Bottom Discharging

Trailing suction hopper dredgers are fitted with bottom doors in the hull of the vessel and can discharge a full load of non-cohesive material in typically 5 to 10 minutes. Following completion of discharging the empty dredger then returns to the dredging area and commences another loading cycle.

9.2.2.2 Rainbowing

This method of discharge is carried out by the fluidising the material in the hopper using jetting pumps delivering water to nozzles situated in the lower parts of the hopper. The operation of the jetting nozzles is sequenced so as to progressively unload the material from one end of the hopper to the other. The re-liquefied material is pumped out of the hopper using the dredge pumps.

This method of discharge allows material to be jetted over the bow of the dredger through a nozzle, and is used where the reclamation areas are close to the discharge site. Typically, a large trailer dredger can discharge over a distance of 50 to 80 metres, depending upon the power available on the dredge pumps and the median grain size of the material being dredged.

Photograph Courtesy of Van Oord.

Figure 17 Trailer Dredgers Rainbowing

9.2.2.3 Pumping Ashore

Typically, most trailer dredgers are also capable of discharging material from their hopper into a floating pipeline via a bow connection and then into shore pipeline for discharge into a reclamation area.

This work method may be limited by the pumping distance required due to the design of and power available on the dredge pump(s). However, this can be supplemented with the use of booster pumps.

Photographs Baggerman Associates Collection

Figure 18 Trailer Dredger Pumping Ashore