Project Application

Volume 6

Inner West Marina

Parramatta River, Sydney

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Contents

Volume 1

Volume 7

Appendix 10:

- Construction Environmental Management Plan
- Operational Environmental Management Plan

Volume 8

Appendix 11:

- Berth Demand Study

Appendix 12:

- Construction Management Plan

  Attachments

  - Drawings CMP00, CMP01, CMP02, CMP03 and CMP04
  - Geotextile Information

Volume 9

Appendix 13:

- Sediment Management Report
- Declaration of Remediation Fill from Environment Protection Agency
- Site Auditor Advice – Letter from GHD

Volume 10

Appendix 14:

- Assessment of Impact on Avian Fauna

Appendix 15:

- Marina Management Plan

Appendix 16:

- Community Consultation Report

Appendix 17:

Navigation Information

- Drawing N01
- NSW Maritime Plan: Traffic Coordination of the Parramatta River
- Ferry Timetable
- NSW Maritime Schedules of Moored and Registered Vessels

APPENDIX 9:

- ESTUARY HYDRODYNAMICS AND PHYSICAL SEDIMENTARY ENVIRONMENT REPORT INCORPORATING TURBIDITY INVESTIGATION

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INNER WEST MARINA, KENDALL BAY, SYDNEY

ENVIRONMENTAL ASSESSMENT

Estuary Hydrodynamics and Physical Sedimentary Environment

Prepared by gbaCOASTAL Pty Ltd

for

Breakfast Point Pty Ltd

October 2009

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SUMMARY

Breakfast Point Pty Ltd is proposing a new 172 berth marina in Kendall Bay at Breakfast Point. The marina, referred to as Inner West Marina, adjoins the Breakfast Point residential development.

GBAC was retained by BPPL to prepare an environmental assessment covering bathymetry and shoreline morphology, water level, wave climate, currents and physical bed sediment characteristics and transport behaviour. Bed scour and turbidity assume particular importance at Kendall Bay because the bed is contaminated, a legacy from the former AGL gasworks at Breakfast Point.

The investigations carried out by GBAC have regard to the current proposed marina layout. Relevant background information has been sourced, collated and reviewed. A site inspection was made in April 2009 when the shoreline was inspected and waves generated by passing vessels were observed. Stormwater outlets were noted.

The assessment describes the existing environment, and addresses its interaction with construction and operation of the proposed marina, and mitigation measures.

A key requirement of DEC is that the proposed marina must not cause any additional resuspension of contaminated sediments over and above that attributed to background processes. To address this aspect is it proposed to install a scour protection blanket over the full area of the marina, extending beyond the edges of the floating facility. The design of the sour blanket is developed having regard to boat movement zones and controlling bed levels in the vicinity of the marina, design water level in Kendall Bay, screw race modelling and design bed velocities, protective rock requirements *(rock size, blanket thickness and footprint)*, geotextile requirements at the underside of the blanket, and construction aspects. An alternative grout-filled mattress blanket concept is also considered.

GBAC has applied a methodology for sizing the rock blanket developed at the US Army Engineer Waterways Experiment Station *(USACE, 1970)*. This same methodology is recommended in PIANC (1997), the current benchmark design guide for rock apron structures. GBAC has prepared the assessment with such skill, care and diligence as is generally exercised by competent members of the consulting engineering profession performing services of a similar nature.

TABLE OF CONTENTS

Page No.

TABLE OF CONTENTS

Page No.

1 INTRODUCTION

1.1 BACKGROUND

Breakfast Point Pty Ltd is proposing a new 172 berth marina in Kendall Bay at Breakfast Point. The marina, referred to as Inner West Marina, adjoins the Breakfast Point residential development. The proposal is shown in TLB Drawings 01013, SK15H, SK16C and SK17A, copies of which were supplied by TLB Engineering *(TLB)* on 6/6/08.

Gary Blumberg & Associates Pty Ltd *(GBA)* previously provided advice in relation to this project. This comprised a preliminary assessment of bed disturbance by propeller wash *(GBA fax f1tlb 2/11/06)*, and a detailed turbidity investigation involving site measurements *(GBA lr761 2/11/07)*. The matter of bed scour and turbidity takes on added importance at Kendall Bay because the bed is contaminated, a legacy from the former AGL gasworks. The investigations in 2006 and 2007 assisted TLB and Breakfast Point Pty Ltd *(BPPL)* formulate the existing marina proposal.

In January 2008 TLB received from the NSW Department of Planning updated Director General's Requirements *(DGRs)* for the construction and operation of the proposed marina. This report addresses the DGRs in relation to estuary hydrodynamics and the physical sedimentary environment *(bed and shoreline)*.

Gary Blumberg & Associates Pty Ltd was renamed gbaCOASTAL Pty Ltd *(GBAC)* on 1/11/08.

1.2 STUDY AREA

The study area includes Kendall Bay and the adjoining channels of the Parramatta River, Sydney NSW. Kendall Bay is located between Cabarita Point *(downstream)* and Mortlake *(upstream)*, on the southern shore of the Parramatta River. The stidy area is shown in **Figure 1**.

1.3 SCOPE OF WORK

GBAC's assessment seeks to address relevant government technical and policy guideline requirements, and marina industry guidelines.

The following are considered particularly relevant to GBAC's assessment:

- Sydney Harbour Catchment REP (SHREP)
- DCP for SHREP
- AS 3962 – Guidelines for Design of Marinas
- Engineering Standards and Guidelines for Maritime Structures *(NSW Maritime)*

The DGRs refer to the requirements of various government agencies and stakeholder groups, the following of which were provided to GBAC to assist in scoping its assessment:

- Sydney Ferries Corporation *(29/6/07)*
- Department of Environment and Conservation, DEC *(25/5/07)*
- Rowing NSW *(7/1/08)*

Based on our review of the briefing material and discussions with TLB, GBAC was retained by BPPL to undertake an investigation covering the following Scope of Work:

(i) Collation and Review of Background Material
(ii) Site Inspections
(iii) Description of Existing Hydrodynamic and Physical Sedimentary Environment
(iv) Summary Description of Marina Proposal
(v) Interaction between Proposal and Existing Hydrodynamic and Physical Sedimentary Environment
(vi) Liaison and Reporting

1.4 ACKNOWLEDGEMENTS

GBAC acknowledges the assistance provided by Howard Bersten in steering the project on behalf of TLB Engineers. We also wish to thank Warren Hornsey of Geofabrics Australia for his assistance.

2 COLLATION AND REVIEW OF BACKGROUND INFORMATION

GBAC has sourced, collated and reviewed relevant background information. This included the four documents listed in **Section 1.3**. Other documents and data sources referenced include:

- Shore Protection Manual *(CERC, 1984)*
- Coastal Engineering Manual *(CERC, 2002)*
- Long-term directional wind statistics for Sydney *(Bureau of Meteorology)*
- AUS chart for Parramatta River *(Royal Australian Navy)*
- 1:4,000 orthophotomap for Kendall Bay / Parramatta River *(CMA)*
- URS Environmental Risk Assessment for Sediments Adjacent to the Former AGL Mortlake Site *(URS, 2006)*
- Current and historical bed surveys of Kendall Bay *(sourced from TLB)*

Other specialists have been engaged to provide advice on marine ecology, contaminated sediments and water quality. GBAC has liaised with these groups as required to source available information on the physical nature and distribution of sediments in the vicinity of Breakfast Point to meet DEC requirements *(DEC requires that the assessment consider nearshore sediments within 200 m of the land based boundary of the former gasworks site).*

DEC also requires that the investigations address "the cumulative impact of the disturbance of the proposed marina construction methods and the effects of operating the range of water craft expected into and out of the marina *(speed, size and draft)* including ferries and Rivercats". The turbidity investigation reported in GBA lr 761 *(2/11/08)* supports these requirements in respect of the marina craft. However, to develop the "cumulative" assessment it is necessary to understand the impact of passing craft.

3 SITE INSPECTIONS

Gary Blumberg from GBAC made a site inspection between 7.30 am and 9.00 am on 30/4/09. Weather was partly cloudy. Light showers may have fallen in the preceding one to two days. Winds were light to moderate from the W early, abating but maintaining direction through the course of the inspection. The tide was low and rising, from a predicted R-0.5 m AHD to RL-0.2 m AHD. Selected photos taken during the inspection are presented below and referenced in the text of this report.

The shoreline was inspected and waves generated by passing vessels were observed. Stormwater outlets were noted.

The eastern shoreline of Kendall Bay comprises a dissected and gently sloped bedrock platform, stretching from the Cabarita Ferry Wharf and beyond, back towards the head of the bay (**Photo 1**). Sand occurs between the rock outcrops within the platform, the accumulation becoming deeper and more prominent with distance into the bay. A well developed beach is located at the southern end, separating the rocky eastern shore from a stand of mangroves at the head of the bay (**Photo 2**). Mangrove peg roots intersperse the trees, extending into the waterway. These protrude across a lower, flatter and slightly muddier foreshore (**Photo 3**).

We estimated the beach slope at 1(v):11 (h) above mean tide level, flattening considerably below mean tide level. It would appear that finer sediments are more dominant below mean tide level. We would expect that the relatively long period ferry waves (**Section 5.3.1**) are the main driver for development and morphology of the beach at the SE corner of the bay.

While the beach is strewn with flotsam and debris at the high water mark, the sand itself appeared to be clean. The grain size grades from medium / course at low to mean tide level, fining slightly above high tide where some wind sorting may have occurred.

The mangroves terminate at the base of a 1:1 sloped dimensioned sandstone revetment which lines the SW corner of the bay. This appears to be an older structure, certainly predating the Breakfast Point development, although it has been repaired. The inclined revetment merges with a vertical seawall which continues along the central areas of the western shore (**Photos 4** to **6**). This wall reverts to a more substantial sandstone boulder revetment further to the north *(estimated boulder size 300-700∅, average 350∅, slope 1:3)*, the toe of which is secured by the base of a former concrete seawall which protected the AGL Gasworks site (**Photo 9**). A small fillet beach occurs at an indent section along the boulder revetment (**Photo 9**). An assessment of the condition and performance of the various walls was not required.

We observed the wash generated by passing vessels. These included eight Rivercat passings, split between upstream movements in the main channel, and downstream movements all stopping in at Cabarita Wharf. The observed Rivercat wash ranged from moderate to substantial *(further description below)*. A few other boat movements did occur in the main channel. These comprised runabouts and one slow upriver passing of a cruiser, each of which produced a negligible wash within the bay.

Our observations of the Rivercat wash are summarised below in **Table 3.1**. We observed shoaled and breaking primary wave heights estimated up to 0.35 to 0.5 m, with wave heights dependent on vessel passing location, direction, speed, and the observation position. The maximum estimated wave height was 0.5 m, caused by two simultaneous Rivercat passings, one upriver and the other downriver (**Photo 4**). The varied alignment of the western shore protection structures (**Photo 5**) led to complex reflections and wave superpositions, adding to localised increased wave heights and wave breaking along the shoreline. Upriver ferry passings at speed appeared to produce more energetic wash in Kendall Bay than slower passings through the bay in to Cabarita Wharf, although these differences may also be attributed to the varied passing directions. We observed considerable stirring of bed sediments along the western shoreline during the simultaneous ferry passings at 8.25 am. This extended some 10-15 m from the wall (**Photos 6** and **7**). While the intensity of the turbid plume subsided within minutes of the event, the background turbidity out in front of the wall progressively increased during the course of our inspection. This could only be attributed to the ferry movements. Wash from other boating traffic was minimal, and wind waves along this shoreline were absent under the existing westerly breeze. Currents potentially attributed to tide, freshwater flows in the Parramatta River, wind, propeller wash and stormwater were not a factor (**Section 5.4**).

We observed seven stormwater outlets at the shoreline. These ranged in size from approximately 300Ø to 1650Ø, with both the smallest and the largest discharging at the same location behind the mangroves at the head of the bay. Two outlets occur at the beach in the SE corner (600Ø and 450Ø), and the remaining three along the western shoreline (approx 750 - 900Ø, not accessed; **Photo 13**).

We observed rip rap placements at various locations along the shoreline. Masonry debris occurs along the upper beach in the SW corner. Along much of the vertical seawall, we observe what appears to be angular basalt rip rap. This ranges in size estimated from 50 to 200Ø, average 100Ø, with a surface slope of between approximately 1:3 and 1:5 (v:h) (**Photos 7** and **13**). Where it joins the seawall the mound under the former jetty comprises larger rock, nominally 200 to 400Ø, with similar surface slopes. These 50 to 200Ø rip rap placements are considered to be stable under the ambient wave environment, including the high wave reflections at the vertical seawall.

TABLE 3.1 OBSERVATIONS OF FERRY WASH IN KENDALL BAY [1]
30 APRIL 2009, 7.30 AM – 9.00 AM

Time (am)	Description of Passing	Maximum Estimated Wave Height [2]	Observation Location	Comments
7.37	Downriver into Cabarita Wharf	0.25 m	Sandy beach at head of bay; east end	Breaking waves at head of bay. Four 0.2-0.25m waves broke on beach. No obvious stirring of bed sediments
7.45	Downriver into Cabarita Wharf; slowed ~300m from wharf and drifted in	0.2 – 0.25 m	Sandy beach at head of bay; east end	Two or three waves; sedate wave action; no obvious stirring or odour
8.00	Downriver into Cabarita Wharf; slowed ~300m from wharf and drifted in	No estimate made	Head of bay, west end	Sedate waves – not greater than typical boat wash; some discolouration at breaker line and inshore
8.08	Upriver in main channel, passing made at good speed	0.3 m	North end of sloped revetment along western shoreline	Four to five primary waves passed inshore, shoaled and broke across shallows at head of bay; much larger apparent disturbance. Water clarity reduced at base of wall
8.25	Upriver in main channel, passing made at speed <u>plus</u> downriver into Cabarita Wharf *(also a faster approach)*. Vessels crossed 100 m downstream of Breakfast Point	0.3 – 0.5 m, 0.5 m waves breaking onto the base of the wall	Between jetty mound and north end of vertical seawall	Significant wash. Waves breaking at shore between the point and jetty mound. Incident and reflected wave interference, with reflected waves returned eastward across the bay. Inshore 10 – 15m from wall turbid after wave action
8.40	Downriver into Cabarita Wharf	0.35 m	Fillet beach along boulder revetment	Three primary waves oblique *(35°)*at shore, followed by numerous smaller and shorter waves, say 0.2 - 0.25 m high
8.51	Upriver in main channel	0.3 m	West end at head of bay	Waves ran inshore at 60° to revetment, then broke over muddy shallows
9.02	Upstream in main channel	0.1 m	Across head of bay	Ferry slowed opposite bay, probably for Mortlake Ferry. Gentle surge across shallows. Sedate waves attributed to lower speed
Notes	(1)	All observed ferries identified as Rivercats. We understand that Harbourcats may also be used on the service, vessels which we know share comparable wash behaviour to Rivercats		
	(2)	From experienced observation		

Photo 1

Photo 2

Photo 3

Photo 4

Photo 5

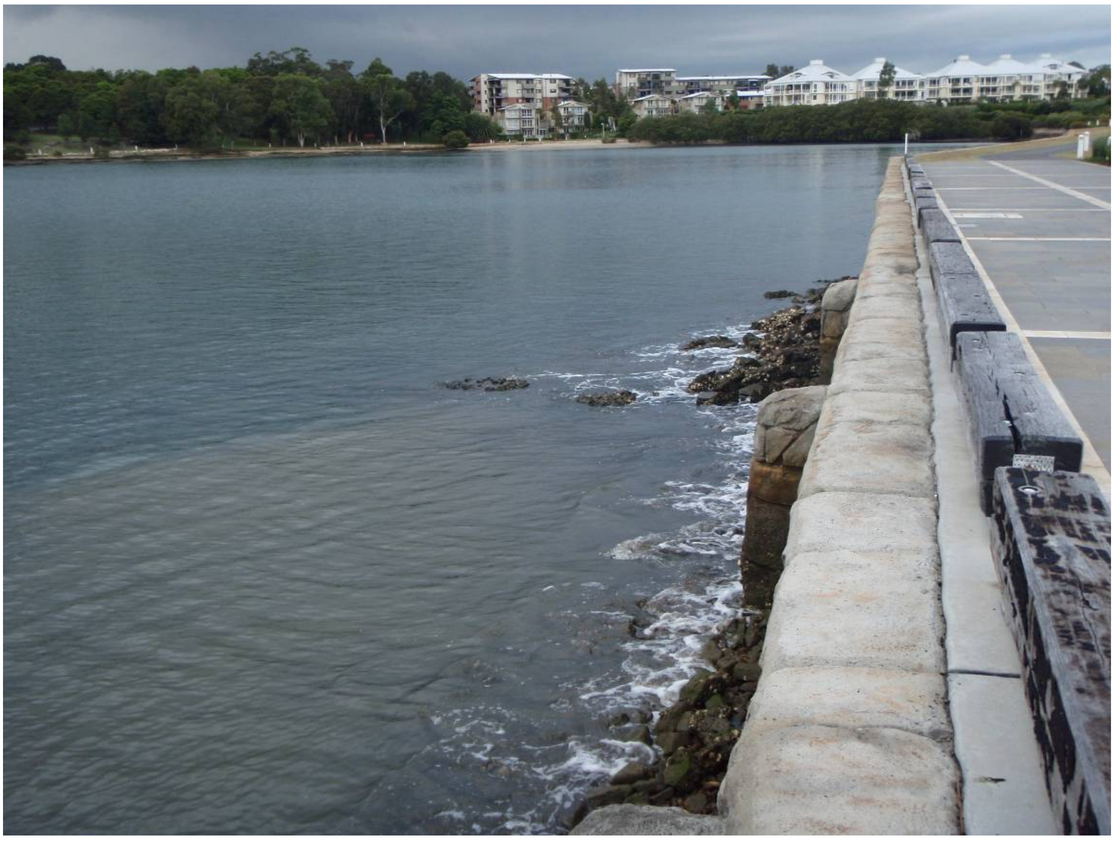

Photo 6

Photo 7

Photo 8

Photo 9

Photo 10

Photo 11

Photo 12

Photo 13

4 SUMMARY DESCRIPTION OF MARINA PROPOSAL

The originally proposed marina layout was shown in TLB Drawings 01013, SK15H, SK16C and SK17A, copies of which were supplied to GBA on 22/10/08. This layout has evolved during the course of GBAC's investigations. The current proposed layout is shown in the following drawings attached to TLB Job No 01013:

Dwg DA01	General Arrangement	Int Rev H
Dwg DA03	Marina Layout	Int Rev E
Dwg DA06	Bed Treatment	Int Rev C
Dwg DA10	Site Analysis	Int Rev E

GBAC's investigations have regard to the current proposed layout. Berth numbers are referenced to the numbering arrangement adopted in Dwg DA03.

The current proposal involves a marina located on the eastern side of Breakfast Point in Kendall Bay. The marina is positioned along a 360 m length of shoreline, with the floating pontoons located between 25 and 160 m out from the seawall.

The marina comprises eight arms, four on the north side of the jetty and four of the south side. The 172 berths, including the floating pontoons, occupy an area of 1.72 ha. If the intermediate fairways and main jetty are included, this area increases to 3.21 ha. The marina comprises mainly double berths, with the berth sizes ranging between 8 m and 25 m, located in mean water depths between 2.9 m and 5.0 m. A new jetty is proposed in the position of the former loading jetty in Kendall Bay. The floating marina is retrained by approximately 160 piles, typically located at the ends of the double-berth finger pontoons. Piles are also located alongside the walkways at 20 to 30 m spacings.

The bed of the marina is to be capped with a scour blanket to guard against erosion and mobilisation of the contaminated bed sediments. The conceptual design for the blanket comprises 300 to 400 mm thick placement of rock over geotextile. The blanket is to extend beyond the limit of the berths and fairways in order to extend the protection of the bed to account for vessel manoeuvring at the outside berths, and to extend the bed protection to a suitable water depth. Blanket protected entry and exit fairways link the marina to the edge of the 200 m wide Kendall Bay Remediation Site. The proposed blanket occupies an area of 5.7 ha.

Construction of the marina is described in the Construction Management Plan which accompanies the application. Basically it involves supply and installation of the following, sequenced as listed:

(i) scour blanket
(ii) piling
(iii) pontoons
(iv) services

The marina proposal is shown in **Figure 2**.

5 EXISTING ENVIRONMENT, INTERACTION WITH PROPOSAL AND MITIGATION MEASURES

The following aspects of the environment are relevant to GBAC's advice:

- Bathymetry and shoreline morphology
- Water level
- Wave climate
- Currents
- Physical bed sediment characteristics and transport behaviour

5.1 BATHYMETRY AND SHORELINE MORPHOLOGY

5.1.1 Existing Environment

Kendall Bay forms a shallow embayment on the southern side of the Parramatta River, between Breakfast Point in the west and the NW tip of Cabarita Park at Cabarita Point in the east. The bay occupies a waterway area of slightly more than 10 ha.

The eastern shore of the bay, adjacent to Cabarita Park, is rocky. The rock becomes covered with sediment towards the southern head of the bay where it sweeps around to the west and eventually joins the seawall along Breakfast Point. Mangroves occupy the intertidal areas at the head of the bay.

The shoreline morphology is punctuated by three prominent cultural features, the Cabarita Ferry Berth at the NW tip of Cabarita Park, the subaqueous mound comprising the remnant of the former loading jetty at Breakfast Point *(position of the proposed jetty within the marina)*, and the seawall-lined promontory of Breakfast Point itself.

The main channel of the Parramatta River adjoins Kendall Bay, separating Morrisons Bay, Raven Point, and Glades Bay *(from west to east)*.

Mean water depths within Kendall Bay range up to 5 m in the central area adjoining the former jetty. The southern half the bay is less than 2 m deep, as is a narrow fringe along the seawall north of the former jetty. The main river channel exhibits two deep holes between Breakfast Point and Glades Bay, where mean depths exceed 15 m. Morrisons Bay and Glades Bay exhibit similar depths to the southern half of Kendall Bay. It would appear that the deepened approach across Kendall Bay to the former jetty is artificial, probably a result of past dredging to allow larger carriers to access the jetty.

The existing bathymetry in the Parramatta River and Kendall bay is shown on AUS 203 Parramatta River. For detailed survey covering the marina site, *Harvey Hydrographic Surveys* undertook surveys of the bed on 6/8/01 and 8/8/01, and these have been combined with a previous survey by NSW Maritime in 2006 to develop the bathymetry shown in the current marina layout (**Section 4**).

Bathymetry and shore morphology is summarised in **Figure 3**.

5.1.2 Interaction with Proposal and Mitigation Measures

Bathymetry and Shore Morphology on Construction of Marina

The existing bathymetry would be advised to tenderers in the technical specification for the installation of the marina. The selected contractor would therefore take account of the existing bathymetry in developing its construction method.

As the site is relatively shallow, diver access to the bed to assist with the installation of the scour blanket is not hindered by water depth. Pile lengths would be short and manageable in maritime construction terms.

Bathymetry and Shore Morphology on Operation of Marina

The marina design has regard to existing water depths, and the slight reduction in those depths as a consequence of placing the scour blanket. Acceptability of water depths at the berths is being addressed by TLB Engineers. The available depths require that the marina is located no closer than 25 m from the seawall at Breakfast Point. The interaction between the proposal and the stability of the bed is addressed in **Section 5.5**.

Construction of Marina on Bathymetry and Shore Morphology

The construction of the marina would have no impact on the bathymetry and shore morphology of Kendall Bay.

Operation of Marina on Bathymetry and Shore Morphology

The scour blanket would result in a small reduction in the water depths. This would vary between approximately 15% at the inshore edge of the blanket, to 6% at the deeper outer areas. These changes would be of no environmental consequence. See also **Sections 5.4** and **5.5**.

5.2 WATER LEVEL

5.2.1 Existing Environment

Water level at Kendall Bay fluctuates primarily in response to astronomical tide. Storm surge, local wind and wave set up, and fresh water flooding may also slightly increase the water level. Sea level rise *(SLR)* as a consequence of climate change will affect water level in Kendall Bay.

Tide

Sydney Harbour and Parramatta River encounter semi-diurnal tides, that is two high tides and two low tides per day. Predicted tidal planes for the Parramatta River in the vicinity of Kendall Bay are presented in **Table 5.1**.

TABLE 5.1 PREDICTED TIDAL PLANES FOR SITE (1)

Tidal Plane		Level (m AHD)
Highest Astronomical Tide	HAT	1.20
Mean High Water Springs	MHWS	0.71
Mean High Water	MHW	0.58
Mean Tide Level	MTL	0.05
Mean Low Water	MLW	-0.54
Mean Low Water Springs	MLWS	-0.66
Lowest Astronomical Tide	LAT	-0.95
Notes (1)	Based on data for Cabarita supplied by NSW Waterways Authority *(J Stimpson 8/2/00 pers comm.)*	

Note that Zero on the Fort Denison Tide Gauge *(ZFDTG)* in Sydney Harbour is RL -0.925 m AHD. High and low tide at the site lags high and low tide at Fort Denison by approximately 9 and 7 minutes respectively.

Storm Surge

Water levels at the site would rise above the predicted tide due to storm surge. Storm surge at the site could be expected with a low pressure system over Sydney. A 10 millibar drop in atmospheric pressure results in a 10 cm increase in water level.

Local Wind and Wave Setup

Local onshore winds act to drag water towards the shore, causing local wind setup. Similarly, local onshore waves cause a mass transfer of water into the surf zone, resulting in local wave setup.

For example, 1 year and 50 year Average Recurrence Interval *(ARI)* winds and wind waves incident at the proposed marina site from the E (refer **Table 5.2**) are predicted to raise the Still Water Level at the shoreline by the following increments respectively:

- 1 to 3 cm due to local wind setup *(CERC, 1977)*
- 6 to 9 cm due to local wave setup *(CERC, 1984)*

Fresh Water Flooding

Rainfall in the Parramatta River catchment drains to the river, and eventually into Sydney Harbour. Flood flows down the river are driven by hydraulic gradients, manifest as water levels over and above the tide. The Parramatta River Flood Study *(PWD, 1986)* developed 50 year ARI flood levels for the main arm of the river, downstream as far as Silverwater Bridge. Here a flood level of RL 1.5 m AHD is predicted, some 800 mm above MHWS. The flood increment at Kendall Bay would be substantially lower.

Sea Level Rise (SLR)

Sea level rise *(SLR)* is a key potential hazard of climate change. SLR is predicted to occur in response to the thermal expansion of the upper layers of the world's oceans and melting of the polar ice sheet.

The current policy position of DECC in respect of SLR along the NSW coast is enunciated in The Draft Sea Level Rise Policy Statement *(DECC, 2009).* Here it is reported that over the 20th centaury, global sea levels have risen by 17 cm and are continuing to rise, and that the current global average rate is approximately three times higher than the historical average. DECC adopts SLR planning benchmarks equal to an increase above 1990 mean sea levels of 40 cm by 2050 and 90 cm by 2100. These values allow for accelerated ice melt and regional SLR variations. According to DECC, the SLR benchmarks consider the most credible national and international projections for SLR and their uncertainties.

5.2.2 Interaction with Proposal and Mitigation Measures

Water Level on Construction of Marina

The existing water level climate would be advised to tenderers in the technical specification for the installation of the marina. The selected contractor would therefore take account of the existing water level climate in developing its final construction method.

Water Level on Operation of Marina

The proposed marina comprises floating pontoons. Articulated pedestrian ramps connect the primary walkways with the shore. The marina would be designed to allow for a high water level accounting for tide, local wind and wave setup, fresh water flooding and SLR planning benchmarks as recently reported by DECC. Based on an operational life of 50 years, and having regard to the degree of inter dependence between the contributing processes, GBAC would recommend that the facility be designed to accommodate the following still water levels:

- maximum RL 1.70 m AHD
- exceeded 1% time RL 1.50 m AHD
- undercut 1% time RL -0.80 m AHD
- minimum RL -0.95 m AHD

Extreme water level fluctuations would influence the design of the pile cut off levels, required depths at berths, and the clearances and articulation of the pedestrian ramps connecting the primary walkways with the shore.

The influence of wave runup on the marina is considered in **Section 5.3**.

Construction of Marina on Water Level

The construction of the marina would have no impact on water level.

Operation of Marina on Water Level

The operation of the marina would have no impact on water level.

5.3 WAVE CLIMATE

5.3.1 Existing Environment

Wave climate at the site is contributed to by wind waves and boat generated waves. The form and general behaviour of these waves are described below.

Water particle oscillations occur within the water column as a consequence of surface waves. These are treated as currents in **Section 5.4**.

Wind Waves

Winds blowing across the water impart a stress on the water surface which can lead to waves. The height and period of the waves depend on the wind speed, the distance over which the wind blows *(called the fetch)*, and the duration of the wind. Shallow water depths can also influence wind wave generation. CERC (1984) presents a method for wind wave forecasting in shallow water developed from the work of Bretschneider and others in the 1950s. This methodology is preserved in CERC (2002).

GBAC has applied CERC (1984) using long-term directional wind data for Sydney adopted in MSB (1987) to generate a directional wind wave climate for the site. Terrain Category 1 in accordance with AS 1170.2 has been adopted. Directional wind fetches and water depths have been interpreted from AUS 203 Parramatta River. The predicted wind wave climate for the site is summarised below in **Table 5.2**. The wind wave fetches are shown in **Figure 4**.

One and 50 year Average Recurrence Interval *(ARI)* wave conditions are reported as these coincide with the wave climate criteria for small craft harbours in AS 3962. Also 50 year wave loadings are also of interest for Ultimate Limit State design of the marina structure. We have included 1 week ARI waves to enable comparison between “everyday” wind and boat generated waves.

It follows from **Table 5.2** that the narrow E fetch to Abbotsford Point results in the largest wind waves for 50 year ARI conditions, Hs = 0.65 m T = 2.2 s. For the 1 year ARI case, the largest wind waves occur from both the E and NE. Weekly wind wave heights range between 0.1 m and 0.2 m significant.

Boat Generated Waves

As water flows past a boat hull, a pressure gradient develops and waves are generated. The wave height and period depends on the boat speed (v), the size and shape of the hull, and the water depth (d).

TABLE 5.2 DESIGN WIND WAVE CLIMATE

Applicable Area within Marina	**Dir**	**Fetch Description**	**1 week ARI**		**1 year ARI**		**50 year ARI**	
			Hs (m) (1)	**T (s)**	**Hs (m)**	**T (s)**	**Hs (m)**	**T (s)**
Northern arm	N	1,000 m fetch into Morrisons Bay; av depth 5 m	0.10	1.1	0.31	1.6	0.53	2.0
Central areas north of jetty	NE	700 m fetch into Glades Bay; av depth 5 m	0.19	1.3	0.34	1.6	0.49	1.8
	E	1,500 m fetch downriver to Abbotsford Point; av depths ~2 m W of Cabarita Point, then 10 m further E to Abbotsford Point; adopt 5 m overall	0.15	1.3	0.39	1.9	0.65	2.2
Areas south of jetty	NE	950 m fetch into Glades Bay; av depth 5 m	0.22	1.4	0.39	1.7	0.56	2.0
Notes	(1)	Significant wave height *(Hs)* is equal to the average of the 1/3 highest waves in a wave train. Note that H max would typically equal 1.4 to 1.6 x Hs for depth-limited conditions						

The depth Froude number [$v / (gd)^{1/2}$] is a particularly important parameter for boat waves. It affects the plan arrangement of the wave field as it diverges from the hull. It also influences the wave height which peaks when the depth Froude number equals one. The wave period is essentially controlled by the boat speed. Boat waves behave differently in a confined channel such as the Upper Parramatta River, compared to open water such as Kendall Bay.

In open water, boat waves may be distinguished as either generated at the bow or the stern. Bow waves are referred to as divergent waves, and stern waves as transverse waves.

Maximum boat wave heights occur close to the sailing line. As the waves propagate away from the sailing line, they loose energy and height. Maximum wave heights occur within the so-called 'near-field', limited to two boat lengths from the sailing line. The waves then propagate into the 'far-field', discussed below.

Boats mainly pass the site in the main river channel between Cabarita Point and Breakfast Point. To access the ferry berth at Cabarita, ferries must navigate into Kendall Bay. From our site observations, it is clear that the ferry sailing path between the Cabarita berth and Breakfast Point passes very close to *(if not through)* the outer end of the northern arm of the proposed marina. Existing vessel sailing paths in and about Kendall Bay are shown in **Figure 5**.

Table 5.3 summarises existing design near-field boat wave conditions expected within the main river between Cabarita Point and Breakfast Point, across the mouth of Kendall Bay. This information is based on available boat wave data, and records of boating movements on the Parramatta River reported in WA (2001) scaled according to recent trends in NSW boating registrations *(1991 -2006 as reported by BIA)*. Ferry passings reflect the current timetable for the Parramatta River service, operated by Sydney Ferries. Typical operating vessel speeds are assumed. The Root-Mean Square wave conditions as assessed by GBAC are included to represent the average boat wave energy conditions for the various types of vessel. The boat wave conditions presented in **Table 5.3** could be expected to occur on a daily basis.

There is considerable seasonal variation in boat traffic volumes. Data in WA (2001) suggests that winter movements on the Parramatta River are less than 60% of summer movements.

To estimate future boat traffic, it would seem reasonable to factor up the existing volumes according to trends in NSW vessel registrations. Linear extrapolation of BIA data 1991 – 2006 indicates that passing boat traffic could increase by 24% by 2020, and by 90% by 2050.

Far-field wave heights may be estimated using a procedure reported in Sorenson and Weggel (1984). Wave height reductions into the far-field vary depending on whether the wave train is divergent or transverse, and are proportional to the boat length and distance from the sailing line (**Table 5.4)**.

TABLE 5.3 EXISTING DESIGN NEAR-FIELD BOAT WAVE CLIMATE

Boat Type	Estimated Number of Passings per Year (1)	Typical Maximum Wave Conditions (2)		Root-Mean-Square Typical Maximum Wave Conditions	
		H max (m)	T (s)	H max (RMS)	T (s)
Recreational power craft	71,000	0.2 – 0.4	1.5 – 2.5	0.27	2.0
Ferries *(Rivercats and Harbourcats)*	25,000	0.25 – 0.35	6 – 8	0.30	7
Charter vessels	3,500	0.3 – 0.4	2.0 – 2.5	0.35	2.2
Work boats	3,600	0.2 – 0.4	1.5 – 2.5	0.30	2.0

Notes	(1)	Based on surveys reported in WA (2001), scaled up to 2009 according to trends in NSW boating registrations 1991 -2006 *(R^2=0.99)*. Ferry movements from April 2009 Sydney Ferries timetable for Parramatta River service
	(2)	Typical maximum wave conditions interpreted from GBAC database including WA (2001) and Blumberg et al (2003). Typical operating speeds are assumed
	(3)	Root-Mean-Square *(RMS)* wave conditions assessed by GBAC. These relate to the average wave energy conditions. H max $_{(RMS)}$ for recreational power craft based on an assessment of waves generated by the expected range of actual vessel sizes and their distribution within the traffic profile, simulated using registration statistics

TABLE 5.4 WAVE HEIGHT REDUCTION FACTORS FOR BOAT WAVES WITH DISTANCE FROM THE SAILING LINE (1)

Boat Length, L (m)	Distance from Sailing Line	Divergent (Bow) Waves	Transverse (Stern) Waves
5	2L	100%	100%
	5L	69%	58%
	20L	38%	24%
	50L	28%	14%
10	2L	100%	100%
	5L	55%	41%
	20L	30%	17%
	50L	22%	10%
30	2L	100%	100%
	5L	38%	24%
	20L	21%	10%
Notes (1)	From procedure reported in Sorenson and Weggel (1984)		

With reference to **Figure 3**, boats passing in the main channel would be between 150 and 300 m from the proposed marina. A typical recreational power craft say 6 m in length would be 25 to 50 boat lengths away. The typical maximum boat wave height generated by this craft is 0.3 m at the sailing line (**Table 5.3**), reducing to between approximately 0.05 and 0.1 m at the marina (estimated from **Table 5.4**). Similarly, a Rivercat passing in the main channel would be 4 to 8 boat lengths away *(L=36 m)*, generating a typical maximum wave of 0.1 m at the marina. However, ferries also enter Kendall Bay to access Cabarita Wharf and these craft would essentially deliver near-field wash wave heights at the edge of the proposed marina.

We assesses that shoaling of the Rivercat or Harbourcat wave would be small at the outskirts of the marina, becoming more prominent in the vicinity of the most landward berths *(16% wave height increment due to shoaling in 2 m water depth).*

Transmitted waves to the proposed marina, to the southern shoreline of Kendall Bay and to the ferry berth at Cabarita are of most interest.

Combined Wind and Boat Generated Waves Incident at Marina

Wind waves would occur at the same time as boat waves except during storms when boats may not be used. It is reasonable to assume that boat waves could occur at the same time as 1 year ARI wind waves, but not with 50 year wind waves.

The question then arises as to how best to combine the wind and boat wave fields at the marina. GBAC has developed a procedure which combines the wave energy of the two wave fields, and then represents these in terms of the individual wind and boat wave periods. Both conditions should then be examined for environmental impact.

Wave climate compliance at a marina needs to be checked for 1 year and 50 year ARI conditions in accordance with AS 3962. It is useful also to include 1 week ARI in order to understand the regular wave energy processed. Existing incident conditions at the proposed marina covering all three cases are developed and presented in **Table 5.5**.

The methodology adopted may be summarised as follows:

(i) marina areas for consideration characterised as in **Table 5.2**
(ii) incident wind wave directions, heights and periods from **Table 5.2**
(iii) design near-field boat wave heights from **Table 5.3**
(iv) ferries and "other boats" distinguished due to wave period differences
(v) design *(minimum)* sailing line distances interpreted from **Figure 3**
(vi) combined wave conditions developed from the combined wave energy, taken as proportional to $(H_wT_w)^2+(H_bT_b)^2$ where w and b refer to wind and boats
(vii) however, if combined H is calculated as greater than the scalar sum of the two component wave heights, then the value is taken to equal that scalar sum

It is reasonable *(and conservative)* to treat the combined wave heights in **Table 5.5** as significant wave heights for the purposes of assessing wave climate compliance. However, maximum wave heights would be less than 1.4 to 1.6 x these values because they already incorporate a maximum boat wave component (refer Note 1 at **Table 5.2**).

The wave direction reported in **Table 5.5** should be regarded as nominal in that the direction of the incident boat waves would not only align with the wind waves.

It follows from **Table 5.5** that 0.7 m significant wave heights are the largest that would impinge on the proposed marina, attributed to a combination of 1 year ARI wind waves with waves generated by passing vessels *(charter vessels, recreational craft or work boats)*. Wind waves attributed to 50 year ARI storms would be slightly smaller, predicted not to exceed 0.65 m. Areas south of the jetty are predicted to encounter combined significant wave heights up to 0.5 m on a weekly basis.

Wave Reflections at the Vertical Seawall

Waves currently reflect off the vertical seawall on the western side of Kendall Bay. The reflection coefficient is large at this vertical wall, particularly at high tide. At low tide, wave breaking does occur across the rip-rip mound at the base of the wall, reducing the energy available to feed wave reflections.

TABLE 5.5 EXISTING COMBINED DESIGN INCIDENT WIND AND BOAT WAVE CLIMATE AT MARINA

Recurrence and Area within Marina	Wave Direction	Wind Wave Heights Hs (m)	Design Near-Field Boat Wave Heights Hmax (m)		Adopted Design Distance Sailing Line to Marina (m)	Design Incident-Boat Wave Heights Hmax (m) (2)		Combined Wave Conditions at Marina (3)			
								Wind Wave Period Controls		Boat Wave Period Controls	
			Ferries	Other Boats		Ferries	Other Boats	Hs (m)	T (s)	Hs (m)	T (s)
1 week ARI waves (1)											
Northern arm	N	0.10	0.30	-	30	0.30	-	0.40	1.1	0.30	7.0
	N	0.10	-	0.35	100	-	0.12	0.26	1.1	0.13	2.2
Central areas north of jetty	NE	0.19	0.30	-	50	0.30	-	0.49	1.3	0.30	7.0
	NE	0.19	-	0.35	150	-	0.09	0.24	1.3	0.14	2.2
	E	0.15	0.30	-	50	0.30	-	0.45	1.3	0.30	7.0
	E	0.15	-	0.35	150	-	0.09	0.21	1.3	0.13	2.2
Areas south of jetty	NE	0.22	0.30	-	70	0.30	-	0.52	1.4	0.30	7.0
	NE	0.22	-	0.35	300	-	0.07	0.25	1.4	0.16	2.2
1 year ARI waves											
Northern arm	N	0.31	0.30	-	30	0.30	-	0.61	1.6	0.31	7.0
	N	0.31	-	0.35	100	-	0.12	0.35	1.6	0.26	2.2
Central areas north of jetty	NE	0.34	0.30	-	50	0.30	-	0.64	1.6	0.31	7.0
	NE	0.34	-	0.35	150	-	0.09	0.36	1.6	0.26	2.2
	E	0.39	0.30	-	50	0.30	-	0.69	1.9	0.32	7.0
	E	0.39	-	0.35	150	-	0.09	0.40	1.9	0.35	2.2
Areas south of jetty	NE	0.39	0.30	-	70	0.30	-	0.69	1.7	0.31	7.0
	NE	0.39	-	0.35	300	-	0.07	0.40	1.7	0.31	2.2
50 year ARI waves											
Northern arm	N	0.53	Boats do not operate in this event					0.53	2.0	Boats do not operate in this event	
Central areas north of jetty	NE	0.49						0.49	1.8		
	E	0.65						0.65	2.2		
Areas south of jetty	NE	0.56						0.56	2.0		

Notes
(1) The major contribution to the 1 week ARI waves are boat waves which occur on a daily basis, particularly ferry waves.
(2) Estimated as the average of the bow and stern waves based on **Table 5.4**
(3) Highlighted wave heights are the largest Hs design incident wave heights at the marina

5.3.2 Interaction with Proposal and Mitigation Measures

Waves on Construction of Marina

It maritime construction terms, the wave climate at the site is sedate. Plant and construction methods would be readily available to work under the ambient wave conditions.

The existing wave climate would be advised to tenderers in the technical specification for the installation of the marina. The selected contractor would therefore take account of the existing wave climate in developing its final construction method.

Waves on Operation of Marina

The acceptability of the wave climate within the marina has been examined for critical berths located at the outer *(eastern)* ends of each of the proposed seven marina arms. The procedure, detailed in **Appendix A**, involved the following checks and assumptions:

(i) ‘moderate’ wave climate compliance against Table 4.2 in AS 3962
(ii) selected critical berth numbers 8, 24, 59, 72, 98, 104, 122, 140, 161 and 172
(iii) combined design incident waves from **Table 5.5** controls
(iv) pontoon widths from Dwg DA03 (**Section 4**)
(v) standard rectangular pontoon section with draft of 400 mm

We find that the ten selected controlling outermost berths all comply with AS 3962 except for berth numbers 8 and 24 at the outer end of Arms 7 and 8 respectively which fail for the 50 year ARI case where the acceptable significant wave height at the berth is 0.19 m compared to the predicted transmitted significant design wave height of 0.28 m, and for the 1 year ARI case controlled by the longer period Rivercat boat wave where acceptable significant wave height at the berth is 0.19 m compared to the predicted transmitted significant wave height of 0.31 m. These two cases are considered below in turn.

50 year ARI case

To remedy this non-compliance, we recommend that the pontoon draft at the outer T-head on Arms 7 and 8 be increased from 400 to 600 mm.

1 year ARI case

Remedying this non-compliance cannot be achieved with a deeper and/or wider pontoon as the 7 s boat wave would not be attenuated by any practical floating structure. To address this matter, we need to further consider the design incident wave condition.

Existing Rivercat waves are described in **Section 5.3.1**. **Table 5.5** adopts a design incident Rivercat wave H max of 0.3 m for areas south of the jetty. This is conservative in that it assumes little if any wave height reduction with distance from the sailing line as described in **Table 5.4**. If critical berth numbers 8 and 24 are located no closer than say 3L from the Rivercat sailing line, or 110 m, then the required 40% attenuation to achieve an effective acceptable incident wave height of 0.2 m should reasonably be achieved. GBAC considers the proposed layout of these critical berths to be marginal, but acceptable, having regard to the above and a number of further conservative *(and mitigative)* circumstances:

- wave climate criteria in AS 3962 pertain to significant wave heights while the boat waves considered here are maximum

- beam-on waves comprise the critical wave direction. Once the incident wave angle changes from beam-on, to oblique, the AS 3962 criteria are relaxed. The beam-on waves would be generated when the ferry is entering Kendall Bay from upriver, or when the ferry is passing in the main channel from downriver. For the bay entry case as the ferry approaches Cabarita Wharf, it must change its heading, introducing obliquity to its wash at the subject berths. Hence the beam-on waves would be generated some distance away, reasonably in excess of 100 m. The upriver passing in the main channel is over 200 m away so is of no consequence.

- the typical maximum ferry wave heights used in this assessment assume boat speeds greater than 10 knots. This speed is unlikely within 100 m of the subject berths.

The floating marina together with its berthed vessels would significantly reduce wind wave penetration, and shorter period boat wave penetration, to the adjacent vertical seawall. These waves *(period less than 2.5 s)* would not be expected to exceed 50 mm inshore of the marina. Furthermore, reflections of these waves at the seawall, back into the marina, would be of no consequence.

Longer period ferry waves *(period 7.0 s)* up to 300 mm in height would pass through the marina with no wave attenuation. A similar assessment to that made in **Appendix A** would show that the long waves are of no consequence to the wave climate at the berths.

The floating marina and its piled restraint system would be designed to accommodate loading from all wave conditions up to the 50 year case as given in **Table 5.5**.

<u>Construction of Marina on Waves</u>

The construction of the marina would have a negligible impact on the wave climate.

<u>Operation of Marina on Waves</u>

The floating marina would cause the short period wind and boat wave energy to dissipate, but not the long period ferry waves which would be unaffected. While it follows that a component of the wave loading currently experienced at the seawall would be reduced, loading due to the higher energy ferry waves would be unchanged. No loads would be increased.

The influence of the floating marina on wave penetration to the western and southern shorelines and potential for reduction in bed disturbance due to wave action, is considered in **Section 5.5**.

5.4 CURRENTS

5.4.1 Existing Environment

Currents at the site are driven by:

- tide;
- freshwater flows in the Parramatta River;
- wind *(unidirectional and oscillatory currents)*;
- boat wash *(wave induced water particle movements and propeller wash)*; and
- stormwater.

Refer also **Appendix D** for discussion regarding the relative influence of the current environment on bed stability.

Tidal Currents

Tide level variations at the site are described in **Section 5.2**. These water level differences drive the tidal currents.

Tidal currents in the Parramatta River adjacent to Kendall Bay are low and complex during high *(slack)* tide, but are easily discernible during peak ebb tide. Under slack tide conditions, water velocities are generally low *(<0.2 m/s)*. During peak ebb tide, currents up to 0.7 m/s flow in a general ESE direction off the end of Breakfast Point *(URS, 2006)*.

Peak flood tide velocities are generally greater than peak ebb tide velocities in shallow estuaries, and this can be significant with respect to overall sediment transport patterns. However, this behaviour is not evident within Kendall Bay where current speeds during the ebb and flood tides are not substantially different *(URS, 2006)*.

Freshwater Flows in Parramatta River

Peak freshwater flows in the main river channel, opposite Kendall Bay, would not be expected to exceed the peak tidal flows. Like the tidal currents, the freshwater flows in Kendall Bay would be lower than in the channel.

Wind-Induced Currents

Wind-induced currents in Kendall Bay would mainly occur due to surface shear and wind wave action *(oscillatory currents)*.

Surface Shear Wind Currents

Winds blowing across a water surface impart a shear stress which drives a surface flow. Measurements show that unidirectional surface currents reach 1 to 2% of the wind speed up to a wind speed of about 7 m/s above which the surface response becomes oscillatory and wave generation takes hold. It follows that maximum unidirectional wind generated currents can reach 0.15 m/s.

Oscillatory Currents due to Wind Waves

Wind waves will generate oscillatory currents *(water particle movements)* which depend on the wave height and period. These currents will be largest at the water surface, and generally attenuate with water depth. In shallow water, the difference between the surface and subsurface oscillatory currents is small *(discussed further below)*.

Boat Wash Currents

Boats wash currents occur due to boat-generated waves and propeller action.

Oscillatory Currents due to Boat Waves

In the same way as wind waves, boat waves generate oscillatory currents which vary according to wave height, wave period, and position in the water column. As outlined above in **Table 5.5**, wind and boat waves interact with one another to produce a combined wave climate at the marina. An assessment of the maximum horizontal currents at the bed of the marina site, based on this combined wave climate, is summarised below in **Table 5.6**. This information, developed from CERC (1984) using Stokes 3rd order wave theory, enables a consideration of the stability of the bed under existing conditions, and the relative impact of the proposed marina.

Table 5.6 shows that for a water depth of 1.0 m, maximum oscillatory currents at the bed exceed 1.0 m/s some 70 times each day as a direct consequence of Rivercat and Harbourcat ferry movements. The maximum daily velocities drop to 0.4 m/s in 2 m of water, and slightly less than 0.3 m/s in 3 m of water. The contribution of wind waves to the maximum current speeds at the bed are minor as can be seen by comparing the currents for 1 year ARI conditions with weekly conditions. Indeed, current speeds at the bed attributed to a 50 year ARI wind wave event are substantially smaller than the maximum current speeds expected on a weekly *(or indeed daily)* basis. The capacity for these currents to mobilise the bed material is addressed in **Section 5.5**.

TABLE 5.6 MAXIMUM EXISTING HORIZONTAL WAVE-INDUCED CURRENTS AT THE BED OF THE SITE [(1)]

Recurrence and Area within Marina	Wave Direction	Combined Wave Conditions Incident at Marina [(1)] Wind Wave Period Controls Hs (m)	Wind Wave Period Controls T (s)	Boat Wave Period Controls Hs (m)	Boat Wave Period Controls T (s)	Maximum Current Speeds (m/s) at the Bed for given Water Depths [(2)] 1m	2m	3m	4m
1 week ARI waves [(3)]									
Northern arm	N	0.40	1.1	0.30	7.0	1.05	0.41	0.28	0.22
	N	0.26	1.1	0.13	2.2	0.15	0.07	0.03	0.01
Central areas north of jetty	NE	0.49	1.3	0.30	7.0	1.05	0.41	0.28	0.22
	NE	0.24	1.3	0.14	2.2	0.16	0.07	0.03	0.01
	E	0.45	1.3	0.30	7.0	1.05	0.41	0.28	0.22
	E	0.21	1.3	0.13	2.2	0.15	0.07	0.03	0.01
Areas south of jetty	NE	0.52	1.4	0.30	7.0	1.05	0.41	0.28	0.22
	NE	0.25	1.4	0.16	2.2	0.19	0.08	0.04	0.02
1 year ARI waves									
Northern arm	N	0.61	1.6	0.31	7.0	1.11	0.42	0.29	0.23
	N	0.35	1.6	0.26	2.2	0.31	0.13	0.06	0.03
Central areas north of jetty	NE	0.64	1.6	0.31	7.0	1.11	0.42	0.29	0.23
	NE	0.36	1.6	0.26	2.2	0.31	0.13	0.06	0.03
	E	0.69	1.9	0.32	7.0	1.17	0.44	0.30	0.24
	E	0.40	1.9	0.35	2.2	0.42	0.18	0.08	0.04
Areas south of jetty	NE	0.69	1.7	0.31	7.0	1.11	0.42	0.29	0.23
	NE	0.40	1.7	0.31	2.2	0.37	0.16	0.07	0.03
50 year ARI waves									
Northern arm	N	0.53	2.0	Boats do not operate in this event		0.59	0.21	0.08	0.03
Central areas north of jetty	NE	0.49	1.8			0.47	0.14	0.04	0.01
	E	0.65	2.2			0.83	0.33	0.15	0.07
Areas south of jetty	NE	0.56	2.0			0.62	0.23	0.08	0.03

Notes	(1)	Sourced from **Table 5.5**. Highlighted wave conditions control in setting maximum current speeds at the bed
	(2)	Developed from CERC (1984) using Stokes 3rd order procedures for describing wave behaviour, based on Hs and calculated 50 mm above the bed. Shoaling neglected from this assessment
	(3)	The major contribution to the 1 week ARI waves are boat waves which occur on a daily basis, particularly ferry waves.

Propeller Action

PIANC (1987) gives a procedure for indicating bottom current speeds due to the action of propellers. Current speed at the bed is directly proportional to axial efflux speed and the diameter of the propeller, and the inverse of the vertical distance between the propeller and the bed. The axial efflux speed depends on installed engine power and the initial diameter of the slipstream behind the propeller.

GBAC has applied the PIANC (1987) methodology to calculate maximum axial current speeds at the bed due to vessels manoeuvring from rest *(conservative case)*. Installed engine power and propeller details for vessels of varying lengths between 8 and 25 m were gauged from available proprietary sources. Our assessment of these speeds for water depths between 2 and 5 m is presented in **Table 5.7**.

TABLE 5.7 MAXIMUM AXIAL CURRENT SPEEDS AT THE BED DUE TO PROPELLER ACTION

Boat Length L (m)	Installed Engine Power (kW)	Propeller Diameter Dp (m)	Axial Efflux Velocity u_0 (m/s)	Maximum Current Speeds (m/s) at the Bed for given Water Depths (2)			
				2m	3m	4m	5m
8	37	0.25	9.7	1.2	0.6	0.4	0.3
10	75	0.28	11.4	1.7	0.8	0.5	0.4
12	80	0.30	11.1	1.7	0.9	0.6	0.4
14	160	0.33	13.2	2.6	1.2	0.8	0.6
16	187	0.35	13.2	3.4	1.4	0.9	0.6
18	224	0.38	13.4	4.3	1.6	1.0	0.7
20	261	0.40	13.5	5.4	1.8	1.1	0.8
25	336	0.60	11.2	11.2	2.6	1.5	1.0
Notes	(1)	Drafts from AS 3962 *(Standards Australia, 2001)*					
	(2)	From Eqns (25) and (26) in PIANC (1987)					

Refer also **Appendix D** for discussion regarding tide conditions at which maximum current speeds at the bed are assessed.

Stormwater Outlet Flows

Seven stormwater outlets occur at the shoreline of the bay, ranging in size from 300 - 1650Ø. At the western shoreline, in the vicinity of the proposed marina, there are three outlets ranging in size from approximately 750 to 900Ø. Rip rap placements of basalt rock are used as scour aprons beside the western outlets (**Photo 13**). We observe 50 to 200Ø rock size at the surface of the aprons, slopes at between 1:3 to 1:5 slopes.

If it is assumed that the outlets and their aprons have experienced flows at or near design discharges, then we would expect the scour aprons to be stable in their existing configurations. Back calculating peak outlet velocities for minimal rolling of apron rocks indicates peak outlet flows between 2 and 3 m/s *(USACE, 1970)*. Assuming the outlets jet just below the water surface, we estimate peak flows to reduce by 80% within 10 m, and by over 90% within 25 m of the outlets. Given that the fresh water jet would dilute and slow in the water surface rather than near the bed, we would expect potential disturbance of bed sediments to be contained within 15 to 20 m of these outlets (applying Albertson et al 1948, and assuming critical velocity of 0.3 /s).

5.4.2 Interaction with Proposal and Mitigation Measures

The currents would potentially load the marina components, including the pontoon, piles and scour blanket.

Tidal currents, fresh water flows and unidirectional wind induced currents would impart loads which are significantly lower than the design wave and berthing loads.

The floating walkways are greater than 30 m from the closest stormwater outlets along the western shore. We estimate that a peak outlet discharge of say 3 m/s would have reduced to no more than 0.2 m/s at the walkways *(Albertson, 1948)*. Uniform flows of 0.2 m/s on the 400 mm draft floating pontoons would not be expected to impart a load exceeding 0.01 kN/m. This is small and is readily accounted for by the design wave and berthing loads.

The 1650Ø outlet at the head of the bay discharges behind a dense stand of mangroves. Because it is over 250 m away, the outlet velocities from this large culvert would not exceed the design velocities at the floating marina attributed to the western outlets.

The influence of the marina proposal on the bed of the bay is addressed in **Section 5.5**.

5.5 PHYSICAL BED SEDIMENT CHARACTERISTICS AND TRANSPORT BEHAVIOUR

5.5.1 Existing Environment

The existing environment is described as follows:

- Physical bed sediment type and distribution
- Existing bed sediment transport behaviour

Physical Bed Sediment Type and Distribution

The type and distribution of bed sediments in Kendall Bay may be described from the results of investigations carried put by URS for AGL, and also investigations by AECOM and Cardno Ecology Lab undertaken for the marina project.

URS Investigations

A total of 34 samples of surficial bed material *(depth 0.02-0.10 m)* were collected by URS from within 200 m of the shoreline of the former AGL site and analysed for particle size distribution. A total of 28 of the sites contained greater than 90% mud *(<0.063 μm)* and the remaining 6 samples contained >10% sand. These coarser gained locations were near the SW corner of Kendall Bay *(ESD01; 18% sand)*, near the small beach on the western shoreline of the bay *(ESD12; 14% sand)*, slightly further along the shore towards Breakfast Point *(ESD17; 13% sand)*; and in the main channel *(ESD19; 22%; ESD27; 33%; ESD35; 23% sand)*. The surface sediments overlie terrestrial clay.

According to URS, the sediment substrate at Breakfast Point was found to be sandy and rocky, probably due to the long-term winnowing of fine grained material from surficial sediments by higher velocity currents attributed to wake from high speed ferries and other vessels that pass the site.

Investigations by AECOM and Cardno Ecology Lab

Ten surface sediment samples were collected in May 2009 from the north side of the jetty within the area of the proposed marina. Median grain size varied from 0.35 mm *(medium sand)* to 0.0025 mm *(fine silt)* with the sandy substrate located 20 to 40 m from the shoreline, and the fine silts between 50 and 100 m. The sediment becomes more sandy progressing northwards across the marina site. This would be due to the increasing influence of higher tidal flows in the main channel which have winnowed out the finer material. Further details are available from the AECOM and Cardno Ecology Lab reports, included in the EIS.

Data from AECOM and Cardno Ecology Lab shows that some 80 to 90% of the marina footprint is covered by mud sized material which is in line with URS result *(refer also* **Appendix D***)*.

Existing Bed Sediment Transport Behaviour

The existing transport behaviour of the bed sediments may be described from a theoretical basis, and from site observations and investigations.

Theoretical Considerations for Bed Sediment Transport in Kendall Bay

Sediment transport is used to describe the movement of solid particles *(sediment)* and the processes that govern their motion. Sediment transport is typically due to a combination of the force of gravity acting on the sediment, and/or the movement of the fluid in which the sediment is entrained. The nature of the sediment itself is also important, and the transport behaviour is distinguished between non-cohesive sediments *(sands)* and cohesive sediments *(muds and clays)*.

In basic terms, the capacity for moving water to erode a sandy bed depends on the size of the sand grains, the density of the grains relative to that of the water, and the water velocity at the bed. Water viscosity *(affected by temperature)* and bed roughness will also influence the behaviour. According to procedures developed in CEM (2002), critical shear velocities at the bed as low as 1 to 2 cm/s are sufficient to initiate erosion of silica sand of diameter between 0.1 and 0.3 mm, rising to 14 cm/s for sand diameter of 0.4 mm. From our observations and field estimates, velocities need to be at least 10 to 25 cm/s before mobilisation at typical medium sandy beds is obvious to the naked eye. It should also be noted that a fine sand exhibits cohesion in salt water.

Cohesive sediments are those in which the attractive forces, predominantly electrochemical, between sediment grains, exceed the submerged weight. The strength of the cohesive bond is a function of the grain mineralogy and water chemistry, particularly salinity.

The mobility of cohesive sediment is a more complex phenomenon. Cohesion *(particle attraction)* is governed by the electrochemistry of the sediment minerals and water, or its state of consolidation. Grain size and shape reduces permeability, resulting in greater resistance to flow. A key indicator of cohesive sediment behaviour is a critical shear for erosion which is significantly greater than the critical shear for deposition *(CEM, 2002)*.

Cohesive sediments are generally not transported as bed load. They almost always are transported in suspension, carried with the ambient water *(advected)* and moved from areas of high sediment concentration to low by mixing *(dispersion)*.

Cohesive sediments rarely settle as individual grains. Collisions between sediment grains are encouraged by differences in settling velocity, turbulence and electrochemical attraction. When cohesive grains collide, they tend to stick together.

As indicator of the relative mobility of sands versus muds and clays, critical sear velocities for the latter are typically in the range 20 to 150 cm/s, which is comparable to that for coarse sands and fine gravels. As would seem to be the case in Kendall Bay, at shoreline margins which are energized by wave action eroded fine sediments *(silt and clay)* are winnowed, carried offshore, and deposited in deeper water. This contrasts with the sand fraction, which usually remains in the littoral zone *(CEM, 2002)*.

For a generalized relationship between average current velocity and sedimentary behaviour it is helpful to refer to the work of Julstrom (1939), reproduced in **Figure 6**.

Existing Bed Sediment Transport Behaviour from Site Observations and Investigations

URS Investigations

URS used backscatterance *(proxy for turbidity)* and ADCP *(acoustic Doppler current profiling)* measurements to characterise potential sediment resuspension by tidal currents. They found a strong correlation between current velocity and turbidity during the ebb tide in the main channel off Kendall Bay. Here maximum tidal velocities of 0.7 m/s were recorded. Observing vertically uniform high turbidity through the water column, URS concluded that the source of the turbidity was advection from upstream rather than local resuspension. The strong tidal currents observed in the main channel do not extend to the shallow waters of Kendall Bay. URS determined that resuspension of surficial sediments due to tidal currents was unlikely in Kendall Bay due to the low current velocities *(URS, 2006)*

Overview

In nominal terms, it would seem reasonable to adopt a disturbance *(erosion)* threshold velocity of say 0.3 m/s for bed sediments at the marina site. While lower velocities could disturb unconsolidated muddy sediments, it is conservative to nominate a reasonable upper bound threshold.

Predevelopment the bed sediments are potentially disturbed by currents induced by wind waves, boat waves, propeller action and stormwater outlet flows (**Section 5.4.1**). Propeller action is localised to the vessel and since craft rarely enter the proposed marine precinct, this influence is currently small. Stormwater flows are also intermittent and because outlet flows are fresh, these would tend to disperse into the water surface with limited disturbance to the bed. Wind waves and boat waves remain the dominant existing processes leading to bed disturbance. Currently some 25,000 fast ferries pass the site each year (**Table 5.3**). Passings of recreational power craft are almost three times that of the fast ferries. Combined boat and wind wave action is assessed to just disturb the bed in a water depth of 3 m some 70 times per day, controlled by the passing of fast ferries. Wind waves in 50 year ARI storms would only disturb bed sediment in water depths up to 2 m (**Table 5.6**).

5.5.2 Interaction with Proposal and Mitigation Measures

The physical bed sediment characteristics would not change as a result of the marina proposal. However, the bed is potentially disturbed.

It is instructive to consider the process for the physical disturbance of surface bed sediments at the marina site, as a consequence of the proposal, in terms of the staging of project. The following stages can be distinguished in respect of the placement of the blanket:

(i) Construction - when the geotextile for the blanket is laid
(ii) Post Construction – nominally six to 12 months after the blanket is installed but during construction of the fixed jetty and floating structure
(iii) Marina operation

At the end of this section, we have attached a conceptual model of bed disturbance and protection to confirm our understanding of the key processes.

Construction

The conceptual design of the blanket as a mitigation measure for addressing propeller wash from vessels in the proposed marina, is considered below *(see Influence of Propeller Wash at Bed and Mitigation Measures)*.

At construction, when the geotextile and rock blanket is laid, it is estimated that the "upper 100 mm of very soft sediments would probably be disturbed" *(Douglas Partners, 2009 attached at* **Appendix F***)*. As the sediments generally become finer *(and softer)* with increasing depth across the marina site, ranging from medium sands within water depths of 2 m, to fine silts deeper than 3 to 4 m, it would be reasonable to expect that the 100 mm disturbance represents an upper bound in average terms when considered over the proposed 56,000 m^2 blanket area.

During placement of the blanket, some of the 100 mm thick upper layer of soft sediment would migrate through the geotextile. Once the geotextile is laid and fixed in position by the overlying rock, further migration of fine sediments through the geotextile could be expected. These outcomes are evident from the results of hydrodynamic and static testing of the geotextile carried out by Geosynthetic Testing Services, GTS (**Appendix B**).

During the construction phase, it would seem reasonable to consider the static submersion test as much more representative of the hydraulic loading environment than the hydrodynamic test. The geotextile is lowered into position and then fixed by rock ballast. The geotextile is not going to be raised and lowered repeatedly. Based on the percentages of sediment transfer through the geotextile established from the testing, the action of placing the geotextile and rock could be expected to approximately feed between say 1 and 20 mm of surface sediment up through the geotextile, with the sediment delivery being much closer to 1 mm than 20 mm. The implied assumption here is that the testing results are independent of the thickness of the sediment sample used *(20 mm used in GTS testing)*.

It is also instructive to consider the degree of potential disturbance of the bed during construction of the blanket by drawing a broad comparison with present day bed disturbance due to passing fast ferries. If it is assumed that all points under the proposed blanket are disturbed for no more than say a couple of minutes during construction of the blanket, then fast ferry movements over a period of no more than one month would be expected to mobilise the equivalent area under the footprint of the blanket *(assessment unit here being area x time)*. Once the blanket is in place and the marina operational *(refer* **Marina Operational Phase** *below)* , it is assessed that currents due to all boat waves including ferry waves, tidal flows, wind action, freshwater flows, stormwater outlet flows, and propeller wash, would be insufficient to mobilise the bed under the blanket. This assessment assumes an average threshold velocity for erosion at the existing unprotected bed of 0.4 m/s *(conservative)*, a critical water depth below which fast ferries are assessed to erode the bed of 2.1 m *(derived from* **Table 5.6)**, and a water level distribution based on long-term data for Fort Denison. A calculation supporting this assessment is outlined in **Appendix E**.

Thus while we could expect some bed sediment to be mobilised during construction, the quantum of this disturbance is small compared to the ongoing disturbance attributed to fast ferry movements.

Mitigation measures relating to disturbance of the bed during the construction phase pertain primarily to the water quality impacts, addressed by others.

Post - Construction

Once the blanket is in place, the disturbance of the bed by fast ferry wave action within the marina footprint is removed. The protection typically occurs in water depths of 2 to 3 m, amounting to a total bed area of some 10,600 m^2, or 19% of the total area of the blanket.

Marina Operation Phase

As for the existing environment, when the marina is operational the bed sediments are potentially disturbed by currents induced by wind waves, boat waves, propeller action and stormwater outlet flows (**Section 5.4.1**). These are unchanged except for:

(i) the continued protection of the bed from fast ferry wave action in 2 to 3 m water depth (see above);

(ii) some protection of the bed from wind and boat wave disturbance in very shallow water *(say 1 m or less)* immediately west and south of the marina due to the calming effect of the marina pontoons and boats, and

(iii) the effects of new propeller wash from vessels in the proposed marina.

The waves generated by boats navigating within the marina, and entering or departing the marina, would be no more energetic than the boat waves currently experienced in Kendall Bay as a result of ambient boating traffic. Boating movements in the vicinity of Kendall Bay would increase as a consequence of the marina, however the wash generating capacity of these boating movements would be small compared to the ambient wash experienced in the bay, attributed mainly to passing fast ferries (**Section 5.3**).

Potential for mobilisation of bed sediments due to propeller wash is a separate matter, considered here under the following headings:

- Turbidity behaviour due to propeller wash
- Influence of propeller wash at bed and mitigation measures
- Far field dispersion of disturbed bed sediments

<u>Turbidity Behaviour due to Propeller Wash</u>

A two-day field investigation was undertaken in Kendall Bay in late September 2007 to provide information on vessel turbidity to assist in the design of the proposed marina. Gary Blumberg & Associates *(GBA)* collaborated with The Ecology Lab to design and implement the investigation to the satisfaction of the then NSW Department of Environment and Conservation *(DEC)* and other stakeholder agencies. The full investigation report is attached at **Appendix C**. A summary is set out below.

Fifty one propeller wash test runs and 92 sets of background turbidity measurements were made. Three vessels were used to perform the wash tests *(boat lengths 11, 14 and 24 m)* representing the range of typical vessels expected to berth within the proposed marina. A full copy of GBA's report is included in the EIS *(J07-16/lr761, 2/11/07).*

The field results permitted an assessment of daily average turbidity for the Kendall Bay Remediation Site *(KBRS)* and profiling of turbidity impacts associated with all vessels earmarked for berthing at the marina.

DEC's requirement was that the proposed marina must not cause any additional resuspension of contaminated sediments over and above that attributed to background processes *(DEC letter to TLB, 7/8/07).* Turbidity measurements were made as a well accepted and practical indicator of suspended sediments.

The key findings from the investigation were presented in terms of propeller wash impacts at the unprotected bed *(no scour apron)* for varying water depths:

- **Two metres** water depth was clearly problematic and is considered unlikely to satisfy DEC's requirements for any of the test vessels.

- **Three metres** water depth was found to be unacceptable for the large *(24m)* vessel, with mixed compliance exhibited for the small *(11 m)* and medium length *(14 m)* vessels. It appeared therefore that 3 m depth approached the acceptable limit for these two sizes of vessels.

- In **four metres** of water, the small *(11 m)* and medium *(14 m)* vessels essentially met DEC's requirement, but the large *(24 m)* vessel did not.

- The small *(11 m)* and medium *(14 m)* vessels clearly satisfied DEC for all manoeuvring in **five metres**, but the large *(24 m)* vessel caused significant turbidity impacts for the case of full thrust starting astern and probably also starting ahead.

While full thrust starting was incorporated into the work to satisfy DEC, it was pointed out by GBA that this does not represent a reasonable operating condition within a marina and may never occur.

The propeller wash tests provided an event-based description of turbidity impacts. However, the spatial and temporal integration of these effects over the bay as a consequence of marina activities was also of interest.

An earlier desk-top investigation by GBA had found a relatively small overall disturbance by propeller wash from marina boats, relative to wave action from ferries past or through Kendall Bay *(GBA fax to TLB dated 2/11/06)*. To further examine total marina impact, GBA applied the available background and vessel test turbidity data to develop an analytical procedure to estimate the level of turbidity impact from proposed marina operations. This assessment indicated that the daily average turbidity within the KBRS would be elevated by less than 1 NTU over and above an assessment of daily average turbidity equal to 10.2 NTU. The overall turbidity impact of the proposed marina was thus predicted to be small.

Influence of Propeller Wash at Bed and Mitigation Measures

While the turbidity impacts of the proposed marina due to propeller wash were found to be small, because there would still be an increase in the background turbidity as a result of propeller wash, DEC's requirement that the proposed marina must not cause any additional resuspension of contaminated sediments over and above that attributed to background processes would not be met. To address this aspect is it proposed to install a scour protection blanket over the full area of the marina, extending beyond the edges of the floating facility by a minimum distance equal to an acceptable navigable fairway width of 1.5 times the maximum length of passing vessels.

Design development of the sour blanket has considered the following:

(i) Boat movement zones and controlling bed levels
(ii) Design water level in Kendall Bay
(iii) Screw race modelling and design bed velocities
(iv) Protective rock requirements: rock size, blanket thickness and footprint
(v) Geotextile
(vi) Construction aspects
(vii) Alternative grout-filled mattress blanket concept

The design development of the scour blanket is based on investigation, available data and standard engineering texts and procedures. The level of confidence attached to the design would be equivalent to that which generally applies in engineering practice.

Boat Movement Zones and Controlling Bed Levels

The berth layout in the proposed marina controls the boat movement zones adopted for this assessment. We have assumed that boats would either enter their berths forwards or in reverse. Turning distances extending inshore of each berth equal to 1.5 times the berth length has been assumed. This demarcates the minimum bed levels over which boats of various lengths would be required pass.

Our assessment of the controlling minimum design bed levels in the proposed marina is described in **Table 5.8**.

TABLE 5.8 CONTROLLING MINIMUM DESIGN BED LEVELS FOR BOATS OF VARIOUS LENGTHS

Boat Length (m)	Controlling Berth No	Bed Level (m AHD)
8	1	-2.8
10	87	-2.9
12	44	-2.9
14	93	-3.4
16	77	-3.0
18	79	-3.3
20	81	-3.5
25	85	-3.9

Design Water Level in Kendall Bay

Water levels in Kendall Bay are described in **Section 5.2.1**. For this assessment we have assumed a water level of RL -0.73 m AHD which is more than 0.1 m lower than Mean Spring Low Tide, exceeded 98% of the time.

Screw Race Modelling and Design Bed Velocities

Our calculation of screw race at the bed has applied procedures developed by Delft Hydraulics Laboratory as outlined in PIANC (1987). Delivered engine thrust of 75% of installed power has been assumed as representing a conservative design condition within the proposed marina. Other variables include propeller diameter and vertical distance between the propeller axis and the bed, derived from available guidelines and proprietary boat information

Our assessment is summarised below in **Table 5.9**. This shows design axial velocities at the bed due to propeller wash ranging from 0.3 m/s for an 8 m boat manoeuvring at low tide over a bed level of RL -5, to in excess of 8 m/s for the hypothetical case of large vessels *(16 m or greater)* over RL -2. The controlling axial bed velocities within the proposed marina are shaded in the table. The maximum bed velocity would be 1.7 m/s attributed to two situations:

(i) 16 m boat manoeuvring over RL -3.0 at the inshore end of the fairway between Arms 3 and 4;

(ii) 25 m boat manoeuvring over RL -3.9 midway along the fairway between Arms 3 and 4.

Protective Rock Requirements: Rock Size, Blanket Thickness and Footprint

The US Army Corps of Engineers has adopted procedures developed by Airy and Isbash to prepare hydraulic design criteria for selection of rock sizes for riprap for channel bottoms downstream from stilling basins and for river closures *(Sheet 712-1, revised 9-70).* This same methodology is also adopted in PIANC (1997) for assessing protection of underwater channel beds and slopes exposed to propeller wash.

We have applied an Isbash coefficient of 0.86 to yield median rock size for the conservative limiting condition of sliding. Rolling and overturning would occur at velocities which are 40% lager than those adopted in our design.

The median rock sizes for bed protection applicable to the range of controlling bed velocities presented in **Table 5.9** are given in **Table 5.10**. The analysis assumes a rock dry density of 2.7 t/m^3 and a typical sea water density of 1025 kg/m^3.

TABLE 5.10 MEDIAN ROCK SIZES FOR BED PROTECTION

Bed velocity (m/s)	Median Rock Mass (kg)	Median Rock Diameter (mm)	Minimum Blanket Thickness (mm)
0.75	<0.05	<33	56
1.00	0.1	41	70
1.25	0.4	66	112
1.50	1.2	95	162
1.75	3.0	129	220
2.00	6.8	169	287

It is normal practice to provide a minimum of two layers of rock to protect against hydraulic loads. Because rocks nest together, the thickness of a two layer system is equal to 1.7 x the median rock diameter. Thus for the range of bed velocities 0.75 m/s to 2.0 m/s given in the table, we calculate median rock masses between 50 g and 6.8 kg and minimum blanket thicknesses up to 290 mm.

Because the protective blanket occupies a certain thickness, it follows that the effective water depths are slightly reduced so the propeller induced bed velocities are slightly larger. It can be shown that by applying a nominal 300 mm blanket thickness would have the effect of increasing the bed velocities in **Table 5.9** by 20 to 40% which is significant and must be accounted for.

TABLE 5.9 SCREW RACE AT BED

Boat Length (m)	Engine Power		Propeller diameter [1] (m)	Axial Efflux Velocity at Propeller [2] (m/s)	Propeller Shaft Distance below Water Surface [1] (m)	Axial Velocity at Bed for Boats Manoeuvring from Rest [2] (m/s)			
	Installed (BHP) [1]	Delivered (kW)				Bed Level (m AHD)			
						-2.0	-3.0	-4.0	-5.0
8	50	28	0.25	8.8	0.7	1.8	0.7	0.4	0.3
10	100	56	0.28	10.4	0.8	2.8	0.9	0.6	0.4
12	150	84	0.30	11.2	0.8	3.2	1.1	0.7	0.5
14	200	112	0.33	11.7	0.9	4.9	1.4	0.8	0.6
16	250	140	0.35	12.0	1.0	8.4	1.7	0.9	0.6
20	350	196	0.40	12.3	1.2		2.3	1.2	0.8
25	400	252	0.60	10.2	1.4		3.5	1.6	1.1

Notes	(1)	Assessment of available proprietary information by GBAC
	(2)	Modelling from PIANC (1987).
	(3)	Controlling axial velocities at bed within proposed marina

The modified screw race at the top of the blanket, for the actual controlling bed levels given in **Table 5.8**, with the associated median rock masses, diameters and minimum blanket thicknesses are summarised in **Table 5.11**.

It is not feasible to construct a rock blanket which is too thin. At the same time, rock supply costs *(or blanket thickness)* must be minimised. Having discussed the feasibility of blanket placement and construction tolerance with an experienced contractor, GBAC proposes a blanket concept design which generally comprises a 300 mm thick rock profile, but is locally thickened to 400 mm in critical zones. This is shown in **Figure 7** and summarised below in **Table 5.12**.

The concept design comprises a total placement of approximately 29,000 tonnes of igneous rock *(probably basalt)*, acceptable for use in the marine environment. The 300 mm thick blanket would mainly comprise rock between 70 – 160 mm in size *(2 – 5 layers)* and the 400 mm thick blanket would mainly comprise rock between 140 – 235 mm in size *(2-3 layers).*

TABLE 5.11 MODIFIED SCREW RACE AT TOP OF BLANKET FOR ACTUAL CONTROLLING BED LEVELS AND ROCK REQUIREMENTS

Boat Length (m)	Controlling Bed Level (m AHD)	Axial Velocity at Top of Blanket (m/s)	Median Rock Mass (kg)	Median Rock Diameter (mm)	Minimum Blanket Thickness (mm)
8	-2.8	0.9	0.06	35	60
10	-2.9	1.3	0.52	72	122
12	-2.9	1.5	1.2	95	162
14	-3.4	1.3	0.52	72	122
16	-3.0	2.2	12	202	343
18	-3.3	2.0	6.8	169	287
20	-3.5	1.9	5.0	152	258
25	-3.9	2.1	9	185	315

Geotextile

It would not be acceptable to place the rock directly onto the bed. The rocks would settle into the bed, effectively reducing the blanket thickness. Also, hydraulic pressures caused by propeller wash could extend into the blanket and potentially mobilise the underlying surface sediments. A geotextile is therefore required to separate the blanket rock from the underlying bed sediments.

It is proposed to include a heavy duty geotextile at the underside of the blanket. To minimise pore size while preserve permeability, a non-woven rather than a woven product is proposed. Elcomax1200R *(or approved equivalent)* is recommended for the application. The key technical properties of this stable-fibre and needled punched polyester product are listed in **Table 5.13**.

TABLE 5.12 CONCEPT DESIGN FOR ROCK SCOUR PROTECTION BLANKET

Item		300 mm Thick Blanket	400 mm Thick Blanket
Design axial velocity at top of blanket (m/s)		1.6 m/s	2.2 m/s
Location		Under full marina footprint extending an additional minimum fairway width *(1.5L_B)* and extending inshore nominally to RL-1.9 bed contour, excluding area where 400 thick blanket is provided	Protecting bed areas where design velocities assessed to exceed 1.6 m/s, located primarily between Arms 3 and 4, but also at the inshore end between Arms 1 and 2 extending N of Arm 1 and S of Arm 2 immediately under the main inshore walkway
Surface area (1)		47,000 m^2	9,000 m^2
Rock dry density		2.7 t/m^3	2.7 t/m^3
Median rock mass range (M_{50})		1.8 – 2.7 kg	12 - 18 kg
Median rock diameter range (D_{50}) (2)		100 - 120 mm	190 – 220 mm
D_{15} range (2)		70 – 100 mm	140 – 190 mm
D_{100} max(2)		160 mm	235 mm
Provisional rock tonnages		24,000 t	5,000 t
Notes	(1)	Preliminary, subject to investigation of type, magnitude and distribution and of containments and consideration of possible reductions in blanket footprint	
	(2)	The rock grading accords with riprap grading envelope given in PIANC (1997). Maximum rock size ensures at least two layers of rock	

TABLE 5.13 PROPOSED GEOTEXTILE AT UNDERSIDE OF ROCK BLANKET (1)

Properties	Key Descriptor	Specification	Test Method
Fabric	Non-woven, needle punched polyester		
Thickness	Under 2kPa	5.7 mm	AS3706.1
Weight	Fabric mass per unit area	1,200 g/m^2	
Permeability	k_g; based on Darcy's Law	1.6x10^{-3} m/s	AS3706.9
Through flow	At 100 mm head	27 L/m^{2}s	AS3706.9
Pore Size	Equivalent opening size EOS_{95}	<75 micron	AS3706.7
Drop cone	Puncture test – H_{50} drop height to create 50 mm hole	12,600 mm	AS3706.5
Trapazoidal tear	Tear test	1000 N	
UV stability	Strength retained after 672 hrs	80%	AS3706.11
Abrasion resistance	Strength retained after 80,000 revs	75%	Rotating Drum
Source	Geofabrics Australia (2006)		
Notes	(1) Or approved equivalent		

At 5.7 mm thick and weighing 1,200 g/m^2, the key impact and tear strength requirements of the geotextile are readily achieved *(drop cone and trapezoidal tear criteria)*, intruding a high Factor of Safety in respect of geotextile strength.

In respect of filtration design, three main requirements must be considered *(PIANC, 1987)*:

- retention
- permeability
- downslope migration

(a) Retention

Retention is achieved by using a geotextile of sufficiently small opening size to prevent migration of the soil particles. At less than 75 micron, the recommended geotextile exhibits the smallest equivalent opening size *(EOS)* available. The EOS corresponds to the diameter of the largest particle *(90 to 95%ile by convention)* able to pass through the geotextile. According to retention assessment methods set out in PIANC (1987), the proposed geotextile is marginal in terms of its retentive capacity for the finer sediments in Kendall Bay. While the general guideline for geotextile retention outlined at Section 3.6.4 in PIANC (1987) indicates compliance, an assessment in accordance with Appendix B of the same document does not. The differences would seem to arise in respect of the various methods which are available to measure EOS, whether this involves wet or dry sieving, and one directional flow or alternate flow.

The hydrodynamic sieve testing undertaken by GTS referred to above, while an aggressive test procedure, indicates a potential mechanism for passage of fines through the Elcomax 1200R. It was therefore important to further consider the performance of the rock blanket itself for protecting its base soil from scour, and the additional protection offered by a geotextile forming the underside of the blanket.

Guidance on the capacity of bed sediments to resist scour under a layer of rocks is provided by research carried out for gabions and reno-mattresses. Physical modelling studies reported on by the US Army Corps of Engineers examined the capacity for current velocities to penetrate rock gabions and potentially erode the underlying material *(Freeman and Fischenich, 2000)*. Since the proposed rock blanket is packed and stable under design flows, it is reasonable to apply these data in the Kendall Bay application. For the design case, we estimate the current velocity at the bottom of the rock blanket, above the geotextile layer, at less than 20% of the velocity at the upper surface of the blanket *(ie 80% reduction through the 300 to 400 thick blanket)*. A geotextile under the blanket provides a further reduction of 25 - 50% *(Freeman and Fischenich, 2000)*, resulting in an effective maximum current velocity under the geotextile no more than 5 – 10% of that at the surface of the blanket, or in the assessment for Kendall Bay approximately 0.1 - 0.2 m/s. We found the same algorithm reported by Agostini et al (1985) in their development of reno-mattress and gabion guidelines for Maccaferri in Italy.

Given that these predicted velocities of 0.1 to 0.2 m/s are less than the nominal threshold velocity of 0.3 m/s adopted for the site, the filtration design would be expected to account for the hydraulic gradients attributed to the propeller wash and thereby contain the underlying sediments. It should be noted that the predicted velocities under the geotextile are comparable if not slightly lower than the exiting tidal and wind induced currents expected in Kendall Bay.

(b) Permeability

The geotextile must maintain a higher permeability that the underlying sediments, and head loss through the geotextile must not be excessive. According to the general permeability requirement in PIANC (1987) developed from Darcy's Law, the permeability of a non-woven geotextile which is greater than 2 mm thick *(measured at normal stress of 2 kPa)* should exceed 50 times the permeability of the soil. As the permeability of the muddy sediments under the blanket would not be expected to exceed 10^{-5} m/s, the geotextile permeability of 0.0016 m/s (**Table 5.13**) satisfies this criterion.

Lending support to the assessment of acceptable geotextile permeability, Lawson (1992) reported on an earlier empirical relationship he developed between minimum required geotextile volume flow rate and characteristic particle size of the soil to be filtered. In order for the geotextile to have an adequate water flow capability to drain a wide range of fine-grained soil types, the minimum requirement of volume water flow through the geotextile was found to be 30 L/m^{2}s under 10 cm head for d_{15} soil particle sizes between 0.005 mm and 0.08 mm. For all intents and purposes, this is achieved with Elcomax 1200R at Kendall Bay (**Table 5.13**).

(c) Downslope Migration

It would appear that downslope migration is a potential issue for sloped revetments protecting muddy riverbanks. Because of the very flat bed gradients encountered under the blanket, this issue is avoided at the site.

Of the polymers used to manufacture geotextiles, polypropylene exhibits the greatest resistance to chemical attack. It is stable within a pH range of 3 to 13, making it one of the most stable polymers available for the manufacturing of geotextiles. Polypropylene is non-biodegradable and is resistant to commonly encountered soil bound chemicals and landfill leaches. It is also inert to most chemicals *(Talukdar, 2005)*. Elcomax is a polypropylene product.

Construction Aspects

The feasibility of constructing the scour protection blanket has been discussed with contractors.

It is proposed that the geotextile would be stitched into large panels, rolled and folded, and deployed from a large barge. The geotextile would be unfurled from the front of the barge, and draped over the bed as the barge is winched forwards along a deployment transect. An excavator located at the back of the barge would bucket rock onto the geotextile, initially to provide ballast and later to achieve the required blanket thickness. A dive team would be used to ensure positioning of the geotextile edges and suitable overlap for adjoining panels.

The availability of the rock size and tonnages has been confirmed with quarry suppliers. It is proposed to use two standard quarry products which comply with rock fill for gabions under RTA Specifications 55, namely:

- Quarry spall 90 – 250 mm
- Quarry spall 75 – 150 mm

The veracity of these products to meet the hydraulic loading design could be confirmed by physical model testing if required *(see above)*.

Alternative Grout-Filled Mattress Blanket Concept

A grout-filled geotextile mattress has been considered as an alternative. This would involve a product such as the 200 mm CBM *(collapsible block mattress)* supplied in Australia by Foreshore Protection. The CBM is fabricated from a 600 g/m^2 woven polyester geotextile. It is laid on the bed and pumped with 20 MPa concrete grout. The main disadvantage is a larger pore size *(generally recognised in the industry although no EOS specification for this product could be found)* and its increased dimension under tensile load.

The CBM consists of regular blocks cast in place in a staggered joint pattern. The fabric is woven to provide articulated joints surrounding the blocks. The articulated joints would therefore occur regularly throughout the blanket without any coverage by blocks or rock, and would be directly exposed to full propeller wash and migration of fines *(even with a 25 to 50% reduction of effective current velocity through the geotextile – refer above)*.

The key advantage of woven fabrics is their excellent tensile strength, but this is not critical for the project. The CBM could be cut to locate and drive piles, but blanket sealing around the piles is not as readily achieved as with the selected rock and geotextile blanket.

<u>Far field dispersion of disturbed bed sediments</u>

The 10 mm of disturbance to the surface bed sediments which occurs over the construction, post-construction and marina operation phases would amount to some 560 m^3 of material. This material would disperse elsewhere in Kendall Bay and beyond, under the action of ambient translational currents, predominantly tidal currents and wind-induced circulations (**Section 5.4.1**).

The question has been posed as to what proportion of this disturbed material may disperse and resettle in the mangroves at the southern end of Kendall Bay *(Howard Bersten, TLB, pers comm)*. Information presented in URS (2006) suggests that fine sediments are largely absent in shallow areas around Kendall Bay where higher energy wave induced currents occur. It follows that much of the dispersed bed sediments could be expected to disperse and settle in the deeper areas of the bay *(or disperse further afield into the Parramatta River)*, rather than into the shallows surrounding the bay.

TLB has made an estimate of sediment movement into the southern shallows of the bay, summarised as follows *(Howard Bersten, TLB, pers comm*:

- 10 mm sediment dispersed from rock blanket
- 50% moves to south
- Of sediment which moves to the south, approximately 85% settles below the low water mark, thus up 15% potentially moves into the mangrove shallows
- Average thickness which may settle over 40,000 m^2 mangrove area approximately 1 mm *(40 m^3)*

GBAC considers the estimate of 40 m^3 dispersed over the mangroves, or less than 10% of the disturbed sediment from the footprint of the blanket, to be reasonable.

Conceptual Model of Bed Disturbance and Protection

To convey our understanding of the key processes affecting the bed of Kendall Bay at the proposed marina, a conceptual model of bed disturbance and protection has been developed. This draws on the key mechanisms described elsewhere in this report, particularly in the above subsections of **Section 5.5.2**.

1	Existing conditions	Near-bed wave-induced currents due to fast ferries disturb large areas within Kendall Bay including the proposed marina footprint area.
2	Commencement of construction	Geotextile forming part of the blanket is lowered onto the bed.
3	Geotextile located onto bed	The geotextile comes to rest on the bed and ballast is placed to temporarily secure the geotextile placement. In the process of coming into contact with the bed and being located to its correct position, disturbance of surface sediments commences. Upper 100 mm of bed sediments probably affected during construction of the blanket *(Douglas Partners, 2009).* Small proportion of the disturbed sediment passes through the geotextile *(<10% of upper 100 mm over the duration of blanket construction)*.
4	Construction completed	300 – 400 mm thick layer of rocks comprising the upper blanket is placed. Disturbance of surface sediments is complete when construction of the blanket is completed. Up to 10 mm of fine surface sediments now occupies the base interstices of the blanket.
5	Post construction (up to 12 months)	Ambient currents, including the controlling wave-induced currents due to fast ferries, are insufficient to remobilise most of the 10 mm of fine sediments within the rock blanket.

6	Marina operation phase commences (at 12 months)	Once vessels take up their berths within the marina, their propeller action is predicted to remobilise all of the 10 mm of fine sediments located within the rock blanket. This material is suspended into the water column, and dispersed elsewhere within Kendall Bay and beyond, under the action of ambient currents. Tidal flows and wind-induced currents would be expected to dominate the dispersion process. The blanket geotextile itself reduces the penetration of ambient currents to the underlying bed sediments such that the velocities under the geotextile are insufficient to mobilise these sediments.
7	Marina operation phase	During operation, minor disturbance of blanket rocks is predicted due to propeller action of vessels located within the marina. Based on the adopted blanket design methods, it is predicted that 0 – 5% of the rocks within the blanket may move over the life of the facility. This disturbance to the blanket rocks is readily addressed by routine maintenance. Any minor mobilisation of the blanket rocks during marina operation and any required maintenance would not be expected to disturb the bed of Kendall Bay under the blanket such that further sediment loss up through the blanket could occur.

The conceptual model of bed disturbance and protection is depicted in **Figure 8**.

6 DESIGN RELIABILITY

Conventional design practice for coastal and maritime engineering structures is deterministic in nature. It is based on the concept of a design load which should not exceed the resistance of the structure. The resistance is addressed in terms of the load that causes a certain design impact or damage, and it is not given as an ultimate force or deformation. This is because the design formulae only give the relationship between wave characteristics and some structural response, such as armour layer damage *(CERC, 2002)*.

Almost all coastal structure design formulae are semiempirical and based mainly on central fitting to model test results. The often considerable scatter in test results is not considered in general because the formulae normally express only the mean values. Consequently, the applied characteristic value of the resistance is then the mean value. The contribution to a safety margin in the design is inherent in the choice of the return period for the design load.

GBAC has applied a methodology for sizing the rock blanket developed at the US Army Engineer Waterways Experiment Station *(USACE, 1970)*. This same methodology is recommended in PIANC (1997), the current benchmark design guide for rock apron structures. While no damage percentages are reported in USACE (1970), permissible damage of 0 - 5% is commonly applied in the design of coastal rock protection structures *(CERC, 1984)*.

The design development of the scour blanket is based on investigation, available data and standard engineering texts and procedures. GBAC has prepared the assessment with such skill, care and diligence as is generally exercised by competent members of the consulting engineering profession performing services of a similar nature.

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Supplement to Bulletin No 96]

FIGURES

FIGURE 1

NOTES

1. BASE PHOTO GOOGELE EARTH PRO 4/09
2. MARINA LAYOUT FROM TLB DA10 REC 8/7/09

0 100m

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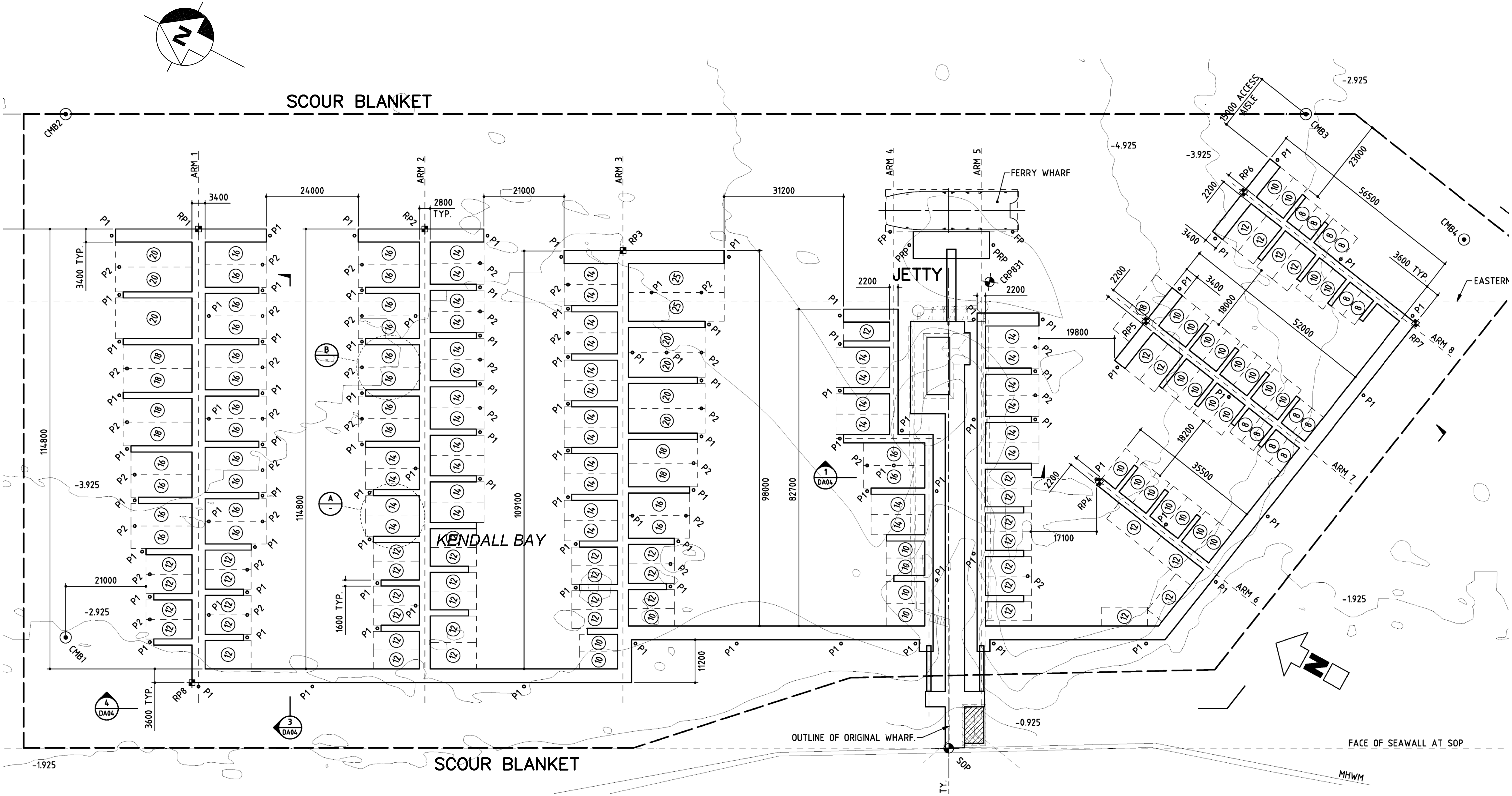
Plot Date 20/9/09

STUDY AREA

FIGURE 2



NOTES

1. BASE PHOTO GOOGELE EARTH PRO 4/09
2. MARINA LAYOUT FROM TLB DA03 REC 8/7/09

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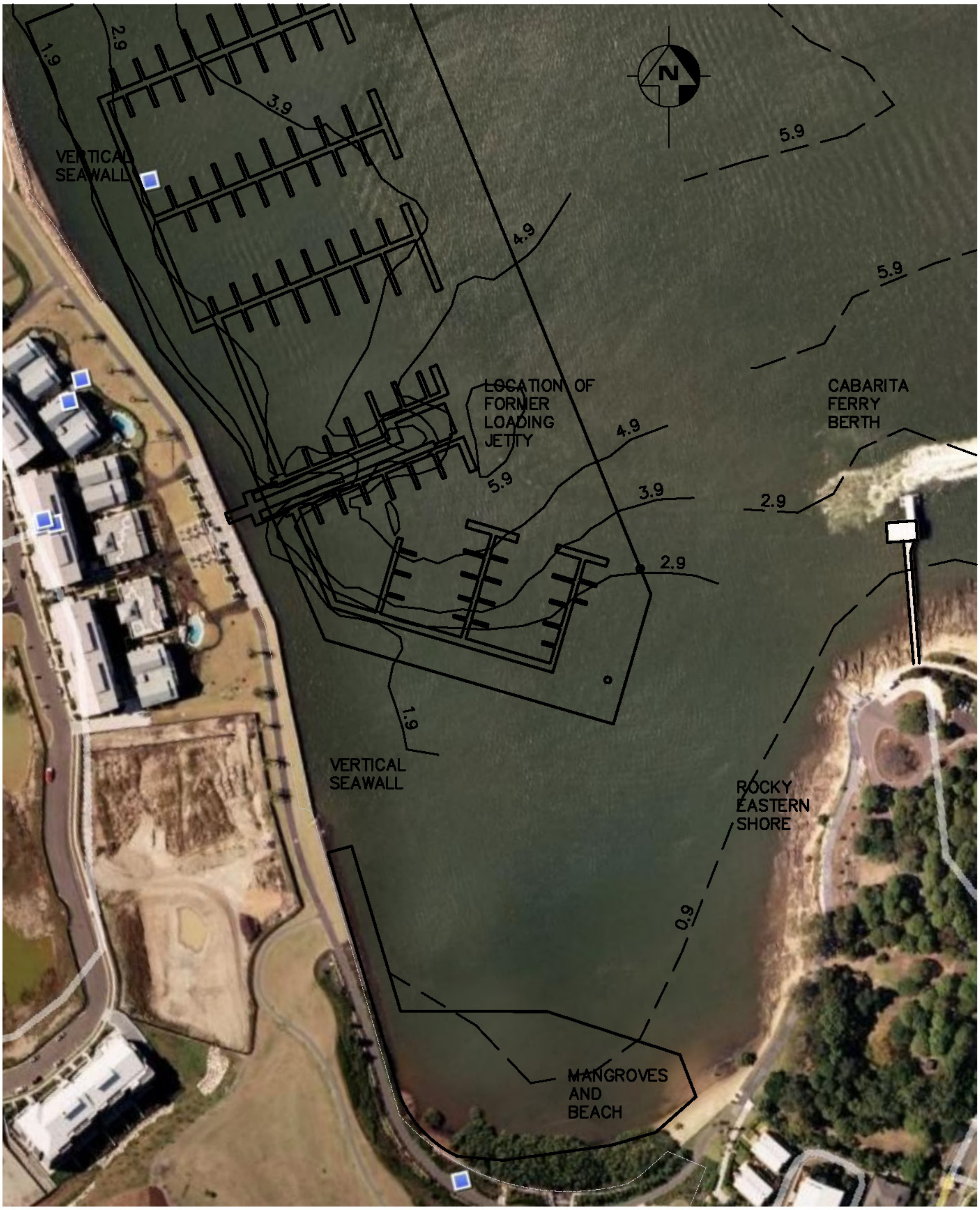
J07-16-1/R80
Plot Date 8/7/09

MARINA PROPOSAL

FIGURE 3



NOTES

1. BASE PHOTO GOOGELE EARTH PRO 4/09
2. MARINA LAYOUT FROM TLB DA03 REC 8/7/09
3. BATHYMETRY FROM HARVEY HYDROGRAPHIC SURVEYS (8/01) AND AUS 203. BED LEVELS IN METRES BELOW AHD. FULL LINE HARVEY, DASHED LINE AUS CHART.

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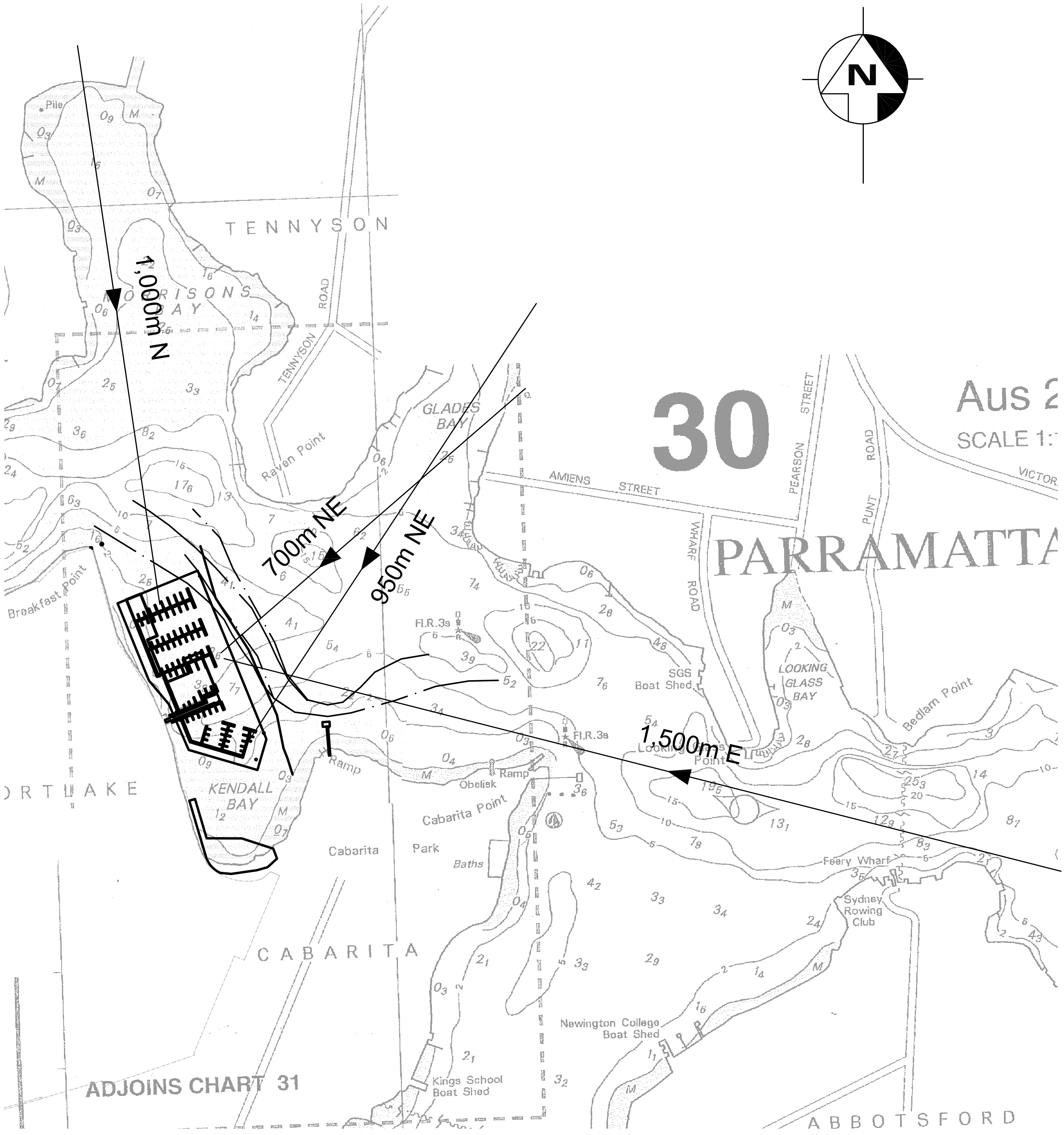
Plot Date 20/10/09

BATHYMETRY AND SHORELINE MORPHOLOGY

FIGURE 4



NOTES

1. BASE CHART AUS 203
2. DEPTHS IM METRES BELOW ZFDTG
3. MARINA LAYOUT FROM TLB DA03 REC 8/9/09

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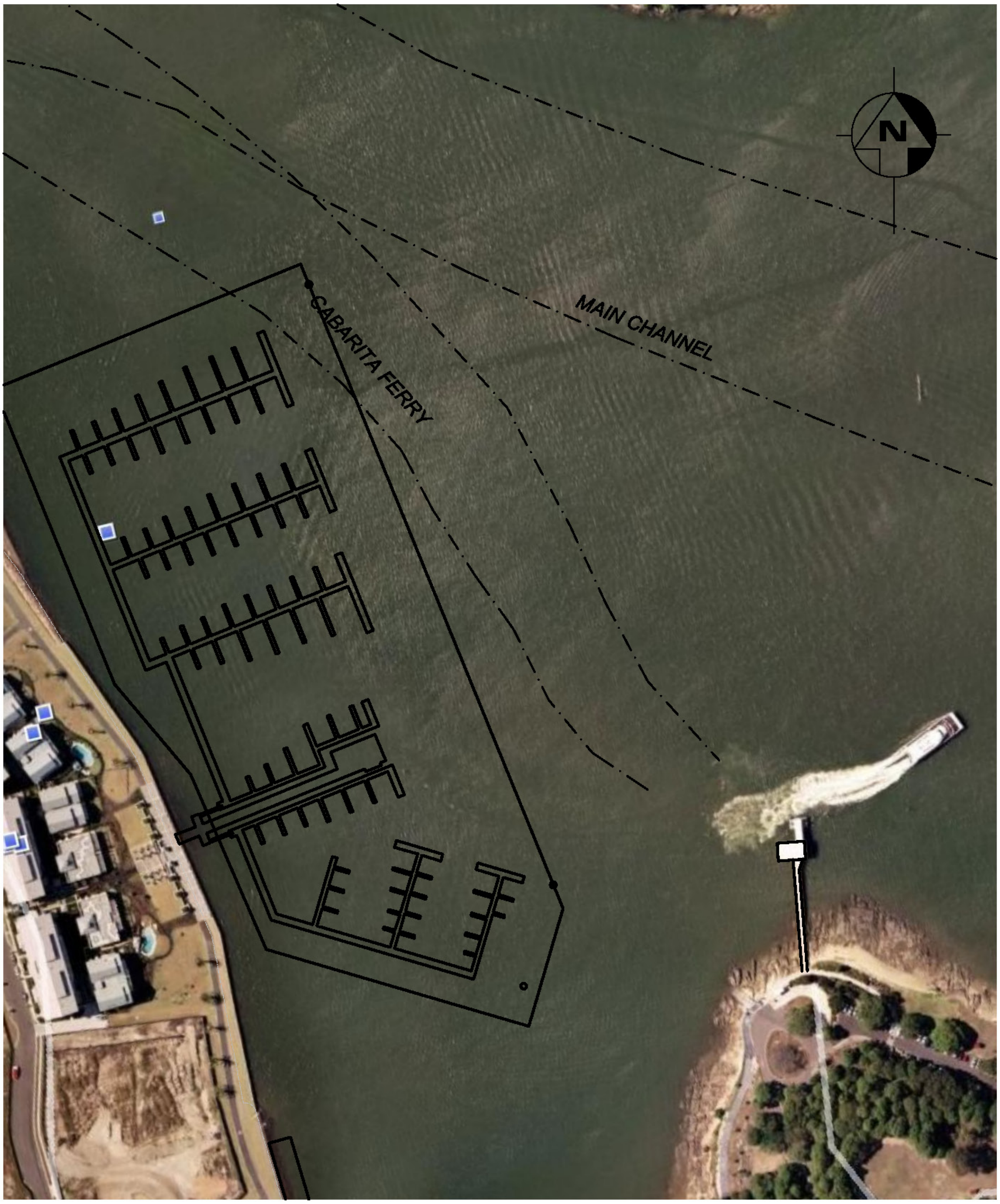
J07–16–1/R80
Plot Date 8/7/09

WIND WAVE
FETCHES

FIGURE 5



NOTES

1. BASE PHOTO GOOGELE EARTH PRO 4/09
2. NAVIGATION CHANNELS FROM OBSERVATION
3. MARINA LAYOUT FROM TLB SK–18, 20/3/09

0 100m

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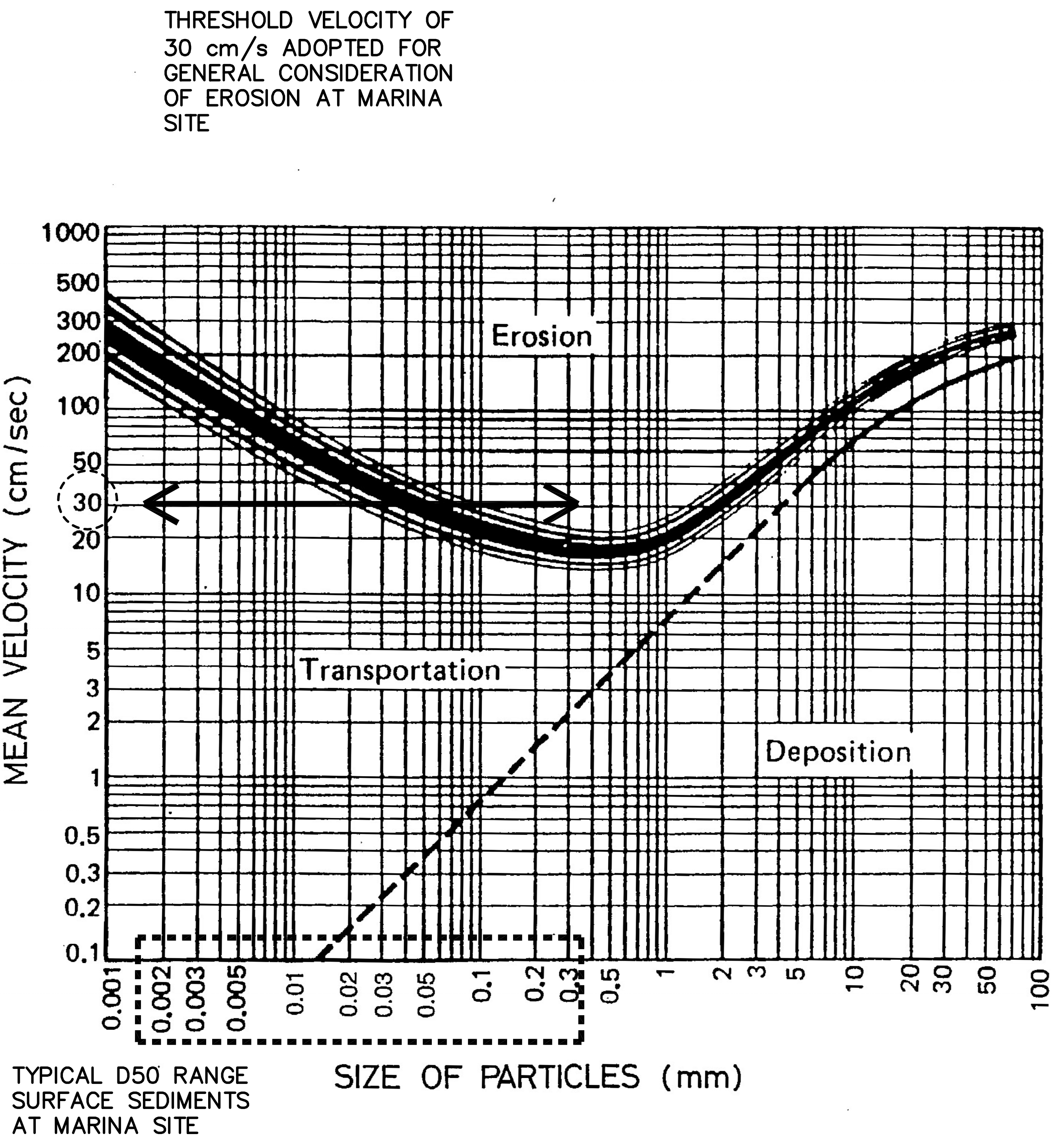
J07–16–1/R80
Plot Date 20/9/09

EXISTING VESSEL
NAVIGATION PATHS



SOURCE HJULSTROM (1939)

GENERALIZED RELATIONSHIP BETWEEN AVERAGE CURRENT VELOCITY AND SEDIMENTARY BEHAVIOUR

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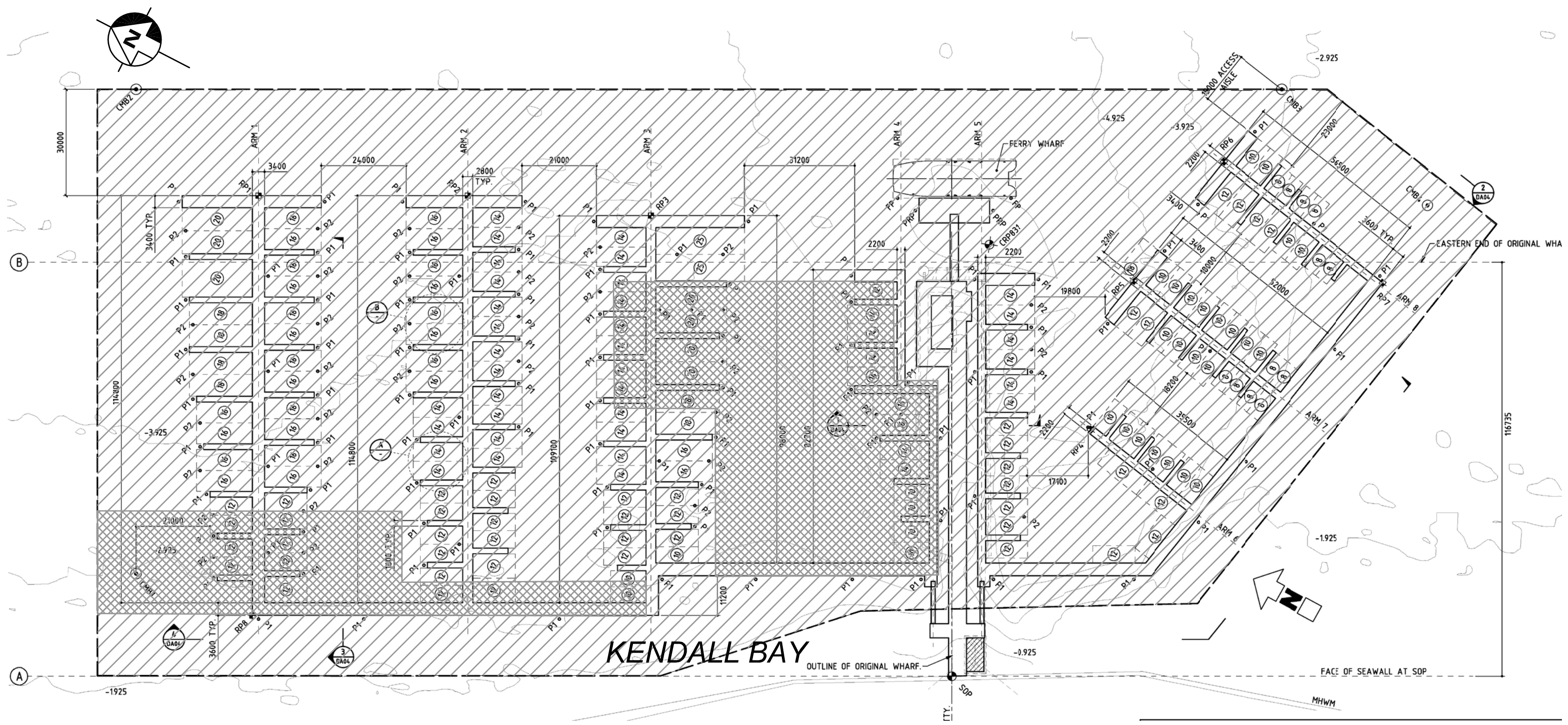
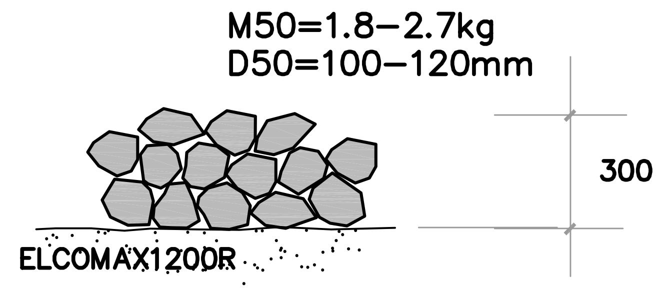
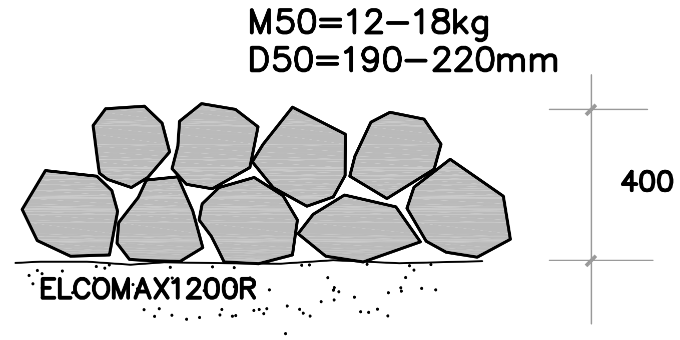
J07–16–1/R80
Plot Date 8/7/09

FIGURE 7



0 50m





400 THICK SCOUR BLANKET

300 THICK SCOUR BLANKET

NOTES

1. MARINA LAYOUT FROM TLB DA03 REC 8/7/09

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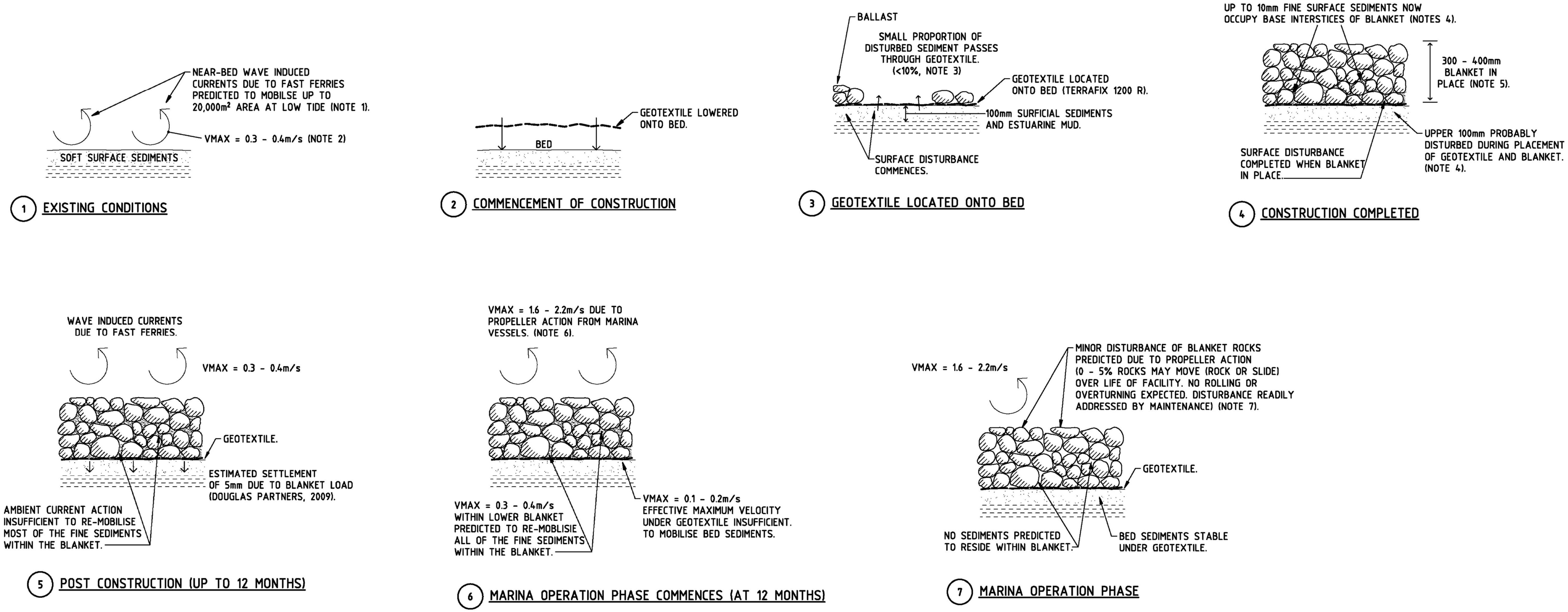
J07–16–1/R80
Plot Date 8/7/09

CONCEPT ARRANGEMENT FOR
SCOUR BLANKET



NOTES

NOTE 1. 19,100m² AREA LOCATED IN DEPTHS <2.8m FOR SWL=RL-0.5m AHD EXPOSED TO NEAR-BED VMAX >0.3m/s (REFER TO APPENDIX E).

NOTE 2. FAST FERRY WAVES DOMINATE MAXIMUM EXISTING HORIZONTAL WAVE-INDUCED CURRENTS AT BED (REFER TO TABLE 5.6).

NOTE 3. <10% IS CONSERVATIVE BASED ON AVERAGE OF 0.7% AND 19% FROM GTS TESTING (APPENDIX B) AND GBAC OPINION THAT 0.7% RESULT. IS LIKELY TO BE MORE REPRESENTATIVE THAT 19% RESULT. (REFER TO SECTION 5.5.2, CONSTRUCTION).

NOTE 4. "UP TO 10mm" FROM <10% x 100mm PROBABLE THICKNESS OF DISTURBANCE OF SURFICIAL SEDIMENTS FROM DOUGLAS PARTNERS (2009).

NOTE 5. DESIGN THICKNESS FOR SCOUR PROTECTION BLANKET ASSUMING ROCK DRY DENSITY OF 2.7t/m³ (REFER TO TABLE 5.12).

NOTE 6. DESIGN AXIAL VELOCITY AT TOP OF BLANKET (REFER TO TABLE 5.11 AND TABLE 5.12).

NOTE 7. LEVEL OF DISTURBANCE TO BLANKET ROCKS ASSESSED FROM BASIS OF BLANKET DESIGN METHODOLOGY (SECTION 5.5.2, MARINA OPERATION PHASE, INFLUENCE OF PROPELLER WASH AT BED AND MITIGATION MEASURES, PROTECTIVE ROCK REQUIREMENTS: ROCK SIZE, BLANKET THICKNESS AND FOOTPRINT) AND CONSIDERATION OF DESIGN RELIABILITY (SECTION 6).

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Plot Date 20/9/09

CONCEPTUAL MODEL OF BED DISTURBANCE AND PROTECTION AT INNER WEST MARINA

APPENDIX

APPENDIX A

WAVE CLIMATE COMPLIANCE CHECK WITHIN PROPOSED MARINA

	Arm No	Critical Berths	Vessel Length	Controlling Wave Condition	Controlling Combined Design Incident Wave Conditions					Direction rel to berth	Pontoon width	Pontoon draft	Kt		Transmitted wave height		Acceptable wave heights for moderate climate [4]		Complies? **OK/Fails**	
					Compass Direction	1 yr		50 yr					1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr
			(m)			Hs (m)	T (s)	Hs (m)	T (s)		(m)	(m)			(m)	(m)	(m)	(m)		
Northern Arm	1	172	20	Wind	N	0.61	1.6	0.53	2.0	Head	2.8	0.4	0.40	0.50	0.24	0.27	0.38	0.75	**OK**	**OK**
				Boat	N	0.26	2.2			Head	2.8	0.4	0.53		0.14		0.38		**OK**	
				Boat	N	0.31	7.0			Head	2.8	0.4	1.00		0.31		0.38		**OK**	
	1	161	12	Wind	N	0.61	1.6	0.53	2.0	Head	2.8	0.4	0.40	0.50	0.24	0.27	0.38	0.75	**OK**	**OK**
				Boat	N	0.26	2.2			Head	2.8	0.4	0.53		0.14		0.38		**OK**	
				Boat	N	0.31	7.0			Head	2.8	0.4	1.00		0.31		0.38		**OK**	
Central Areas	2	140	16	Wind	E [1]	0.69	1.9	0.65	2.2	Oblique	2.8	0.4	0.49	0.53	0.34	0.34	0.38	0.75	**OK**	**OK**
		(or 122)	(or 14) [2]	Boat	E	0.35	2.2			Oblique	2.8	0.4	0.53		0.19		0.38		**OK**	
				Boat	E	0.32	7.0			Oblique	2.8	0.4	1.00		0.32		0.38		**OK**	
	3	98	25	Wind	E [1]	0.69	1.9	0.65	2.2	Oblique	2.8	0.4	0.49	0.53	0.34	0.34	<0.38	0.5	**OK**	**OK**
				Boat	E	0.35	2.2			Oblique	2.8	0.4	0.53		0.19		0.38		**OK**	
				Boat	E	0.32	7.0			Oblique	2.8	0.4	1.00		0.32		0.38		**OK**	
	4	72	12	Wind	E [1]	0.69	1.9	0.65	2.2	Oblique	2.8	0.4	0.49	0.53	0.34	0.34	<0.38	0.5	**OK**	**OK**
				Boat	E	0.35	2.2			Oblique	2.8	0.4	0.53		0.19		0.38		**OK**	
				Boat	E	0.32	7.0			Oblique	2.8	0.4	1.00		0.32		0.38		**OK**	
South of Jetty	5	59	14	Wind	NE	0.69	1.7	0.56	2.0	Oblique	2.8	0.4	0.41	0.50	0.28	0.28	<0.38	0.5	**OK**	**OK**
				Boat	NE	0.31	2.2			Oblique	2.8	0.4	0.53		0.16		0.38		**OK**	
				Boat	NE	0.31	7.0			Oblique	2.8	0.4	1.00		0.31		0.38		**OK**	
	7 [3]	24 [3]	12	Wind	NE	0.69	1.7	0.56	2.0	Beam	2.8	0.4	0.41	0.50	0.28	0.28	0.38	0.19	**OK**	**Fails**
				Boat	NE	0.31	2.2			Beam	2.8	0.4	0.53		0.16		0.19		**OK**	
				Boat	NE	0.31	7.0			Beam	2.8	0.4	1.00		0.31		0.19		**Fails**	
Notes	(1)	E controls over NE																		
	(2)	Same as Berth 104 on Arm 3																		
	(3)	Same as Berth 8 on Arm 8																		
	(4)	From AS3962																		

	Arm No	Critical Berths	Vessel Length	Controlling Wave Condition	Controlling Combined Design Incident Wave Conditions					Direction rel to berth	Pontoon width	Pontoon draft	Kt		Transmitted wave height		Acceptable wave heights for moderate climate [4]		Complies? **OK/Fails**	
					Compass Direction	1 yr		50 yr					1 yr	50 yr	1 yr	50 yr	1 yr	50 yr	1 yr	50 yr
			(m)			Hs (m)	T (s)	Hs (m)	T (s)		(m)	(m)			(m)	(m)	(m)	(m)		
Northern Arm	1	172	20	Wind	N	0.61	1.6	0.53	2.0	Head	2.8	0.6	0.22	0.34	0.13	0.18	0.38	0.75	**OK**	**OK**
				Boat	N	0.26	2.2			Head	2.8	0.6	0.36		0.09		0.38		**OK**	
				Boat	N	0.31	7.0			Head	2.8	0.6	1.00		0.31		0.38		**OK**	
	1	161	12	Wind	N	0.61	1.6	0.53	2.0	Head	2.8	0.6	0.22	0.34	0.13	0.18	0.38	0.75	**OK**	**OK**
				Boat	N	0.26	2.2			Head	2.8	0.6	0.36		0.09		0.38		**OK**	
				Boat	N	0.31	7.0			Head	2.8	0.6	1.00		0.31		0.38		**OK**	
Central Areas	2	140	16	Wind	E [1]	0.69	1.9	0.65	2.2	Oblique	2.8	0.6	0.32	0.36	0.22	0.23	0.38	0.75	**OK**	**OK**
		(or 122)	(or 14) [2]	Boat	E	0.35	2.2			Oblique	2.8	0.6	0.36		0.13		0.38		**OK**	
				Boat	E	0.32	7.0			Oblique	2.8	0.6	1.00		0.32		0.38		**OK**	
	3	98	25	Wind	E [1]	0.69	1.9	0.65	2.2	Oblique	2.8	0.6	0.32	0.36	0.22	0.23	<0.38	0.5	**OK**	**OK**
				Boat	E	0.35	2.2			Oblique	2.8	0.6	0.36		0.13		0.38		**OK**	
				Boat	E	0.32	7.0			Oblique	2.8	0.6	1.00		0.32		0.38		**OK**	
	4	72	12	Wind	E [1]	0.69	1.9	0.65	2.2	Oblique	2.8	0.6	0.32	0.36	0.22	0.23	<0.38	0.5	**OK**	**OK**
				Boat	E	0.35	2.2			Oblique	2.8	0.6	0.36		0.13		0.38		**OK**	
				Boat	E	0.32	7.0			Oblique	2.8	0.6	1.00		0.32		0.38		**OK**	
South of Jetty	5	59	14	Wind	NE	0.69	1.7	0.56	2.0	Oblique	2.8	0.6	0.27	0.34	0.19	0.19	<0.38	0.5	**OK**	**OK**
				Boat	NE	0.31	2.2			Oblique	2.8	0.6	0.36		0.11		0.38		**OK**	
				Boat	NE	0.31	7.0			Oblique	2.8	0.6	1.00		0.31		0.38		**OK**	
	7 [3]	24 [3]	12	Wind	NE	0.69	1.7	0.56	2.0	Beam	2.8	0.6	0.27	0.34	0.19	0.19	0.38	0.19	**OK**	**OK**
				Boat	NE	0.31	2.2			Beam	2.8	0.6	0.36		0.11		0.19		**OK**	
				Boat	NE	0.31	7.0			Beam	2.8	0.6	1.00		0.31		0.19		**Fails**	

Notes
(1) E controls over NE
(2) Same as Berth 104 on Arm 3
(3) Same as Berth 8 on Arm 8
(4) From AS3962

APPENDIX B

HYDRODYNAMIC SIEVE AND STATIC SUBMERSION TESTS OF ELCOMAX 1200R AND TTF750 GEOTEXTILES (GEOSYNTHETIC TESTING SERVICES)

Appendix B - Hydrodynamic Sieve And Static Submersion Tests Of Elcomax 1200r and TTF750 Geotextiles (Geosynthetic Testing Services)

Geosynthetic Testing Services (GTS) undertook hydrodynamic sieve and static submersion tests of the Elcomax 1200R geotextile to gauge its capacity for retention of the bed sediments. Four samples were collected for testing by Cardno Ecology Lab *(CEL)*, selected as broadly representing the range of bed sediment types observed at the marina site and also as occupying the zone of the marina area considered particularly contaminated *(intermediate water depths on the northern side of the former jetty)*.

The GST test samples correlate with the CEL field samples as follows:

GST Refernces	**CEL Refence**
GT1	Piston Core 1 (approx top 100 cm)
GT2	Piston Core 9 (approx top 100 cm)
GT3	BG5
GT4	SG8 plus some from PC15

Hydrodynamic sieve testing involving some 2,300 cycles of emersion *(7 s)* followed by drainage *(30 s)* over 24 hours, of a 100 mm diameter geotextile swatch containing a 20 mm thick sample of bed sediment, resulted in 6 to 32 % passing of the sediment sample *(average 19%).* Static testing involving 48 hours of emersion without movement resulted in 0.2 to 1.3 % passing *(average 0.7%)*.

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-1**

CLIENT: **Geofabrics Australasia Pty Ltd**

ISSUE DATE: **3rd July 2009**

ATTENTION: **Warren Hornsey**
Geofabrics Australasia Pty Ltd

Dear Sir,

Please find the following test report for testing performed on the samples supplied.

1. SAMPLE DESCRIPTION

1 Sludge sample, identified as:

- 2467-1 GT1, Breakfast Point Marina, 33Y0809

2 Non Woven samples, identified as:

- 2467-A 1200R
- 2467-B TTF750

2. TEST METHODS

Test Method	Standard	2467-1A	2467-1B
Hydrodynamic Sieve Test % Passing	NFG 38-017 (Modified)	5.78%	36.26%
Static Submersion Test % Passing	In House	0.51%	0.36%

Note: The above test methods are not NATA accredited.

For and on behalf of
GEOSYNTHETIC TESTING SERVICES

Natalie Bell
Laboratory Manager

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

CLIENT: **Geofabrics Australasia Pty Ltd**

TERMS AND CONDITIONS UNDER WHICH THIS TEST REPORT IS ISSUED

Geosynthetic Testing Services is accredited by the NATIONAL ASSOCIATION OF TESTING AUTHORITIES (NATA) to perform specific tests. However, it should be noted that:

(i) This test report is prepared based on the test(s) requested by the customer on the specific samples submitted to Geosynthetic Testing Services. Results quoted on test reports refer only to the samples submitted by the customer.

(ii) NATA endorsed tests are conducted in full compliance with the applicable Standard test method and reports are issued in accordance with NATA's terms of accreditation.

(iii) Any opinion, interpretation or comments expressed in this report or in relation to this report are outside the scope of NATA accreditation. Geosynthetic Testing Services accepts no responsibility for the interpretation of test results, no warranty is granted - implied or otherwise. We shall not be liable for any subsequent loss or damage incurred by the customer as a result of information supplied.

(iv) Tests not covered by NATA accreditation are performed in accordance with the referenced Standard test method without modification unless noted on the applicable test report.

(v) All test reports are confidential to the customer and will not be issued by us to any third party unless written authorisation is issued by the customer.

(vi) Customers wishing to copy any report must obtain written permission from us on each occasion. Only complete test reports (including cover pages and information relevant to the report) can be copied and passed to third parties. No omissions or additions are allowed. Results supplied in our reports shall not be used in advertising or promotional literature without our written permission.

(vii) Faxed copies of test reports will be sent where specified by the customer, however, these reports must be destroyed once the original reports are received by the customer.

(viii) The customer shall always inform us at the outset if the testing requested is known to be required for the purpose of litigation. If the report is required as evidence in a court of law, ample advance notification is required in order to provide time for legal advice and/or consideration of all relevant documentation. We must be shown full particulars of any claim which is to be pursued or defended.

(ix) We shall endeavour to complete testing promptly, however we will not accept liability for any loss arising from the delay in production of test results.

(x) Samples supplied by the customer shall be retained by Geosynthetic Testing Services for a period of one (1) month from the date of testing, after which the samples will be disposed of unless otherwise requested by the customer.

Effective: 1st January 1996

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-1A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE: 1200R SLUDGE ID: GT1
START DATE: 01-06-2009 START TIME: 12:45pm
END DATE: 02-06-2009 END TIME: 12:45pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**41.30%**

Sample Number:	(1)		(2)	
Initial Weight of Wet Sludge:	231.04	g	219.64	g
Adjusted using Moisture Content:	135.62	g	128.93	g
Weight of Dried Sludge Passing:	5.26	g	7.14	g
Weight of Dried Sludge Retained:	103.19	g	99.42	g
USING DRIED END PORTIONS				
% Passing	4.85	%	6.70	%

AVERAGE % PASSING	**5.78**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 29% error.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-1A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE: 1200R
START DATE: 15-06-2009
END DATE: 17-06-2009

SLUDGE ID: GT1
START TIME: 3:10pm
END TIME: 3:10pm

CYCLE IN WATER: 48 hours without movement

TESTED BY: N.Bell
SPECIMEN FACE: N/A

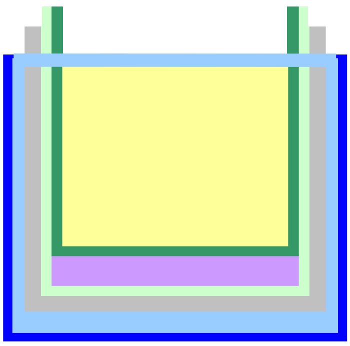
SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**41.3%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	231.64 g	255.39 g
Adjusted using Moisture Content:	135.97 g	149.91 g
Weight of Dried Sludge Passing:	0.59 g	0.64 g
Weight of Dried Sludge Retained:	111.10 g	130.16 g
USING DRIED END PORTIONS		
% Passing	0.53 %	0.49 %

AVERAGE % PASSING	**0.51**

DIAGRAM OF TEST SETUP:



Key:
- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- 1200R Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 29% error.
Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

GEOSYNTHETIC TESTING SERVICES TEST REPORT

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

Our Reference: **2467-1B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE:	TTF750	SLUDGE ID:	GT1
START DATE:	09-06-2009	START TIME:	5pm
END DATE:	10-06-2009	END TIME:	5pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**41.30%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	233.47 g	210.12 g
Adjusted using Moisture Content:	137.05 g	123.34 g
Weight of Dried Sludge Passing:	36.66 g	41.22 g
Weight of Dried Sludge Retained:	77.18 g	61.03 g
USING DRIED END PORTIONS		
% Passing	32.20 %	40.31 %

AVERAGE % PASSING	**36.26**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 29% error.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-1B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE:	TTF750	SLUDGE ID:	GT1
START DATE:	15-06-2009	START TIME:	3:10pm
END DATE:	17-06-2009	END TIME:	3:10pm
CYCLE IN WATER:	48 hours without movement		

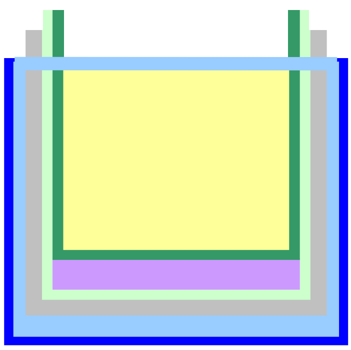
TESTED BY:	N.Bell		
SPECIMEN FACE:	Non Woven Side Up	SPECIMEN CONDITIONING:	Atmospheric

Average Moisture Content	**41.30%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	200.63 g	225.72 g
Adjusted using Moisture Content:	117.77 g	132.50 g
Weight of Dried Sludge Passing:	0.32 g	0.67 g
Weight of Dried Sludge Retained:	95.75 g	170.85 g
USING DRIED END PORTIONS		
% Passing	0.33 %	0.39 %

AVERAGE % PASSING	**0.36**

DIAGRAM OF TEST SETUP:



Key:

- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- TTF750 Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 29% error.

Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

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GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-2**

CLIENT: **Geofabrics Australasia Pty Ltd**

ISSUE DATE: **3rd July 2009**

ATTENTION: **Warren Hornsey**
Geofabrics Australasia Pty Ltd

Dear Sir,

Please find the following test report for testing performed on the samples supplied.

1. SAMPLE DESCRIPTION

1 Sludge sample, identified as:

- 2467-1 GT2, Breakfast Point Marina, 33Y0809

2 Non Woven samples, identified as:

- 2467-A 1200R
- 2467-B TTF750

2. TEST METHODS

Test Method	Standard	2467-2A	2467-2B
Hydrodynamic Sieve Test % Passing	NFG 38-017 (Modified)	31.90%	39.00%
Static Submersion Test % Passing	In House	1.31%	0.72%

Note: The above test methods are not NATA accredited.

For and on behalf of
GEOSYNTHETIC TESTING SERVICES

Natalie Bell
Laboratory Manager

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

CLIENT: **Geofabrics Australasia Pty Ltd**

TERMS AND CONDITIONS UNDER WHICH THIS TEST REPORT IS ISSUED

Geosynthetic Testing Services is accredited by the NATIONAL ASSOCIATION OF TESTING AUTHORITIES (NATA) to perform specific tests. However, it should be noted that:

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Effective: 1st January 1996

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GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-2A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE: 1200R SLUDGE ID: GT2
START DATE: 01-06-2009 START TIME: 12:45pm
END DATE: 02-06-2009 END TIME: 12:45pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**45.10%**

Sample Number:	(1)		(2)	
Initial Weight of Wet Sludge:	221.44	g	218.67	g
Adjusted using Moisture Content:	121.57	g	120.05	g
Weight of Dried Sludge Passing:	31.25	g	33.30	g
Weight of Dried Sludge Retained:	69.49	g	68.30	g
USING DRIED END PORTIONS				
% Passing	31.02	%	32.78	%

AVERAGE % PASSING	**31.90**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 19% error.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-2A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE: 1200R SLUDGE ID: GT2
START DATE: 02-06-2009 START TIME: 5pm
END DATE: 04-06-2009 END TIME: 5pm

CYCLE IN WATER: 48 hours without movement

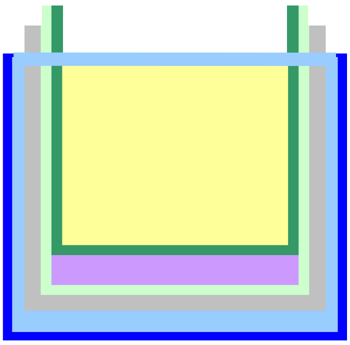
TESTED BY: N.Bell
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**45.10%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	225.01 g	251.93 g
Adjusted using Moisture Content:	123.53 g	138.31 g
Weight of Dried Sludge Passing:	1.11 g	1.93 g
Weight of Dried Sludge Retained:	122.55 g	110.21 g
USING DRIED END PORTIONS		
% Passing	0.90 %	1.72 %

AVERAGE % PASSING	**1.31**

DIAGRAM OF TEST SETUP:



Key:
- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- 1200R Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 19% error.
Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-2B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE:	TTF750	SLUDGE ID:	GT2
START DATE:	01 & 11-06-2009	START TIME:	12:45pm & 4:30pm
END DATE:	02 & 12-06-2009	END TIME:	12:45pm & 4:30pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**45.10%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	208.24 g	213.41 g
Adjusted using Moisture Content:	114.32 g	117.16 g
Weight of Dried Sludge Passing:	33.86 g	42.19 g
Weight of Dried Sludge Retained:	60.76 g	57.74 g
USING DRIED END PORTIONS		
% Passing	35.79 %	42.22 %

AVERAGE % PASSING	**39.00**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10μm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 19% error.

INSPECTING OFFICER: [signature]
Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-2B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE: TTF750 SLUDGE ID: GT2
START DATE: 15-06-2009 START TIME: 3:10pm
END DATE: 17-06-2009 END TIME: 3:10pm
CYCLE IN WATER: 48 hours without movement

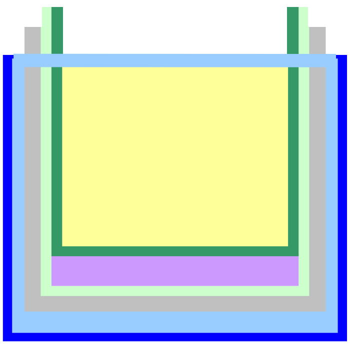
TESTED BY: N.Bell
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**45.10%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	226.89 g	221.86 g
Adjusted using Moisture Content:	124.56 g	121.80 g
Weight of Dried Sludge Passing:	0.67 g	0.84 g
Weight of Dried Sludge Retained:	106.44 g	103.19 g
USING DRIED END PORTIONS		
% Passing	0.63 %	0.81 %

AVERAGE % PASSING	**0.72**

DIAGRAM OF TEST SETUP:



Key:
- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- TTF750 Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 19% error.

Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-3**

CLIENT: **Geofabrics Australasia Pty Ltd**

ISSUE DATE: **3rd July 2009**

ATTENTION: **Warren Hornsey**
Geofabrics Australasia Pty Ltd

Dear Sir,

Please find the following test report for testing performed on the samples supplied.

1. SAMPLE DESCRIPTION

1 Sludge sample, identified as:

- 2467-3 GT3, Breakfast Point Marina, 33Y0809

2 Non Woven samples, identified as:

- 2467-A 1200R
- 2467-B TTF750

2. TEST METHODS

Test Method	Standard	2467-3A	2467-3B
Hydrodynamic Sieve Test % Passing	NFG 38-017 (Modified)	32.83%	38.45%
Static Submersion Test % Passing	In House	0.86%	0.33%

Note: The above test methods are not NATA accredited.

For and on behalf of
GEOSYNTHETIC TESTING SERVICES

Natalie Bell
Laboratory Manager

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

CLIENT: **Geofabrics Australasia Pty Ltd**

TERMS AND CONDITIONS UNDER WHICH THIS TEST REPORT IS ISSUED

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Effective: 1st January 1996

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-3A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE:	1200R	SLUDGE ID:	GT3
START DATE:	11-06-2009	START TIME:	4:30pm
END DATE:	12-06-2009	END TIME:	4:30pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**43.50%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	220.66 g	233.25 g
Adjusted using Moisture Content:	124.67 g	131.79 g
Weight of Dried Sludge Passing:	32.12 g	37.29 g
Weight of Dried Sludge Retained:	67.69 g	74.08 g
USING DRIED END PORTIONS		
% Passing	32.18 %	33.48 %

AVERAGE % PASSING	**32.83**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10μm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 29% error.

INSPECTING OFFICER: Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-3A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE: 1200R SLUDGE ID: GT3
START DATE: 17-06-2009 START TIME: 5pm
END DATE: 19-06-2009 END TIME: 5pm

CYCLE IN WATER: 48 hours without movement

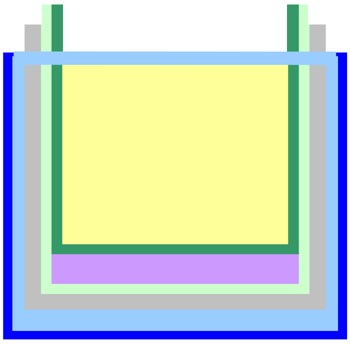
TESTED BY: N.Bell
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**43.50%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	200.25 g	248.74 g
Adjusted using Moisture Content:	113.14 g	140.54 g
Weight of Dried Sludge Passing:	1.55 g	0.88 g
Weight of Dried Sludge Retained:	131.34 g	159.71 g
USING DRIED END PORTIONS		
% Passing	1.16 %	0.55 %

AVERAGE % PASSING	**0.86**

DIAGRAM OF TEST SETUP:



Key:
- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- 1200R Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 29% error.
Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:
Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-3B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE:	TTF750	SLUDGE ID:	GT3
START DATE:	11-06-2009	START TIME:	4:30pm
END DATE:	12-06-2009	END TIME:	4:30pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**43.50%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	237.85 g	253.89 g
Adjusted using Moisture Content:	134.39 g	143.45 g
Weight of Dried Sludge Passing:	46.44 g	41.95 g
Weight of Dried Sludge Retained:	64.10 g	78.28 g
USING DRIED END PORTIONS		
% Passing	42.01 %	34.89 %

AVERAGE % PASSING	**38.45**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 29% error.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-3B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE:	TTF750	SLUDGE ID:	GT3
START DATE:	17-06-2009	START TIME:	5pm
END DATE:	19-06-2009	END TIME:	5pm
CYCLE IN WATER:	48 hours without movement		

TESTED BY: N.Bell

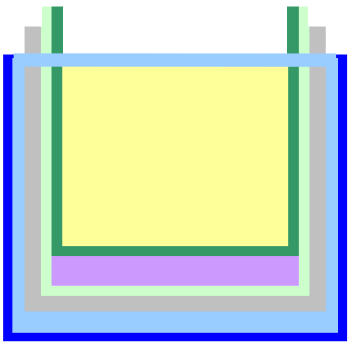
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**43.50%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	219.33 g	208.99 g
Adjusted using Moisture Content:	123.92 g	118.08 g
Weight of Dried Sludge Passing:	0.33 g	0.31 g
Weight of Dried Sludge Retained:	92.88 g	99.20 g
USING DRIED END PORTIONS		
% Passing	0.35 %	0.31 %

AVERAGE % PASSING	**0.33**

DIAGRAM OF TEST SETUP:



Key:

- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- TTF750 Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 29% error.

Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 03 / 07 / 2009

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GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-4**

CLIENT: **Geofabrics Australasia Pty Ltd**

ISSUE DATE: **1st July 2009**

ATTENTION: **Warren Hornsey**
Geofabrics Australasia Pty Ltd

Dear Sir,

Please find the following test report for testing performed on the samples supplied.

1. SAMPLE DESCRIPTION

1 Sludge sample, identified as:

- 2467-4 GT4, Contaminated Sediments from SGS & PCIAor15

2 Non Woven samples, identified as:

- 2467-A 1200R
- 2467-B TTF750

2. TEST METHODS

Test Method	Standard	2467-4A	2467-4B
Hydrodynamic Sieve Test % Passing	NFG 38-017 (Modified)	6.32 %	7.70 %
Static Submersion Test % Passing	In House	0.21 %	0.20 %

Note: The above test methods are not NATA accredited.

For and on behalf of
GEOSYNTHETIC TESTING SERVICES

Natalie Bell
Laboratory Manager

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

TERMS AND CONDITIONS UNDER WHICH THIS TEST REPORT IS ISSUED

Geosynthetic Testing Services is accredited by the NATIONAL ASSOCIATION OF TESTING AUTHORITIES (NATA) to perform specific tests. However, it should be noted that:

(i) This test report is prepared based on the test(s) requested by the customer on the specific samples submitted to Geosynthetic Testing Services. Results quoted on test reports refer only to the samples submitted by the customer.

(ii) NATA endorsed tests are conducted in full compliance with the applicable Standard test method and reports are issued in accordance with NATA's terms of accreditation.

(iii) Any opinion, interpretation or comments expressed in this report or in relation to this report are outside the scope of NATA accreditation. Geosynthetic Testing Services accepts no responsibility for the interpretation of test results, no warranty is granted - implied or otherwise. We shall not be liable for any subsequent loss or damage incurred by the customer as a result of information supplied.

(iv) Tests not covered by NATA accreditation are performed in accordance with the referenced Standard test method without modification unless noted on the applicable test report.

(v) All test reports are confidential to the customer and will not be issued by us to any third party unless written authorisation is issued by the customer.

(vi) Customers wishing to copy any report must obtain written permission from us on each occasion. Only complete test reports (including cover pages and information relevant to the report) can be copied and passed to third parties. No omissions or additions are allowed. Results supplied in our reports shall not be used in advertising or promotional literature without our written permission.

(vii) Faxed copies of test reports will be sent where specified by the customer, however, these reports must be destroyed once the original reports are received by the customer.

(viii) The customer shall always inform us at the outset if the testing requested is known to be required for the purpose of litigation. If the report is required as evidence in a court of law, ample advance notification is required in order to provide time for legal advice and/or consideration of all relevant documentation. We must be shown full particulars of any claim which is to be pursued or defended.

(ix) We shall endeavour to complete testing promptly, however we will not accept liability for any loss arising from the delay in production of test results.

(x) Samples supplied by the customer shall be retained by Geosynthetic Testing Services for a period of one (1) month from the date of testing, after which the samples will be disposed of unless otherwise requested by the customer.

Effective: 1st January 1996

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-4A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE:	1200R	SLUDGE ID:	GT4
START DATE:	01-06-2009	START TIME:	12:45pm
END DATE:	02-06-2009	END TIME:	12:45pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**44 .0%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	232.77 g	218.55 g
Adjusted using Moisture Content:	130.35 g	122.39 g
Weight of Dried Sludge Passing:	6.98 g	6.68 g
Weight of Dried Sludge Retained:	105.01 g	97.47 g
USING DRIED END PORTIONS		
% Passing	6.23 %	6.41 %

AVERAGE % PASSING	**6.32**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10μm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 15% error.

INSPECTING OFFICER: Natalie Bell
Laboratory Manager

DATE: 01 / 07 / 2009

79 Boronia Street, Albury NSW 2640 Australia; PO Box 590, Lavington NSW 2641 Australia; PH: (612) 6022 7913 FAX: (612) 6040 4870

GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-4A**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE:	1200R	SLUDGE ID:	GT4
START DATE:	02-06-2009	START TIME:	5pm
END DATE:	04-06-2009	END TIME:	5pm

CYCLE IN WATER: 48 hours without movement

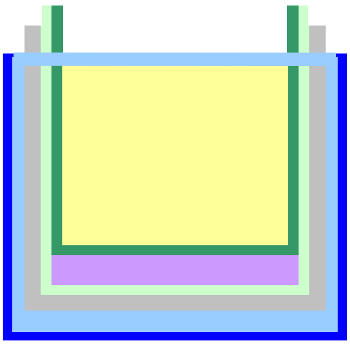
TESTED BY: N.Bell
SPECIMEN FACE: N/A SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**44 .0%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	233.10 g	243.01 g
Adjusted using Moisture Content:	130.54 g	136.09 g
Weight of Dried Sludge Passing:	0.19 g	0.32 g
Weight of Dried Sludge Retained:	117.82 g	124.13 g
USING DRIED END PORTIONS		
% Passing	0.16 %	0.26 %

AVERAGE % PASSING	**0.21**

DIAGRAM OF TEST SETUP:



Key:
- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- 1200R Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 15% error.
Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:

Natalie Bell
Laboratory Manager

DATE: 01 / 07 / 2009

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GEOSYNTHETIC TESTING SERVICES TEST REPORT

Our Reference: **2467-4B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Determination of the Filtration Aperture – Hydrodynamic Sieve (Modified) NFG 38-017 - 1989

PRODUCT CODE:	TTF750	SLUDGE ID:	GT4
START DATE:	09-06-2009	START TIME:	5pm
END DATE:	10-06-2009	END TIME:	5pm

CYCLE IN WATER: Drainage time of 30 seconds, immersion time of 7 seconds for 24 hours

TESTED BY: N.Bell & J.McPhee
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**44 .0%**

Sample Number:	(1)	(2)
Initial Weight of Wet Sludge:	201.24 g	207.99 g
Adjusted using Moisture Content:	112.69 g	116.47 g
Weight of Dried Sludge Passing:	8.81 g	8.55 g
Weight of Dried Sludge Retained:	106.14 g	101.91 g
USING DRIED END PORTIONS		
% Passing	7.66 %	7.74 %

AVERAGE % PASSING	**7.70**

VARIATIONS TO TEST METHOD: Several variations to the test method were adapted – supplied sludge was used instead of graded sand, sludge was weighed and used wet at the start of the test instead of dried, a moisture content was conducted, the wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point, 2 specimens were tested instead of 6, results are presented in % passing instead of aperture size, and passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

COMMENTS: Due to the nature of the test there was an approximate 15% error.

INSPECTING OFFICER: Natalie Bell
Laboratory Manager

DATE: 01 / 07 / 2009

GEOSYNTHETIC TESTING SERVICES TEST REPORT

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Our Reference: **2467-4B**

CLIENT: **Geofabrics Australasia Pty Ltd**

Static Submersion Test
In House Method

PRODUCT CODE: TTF750 SLUDGE ID: GT4
START DATE: 02-06-2009 START TIME: 5pm
END DATE: 04-06-2009 END TIME: 5pm
CYCLE IN WATER: 48 hours without movement

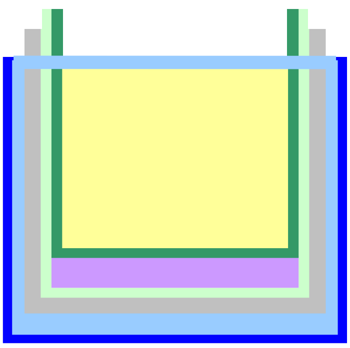
TESTED BY: N.Bell
SPECIMEN FACE: Non Woven Side Up SPECIMEN CONDITIONING: Atmospheric

Average Moisture Content	**44 .0%**

Sample Number:	(1)		(2)	
Initial Weight of Wet Sludge:	223.30	g	218.72	g
Adjusted using Moisture Content:	125.05	g	122.48	g
Weight of Dried Sludge Passing:	0.36	g	0.12	g
Weight of Dried Sludge Retained:	124.99	g	109.34	g
USING DRIED END PORTIONS				
% Passing	0.29	%	0.11	%

AVERAGE % PASSING	**0.20**

DIAGRAM OF TEST SETUP:



Key:
- Water
- 100mm Cover of Coarse Sand
- A64 Sample
- TTF750 Specimen
- Sludge
- Inner Support Pan with mesh bottom
- Outer Collection Pan

COMMENTS: Due to the nature of the test there was an approximate 15% error.

Wet sludge sample had to be washed onto the clamped fabric specimen at the beginning of the test which may have accelerated the test as a very small amount of sludge particles were visibly passing through the fabric at this point. Passing water and suspended sludge had to be filtered through filter paper which would have removed any particles < 10µm from the end result.

INSPECTING OFFICER:
Natalie Bell
Laboratory Manager

DATE: 01 / 07 / 2009

APPENDIX C

GBA TURBIDITY INVESTIGATION NOVEMBER 2007

Gary Blumberg & Associates Pty Ltd
Consulting Engineers
ACN 085 739 322

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Naremburn 2065
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COASTAL, ESTUARY AND RIVER ENGINEERING SPECIALISTS

gpb:gpb/07-16/lr761

2 November, 2007

Taylor Lauder Bersten
514 Millar Street
CAMMERAY NSW 2062

Attention: Mr Howard Bersten

Dear Howard

**BREAKFAST POINT MARINA, KENDAL BAY, PARRAMATTA RIVER
TURBIDITY INVESTIGATION**

We refer to our recent discussions in regard to the above, in particular Gary Blumberg & Associates' *(GBA)* Fee Proposal addressed to Taylor Lauder Bersten (TLB) dated 27/6/07 and Breakfast Point Pty Ltds Minor Consultancy Agreement dated 4/7/07 *(to be amended in accordance with N Jackman's email dated 20/9/07)*. GBA is pleased to report here in this matter, set out under the following main headings:

(1) Introduction
(2) Design and Implementation of Turbidity Investigation
(3) Background Turbidity in Kendal Bay
(4) Turbidity associated with Proposed Marina in Kendal Bay
(5) Impact of Proposed Marina Operations on Background Turbidity in Kendal Bay
(6) Conclusions
(7) References

Note that all reference to Relative Level *(RL)* in this report is in metres, to Zero on the Fort Denison Tide Gauge *(ZFDTG)*. RL 0 is approximately Lowest Astronomical Tide *(LAT).*

URS (2006) defines a Remediation Site adjoining the former AGL gasworks site at Breakfast Point. The Remediation Site occupies a 200 m wide of waterway zone directly adjoining the shoreline. It extends from the south end of Kendal Bay, north around Breakfast Point, and then west to the western boundary of the former AGL site. Since the proposed marina is located within Kendal Bay on the eastern side of Breakfast Point, reference to the Remediation Site in this report is limited to that portion on the eastern side of Breakfast Point. Accordingly, we refer in this report to the Kendal Bay Remediation Site *(KBRS).*

1 INTRODUCTION

The current Breakfast Point Marina proposal entails 179 wet berths located on the western shore of Kendal Bay, Kendal Bay is located on the south shore of the Parramatta River between Cabarita Point and Breakfast Point, approximately midway between Gladesville Bride and Ryde Road Bridge.

Taylor Lauder Bersten *(TLB)* is advising adjoining landownder, Rosecorp Pty Ltd, in relation to the Development Application for the marina and its supporting environmental assessments.

In November 2006, GBA prepared for TLB a preliminary desk-top assessment of bed disturbance caused by propeller wash from vessels to be berthed within the proposed marina, and compared this to long period surge wash attributed to ferry passings. This investigation found that the proposed marina vessels would have a relatively small influence on the overall turbidity climate in Kendal Bay.

Subsequent discussions between TLB and the Department of Environment and Conservation *(DEC)* outlined the need for additional, more detailed advice. A boat wash turbidity investigation was required to provide the further information to address DEC's requirements.

2 DESIGN AND IMPLEMENTATION OF TURBIDITY INVESTIGATION

2.1 Investigation Design

Investigations undertaken by URS for the former adjoining landowner, AGL, found that pollutants reside to varying extents within the sediments comprising the bed of Kendal Bay *(URS, 2006)*. These pollutants attach primarily to the fine fraction of the sediments *(muds and clays)*, and it is this fine fraction which dominates the size of suspended sediments contained within a turbid plume. Thus the generation and advection of turbidity in the bay is a mechanism whereby pollutants may be transported from one point to another which is environmentally undesirable.

The main objective for the boat wash turbidity investigation, developed in consultation with DEC, was to establish whether marina activities are likely to cause any additional resuspension of contaminated sediments over and above that attributed to background processes; wind action, tidal currents and wash from ambient boat traffic.

The investigation would provide a basis to enable any pollutant impacts to be assessed *(eg. pollutant transfer into the waterbody and/or advection and relocation of contaminated fines)*, and if these are found to be significant, to develop an appropriate management response.

GBA assisted TLB in its discussions with DEC and other stakeholder agencies to agree on an acceptable investigation design, documented in GBA letter lr754 finalised 21 August 2007 attached in **Appendix A**. The investigation design covered the following elements:

- investigation objective
- background enquiry and lessons from other investigations
- investigation risks at Kendal Bay
- environmental contingency actions *(to minimise investigation risks)*

Final liaison on investigation details took place with DEC, NSW Department of Commerce and NSW Maritime in August and September 2007. The investigation was scheduled for 25 and 26 September 2007.

2.2 Investigation Implementation

The investigation took place as scheduled. We refer elsewhere in this report to the 25 September 2007 as Day 1, and the 26 September 2007 as Day 2. Selected photographs taken during the field investigation are included at the end of the report.

Weather during the investigation was fine, with light to moderate winds and a mainly falling tide. No rain had fallen in the previous 2 to 3 days. Predicted tide and observed wind conditions at the site *(including estimated 10 minute average wind speed)* are summarised in **Table 1**.

TABLE 1	**TIDE AND WIND CONDITIONS 25-26 SEPTEMBER 2007**
Tide	**Description**
Day 1	High tide RL1.4 at 7.00 am, falling to RL0.35 at 1.00 pm
Day 2	High tide RL 1.6 at 8.00 am, falling to RL0.25 at 2.00 pm
Wind	
Day 1	Calm before 10.30 am, then 4-6 k NE winds to 11.30 am, steadily increasing to 8-12 k to 12.30 am, and then constant 10-12 k to 2.30 pm
Day 2	Calm to < 2 k W winds to 9.30 am. NE sea breeze started 10.30 am, steadily increasing to 8-12 k to 11.30 am, and then constant 10-12 k to 2.30 pm

Detailed weather records from the Bureau of Meteorology for Sydney Olympic Park are provided in **Appendix B.**

GBA retained the services of The Ecology Lab *(EL)* to assist with the turbidity investigation. EL provided a four-man team including a Scientific Diver, two vessels *(5 m dive boat and runabout)*, two portable turbidity meters, two portable depth sounders and a GPS. This was supplemented with a two-man team from GBA, a third work boat, two additional turbidity metres *(one used and one backup)* and an additional GPS.

The work involved running three Test Vessels, representative of those to be berthed at the marina, over varying water depths and monitoring the turbidity released by propeller wash stirring the bed. Details of the three vessels are provided in **Table 2**.

TABLE 2	**VESSELS USED FOR TURBIDITY INVESTIGATION**				
Vessel Descriptor	**Type / Name**	**Length**	**Draft**	**Machinery**	**% Boats in Marina which are the Same Size or Smaller**
"Small" (**Photos 2**, **5** and **6**)	Riviera Flybridge 37	11.3 m	1.0 m	Twin Cummins B370 diesel	20
"Medium" (**Photos 9-15**, **19**, **21**)	Riviera M430	14.3 m	0.8 m	300 hp Volvo Penta Turbo	71
"Large" (**Photos 16** and **17**)	MV Bennelong 80	24.4 m	2.0 – 2.2 m	2x220 hp Rolls Royce engines, 3:1 reduction; twin prop 1m∅ approx	100

Turbidity measurements were made at a fixed probe, and a mobile probe. The fixed probe was taped to a stake and 0.5 m above the bed directly under the vessel sailing line. Monitoring of fixed probe readings was made from the dive boat, anchored some 15 m away from the fixed probe. The mobile probe, from which made surface measurements were made, was operated from a runabout used to track any visible plume. All turbidity readings comprised replicate pairs.

To gauge the relationship between turbidity and Total Suspended Solids *(TSS)* 14 water samples were also collected intermittently during the Test Vessel work. These were collected in Niskin bottles by EL, opened for filling in the water surface propeller wash plumes.

The Test Vessels were operated along a sailing track with depths representative of those which could be encountered in the marina, and travelling between the marina and the main channel of the Parramatta River. To manage risk of potential contaminant release, the sailing track was located over a section of bed within and adjoining the footprint of the proposed marina, considered least contaminated as shown by the URS data. Water depths investigated comprised 2, 3, 4 and 5 m. Vessels were manoeuvred underway at a constant 4 knots, accelerating ahead from stationary at full thrust, and accelerating astern from stationary at full thrust. While full thrust acceleration was not considered representative of boat manoeuvring in a marina, DEC requested that this be included to simulate worst-case operating conditions. Commencing the acceleration tests had the stern of the vessel located directly over the fixed probe. Various replicate runs were made where time and conditions permitted. The vessel test zone showing the sailing track and bed contours is shown in **Figure 1**.

A summary of the propeller wash test runs is provided in **Table 3**. Each tick denotes a single test run.

TABLE 3	**PROPELLER WASH TEST RUNS**								
Date and Depth	**Small Boat**			**Medium Boat**			**Large Boat**		
	Under way	**Full Thrust Ahead**	**Full Thrust Astern**	**Under way**	**Full Thrust Ahead**	**Full Thrust Astern**	**Under way**	**Full Thrust Ahead**	**Full Thrust Astern**
Day 1									
2 m	✓✓	✓✓	✓✓						
3 m	✓✓	✓✓	✓✓						
4 m									✓
5 m									
Day 2									
2 m									
3 m	✓	✓	✓	✓✓	✓✓	✓✓			
4 m	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓		✓	
5 m	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓✓	✓	✓

During both days of the investigation, background turbidity readings were collected within the Kendal Bay Remediation Site *(KBRS, refer above)*. These readings, made from the second runabout using GPS fix and portable depth sounder, were collected 0.5 m above the bed at the URS sediment sampling locations reported in URS (2006). While turbidity measurements were made by URS at various other locations in Kendal Bay *(synoptic turbidity mapping sites in Appendix H, URS 2006)*, for the marina investigations it was considered most useful to characterise the turbidity in the immediate vicinity of locations where bed sediment contamination levels are known. The URS sediment sampling locations are shown in **Figure 1**. A summary of the extent of background monitoring work by GBA is provided in **Table 4**. Each tick denotes a single set of readings.

TABLE 4 BACKGROUND TURBIDITY MONITORING

URS Site	Interval Time of Readings															
	Day 1								Day 2							
	To 7.00	7:00 8:00	8:00 9:00	9:00 10:00	10:00 11:00	11:00 12:00	12:00 13:00	After 13:00	To 7.00	7:00 8:00	8:00 9:00	9:00 10:00	10:00 11:00	11:00 12:00	12:00 13:00	13:00 14:00
1	✓✓✓								✓✓	✓✓			✓✓		✓	
2									✓✓	✓			✓		✓	
3									✓		✓	✓			✓	
4					✓ (x7)	✓			✓✓			✓✓				✓
5					✓				✓			✓✓				
6					✓				✓		✓					
7		✓						✓	✓✓		✓✓		✓✓			
8				✓					✓							✓
9	✓✓✓				✓			✓✓✓	✓✓			✓				
10							✓	✓	✓			✓				
11			✓			✓			✓							
12				✓					✓✓			✓✓	✓			
13						✓			✓			✓				
14							✓		✓							
15								✓✓			✓					
16		✓							✓✓							
17		✓					✓		✓✓							
18		✓							✓							
19			✓									✓				

URS (2006) found that wave action from ferry traffic caused elevated turbidity near the bed. Since ambient wave action from boats forms part of the background climate in Kendal Bay and given that ferry waves form a prominent component of boat wave energy delivered to Kendal Bay, it was of interest to observe ferry passings and note any perturbations in turbidity results which may be attributed to these passing ferries. Sydney Ferries' timetable for ferries passing Kendal Bay is included in **Appendix C***,* with predicted passings during each day of our turbidity monitoring summarised in **Figure 2**. We observed and recorded 22 ferry passings during our two day field exercise.

Sydney Ports were retained to deploy a 100 m long boom fence to manage any surface turbidity plume generated during the investigation. Details of the boom fence are included in **Appendix A**. Having regard to an expected clockwise current circulation in the bay during the ebb tide, the boom was located on the northern side of the vessel sailing track. We also had on hand absorbent booms and sorbent materials to attend to any visible surface slicks, however these were not required.

Calibration of the turbidity was undertaken by The Ecology Lab with the assistance of Yeocal Instruments in Brookvale. Calibration details are included in **Appendix D**.

Erwin Benker and Peter Skeynes from DEC visited the site on Day 1 to observe the monitoring exercise (**Photo 2**).

3 BACKGROUND TURBIDITY IN KENDAL BAY

3.1 Background Turbidity Results

3.1.1 URS Data

URS (2006) reported Synoptic Turbidity Mapping undertaken on 30 and 31 January 2006. No rain fell on the first day and 0.4 mm of rain was recorded on the second. A large spring tide occurred on both days, falling from RL 2 mid morning, to RL 0.1 mid afternoon. Winds were E to NE on the first day, and S to SE on the second. On 30 January the mean wind speed *(assumed 10 minute duration averaged)* was less than 10 km/hr to midday, then a constant 15 km/h for the remainder of the day. On 31 January the mean wind speed was 10 km/h early in that morning, falling to 5 km/h in the middle of the day and then increasing back to 10 km/h through the afternoon. Further details on the weather conditions are given in URS (2006).

URS collected turbidity measurements 0.5 m above the bed within the Remediation Site. Three rounds of measurements *(surveys)* were made on each day, each round of measurements completed within about one hour to provide time-snapshots of turbidity. While the URS turbidity measurements were spread throughout the bay *(and not necessarily at repeated locations)*, for the purposes of the marina investigation we have spatially interpolated the URS data to correlate with the locations of the URS sediment sampling sites. Our assessment of the URS data for the 30 and 31 January 2006 is presented in **Figures 3** and **4** respectively.

By and large, the URS data show progressively increasing turbidity through each of the days, from 10 – 20 NTU recorded late morning, increasing to 15 – 30 NTU late afternoon / evening. The maximum turbidity of 66 NTU occurred at URS Site 1, attributed to NE wind waves stirring the shallows at the southern corner of Kendal Bay.

3.1.2 GBA Data

The GBA background data for Days 1 and 2 are presented in **Figures 5** and **6** respectively. Tabulated data is presented in Table E.1 in **Appendix E**. Raw data *(GBA field notes)* are retained by GBA in a separate pdf archive.

As for URS, these data show progressively increasing turbidity through each of the two days. Before about 7.30 am, turbidity levels were around 5 -10 NTU throughout the KBRS, increasing generally to 10 – 25 NTU by midday. The maximum turbidity reading of 120 NTU made at URS Site 4 at 10.30 am is considered to be spurious, attributed to the probe making contact with the bed. The readings of 50 to 60 NTU at URS Sites 1 and 2 made early afternoon on Day 2 are considered to be representative of levels attained in the southern shallows of the bay under typical moderate NE wind conditions for this time of the year.

We note the comment in URS (2006) regarding lower current velocity thresholds to resuspend sediments in summer due to favourable biological and physicochemical conditions in warmer water, and on this basis could reasonably anticipate for Kendal Bay lower background turbidity levels in winter and higher background turbidity levels in summer.

In addition to wind waves, it would be our opinion that the relatively long period waves generated by passing ferries would contribute significantly to the background wave energy climate in Kendal Bay. Ferry passings at the site started around 6.30 am, peaked between 7.00 am and 9.00 am at between 5 – 7 passings per hour, then reduced to 3 to 4 passings per hour for the remainder of the day. While GBA did do not observe a general increase in background turbidity in Kendal Bay during the 7.00 am to 9.00 am ferry peak, we did capture an "event" at URS Site 4, where background turbidity doubled from around 20 to 40 NTU during the passing of a Rivercat *(10.30 am, 25/9/07).* This turbidity behaviour associated with ferry movements is consistent with that reported in URS (2006).

GBA also observed relatively high background turbidity levels at URS Sites 7, 9 and 10 between 13:00 and 14:00 hrs on Day 1. It is possible that anchoring and/or manoeuvring of the large test vessel MV Bennelong at that time stirred bed material influencing the background readings.

4 TURBIDITY ASSOCIATED WITH PROPOSED MARINA IN KENDAL BAY

4.1 Preliminary Marina Layout and Operation

A preliminary marina layout prepared by Taylor Lauder Bersten for Rosecorp is shown in **Figure 1**. The marina comprises seven arms incorporating 179 wet berths. For assessment purposes, we refer to Arms A to G inclusive from north to south. Each arm includes Outer (O) and Inner (I) berths, which we have numbered consecutively from 1 at the inshore end.

The berths are located over bed levels varying from RL-1.6 at the SW corner of the marina *(8 m Berth FI1)*, to almost RL -5 at the outer end of Arm DI *(16 m Berth DI12).* The berth sizes, numbers, percentile distribution in the marina and bed RLs are summarised below in **Table 5**.

TABLE 5 PRELIMINARY MARINA LAYOUT BERTH SIZES AND DISTRIBUTION

Berth Lengths (m)	Number	% Boats in Marina which are the Same Size or Smaller	Bed RL		
			Maximum	Minimum	Average
8	11	6	-3.2	-1.6	-2.3
10	26	20	-4.4	-2.0	-3.7
12	46	46	-3.5	-2.0	-2.6
14	45	71	-4.5	-1.9	-2.9
16	30	88	-5.0	-2.1	-3.2
18	10	93	-3.2	-2.3	-2.7
20	2	95	-3.4	-3.3	-3.4
25	9	100	-3.5	-3.0	-3.3
Total	**179**				

Thus over 80% of the marina comprises 10 – 16 m berths. The average bed RL's range from RL-2.3 for 8 m berths, to RL -3.7 for 10 m berths.

The marina layout design at Breakfast Point is still evolving. We understand that the preliminary marina layout adopted for our assessment may have already changed slightly, however we would not expect minor modifications *(minor spatial refinements, minor rearranging of vessel berths, etc)* to materially change the outcome of this assessment.

We understand that the facility would be a private facility to service the Breakfast Point residential development.

4.2 Turbidity Results from Manoeuvring of Marina Vessels

Turbidity from manoeuvring of marina vessels could be attributed to propeller wash stirring the bed. The site investigation undertaken on 25 and 26 September 2007 was to examine this process.

The results of the manoeuvring tests are presented in **Figures 7** to **18** inclusive. Tabulated data is presented in Tables E.2 to E.10 in **Appendix E**. Raw data *(EL field notes)* are retained by GBA in a separate pdf archive.

The methodology adopted by The Ecology Lab *(EL)* was to measure turbidity in replicate pairs *(practically say within 5 – 10 s of one another)*, with the average of the pair of readings adopted by in this report as the turbidity measurement.

The reader should appreciate the inherent variability of estuarine turbidity and/or its field measurement. Our observations at Kendal Bay commonly encountered a variability of about +/-10 %, eg a reading of say 10 NTU at a point in time could rapidly fluctuate between say 9 and 11 NTU without an apparent change in turbidity condition. The results presented in this report should be interpreted accordingly.

Our overview comments are as set out below.

4.2.1 Small Vessel Manoeuvring Test Results

2 m Water Depth (Figure 7)

Large bed disturbance and resultant turbidity was encountered with the small vessel in 2 m water depth. For full thrust starting ahead and full thrust starting astern, peak turbidity levels of between 150 and 250 NTU above background were measured, primarily in the water surface. Turbidity levels returned to background within 4 to 7 mins of commencement of testing.

For 4 knots underway with the small vessel, peak turbidity levels up to 180 NTU above background were measured at depth, and up to 20 - 30 NTU above background in the water surface. Turbidity levels returned to background within 4 to 10 mins of commencement.

3 m Water Depth (Figures 8 and 9)

Small to moderate bed disturbance and resultant turbidity was encountered with the small vessel in 3 m water depth. For full thrust starting ahead and full thrust starting astern, peak turbidity levels of between 3 and 65 NTU above background were measured, primarily in the water surface. Turbidity levels returned to background within 1 to 3.5 mins of commencement.

For 4 knots underway, minimal changes in background turbidity could be discerned.

4 m Water Depth (Figure 10)

Minimal bed disturbance and resultant turbidity was encountered with the small vessel in 4 m water depth for full thrust starting ahead, full thrust starting astern and 4 knots underway. Turbidity peaked at 2 NTU above background, returning to background levels within 2 to 4 mins of commencement.

5 m Water Depth (Figure 11)

Minimal bed disturbance and resultant turbidity was encountered with the small vessel in 5 m water depth for full thrust starting ahead, full thrust starting astern and 4 knots underway. Turbidity peaked at 5 NTU above background for one of the six runs, returning to background levels within 3 mins of commencement.

4.2.2 Medium Vessel Manoeuvring Test Results

2 m Water Depth

The Riviera 47 was not tested in 2 m as this depth was judged unsafe by the helmsman to manoeuvre the vessel.

3 m Water Depth (Figure 12)

Minimal to small bed disturbance and resultant turbidity was encountered with the medium sized vessel in 3 m water depth for full thrust starting ahead, full thrust starting astern and 4 knots underway. Turbidity peaked at 30 NTU above background for one of the six runs, returning to background levels within 4 mins of commencement. For four of the 6 runs, turbidity was contained to within 5 NTU of background.

4 m Water Depth (Figure 13)

Minimal bed disturbance and resultant turbidity was encountered with the medium sized vessel in 4 m water depth for full thrust starting ahead, full thrust starting astern and 4 knots underway. Turbidity peaked at 5 NTU above background, returning to background levels within 2 to 4 mins of commencement.

5 m Water Depth (Figure 14)

Minimal bed disturbance and resultant turbidity was encountered with the medium sized vessel in 5 m water depth for full thrust starting ahead, full thrust starting astern and 4 knots underway. Turbidity peaked at 6 NTU above background, returning to background levels within 7 mins of commencement. The reason for the unusually long period for return to background was not apparent.

4.2.3 Large Vessel Manoeuvring Test Results

2 and 3 m Water Depth

The MV Bennelong draws between 2.0 and 2.2 m and therefore could not be tested in 2 m water depth. The vessel was not tested in 3 m as this depth was judged unsafe by the helmsman to manoeuvre the vessel.

4 m Water Depth (Figures 15 and 16)

Large bed disturbance and resultant turbidity was encountered with the large vessel in 4 m water depth.

For full thrust starting astern, peak turbidity levels reached 340 NTU above background in the water surface, returning to background in 8 to 10 mins of commencement. Turbidity levels above background were not encountered at the fixed near-bed probe, presumably because the propeller jet and its entrained bed sediments were encountered at the probe for a sufficient period of time.

For full thrust starting ahead, peak turbidity levels reached 38 NTU above background in the water surface, returning to background in approximately 30 mins of commencement. Turbidity levels above background were not encountered at the fixed near-bed probe, presumably because the propeller jet and its entrained bed sediments were not encountered at the probe for a sufficient period of time.

5 m Water Depth (Figures 17)

Minimal to large bed disturbance and resultant turbidity was encountered with the large vessel in 5 m water depth for one of four runs conducted at this depth.

For full thrust starting astern, peak turbidity levels reached 460 NTU above background at depth, and 200 NTU above background in the water surface, returning to background in 5 to 11 mins of commencement.

For full thrust starting ahead, peak turbidity levels reached 30 NTU above background at depth, and 20 NTU above background in the water surface, returning to background in 6.5 mins of commencement.

For 4 knots underway with the large vessel, minimal turbidity impacts were measured.

4.2.4 Correlation between TSS and Turbidity

This investigation has adopted turbidity as a readily measured water quality parameter to characterise the concentration of suspended bed sediments in the water column. This approach is reasonable as confirmed by the high correlation between Total Suspended

Solids *(TSS)* and turbidity demonstrated by EL's Niskin bottle sampling and testing (**Figure 19**).

The TSS and turbidity analyses of the water samples were carried out by the Australian Government National Measurement Institute laboratory in Pymble. The TSS laboratory results are attached in **Appendix F**.

4.2.5 Concluding Remarks on Turbidity Results from Manoeuvring of Marina Vessels

DEC's primary interest is to establish whether proposed marina activities are likely to cause any additional resuspension of contaminated sediments over and above that attributed to background processes; in particular ambient boat traffic *(DEC letter to TLB, 7/8/07)*. Turbidity is considered a suitable indicator of suspended sediments. Given the variable nature of turbidity and its measurement, it would seem reasonable to interpret DEC's requirement in terms of a threshold percentage above background. There is also the question as to whether DEC is seeking to apply the resuspension requirement near the bed, in the water surface, or both. While these matters should be clarified with DEC, there are certain broad observations that can be made from the vessel test results.

Two metres water depth is clearly problematic. The medium *(14 m)* and large *(25 m)* vessels could not be *(either physically or safely)* operated in 2 m of water. The small vessel *(11 m)* exhibited significant turbidity impacts (**Figure 7**) and we consider would not satisfy DEC's requirements.

Three metres water depth is certainly unacceptable for the large *(25 m)* vessel which was unable to safely operate in that condition. The small *(11 m)* and medium *(14 m)* vessels are found to satisfy DEC when underway, but exhibit mixed results for the full thrust start-ups *(some showing resuspension and others not)*. This suggests that 3 m depth is near the acceptable limit for these sizes of vessels as required by DEC, but this will depend on their clarification. It should be acknowledged that full thrust is not a reasonable operating condition within a marina and may never occur.

In four metres of water, the small *(11 m)* and medium *(14 m)* vessels meet DEC's requirement with very minor exceedences *(largely within measurement variability)*, and we expect this should be acceptable. The large *(25 m)* vessel causes unacceptable turbidity impacts at 4 m.

The small *(11 m)* and medium *(14 m)* vessels clearly satisfy DEC for all manoeuvring but the large *(25 m)* vessel causes significant turbidity impacts with full thrust starting astern and probably also starting ahead.

In closing, we would make one further comment on the large *(25 m)* vessel used for testing. The hull shapes and propulsion arrangements of larger craft is quite variable, and we understand that that this does have a bearing on the capacity of these vessels to stir the bed. More modern-type designs and lower displacement hullforms may exhibit a less turbulent propeller wash than beamier timber boats such as MV Bennelong *(Steve Morton, owner*

MV Bennelong pers comm). After much enquiry, MV Bennelong was the only craft of the required length that was available to assist with the exercise. While the type of large vessel that may be berthed at Breakfast Point is not known at this time, subject to the outcome of possible further investigation with large vessels it could be suggested that vessel-type for particular large berths is prescribed to in order to manage turbidity impacts.

4.3 Interpretation of Turbidity Results from Manoeuvring of Marina Vessels

The turbidity results from the vessel manoeuvring tests are valuable for making informed judgements on how different classes of vessel may stir the bed of Kendal Bay and impact on local turbidity. The range of vessel sizes tested was agreed with DEC, selected as a fair representation of vessels to be berthed in the marina. GBA has examined the turbidity results from the vessel tests, and by reasonable interpolation and extrapolation, developed a predictive profile of turbidity results for all vessel sizes earmarked for berthing at the Breakfast Point Marina. This profile is summarised in **Appendix G**.

5 IMPACTS OF TURBIDITY FROM PROPOSED MARINA OPERATIONS ON BACKGROUND TURBIDITY IN KENDAL BAY

5.1 Introduction

The turbidity investigation sought to establish whether marina activities are likely to cause additional resuspension of contaminated sediments over and above that caused by current vessel activities. This would provide a basis to enable any pollutant impacts to be assessed *(eg. pollutant transfer into the waterbody and/or advection and relocation of contaminated fines)*, and if these are found to be significant, to develop an appropriate management response.

While the current marina layout is most unlikely to meet DEC's requirements of no additional resuspension of bed sediments *(subject to clarification)*, it is instructive to consider the extent to which operations in the marina could influence the overall background turbidity in the Kendal Bay Remediation Site *(KBRS)*.

5.2 Turbidity Calculation to Compare Background and Marina Activities

We have formulated a calculation which characterises the daily average background turbidity in the KBRS, and compares this with <u>a conservative assessment of the increase in background turbidity that would occur assuming the marina was fully berthed, and all vessels departed, exited the KBRS, and returned to their berths within a single day</u>. Our calculation methodology and assumptions are summarised below in **Section 5.2.2**. Spreadsheet output are included in **Appendix H**.

5.2.1 Calculation of Background Turbidity in KBRS

Based on the results of the Synoptic Turbidity Mapping by URS (2006) and our background monitoring over the two day exercise in September 2007, background turbidity values for 0.5 m above the bed have been established for precincts demarcated by the URS sediment sampling sites. The daily seasonal data has been interpreted to account for diurnal and seasonal variability. The overall result is summarised below in **Table 6**.

TABLE 6 BACKGROUND TURBIDITY IN KENDAL BAY REMEDIATION SITE

Precinct surrounding URS Sediment Sampling Site (1)	Precinct Area (m^2)	Turbidity (NTU) (2)			
		Daily Summer Average (Oct through Apr)	Daily Winter Average (May through Sept)	Daily Average	Contribution from Precinct to Daily Average
1	12,400	24	13	19	1.9
2	8,200	21	11	17	1.1
3	5,500	13	6	10	0.4
4	7,500	11	5	9	0.5
5	7,500	10	4	8	0.4
6	8,100	11	5	8	0.5
7	6,800	10	4	8	0.4
8	6,400	12	6	9	0.5
9	7,400	10	4	8	0.4
10	10,100	12	6	9	0.7
11	5,400	12	6	9	0.4
12	8,200	11	4	8	0.5
13	7,700	11	5	9	0.5
14	5,900	12	6	9	0.4
15	5,500	13	6	10	0.4
16	7,700	11	5	9	0.5
17	7,600	11	5	9	0.5
Daily Average Turbidity for Kendal Bay Remediation Site					**10.2**

Notes	(1)	Precinct arrangement shown in Figure H.1 included in **Appendix H.**
	(2)	Turbidity values for 0.5 m above the bed.

Thus GBA calculates the daily average turbidity for Kendal Bay at 10 NTU. This may be compared to the maximum daily value of 24 NTU established for the area surrounding URS Site 1 in summer, and the minimum daily value of 4 NTU established for the areas surrounding URS Sites 5, 7, 9 and 12 in winter.

5.2.2 Assessed Increase in Background Turbidity assuming Marina Fully Berthed, with all Vessels Departing and Returning to their Berths within a Single Day

A large range of possible marina usage scenarios could be examined. The approach taken by GBA was to consider a single unlikely *(conservative)* scenario utilising the measurement data, and assess the impact implications for background turbidity in the bay.

The following methodology was applied:

(i) for each return movement to and from each berth, each vessel was assumed to apply full thrust ahead for 5 s at the berth depth, apply full thrust astern for 5 s at the berth depth, and navigate underway at a constant 4 knots between the berth and the outer edge of the KBRS;

(ii) using the turbidity results summarised in **Appendix G**, turbidity above background applied to each depth interval was assessed to equal the average turbidity value recorded for that depth, occurring for a period equal to the time taken to navigate the depth interval plus the time taken for the turbidity to return to background recorded for that depth event *(event time)*;

(iii) the assessment was completed for mean tide (RL 0.9) given that the tide would exceed and fall below mean tide equally over time;

(iv) in accordance with (iii), turbidity above background generated for the 2 m depth tests was taken to represent the turbidity above background for bed level intervals less than RL 1.6 *(average depth less than 2.5 m)*, for the 3 m tests between RL 1.6 and RL 2.6 *(average depth 2.5 to 3.5 m)*, for the 4 m tests between RL 2.6 and RL 3.6 *(average depth 3.5 to 4.5 m)*, and for the 5 m tests greater than RL 3.6 *(average depth greater than 4.5 m)*;

(v) the bed area affected by propeller wash *(impact corridor)* was taken to equal the impact swath width multiplied by the boat travel distance. A propeller wash jet angle of 20 degrees in the vertical and horizontal was assumed to apply based on an indicative application presented in PIANC (1987) *(refer Figure 3.17 from PIANC reproduced in* **Appendix H***).* The impact swath width accounted for propeller diameter and number, assumed to vary from a single 0.3 m ∅ propeller for an 8 m vessel, to twin 1.0 m ∅ propellers centred 3.5 m apart for a 25 m vessel;

(vi) the impact contribution to average KBRS turbidity above background was then summed for each return boat movement from each berth, weighted for affected bed area compared to the area of the KBRS and the duration of the impact compared to a single day.

By way of example, the assessment of the total contribution to increased turbidity above background for Berth Number 14 at A Arm, Inner *(Berth AI14)* is summarised below in **Table 7** *(refer also* **Section 4.1***)*. Details of the assessment for the full marina are shown in spreadsheet form included in **Appendix H**.

This simplified but conservative assessment indicates that the daily average turbidity within the KBRS would be elevated by less than 1 NTU; by any reasonable measure a small turbidity impact.

6 CONCLUSIONS

A two-day field investigation was undertaken in late September 2007 to provide additional information to support further assessment of vessel turbidity impacts from Breakfast Point Marina. Gary Blumberg & Associates *(GBA)* has collaborated with The Ecology Lab to design and implement the investigation to the satisfaction of DEC and other stakeholder agencies. Fifty one propeller wash test runs and 92 sets of background turbidity measurements were made. The field results permitted an assessment of daily average turbidity for the Kendal Bay Remediation Site *(KBRS)* and profiling of turbidity impacts associated with all vessels earmarked for berthing at the marina.

DEC's primary interest is to establish whether proposed marina activities are likely to cause any additional resuspension of contaminated sediments over and above that attributed to background processes; in particular ambient boat traffic *(DEC letter to TLB, 7/8/07)*. Turbidity is considered a suitable indicator of suspended sediments. While certain aspects of DEC's requirements should be clarified (**Section 4.2.5**), there are broad observations regarding the acceptability of the current marina layout that can be made from the vessel test results.

Two metres water depth is clearly problematic and is unlikely to satisfy DEC's requirements for any of the test vessels. **Three metres** water depth is certainly unacceptable for the large *(25 m)* vessel, with mixed compliance exhibited for the small *(11 m)* and medium *(14 m)* vessels. It appears therefore that 3 m depth approaches the acceptable limit for these two sizes of vessels. In **four metres** of water, the small *(11 m)* and medium *(14 m)* vessels essentially meet DEC's requirement, but the large *(25 m)* vessel does not. The small *(11 m)* and medium *(14 m)* vessels clearly satisfy DEC for all manoeuvring in **five metres**, but the large *(25 m)* vessel caused significant turbidity impacts for the case of full thrust starting astern and probably also starting ahead.

TABLE 7 EXAMPLE OUTPUT FROM MARINA TURBIDITY ASSESSMENT

Berth Code AI14 Berth length 16 m Berth bed RL -3.3				
Water depth (m)	2	3	4	5
Start RL		1.6	2.6	3.6
End RL	1.6	2.6	3.6	
Travel distance (m)	0	0	76	20
Average turbidity above background applied over impact corridor (NTU)				
Full thrust astern	100	25	25	7
Full thrust ahead	100	25	20	2
Underway 4 knots	50	7	4	0
Event time (s)				
Full thrust astern	2000	500	250	250
Full thrust ahead	2000	1000	500	100
Underway 4 knots	1000	250	90	25
Bed disturbance area for return trip (m^2)				
Starting and stopping (full thrust)	0	0	100	0
Underway	0	0	855	250
Contribution to increased turbidity above background in KBRS (NTU)				
Full thrust astern	0	0	5.9×10^{-5}	0
Full thrust ahead	0	0	9.4×10^{-5}	0
Underway 4 knots	0	0	2.3×10^{-5}	0
Total contribution to increased turbidity above background in KBRS (NTU)	**0**	**0**	**1.7×10^{-4}**	**0**

While full thrust starting was incorporated into the work to satisfy DEC, it should be acknowledged it does not represent a reasonable operating condition within a marina and may never occur.

The propeller wash tests provide an event-based description of turbidity impacts. However, it is also of interest to consider the spatial and temporal integration of these effects over the bay as a consequence of marina activities.

An earlier investigation by GBA that found a relatively small overall disturbance by propeller wash from marina boats relative to wave action from ferries past or through Kendal Bay *(GBA fax to TLB dated 2/11/06).* To further examine total marina impact, GBA has applied the available background and vessel test turbidity data to develop a simplified *(but conservative)* assessment of impact of turbidity from proposed marina operations on background turbidity in Kendal Bay. This assessment indicates that the daily average turbidity within the KBRS would be elevated by less than 1 NTU over and above our assessment of daily average turbidity equal to 10.2 NTU. The overall turbidity impact of the proposed marina is thus predicted to be small.

7 REFERENCES

URS (2006)
Environmental Risk Assessment for Sediments Adjacent to the Former AGL Mortlake Site
Prepared for AGL Pty Ltd, draft report, 31/5/07

PIANC (1987)
Guidelines for the Design and Construction of Flexible Revetments incorporating Geotextiles for Inland Waterways
Report of Working Group 4, Supplement to Bulletin No 57

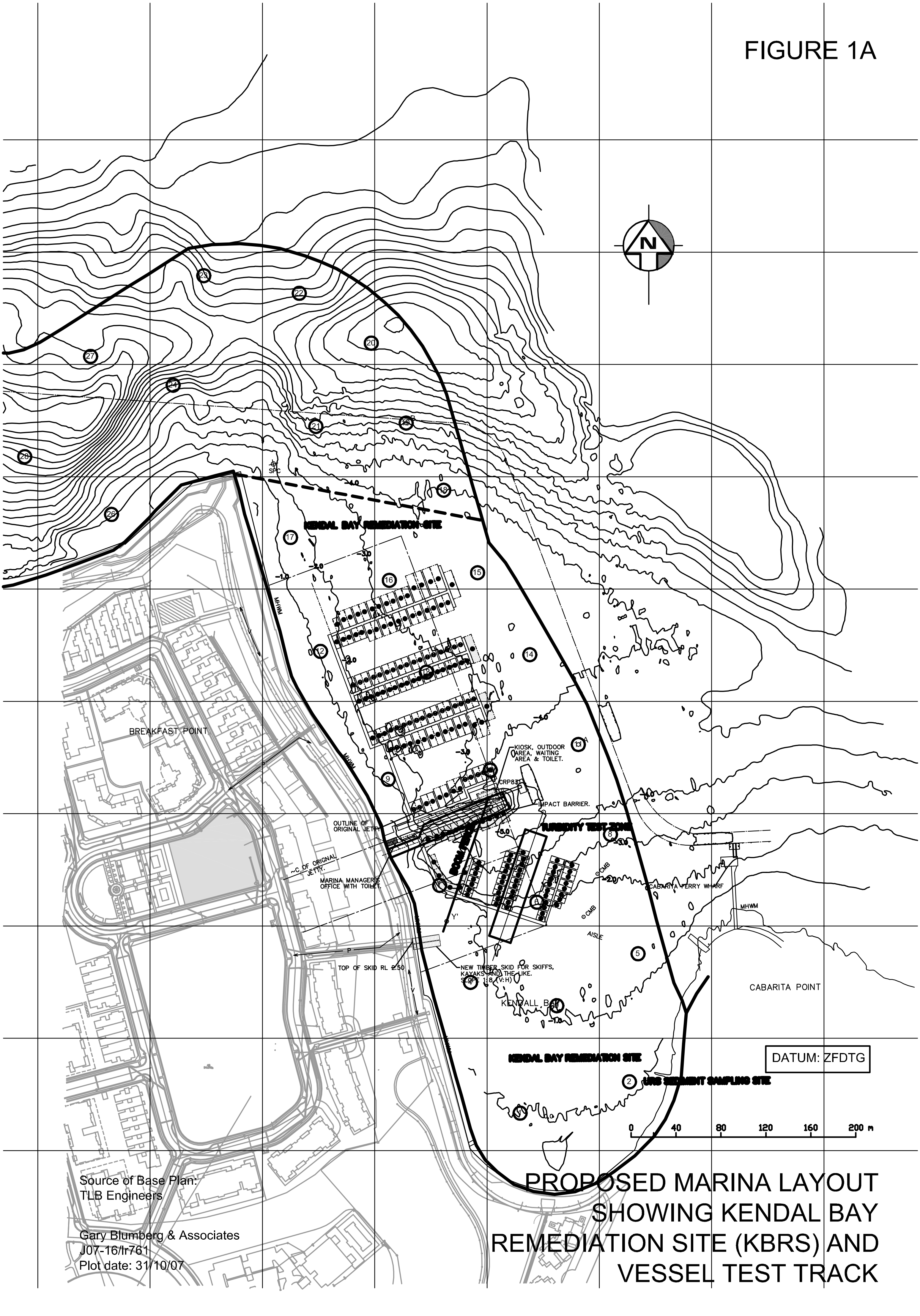
We trust that the above meets your immediate requirements in this matter. Should you need any further information or clarification, please do not hesitate to contact the undesigned.

Yours faithfully
GARY BLUMBERG & ASSOCIATES

G P Blumberg
Principal

FIGURES

FIGURE 1A



PROPOSED MARINA LAYOUT SHOWING KENDAL BAY REMEDIATION SITE (KBRS) AND VESSEL TEST TRACK

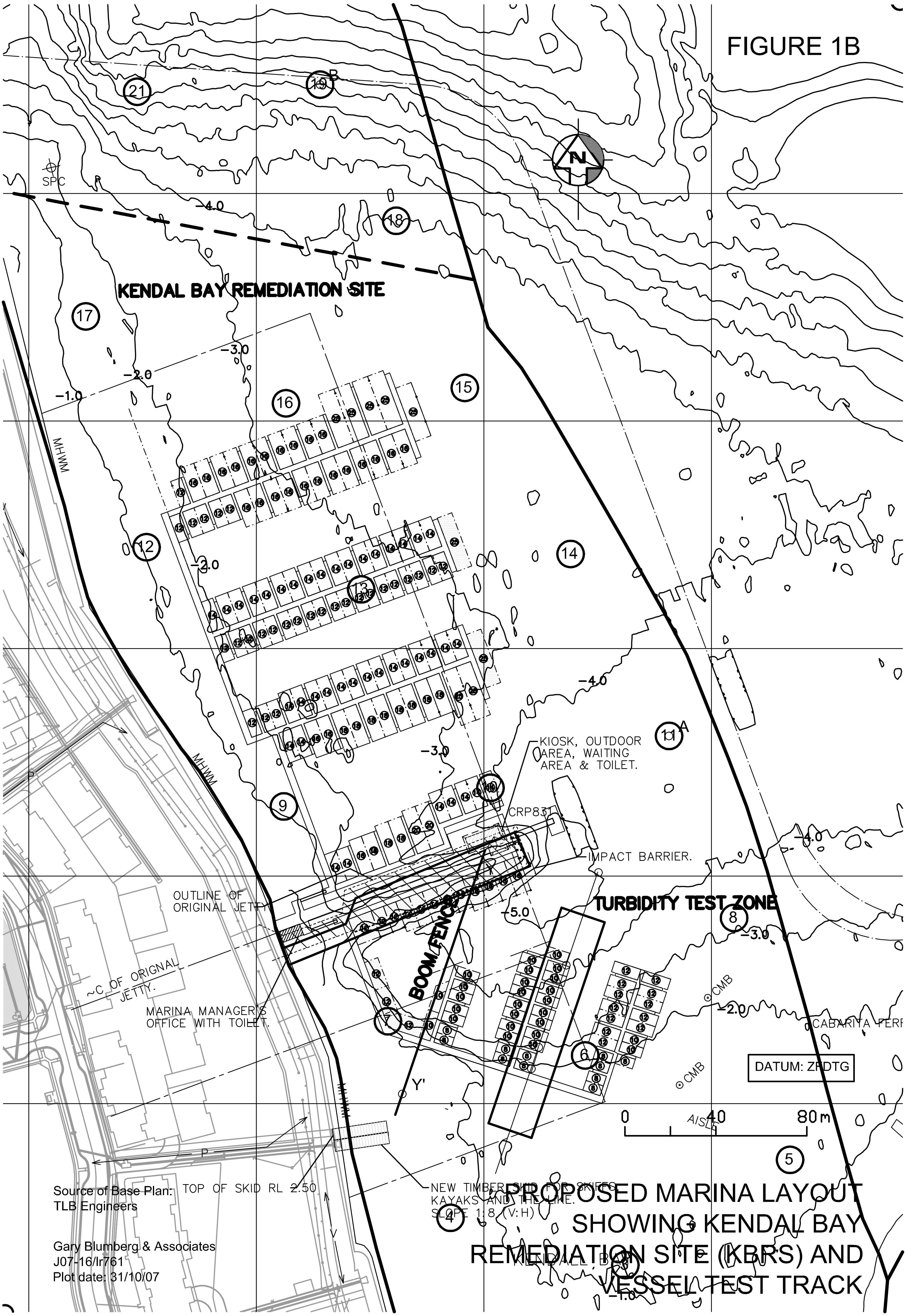


FIGURE 1B
KENDAL BAY REMEDIATION SITE
TURBIDITY TEST ZONE
BOOM FENCE
KIOSK, OUTDOOR AREA, WAITING AREA & TOILET.
CRP831
IMPACT BARRIER.
OUTLINE OF ORIGINAL JETTY
~C OF ORIGNAL JETTY.
MARINA MANAGER'S OFFICE WITH TOILET.
MHWM
SPC
CMB
CABARITA FERR
DATUM: ZPDTG
0 40 80m
AISLE
TOP OF SKID RL 2.50
NEW TIMBER SKID FOR SKIFFS KAYAKS AND THE LIKE. SLOPE 1:8 (V:H)
Source of Base Plan: TLB Engineers
Gary Blumberg & Associates
J07-16/lr761
Plot date: 31/10/07
PROPOSED MARINA LAYOUT SHOWING KENDAL BAY REMEDIATION SITE (KBRS) AND VESSEL TEST TRACK

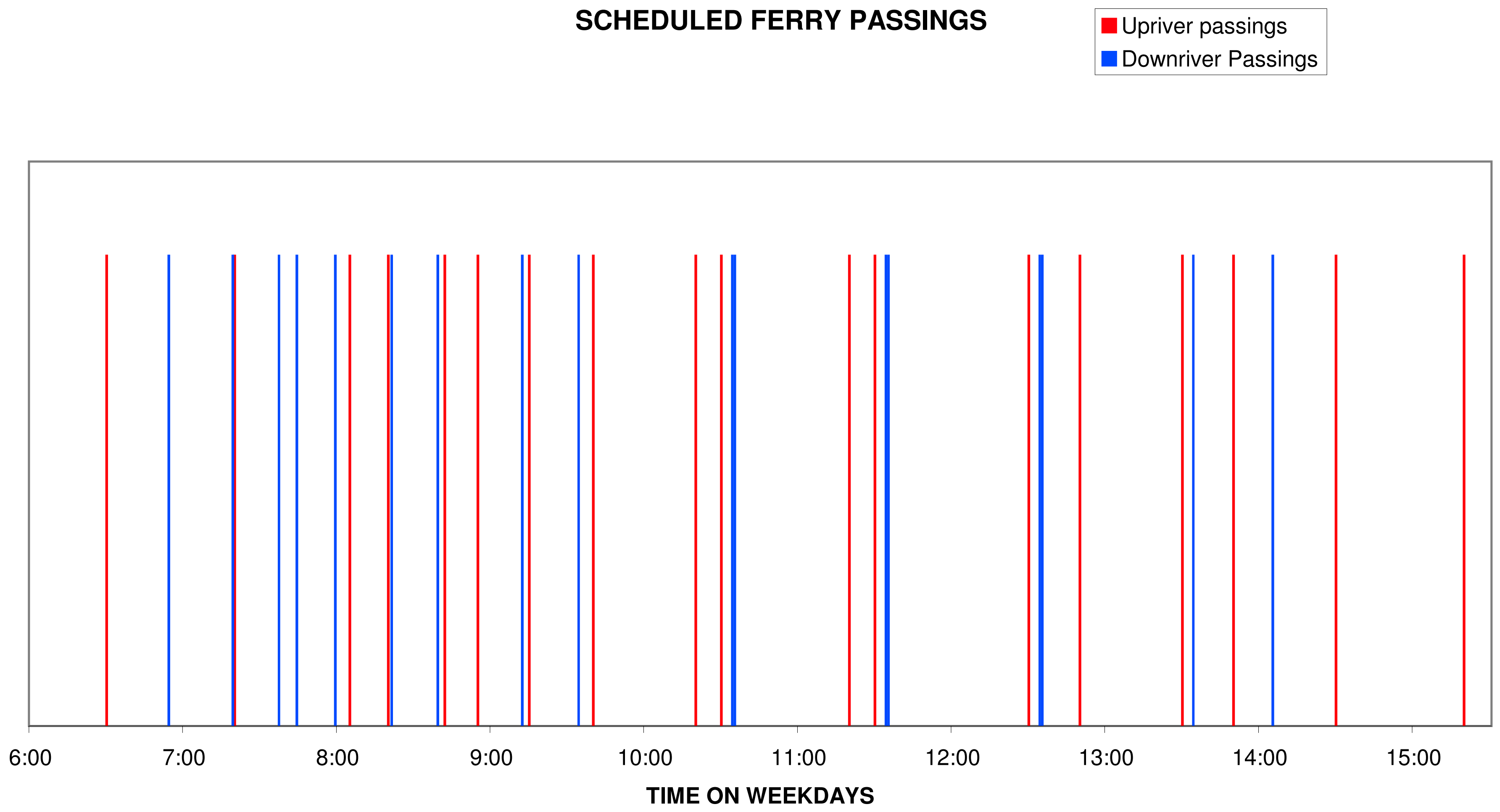

SCHEDULED FERRY PASSINGS
Upriver passings
Downriver Passings
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
TIME ON WEEKDAYS

FIGURE 2

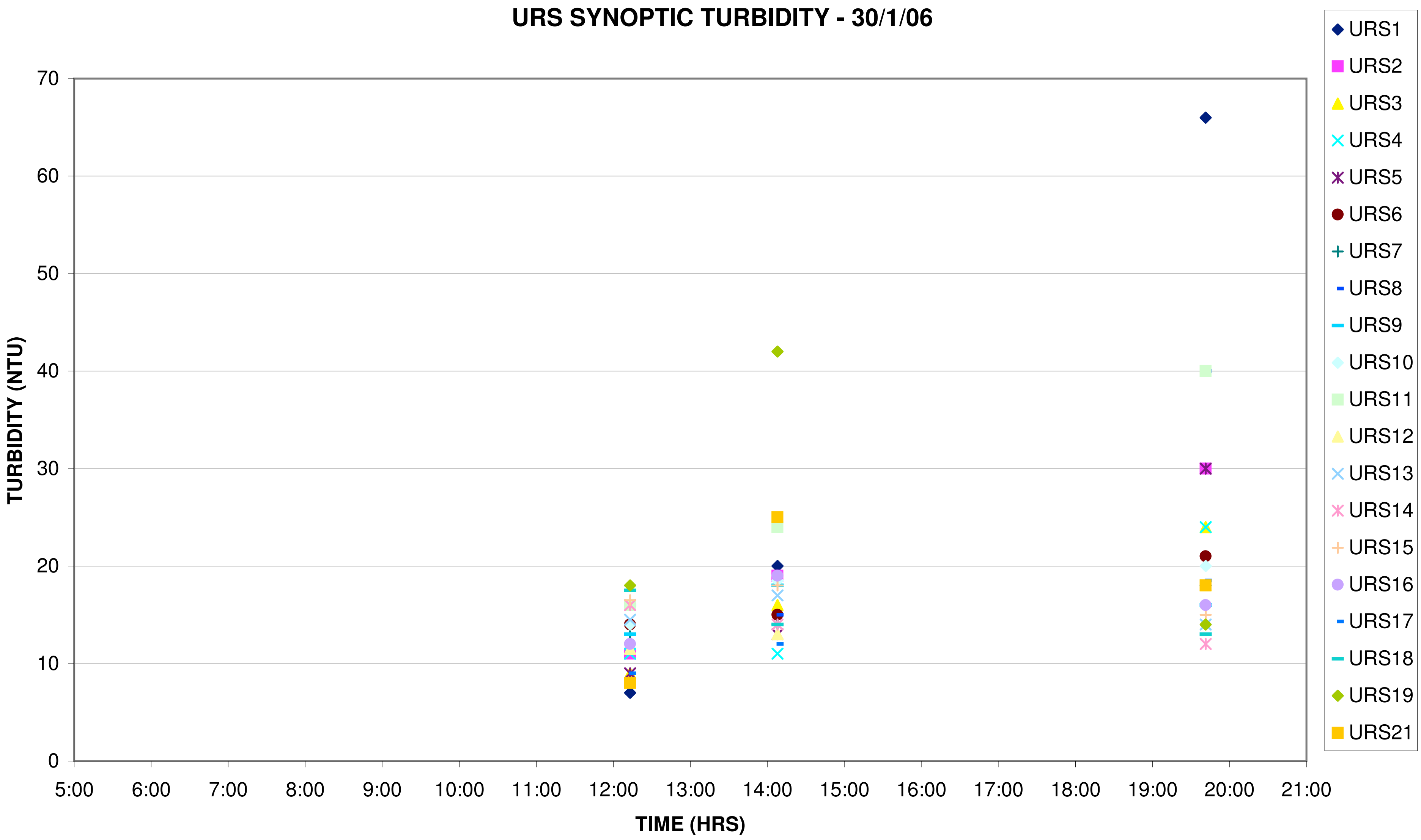

URS SYNOPTIC TURBIDITY - 30/1/06
TURBIDITY (NTU)
70
60
50
40
30
20
10
0
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
15:00
16:00
17:00
18:00
19:00
20:00
21:00
TIME (HRS)
URS1
URS2
URS3
URS4
URS5
URS6
URS7
URS8
URS9
URS10
URS11
URS12
URS13
URS14
URS15
URS16
URS17
URS18
URS19
URS21

FIGURE 3

Prepared by G Blumberg 26/10/2007 9:52 PM

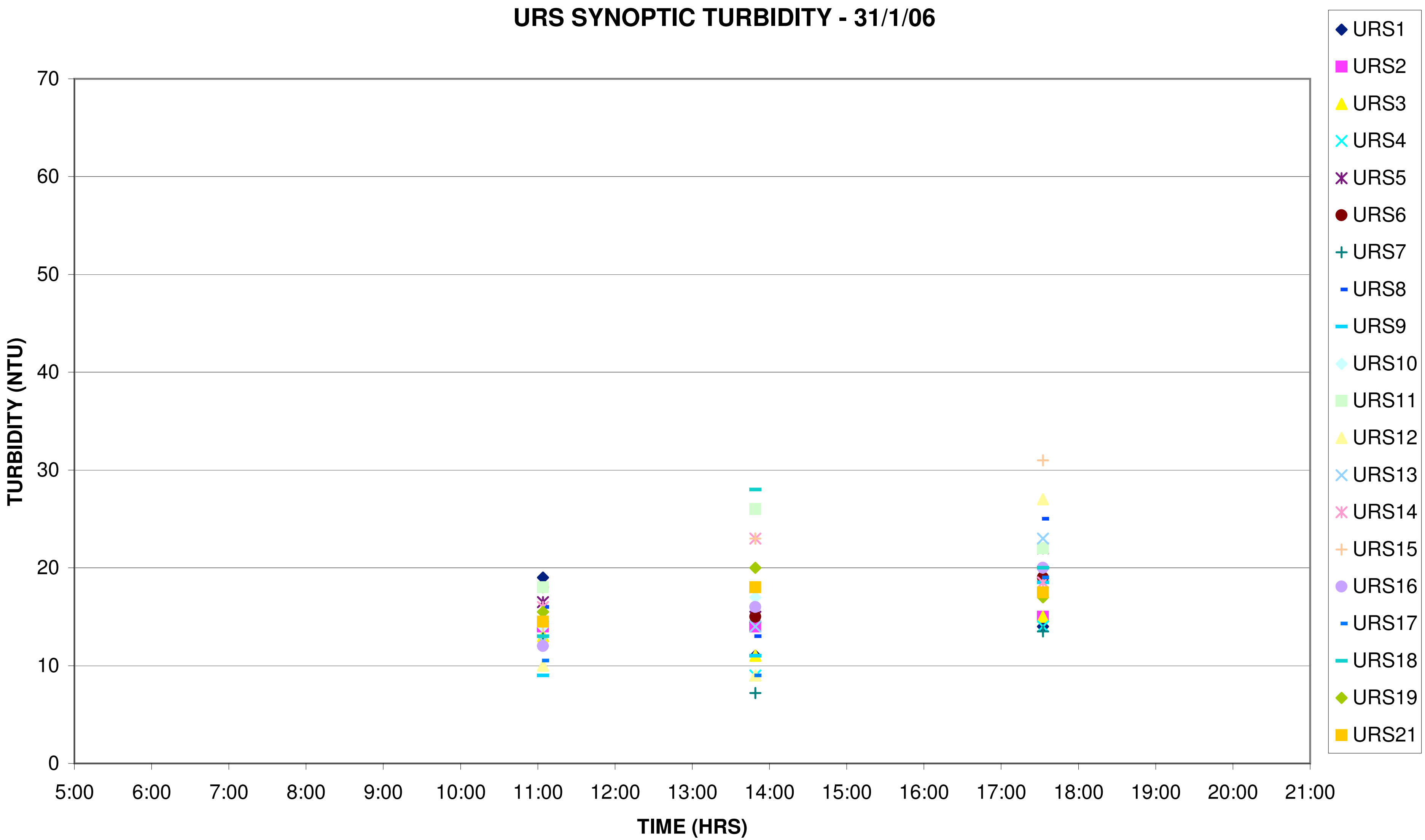
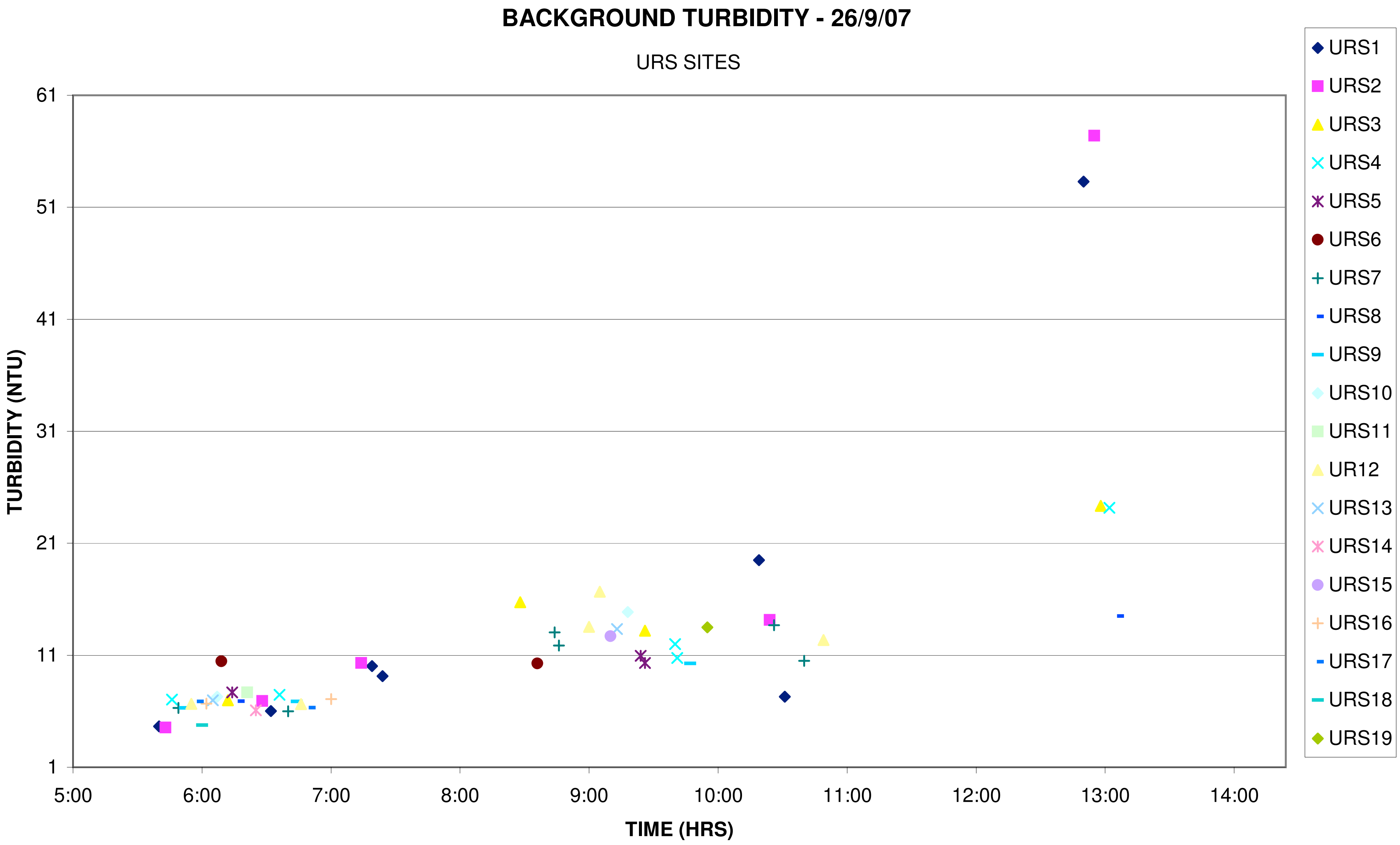


FIGURE 4

Prepared by G Blumberg 26/10/2007 9:52 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(5) URS 26-9-07

FIGURE 5

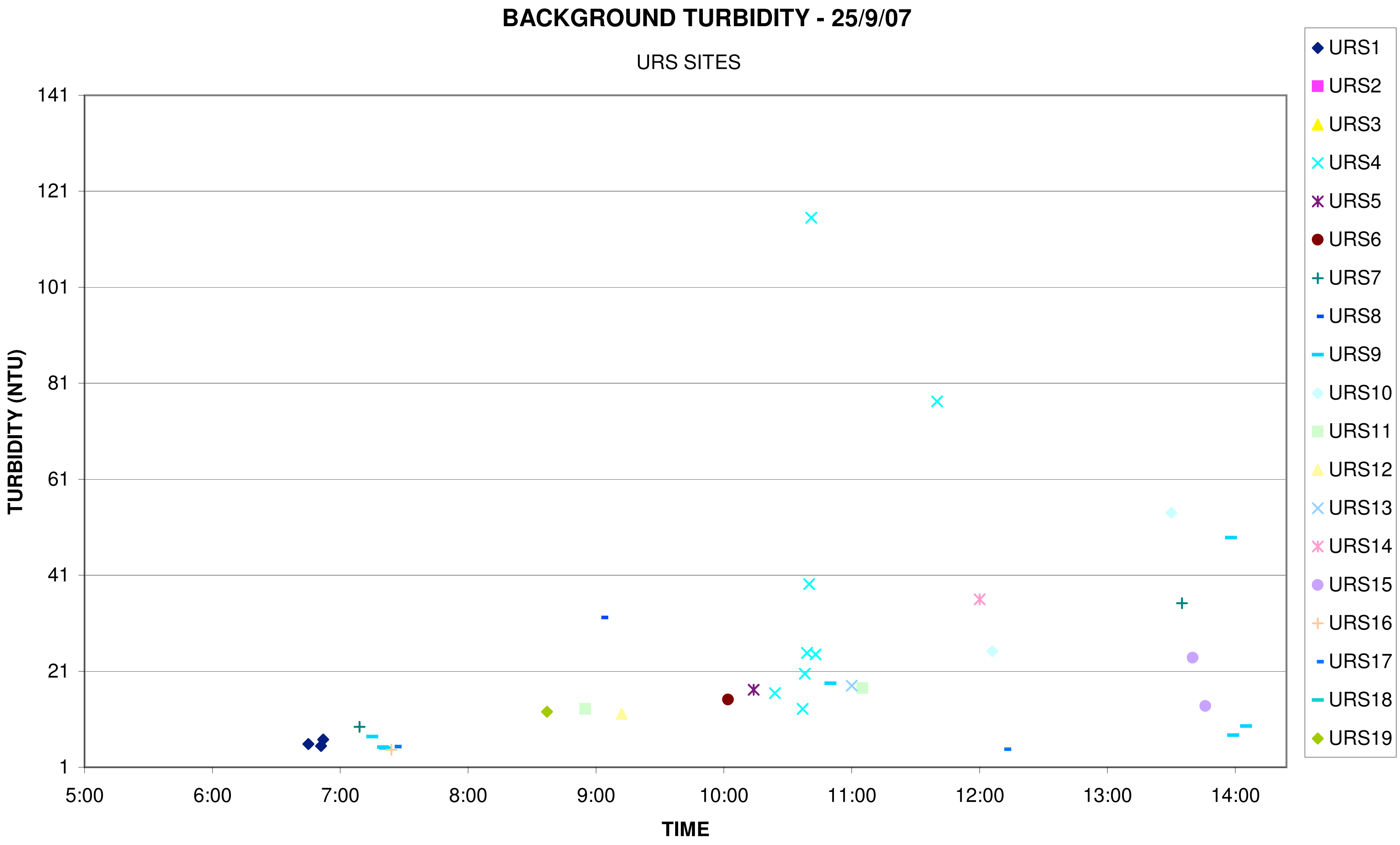
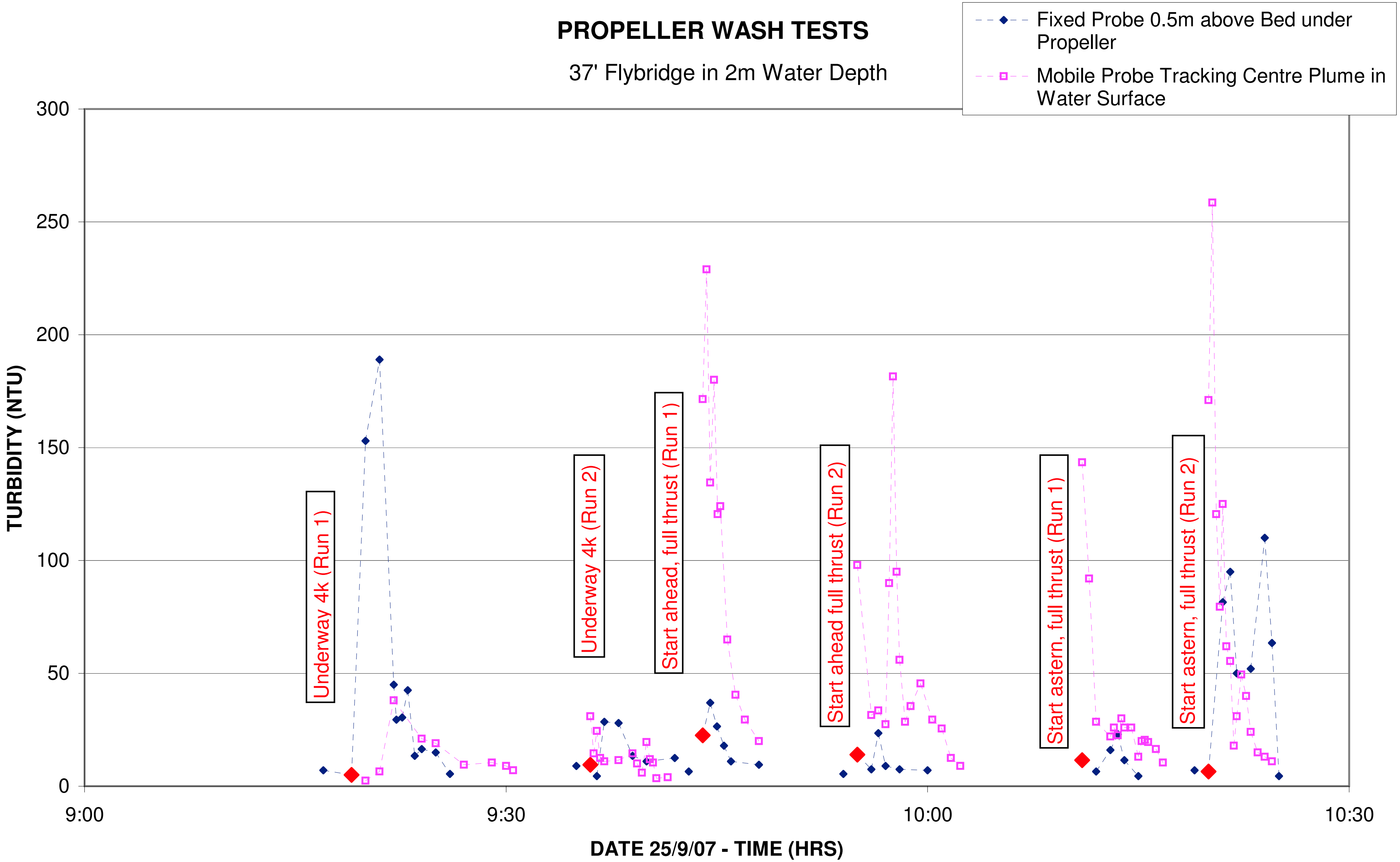

BACKGROUND TURBIDITY - 25/9/07
URS SITES
TURBIDITY (NTU)
141
121
101
81
61
41
21
1
5:00
6:00
7:00
8:00
9:00
10:00
11:00
12:00
13:00
14:00
TIME
URS1
URS2
URS3
URS4
URS5
URS6
URS7
URS8
URS9
URS10
URS11
URS12
URS13
URS14
URS15
URS16
URS17
URS18
URS19

FIGURE 6

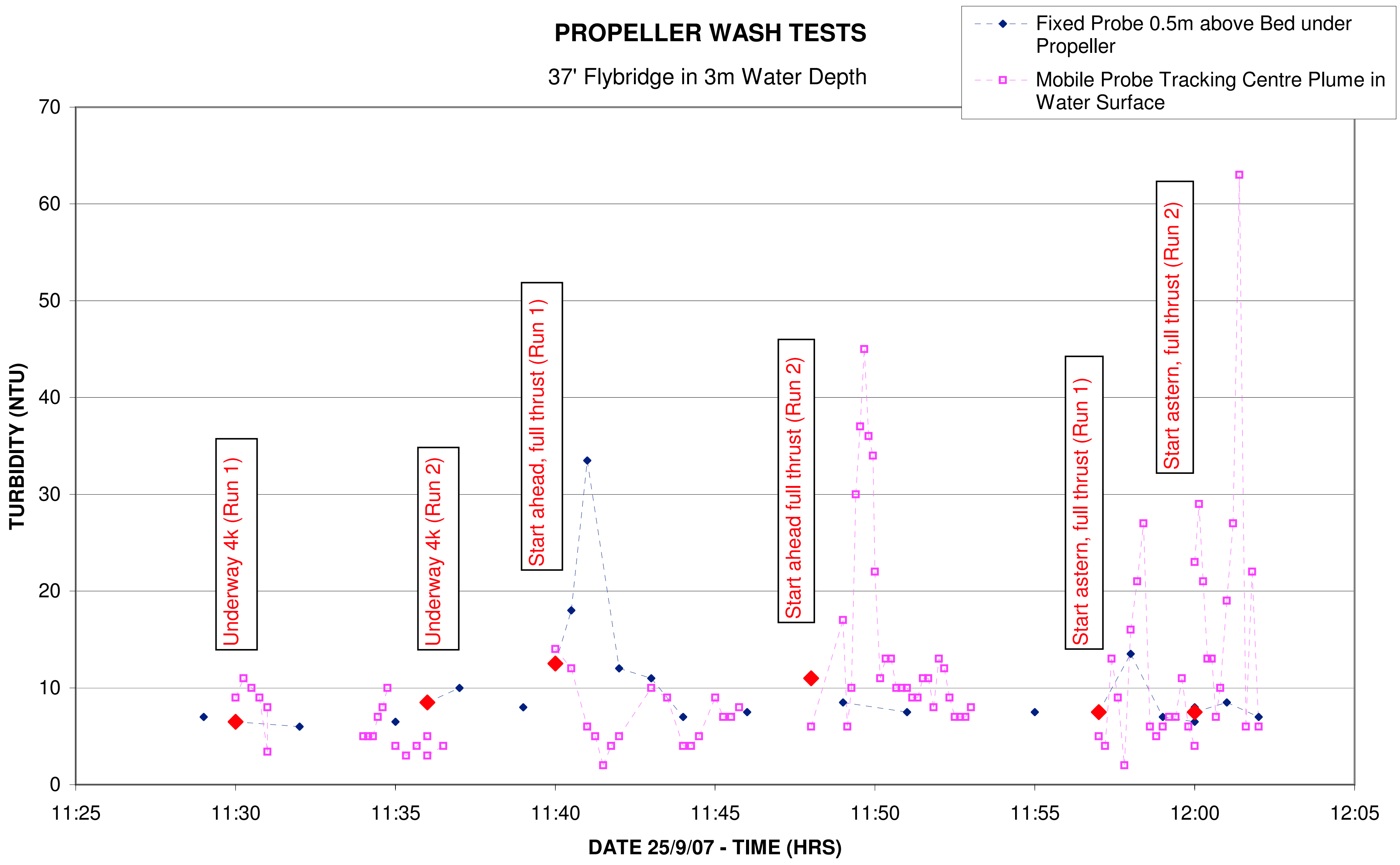
Prepared by G Blumberg 26/10/2007 9:53 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(7) 37'@2m Plt(av)

FIGURE 7

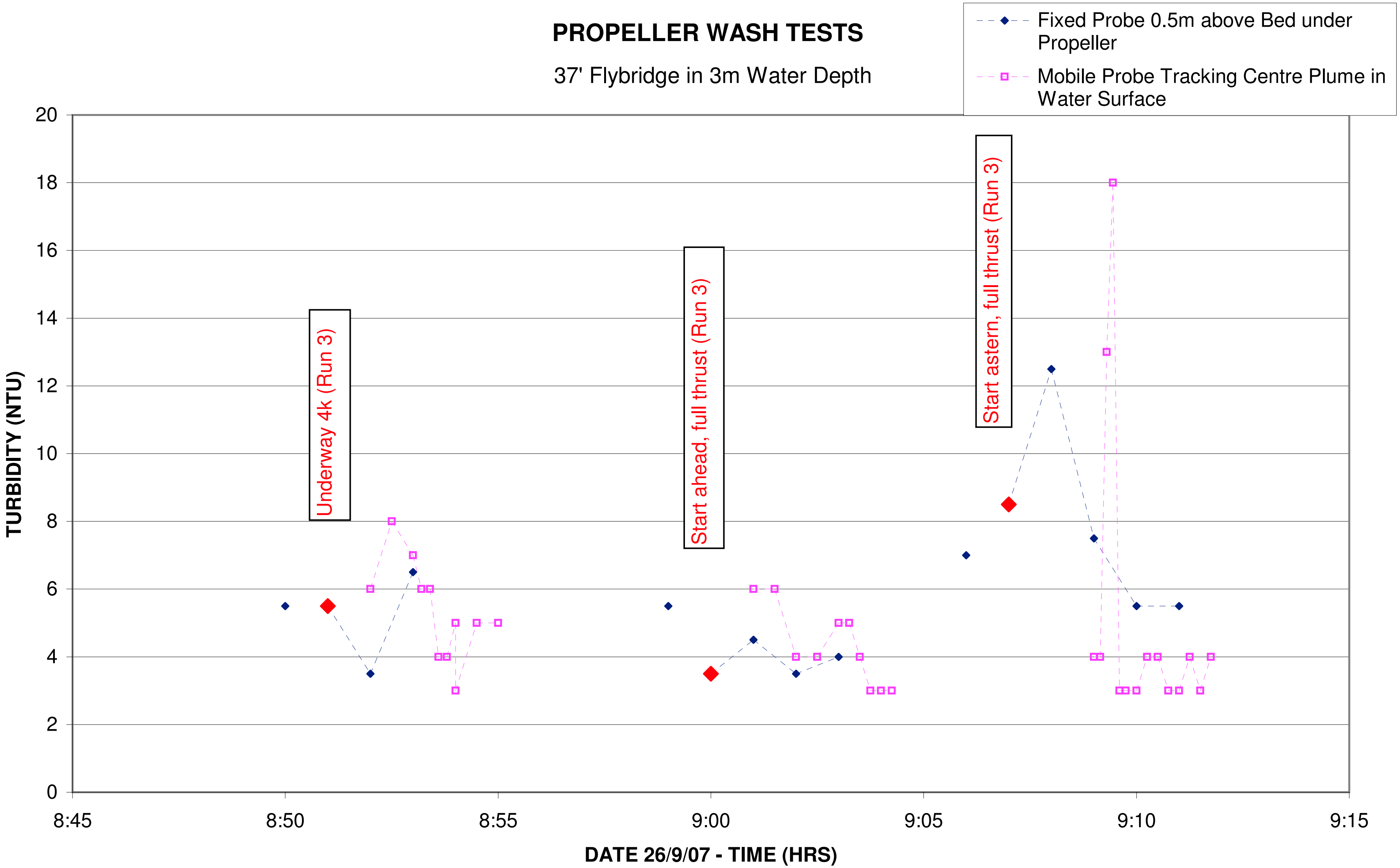
Prepared by G Blumberg 26/10/2007 9:54 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(8) 37'@3m Plt(av1)

FIGURE 8

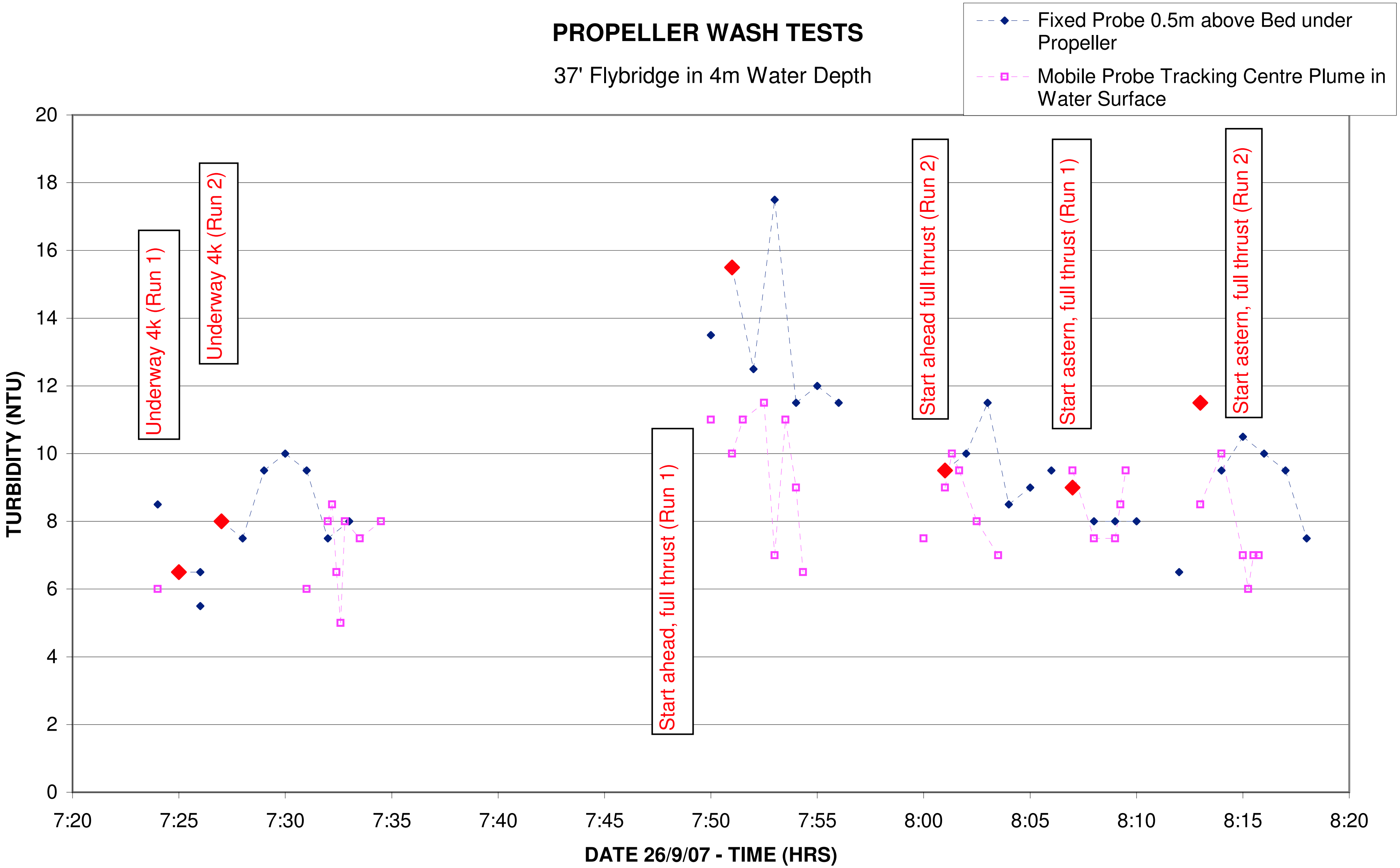
Prepared by G Blumberg 26/10/2007 9:54 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(9) 37'@3m Plt(av2)

FIGURE 9

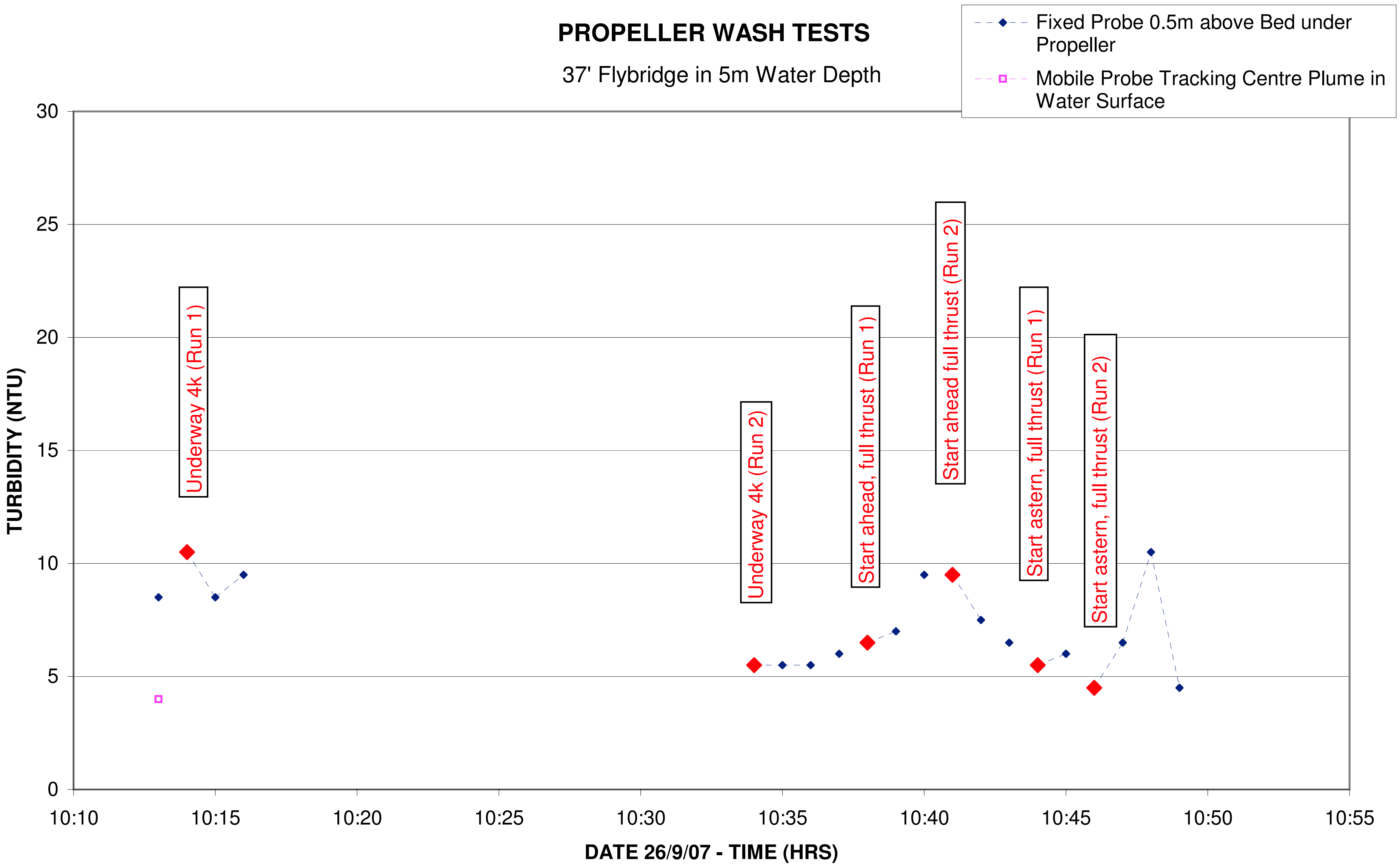
Prepared by G Blumberg 26/10/2007 9:54 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(10) 37'@4m Plt(av)

FIGURE 10

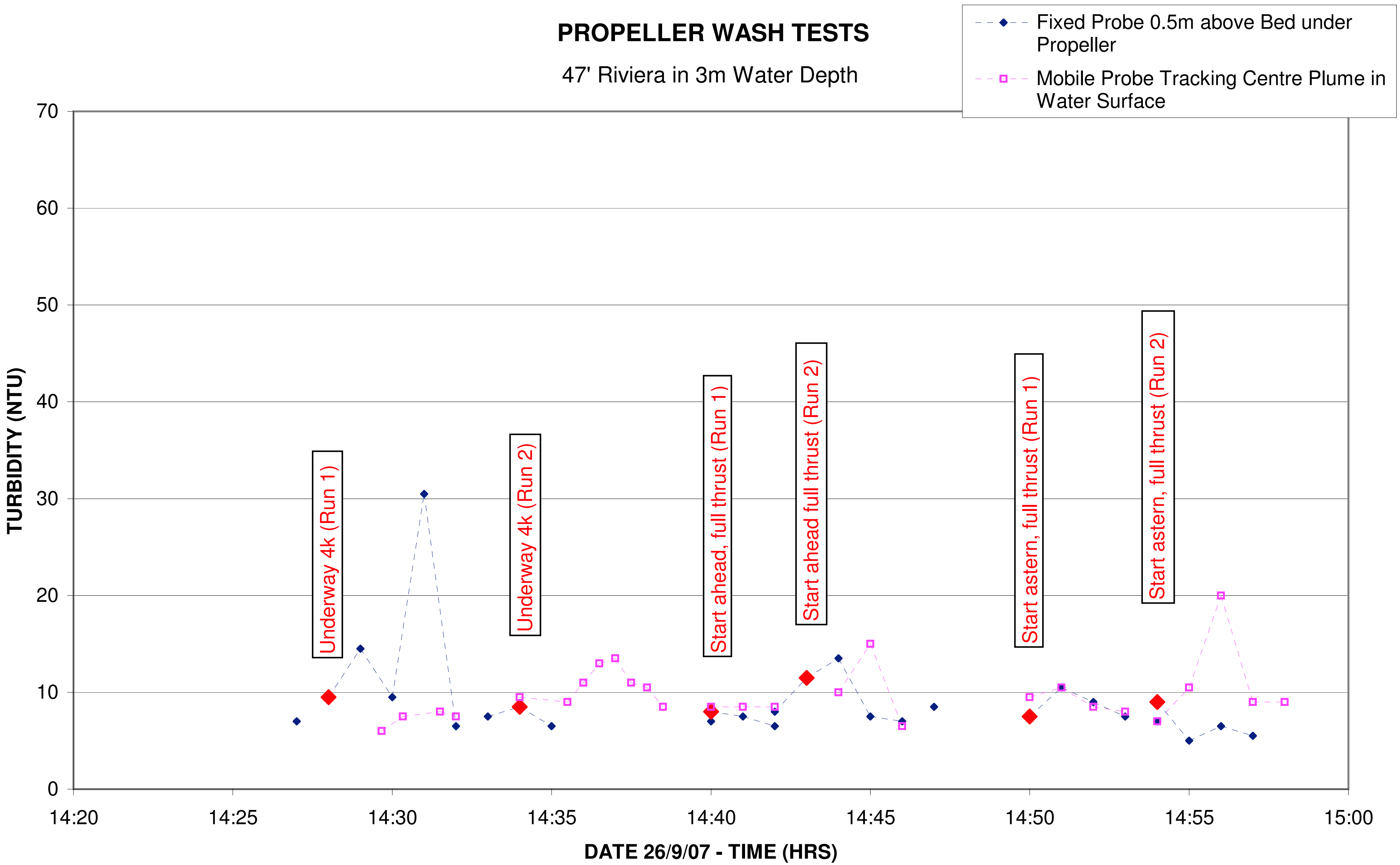
Prepared by G Blumberg 26/10/2007 9:55 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(11) 37'@5m Plt(av)

FIGURE 11

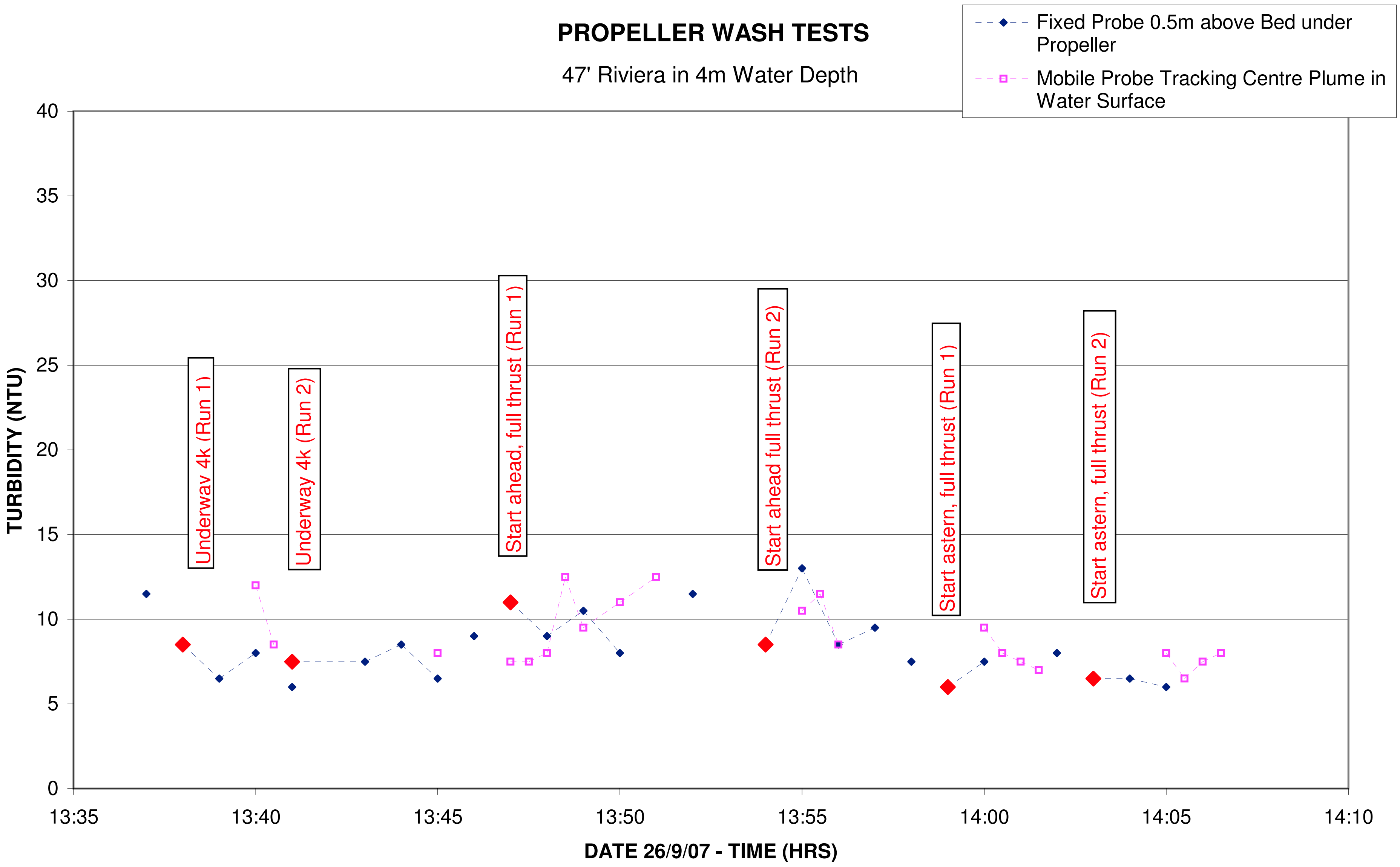
Prepared by G Blumberg 26/10/2007 9:56 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(12) 47'@3m Plt(av)

FIGURE 12

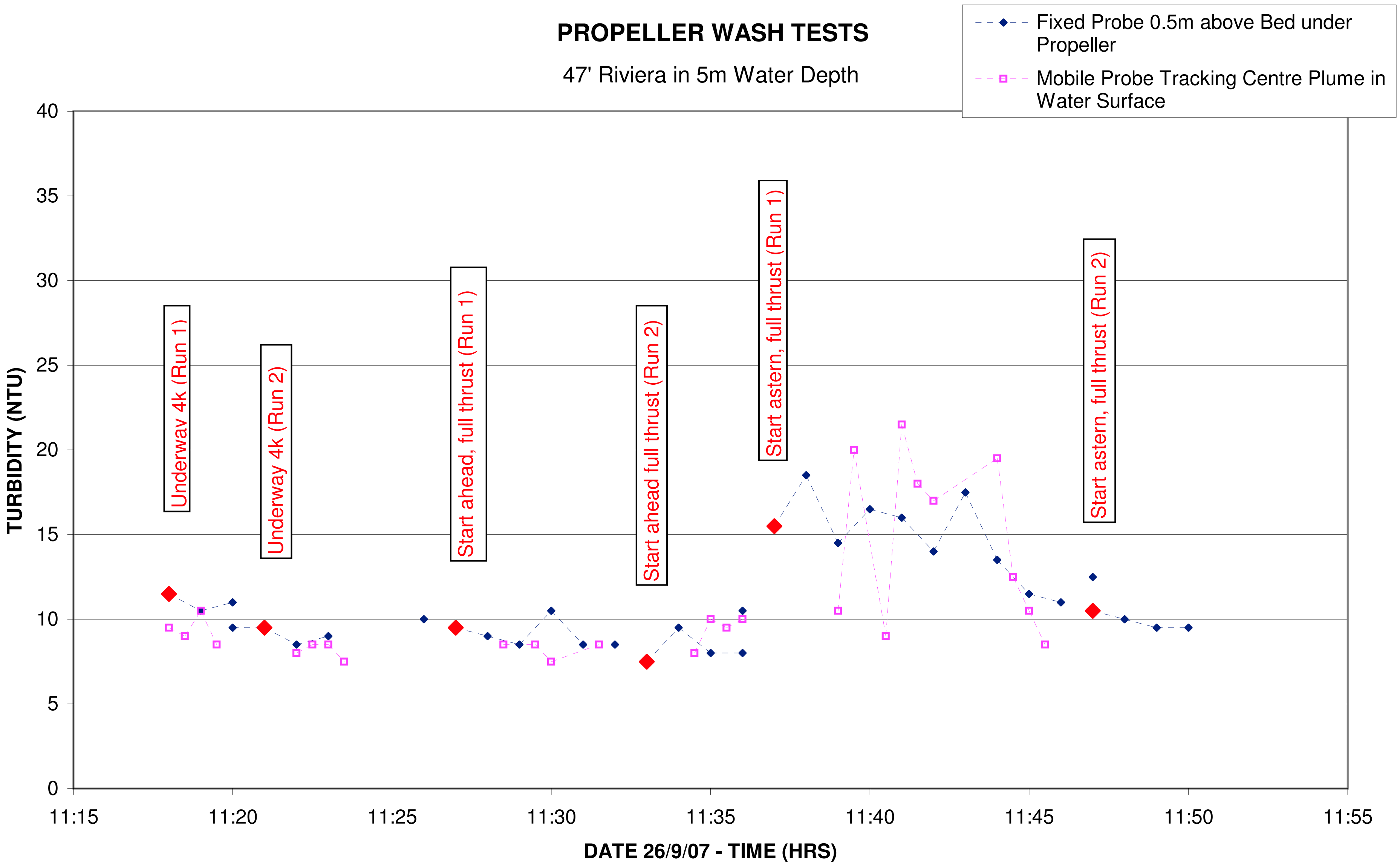
Prepared by G Blumberg 26/10/2007 9:56 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(13) 47'@4m Plt(av)

FIGURE 13

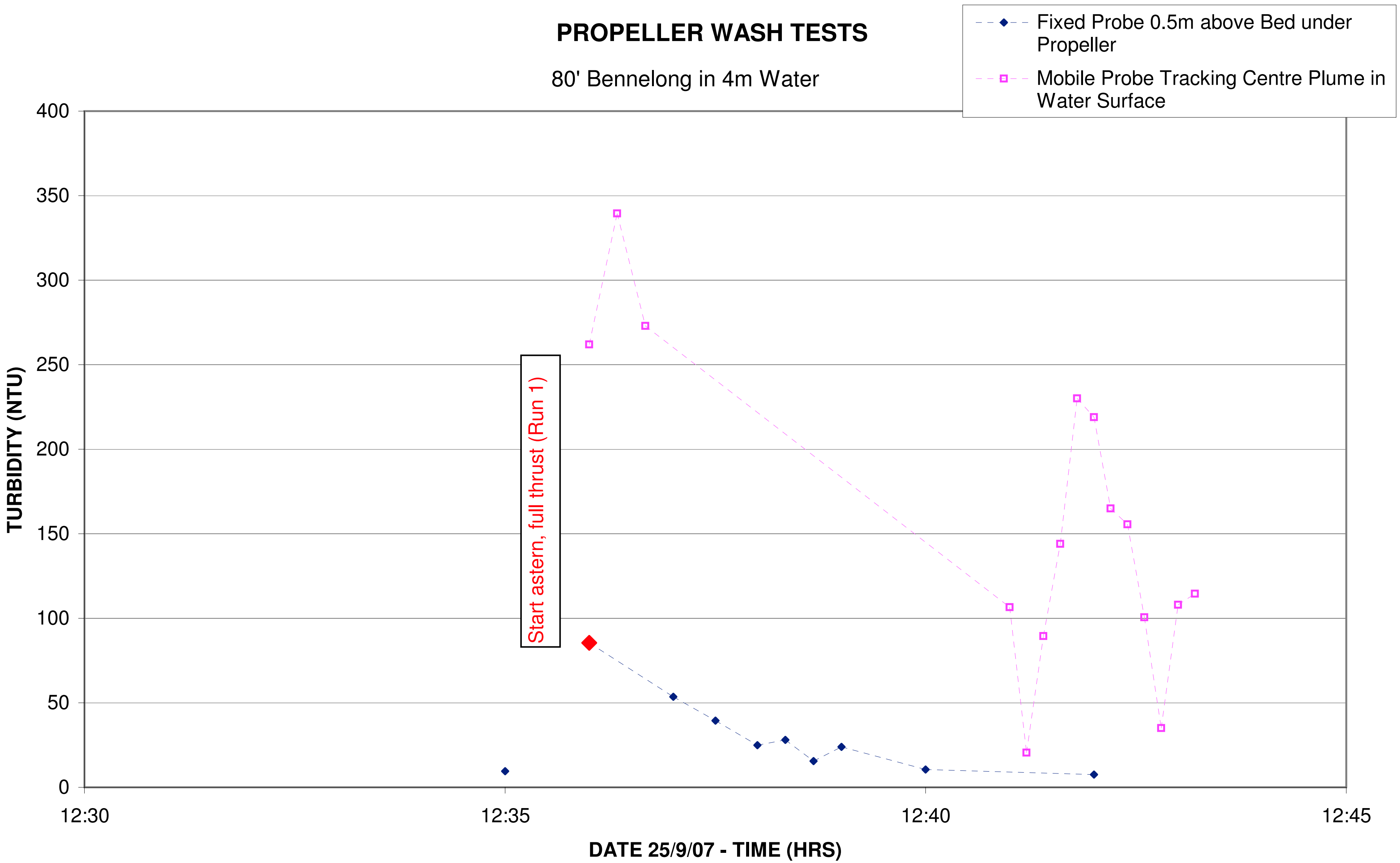
Prepared by G Blumberg 26/10/20079:57 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(14) 47'@5m Plt(av)

FIGURE 14

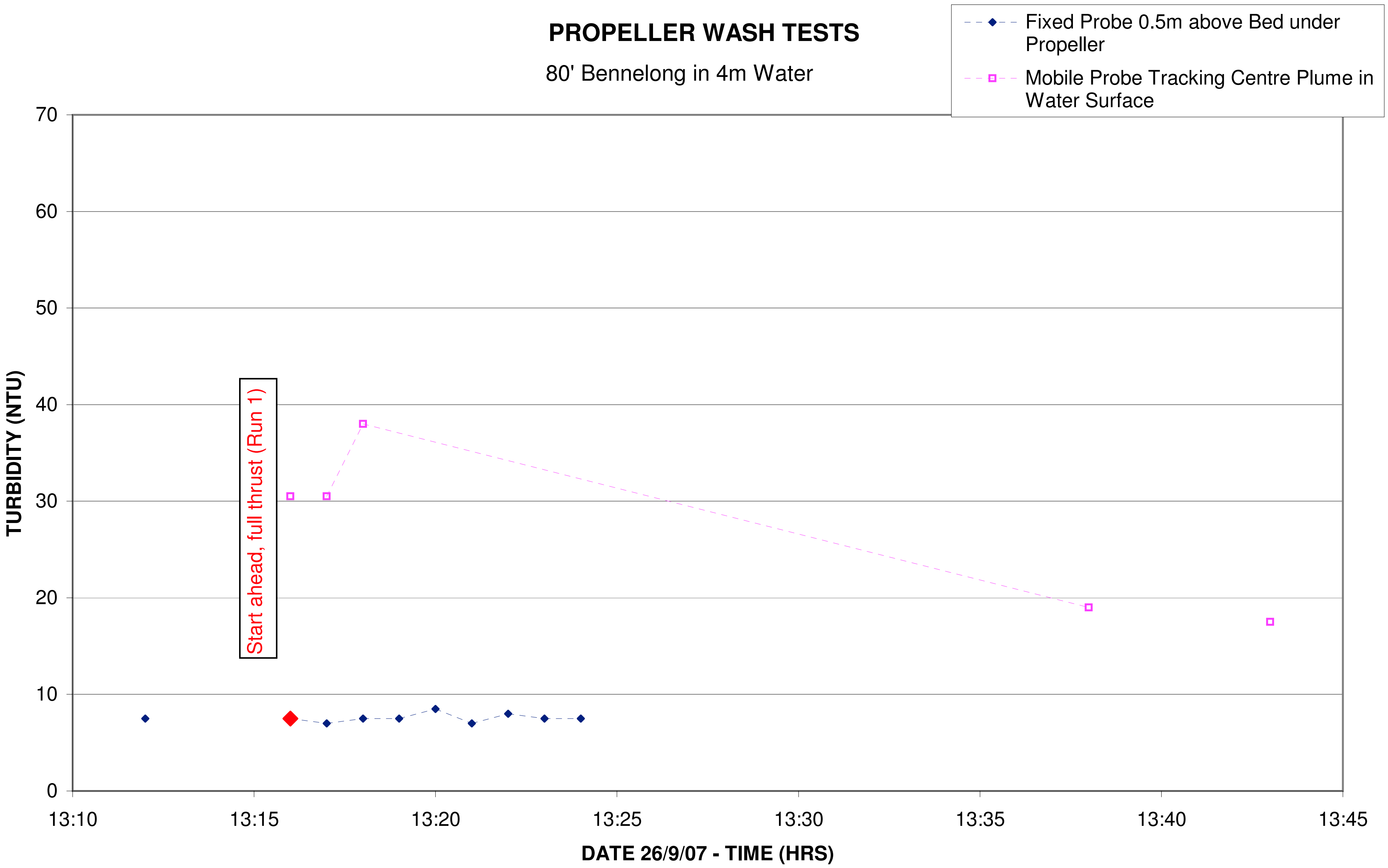
Prepared by G Blumberg 26/10/2007 9:57 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(15) 80'@4m Plt(av1)

FIGURE 15

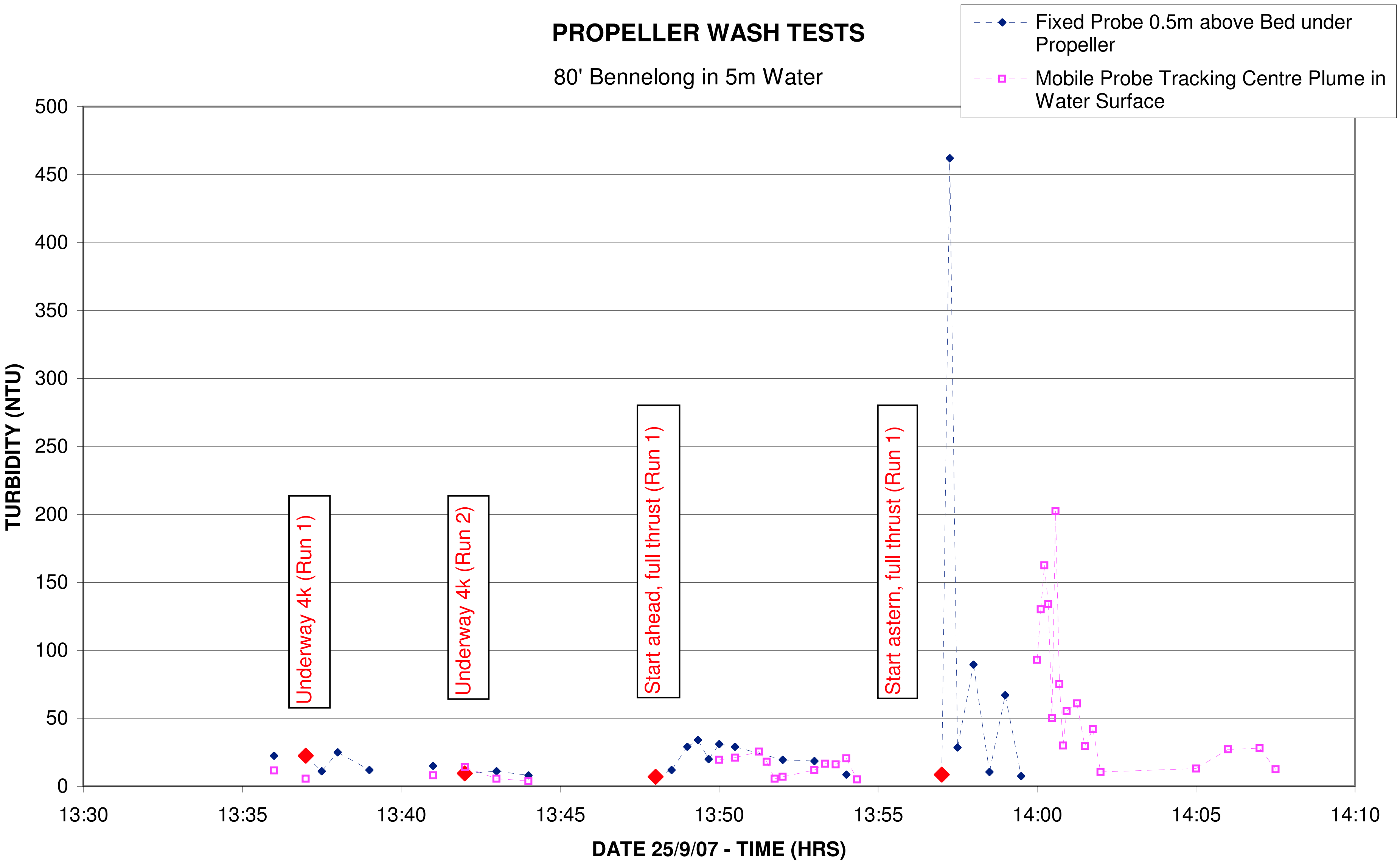
Prepared by G Blumberg 26/10/2007 9:58 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(16) 80'@4m Plt(av2)

FIGURE 16

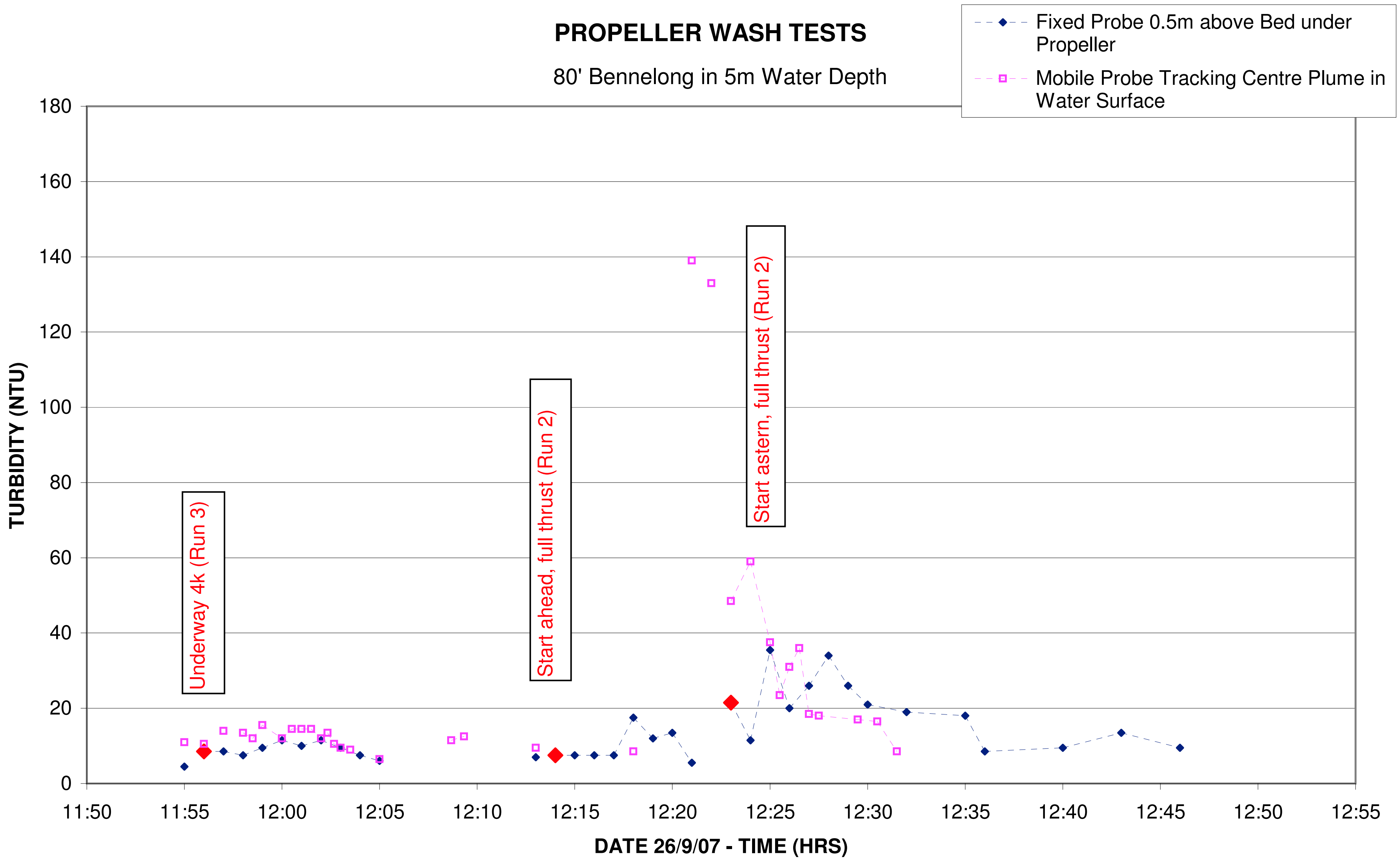
Prepared by G Blumberg 26/10/2007 9:58 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Field results draft v2.xls(17) 80'@5m Plt(av1)

FIGURE 17

Prepared by G Blumberg 31/10/2007 8:37 PM



GBA J07-16/lr761
C:\GBA\Job Files\Current Jobs\2007\07-16 Kendal Bay Marina\Working\Field results draft v2.xls(18) 80'@5m Plt(av2)

FIGURE 18

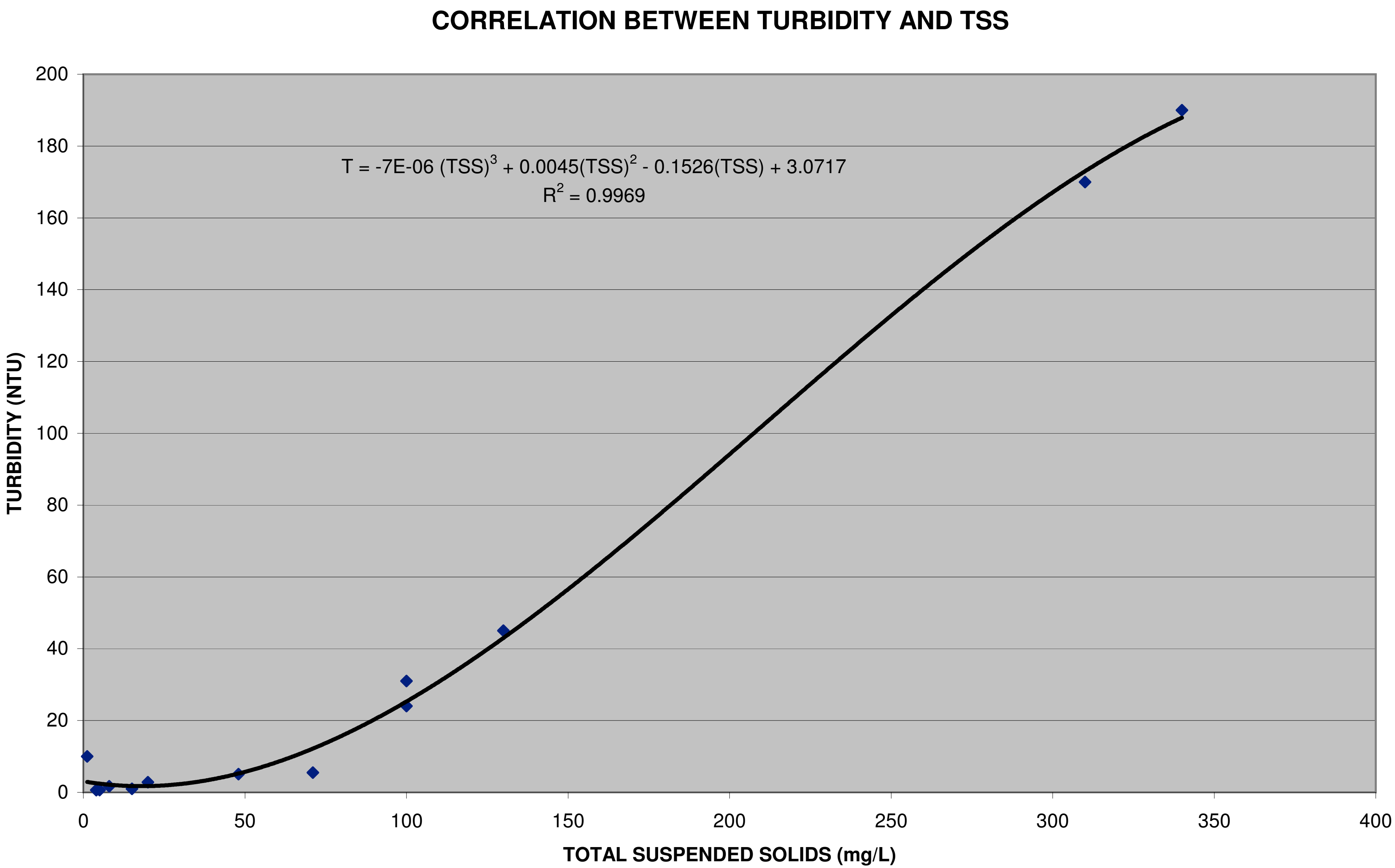

CORRELATION BETWEEN TURBIDITY AND TSS
T = -7E-06 (TSS)^3 + 0.0045(TSS)^2 - 0.1526(TSS) + 3.0717
R^2 = 0.9969
TURBIDITY (NTU)
TOTAL SUSPENDED SOLIDS (mg/L)
0
20
40
60
80
100
120
140
160
180
200
0
50
100
150
200
250
300
350
400

FIGURE 19

SELECTED PHOTOGRAPHS TAKEN DURING THE FIELD INVESTIGATION

1

2

3

4

5

6


2007/09/25

7


YAMAHA
Webster's
TwinFisher 5.0
BA709N
2007/09/25

8


2007/09/26

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20

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APPENDICES

APPENDIX A

TURBIDITY INVESTIGATION DESIGN BY GBA

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ph 02 9460 7663
fax 02 9460 7664

COASTAL, ESTUARY AND RIVER ENGINEERING SPECIALISTS

gpb:gpb/99-7-29/lr745

21 August, 2007

Taylor Lauder Bersten
514 Millar Street
CAMMERAY NSW 2062

Attention: Mr Howard Bersten

Dear Howard

BREAKFAST POINT MARINE WORKS, KENDALL BAY, PARRAMATTA RIVER
FINAL DESIGN FOR BOAT WASH TURBIDITY INVESTIGATION

Gary Blumberg & Associates *(GBA)* has consulted with Taylor Lauder Bersten *(TLB),* and through TLB, with the Department of Environment and Climate Change *(DECC),* in formulating a final design for a boat wash turbidity investigation at Kendall Bay, Parramatta River. The investigation design is described below.

1 BACKGROUND

The Breakfast Point Marina proposal entails some 176 berths located on the western shore of Kendall Bay, Parramatta River. Taylor Lauder Bersten *(TLB)* is advising Rosecorp Pty Ltd in relation to the Development Application and supporting environmental assessments.

In November 2006, GBA prepared for TLB a preliminary desk-top assessment of bed disturbance caused by propeller wash from vessels to be berthed within the proposed marina, and compared this to long period surge wash attributed to ferry passings. This investigation found that the proposed marina vessels would have a relatively small influence on the overall turbidity climate in Kendall Bay (**Section 4.1.3**). Subsequent discussions between TLB and DECC outlined the need for additional, more detailed advice. A boat wash turbidity investigation was required to provide the further information to address DECC's requirements.

2 OBJECTIVE OF TURBIDITY INVESTIGATION

Investigations undertaken by URS for the former adjoining landowner AGL found that pollutants reside to varying extents within the sediments comprising the bed of Kendall Bay. These pollutants attach primarily to the fine fraction of the sediments *(muds and clays)*, and it is this fine fraction which dominates the size of suspended sediments contained within a turbid plume. Thus the generation and advection of turbidity in the bay is a mechanism whereby pollutants may be transported from one point to another which is environmentally undesirable.

The main objective for the boat wash turbidity investigation, developed in consultation with DECC, is to establish whether marina activities are likely to cause any additional resuspension of contaminated sediments over and above that caused by current vessel activities.

The investigation would provide a basis to enable any pollutant impacts to be assessed *(eg. pollutant transfer into the waterbody and/or advection and relocation of contaminated fines)*, and if these are found to be significant, to develop an appropriate management response.

3 BACKGROUND ENQUIRY AND LESSONS FROM OTHER INVESTIGATIONS

3.1 General

In developing our design for the turbidity investigation, GBA has:

(i) reviewed the report entitled Environmental Risk Assessment for Sediments Adjacent to the Former AGL Mortlake site *(URS, 2006)*;

(ii) discussed the matter with TLB specialist subconsultant Mr Bill Rooney, WS Rooney & Associates *(31/5/07 pers comm)*;

(iii) appraised the turbidity investigation undertaken by Marine Pollution Research *(MPR)* for the Rose Bay and Point Piper Marina EIS *(JBA, 2006)* and discussed the exercise with Mr Paul Anink of MPR *(1/6/07 pers comm)*;

(iv) consulted with environmental engineers and marine ecologists, The Ecology Lab *(EL)*, to help refine the investigation design *(meeting held 23/7/07)*. GBA proposes to collaborate with EL to support the field investigation.

3.2 URS Turbidity Investigation in Kendall Bay

URS (2006) provides a thorough overview of the turbidity regime in Kendall Bay involving measurements of currents and turbidities, and installation of sediment traps. While a source of useful background information, the URS work does not permit a direct consideration of the effects of the proposed marina activities on the turbidity climate of Kendall Bay.

In addition, URS make a minor reference to the influence of fast ferries on turbidity within Kendall Bay. As this also relates to the interaction of vessel activities, it does provide an important context for the turbidity assessment for the marina proposal and warrants further consideration.

3.3 Turbidity Investigation for Rose Bay Marina

To support the environmental investigations for the Rose Bay Marina in Sydney Harbour, Marine Pollution Research *(MPR)* recently undertook a turbidity investigation. The aim of the Rose Bay investigation is shared for Kendall Bay, hence it is of interest for us to understand what was done at Rose Bay, how successful this was, and whether a similar approach might have merit at Kendall Bay.

MPR measured turbidity at a point 0.45 m above the bed generated by propeller wash from an overhead pass of a vessel *(directly over sensor position)* with 30 HP inboard diesel motor and propeller located 0.9 m below the water surface, for water depths of 1.5 and 2.9 m, and vessel speeds up to 8 knots.

For the shallower 1.5 m condition and unidirectional vessel passings up to 6 knots, no *(additional)* turbidity was discerned. However, with fast stops and starts over the sensor, turbidity was encountered but returned to background levels within 10 to 20 s.

For the deeper 2.9 m condition with unidirectional vessel passings up to 8 knots, no turbidity was discerned, but with fast stops and starts over the sensor "limited" turbidity was induced returning to background levels within 90 s.

The MPR investigation involved a roving turbidity meter with the sensor fixed to a stake and cable-connected to the processor/logger manually operated at a nearby support dinghy. A diver assisted with the exercise, deploying the sensors and also observing the turbidity plume during turbidity measurements. The influence of fast ferries on turbidity was not examined. The relatively short time for the increased turbidity to return to background levels was attributed to the low silt content in the local sediments. By their own account, MPR was pleased with the experimental design and outcome at Rose Bay and would not envisage any changes for a similar future exercise.

The bed sediment in Kendall Bay contains more mud than the bed sediment in Rose Bay. It follows that lower current velocities are likely to stir the bed in Kendall Bay, and the time for a turbid plume to resettle is likely to be longer. Also, bed disturbance from wind waves may more readily confound an exercise in Kendall Bay compared to Rose Bay. In spite of these differences, it is our opinion that the general investigation methodology adopted in Rose Bay has application in Kendall Bay, with some refinement.

4 TURBIDITY INVESTIGATION DESIGN FOR KENDALL BAY

DECC has reviewed the development of the investigation design, queried some aspects and requested certain inclusions. DECC has also confirmed its main objective for the investigation (**Sections 1** and **2**). The final turbidity investigation design, described below, has attended to DECC's queries, inclusion requests and investigation objective.

GBA, in association with EL and TLB, have designed a **Low Risk** investigation incorporating **Environmental Contingency Actions**.

4.1 Low Risk Exercise

We characterises the "low risk" nature of the proposed turbidity monitoring exercise under the following main headings:

- monitoring of single vessel turbidity disturbance;
- working in an area of relatively low contamination;
- expectation of relatively low turbidity disturbance from single test vessels compared to ambient vessel traffic;
- need to avoid confounding influence of high turbidity.

Investigation details of specific interest to DECC are confirmed in the descriptions.

4.1.1 Monitoring of Single Vessel Turbidity Disturbance

Our exercise involves the separate testing of two test vessels; namely:

(i) Riviera M430 *(L=47' [14m], 2x500 hp (1) Volvo Penta Turbo engines)*
(ii) Pace 40 *(L=40' [12m], 2x320 hp twin drive)*

(1) While the specification for this vessel identifies 2x300hp engines, the Riviera M430 being made available incorporates 2x500hp engines.

DECC requested that the Test Vessels represent the "average" boat likely to use the marina. Based on TLB's provisional marina layout, vessel lengths for berthing range between 8 and 25 m. The nominated Test Vessels, representing the 20-44%ile [L=12m] and 44-69%ile [L=14m] of vessel lengths, suitably addresses this requirement.

To satisfy the requirements of DECC, the vessels would be operated in displacement and/or semi-displacement mode. The test scenarios would include typical marina manoeuvring actions such as near stationary full thrust astern and ahead, as well as unidirectional passing at various speeds.

DECC did request that the engine power of the Test Vessels reside in the 250 to 300 hp range. While such craft are not available for our work, we would instruct the helmsmen to operate the Test Vessels such that the power to the drives does not exceed 300 hp. ie 60% max thrust for the Riviera and 90% max thrust for the Pace.

GBA understands that average daily boat traffic in the Parramatta River, in the vicinity of Kendall Bay, is in the order of 200 movements, some 30% of which are fast ferries of which half cross the bay to and from Cabarita Wharf. Based on GBA's understanding of the wash behaviour of the fast ferries, it is our submission that the turbidity which is likely to be generated by our single Test Vessel passes would not be disproportionate to the turbidity response generally of ambient vessel traffic which passes and crosses Kendall Bay.

4.1.2 Working in an Area of Relatively Low Contamination

The investigation would be conducted within the footprint of he proposed marina, located on the western side of Kendall Bay.

The vessels would work in a localised area on the southern side of the line of the former AGL wharf. URS (2006) found that the total PAH levels in the surface bed sediments were significantly lower in this area compared to the inshore areas on the northern side of the former wharf – refer SK-01. Propeller wash would be limited to a single track *(Test Track)* approximately 5 m wide and 100 m long, located along the centreline of the Turbidity Test Zone *(TTZ)* as shown in the sketch. The 500 m^2 area of the Test Track may be compared to the total area of Kendall Bay of 20 Ha *(<0.5%).*

The Test Vessels would operate over bed levels of RL -1, -2 and -3 m ZFDTG, the bed levels mainly encountered in the proposed marina. If turbidity is generated at RL-3 m, we would extend the work to RL-4 m and beyond if time and conditions permit.

DECC has requested that the testing covers a low tide situation *(specifically a water level of RL 0.3 m ZFDTG)* when propeller disturbance at the bed would be a largest. Since we are targeting different depths and would include the minimum possible depth that these boats can operate in, DECC's request is attended to. Our results could be extrapolated to all states of the tide, including the minimum tide height of RL 0.3 m requested by DECC. We would expect that the helmsmen of the Test Vessels would be prepared to operate to depths that provide a minimum underkeel clearance of say 300 to 400 mm. On that basis, the exercise should cover depths to a minimum of 1.5 m. Note that the minimum bed levels in the proposed marina are currently adopted at RL-2 m, but may be slightly lower at say RL-1.8 m for the 8 and 6 m berths at the far southern end.

It is proposed to have the Test Vessel move along the Test Track at variable speeds and variable levels of thrust, simulating the range of movement of vessels within the proposed marina. Turbidity would be measured 0.5 m above the bed throughout *(same as URS)*, initially at the centre of the Test Track immediately following a passing, and then at distances of 10 and 20 m from the Test Track measured at right angles to the track. The bed levels at these test points would, for all intents and purposes, be the same as that at the centreline of the Test Track. We are confident that this approach would capture the worst case turbidity condition immediately below the vessel.

We propose to have two twin-person teams working separately in two runabouts monitoring turbidity. A suitably calibrated, portable turbidity meter would be operated from each runabout, with x-y location by manual GPS, and z location by portable depth sounder. The investigation design is such that disturbance of the bed by the monitoring technique is avoided. Diver assistance for the exercise *(as was used at Rose Bay)* was initially envisaged, but later discarded in that the movement of the diver itself was considered likely to generate turbidity given the finer bed sediments in Kendall Bay.

We propose to have the Test Vessels arrive at the site ready for work from 9.00 am on Tuesday 28 August, and intend to have completed our monitoring before 1.00 pm. We propose to replicate the entire exercise the following day. Poor weather or elevated background turbidity due to antecedent rainfall would trigger a roll forward of the exercise.

The survey team involving GBA and EL would be on site at first light on both monitoring days. We propose to measure the background turbidity at the same locations to be monitored later in the morning, prior to the arrival of the Test Vessels. We are interested to monitor the influence of fast ferry wave action on the turbidity at the bed, flagged as a significant localised affect in the URS (2006).

Finally, we also propose to have Skyshots Pty Ltd take aerial photographs of the monitoring work. We are hopeful that this would provide a useful visual gauge of the degree of disturbance of propeller action from the Test Vessels, and also from ambient vessel activity.

4.1.3 Expectation of Relatively Low Turbidity Disturbance from Single Test Vessels compared to Ambient Vessel Traffic

GBA has previously assessed the influence on sediment transport of propeller wash from boating movements to and from the proposed facility, and compared this to wave action from passing fast ferries *(GBA fax to TLB 23/4/07)*. Using desk-top methods, we estimated that 18 boat movements in and out of the proposed marina facility *(10% of the 176 berths)* would generate potential bed sediment transport in Kendall Bay equivalent to <2% of that attributed to wave action from passing fast ferries. We would expect to carry out less than 18 passings with our test vessel on each of our 2 days of turbidity monitoring. Based on our assessment for TLB, we would expect the relative impact of the proposed field investigation on turbidity in the bay to be small.

4.1.4 Need to Avoid Confounding Influence of High Turbidity

By its nature, excessive turbidity would confound our field work. We would need to wait for turbidity to settle down between runs, otherwise we would not be in a position to assess turbidity impacts.

4.2 ENVIRONMENTAL CONTINGENCY ACTIONS

In spite of our opinion that the exercise is low risk, DECC has requested that environmental contingency actions be designed and implemented. GBA proposes to implement each of the following three environmental contingency actions.

4.2.1 Boom and Silt Curtain

GBA has arranged to retain Sydney Ports, Operations Division, to supply and deploy a 100 m long fence boom immediately adjacent and parallel to the northern edge of the TTZ as shown in attached sketch **SK-02**. In this regard we note the following:

(i) it is impractical to fully contain the test area with a boom given the space needed by the vessel to start, stop and manoeuvre;

(ii) it is our assessment that the main currents in this bay would be clockwise – these would be driven by tidal circulations and the predominant S through W wind patterns encountered during Winter and Spring mornings in the Sydney area - hence a linear curtain located on the NW side of the TTZ is appropriate;

(iii) it is the western shoreline of the bay that is most accessible to the public and limiting the potential for a disturbance at or close to this shore is a prudent measure.

Sydney Ports advise that the boom fence is 500 m wide at the water surface and penetrates to a depth of 300 mm. Its function is to contain any slick that may develop as a consequence of disturbing the bed sediments, and any possible release of hydrocarbons. Sydney Ports do not posses or use boom fences, curtains and the like that penetrate to larger depths. They consider these impractical and of little additional benefit to pollution mitigation *(GB to G Edgley, Sydney Ports, pers comm)*. We would also make the point that any near-bed curtain structure could itself disturb the bed and thereby confound the monitoring work.

The boom fence would be buoyed and night-lit over the duration of its deployment.

4.2.2 Visual Check for Discolouration at Water Surface

We would keep a continuous watch on the extent of turbid discolouration at the water surface. If a visible plume generated by the action of the test vessel extends outside the -20/+20 m Turbidity Test Zone limits, the exercise would be suspended until the discolouration is no longer visible.

4.2.3 Turbidity Check at Edge of Remediation Site

At hourly intervals during turbidity monitoring with the Test Vessel, we would measure the turbidity level at Points A and B (see attached sketch **SK-03**). If the turbidity measurements at one or both of these points exceeds, by more than 10%, the greater of the individual maximum background turbidity levels for Points A and B as measured by URS in January 2006, and as measured by GBA / EL for fast ferry passings *(these measurements to be made immediately prior to the vessel test work between 6.30 am and 9.00 am)*, then the exercise would be suspended until further measurements at Points A and B demonstrate that this limit is not exceeded.

Thus turbidity, in excess of 10% above background, would not be permitted to move from the Remediation Site *(as defined by URS)* into the Parramatta River.

5 REFERENCES

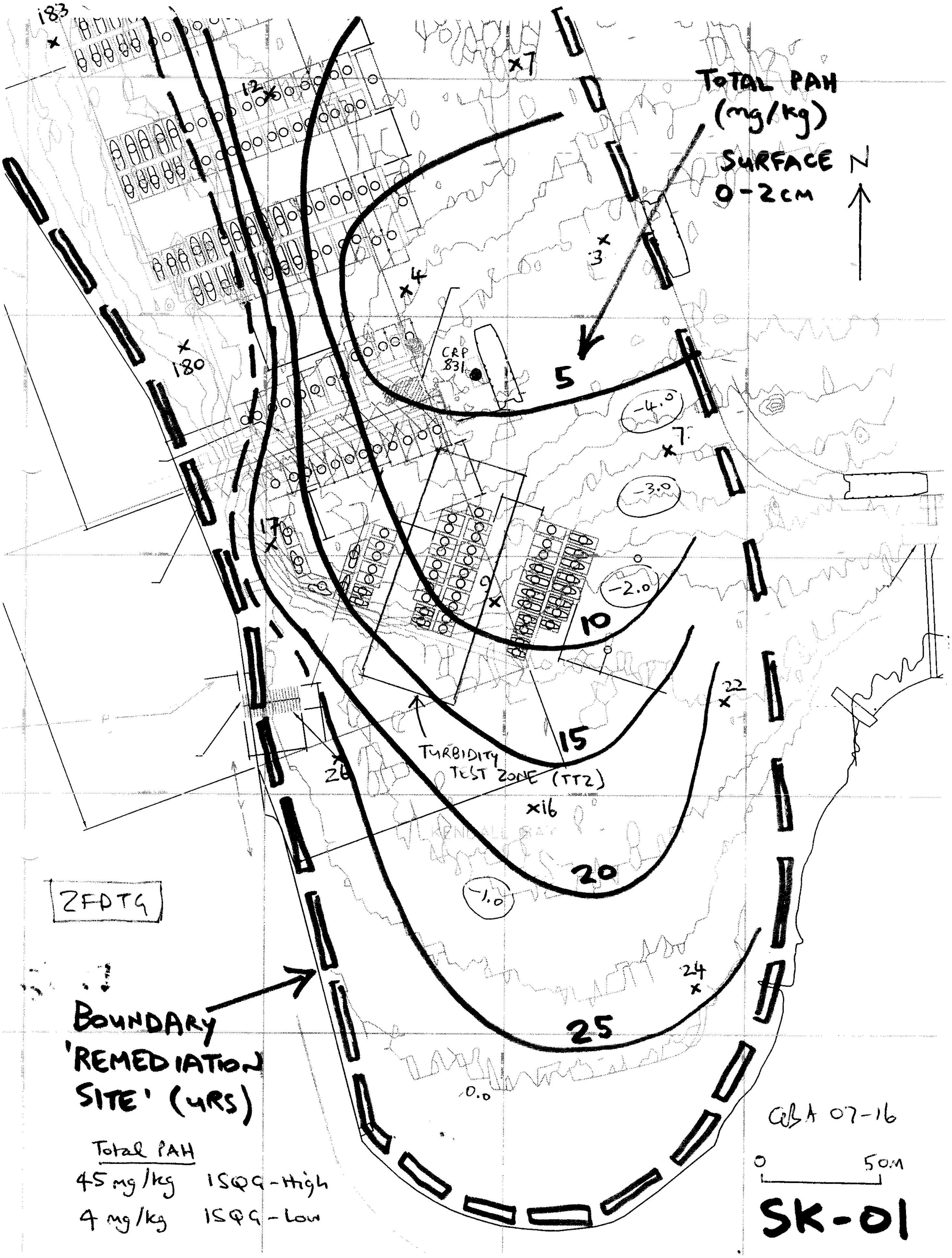
URS (2006)
Environmental Risk Assessment for Sediments Adjacent to the Former AGL Mortlake Site
Prepared for AGL Pty Ltd, draft report, 31 May 2006

JBA Urban Planning Consultants (2006)
Redevelopment of Rose Bay and Point Piper Marinas
Environmental Impact Statement
Submitted to Woollahra Council on behalf of Addenbrooke Pty Ltd, November 2006

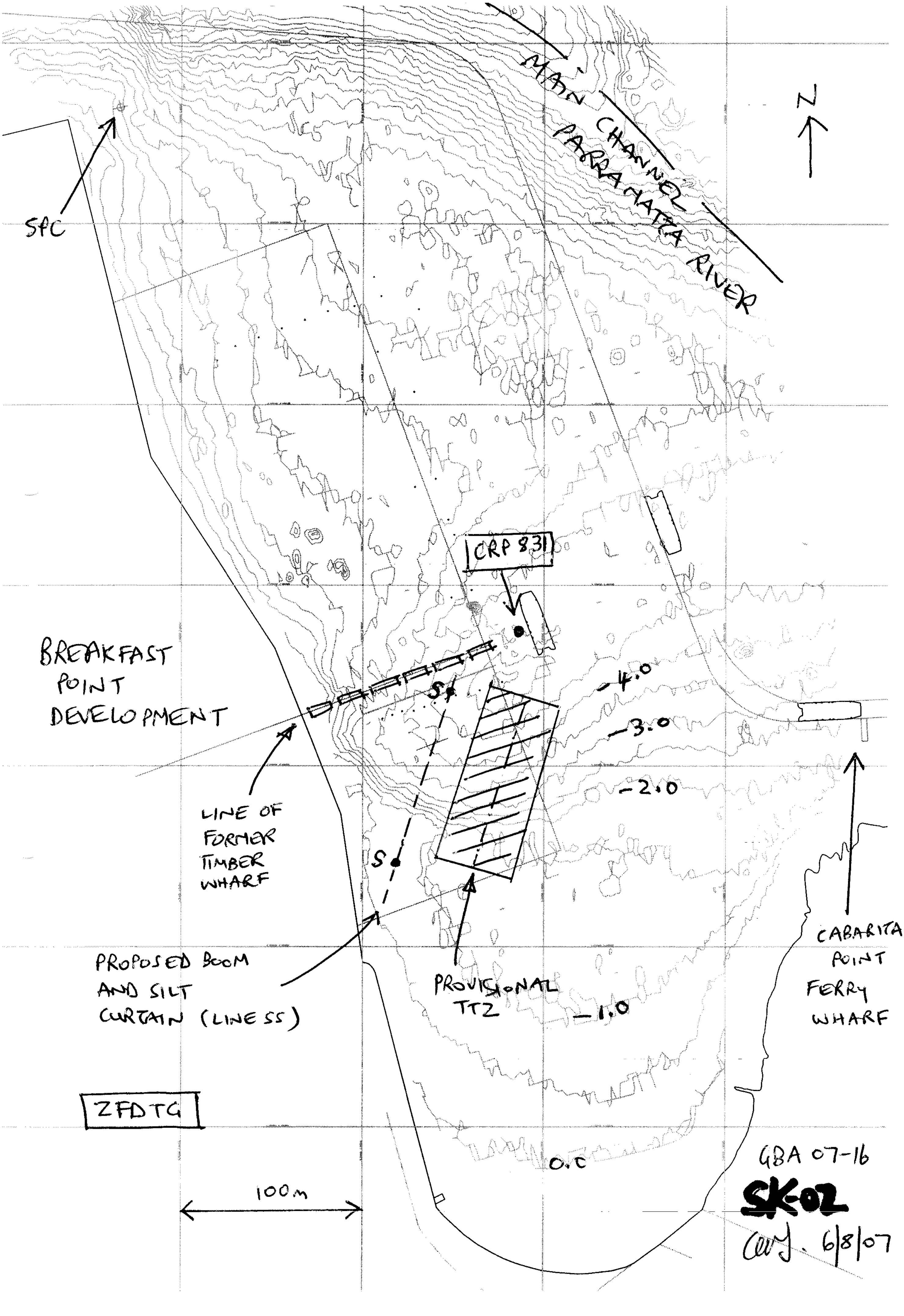
We trust that the above meets your immediate requirements in this matter. Should you need any further information or clarification, please do not hesitate to contact the undesigned.

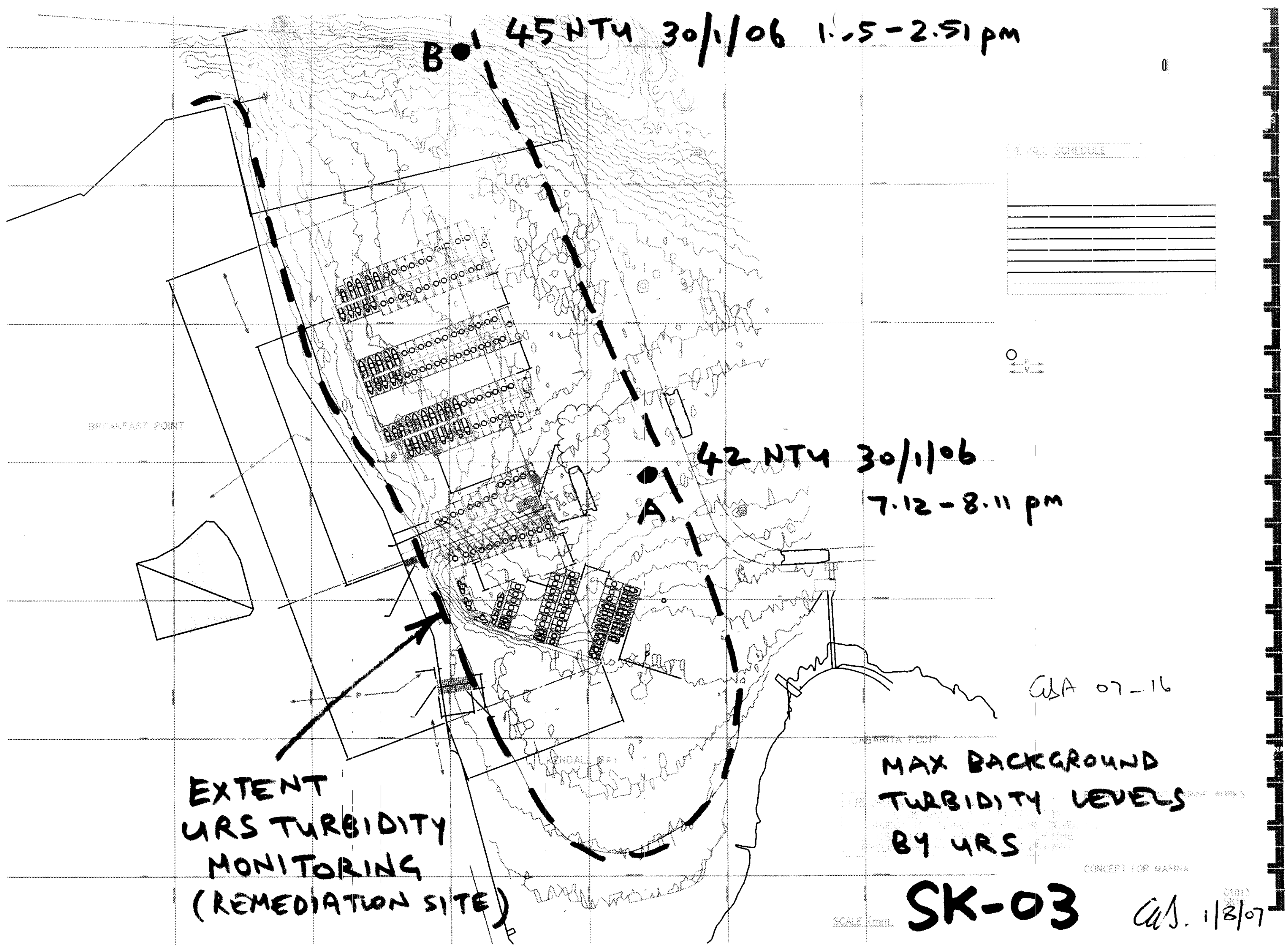
Yours faithfully
GARY BLUMBERG & ASSOCIATES

G P Blumberg
Principal



> ISQG-H ... likely to cause adverse effects to benthic organisms] URS descriptors.
< ISQG-L ... potential adverse effects unlikely


MAIN CHANNEL
PARRAMATTA RIVER
N
SPC
CRP 831
BREAKFAST POINT DEVELOPMENT
-4.0
-3.0
-2.0
-1.0
0.0
S
S
LINE OF FORMER TIMBER WHARF
PROPOSED BOOM AND SILT CURTAIN (LINE SS)
PROVISIONAL TTZ
CABARITA POINT FERRY WHARF
ZFDTG
100m
GBA 07-16
SK-02
6/8/07



B 45 NTU 30/1/06 1.05-2.51 pm
A 42 NTU 30/1/06 7.12-8.11 pm
BREAKFAST POINT
CABARITA POINT
EXTENT URS TURBIDITY MONITORING (REMEDIATION SITE)
MAX BACKGROUND TURBIDITY LEVELS BY URS
CSA 07-16
CONCEPT FOR MARINA
SCALE (mm)
SK-03
CS. 1/8/07

APPENDIX B

WEATHER DETAILS FOR 25 AND 26 SEPTEMBER 2007 (BUREAU OF METEOROLOGY)

Gary Blumberg

From: Ana Knight [A.Knight@bom.gov.au] on behalf of REQNSW [reqnsw@bom.gov.au]
Sent: Tuesday, 30 October 2007 11:39 AM
To: gba@tpg.com.au
Subject: Climate Data Files: REQUEST FOR WIND DATA [SEC=UNCLASSIFIED]
Attachments: gaSydneyOlympicPark.zip; gaTaxInvoice.pdf

Hi Gary

Attached are your files.

Hourly wind speed/direction/gust data for Sydney Olympic Park {station number 66195}, from 25/9/07 to 26/9/07.

A TAX INVOICE FOR DATA RECEIVED IS ATTACHED TO THIS EMAIL.

***
We are always trying to improve our service, but we need your help.
By completing our online feedback form you can make a real difference.
To share your views with us, go to www.bom.gov.au/climate/feedback/nsw.shtml
***

Please read the following instructions carefully.
You may have been supplied with multiple file formats. For best results,

1. Extract the data files from the zipped archive and save them to your hard drive. **You must do this first!**
2. Open your spreadsheet program (ie. EXCEL, Lotus) first, then open the files through this program. **DO NOT DOUBLE CLICK!** A text import wizard should open up. Select "Delimited", press NEXT, now click "Comma" separated.

Please read the following explanation of your data files

- The text file containing the word "Data", holds your requested data. The file is in comma separated spreadsheet format and can be opened using your spreadsheet software, i.e.. Lotus 123, EXCEL, etc.
- The text file containing the word "Notes", includes information relating to the file format and quality of the requested data. This file can be opened using your word processor software, i.e.. WORD, NOTEPAD, etc.
- The text file containing the word "StnDet", includes information on the recording station (Station Name, latitude and longitude, elevation, and when the station opened). The format for this file is located in the "Notes" file above. This file can be opened using your word processor software, i.e.. WORD, NOTEPAD, etc.
- Your data files may be zipped up, click on "winzip" to download the "Evaluation Version" of the Winzip program (if you don't have it already). Once you have a version of winzip on your computer, unzipping files is as easy as clicking on the .zip file.
- All due care has been taken to minimise transmission of any computer virus with your data, however the Bureau of Meteorology cannot accept responsibility for any virus received during transmission of data or otherwise.

Any queries please email back.
Regards,

Ana.
NSW Climate Services Centre
Bureau of Meteorology
ABN: 92 637 533 532

Fax: (02) 9296 1567
Switchboard: (02) 9296 1555

Other useful links:-
Radar Images: http://www.bom.gov.au/weather/radar
Climate averages: http://www.bom.gov.au/climate/averages
Search our recording stations: http://www.bom.gov.au/climate/how/sitedat.shtml
Forecasts and Observations: http://www.bom.gov.au/weather/nsw

* Percentage complete between first and last records assumes 48 observation per day.
Some days there may be more then 48 reports if there have been significant changes in
the weather, so the percentage completeness is an estimate.

st,066195,66 ,SYDNEY OLYMPIC PARK (SYDNEY OLYMPIC PK A,08/1995,
,-33.8521, 151.0646,GPS   ,NSW, 28.0,   ,95765,2007,2007,101,
0,100, 0, 0, 0,#

```
hm,Station Number,Day/Month/Year Hour24:Minutes in DD/MM/YYYY HH24:MI format in
Local time,Precipitation since 9am local time in mm,Quality of precipitation
since 9am local time,Air Temperature in degrees C,Quality of air temperature,Wet
bulb temperature in degrees C,Quality of Wet bulb temperature,Dew point
temperature in degrees C,Quality of dew point temperature,Relative humidity in
percentile,Quality of relative humidity,Wind speed in km/h,Wind speed
quality,Wind direction in degrees true,Wind direction quality,Speed of maximum
windgust in last 10 minutes in  km/h,Quality of speed of maximum windgust in
last 10 minutes,Mean sea level pressure in hPa,Quality of mean sea level
pressure,AWS Flag,#
hm, 66195,25/09/2007 00:00,   0.0,N, 15.1,N,     , , 12.4,N, 84,N,  0,N,  0,N,
5,N,      , , 1,#
hm, 66195,25/09/2007 00:30,   0.0,N, 14.7,N,     , , 12.2,N, 85,N,  0,N,  0,N,
5,N,      , , 1,#
hm, 66195,25/09/2007 01:00,   0.0,N, 14.4,N,     , , 11.9,N, 85,N,  2,N, 90,N,
8,N,      , , 1,#
hm, 66195,25/09/2007 01:30,   0.0,N, 14.1,N,     , , 12.0,N, 87,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,25/09/2007 02:00,   0.0,N, 13.8,N,     , , 11.7,N, 87,N,  0,N,  0,N,
4,N,      , , 1,#
hm, 66195,25/09/2007 02:30,   0.0,N, 13.6,N,     , , 11.9,N, 89,N,  2,N, 50,N,
8,N,      , , 1,#
hm, 66195,25/09/2007 03:00,   0.0,N, 13.4,N,     , , 11.7,N, 89,N,  5,N, 30,N,
8,N,      , , 1,#
hm, 66195,25/09/2007 03:30,   0.0,N, 12.7,N,     , , 11.3,N, 91,N,  2,N, 70,N,
5,N,      , , 1,#
hm, 66195,25/09/2007 04:00,   0.0,N, 12.5,N,     , , 11.3,N, 92,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,25/09/2007 04:30,   0.0,N, 12.3,N,     , , 11.2,N, 93,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,25/09/2007 05:00,   0.0,N, 12.1,N,     , , 11.0,N, 93,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,25/09/2007 05:30,   0.0,N, 12.0,N,     , , 10.8,N, 92,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,25/09/2007 06:00,   0.0,N, 11.8,N,     , , 10.6,N, 92,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,25/09/2007 06:30,   0.0,N, 12.1,N,     , , 11.0,N, 93,N,  0,N,  0,N,
0,N,      , , 1,#
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0,N,      , , 1,#
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8,N,      , , 1,#
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11,N,      , , 1,#
hm, 66195,25/09/2007 09:30,   0.0,N, 18.4,N,     , ,  9.2,N, 55,N,  2,N, 70,N,
8,N,      , , 1,#
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9,N,      , , 1,#
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0,N,      , , 1,#
hm, 66195,25/09/2007 11:00,   0.0,N, 21.0,N,     , ,  9.3,N, 47,N,  2,N,150,N,
9,N,      , , 1,#
hm, 66195,25/09/2007 11:30,   0.0,N, 21.4,N,     , ,  6.2,N, 37,N,  8,N, 40,N,
17,N,      , , 1,#
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13,N,      , , 1,#
hm, 66195,25/09/2007 12:30,   0.0,N, 21.4,N,     , , 10.0,N, 48,N,  9,N, 90,N,
17,N,      , , 1,#
hm, 66195,25/09/2007 13:00,   0.0,N, 20.7,N,     , ,  9.6,N, 49,N, 13,N,100,N,
22,N,      , , 1,#
hm, 66195,25/09/2007 13:30,   0.0,N, 20.6,N,     , ,  9.3,N, 48,N, 13,N, 90,N,
24,N,      , , 1,#
hm, 66195,25/09/2007 14:00,   0.0,N, 20.4,N,     , ,  9.0,N, 48,N, 11,N, 90,N,
22,N,      , , 1,#
```

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21,N,      , , 1,#
hm, 66195,25/09/2007 15:00,   0.0,N, 20.0,N,     , ,  8.4,N, 47,N, 13,N, 90,N,
24,N,      , , 1,#
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26,N,      , , 1,#
hm, 66195,25/09/2007 16:00,   0.0,N, 19.2,N,     , ,  8.3,N, 49,N, 13,N, 80,N,
26,N,      , , 1,#
hm, 66195,25/09/2007 16:30,   0.0,N, 19.0,N,     , ,  8.4,N, 50,N,  8,N,100,N,
22,N,      , , 1,#
hm, 66195,25/09/2007 17:00,   0.0,N, 18.3,N,     , ,  8.6,N, 53,N,  9,N, 90,N,
24,N,      , , 1,#
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21,N,      , , 1,#
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15,N,      , , 1,#
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9,N,      , , 1,#
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4,N,      , , 1,#
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0,N,      , , 1,#
hm, 66195,25/09/2007 21:00,   0.0,N, 15.1,N,     , ,  9.1,N, 67,N,  0,N,  0,N,
0,N,      , , 1,#
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0,N,      , , 1,#
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0,N,      , , 1,#
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0,N,      , , 1,#
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8,N,      , , 1,#
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5,N,      , , 1,#
hm, 66195,26/09/2007 00:30,   0.0,N, 13.9,N,     , ,  9.4,N, 74,N,  0,N,  0,N,
0,N,      , , 1,#
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9,N,      , , 1,#
hm, 66195,26/09/2007 02:00,   0.0,N, 12.7,N,     , ,  9.0,N, 78,N,  5,N,260,N,
8,N,      , , 1,#
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9,N,      , , 1,#
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9,N,      , , 1,#
hm, 66195,26/09/2007 04:00,   0.0,N, 12.1,N,     , ,  8.8,N, 80,N,  9,N,250,N,
11,N,      , , 1,#
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8,N,      , , 1,#
hm, 66195,26/09/2007 05:00,   0.0,N, 11.9,N,     , ,  8.9,N, 82,N,  8,N,260,N,
9,N,      , , 1,#
hm, 66195,26/09/2007 05:30,   0.0,N, 11.6,N,     , ,  8.7,N, 82,N,  2,N,250,N,
5,N,      , , 1,#
hm, 66195,26/09/2007 06:00,   0.0,N, 11.5,N,     , ,  8.7,N, 83,N,  0,N,  0,N,
0,N,      , , 1,#
hm, 66195,26/09/2007 06:30,   0.0,N, 12.1,N,     , ,  9.2,N, 82,N,  2,N,250,N,
8,N,      , , 1,#
hm, 66195,26/09/2007 07:00,   0.0,N, 12.9,N,     , ,  9.4,N, 79,N,  8,N,290,N,
11,N,      , , 1,#
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hm, 66195,26/09/2007 07:30,   0.0,N, 13.9,N,   , , 9.6,N, 75,N, 8,N,290,N,
9,N,   , , 1,#
hm, 66195,26/09/2007 08:00,   0.0,N, 14.9,N,   , , 9.5,N, 70,N, 8,N,250,N,
9,N,   , , 1,#
hm, 66195,26/09/2007 08:30,   0.0,N, 16.5,N,   , , 10.2,N, 66,N, 5,N,250,N,
11,N,   , , 1,#
hm, 66195,26/09/2007 09:00,   0.0,N, 17.5,N,   , , 10.4,N, 63,N, 5,N,240,N,
11,N,   , , 1,#
hm, 66195,26/09/2007 09:30,   0.0,N, 19.0,N,   , , 10.1,N, 56,N, 2,N, 60,N,
8,N,   , , 1,#
hm, 66195,26/09/2007 10:00,   0.0,N, 19.9,N,   , , 10.6,N, 55,N, 4,N, 20,N,
9,N,   , , 1,#
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15,N,   , , 1,#
hm, 66195,26/09/2007 11:00,   0.0,N, 20.1,N,   , , 10.8,N, 55,N, 9,N, 40,N,
17,N,   , , 1,#
hm, 66195,26/09/2007 11:30,   0.0,N, 19.4,N,   , , 9.3,N, 52,N, 9,N, 90,N,
21,N,   , , 1,#
hm, 66195,26/09/2007 12:00,   0.0,N, 20.0,N,   , , 9.3,N, 50,N, 9,N, 80,N,
18,N,   , , 1,#
hm, 66195,26/09/2007 12:30,   0.0,N, 19.8,N,   , , 10.2,N, 54,N, 11,N, 90,N,
22,N,   , , 1,#
hm, 66195,26/09/2007 13:00,   0.0,N, 20.5,N,   , , 10.9,N, 54,N, 9,N, 90,N,
21,N,   , , 1,#
hm, 66195,26/09/2007 13:30,   0.0,N, 19.9,N,   , , 10.6,N, 55,N, 9,N,110,N,
22,N,   , , 1,#
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24,N,   , , 1,#
hm, 66195,26/09/2007 14:30,   0.0,N, 19.9,N,   , , 11.2,N, 57,N, 13,N, 80,N,
24,N,   , , 1,#
hm, 66195,26/09/2007 15:00,   0.0,N, 19.6,N,   , , 11.1,N, 58,N, 17,N, 70,N,
28,N,   , , 1,#
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26,N,   , , 1,#
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26,N,   , , 1,#
hm, 66195,26/09/2007 16:30,   0.0,N, 18.5,N,   , , 11.1,N, 62,N, 15,N, 80,N,
24,N,   , , 1,#
hm, 66195,26/09/2007 17:00,   0.0,N, 18.1,N,   , , 11.2,N, 64,N, 13,N, 60,N,
28,N,   , , 1,#
hm, 66195,26/09/2007 17:30,   0.0,N, 17.8,N,   , , 11.4,N, 66,N, 17,N, 80,N,
26,N,   , , 1,#
hm, 66195,26/09/2007 18:00,   0.0,N, 17.5,N,   , , 11.3,N, 67,N, 13,N, 60,N,
24,N,   , , 1,#
hm, 66195,26/09/2007 18:30,   0.0,N, 17.3,N,   , , 11.4,N, 68,N, 11,N, 70,N,
17,N,   , , 1,#
hm, 66195,26/09/2007 19:00,   0.0,N, 17.3,N,   , , 11.3,N, 68,N, 11,N, 60,N,
21,N,   , , 1,#
hm, 66195,26/09/2007 19:30,   0.0,N, 17.2,N,   , , 11.5,N, 69,N, 9,N, 50,N,
17,N,   , , 1,#
hm, 66195,26/09/2007 20:00,   0.0,N, 17.2,N,   , , 11.5,N, 69,N, 8,N, 50,N,
13,N,   , , 1,#
hm, 66195,26/09/2007 20:30,   0.0,N, 17.2,N,   , , 11.5,N, 69,N, 11,N, 40,N,
21,N,   , , 1,#
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21,N,   , , 1,#
hm, 66195,26/09/2007 21:30,   0.0,N, 16.7,N,   , , 12.1,N, 74,N, 11,N, 20,N,
17,N,   , , 1,#
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15,N,   , , 1,#
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15,N,   , , 1,#
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17,N,   , , 1,#
hm, 66195,26/09/2007 23:30,   0.2,N, 16.2,N,   , , 12.4,N, 78,N, 8,N, 10,N,
13,N,   , , 1,#

NOTES FOR HM01X_P COMPLETED ON 30/10/2007

All observations between 2007092500:00 and 2007092623:59 Local time.

DATA FILE DETAILS

```
Byte Location , Byte Size  , Explanation
----------------------------------------

1-2           ,2           , Record identifier - hm
4-9           ,6           , Bureau of Meteorology Station Number.
11-26         ,16          , _*(Local time)Day/Month/Year Hour24:Minutes in
DD/MM/YYYY HH24:MI format in Local time
28-33         ,6           , Precipitation since 9am local time in mm
35            ,1           , * Quality of precipitation since 9am local time
37-41         ,5           , Air Temperature in degrees C
43            ,1           , * Quality of Air Temperature
45-49         ,5           , Wet bulb temperature in degrees C
51            ,1           , * Quality of Wet Bulb Temperature
53-57         ,5           , Dew point temperature in degrees C
59            ,1           , * Quality of Dew point Temperature
61-63         ,3           , ** Relative humidity in percentage %
65            ,1           , * Quality of Relative humidity
67-69         ,3           , *-* Wind speed in km/h
71            ,1           , * Quality of Wind speed
73-75         ,3           , *-* Wind direction in degrees
77            ,1           , * Quality of Wind direction
79-81         ,3           , *-* Speed of maximum wind gust in last 10 minutes
in km/h
83            ,1           , * Quality of speed of maximum wind gust in last 10
minutes
85-90         ,6           , Mean sea level pressure in hPa
92            ,1           , * Quality of mean sea level pressure
94-95         ,2           , **** Automatic Weather Station Flag
97            ,1           , # symbol, end of record indicator.
```

_* LOCAL TIME

For locations where Daylights Savings occurs, the clock jumps an hour at the start and finish of Daylight Savings.

When Daylight Saving begins the clock moves forward an hour at 2.00am to 3.00am
(Half hourly observations will occur at 01:00, 01:30, 03:00, 03:30)

When Daylight Savings ends the clock moves back an hour at 2.00am
(half hourly observations will occur at 01:00, 01:30, 02:00, 02:30, 02:00, 02:30, 03:00, 03:30)

* QUALITY FLAG DESCRIPTIONS

Y: quality controlled and acceptable
N: not quality controlled
W: quality controlled and considered wrong
S: quality controlled and considered suspect
I: quality controlled and inconsistent with other known information

- WIND

Wind speed and direction are mostly an average over the 10 minutes prior to observation time. Where there is an observer present (AWS_FLAG=0) and a marked discontinuity occurs then only data after the discontinuity is used and therefore the time period is less. In this case a marked discontinuity is a 'sustained change in wind direction of 30 degrees or more, with a wind speed of 10 knots or more before or after the change ... or... a change in wind speed of 10 knots or more, lasting at least two minutes'. Wind gusts reported are the highest 1 second value over the last 10 minutes. Wind direction can be output as either degrees or points of the compass (8 or 16). If degrees are output, then values are rounded to the nearest 10 degrees and directions ending in 5 are rounded up (eg 105 degrees rounds to 110 degrees).

**** AWS (AUTOMATIC WEATHER STATION) FLAG

AWS (Automatic Weather Station) flag
0 Manned
1 Automatic
2 Hybrid

Indicates whether the observations are completely automatic or whether an observer is present, or a hybrid.In a couple of situations some differences occur due to the observation method. For example, Automatic Weather Station algorithms have had some difficulties in responding quickly to significant wind changes. Depending on the direction change the AWS may take several minutes to register the change and output a special weather report.

GAPS AND MISSING DATA

Very few sites have a complete unbroken record of climate information. A site may have been closed, reopened, upgraded to a full weather site or downgraded to a rainfall only site during its existence causing breaks in the record for some or all elements. Some gaps may be for one element due to a damaged instrument, others may be for all elements due to the absence or illness of an observer.

INSTUMENTS AND OBSERVATIONAL PRACTICES

Historically a nearby site (within about 1 mile in earlier days) may have used the same
site number. There may have been changes in instrumentation and/or observing practices
over the period included in a dataset, which may have an effect on the long-term record.
In recent years many sites have had observers replaced by Automatic Weather Stations,
either completely or at certain times of the day.

TIME

For a part of the year some Australian States adopt Daylight Savings Time (DST), and
observers continue to take observations according to the local clock. Times provided
with this data are Local Time, unless otherwise noted.

Care needs to be taken when comparing values from year to year or month to month, because for
some elements the effect of one hour can be marked, for example air temperature often rises
sharply between 8am and 9am.

Daylight Savings has been used in many Australian states since 1973. The
changeovers occur almost always in October and March, but exact dates vary
from State to State and year to year. More information can be found at:
http://www.bom.gov.au/climate/averages/tables/daysavtm.shtml

COPYRIGHT

LIABILITY

While every effort is made to supply the best data available this may not be possible
in all cases. We do not give any warranty, nor accept any liability in relation
to the information given, except that liability (if any), that is required by law.

IF DATA IS NOT AS REQUESTED

If the data provided are not as requested, the data will be repeated at no extra cost,
provided that:
a) the Bureau is notified within 60 days.
b) the printout/disc/data file is returned to the Bureau for checking.
c) there has been a fault or error in providing the data.

Where there has been no fault or error of provision, the cost involved in
requested corrective action such as resending the data or providing alternative
sites will be charged for as necessary.

SITE DETAILS FILE

This file contains the details for the current site or are those which applied when the site
was closed. Many sites have been moved, downgraded, upgraded etc over the years.

Byte Location	Byte Size	Explanation
1-2	2	Record identifier - st
4-9	6	Bureau of Meteorology Station Number.
11-14	4	Rainfall district code
16-55	40	Station Name.
57-63	7	Month/Year site opened. (MM/YYYY)
65-71	7	Month/Year site closed. (MM/YYYY)
73-80	8	Latitude to 4 decimal places, in decimal degrees.
82-90	9	Longitude to 4 decimal places, in decimal degrees.
92-106	15	Method by which latitude/longitude was derived.
108-110	3	State.
112-117	6	Height of station above mean sea level in metres.
119-124	6	Height of barometer above mean sea level in metres.
126-130	5	WMO (World Meteorological Organisation) Index Number.
132-135	4	First year of data supplied in data file.
137-140	4	Last year of data supplied in data file.
142-144	3	Percentage complete between first and last records.
146-148	3	Percentage of values with quality flag 'Y'.
150-152	3	Percentage of values with quality flag 'N'.
154-156	3	Percentage of values with quality flag 'W'.
158-160	3	Percentage of values with quality flag 'S'.
162-164	3	Percentage of values with quality flag 'I'.
166	1	# symbol, end of record indicator.

LATITUDES AND LONGITUDES

Latitudes and longitudes are given to 4 decimal places, but in many cases will not be accurate to 4 decimal places. This is because in the early days the positions of stations were estimated from maps. Gradually the network of open stations is being checked (and if necessary corrected) using GPS (Global Positioning System). The method used is given in the site details file.

WMO INDEX NUMBER

This is the number assigned to a site that makes international weather reports every day. The number is not actively used in the climate archive, and only a few hundred such numbers are assigned at any time. These are not perpetual but may be reassigned where a site no longer makes the international reports (synops); thus a particular number cannot be regarded as unique and exclusive to any particular site.

PERCENTAGE INFORMATION

In some cases the percentage completeness will be overestimated. This will occur if the database has incomplete information about the element being selected. In cases where several elements are selected, rows with a least one of the elements available are considered complete. Where only a limited amount of data is available and the percentage

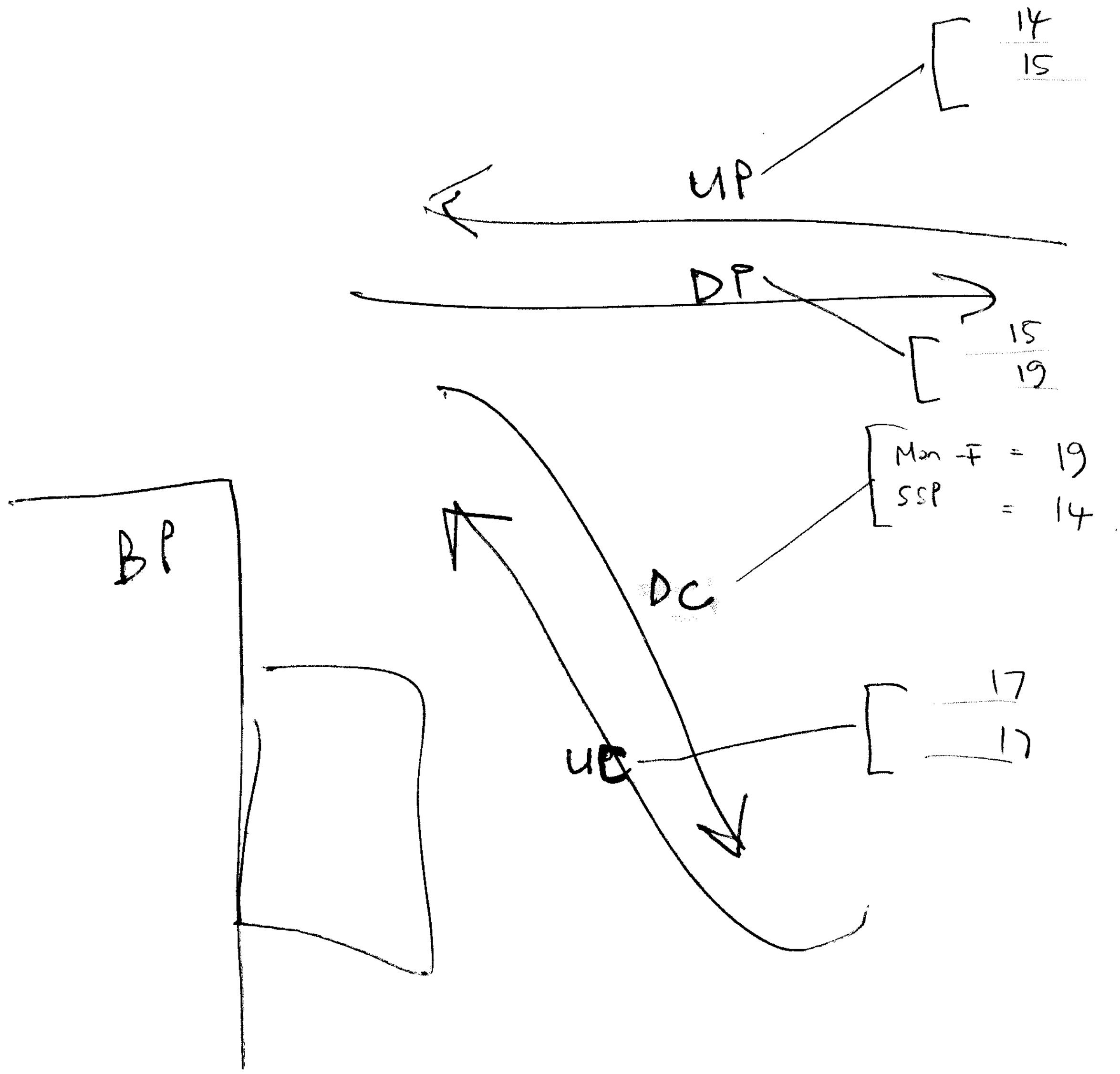
completeness
is less than 0.5%, an "*" has been used.

An "*" is also used if the percentage of values with a particular quality flag is non zero
and less than 0.5%.

APPENDIX C

RIVERCAT TIMETABLE FOR PARRAMATTA RIVER

CM 30/10/06



Weekly Movements – Rivercats/Harbourcats

Cabarita up → 17x5 + 17x2 = 17x7 = 119 movements/week

down → 19x5 + 14x2 = 95 + 28 = 123 " "

Passing channel up → 14x5 + 15x2 = 70 + 30 = 100

down → 15x5 + 19x2 = 75 + 38 = 113

455 movements/week.

Monday to Friday

Services to Rydalmere / Parramatta

	Circular Quay (A)	Milsons Point # (B)	McMahons Point # (C)	Darling Harbour # (D)	Drummoyne (E)	Huntleys Point (F)	Chiswick (G)	Abbotsford (H)	Bayview Park (I)	Cabarita (J)	Kissing Point (K)	Meadowbank (L)	Sydney Olympic Park (M)	Rydalmere (N)	Parramatta (arrive) (O)
AM	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	-	6.18	6.22	-	6.26	-	-	-	6.35	-	6.50	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	6.55	-	-	-	-	-	-	7.15	-	-	-	7.25	7.30	-	-
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
	-	-	-	7.20	-	-	-	-	7.45	-	-	-	-	-	-
	7.45	-	-	-	-	-	-	-	-	-	-	8.10	-	-	-
	8.00	-	-	-	-	-	-	-	-	-	-	8.25	-	-	-
	8.20	-	-	-	-	8.32	-	8.37	-	-	-	8.47	8.49	8.59	-
	8.40	-	-	-	-	-	-	-	-	-	-	9.00	-	-	-
p	9.00	-	-	-	-	-	-	-	-	-	-	-	-	9.35	9.55
	9.10	-	-	-	9.23	9.28	9.31	9.35	-	9.38	9.42	9.47	9.50	10.00	-
	9.50	-	-	10.00	10.13	10.18	10.21	10.25	-	10.28	10.32	10.37	10.40	10.50	-
p	10.00	-	-	-	-	-	-	-	-	-	-	-	-	10.35	10.55
	10.50	-	-	11.00	11.13	11.18	11.21	11.25	-	11.28	11.32	11.37	11.40	11.50	-
p	11.00	-	-	-	-	-	-	-	-	-	-	-	-	11.35	11.55
PM	11.50	-	-	12.00	12.13	12.18	12.21	12.25	-	12.28	12.32	12.37	12.40	12.50	-
p	12.30	-	-	-	-	-	-	-	-	-	-	-	-	1.05	1.25
	12.50	-	-	1.00	1.13	1.18	1.21	1.25	-	1.28	1.32	1.37	1.40	1.50	-
p	1.30	-	-	-	-	-	-	-	-	-	-	-	-	2.05	2.25
	1.50	-	-	2.00	2.13	2.18	2.21	2.25	-	2.28	2.32	2.37	2.40	2.50	-
p	3.00	-	-	-	-	-	-	-	-	-	-	-	-	3.35	3.55
	3.10	3.14	-	3.25	3.38	3.43	3.46	3.50	-	3.55	4.00	4.05	4.09	-	-
p	4.00	-	-	-	-	-	-	-	-	-	-	-	-	4.35	4.55
	4.05	4.09	4.12	-	4.22	4.27	4.30	4.34	-	4.37	4.41	4.46	-	4.56	-
	4.20	-	-	4.30	4.43	4.48	4.51	4.55	5.00	-	-	-	-	-	-
	4.50	4.54	4.57	5.10	5.23	5.28	5.31	5.35	-	5.38	5.42	5.47	5.51	6.01	-
	5.15	5.19	5.22	-	5.34	5.39	5.42	5.46	-	5.49	-	5.56	-	6.05	-
	-	-	-	5.35	5.48	5.53	5.56	6.00	6.05	-	-	-	-	-	-
p	5.35	-	-	5.50	6.03	6.08	6.11	6.15	-	6.18	6.22	6.27	6.32	6.42	7.02
	5.50	5.54	5.57	-	6.09	6.14	6.18	6.21	-	6.24	6.28	6.33	6.38	6.48	-
p	6.15	-	-	6.25	6.38	6.42	6.45	6.49	-	6.52	6.56	7.01	7.04	7.14	7.29
	-	-	-	6.45	6.58	7.03	7.06	7.10	-	-	-	7.19	-	-	-
	6.45	6.49	6.52	-	7.02	7.07	7.10	7.14	-	7.17	-	7.24	-	7.34	-
	7.20	7.24	7.27	7.35	7.47	7.52	7.56	7.59	-	8.02	8.06	8.10	-	-	-
	8.20	-	-	8.30	8.43	8.48	8.51	8.55	-	8.58	9.02	9.07	-	-	-
	9.40	-	-	9.50	10.03	10.08	10.11	10.15	-	10.18	10.22	10.27	-	-	-

Services to Circular Quay

Parramatta (depart) (O)	Rydalmere (N)	Sydney Olympic Park (M)	Meadowbank (L)	Kissing Point (K)	Cabarita (J)	Bayview Park (I)	Abbotsford (H)	Chiswick (G)	Huntleys Point (F)	Drummoyne (E)	McMahons Point (C)	Milsons Point (B)	Darling Harbour (D)	Circular Quay (A)
-	-	-	-	-	-	6.40	6.45	6.49	6.52	6.57	7.07	7.10	7.20	-
-	-	-	6.45	6.50	6.55	-	7.00	7.04	7.07	7.12	7.22	-	7.26	7.38
-	6.55	7.05	7.10	7.15	7.20	-	7.25	7.29	7.32	7.37	7.47	7.49	-	7.55
-	7.15	-	7.30	-	7.38	-	7.43	7.47	7.50	7.55	8.06	8.08	-	8.14
-	-	7.31	7.35	7.40	7.45	-	7.50	7.54	7.57	8.02	-	-	8.15	8.25
-	7.35	7.45	7.50	7.55	8.00	-	8.05	8.10	-	8.15	8.28	8.30	-	8.35
-	-	-	-	-	-	7.53	7.58	8.02	8.05	8.10	-	-	8.25	8.35
-	-	-	8.15	-	8.22	-	8.25	-	8.30	8.35	-	8.47	-	8.52
-	-	-	8.30	8.35	8.40	-	8.45	8.49	8.52	8.57	9.07	9.09	-	9.13
-	9.10	9.20	9.25	9.30	9.35	-	9.38	9.42	9.45	9.50	-	-	-	10.03
-	-	-	9.05	-	9.13	-	9.18	9.22	9.25	9.30	-	-	9.45	9.55
10.00	10.20	-	-	-	-	-	-	-	-	-	-	-	-	10.55
-	10.10	10.20	10.25	10.30	10.35	-	10.38	10.42	10.45	10.50	-	-	11.00	11.10
-	11.10	11.20	11.25	11.30	11.35	-	11.38	11.42	11.45	11.50	-	-	12.00	12.10
11.00	11.20	-	-	-	-	-	-	-	-	-	-	-	-	11.55
-	12.10	12.20	12.25	12.30	12.35	-	12.38	12.42	12.45	12.50	-	-	1.00	1.10
12.00	12.20	-	-	-	-	-	-	-	-	-	-	-	-	12.55
-	1.10	1.20	1.25	1.30	1.35	-	1.38	1.42	1.45	1.50	-	-	2.00	2.10
1.30	1.50	-	-	-	-	-	-	-	-	-	-	-	-	2.25
-	2.10	2.20	2.25	2.30	2.35	-	2.38	2.42	2.45	2.50	-	-	3.03	3.13
2.30	2.50	-	-	-	-	-	-	-	-	-	-	-	-	3.25
-	3.10	3.20	3.25	3.30	3.35	-	3.38	3.42	3.45	3.50	-	-	-	4.08
4.00	4.20	-	-	-	-	-	-	-	-	-	-	-	-	4.55
-	-	4.10	4.15	4.20	4.25	-	4.28	4.31	4.34	4.39	-	-	-	5.00
5.00	5.20	5.30	5.35	-	5.42	-	5.45	5.49	5.52	5.57	-	-	-	6.07
-	5.00	5.10	-	-	-	-	-	-	-	-	-	-	-	5.43
-	-	-	-	-	-	5.07	-	-	-	-	-	-	5.30	-
-	6.05	-	-	-	-	-	-	-	-	-	-	-	-	6.40
-	6.10	6.20	6.25	6.30	6.35	-	6.38	6.42	6.45	6.50	-	-	-	7.05
-	-	-	-	-	-	6.07	-	-	-	-	-	-	6.30	-
7.10	7.25	7.35	7.38	7.42	7.45	-	7.48	7.52	7.55	7.59	-	-	-	8.15
-	6.50	-	7.03	-	-	-	7.11	7.15	7.18	7.22	-	-	-	7.38
7.30	7.45	-	-	-	-	-	8.02	-	-	-	-	-	-	8.20
-	-	-	7.20	-	-	-	-	-	-	-	-	-	-	7.45
-	7.35	-	-	-	-	-	-	-	-	-	-	-	-	8.13
-	-	-	8.12	-	-	-	-	-	-	-	-	-	-	8.40
-	-	-	9.09	-	-	-	-	-	-	-	-	-	-	9.35
-	-	-	10.29	-	-	-	-	-	-	-	-	-	-	10.55

Saturday, Sunday and Public Holidays

Services to Rydalmere / Parramatta

	Circular Quay (A)	Darling Harbour # (D)	Drummoyne (E)	Huntleys Point (F)	Chiswick (G)	Abbotsford (H)	Cabarita (J)	Kissing Point (K)	Meadowbank (L)	Sydney Olympic Park (M)	Rydalmere (N)	Parramatta (arrive) (O)
AM	-	-	-	-	-	-	-	-	-	-	-	-
p	8.00	-	-	-	-	-	-	-	-	-	8.35	8.55
	8.05	8.15	-	-	-	-	-	-	-	8.34	-	-
	8.50	9.00	9.13	9.17	9.20	9.25	9.28	9.32	9.37	9.40	-	-
p	9.00	-	-	-	-	-	-	-	-	-	9.35	9.55
	9.25	9.35	9.48	9.52	9.55	10.00	10.03	10.07	10.12	10.15	-	-
p	10.00	-	-	-	-	-	-	-	-	-	10.35	10.55
	10.00	-	-	-	-	-	-	-	-	10.35	-	-
	10.45	-	-	-	-	-	-	-	-	11.15	-	-
p	11.00	-	-	-	-	-	-	-	-	-	11.35	11.55
PM	11.40	-	-	-	-	-	-	-	-	12.10	-	-
	12.00	12.10	12.23	12.27	12.30	12.35	12.38	12.42	12.47	12.50	-	-
p	12.30	-	-	-	-	-	-	-	-	-	1.05	1.25
	12.45	12.55	1.08	1.12	1.15	1.20	1.23	1.27	1.32	1.35	-	-
p	1.30	-	-	-	-	-	-	-	-	-	2.05	2.25
	1.45	1.55	2.08	2.12	2.15	2.20	2.23	2.27	2.32	2.35	-	-
	2.25	-	-	-	-	-	-	-	-	3.00	-	-
	2.40	2.50	3.03	3.07	3.10	3.15	3.18	3.22	3.27	3.30	-	-
p	3.00	-	-	-	-	-	-	-	-	-	3.35	3.55
	3.15	3.25	3.38	3.42	3.45	3.50	3.53	3.57	4.02	4.05	-	-
p	4.00	-	-	-	-	-	-	-	-	-	4.35	4.55
	4.00	4.10	4.23	4.27	4.30	4.35	4.38	4.42	4.47	4.50	-	-
	4.10	4.20	4.33	4.37	4.40	4.45	4.48	4.52	4.57	5.00	-	-
	4.45	4.55	5.08	5.12	5.15	5.20	5.23	5.27	5.32	5.35	-	-
p	5.00	-	-	-	-	-	-	-	-	-	5.35	5.55
	5.00	5.10	5.23	5.27	5.30	5.35	5.38	5.42	5.47	5.50	-	-
	5.30	5.40	5.53	5.57	6.00	6.05	6.08	6.12	6.17	6.20	-	-
p	6.00	-	-	-	-	-	-	-	-	-	6.35	6.55
	6.05	6.15	6.28	6.32	6.35	6.40	6.43	6.47	6.52	6.55	-	-
	6.25	-	6.38	6.42	6.45	6.50	6.53	6.57	7.02	7.05	-	-
Saturday and Public Holidays only	*7.05	*7.15	*7.28	*7.32	*7.35	*7.40	*7.43	*7.47	*7.52	-	-	-
	*8.20	*8.30	*8.43	*8.47	*8.50	*8.55	*8.58	*9.02	*9.07	-	-	-
	*9.35	*9.45	*9.58	*10.02	*10.05	*10.10	*10.13	*10.17	*10.22	-	-	-

Services to Circular Quay

Parramatta (depart) (O)	Rydalmere (N)	Sydney Olympic Park (M)	Meadowbank (L)	Kissing Point (K)	Cabarita (J)	Abbotsford (H)	Chiswick (G)	Huntleys Point (F)	Drummoyne (E)	Darling Harbour (D)	Circular Quay (A)
-	-	7.10	7.15	7.20	7.25	7.28	7.32	7.35	7.40	7.50	7.59
9.00	9.20	-	-	-	-	-	-	-	-	-	9.55
-	-	8.35	8.40	8.45	8.50	8.53	8.57	9.00	9.05	-	9.20
-	-	9.45	9.50	9.55	10.00	10.03	10.07	10.10	10.15	10.25	10.34
10.00	10.20	-	-	-	-	-	-	-	-	-	10.55
-	-	10.20	10.25	10.30	10.35	10.38	10.42	10.45	10.50	11.00	11.09
11.00	11.20	-	-	-	-	-	-	-	-	-	11.55
-	-	10.40	10.45	10.50	10.55	10.58	11.02	11.05	11.10	11.20	11.29
-	-	11.20	11.25	11.30	11.35	11.38	11.42	11.45	11.50	12.00	12.09
12.00	12.20	-	-	-	-	-	-	-	-	-	12.55
-	-	12.15	12.20	12.25	12.30	12.33	12.37	12.40	12.45	12.55	1.04
-	-	12.55	1.00	1.05	1.10	1.13	1.17	1.20	1.25	1.35	1.44
1.30	1.50	-	-	-	-	-	-	-	-	-	2.25
-	-	1.40	1.45	1.50	1.55	1.58	2.02	2.05	2.10	2.25	2.35
2.30	2.50	-	-	-	-	-	-	-	-	-	3.25
-	-	2.40	2.45	2.50	2.55	2.58	3.02	3.05	3.10	3.25	3.35
-	-	3.05	3.10	3.15	3.20	3.23	3.27	3.30	-	3.45	3.54
-	-	3.35	-	-	-	-	-	3.50	-	-	4.05
4.00	4.20	-	-	-	-	-	-	-	-	-	4.55
-	-	4.10	-	-	4.23	4.26	4.29	-	4.34	-	4.50
5.00	5.20	-	-	-	-	-	-	-	-	-	5.55
-	-	4.55	-	-	-	-	-	5.10	-	-	5.30
-	-	5.05	5.10	5.15	5.20	5.23	5.27	5.30	5.35	5.45	5.54
-	-	5.40	-	-	-	-	-	-	-	6.13	6.22
6.00	6.20	-	-	-	-	-	-	-	-	-	6.55
-	-	5.55	-	-	-	-	-	-	-	-	6.25
-	-	6.22	-	-	-	-	-	-	-	-	6.53
7.00	7.20	-	-	-	-	-	-	-	-	-	7.55
-	-	7.00	7.05	7.10	7.15	7.18	7.22	7.25	7.30	7.40	7.50
-	-	7.07	-	-	-	-	-	-	-	-	7.38
-	-	-	*7.54	-	-	-	-	-	-	-	*8.17
-	-	-	*9.09	-	-	-	-	-	-	-	*9.32
-	-	-	*10.24	-	-	-	-	-	-	-	*10.47

Key

p - Parramatta services
* - Saturday and Public Holiday service only
# - Services only pick up from these wharves and do not set down

Christmas Day Services

Christmas Day services are listed on our website www.sydneyferries.info

14
17

15 DP ← Downer passing
19 DC ↑ Downer into Cabarita

15
17

19
14

APPENDIX D

CALIBRATION DETAILS FOR TURBIDITY PROBES

with email from CB 18/10/07

The Ecology Lab Pty Ltd
Marine and Freshwater Studies
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MEMORANDUM

18 October 2007

No. Pages: 2

To: Gary Blumberg

From: Craig Blount

Re: Summary of Operations in the Kendall Bay Turbidity Study

Calibration of Probes

Three turbidity probes were used in the study. Prior to the study and following its completion all three probes were checked against standard solutions by Geoff Yeomans from YEOKAL Pty Ltd (see Table below). Prior to the study, the three probes recorded measurements to within ±2 ntu of the 0 ntu standard solution and to within ±1 ntu of the 200 ntu standard solution. Following completion of the study, readings from all three probes remained close to the 0 ntu standard solution (i.e. within ±3 ntu). The probes used to monitor the test events (WP-89 and Yeokal 2) recorded values that were ~5% less than the 200 ntu standard and the probe used for recording background levels at various locations within the bay (Yeokal 1) recorded a value that was ~11% less than the 200 ntu standard. These deviations from the upper standard are not large enough to effect the interpretation of the results from the study but should be considered when presenting data.

✓ ok. 19/10/07

	Test Solution			
	0 ntu Standard		200 ntu Standard	
Probe	Before Study	After Study	Before Study	After Study
WP-89	0.2	0.4	199.0	190.0
Yeokal 1	-1.8	-2.8	200.0	177.0
Yeokal 2	0.5	1.1	200.1	190.5

Turbidity Monitoring

Turbidity was recorded associated with forward motion, reversing and start-up of three test vessels (small, medium and large) at a range of depths (2-5m). Prior to and after each event, turbidity was recorded by a probe fixed to the seabed directly beneath the vessel and, in the event of a disturbance to sediment, from a (mobile) probe kept in the plume. Where a plume occurred (i.e. where turbidity associated with a test event increased above levels recorded prior to the event), the duration of the plume and maximum distance travelled was recorded. The duration of a plume was determined as the time taken for turbidity to return to levels recorded prior to the test event. Turbidity was also measured throughout the duration of the two days of the study at various locations around the bay, away from the locations of the test events. Water samples were collected over a range of turbidity recordings to obtain measurements of total suspended solids.

Seagrass Mapping

With the assistance of submersible scooters, a thorough search of Kendall Bay was made for seagrass by staff using snorkel. Where seagrass was found, the location was recorded using a hand-held GPS in WGS 84 datum and the distribution mapped onto an aerial photo of the area.

Yours faithfully,

Dr Craig Blount

Senior Environmental Scientist

19/10/07.

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS WP89 Turbidity Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

Turbidity	☑ 0 NTU	☐ 90 NTU	☑ 360 NTU	☐ 900 NTU	☐ NTU
☑ Electrodes cleaned/checked		☐ Charged			

* Calibration solution traceability information is available upon request.

Date: 21.09.07 Checked by: Pete

Signed: DA

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	WP88 Operational check / Battery Voltage @ 100%
☑	☐	☐	Turbidity Sensor
☑	☐	☐	Turbidity Sensor cable 20m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☑	☐	☐	Quick Guide Sheet
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials: DA

EE Quote Reference	3059	Condition on return
Customer Ref	210157	
Equipment ID	WP89SA	
Equipment serial no.	54046	
Return Date	27/09/07	
Return Time		

Melbourne **Sydney** **Brisbane** **Perth** **Auckland** **Kuala Lumpur**

Sydney – Unit 1, 28 Barcoo St, Chatswood NSW 2067 Australia
Tel: +61-2-9417-1513 Fax: +61-2-9417-7669
Email: rentals.syd@enviroequip.com Internet: www.rentals.enviroequip.com

ENVIROEQUIP RENTALS

Your Friend in the Field

Equipment Report - TPS WP88 Turbidity Meter

This Water Quality Meter has been performance checked / calibrated* as follows:

Turbidity	☑ 0 NTU	☐ 90 NTU	☑ 360 NTU	☐ 900 NTU	☐ ... NTU
☑ Electrodes cleaned/checked		☑ Charged			

* Calibration solution traceability information is available upon request.

Date: 04.09.07 Checked by: PETE

Signed: JA

Please check that the following items are received and that all items are cleaned and decontaminated before return. A minimum $20 cleaning / service / repair charge may be applied to any unclean or damaged items. Items not returned will be billed for at the full replacement cost.

Sent	Received	Returned	Item
☑	☐	☐	WP88 Operational check / Battery Voltage @ 100%
☑	☐	☐	Turbidity Sensor
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☑	☐	☐	Turbidity Sensor cable 20 m
☑	☐	☐	Battery charger: 240V AC to 12V DC 200mA
☑	☐	☐	Instruction Manual
☐	☐	☐	Quick Guide Sheet
☑	☐	☐	Carry Case
☐	☐	☐	
☐	☐	☐	

Processors Signature/ Initials: JA.

EE Quote Reference	3059	Condition on return
Customer Ref	21015	
Equipment ID	10P855A	
Equipment serial no.	T0556	
Return Date	27/09/07	
Return Time		

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APPENDIX E

TABULATED TURBIDITY DATA FROM KENDAL BAY
(25-26 SEPTEMBER 2007)

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TABLE E.1

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26/09/2007	14:00
26/09/2007	14:01
26/09/2007	14:02
26/09/2007	14:03
26/09/2007	14:04
26/09/2007	14:05
26/09/2007	14:06
26/09/2007	14:07
26/09/2007	14:08
26/09/2007	14:09
26/09/2007	14:10
26/09/2007	14:11
26/09/2007	14:12
26/09/2007	14:13
26/09/2007	14:14
26/09/2007	14:15
26/09/2007	14:16
26/09/2007	14:17
26/09/2007	14:18
26/09/2007	14:19
26/09/2007	14:20
26/09/2007	14:21
26/09/2007	14:22
26/09/2007	14:23
26/09/2007	14:24
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26/09/2007	14:26
26/09/2007	14:27
26/09/2007	14:28
26/09/2007	14:29
26/09/2007	14:30
26/09/2007	14:31
26/09/2007	14:32
26/09/2007	14:33
26/09/2007	14:34
26/09/2007	14:35
26/09/2007	14:36

Date	Fixed Probe Location Depth	Time	Bottom Depth	GPS		Secchi Disc	Turbidity	TSS Sampling Code	ORP	Temp	Salinity	Conductivity	pH	DO	
			(m)	Northing	Easting	(m)	(NTU)			(deg C)	(ppt)	(mS)		%	(mg/L)
25/09/2007	2.0 m	7:25	2.2	325,514	5,253,813	1.9	5.9	1	465	17.4	33.1	50.5	7.9	85	5.7
		7:26	2.2			1.9	5.9	2	461	17.4	33.1	50.5	7.9	86	6.7
	3.0 m	7:35	3.7	325,541	6,253,843	2.0	6.4	3	416	17.4	33.1	50.6	7.8	86	6.8
		7:36	3.7			2.0	4.4	4	417	17.4	33.1	50.6	7.9	86	6.8
	4.0 m	7:42	4.3	325,561	6,253,865	2.1	2.9	5	415	17.4	33.1	50.5	7.9	88	6.9
		7:43	4.3			2.1	3.5	6	416	17.4	33.1	50.6	7.9	87	6.8
	5.0 m	7:48	5.3	325,597	6,253,917	2.1	2.0	7	409	17.6	33.0	50.4	7.9	87	6.8
		7:49	5.3			2.1	2.1	8	410	17.6	33.0	50.4	7.9	87	6.9
	Comparison of Probe Readings														
	2.0 m	9:00	2.3	Fixed Probe			5.5								
							6.2								
	2.0 m	0:00	2.3	Mobile Probe			2.0								
							1.9								
26/09/2007	3.0 m	6:52	3.3				6.6		362	17.7	33.2	50.7	8.1	86	
			3.3				5.7		364	17.8	33.4	50.8	8.1	86	
	4.0 m	6:55	4.3				7.6		366	17.7	33.0	50.7	8.1	86	
			4.3				6.9		367	17.7	33.3	50.7	8.1	86	
	5.0 m	6:58	5.1				7.9		369	17.7	33.3	50.8	8.0	85	
			5.1				8.1		370	17.7	33.3	50.8	8.0	85	

TABLE E.2

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
25/09/2007							9:17	7		Background prior to disturbance
								7		
	37' Flybridge	2.0		1	Underway	4 knots	**9:19**	7		
								3		
							9:20	156	3	
								150	2	
							9:21	169	5	
								209	8	
							9:22	35	23	
								55	53	
								31		
								28		
								30		
								31		
							9:23	41		
								44		
								12		
								15		
							9:24	19	25	
								14	17	
							9:25	16	11	
								14	27	
							9:26	5		
								6		
							9:27		7	
									12	
							9:28			
							9:29		11	
									10	

TABLE E.3

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
							9:30		11	
									7	Plume moved 3m
25/09/2007							9:35	12		Background prior to disturbance
								6		
	37' Flybridge	2.0	2.5	2	Underway	4 knots	**9:36**	7	33	Mobile probe boat followed Flybride in
								12	29	
									13	
									16	
								4	34	
								5	15	
									10	
									15	
							9:37	19	10	
								38	12	
							9:38	27	12	
								29	11	
							9:39	13	16	
								14	13	
									10	
									10	
									9	
									3	
							9:40	10	18	
								12	21	
									12	
									12	
									11	
									10	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									4	
							9:41		3	Plume went ~10m SW/SE
									4	
							9:42	10		
								15		
25/09/2007							9:43	6		Background prior to disturbance
								7		
	37' Flybridge	2.0	2.5	1	Starting ahead	Full thrust	**9:44**	15	135	
								30	208	Plume starting to move N
									205	
									253	
								34	94	
								40	175	
									172	
									188	
									131	
							9:45	23	110	
								30	135	
								19	113	
								17	97	
							9:46	13	33	
								9	40	
									41	
							9:47		37	
									22	
							9:48	9	20	Niskan samples collected Nos 9 and 10
								10		
							9:49			Plume traveled ~20m SW

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
25/09/2007							9:54	5		Background prior to disturbance
								6		
	37' Flybridge	2.0		2	Starting ahead	Full thrust	**9:55**	20	39	
					S to N			8	157	
							9:56	10	20	
								5	43	Niskan samples collected Nos 11 and 12
								20	40	
								27	27	
							9:57	11	12	
								7	43	
									66	
									114	
									176	
									187	
									157	
									33	
							9:58	7	60	
								8	52	Secchi disc 1.3m
									32	
									25	
									57	
							9:59		14	
									41	
							10:00	7	50	
									33	
									26	
									24	
									27	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									13	
									12	
									9	Plume moves 15-20m to S
25/09/2007							10:11	11		Background prior to disturbance
								12		
	37' Flybridge	2.0		1	Starting astern	Full thrust	**10:11**		137	Niskin samples collected Nos 13 and 14
									150	
									154	
									30	
							10:12	7	37	
								6	20	
							10:13	15	4	
								17	40	
									28	
									24	
								17	25	
								29	20	
									24	
									36	
							10:14	13	34	
								10	18	
									25	
									27	
							10:15	5	13	
								4	13	
									27	
									13	
									17	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									24	
									20	
							10:16		19	
									17	
									16	
									10	
							10:17		11	Plume moves ~10-15m SSW. Intense start then dissipated quickly.
25/09/2007							10:19	6		Background prior to disturbance
								8		
	37' Flybridge	2.0		2	Starting astern	Full thrust	**10:20**	6	162	
								7	180	
									225	
									292	
									188	
									53	
									57	
									102	
							10:21	58	151	
								105	99	
									63	
									61	
								90	67	
								100	44	
									21	
									15	
							10:22	60	14	
								40	48	

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									60	
									39	
									45	
									35	
							10:23	55	22	
								49	26	
									17	
									13	
							10:24	100	10	
								120	16	
								63	12	
								64	10	
							10:25	4		
								5		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
25/09/2007		3.0					11:29	6		Background prior to disturbance
								8		
	37' Flybridge			1	Underway	4 knots	**11:30**	6	9	
								7	11	
									10	
									9	
									3.4	
			3.2				11:31		8	
			3.0				11:32	5		
								7		No visible plume at surface
25/09/2007		3.0	3.6				11:35	6	4	Background prior to disturbance
								7	3	
									4	
									5	
	37' Flybridge			2	Underway	4 knots	**11:36**	10	3	
								7	4	
								12		
								8		No visible plume at surface
26/09/2007		3.0					8:50	5		Background prior to disturbance
								6		
	37' Flybridge			3	Underway	4 knots	**8:51**	5		
								6		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
			3.4				8:52	3	6	
								4	8	
							8:53	6	7	
								7	6	No visible plume in water surface
									6	
									4	
									4	
									5	
			3.3				8:54		3	
									5	
									5	
25/09/2007							11:34		5	Background surface readings
									5	
									5	
									7	
									8	
									10	
							11:39	7		Background prior to disturbance
								9		
	37' Flybridge			1	Starting ahead	Full thrust	**11:40**	11	14	Mobile probe time corrected +1min to corrolated with fixed probe results
								14		
								17	12	
								19		
							11:41	23	6	
								44	5	
			2.6						2	
									4	
			2.6				11:42	14	5	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
								10		
							11:43	12	10	
								10	9	
							11:44	6	4	
			2.7					8	4	
									5	Plume travelled ~3m
							11:45		9	Background surface readings
									7	
									7	
									8	
25/09/2007							11:46	6		Background prior to disturbance
								9		
	37' Flybridge			2	Starting ahead	Full thrust	**11:48**	10	6	
								12	6	
							11:49	7	17	
								10	6	
									10	
									30	
									37	
									45	
									36	
									34	
							11:50		22	
									11	
									13	Mobile probe results from here may have been recorded over several minutes
									13	
									10	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									10	
									10	
									9	
									9	
									11	
									11	
									8	
									13	
									12	
									9	
									7	
									7	
									7	
									8	
							11:51	7		
								8		Plume moved ~15m to SW
26/09/2007		3.1					8:59	5		Background prior to disturbance
								6		
	37' Flybridge			3	Starting ahead	Full thrust	**9:00**	3		
								4		
							9:01	3	6	
								6	6	
							9:02	3	4	
								4	4	
							9:03	3	5	
								5	5	No plume at water surface
									4	
									3	
							9:04		3	

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									3	
25/09/2007		3.0					11:55	7		Background prior to disturbance
								8		
	37' Flybridge		3.6	1	Starting astern	Full thrust	**11:57**	6	5	
								9	4	
									13	
									9	
									2	
							11:58	17	16	
								10	21	
									27	
									6	
									5	
							11:59	6	6	Mobile probe results from here may have been recorded over several minutes
								8	7	
									7	
									11	
									6	
									4	Plume travelled ~5m at water surface
							12:00	6		
								7		
25/09/2007		3.0					12:00	7		Background prior to disturbance
								9		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
	37' Flybridge			2	Starting astern	Full thrust	**12:00**	7	23	
								8	29	
									21	
									13	
									13	
									7	
									10	
							12:01	9	19	
								8	27	
									63	
									6	
									22	
							12:02	6	6	Plume travelled ~5m at water surface
								8		
26/09/2007		3.1					9:06	6		Background prior to disturbance
								8		
				3	Starting astern	Full thrust	**9:07**	8		
								9		
							9:08	11		
								14		
							9:09	10	4	
								5	4	
									13	
									18	
									3	
									3	
							9:10	4	3	
								7	4	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									4	
									3	
							9:11	4	3	
								7	4	No visible plume at water surface
									3	
									4	

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
26/09/2007		4.3					7:24	8		Background prior to disturbance
								9		
	37' Flybridge			1	Underway	4 knots	**7:25**	7	6	
								6	6	
									6	
									5	
									5	
									5	
							7:26	6		
								7		No visible plume at water surface
26/09/2007		4.3					7:26	5		Background prior to disturbance
								6		
	37' Flybridge			2	Underway	4 knots	**7:27**	9		
								7		
							7:28	6		
								9		
							7:29	10		
								9		
							7:30	9		
								11		
							7:31	9		
								10		
							7:32	7	6	
								8	6	
									6	

TABLE E.5

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									6	
									7	
									8	
									8	
									8	
									9	
							7:33	7	8	
								9	7	No visible plume at water surface
							7:34		6	
									5	
							7:35		5	
							7:36		8	
							7:37		8	
									7	
							7:38		8	Mobile probe results from here may have been recorded over several minutes
									8	
									8	
									8	
26/09/2007		4.3					7:50	12		Background prior to disturbance
								15		
	37' Flybridge		4.3	1	Starting ahead	Full thrust	**7:51**	14	10	
								17	12	
									11	
							7:52	11	10	
								14	10	
									9	
							7:53	20	10	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
								15	10	
									11	
									11	
							7:54	12	13	
								11	10	
									7	
									7	No visible plume at water surface
									11	
									11	
							7:55	11	9	Mobile probe results from here may have been recorded over several minutes
								13	9	
									7	
									6	
							7:56	10		
								13		
26/09/2007							8:00	11		Background prior to disturbance
								13		
	37' Flybridge		4.3	2	Starting ahead	Full thrust	**8:01**	8	7	
								11	8	
									11	
									12	
									8	
							8:02	9	8.4	
								11	9	
							8:03	10	9	
								13	11	
									9	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
							8:04	7	10	
								10	9	No visible plume at surface
									9	
							8:05	7	7	
								11	7	
26/09/2007		4.2					8:06	9		Background prior to disturbance
								10		
	37' Flybridge			1	Starting astern	Full thrust	**8:07**	8		
								10		
							8:08	7		
								9		
			4.1				8:09	7	8	
								9	9	
									10	
									9	No visible plume at surface
									8	
									7	
									7	
									8	
			4.2				8:10	7	7	
								9	10	
									10	
									9	
26/09/2007							8:12	6		
								7		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
	37' Flybridge			2	Starting astern	Full thrust	**8:13**	10		
								13		
							8:14	8		
								11		
			4.3				8:15	9	11	
								12	10	
									9	
									8	
									11	
									9	
									7	
									7	No visible plume at water surface
							8:16	9	6	
								11	6	
									7	
							8:17	9	7	
								10	7	
							8:18	7		
								8		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
26/09/2007		5.3					10:13	8		Background prior to disturbance
								9		
	37' Flybridge			1	Underway	4 knots	**10:14**	10		
								11	5	
									5	
							10:15	8	7	
								9	6	
									5	No visible plume at water surface
									5	
							10:16	9	8	
								10	7	
									6	
									7	
							10:22		6	
									6	
							10:23			
26/09/2007		5.1					10:34	5		Background prior to disturbance
								6		
				2	Underway	4 knots	**10:34**	5		
								6		
			5.2				10:35	4	6	
								7	4	
									4	
									5	
							10:36	5	6	
								6	5	No visible plume at water surface

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
26/09/2007		5.2					10:37	5		Background prior to disturbance
								7		
	37' Flybridge		5.2	1	Starting ahead	Full thrust	**10:38**	6	7	Run type designated on mobile probe raw data sheet
								7	6	
									5	
									6	
							10:39	6		
								8		No visible plume at water surface
26/09/2007		5.2					10:40	9		Background prior to disturbance
								10		
			5.2	1	Starting ahead	Full thrust	**10:41**	8	4	Run type designated on mobile probe raw data sheet
								11	4	
									4	
									5	No visible plume at water surface
							10:42	7	4	
								8	4	
26/09/2007		5.2					10:43	5		Background prior to disturbance
								8		
	37' Flybridge		5.2	1	Starting astern	Full thrust	**10:44**	5	5	
								6	5	
									4	
									4	

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
							10:45	5	5	
								7	8	No visible plume at water surface
									4	
									4	
26/09/2007		5.2					10:45	5		Background prior to disturbance
								7		
	37' Flybridge		5.2	2	Starting astern	Full thrust	**10:46**	4		
								5		
							10:47	6		
								7		
									4	
									4	
							10:48	10	5	
								11	6	
									4	
									4	
							10:49	4	5	
								5	5	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
26/09/2007		3.0					14:27	6		Background prior to disturbance
								8		
	47' Riviera			1	Underway	4 knots	**14:28**	7		
								12		
							14:29	13		
								16		
			3.4						6	
								8	6	
								11	8	
									7	
										Mobile probe error, reading -30
							14:31	29		No visible plume at surface
								32	9	
									7	
							14:32	6	8	
								7	7	
26/09/2007		3.0					14:33	7		Background prior to disturbance
								8		
	47' Riviera			2	Underway	4 knots	**14:34**	7	10	
								10	9	
							14:35	6		
								7	9	
									9	
							14:36		11	
									11	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									13	
									13	
							14:37		13	
									14	
									10	Plume moved ~5m
									12	
							14:38		11	
									10	
									9	
									8	
26/09/2007		3.0					14:40	6		Background prior to disturbance
								8		
	47' Riviera			1	Starting ahead	Full thrust	**14:40**	7	7	
								9	10	
							14:41	7	8	
								8	9	No visible plume at surface
							14:42	6	9	
								7	8	
26/09/2007		3.0					14:42	8		Background prior to disturbance
								8		
	47' Riviera			2	Starting ahead	Full thrust	**14:43**	11		
								12		
							14:44	12	11	
								15	9	
							14:45	6	16	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
								9	14	
							14:46	6	6	Plume moves ~5m
								8	7	
26/09/2007		3.0					14:47	9		Background prior to disturbance
								8		
	47' Riviera			1	Starting astern	Full thrust	**14:50**	6	9	
								9	10	
							14:51	8	11	
								13	10	
							14:52	8	8	
								10	9	
							14:53	6	9	No visible plume at surface
								9	7	
26/09/2007		3.0					14:54	7		Background prior to disturbance
	47' Riviera			2	Starting astern	Full thrust	**14:54**	9	7	
									7	
							14:55	4	11	
								6	10	
							14:56	5	21	
								8	19	
							14:57	5	10	
								6	8	
							14:58		8	
									10	Plume moved ~5m

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
26/09/2007		4.2					13:37	10		Background prior to disturbance
								13		
	47' Riviera	4.2		1	Underway	4 knots	**13:38**	8		No visible plume at surface
								9		
							13:39	6		
								7		
			4.4				13:40	7	13	
			4.4					9	11	
			4.2						8	
									9	
26/09/2007		4.2					13:41	6		Background prior to disturbance
	47' Riviera			2	Underway	4 knots	**13:41**	9		No visible plume at surface
							13:43	6		
								9		
							13:44	7		
								10		
			4.2				13:45	6	8	
								7	8	
26/09/2007		4.2					13:46	7		Background prior to disturbance
								11		
	47' Riviera			1	Starting ahead	Full thrust	**13:47**	8	7	

TABLE E.8

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
								14	8	
									7	
									8	
							13:48	7	8	
								11	8	
									13	
									12	
							13:49	8	10	
								13	9	
							13:50	6	11	No visible plume at surface
								10	11	
							13:51		10	
									15	
26/09/2007		4.1					13:52	9		Background prior to disturbance
								14		
	47'			2	Starting ahead	Full thrust	**13:54**	6		
								11		
							13:55	12	10	
								14	11	
									10	
									13	
							13:56	7	9	
								10	8	
							13:57	8		No visible plume at surface
								11		
26/09/2007		4.1					13:58	7		Background prior to disturbance
								8		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
				1	Starting astern	Full thrust	**13:59**	4		
								8		No visible plume at surface
							14:00	6	10	
								9	9	
									8	
									8	
							14:01		8	
									7	
									7	
									7	
26/09/2007		4.1					14:02	6		Background prior to disturbance
								10		
				2	Starting astern	Full thrust	**14:03**	6		
								7		
							14:04	5		
								8		
							14:05	5	8	No visible plume at surface
								7	8	
									6	
									7	
							14:06		7	
									8	
									7	
									9	

TABLE E.8

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed	Mobile Probe in Surface / Plume	
			4.7				11:18	11	9	
								12	10	
									9	
									9	
							11:19	10	9	
								11	12	
			5.2						9	
									8	
							11:20	10		No visible plume in water surface
								12		
26/09/2007							11:20	8		Background prior to disturbance
								11		
	47' Riviera	5.0		2	Underway	4 knots	**11:21**	9		
								10		
			5.1				11:22	8	7	
								9	9	
									9	
									8	
							11:23	8	8	No visible plume in water surface
								10	9	
									7	
									8	

Date	**Vessel**	**Water Depth (m)**		**Run**	**Type of Manoeuvre**	**Speed / Thrust**	Time	**Turbidity (NTU)**		**Comments**
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed	Mobile Probe in Surface / Plume	
26/09/2007		4.9					11:26	9		Background prior to disturbance
								11		
	47' Riviera	5.0		1	Starting ahead	Full thrust	**11:27**	9		
								10		
							11:28	8		
								10	7	
									10	
							11:29	9		
								8	8	
									9	
							11:30	9	8	No visible plume in water surface
								12	7	
							11:31	8		
								9	8	
									9	
26/09/2007		4.9					11:32	8		
								9		
	47' Riviera	5.0		1	Starting ahead	Full thrust	**11:33**	7		
								8		
										No visible plume in water surface
							11:34	9		
								10	8	
									8	

TABLE E.9

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed	Mobile Probe in Surface / Plume	
							11:35	7	10	
								9	10	
									10	
									9	
							11:36	7	10	
								9	10	
26/09/2007		4.9					11:36	10		
								11		
	47' Riviera	5.0		1	Starting astern	Full thrust	**11:37**	14		
								17		
							11:38	16		
								21		
			4.9				11:39	13	12	
								16	9	
			4.5						20	Move boat to plume
									20	
							11:40	13		Small plume
								20	9	
									9	
							11:41	11	19	Plume moves ~5m SW
								21	24	
									19	
									17	
							11:42	13	18	
								15	16	
							11:43	15		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed	Mobile Probe in Surface / Plume	
								20		
			4.7				11:44	11	22	
								16	17	
									12	
									13	
							11:45	10	10	
								13	11	
									11	
									6	
							11:46	10		
								12		
26/09/2007		4.9					11:47	11		
								14		
	47' Riviera	5.0		2	Starting astern	Full thrust	**11:47**	9		
								12		
							11:48	9		
								11		
							11:49	8		No visible plume at surface
								11		
							11:50	8		
								11		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
25/09/2007							12:35	8		Background prior to disturbance
								11		
	80' Bennelong	3.6	3.4	1	Starting astern	Full thrust	**12:36**	75	290	
								96	234	
									480	
									199	
									237	
									309	
							12:37	27		
								80		
								38		
								41		
							12:38	24		
								26		
								37		
								19		
								8		
								23		
							12:39	27		
								21		
							12:40	14		
							12:41	7	106	
									107	
									12	
									29	
									56	
									123	
									130	
									158	
									212	
									248	

TABLE E.10

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
							12:42	7	217	
								8	221	
									158	
									172	
			3.8						176	
									135	
									106	
									95	
			3.0						50	Plume 50m from start
									20	
									106	
									110	
									115	Plume extended over ~100m to boom fence
									114	Niskin samples collected Nos 15 and 16
26/09/2007		4.1					13:12	6		Background prior to disturbance
								9		
	80' Bennelong	4.0	3.4	1	Starting ahead	Full thrust	**13:16**	7	35	
								8	26	
							13:17	8	35	
								6	26	
							13:18	7	25	
								8	51	Visible plume in water surface
							13:19	8		
								7		
							13:20	9		
								8		
							13:21	6		
								8		
							13:22	7		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
								9		
							13:23	7		
								8		
							13:24	9		
								6		
							13:25			
							13:26			
							13:27			
							13:28			
							13:29			
							13:30			
							13:31			
							13:32			
							13:33			
							13:34			
							13:35			
							13:36			
							13:37			
			3.1				13:38		19	
									16	
							13:39			
							13:40			
							13:41			
							13:42			
			1.0				13:43		19	
									15	Plume travelled ~60m to boom fence

TABLE E.10

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
25/09/2007							13:36	23		Background prior to disturbance
								22		
	80' Bennelong	5.0	5.3	1	Underway	4 knots	**13:37**	32	11	
								13	12	
								14		
							13:38	8	9	
								23	6	
								27		
							13:39	9	7	
								15	6	No plume visible in the water surface
							13:40		6	
									5	
25/09/2007							13:41	13		Background prior to disturbance
								17		
	80' Bennelong	5.0	5.4	2	Underway	4 knots	**13:42**	10	10	
								9	6	
							13:43	10	7	
								12	8	
							13:44	7	6	
								9	4	No visible plume in water surface
							13:45		22	Mobile probe results from here may have been recorded over several minutes
									6	
									6	
									5	
									4	
									4	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
26/09/2007		4.9					11:55	5		Background prior to disturbance
								4		
	80' Bennelong	5.0	4.5	3	Underway	4 knots	**11:56**	8		
								9		
							11:57	9		Plume visible at water surface
								8		
							11:58	7		
								8		
							11:59	10	10	
								9	12	
			4.5				12:00	11	14	
								12	18	
									24	
									16	
			4.9				12:01	9	10	
								11	11	
									8	
									10	
			5.1				12:02	14	13	
								9	15	
			5.0						13	
									10	
									15	
									12	
							12:03	8	12	
								11	12	
									16	
									15	
							12:04	7	12	
								8	12	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									14	
									15	
							12:05	5	16	
								7	13	
									16	
									13	
							12:06		10	
									14	
									13	
							12:07		14	
									12	
							12:08		9	
									9	
									10	
									9	Plume moved ~20m to W
26/09/2007							12:13		6	Background prior to disturbance
									7	
	80' Bennelong	5.0		2	Starting ahead	Full thrust	**12:14**	7		
								8		
			4.8						12	
									11	
							12:15	7	13	
								8	12	
									14	
									11	
							12:16	8	14	
								7	9	
									9	
									10	
							12:17	8	10	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
								7	11	
									10	
									9	
							12:18	17		No plume visible at water surface
								18		
							12:19	10		
								14		
							12:20	15		
								12		
							12:21	5		
								6		
25/09/2007							13:47		9	Background prior to disturbance
									11	
	80' Bennelong	5.0		2	Starting ahead	Full thrust	**13:48**	8		
								6		
								10		
								14		
							13:49	36		
								22		
								25		
								43		
								25		
								15		
			5.4				13:50	17	31	
								45	10	
								29	30	
							13:51		27	
									17	
									22	
									20	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									19	
									22	
									20	
			5.3				13:52	20	24	Niskin samples collected Nos 17 amd 18
								19	27	
							13:53	17	20	
								20	16	
									5	
									6	
									8	
									6	To W of plume
							13:54		10	
									14	
									16	
									17	
									16	
									16	
									14	
									27	
									5	
									5	Plume travelled 20m
26/09/2007		4.9					12:22		8	Background prior to disturbance
									9	
	80' Bennelong	5.0		2	Starting astern	Full thrust	**12:23**	21		
								22		
							12:24	10		Large visible plume
								13		
							12:25	30	175	
								41	160	
									147	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
									131	
							12:26	19	107	
								21	98	
									115	
									98	
							12:27	24	128	
								28	138	
									47	
									40	
							12:28	33		
								35		
							12:29	24		
								28		
									58	Niskin samples collected
							12:30	19	46	Following the plume shoreward
								23	36	
							12:31		61	
									59	
							12:32	18		
								20		
							12:33			
							12:24			
							12:35	17		
								19		
							12:36	8		
								9		
			4.2				12:37		38	
									37	
							12:38		25	
									22	
							12:39		33	
									29	
							12:40	8	52	
								11	20	

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
			4.1				12:41		21	
									16	
			4.3				12:42		17	
									19	
							12:43	13	19	
								14	15	
							12:44			
			4.2				12:45		17	
									16	
							12:46	9		
								10		
							12:47			
							12:48			
							12:49			
			1.0				12:50		9	
									8	Plum moved onshore
25/09/2007							13:54	8		
								9		
	80' Bennelong	5.0		2	Starting astern	Full thrust	**13:57**	500		Visible plume
								424		
								45		
								12		
							13:58	100		
								79		
								13		
								8		
							13:59	65		
								69		
								7		
								8		

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
			5.1				14:00		34	
									43	
									30	
									37	
									51	
									25	
									80	
									106	
									126	
									134	
									150	
									175	
									196	
									72	
									35	
									65	
									200	
							14:01		205	Niskin samples collected Nos 19 and 20
									110	
									40	
									35	
									25	
									76	
									35	
							14:02		64	
									58	
							14:05		34	
									25	
							14:06		57	
									27	
							14:07		12	
									9	
									12	
									14	

TABLE E.11

Date	Vessel	Water Depth (m)		Run	Type of Manoeuvre	Speed / Thrust	Time	Turbidity (NTU)		Comments
		Fixed Probe	Mobile Probe in Surface / Plume				(Event time in **red**)	Fixed Probe 0.5m above Bed under Propeller	Mobile Probe tracking Centre Plume in Water Surface	
							14:08		28	
									26	
									36	
									20	
							14:10		15	
									10	
							14:12			Plume moved shoreward

APPENDIX F

TSS LABORATORY RESULTS

Australian Government
National Measurement Institute

NATA

REPORT OF ANALYSIS

Report No. RN644691

Client	: THE ECOLOGY LAB P/L 4 GREEN ST BROOKVALE NSW 2100	Job No.	: ECOL01/071016
		Quote No.	: QT-00782
		Order No.	:
		Date Sampled	:
		Date Received	: 16-OCT-2007
Attention	: CRAIG BLOUNT	Sampled By	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	Phone	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
N07/036807	TEL_1	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036808	TEL_3	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036809	TEL_6	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036810	TEL_7	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708

Lab Reg No.		N07/036807	N07/036808	N07/036809	N07/036810	
Sample Reference	Units	TEL_1	TEL_3	TEL_6	TEL_7	Method
Miscellaneous						
Suspended Solids	mg/L	10	5	4	4	NW_S13
Turbidity	NTU	1.2	0.6	0.6	0.6	NW_B11

Wei Huang, Analyst
Inorganics - NSW
Accreditation No. 198

26-OCT-2007

REPORT OF ANALYSIS

Report No. RN644691

Client	: THE ECOLOGY LAB P/L 4 GREEN ST BROOKVALE NSW 2100	Job No. Quote No. Order No. Date Sampled Date Received	: ECOL01/071016 : QT-00782 : : : 16-OCT-2007
Attention	: CRAIG BLOUNT	Sampled By	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	Phone	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
N07/036811	TEL_10	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036812	TEL_11	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036813	TEL_13	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036814	TEL_14	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708

Lab Reg No.		N07/036811	N07/036812	N07/036813	N07/036814	
Sample Reference	Units	TEL_10	TEL_11	TEL_13	TEL_14	Method
Miscellaneous						
Suspended Solids	mg/L	8	15	71	48	NW_S13
Turbidity	NTU	1.7	1.0	5.5	5.1	NW_B11

Wei Huang, Analyst
Inorganics - NSW
Accreditation No. 198

26-OCT-2007

REPORT OF ANALYSIS

Report No. RN644691

Client	: THE ECOLOGY LAB P/L 4 GREEN ST BROOKVALE NSW 2100	Job No. Quote No. Order No. Date Sampled Date Received	: ECOL01/071016 : QT-00782 : : : 16-OCT-2007
Attention	: CRAIG BLOUNT	Sampled By	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	Phone	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
N07/036815	TEL_15	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036816	TEL_16	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036817	TEL_17	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036818	TEL_20	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708

Lab Reg No.		N07/036815	N07/036816	N07/036817	N07/036818	
Sample Reference	Units	TEL_15	TEL_16	TEL_17	TEL_20	Method
Miscellaneous						
Suspended Solids	mg/L	340	310	20	100	NW_S13
Turbidity	NTU	190	170	2.8	24	NW_B11

Wei Huang, Analyst
Inorganics - NSW
Accreditation No. 198

26-OCT-2007

REPORT OF ANALYSIS

Report No. RN644691

Client	: THE ECOLOGY LAB P/L 4 GREEN ST BROOKVALE NSW 2100	Job No.	: ECOL01/071016
		Quote No.	: QT-00782
		Order No.	:
		Date Sampled	:
		Date Received	: 16-OCT-2007
Attention	: CRAIG BLOUNT	Sampled By	: CLIENT
Project Name	:		
Your Client Services Manager	: BRIAN WOODWARD	Phone	: (02) 94490151

Lab Reg No.	Sample Ref	Sample Description
N07/036819	TEL_21	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708
N07/036820	TEL_22	WATER KENDAL BAY TURBIDITY STUDY JOB 19/0708

Lab Reg No.		N07/036819	N07/036820			
Sample Reference	Units	TEL_21	TEL_22			Method
Miscellaneous						
Suspended Solids	mg/L	100	130			NW_S13
Turbidity	NTU	31	45			NW_B11

Wei Huang, Analyst
Inorganics - NSW
Accreditation No. 198

26-OCT-2007

NATA
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This Report supersedes reports: RN644571

APPENDIX G

PREDICTIVE PROFILE OF TURBIDITY IMPACTS FOR ALL VESSEL SIZES EARMARKED FOR BERTHING AT BREAKFAST POINT MARINA

Prepared by G Blumberg 31/10/2007 6:37 PM

Assumptions:

1 Max turbidity is "worst case" over the event between 0.5 m and surface readings
2 Av turbidity is "time-based average" over the event, established graphically be inspection
3 Av turbidity is "worst case" between 0.5m and surface readings

Red cells are variables
Purple and blue cells calc automatically

Boat Length		Depth	Run		Start Ahead (Full thrust)							Start Astern (Full thrust)							Underway (4k)						
(ft)	(m)	(m)			BG turbidity	Max turbidity	Time to BG		Av turbidity	Max turbid >BG	Average turbid > BG	Bg turbidity	Max turbidity	Time to bg		Av turbid	Max turbid >bg	Average turbid > bg	Bg turbidity	Max turbidity	Time to bg		Av turbid	Max turbid >bg	Average turbid > bg
					(NTU)	(NTU)	(Mins)	(secs)	(NTU)	(NTU)	(NTU)	(NTU)	(NTU)	(Mins)	(secs)	(NTU)	(NTU)	(NTU)	(NTU)	(NTU)	(Mins)	(secs)	(NTU)	(NTU)	(NTU)
37	11	2	1		25	230	4	240	75	205	50	8	145	5	270	30	137	22	8	190	8	480	45	182	37
			2		10	180	6	360	45	170	35	8	260	5	300	45	252	37	8	35	5	270	20	27	12
				av	18	205	5	300	60	205	43	8	203	5	285	38	252	30	8	113	6	375	33	182	25
		3	1		12	34	2	120	16	22	4	8	27	1	60	13	19	5	7	12	2	90	9	5	2
			2		11	45	3	180	15	34	4	8	63	2	90	20	55	12	9	10	1	60	10	1	1
			3		4	6	3	204	5	2	1	8	18	2	144	10	10	2	6	8	1	30	7	3	2
				av	9	28	3	168	12	34	3	8	36	2	98	14	55	6	7	10	1	60	9	5	1
		4	1		16	18	3	150	17	3	2	9	9	0	0	9	0	0	6	6	0	0	6	0	0
			2		9	12	3	168	11	3	2	11	11	0	0	11	0	0	8	10	4	258	9	2	1
				av	12	15	3	159	14	3	2	10	10	0	0	10	0	0	7	8	2	129	8	2	1
		5	1		10	10	0	0	10	0	0														
			2		11	11	0	0	11	0	0														
				av	11	11	0	0	11	0	0														
47	14	3	1		9	9	0	0	9	0	0	8	10	3	180	9	2	1	10	30	4	228	15	20	5
			2		11	15	2	138	13	4	2	9	20	3	180	13	11	4	9	13	4	258	11	5	3
				av	10	12	1	69	11	4	1	9	15	3	180	11	11	3	9	22	4	243	13	20	4
		4	1		11	13	4	234	12	2	1	6	9	3	168	8	3	2	9	12	2	144	10	4	2
			2		9	14	2	114	11	5	3	7	8	3	195	8	1	1	8	8	0	0	8	0	0
				av	10	13	3	174	12	5	2	6	9	3	182	8	3	1	8	10	1	72	9	4	1
		5	1		9	9	0	0	9	0	0	16	22	7	444	17	7	2	12	12	0	0	12	0	0
			2		8	8	0	0	8	0	0	11	11	0	0	11	1	1	11	11	0	0	11	0	0
				av	8	8	0	0	8	0	0	13	17	4	222	14	7	1	12	12	0	0	12	0	0
80	24	4	1		9	39	30	1800	25	30	16	80	345	9	540	175	265	95							
		5	1		8	35	7	390	23	27	15	8	460	8	480	50	452	42	22	22	0	0	22	0	0
			2		8	19	8	450	12	11	4	21	59	6	378	35	38	14	10	10	0	0	10	0	0
			3																9	16	8	450	12	7	3
				av	8	27	7	420	18	27	10	15	260	7	429	43	452	28	14	16	3	150	15	7	1

Procedure		
	1	Red boat lengths included in marina
	2	Blue values directly from data in "Boat Turbidity Results" sheet
	3	Green values are amended (adjusted up) data to permit prudent interpretation
	4	Purple values populated by interpolation of data

		Start Ahead (Full Thrust)			Start Astern (Full Thrust)			Underway (4k)		
Depth	Boat Length	Event time	Max turb > bg during event	Av turb > bg during event	Event time	Max turb > bg during event	Av turb > bg during event	Event time	Max turb > bg during event	Av turb > bg during event
(m)	(m)	(s)	(NTU)	(NTU)	(s)	(NTU)	(NTU)	(s)	(NTU)	(NTU)
2	8	100	100	10	100	100	10	50	15	5
	9									
2	10	200	150	20	200	150	20	200	60	15
	11	300	205	43	285	252	30	375	182	25
2	12	700	300	50	700	300	50	500	200	35
	13									
2	14	1200	450	70	1200	450	70	750	300	40
	15									
2	16	2000	600	100	2000	600	100	1000	400	50
	17									
3	8	50	20	2	50	20	3	30	3	1
	9									
3	10	100	20	2	100	20	3	50	4	1
	11	168	34	3	98	55	6	60	5	1
3	12	120	40	2	100	50	6	100	10	2
	13									
3	14	200	40	6	200	50	6	243	20	4
	15									
3	16	1000	100	25	500	100	25	250	30	7
	17									
3	18	2000	150	50	800	200	50	300	40	10
	19									
3	20	3000	200	100	1200	300	100	350	80	20
	21									
	22									
	23									
	24									
3	25	4000	400	200	2000	600	300	500	200	50
4	8	0	0	0	0	0	0	0	0	0
	9									
4	10	100	2	1	0	0	0	50	2	1
	11	159	3	2	0	0	0	129	2	1
4	12	165	4	2	80	2	1	100	3	1
	13									
4	14	174	5	2	182	3	1	72	4	1
	15									
4	16	500	40	20	250	50	25	90	7	4
	17									
4	18	800	80	35	320	100	45	110	12	6
	19									
4	20	1100	120	50	390	200	70	130	15	8
	21									
	22									
	23									
	24									
4	25	1800	200	80	540	400	95	190	20	10
5	8	0	0	0	0	0	0	0	0	0
	9									
5	10	0	5	0	0	5	0	0	0	0
	11	0	11	0						
5	12	0	12	0	100	12	0	0	0	0
	13									
5	14	0	15	0	222	7	1	0	0	0
	15									
5	16	100	17	2	250	100	7	25	1	0
	17									
5	18	200	19	4	300	200	14	25	2	1
	19									

Procedure	1	Red boat lengths included in marina											
	2	Blue values directly from data in "Boat Turbidity Results" sheet											
	3	Green values are amended (adjusted up) data to permit prudent interpretation											
	4	Purple values populated by interpolation of data											
			Start Ahead (Full Thrust)				Start Astern (Full Thrust)				Underway (4k)		
Depth	Boat Length		Event time	Max turb > bg during event	Av turb > bg during event		Event time	Max turb > bg during event	Av turb > bg during event		Event time	Max turb > bg during event	Av turb > bg during event
(m)	(m)		(s)	(NTU)	(NTU)		(s)	(NTU)	(NTU)		(s)	(NTU)	(NTU)
5	20		300	21	6		350	300	21		75	3	2
	21												
	22												
	23												
	24												
5	25		420	27	10		429	452	28		150	7	1

APPENDIX H

ASSESSMENT OF INCREASE IN BACKGROUND TURBIDITY ASSUMING MARINA FULLY BERTHED, AND ALL VESSELS DEPART, EXIT KENDAL BAY REMEDIATION SITE, AND RETURN TO BERTH WITHIN A SINGLE DAY

Assumptions:

Full thrust time (ahead and Astern) when starting and stopping	5
Assumed average speed when starting and stopping	2

4 knots 2 m/s

						Travel Dist to edge Remed Site over Test Depths (m)					Underway Time - Return Travel (seconds)					Start Reverse Thrust Av Turbidity above BG (NTU)				Start Ahead Thrust Av Turbidity above BG (NTU)			
Berth Code						Start RL		1.6	2.6	3.6	Start RL		2	3	4	Water depths				Water depths			
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	End RL	1.6	2.6	3.6		End RL	2	3	4		2	3	4	5	2	3	4	5
			Mean tide water depth			Total	2 or less	3	4	5 or more		2 or less	3	4	5 or more								
1	A	O	1	12	2.0	205	0	55	60	90		0	27	29	44	50	6	1	0	50	2	2	0
2			2	16	2.2	197	0	47	60	90		0	23	29	44	100	25	25	7	100	25	20	2
3			3	16	2.3	189	0	39	60	90		0	19	29	44	100	25	25	7	100	25	20	2
4			4	16	2.5	181	0	31	60	90		0	15	29	44	100	25	25	7	100	25	20	2
5			5	16	2.7	178	0	23	65	90		0	11	32	44	100	25	25	7	100	25	20	2
6			6	16	3.0	170	0	15	65	90		0	7	32	44	100	25	25	7	100	25	20	2
7			7	16	3.0	160	0	0	70	90		0	0	34	44	100	25	25	7	100	25	20	2
8			8	16	3.1	152	0	0	62	90		0	0	30	44	100	25	25	7	100	25	20	2
9			9	16	3.2	144	0	0	54	90		0	0	26	44	100	25	25	7	100	25	20	2
10			10	16	3.3	136	0	0	46	90		0	0	22	44	100	25	25	7	100	25	20	2
11			11	16	3.4	128	0	0	38	90		0	0	18	44	100	25	25	7	100	25	20	2
12			12	25	3.5	133	0	0	43	90		0	0	21	44	100	300	95	28	100	200	80	10
13			13	25	3.5	125	0	0	35	90		0	0	17	44	100	300	95	28	100	200	80	10
14			14	25	3.5	117	0	0	5	112		0	0	2	54	100	300	95	28	100	200	80	10
15			15	25	3.5	109	0	0	0	109		0	0	0	53	100	300	95	28	100	200	80	10
16	A	T	1	25	3.5	101	0	0	0	101		0	0	0	49	100	300	95	28	100	200	80	10
17	A	I	1	12	2.0	200	0	50	130	20		0	24	63	10	50	6	1	0	50	2	2	0
18			2	12	2.2	192	0	42	130	20		0	20	63	10	50	6	1	0	50	2	2	0
19			3	12	2.3	184	0	34	130	20		0	17	63	10	50	6	1	0	50	2	2	0
20			4	12	2.5	176	0	26	130	20		0	13	63	10	50	6	1	0	50	2	2	0
21			5	12	2.6	168	0	18	130	20		0	9	63	10	50	6	1	0	50	2	2	0
22			6	16	2.7	160	0	5	135	20		0	2	66	10	100	25	25	7	100	25	20	2
23			7	16	2.8	152	0	0	132	20		0	0	64	10	100	25	25	7	100	25	20	2
24			8	16	2.9	144	0	0	124	20		0	0	60	10	100	25	25	7	100	25	20	2
25			9	16	3.0	136	0	0	116	20		0	0	56	10	100	25	25	7	100	25	20	2
26			10	16	3.1	128	0	0	108	20		0	0	52	10	100	25	25	7	100	25	20	2
27			11	16	3.1	120	0	0	100	20		0	0	49	10	100	25	25	7	100	25	20	2
28			12	16	3.2	112	0	0	92	20		0	0	45	10	100	25	25	7	100	25	20	2
29			13	16	3.2	104	0	0	84	20		0	0	41	10	100	25	25	7	100	25	20	2
30			14	16	3.3	96	0	0	76	20		0	0	37	10	100	25	25	7	100	25	20	2
31			15	16	3.4	88	0	0	68	20		0	0	33	10	100	25	25	7	100	25	20	2
32			16	16	3.4	80	0	0	60	20		0	0	29	10	100	25	25	7	100	25	20	2
33			17	16	3.5	72	0	0	52	20		0	0	25	10	100	25	25	7	100	25	20	2
34	B	O	1	14	2.0	205	0	55	130	20		0	27	63	10	70	6	1	1	70	6	2	0
35			2	14	2.2	197	0	47	130	20		0	23	63	10	70	6	1	1	70	6	2	0
36			3	14	2.4	189	0	39	130	20		0	19	63	10	70	6	1	1	70	6	2	0
37			4	14	2.5	181	0	31	130	20		0	15	63	10	70	6	1	1	70	6	2	0
38			5	14	2.5	173	0	23	130	20		0	11	63	10	70	6	1	1	70	6	2	0
39			6	14	2.6	165	0	15	130	20		0	7	63	10	70	6	1	1	70	6	2	0
40			7	14	2.6	157	0	0	137	20		0	0	67	10	70	6	1	1	70	6	2	0
41			8	14	2.7	149	0	0	129	20		0	0	63	10	70	6	1	1	70	6	2	0
42			9	14	2.7	141	0	0	121	20		0	0	59	10	70	6	1	1	70	6	2	0
43			10	14	2.8	133	0	0	113	20		0	0	55	10	70	6	1	1	70	6	2	0
44			11	14	2.8	125	0	0	105	20		0	0	51	10	70	6	1	1	70	6	2	0
45			12	14	2.9	117	0	0	97	20		0	0	47	10	70	6	1	1	70	6	2	0
46			13	14	2.9	109	0	0	89	20		0	0	43	10	70	6	1	1	70	6	2	0
47			14	14	3.0	101	0	0	81	20		0	0	39	10	70	6	1	1	70	6	2	0
48			15	14	3.0	93	0	0	73	20		0	0	35	10	70	6	1	1	70	6	2	0
49			16	14	3.1	85	0	0	65	20		0	0	32	10	70	6	1	1	70	6	2	0
50			17	14	3.2	77	0	0	57	20		0	0	28	10	70	6	1	1	70	6	2	0
51	B	T	1	25	3.3	85	0	0	65	20		0	0	32	10	100	300	95	28	100	200	80	10
52	B	I	1	12	2.1	210	0	90	120	0		0	44	58	0	50	6	1	0	50	2	2	0
53			2	12	2.2	202	0	82	120	0		0	40	58	0	50	6	1	0	50	2	2	0
54			3	12	2.3	194	0	74	120	0		0	36	58	0	50	6	1	0	50	2	2	0
55			4	12	2.4	186	0	66	120	0		0	32	58	0	50	6	1	0	50	2	2	0

	Underway Av Turbidity above BG (NTU)				Start Reverse Thrust Turbidity -Event time (s)				Start Ahead Thrust Turbidity -Event time (s)				Underway Turbidity -Event time (s)				Bed Disturbance Area per return trip (m2)				Bed disturbance area starting and stoppin		
	Water depths				Water depths				Water depths				Water depths				Water depths				Water depths		
Berth No	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4
1	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	704	1008	1872	0	64	0
2	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	592	756	1134	0	83	0
3	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	491	756	1134	0	83	0
4	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	391	756	1134	0	83	0
5	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	290	819	1134	0	83	0
6	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	189	819	1134	0	83	0
7	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	882	1134	0	0	103
8	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	781	1134	0	0	103
9	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	680	1134	0	0	103
10	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	580	1134	0	0	103
11	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	479	1134	0	0	103
12	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	731	1530	0	0	125
13	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	595	1530	0	0	125
14	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	85	1904	0	0	125
15	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	0	1853	0	0	0
16	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	0	1717	0	0	0
17	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	440	1144	176	0	64	0
18	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	370	1144	176	0	64	0
19	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	299	1144	176	0	64	0
20	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	229	1144	176	0	64	0
21	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	158	1144	176	0	64	0
22	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	63	1701	252	0	83	0
23	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1663	252	0	0	103
24	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1562	252	0	0	103
25	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1462	252	0	0	103
26	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1361	252	0	0	103
27	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1260	252	0	0	103
28	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1159	252	0	0	103
29	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	1058	252	0	0	103
30	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	958	252	0	0	103
31	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	857	252	0	0	103
32	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	756	252	0	0	103
33	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	655	252	0	0	103
34	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	490	1157	178	0	65	0
35	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	418	1157	178	0	65	0
36	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	347	1157	178	0	65	0
37	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	276	1157	178	0	65	0
38	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	205	1157	178	0	65	0
39	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	134	1157	178	0	65	0
40	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	1219	178	0	0	85
41	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	1148	178	0	0	85
42	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	1077	178	0	0	85
43	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	1006	178	0	0	85
44	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	935	178	0	0	85
45	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	863	178	0	0	85
46	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	792	178	0	0	85
47	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	721	178	0	0	85
48	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	650	178	0	0	85
49	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	579	178	0	0	85
50	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	507	178	0	0	85
51	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	1105	340	0	0	125
52	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	792	1056	0	0	64	0
53	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	722	1056	0	0	64	0
54	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	651	1056	0	0	64	0
55	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	581	1056	0	0	64	0

Assumptions:

Full thrust time (ahead and Astern) when starting and stopping 5

Assumed average speed when starting and stopping 2

4 knots 2 m/s

						Travel Dist to edge Remed Site over Test Depths (m)					Underway Time - Return Travel (seconds)				Start Reverse Thrust Av Turbidity above BG (NTU)				Start Ahead Thrust Av Turbidity above BG (NTU)				Underway Av Turbidity above BG (NTU)				Start Reverse Thrust Turbidity -Event time (s)				Start Ahead Thrust Turbidity -Event time (s)				Underway Turbidity -Event time (s)				Bed Disturbance Area per return trip (m2)				Bed disturbance area starting and stoppin		
Berth Code						Start RL		1.6	2.6	3.6	Start RL		2	3	4	Water depths				Water depths				Water depths				Water depths				Water depths				Water depths				Water depths				Water depths		
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (- ve m)	End RL	1.6	2.6	3.6		End RL	2	3	4		2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4
		Mean tide water depth				Total	2 or less	3	4	5 or more		2 or less	3	4	5 or more																																			
56			5	12	2.5	178	0	58	120	0		0	28	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	510	1056	0	0	64	0
57			6	12	2.5	170	0	50	120	0		0	24	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	440	1056	0	0	64	0
58			7	12	2.6	162	0	42	120	0		0	20	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	370	1056	0	0	64	0
59			8	12	2.6	154	0	34	120	0		0	17	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	299	1056	0	0	64	0
60			9	12	2.6	146	0	26	120	0		0	13	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	229	1056	0	0	64	0
61			10	12	2.7	138	0	18	120	0		0	9	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	158	1056	0	0	64	0
62			11	12	2.7	130	0	10	120	0		0	5	58	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	88	1056	0	0	64	0
63			12	12	2.8	125	0	0	125	0		0	0	61	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	1100	0	0	0	84
64			13	12	2.8	118	0	0	118	0		0	0	57	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	1038	0	0	0	84
65			14	12	2.8	118	0	0	118	0		0	0	57	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	1038	0	0	0	84
66			15	12	2.9	113	0	0	113	0		0	0	55	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	994	0	0	0	84
67			16	12	2.9	105	0	0	105	0		0	0	51	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	924	0	0	0	84
68			17	12	3.0	97	0	0	97	0		0	0	47	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	854	0	0	0	84
69			18	12	3.0	88	0	0	88	0		0	0	43	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	774	0	0	0	84
70			19	12	3.0	79	0	0	79	0		0	0	38	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	0	695	0	0	0	84
71	C	O	1	12	2.0	223	0	105	118	0		0	51	57	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	924	1038	0	0	64	0
72			2	12	2.1	217	0	99	118	0		0	48	57	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	871	1038	0	0	64	0
73			3	12	2.2	211	0	93	118	0		0	45	57	0	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	818	1038	0	0	64	0
74			4	14	2.2	204	0	86	118	0		0	42	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	765	1050	0	0	65	0
75			5	14	2.3	198	0	80	118	0		0	39	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	712	1050	0	0	65	0
76			6	14	2.3	191	0	73	118	0		0	35	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	650	1050	0	0	65	0
77			7	14	2.4	185	0	67	118	0		0	33	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	596	1050	0	0	65	0
78			8	14	2.5	177	0	59	118	0		0	29	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	525	1050	0	0	65	0
79			9	14	2.5	171	0	53	118	0		0	26	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	472	1050	0	0	65	0
80			10	14	2.6	163	0	45	118	0		0	22	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	401	1050	0	0	65	0
81			11	14	2.6	158	0	40	118	0		0	19	57	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	356	1050	0	0	65	0
82			12	14	2.7	145	0	20	125	0		0	10	61	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	178	1113	0	0	65	0
83			13	14	2.7	119	0	0	119	0		0	0	58	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	1059	0	0	0	85
84			14	14	2.8	113	0	0	113	0		0	0	55	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	1006	0	0	0	85
85			15	14	2.8	107	0	0	107	0		0	0	52	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	952	0	0	0	85
86			16	14	2.9	100	0	0	100	0		0	0	49	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	890	0	0	0	85
87			17	14	2.9	94	0	0	94	0		0	0	46	0	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	837	0	0	0	85
88	C	T	1	25	3.0	105	0	0	105	0		0	0	51	0	100	300	95	28	100	200	80	10	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	1785	0	0	0	125
89	C	I	1	14	1.9	194	0	53	46	95		0	26	22	46	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	472	409	846	0	65	0
90			2	14	2.0	189	0	48	46	95		0	23	22	46	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	427	409	846	0	65	0
91			3	16	2.1	182	0	41	46	95		0	20	22	46	100	25	25	7	100	25	20	2	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	517	580	1197	0	83	0
92			4	16	2.2	175	0	34	46	95		0	17	22	46	100	25	25	7	100	25	20	2	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	428	580	1197	0	83	0
93			5	18	2.3	168	0	27	46	95		0	13	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	354	603	1245	0	86	0
94			6	18	2.4	162	0	21	46	95		0	10	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	275	603	1245	0	86	0
95			7	18	2.5	154	0	13	46	95		0	6	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	170	603	1245	0	86	0
96			8	18	2.5	148	0	7	46	95		0	3	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	92	603	1245	0	86	0
97			9	18	2.6	141	0	0	46	95		0	0	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	0	603	1245	0	0	106
98			10	18	2.7	135	0	0	40	95		0	0	19	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	0	524	1245	0	0	106
99			11	18	2.8	129	0	0	34	95		0	0	17	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	0	445	1245	0	0	106
100			12	18	2.9	123	0	0	28	95		0	0	14	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	0	367	1245	0	0	106
101			13	25	3.0	123	0	0	28	95		0	0	14	46	100	300	95	28	100	200	80	10	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	476	1615	0	0	125
102			14	25	3.2	116	0	0	21	95		0	0	10	46	100	300	95	28	100	200	80	10	50	50	10	1	2000	2000	540	429	2000	4000	1800	420	1000	500	190	150	0	0	357	1615	0	0	125
103	D	O	1	14	2.2	199	10	48	46	95		5	23	22	46	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	89	427	409	846	45	65	0
104			2	14	2.5	192	3	48	46	95		1	23	22	46	70	6	1	1	70	6	2	0	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	27	427	409	846	45	65	0
105			3	16	2.7	186	0	45	46	95		0	22	22	46	100	25	25	7	100	25	20	2	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	567	580	1197	0	83	0
106			4	16	2.9	180	0	39	46	95		0	19	22	46	100	25	25	7	100	25	20	2	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	491	580	1197	0	83	0
107			5	18	3.0	174	0	33	46	95		0	16	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	432	603	1245	0	86	0
108			6	18	3.2	168	0	27	46	95		0	13	22	46	100	50	45	14	100	50	35	4	50	10	6	1	2000	800	320	300	2000	2000	800	200	1000	300	110	25	0	354	603	1245	0	86	0
109			7	20	3.3	162	0	21	46	95		0	10	22	46	100	100	70	21	100	100	50	6	50	20	8	2	2000	1200	390	350	2000	3000	1100	300	1000	350	130	75	0	286	626	1292	0	88	0
110			8	20	3.4	156	0	15	46	95		0	7	22	46	100	100	70	21	100	100	50	6	50	20	8	2	2000	1200	390	350	2000	3000	1100	300	1000	350	130	75	0	204	626	1292	0	88	0

Assumptions:

Full thrust time (ahead and Astern) when starting and stopping: 5

Assumed average speed when starting and stopping: 2

	Berth Code					Travel Dist to edge Remed Site over Test Depths (m)					Underway Time - Return Travel (seconds) (4 knots, 2 m/s)					Start Reverse Thrust Av Turbidity above BG (NTU)				Start Ahead Thrust Av Turbidity above BG (NTU)			
						Start RL		1.6	2.6	3.6	Start RL		2	3	4	Water depths				Water depths			
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	End RL	1.6	2.6	3.6		End RL	2	3	4		2	3	4	5	2	3	4	5
			Mean tide water depth			Total	2 or less	3	4	5 or more		2 or less	3	4	5 or more								
111			9	14	3.5	149	0	8	46	95		0	4	22	46	70	6	1	1	70	6	2	0
112			10	14	3.7	144	0	3	46	95		0	1	22	46	70	6	1	1	70	6	2	0
113			11	14	3.9	138	0	3	40	95		0	1	19	46	70	6	1	1	70	6	2	0
114			12	14	4.0	131	0	3	33	95		0	1	16	46	70	6	1	1	70	6	2	0
115			13	14	4.2	121	0	0	26	95		0	0	13	46	70	6	1	1	70	6	2	0
116	D	I	1	12	3.0	208	0	20	38	150		0	10	18	73	50	6	1	0	50	2	2	0
117			2	12	3.3	199	0	11	38	150		0	5	18	73	50	6	1	0	50	2	2	0
118			3	12	3.5	193	0	5	38	150		0	2	18	73	50	6	1	0	50	2	2	0
119			4	14	3.7	187	0	0	37	150		0	0	18	73	70	6	1	1	70	6	2	0
120			5	14	3.9	181	0	0	31	150		0	0	15	73	70	6	1	1	70	6	2	0
121			6	14	4.0	175	0	0	25	150		0	0	12	73	70	6	1	1	70	6	2	0
122			7	14	4.3	169	0	0	19	150		0	0	9	73	70	6	1	1	70	6	2	0
123			8	14	4.5	163	0	0	13	150		0	0	6	73	70	6	1	1	70	6	2	0
124			9	16	4.7	156	0	0	3	153		0	0	1	74	100	25	25	7	100	25	20	2
125			10	16	4.8	149	0	0	0	149		0	0	0	72	100	25	25	7	100	25	20	2
126			11	16	4.9	142	0	0	0	142		0	0	0	69	100	25	25	7	100	25	20	2
127			12	16	5.0	135	0	0	0	135		0	0	0	66	100	25	25	7	100	25	20	2
128	E	O	1	12	3.3	205	0	20	35	150		0	10	17	73	50	6	1	0	50	2	2	0
129			2	12	3.2	210	0	25	35	150		0	12	17	73	50	6	1	0	50	2	2	0
130			3	12	2.5	210	0	25	35	150		0	12	17	73	50	6	1	0	50	2	2	0
131			4	10	3.0	205	0	20	35	150		0	10	17	73	20	3	0	0	20	2	1	0
132			5	10	3.7	197	0	12	35	150		0	6	17	73	20	3	0	0	20	2	1	0
133	E	I	1	8	2.7	205	0	25	30	150		0	12	15	73	10	3	0	0	10	2	0	0
134			2	8	3.2	200	0	20	30	150		0	10	15	73	10	3	0	0	10	2	0	0
135			3	10	3.5	193	0	13	30	150		0	6	15	73	20	3	0	0	20	2	1	0
136			4	10	3.7	188	0	8	30	150		0	4	15	73	20	3	0	0	20	2	1	0
137			5	10	3.9	182	0	2	30	150		0	1	15	73	20	3	0	0	20	2	1	0
138			6	10	4.0	177	0	0	27	150		0	0	13	73	20	3	0	0	20	2	1	0
139			7	10	4.2	170	0	0	20	150		0	0	10	73	20	3	0	0	20	2	1	0
140	F	O	1	8	2.3	210	0	30	30	150		0	15	15	73	10	3	0	0	10	2	0	0
141			2	8	3.0	205	0	25	30	150		0	12	15	73	10	3	0	0	10	2	0	0
142			3	10	3.3	200	0	20	30	150		0	10	15	73	20	3	0	0	20	2	1	0
143			4	10	3.5	195	0	15	30	150		0	7	15	73	20	3	0	0	20	2	1	0
144			5	10	3.7	190	0	10	30	150		0	5	15	73	20	3	0	0	20	2	1	0
145			6	10	3.9	176	0	0	26	150		0	0	13	73	20	3	0	0	20	2	1	0
146			7	10	4.0	171	0	0	21	150		0	0	10	73	20	3	0	0	20	2	1	0
147			8	10	4.2	165	0	0	15	150		0	0	7	73	20	3	0	0	20	2	1	0
148			9	10	4.3	159	0	0	9	150		0	0	4	73	20	3	0	0	20	2	1	0
149			10	10	4.4	156	0	0	3	153		0	0	1	74	20	3	0	0	20	2	1	0
150	F	T	1	10	4.3	153	0	0	3	150		0	0	1	73	20	3	0	0	20	2	1	0
151	F	I	1	8	2.0	225	0	65	40	120		0	32	19	58	10	3	0	0	10	2	0	0
152			2	8	2.5	220	0	60	40	120		0	29	19	58	10	3	0	0	10	2	0	0
153			3	10	3.0	215	0	55	40	120		0	27	19	58	20	3	0	0	20	2	1	0
154			4	10	3.2	210	0	50	40	120		0	24	19	58	20	3	0	0	20	2	1	0
155			5	10	3.4	205	0	45	40	120		0	22	19	58	20	3	0	0	20	2	1	0
156			6	10	3.6	200	0	40	40	120		0	19	19	58	20	3	0	0	20	2	1	0
157			7	10	3.7	194	0	34	40	120		0	17	19	58	20	3	0	0	20	2	1	0
158			8	10	3.9	189	0	29	40	120		0	14	19	58	20	3	0	0	20	2	1	0
159			9	10	4.0	183	0	23	40	120		0	11	19	58	20	3	0	0	20	2	1	0
160			10	10	4.2	178	0	5	53	120		0	2	26	58	20	3	0	0	20	2	1	0
161	G	O	1	8	1.6	230	0	70	40	120		0	34	19	58	10	3	0	0	10	2	0	0
162			2	8	1.8	225	0	65	40	120		0	32	19	58	10	3	0	0	10	2	0	0
163			3	8	1.9	220	0	60	40	120		0	29	19	58	10	3	0	0	10	2	0	0
164			4	8	2.0	215	0	55	40	120		0	27	19	58	10	3	0	0	10	2	0	0
165			5	12	2.3	210	0	50	40	120		0	24	19	58	50	6	1	0	50	2	2	0

Berth No	Underway Av Turbidity above BG (NTU)				Start Reverse Thrust Turbidity -Event time (s)				Start Ahead Thrust Turbidity -Event time (s)				Underway Turbidity -Event time (s)				Bed Disturbance Area per return trip (m2)				Bed disturbance area starting and stoppin		
	Water depths				Water depths				Water depths				Water depths				Water depths				Water depths		
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4
111	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	71	409	846	0	65	0
112	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	27	409	846	0	65	0
113	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	27	356	846	0	65	0
114	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	27	294	846	0	65	0
115	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	231	846	0	0	85
116	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	176	334	1320	0	64	0
117	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	97	334	1320	0	64	0
118	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	44	334	1320	0	64	0
119	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	329	1335	0	0	85
120	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	276	1335	0	0	85
121	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	223	1335	0	0	85
122	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	169	1335	0	0	85
123	40	4	1	0	1200	200	182	222	1200	200	174	0	750	243	72	0	0	0	116	1335	0	0	85
124	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	38	1928	0	0	103
125	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	0	1877	0	0	0
126	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	0	1789	0	0	0
127	50	7	4	0	2000	500	250	250	2000	1000	500	100	1000	250	90	25	0	0	0	1701	0	0	0
128	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	176	308	1320	0	64	0
129	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	220	308	1320	0	64	0
130	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	220	308	1320	0	64	0
131	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	174	305	1305	0	64	0
132	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	104	305	1305	0	64	0
133	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	215	258	1290	0	63	0
134	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	172	258	1290	0	63	0
135	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	113	261	1305	0	64	0
136	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	70	261	1305	0	64	0
137	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	17	261	1305	0	64	0
138	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	235	1305	0	0	84
139	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	174	1305	0	0	84
140	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	258	258	1290	0	63	0
141	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	215	258	1290	0	63	0
142	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	174	261	1305	0	64	0
143	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	131	261	1305	0	64	0
144	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	87	261	1305	0	64	0
145	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	226	1305	0	0	84
146	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	183	1305	0	0	84
147	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	131	1305	0	0	84
148	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	78	1305	0	0	84
149	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	26	1331	0	0	84
150	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	0	26	1305	0	0	84
151	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	559	344	1032	0	63	0
152	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	516	344	1032	0	63	0
153	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	479	348	1044	0	64	0
154	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	435	348	1044	0	64	0
155	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	392	348	1044	0	64	0
156	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	348	348	1044	0	64	0
157	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	296	348	1044	0	64	0
158	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	252	348	1044	0	64	0
159	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	200	348	1044	0	64	0
160	15	1	1	0	200	100	0	0	200	100	100	0	200	50	50	0	0	44	461	1044	0	64	0
161	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	602	344	1032	0	63	0
162	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	559	344	1032	0	63	0
163	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	516	344	1032	0	63	0
164	5	1	0	0	100	50	0	0	100	50	0	0	50	30	0	0	0	473	344	1032	0	63	0
165	35	2	1	0	700	100	80	100	700	120	165	0	500	100	100	0	0	440	352	1056	0	64	0

Assumptions:

Full thrust time (ahead and Astern) when starting and stopping | 5

Assumed average speed when starting and stopping | 2

											4	knots	2	m/s	
						Travel Dist to edge Remed Site over Test Depths (m)					Underway Time - Return Travel (seconds)				
	Berth Code					Start RL		1.6	2.6	3.6	Start RL		2	3	4
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	End RL	1.6	2.6	3.6		End RL	2	3	4	
			Mean tide water depth			Total	2 or less	3	4	5 or more		2 or less	3	4	5 or more
166			6	12	2.5	205	0	45	40	120		0	22	19	58
167			7	12	2.7	199	0	39	40	120		0	19	19	58
168			8	12	2.9	194	0	34	40	120		0	17	19	58
169			9	12	3.0	188	0	28	40	120		0	14	19	58
170			10	12	3.2	183	0	10	53	120		0	5	26	58
171			11	12	3.3	178	0	5	53	120		0	2	26	58
172	G	I	1	8	2.0	223	5	90	33	95		2	44	16	46
173			2	10	2.0	218	0	90	33	95		0	44	16	46
174			3	10	2.0	213	0	85	33	95		0	41	16	46
175			4	12	2.2	208	0	80	33	95		0	39	16	46
176			5	12	2.3	203	0	75	33	95		0	36	16	46
177			6	12	2.5	198	0	70	33	95		0	34	16	46
178			7	12	2.6	193	0	65	33	95		0	32	16	46
179			8	12	2.8	188	0	60	33	95		0	29	16	46

Berth No	Start Reverse Thrust Av Turbidity above BG (NTU)				Start Ahead Thrust Av Turbidity above BG (NTU)				Underway Av Turbidity above BG (NTU)				Start Reverse Thrust Turbidity -Event time (s)			
	Water depths				Water depths				Water depths				Water depths			
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5
166	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
167	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
168	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
169	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
170	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
171	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
172	10	3	0	0	10	2	0	0	5	1	0	0	100	50	0	0
173	20	3	0	0	20	2	1	0	15	1	1	0	200	100	0	0
174	20	3	0	0	20	2	1	0	15	1	1	0	200	100	0	0
175	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
176	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
177	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
178	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100
179	50	6	1	0	50	2	2	0	35	2	1	0	700	100	80	100

Berth No	Start Ahead Thrust Turbidity -Event time (s)				Underway Turbidity -Event time (s)				Bed Disturbance Area per return trip (m2)				Bed disturbance area starting and stoppin		
	Water depths				Water depths				Water depths				Water depths		
	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4
166	700	120	165	0	500	100	100	0	0	396	352	1056	0	64	0
167	700	120	165	0	500	100	100	0	0	343	352	1056	0	64	0
168	700	120	165	0	500	100	100	0	0	299	352	1056	0	64	0
169	700	120	165	0	500	100	100	0	0	246	352	1056	0	64	0
170	700	120	165	0	500	100	100	0	0	88	466	1056	0	64	0
171	700	120	165	0	500	100	100	0	0	44	466	1056	0	64	0
172	100	50	0	0	50	30	0	0	43	774	284	817	43	63	0
173	200	100	100	0	200	50	50	0	0	783	287	827	0	64	0
174	200	100	100	0	200	50	50	0	0	740	287	827	0	64	0
175	700	120	165	0	500	100	100	0	0	704	290	836	0	64	0
176	700	120	165	0	500	100	100	0	0	660	290	836	0	64	0
177	700	120	165	0	500	100	100	0	0	616	290	836	0	64	0
178	700	120	165	0	500	100	100	0	0	572	290	836	0	64	0
179	700	120	165	0	500	100	100	0	0	528	290	836	0	64	0

						s (each)					Area Remed Site affected by Marina	127912	m2		Area Remed Site affected by Marina	127912	m2										
						m/s					Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Contribution from being underway to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Total contribution to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				
						a when g (m2)	Bed Disturbance Area per return trip excluding area when starting and stopping (m2)				Turbidity allowance from full thrust astern				Turbidity allowance from full thrust ahead				Turbidity allowance from constant 4 knots				Turbidity allowance from constant 4 knots				TOTAL TURBIDITY
	Berth Code						Water depths				Water depths				Water depths				Water depths				Water depths				
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	(NTU)
			Mean tide water depth																								0.043631511
1	A	O	1	12	2.0	0	0	640	1008	1872	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.46743E-05	1.17774E-05	0	0	1.97704E-05	1.17774E-05	0	3.155E-05
2			2	16	2.2	0	0	509	756	1134	0	9.4817E-05	0	0	0	0.00018869	0	0	0	8.79894E-05	3.2596E-05	0	0	0.0003715	3.2596E-05	0	4.041E-04
3			3	16	2.3	0	0	408	756	1134	0	9.4817E-05	0	0	0	0.00018869	0	0	0	6.95667E-05	3.2596E-05	0	0	0.000353078	3.2596E-05	0	3.857E-04
4			4	16	2.5	0	0	308	756	1134	0	9.4817E-05	0	0	0	0.00018869	0	0	0	5.16398E-05	3.2596E-05	0	0	0.000335151	3.2596E-05	0	3.677E-04
5			5	16	2.7	0	0	207	819	1134	0	9.4817E-05	0	0	0	0.00018869	0	0	0	3.42089E-05	3.60318E-05	0	0	0.00031772	3.60318E-05	0	3.538E-04
6			6	16	3.0	0	0	106	819	1134	0	9.4817E-05	0	0	0	0.00018869	0	0	0	1.72738E-05	3.60318E-05	0	0	0.000300785	3.60318E-05	0	3.368E-04
7			7	16	3.0	0	0	0	779	1134	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	3.49564E-05	0	0	0	0.000188502	0	1.885E-04
8			8	16	3.1	0	0	0	678	1134	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	2.94798E-05	0	0	0	0.000183026	0	1.830E-04
9			9	16	3.2	0	0	0	577	1134	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	2.42867E-05	0	0	0	0.000177832	0	1.778E-04
10			10	16	3.3	0	0	0	477	1134	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	1.93769E-05	0	0	0	0.000172923	0	1.729E-04
11			11	16	3.4	0	0	0	376	1134	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	1.47505E-05	0	0	0	0.000168296	0	1.683E-04
12			12	25	3.5	0	0	0	606	1530	0	0	0.00058561	0	0	0	0.00163325	0	0	0	0.00011563	2.6815E-05	0	0	0.002334483	2.6815E-05	2.361E-03
13			13	25	3.5	0	0	0	470	1530	0	0	0.00058561	0	0	0	0.00163325	0	0	0	8.80284E-05	2.6815E-05	0	0	0.002306882	2.6815E-05	2.334E-03
14			14	25	3.5	0	0	0	-40	1904	0	0	0.00058561	0	0	0	0.00163325	0	0	0	-6.9647E-06	3.5209E-05	0	0	0.002211889	3.5209E-05	2.247E-03
15			15	25	3.5	0	0	0	0	1853	0	0	0	0	0	0	0	0	0	0	0	3.4022E-05	0	0	0	3.4022E-05	3.402E-05
16	A	T	1	25	3.5	0	0	0	0	1717	0	0	0	0	0	0	0	0	0	0	0	3.0922E-05	0	0	0	3.0922E-05	3.092E-05
17	A	I	1	12	2.0	0	0	376	1144	176	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	8.45601E-06	1.68839E-05	0	0	1.35521E-05	1.68839E-05	0	3.044E-05
18			2	12	2.2	0	0	306	1144	176	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	6.65798E-06	1.68839E-05	0	0	1.17541E-05	1.68839E-05	0	2.864E-05
19			3	12	2.3	0	0	235	1144	176	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	4.95891E-06	1.68839E-05	0	0	1.0055E-05	1.68839E-05	0	2.694E-05
20			4	12	2.5	0	0	165	1144	176	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	3.35879E-06	1.68839E-05	0	0	8.45489E-06	1.68839E-05	0	2.534E-05
21			5	12	2.6	0	0	94	1144	176	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.85762E-06	1.68839E-05	0	0	6.95372E-06	1.68839E-05	0	2.384E-05
22			6	16	2.7	0	0	-20	1701	252	0	9.4817E-05	0	0	0	0.00018869	0	0	0	-3.1977E-06	9.57557E-05	0	0	0.000280313	9.57557E-05	0	3.761E-04
23			7	16	2.8	0	0	0	1560	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	8.70071E-05	0	0	0	0.000240553	0	2.406E-04
24			8	16	2.9	0	0	0	1459	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	7.93346E-05	0	0	0	0.00023288	0	2.329E-04
25			9	16	3.0	0	0	0	1359	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	7.19453E-05	0	0	0	0.000225491	0	2.255E-04
26			10	16	3.1	0	0	0	1258	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	6.48395E-05	0	0	0	0.000218385	0	2.184E-04
27			11	16	3.1	0	0	0	1157	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	5.8017E-05	0	0	0	0.000211563	0	2.116E-04
28			12	16	3.2	0	0	0	1056	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	5.14778E-05	0	0	0	0.000205024	0	2.050E-04
29			13	16	3.2	0	0	0	955	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	4.52221E-05	0	0	0	0.000198768	0	1.988E-04
30			14	16	3.3	0	0	0	855	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	3.92497E-05	0	0	0	0.000192795	0	1.928E-04
31			15	16	3.4	0	0	0	754	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	3.35607E-05	0	0	0	0.000187106	0	1.871E-04
32			16	16	3.4	0	0	0	653	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	2.8155E-05	0	0	0	0.000181701	0	1.817E-04
33			17	16	3.5	0	0	0	552	252	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	2.30327E-05	0	0	0	0.000176578	0	1.766E-04
34	B	O	1	14	2.0	0	0	425	1157	178	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	3.88933E-05	1.06083E-05	0	0	5.32505E-05	1.06083E-05	0	6.386E-05
35			2	14	2.2	0	0	354	1157	178	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	3.19113E-05	1.06083E-05	0	0	4.62685E-05	1.06083E-05	0	5.688E-05
36			3	14	2.4	0	0	283	1157	178	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	2.5117E-05	1.06083E-05	0	0	3.94742E-05	1.06083E-05	0	5.008E-05
37			4	14	2.5	0	0	211	1157	178	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	1.85103E-05	1.06083E-05	0	0	3.28675E-05	1.06083E-05	0	4.348E-05
38			5	14	2.5	0	0	140	1157	178	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	1.20912E-05	1.06083E-05	0	0	2.64484E-05	1.06083E-05	0	3.706E-05
39			6	14	2.6	0	0	69	1157	178	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	5.85982E-06	1.06083E-05	0	0	2.0217E-05	1.06083E-05	0	3.083E-05
40			7	14	2.6	0	0	0	1135	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	1.06665E-05	0	0	0	1.46301E-05	0	1.463E-05
41			8	14	2.7	0	0	0	1064	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	9.71692E-06	0	0	0	1.36806E-05	0	1.368E-05
42			9	14	2.7	0	0	0	992	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	8.8049E-06	0	0	0	1.27686E-05	0	1.277E-05
43			10	14	2.8	0	0	0	921	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	7.93041E-06	0	0	0	1.18941E-05	0	1.189E-05
44			11	14	2.8	0	0	0	850	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	7.09345E-06	0	0	0	1.10571E-05	0	1.106E-05
45			12	14	2.9	0	0	0	779	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	6.29402E-06	0	0	0	1.02577E-05	0	1.026E-05
46			13	14	2.9	0	0	0	708	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	5.53211E-06	0	0	0	9.49578E-06	0	9.496E-06
47			14	14	3.0	0	0	0	636	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	4.80774E-06	0	0	0	8.7714E-06	0	8.771E-06
48			15	14	3.0	0	0	0	565	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	4.1209E-06	0	0	0	8.08456E-06	0	8.085E-06
49			16	14	3.1	0	0	0	494	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	3.47158E-06	0	0	0	7.43525E-06	0	7.435E-06
50			17	14	3.2	0	0	0	423	178	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	2.8598E-06	0	0	0	6.82346E-06	0	6.823E-06
51	B	T	1	25	3.3	0	0	0	980	340	0	0	0.00058561	0	0	0	0.00163325	0	0	0	0.000196462	4.9134E-06	0	0	0.002415316	4.9134E-06	2.420E-03
52	B	I	1	12	2.1	0	0	728	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.89304E-05	1.51213E-05	0	0	2.40265E-05	1.51213E-05	0	3.915E-05
53			2	12	2.2	0	0	658	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.66377E-05	1.51213E-05	0	0	2.17337E-05	1.51213E-05	0	3.686E-05
54			3	12	2.3	0	0	587	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.44438E-05	1.51213E-05	0	0	1.95399E-05	1.51213E-05	0	3.466E-05
55			4	12	2.4	0	0	517	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.23489E-05	1.51213E-05	0	0	1.7445E-05	1.51213E-05	0	3.257E-05

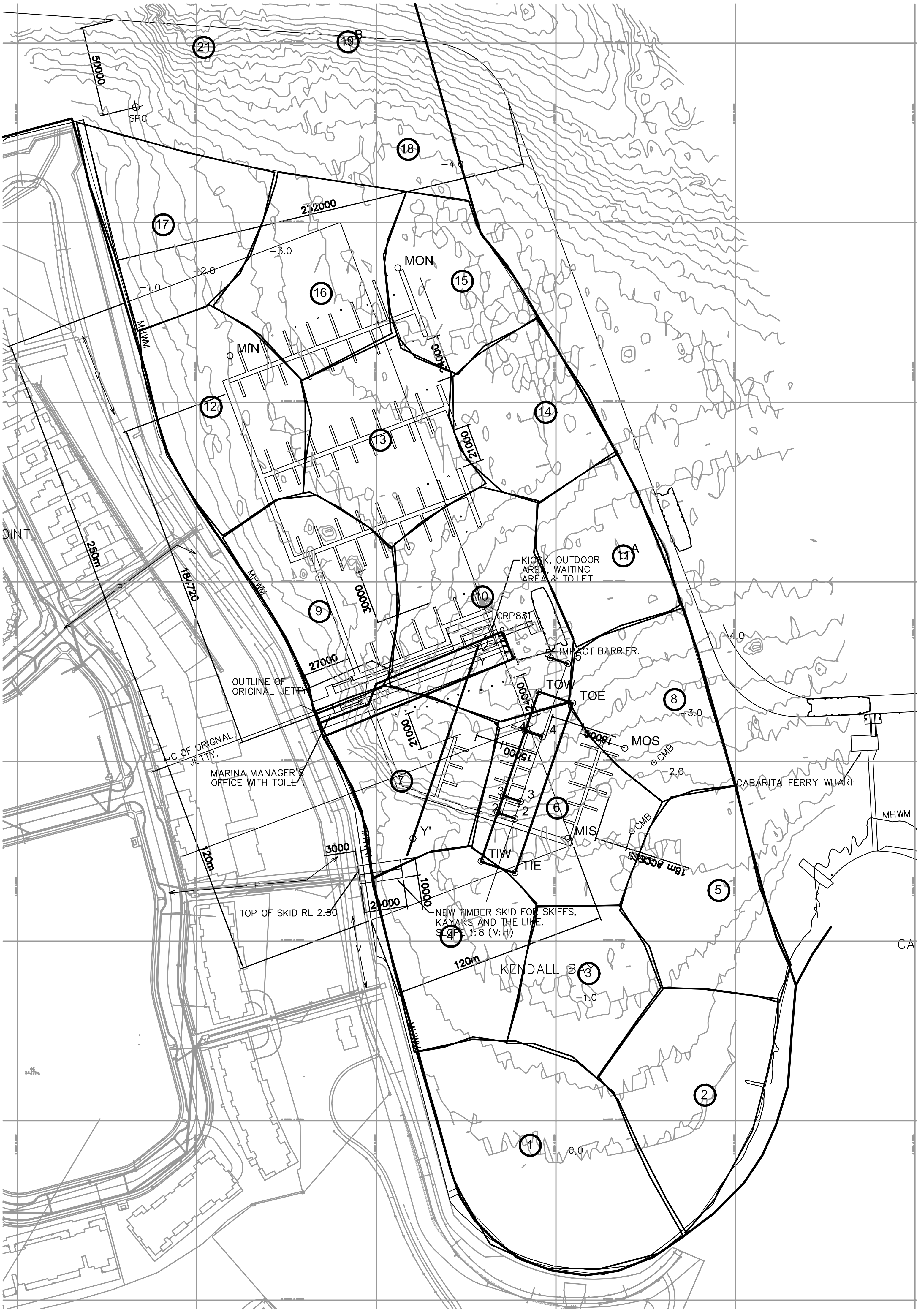
						s (each)					Area Remed Site affected by Marina	127912	m2		Area Remed Site affected by Marina	127912	m2													
						m/s					Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Contribution from being underway to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Total contribution to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				
						a when g (m2)	Bed Disturbance Area per return trip excluding area when starting and stopping (m2)				Turbidity allowance from full thrust astern				Turbidity allowance from full thrust ahead				Turbidity allowance from constant 4 knots				Turbidity allowance from constant 4 knots				TOTAL TURBIDITY
	Berth Code						Water depths				Water depths				Water depths				Water depths				Water depths				
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	(NTU)
			Mean tide water depth																								0.043631511
56			5	12	2.5	0	0	446	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.0353E-05	1.51213E-05	0	0	1.54491E-05	1.51213E-05	0	3.057E-05
57			6	12	2.5	0	0	376	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	8.45601E-06	1.51213E-05	0	0	1.35521E-05	1.51213E-05	0	2.867E-05
58			7	12	2.6	0	0	306	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	6.65798E-06	1.51213E-05	0	0	1.17541E-05	1.51213E-05	0	2.688E-05
59			8	12	2.6	0	0	235	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	4.95891E-06	1.51213E-05	0	0	1.0055E-05	1.51213E-05	0	2.518E-05
60			9	12	2.6	0	0	165	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	3.35879E-06	1.51213E-05	0	0	8.45489E-06	1.51213E-05	0	2.358E-05
61			10	12	2.7	0	0	94	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.85762E-06	1.51213E-05	0	0	6.95372E-06	1.51213E-05	0	2.208E-05
62			11	12	2.7	0	0	24	1056	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	4.5541E-07	1.51213E-05	0	0	5.55151E-06	1.51213E-05	0	2.067E-05
63			12	12	2.8	0	0	0	1016	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	1.47717E-05	0	0	0	1.8002E-05	0	1.800E-05
64			13	12	2.8	0	0	0	954	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	1.35826E-05	0	0	0	1.68129E-05	0	1.681E-05
65			14	12	2.8	0	0	0	954	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	1.35826E-05	0	0	0	1.68129E-05	0	1.681E-05
66			15	12	2.9	0	0	0	910	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	1.27565E-05	0	0	0	1.59868E-05	0	1.599E-05
67			16	12	2.9	0	0	0	840	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	1.14749E-05	0	0	0	1.47052E-05	0	1.471E-05
68			17	12	3.0	0	0	0	770	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	1.02427E-05	0	0	0	1.3473E-05	0	1.347E-05
69			18	12	3.0	0	0	0	690	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	8.91571E-06	0	0	0	1.2146E-05	0	1.215E-05
70			19	12	3.0	0	0	0	611	0	0	0	6.4606E-07	0	0	0	2.5842E-06	0	0	0	7.65131E-06	0	0	0	1.08816E-05	0	1.088E-05
71	C	O	1	12	2.0	0	0	860	1038	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	2.34961E-05	1.47781E-05	0	0	2.85922E-05	1.47781E-05	0	4.337E-05
72			2	12	2.1	0	0	807	1038	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	2.16281E-05	1.47781E-05	0	0	2.67242E-05	1.47781E-05	0	4.150E-05
73			3	12	2.2	0	0	754	1038	0	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.98158E-05	1.47781E-05	0	0	2.49119E-05	1.47781E-05	0	3.969E-05
74			4	14	2.2	0	0	701	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	6.77208E-05	9.21393E-06	0	0	8.2078E-05	9.21393E-06	0	9.129E-05
75			5	14	2.3	0	0	648	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	6.19214E-05	9.21393E-06	0	0	7.62786E-05	9.21393E-06	0	8.549E-05
76			6	14	2.3	0	0	585	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	5.52888E-05	9.21393E-06	0	0	6.9646E-05	9.21393E-06	0	7.886E-05
77			7	14	2.4	0	0	532	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	4.97181E-05	9.21393E-06	0	0	6.40753E-05	9.21393E-06	0	7.329E-05
78			8	14	2.5	0	0	461	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	4.24546E-05	9.21393E-06	0	0	5.68118E-05	9.21393E-06	0	6.603E-05
79			9	14	2.5	0	0	407	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	3.71302E-05	9.21393E-06	0	0	5.14874E-05	9.21393E-06	0	6.070E-05
80			10	14	2.6	0	0	336	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	3.01951E-05	9.21393E-06	0	0	4.45523E-05	9.21393E-06	0	5.377E-05
81			11	14	2.6	0	0	292	1050	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	2.5956E-05	9.21393E-06	0	0	4.03132E-05	9.21393E-06	0	4.953E-05
82			12	14	2.7	0	0	114	1113	0	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	9.73245E-06	1.00171E-05	0	0	2.40897E-05	1.00171E-05	0	3.411E-05
83			13	14	2.7	0	0	0	975	0	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	8.58276E-06	0	0	0	1.25464E-05	0	1.255E-05
84			14	14	2.8	0	0	0	921	0	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	7.93041E-06	0	0	0	1.18941E-05	0	1.189E-05
85			15	14	2.8	0	0	0	868	0	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	7.29917E-06	0	0	0	1.12628E-05	0	1.126E-05
86			16	14	2.9	0	0	0	806	0	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	6.58941E-06	0	0	0	1.05531E-05	0	1.055E-05
87			17	14	2.9	0	0	0	752	0	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	6.00391E-06	0	0	0	9.96757E-06	0	9.968E-06
88	C	T	1	25	3.0	0	0	0	1660	0	0	0	0.00058561	0	0	0	0.00163325	0	0	0	0.000361949	0	0	0	0.002580803	0	2.581E-03
89	C	I	1	14	1.9	0	0	407	409	846	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	3.71302E-05	2.6208E-06	0	0	5.14874E-05	2.6208E-06	0	5.411E-05
90			2	14	2.0	0	0	363	409	846	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	3.27738E-05	2.6208E-06	0	0	4.7131E-05	2.6208E-06	0	4.975E-05
91			3	16	2.1	0	0	434	580	1197	0	9.4817E-05	0	0	0	0.00018869	0	0	0	7.41259E-05	2.35646E-05	0	0	0.000357637	2.35646E-05	0	3.812E-04
92			4	16	2.2	0	0	345	580	1197	0	9.4817E-05	0	0	0	0.00018869	0	0	0	5.83043E-05	2.35646E-05	0	0	0.000341815	2.35646E-05	0	3.654E-04
93			5	18	2.3	0	0	268	603	1245	0	0.00031139	0	0	0	0.00077558	0	0	0	7.59847E-05	4.32926E-05	8.0083E-06	0	0.001162954	4.32926E-05	8.0083E-06	1.214E-03
94			6	18	2.4	0	0	190	603	1245	0	0.00031139	0	0	0	0.00077558	0	0	0	5.32166E-05	4.32926E-05	8.0083E-06	0	0.001140186	4.32926E-05	8.0083E-06	1.191E-03
95			7	18	2.5	0	0	85	603	1245	0	0.00031139	0	0	0	0.00077558	0	0	0	2.35035E-05	4.32926E-05	8.0083E-06	0	0.001110473	4.32926E-05	8.0083E-06	1.162E-03
96			8	18	2.5	0	0	6	603	1245	0	0.00031139	0	0	0	0.00077558	0	0	0	1.70208E-06	4.32926E-05	8.0083E-06	0	0.001088672	4.32926E-05	8.0083E-06	1.140E-03
97			9	18	2.6	0	0	0	497	1245	0	0	0.00013961	0	0	0	0.00026896	0	0	0	3.57132E-05	8.0083E-06	0	0	0.000444288	8.0083E-06	4.523E-04
98			10	18	2.7	0	0	0	419	1245	0	0	0.00013961	0	0	0	0.00026896	0	0	0	2.94046E-05	8.0083E-06	0	0	0.000437979	8.0083E-06	4.460E-04
99			11	18	2.8	0	0	0	340	1245	0	0	0.00013961	0	0	0	0.00026896	0	0	0	2.33445E-05	8.0083E-06	0	0	0.000431919	8.0083E-06	4.399E-04
100			12	18	2.9	0	0	0	261	1245	0	0	0.00013961	0	0	0	0.00026896	0	0	0	1.7533E-05	8.0083E-06	0	0	0.000426107	8.0083E-06	4.341E-04
101			13	25	3.0	0	0	0	351	1615	0	0	0.00058561	0	0	0	0.00163325	0	0	0	6.46611E-05	2.8659E-05	0	0	0.002283515	2.8659E-05	2.312E-03
102			14	25	3.2	0	0	0	232	1615	0	0	0.00058561	0	0	0	0.00163325	0	0	0	4.20256E-05	2.8659E-05	0	0	0.002260879	2.8659E-05	2.290E-03
103	D	O	1	14	2.2	0	45	363	409	846	0.00033964	7.1786E-06	0	0	0.00033964	7.1786E-06	0	0	0.000121579	3.27738E-05	2.6208E-06	0	0.00080086	4.7131E-05	2.6208E-06	0	8.506E-04
104			2	14	2.5	0	-18	363	409	846	0.00033964	7.1786E-06	0	0	0.00033964	7.1786E-06	0	0	-4.8413E-05	3.27738E-05	2.6208E-06	0	0.00063087	4.7131E-05	2.6208E-06	0	6.806E-04
105			3	16	2.7	0	0	484	580	1197	0	9.4817E-05	0	0	0	0.00018869	0	0	0	8.33373E-05	2.35646E-05	0	0	0.000366848	2.35646E-05	0	3.904E-04
106			4	16	2.9	0	0	408	580	1197	0	9.4817E-05	0	0	0	0.00018869	0	0	0	6.95667E-05	2.35646E-05	0	0	0.000353078	2.35646E-05	0	3.766E-04
107			5	18	3.0	0	0	347	603	1245	0	0.00031139	0	0	0	0.00077558	0	0	0	9.91671E-05	4.32926E-05	8.0083E-06	0	0.001186137	4.32926E-05	8.0083E-06	1.237E-03
108			6	18	3.2	0	0	268	603	1245	0	0.00031139	0	0	0	0.00077558	0	0	0	7.59847E-05	4.32926E-05	8.0083E-06	0	0.001162954	4.32926E-05	8.0083E-06	1.214E-03
109			7	20	3.3	0	0	198	626	1292	0	0.0009595	0	0	0	0.00239278	0	0	0	0.000128804	6.89838E-05	2.8319E-05	0	0.00348108	6.89838E-05	2.8319E-05	3.578E-03
110			8	20	3.4	0	0	116	626	1292	0	0.0009595	0	0	0	0.00239278	0	0	0	7.50021E-05	6.89838E-05	2.8319E-05	0	0.003427278	6.89838E-05	2.8319E-05	3.525E-03

						s (each) / m/s / a when g (m2)	Bed Disturbance Area per return trip excluding area when starting and stopping (m2)				Area Remed Site affected by Marina 127912 m2 — Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU) — Turbidity allowance from full thrust astern				Area Remed Site affected by Marina 127912 m2 — Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU) — Turbidity allowance from full thrust ahead				Contribution from being underway to increased turbidity above BG affecting the Remed Site per return trip per day (NTU) — Turbidity allowance from constant 4 knots				Total contribution to increased turbidity above BG affecting the Remed Site per return trip per day (NTU) — Turbidity allowance from constant 4 knots				TOTAL TURBIDITY
Berth Code							Water depths				Water depths				Water depths				Water depths				Water depths				
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	(NTU)
			Mean tide water depth																								0.043631511
111			9	14	3.5	0	0	7	409	846	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	5.61272E-07	2.6208E-06	0	0	1.49185E-05	2.6208E-06	0	1.754E-05
112			10	14	3.7	0	0	-38	409	846	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	-3.1354E-06	2.6208E-06	0	0	1.12218E-05	2.6208E-06	0	1.384E-05
113			11	14	3.9	0	0	-38	356	846	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	-3.1354E-06	2.20859E-06	0	0	1.12218E-05	2.20859E-06	0	1.343E-05
114			12	14	4.0	0	0	-38	294	846	0	7.1786E-06	0	0	0	7.1786E-06	0	0	0	-3.1354E-06	1.75436E-06	0	0	1.12218E-05	1.75436E-06	0	1.298E-05
115			13	14	4.2	0	0	0	147	846	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	8.43603E-07	0	0	0	4.80727E-06	0	4.807E-06
116	D	I	1	12	3.0	0	0	112	334	1320	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	2.22364E-06	3.58397E-06	0	0	7.31973E-06	3.58397E-06	0	1.090E-05
117			2	12	3.3	0	0	33	334	1320	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	6.25275E-07	3.58397E-06	0	0	5.72137E-06	3.58397E-06	0	9.305E-06
118			3	12	3.5	0	0	-20	334	1320	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	-3.7072E-07	3.58397E-06	0	0	4.72537E-06	3.58397E-06	0	8.309E-06
119			4	14	3.7	0	0	0	245	1335	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	1.49452E-06	0	0	0	5.45819E-06	0	5.458E-06
120			5	14	3.9	0	0	0	191	1335	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	1.13068E-06	0	0	0	5.09434E-06	0	5.094E-06
121			6	14	4.0	0	0	0	138	1335	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	7.87947E-07	0	0	0	4.75161E-06	0	4.752E-06
122			7	14	4.3	0	0	0	85	1335	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	4.66323E-07	0	0	0	4.42999E-06	0	4.430E-06
123			8	14	4.5	0	0	0	31	1335	0	0	1.5686E-06	0	0	0	2.3951E-06	0	0	0	1.6581E-07	0	0	0	4.12947E-06	0	4.129E-06
124			9	16	4.7	0	0	0	-65	1928	0	0	5.9414E-05	0	0	0	9.4131E-05	0	0	0	-2.1582E-06	0	0	0	0.000151387	0	1.514E-04
125			10	16	4.8	0	0	0	0	1877	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000E+00
126			11	16	4.9	0	0	0	0	1789	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000E+00
127			12	16	5.0	0	0	0	0	1701	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.000E+00
128	E	O	1	12	3.3	0	0	112	308	1320	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	2.22364E-06	3.26043E-06	0	0	7.31973E-06	3.26043E-06	0	1.058E-05
129			2	12	3.2	0	0	156	308	1320	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	3.16573E-06	3.26043E-06	0	0	8.26183E-06	3.26043E-06	0	1.152E-05
130			3	12	2.5	0	0	156	308	1320	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	3.16573E-06	3.26043E-06	0	0	8.26183E-06	3.26043E-06	0	1.152E-05
131			4	10	3.0	0	0	111	305	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	5.97001E-07	1.84576E-06	0	0	3.61353E-06	1.84576E-06	0	5.459E-06
132			5	10	3.7	0	0	41	305	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	2.06599E-07	1.84576E-06	0	0	3.22313E-06	1.84576E-06	0	5.069E-06
133	E	I	1	8	2.7	0	0	152	258	1290	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	5.79524E-07	0	0	0	2.14717E-06	0	0	2.147E-06
134			2	8	3.2	0	0	109	258	1290	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	3.9164E-07	0	0	0	1.95929E-06	0	0	1.959E-06
135			3	10	3.5	0	0	50	261	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	2.52725E-07	1.52475E-06	0	0	3.26926E-06	1.52475E-06	0	4.794E-06
136			4	10	3.7	0	0	6	261	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	2.97413E-08	1.52475E-06	0	0	3.04627E-06	1.52475E-06	0	4.571E-06
137			5	10	3.9	0	0	-46	261	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	-2.1262E-07	1.52475E-06	0	0	2.80392E-06	1.52475E-06	0	4.329E-06
138			6	10	4.0	0	0	0	151	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	8.64524E-07	0	0	0	1.65785E-06	0	1.658E-06
139			7	10	4.2	0	0	0	91	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	4.88947E-07	0	0	0	1.28227E-06	0	1.282E-06
140	F	O	1	8	2.3	0	0	195	258	1290	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	7.86294E-07	0	0	0	2.35394E-06	0	0	2.354E-06
141			2	8	3.0	0	0	152	258	1290	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	5.79524E-07	0	0	0	2.14717E-06	0	0	2.147E-06
142			3	10	3.3	0	0	111	261	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	5.97001E-07	1.52475E-06	0	0	3.61353E-06	1.52475E-06	0	5.138E-06
143			4	10	3.5	0	0	67	261	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	3.47268E-07	1.52475E-06	0	0	3.3638E-06	1.52475E-06	0	4.889E-06
144			5	10	3.7	0	0	24	261	1305	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	1.16642E-07	1.52475E-06	0	0	3.13317E-06	1.52475E-06	0	4.658E-06
145			6	10	3.9	0	0	0	143	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	8.08577E-07	0	0	0	1.6019E-06	0	1.602E-06
146			7	10	4.0	0	0	0	99	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	5.40308E-07	0	0	0	1.33363E-06	0	1.334E-06
147			8	10	4.2	0	0	0	47	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	2.43606E-07	0	0	0	1.03693E-06	0	1.037E-06
148			9	10	4.3	0	0	0	-5	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	-2.5582E-08	0	0	0	7.67743E-07	0	7.677E-07
149			10	10	4.4	0	0	0	-57	1331	0	0	0	0	0	0	7.9332E-07	0	0	0	-2.6725E-07	0	0	0	5.26069E-07	0	5.261E-07
150	F	T	1	10	4.3	0	0	0	-57	1305	0	0	0	0	0	0	7.9332E-07	0	0	0	-2.6725E-07	0	0	0	5.26069E-07	0	5.261E-07
151	F	I	1	8	2.0	0	0	496	344	1032	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	2.76254E-06	0	0	0	4.33019E-06	0	0	4.330E-06
152			2	8	2.5	0	0	453	344	1032	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	2.42356E-06	0	0	0	3.9912E-06	0	0	3.991E-06
153			3	10	3.0	0	0	415	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	2.88014E-06	2.18586E-06	0	0	5.89667E-06	2.18586E-06	0	8.083E-06
154			4	10	3.2	0	0	372	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	2.49665E-06	2.18586E-06	0	0	5.51318E-06	2.18586E-06	0	7.699E-06
155			5	10	3.4	0	0	328	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	2.13228E-06	2.18586E-06	0	0	5.14881E-06	2.18586E-06	0	7.335E-06
156			6	10	3.6	0	0	285	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	1.78701E-06	2.18586E-06	0	0	4.80354E-06	2.18586E-06	0	6.989E-06
157			7	10	3.7	0	0	232	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	1.3979E-06	2.18586E-06	0	0	4.41444E-06	2.18586E-06	0	6.600E-06
158			8	10	3.9	0	0	189	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	1.09467E-06	2.18586E-06	0	0	4.1112E-06	2.18586E-06	0	6.297E-06
159			9	10	4.0	0	0	137	348	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	7.56013E-07	2.18586E-06	0	0	3.77254E-06	2.18586E-06	0	5.958E-06
160			10	10	4.2	0	0	-20	461	1044	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	-9.4877E-08	3.15957E-06	0	0	2.92166E-06	3.15957E-06	0	6.081E-06
161	G	O	1	8	1.6	0	0	539	344	1032	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	3.12041E-06	0	0	0	4.68806E-06	0	0	4.688E-06
162			2	8	1.8	0	0	496	344	1032	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	2.76254E-06	0	0	0	4.33019E-06	0	0	4.330E-06
163			3	8	1.9	0	0	453	344	1032	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	2.42356E-06	0	0	0	3.9912E-06	0	0	3.991E-06
164			4	8	2.0	0	0	410	344	1032	0	9.4059E-07	0	0	0	6.2706E-07	0	0	0	2.10346E-06	0	0	0	3.67111E-06	0	0	3.671E-06
165			5	12	2.3	0	0	376	352	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	8.45601E-06	3.80352E-06	0	0	1.35521E-05	3.80352E-06	0	1.736E-05

TABLE H

						s (each)					Area Remed Site affected by Marina	127912	m2		Area Remed Site affected by Marina	127912	m2										
						m/s					Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Contribution from starting and stopping to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Contribution from being underway to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				Total contribution to increased turbidity above BG affecting the Remed Site per return trip per day (NTU)				
						a when g (m2)	Bed Disturbance Area per return trip excluding area when starting and stopping (m2)				Turbidity allowance from full thrust astern				Turbidity allowance from full thrust ahead				Turbidity allowance from constant 4 knots				Turbidity allowance from constant 4 knots				TOTAL TURBIDITY
	Berth Code						Water depths				Water depths				Water depths				Water depths				Water depths				
Berth No	Arm	Inner / Outer / T-head	No	Length (m)	Berth Bed RL (-ve m)	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	2	3	4	5	(NTU)
			Mean tide water depth																								0.043631511
166			6	12	2.5	0	0	332	352	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	7.32065E-06	3.80352E-06	0	0	1.24167E-05	3.80352E-06	0	1.622E-05
167			7	12	2.7	0	0	279	352	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	6.00924E-06	3.80352E-06	0	0	1.11053E-05	3.80352E-06	0	1.491E-05
168			8	12	2.9	0	0	235	352	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	4.95891E-06	3.80352E-06	0	0	1.0055E-05	3.80352E-06	0	1.386E-05
169			9	12	3.0	0	0	182	352	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	3.74954E-06	3.80352E-06	0	0	8.84564E-06	3.80352E-06	0	1.265E-05
170			10	12	3.2	0	0	24	466	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	4.5541E-07	5.30599E-06	0	0	5.55151E-06	5.30599E-06	0	1.086E-05
171			11	12	3.3	0	0	-20	466	1056	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	-3.7072E-07	5.30599E-06	0	0	4.72537E-06	5.30599E-06	0	1.003E-05
172	G	I	1	8	2.0	0	0	711	284	817	4.0854E-06	9.4059E-07	0	0	4.0854E-06	6.2706E-07	0	0	0	4.74077E-06	0	0	8.1708E-06	6.30842E-06	0	0	1.448E-05
173			2	10	2.0	0	0	720	287	827	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	6.09952E-06	1.71506E-06	0	0	9.11606E-06	1.71506E-06	0	1.083E-05
174			3	10	2.0	0	0	676	287	827	0	1.8099E-06	0	0	0	1.2066E-06	0	0	0	5.58229E-06	1.71506E-06	0	0	8.59882E-06	1.71506E-06	0	1.031E-05
175			4	12	2.2	0	0	640	290	836	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.60799E-05	3.04861E-06	0	0	2.1176E-05	3.04861E-06	0	2.422E-05
176			5	12	2.3	0	0	596	290	836	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.47126E-05	3.04861E-06	0	0	1.98087E-05	3.04861E-06	0	2.286E-05
177			6	12	2.5	0	0	552	290	836	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.3384E-05	3.04861E-06	0	0	1.84801E-05	3.04861E-06	0	2.153E-05
178			7	12	2.6	0	0	508	290	836	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.2094E-05	3.04861E-06	0	0	1.71901E-05	3.04861E-06	0	2.024E-05
179			8	12	2.8	0	0	464	290	836	0	3.6483E-06	0	0	0	1.4478E-06	0	0	0	1.08427E-05	3.04861E-06	0	0	1.59388E-05	3.04861E-06	0	1.899E-05

TABLE H



KIOSK, OUTDOOR AREA, WAITING AREA & TOILET.
CRP831
IMPACT BARRIER.
OUTLINE OF ORIGINAL JETTY
C OF ORIGNAL JETTY.
MARINA MANAGER'S OFFICE WITH TOILET.
TOP OF SKID RL 2.50
NEW TIMBER SKID FOR SKIFFS, KAYAKS AND THE LIKE. SLOPE 1:8 (V:H)
KENDALL BAY
CABARITA FERRY WHARF
MHWM
MON
MIN
MOS
MIS
TOW
TOE
TIW
TIE
CMB
SPC
250m
120m
18m ACCESS
232000
50000
184720
30000
27000
24000
21000
15000
10000
3000

3.3.1.8 Secondary waves

Secondary waves combine to form interference peaks; the wave height of the peaks at the revetment can be taken as,

$$H_I = h\left(\frac{s}{h}\right)^{-0,33} F_h^{\,4} \qquad (23)$$

where s = distance across the water surface from the ship's side to the revetment.

The wave length can be found from, $L_{wl} = 0,67 \cdot 2\pi \cdot \frac{V_s^2}{g}$ (24)

for the range

$$6,5 < h < 8,5$$

$$F_h < 0,7$$

The direction of propagation can be taken as 55 °C normal to the revetment. Secondary waves induced by pushtows and coaster are not usually a determinant load [3] [51].

3.3.1.9 Screw race

An indication of bottom velocities [50] due to the action of the propeller can be obtained with,

$$u_b = \alpha_2 \, u_o \frac{D_o}{z_b} \qquad (25)$$

where u_b = velocity at bed
α_2 = coefficient
u_o = the axial efflux velocity = $1,15\left(\frac{P_D}{D_o^2}\right)^{0,33}$ (26)

z_b = vertical distance from propeller axis to bed of fairway.

and,
D_o = initial diameter of slipstream behind propeller
= D_p (for ships with a propeller in a nozzle)
= 0.7 D_p (for ships without a nozzle)
where D_p = diameter of the propeller
and, P_D = installed engine power in kW

The coefficient α_2 varies between 0.25 and 0.75 depending on the ship type and the rudder configuration.

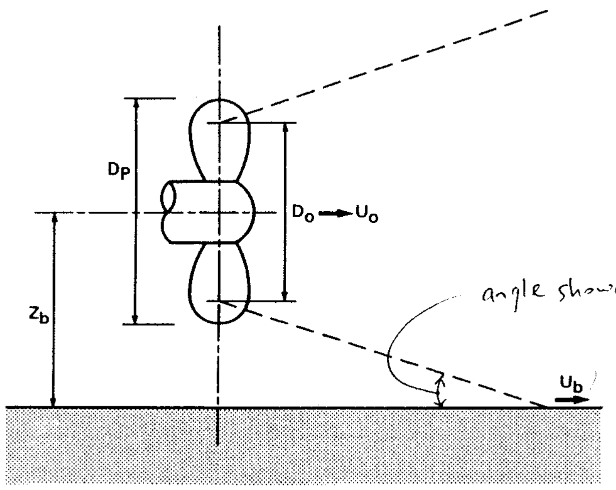


FIG. 3.17 : Velocity behind a propeller

APPENDIX D

GBAC RESPONSE TO DECC LETTER TO ROSE PROPERTY GROUP DATED 25/8/09

APPENDIX D - GBAC RESPONSE TO DECC LETTER TO ROSE PROPERTY GROUP DATED 25/8/09

DECC provided comments on draft submissions outlining the proposed marina development, including GBAC's Issue 1 draft report dated 9/7/09. A copy of DECC's letter is attached.

GBAC responds below to relevant comments.

1. DECC comments that flood tide data and river based catchment flood events have not been considered in the estimation of water velocities.

The velocities in question are addressed in **Section 5.4.1**. Given that these velocities are an order of magnitude less than the propeller wash velocities, in and of themselves tidal currents and freshwater flows are irrelevant to the post-development current field and the stability of the bed. The propeller wash velocities control the blanket design.

2. DECC notes that the propeller bed velocities have been determined under low tide conditions. DECC considers that the water levels adopted should be based on low *(or depressed)* water conditions, which would account for both atmospheric and tidal influences *(noting that mean water depressions of 0.4 m may occur due to combinations of oceanic events and synoptic conditions)*. DECC says that this would allow for an estimation of propeller bed velocities at minimum water depths.

The propeller wash velocities presented in the report are calculated for a water level of RL-0.725m AHD. Based on tide gauge records in Sydney Harbour, this water level is exceeded 98% of the time. *(The water level difference between Fort Denison and the site is small as evidenced by minor variations in predicted tidal planes between the two locations).* GBAC considers RL-0.725 m AHD to be a reasonable low water level selection for blanket design. GBAC notes that mean water level depressions attributed to combinations of oceanic and synoptic conditions are already accounted for in the adopted water level exceedence parameter.

3. DECC comments on the summaries presented in the report of the URS investigations and the investigations by AECOM and Cardno Ecology Lab (Section 5.5.1, Physical Bed Sediment Type and Distribution). DECC writes that the gbaCOASTAL report also indicates that there is some disagreement between the grainsize analysis or previous sediment investigations conducted by URS and AECOM/Cardno Ecology Lab.

GBAC does not concur with the assessment of DECC that there is disagreement. Data from AECOM and Cardno Ecology Lab shows that some 80 to 90% of the marina footprint is covered by mud sized material which is in line with URS result.

4. DECC raises a concern that the migration of fine sediments through the geotextile appears to defy the purpose of the blanket (Section 5.5.2).

In addressing this comment, GBAC has reviewed and amended **Section 5.5.2**, **Construction**. **Appendix E** has been added.

We would also direct the reader to the discussion on long-term migration flux in **Section 5.5.2**, **Marina Operation Phase**, **Influence of Propeller Wash at Bed and Mitigation Measures**, **Geotextile**, **Retention**, which concludes as follows with respect to the sediments under the blanket:

"Given that these predicted velocities of 0.1 to 0.2 m/s are less than the nominal threshold velocity of 0.3 m/s adopted for the site, the filtration design would be expected to account for the hydraulic gradients attributed to the propeller wash and thereby contain the underlying sediments. It should be noted that the predicted velocities under the geotextile are comparable if not slightly lower than the exiting tidal and wind induced currents expected in Kendall Bay".

The long-term migration flux of fine sediments through the geotextile is assessed to be small and less than that which exists today with no blanket.

Our reference: DOC09/39351
Contact: Matthew Hart, (02) 9995 5707

Mr Ray Kearns
Development Manager
Rose Property Group Pty Ltd
51 Riley Street
Woolloomooloo NSW 2011

Dear Mr Kearns

Proposed Inner West Marina, Kendall Bay

I am writing in relation to the proposed Inner West Marina at Kendall Bay on the Parramatta River. We have received and reviewed the following information outlining a proposal to install a blanket over contaminated sediments at Kendall Bay as part of the proposed marina development:

- AECOM (2009). *Construction Environmental Management Plan – Proposed Inner West Marina, Kendall Bay, Parramatta River, NSW* (draft report). 13 July;
- gbaCOASTAL (2009). *Estuary Hydrodynamics and Physical Sedimentary Environment – Inner West Marina, Kendall Bay, Sydney* (draft report). 9 July;
- TLB Engineers (2009). *Construction Management Plan – Inner West Marina Sydney* (draft report). 9 July; and
- TLB Engineers (2009). *Overview of Blanket Over Bed – Inner West Marina Sydney.* 9 July.

Please note that the Department of Environment, Climate Change and Water (DECCW) is currently regulating the sediments within 200 metres of the land boundary of Breakfast Point, including the area of the proposed marina. The regulation is by way of declaration and order under the *Contaminated Land Management Act 1997* (CLM Act). The order, issued to NSW Maritime as owner of the bed sediments, requires that the sediments are not disturbed unless approved by DECCW.

Previous investigations conducted at the site indicate that boating activities typical to those occurring at a marina caused the disturbance of the sediments and we understand that the purpose of the proposed blanket is to prevent such disturbance. In this context, our comments relating to the proposed blanket are provided at attachment 1. These comments and "identified further information that is required" are provided to assist you in facilitating any application to progress the proposal.

If you have any questions regarding the matters discussed in this letter please contact Matthew Hart on (02) 9995 5707.

Yours sincerely

25/8/2009

NIALL JOHNSTON
Manager Contaminated Sites
<u>Environment Protection and Regulation</u>

The Department of Environment and Climate Change is now known as the Department of Environment, Climate Change and Water

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Department of **Environment and Climate Change** NSW

Attachment 1

The blanket

We understand that the proposal includes the placement of geotextile in strips over an approximate area of 5.7 ha of bed sediment, covering the footprint of the proposed marina. A rock armour of basalt (approximate thickness 300mm) will be placed over the geotextile. As noted above, the footprint of the proposed marina lies wholly within the area currently regulated under the CLM Act.

The manufacturer of the geotextile claims that the material is resistant to degradation by biological processes and hydrocarbon contaminants, and that the material has a design life of greater than 100 years. However, no information has been provided by the proponent to demonstrate that this is the case. **Relevant information must be provided.**

Placement of the blanket and piles

The gbaCOASTAL report notes that the upper 100mm of very soft sediments would probably be disturbed during placement of the geotextile and that fine sediments could be expected to migrate through the geotextile once in place. This is of concern as it appears to defy the purpose of the blanket. Furthermore, low density material that passes through the geotextile may potentially be disturbed at low bed velocities caused by propeller movement during the operation of the marina.

The gbaCOASTAL report also indicates that there is some disagreement between the grainsize analysis of previous sediment investigations conducted by URS and AECOM/Cardno Ecology Lab. The URS results, as reported in the gbaCOASTAL report, indicate that the majority of sediment samples are dominated by the mud fraction, whilst the AECOM/Cardno results indicate that median grainsize ranges from sand to silt. The grainsize of the sediments is expected to have some bearing on the amount of material that passes through the geotextile, **therefore further consideration or clarification of the grainsize analytical results is required.**

We are concerned about the potential differential settlement of sediments during the placement of the strips of geotextile and rock armour. Care must be taken to ensure sufficient overlap of the geotextile, particularly during the placement of the rock armour on each strip of geotextile. If the marina is approved, we expect the blanket placement works to be completed by a highly experienced contractor. For example, the contractor will have to take account of the potential affect of tidal velocities on the blanket placement works.

Given the reported strength of the geotextile, the proponent should give consideration to how they, or their contractor, will ensure that the pile blades pierce the geotextile and not push the geotextile into the soft sediments, potentially disturbing the sediments. A geotextile collar must be placed around each pile as soon as practicable to prevent the suspension of sediments.

Other issues that require consideration include:

- Whether the permeability of the geotextile is sufficient to allow for the migration of gas generated in the sediments to prevent the build up of gas beneath the blanket;

- How boating activity in the area, particularly the regular Rivercat movements, will impact the placement of the material and how this will be managed; and

- The source of the basalt rock armour and whether the use of the basalt will result in contamination (through leaching) or turbidity.

Environmental protection measures and monitoring

It is noted that protective measures have been proposed to capture disturbed product and/or sediments during the construction works, including the use of booms and silt curtains. These measures are unlikely to address any dissolved phase contamination that may be mobilised by the disturbance of the sediments. We understand that temporary piles will be installed to secure the booms and silt curtains, however it is not clear how the piles will be installed. **Further information on the pile installation methodology, including measures to minimise the disturbance of potentially contaminated sediments, is required.**

The proposed baseline water monitoring should be conducted over a period of at least two months prior to and during site establishment works (e.g. prior to temporary pile installation) and we recommend that this monitoring be conducted on a weekly basis.

Further information on the water monitoring activities (e.g. monitoring locations) that would be required during the proposed construction works is required. We consider that the proposed monitoring frequency of one week is insufficient during the blanket placement works given the likelihood of sediment disturbance during these works, and recommend that the monitoring be conducted on a daily basis (at least initially).

In the AECOM draft report, it is noted that the monitoring program will be decided in consultation with NSW Maritime. The proponent will need to ensure that the requirements (such as licensing requirements) of all relevant regulatory authorities are met throughout the proposed works.

Estuary hydrodynamics and water levels

We note that flood tide data and river-based catchment flood events have not been considered in the estimation of water velocities. It is anticipated that Kendall Bay would contain an eddy structure, however the influence of catchment flood events on the location of the interaction of the eddy structure with the flow of water via the main river channel has not been determined. We consider that river-based catchment flood events and the potential eddy need to be considered and compared against other factors that may influence the blanket, such as propeller velocities.

We note that propeller bed velocities have been determined under low tide conditions. We consider that the water levels adopted to estimate propeller velocities should be based on low (or depressed) water conditions, which would account for both atmospheric and tidal influences (noting that mean water depressions of 0.4 metres may occur due to combinations of oceanic events and synoptic conditions). This would allow for an estimation of propeller bed velocities at minimum water depths.

Consultation of the Department of Industry and Investment

Given the intensive boating activity in the marina (if approved) over the long term, it is possible that there will only be minimal or no recolonisation of the blanket area, resulting in almost 6 ha with minimal life. Consequently, the proponent will need to consult the Department of Industry and Investment (DII) (formerly the Department of Primary Industries) regarding the proposed use of the blanket and to determine whether a licence to cover the bed of the harbour is required from DII. The proponent may also need to provide an ecological survey to DII.

Ongoing maintenance of the blanket

We are concerned about the long-term maintenance of the blanket. Particular attention will need to be given to the edge of the blanket to ensure that it is not damaged or lifted by propeller wash or surface waves (in shallower water). Also, the operator of the marina must ensure that the use of anchors will not occur at the marina.

The movement of the piles has the potential to cause localised disturbance of sediments. Whilst we note that geotextile collars will be placed around the piles, the proponent needs to assess whether the piles will act as pathways for the migration of contaminants in the long term.

Certain diagrams of the proposed marina provided by the proponent indicate that a ferry docking area is included in the design. Ferry movements directly above the blanket may increase the likelihood of the sediments that pass through the pores of the blanket being disturbed. Given that there is a pre-existing ferry wharf on the opposite side of Kendall Bay, we consider that the proposed ferry docking area may not be warranted and we recommend that the necessity of the ferry docking area be reassessed.

In summary, there are a number of matters that need to be addressed before we could indicate whether the proposed use of the blanket is appropriate. Given significant uncertainties, the proponent should demonstrate that such a geotextile approach has been used before to prevent the disturbance of contaminated sediments. **This should include the provision of case studies to demonstrate that the geotextile is resistant to degradation by the type of contamination present in the Kendall Bay sediments.** The case studies should include situations where the geotextile has been used with a rock overburden to cover hydrocarbon-contaminated, fine-grained (i.e. muddy) sediments to minimise disturbance in an area subject to potential disturbance by watercraft movements or similar.

Please note that we have provided this attachment to both the Department of Planning and the proponent Rose property Group Pty Ltd.

APPENDIX E

CALCULATION TO ADDRESS DEGREE OF POTENTIAL DISTURBANCE OF THE BED DURING CONSTRUCTION OF THE BLANKET: BROAD COMPARISON WITH PRESENT DAY BED DISTURBANCE DUE TO PASSING FAST FERRIES

Job No	07-16
Job	Inner West Marina, Kendall Bay, Sydney
Date	9-10-09
Prepared by	GPS

gbaCOASTAL Pty Ltd
Consulting Engineers

Currents at the bed in Kendall Bay are attributed to boat waves, wind waves, and to a much lesser extent tidal currents etc.

Today water particle velocities at the bed within the proposed marina footprint are controlled by waves generated by fast ferries.

d (m)	Umax (m/s)	Occurrance
1.0	1.0	~ 68x/day
2.0	0.41	"
3.0	0.28	"

Table 5.6 GBAC (2009)

(3.0 / 0.28: no movement at bed expected)

∴ for $d \leq 2.8$ m $U_{max} \gtrsim 0.3$ m/s ← nominal critical velocity adopted by GBAC

≤ 2.1 m $\gtrsim 0.4$ m/s ← conservative critical velocity (to deliver a higher level of confidence to this assessment)

Consider SWL's of RL 0.5, 0.0 and −0.5 m AHD representing typical tidal levels

WL (m AHD)	WL (ZFDTG m)	% time WL is lower	Blanket area for d ≤ 2.8 m: Bed level (m AHD)	Area (m²)	Blanket area for d ≤ 2.1 m: Bed level (m AHD)	Area (m²)
0.5	1.425	82%	−2.3	3256	−1.6	265
0.0	0.925	50%	−2.8	8293	−2.1	2041
−0.5	0.425	10%	−3.3	19109	−2.6	6168

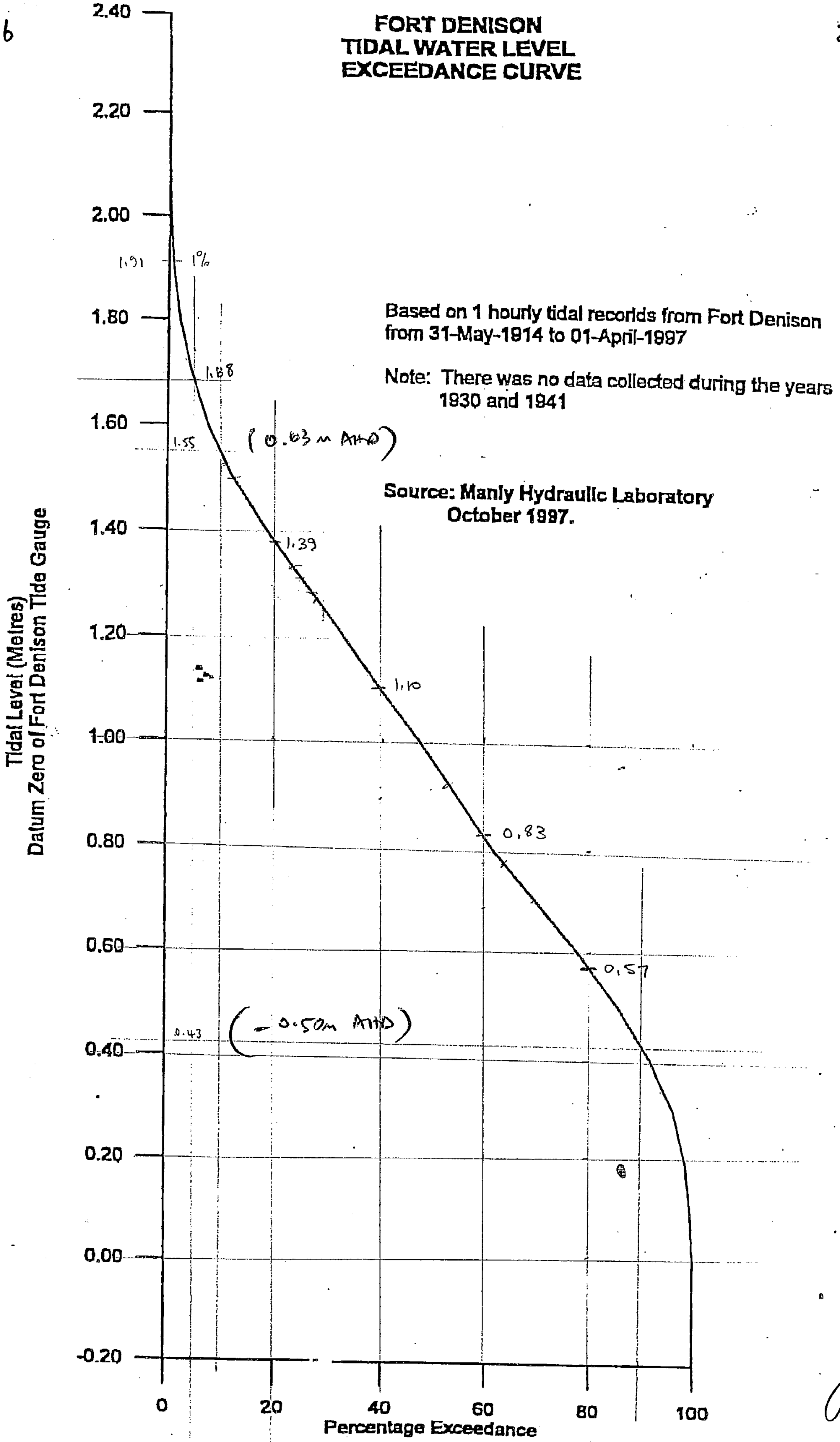
% time WL is lower: determined from long-term WL exceedance data for Fort Denison (p2)

Areas: measured in Autocad (see attached plans (p3 + p4))

eg. Every time a fast ferry passes at WL = RL 0 m AHD, 8293 m² within the footprint of the proposed blanket would be stirred by wave induced currents $\gtrsim$ 0.3 m/s

07-16

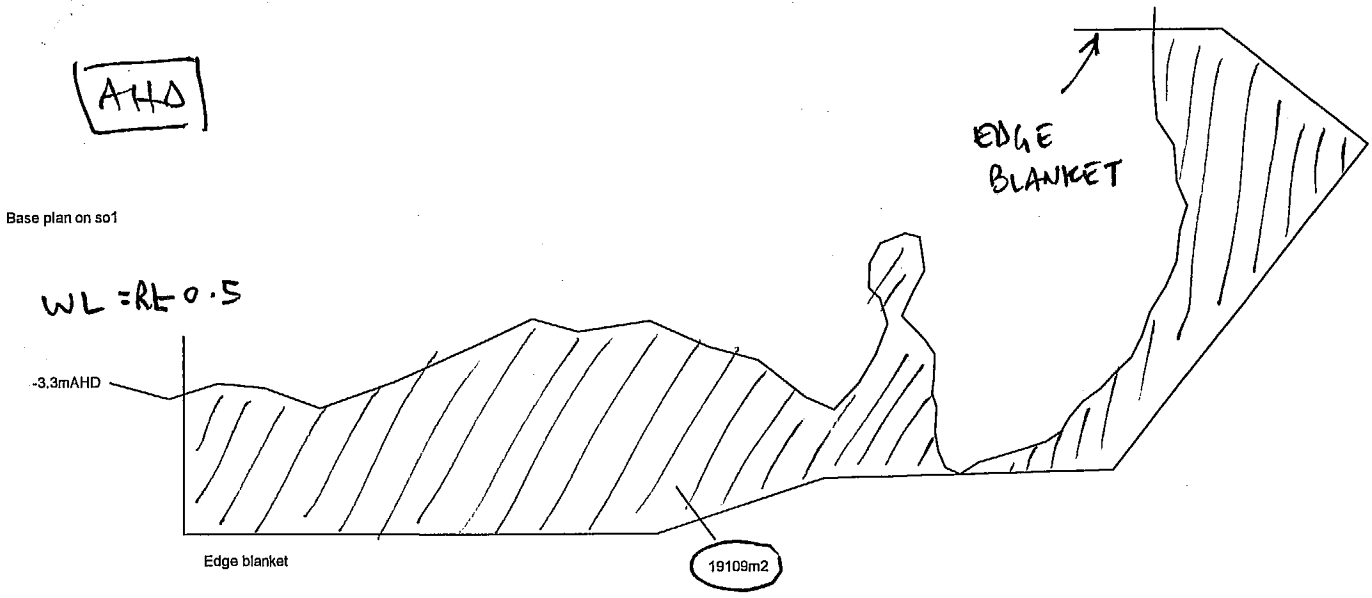
2 of 7



10/9/09

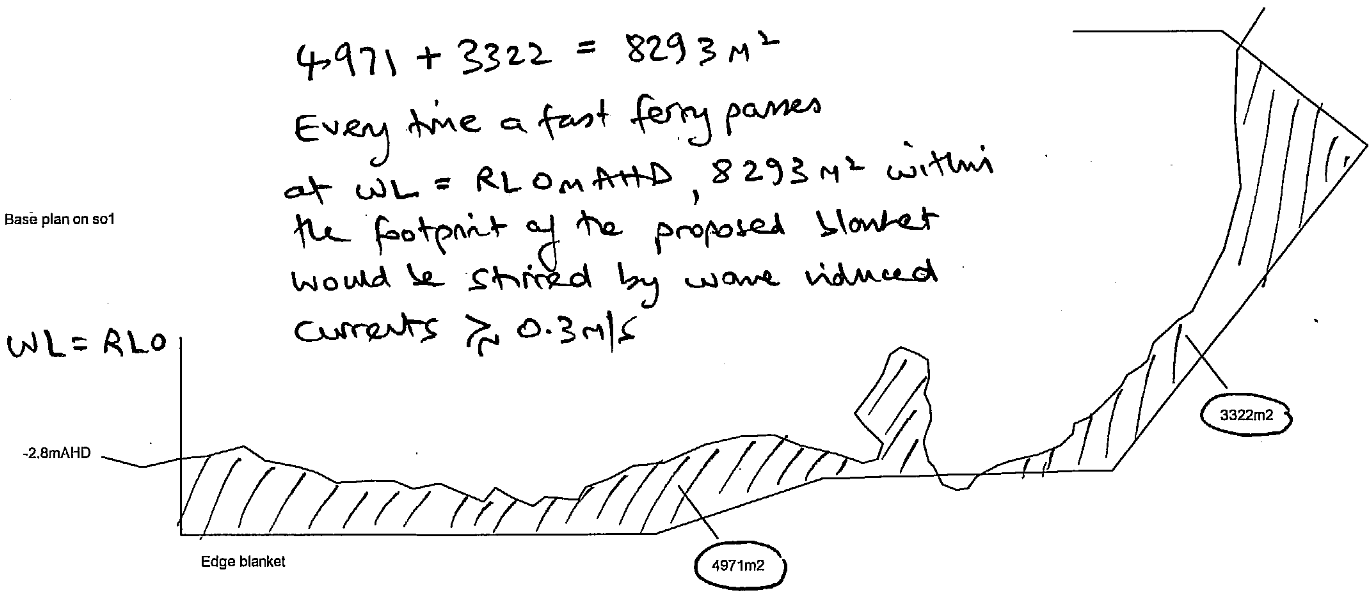
$d \leq 2.8m$ $u_{max} \geq 0.3m/s$

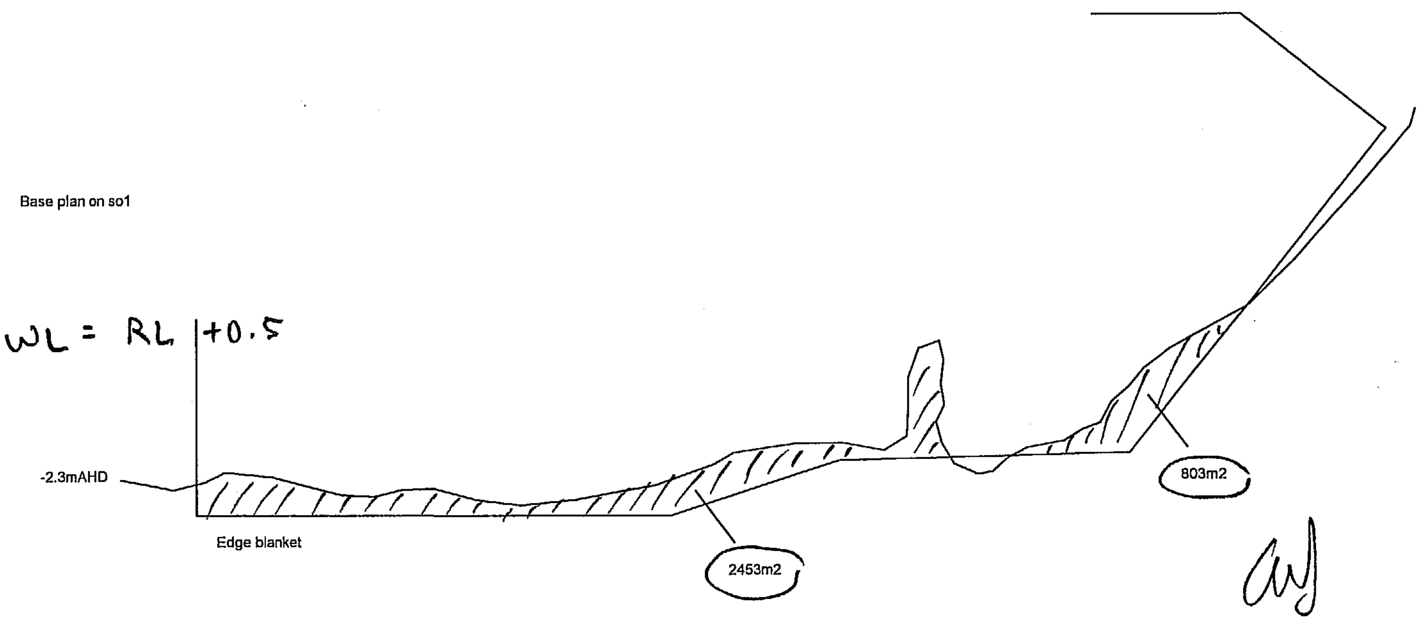
AHD



4971 + 3322 = 8293 m²

Every time a fast ferry passes at WL = RL 0m AHD, 8293 m² within the footprint of the proposed blanket would be stirred by wave induced currents ≥ 0.3m/s





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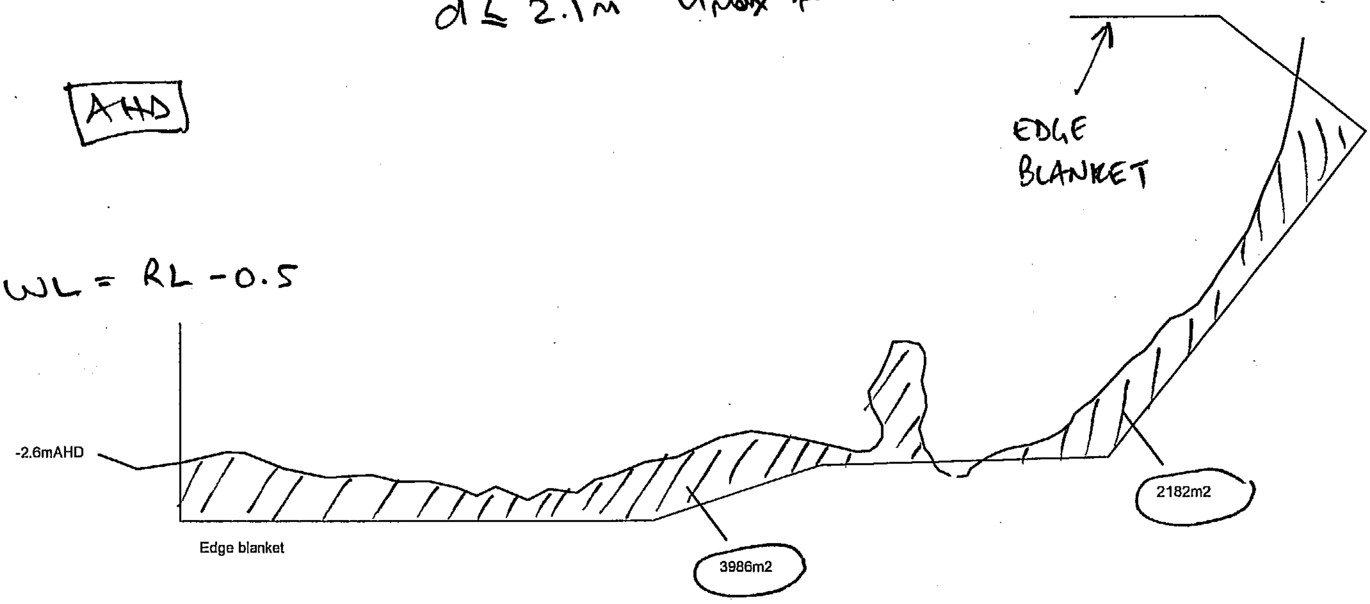
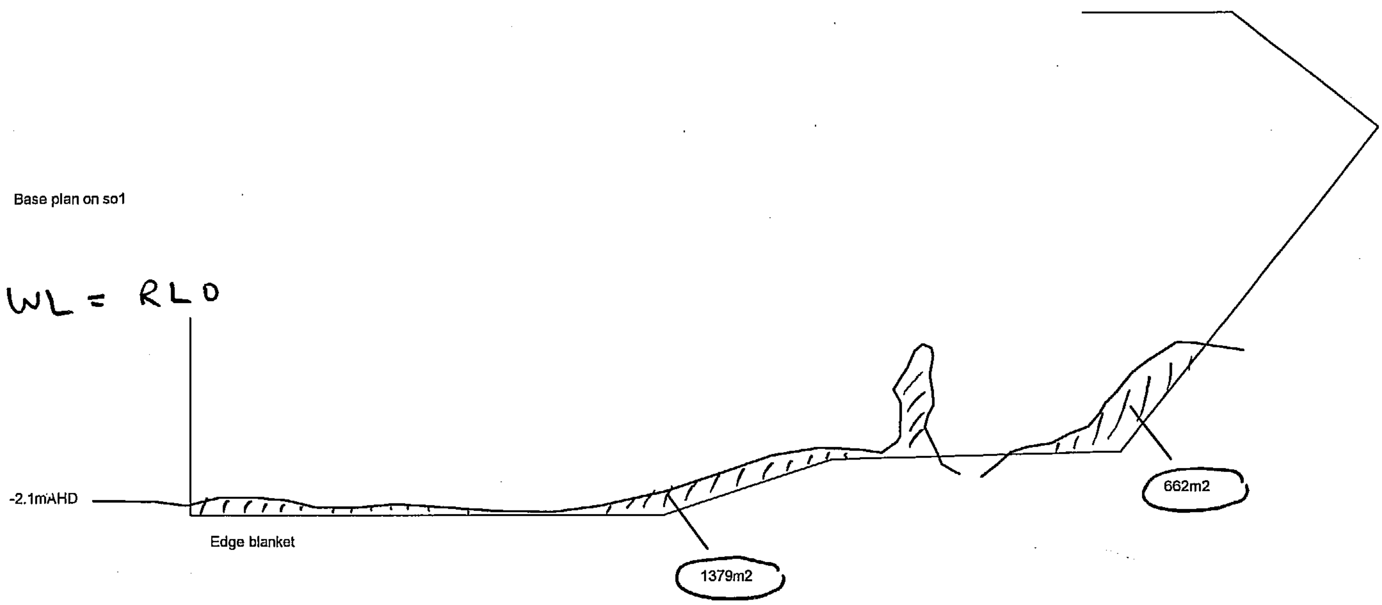
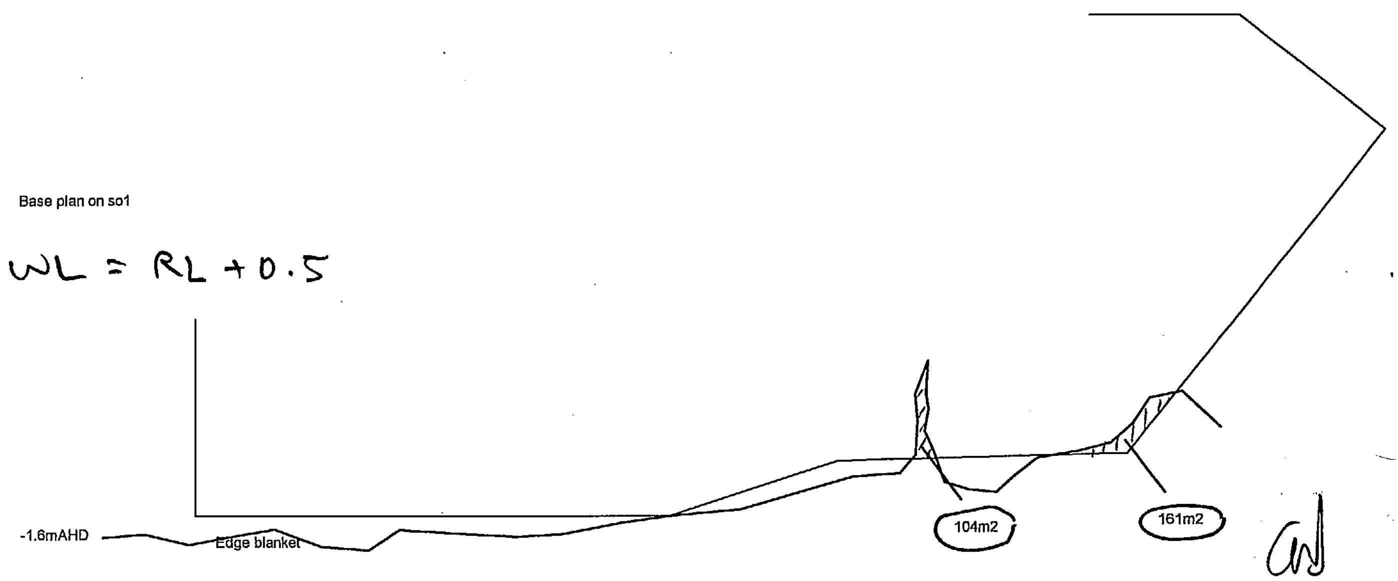
$d \leq 2.1m \quad u_{max} \geq 0.4 m/s$

AHD



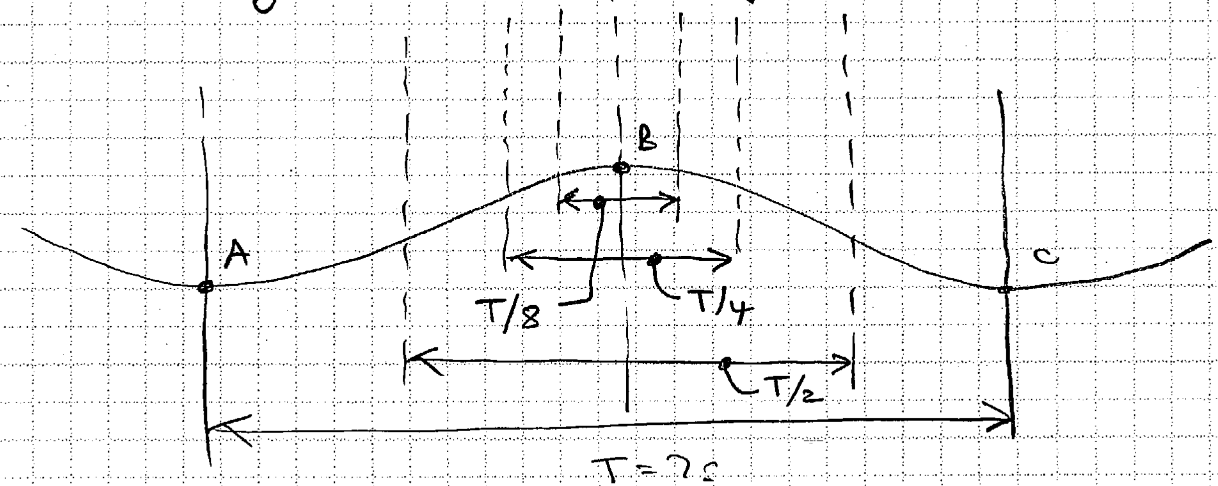




9/10/09

Fast ferries pass 68 x / day (Table 5.3 : 25,000/365 = 68)

Expect 2 long (T=7s) waves per passing



$|U_{max}|$ occurs under crests and troughs (A, B, C ....)

It would be reasonable to assume that $|U_{max}|$ lasts for T/8 per wave passing. While U_{max} is theoretically an instantaneous measure, it would not change appreciably close to the crest and close to the trough.

∴ Assume $|U_{max}|$ lasts for $2(7/8) = 14/8$ s per passing

Since 68 passings/day ⇒ $68 \times 14/8 = 119$ s per day.

So in any one year: $|U_{max}|$ lasts for $119 \times 365 = 43,435$ s/yr

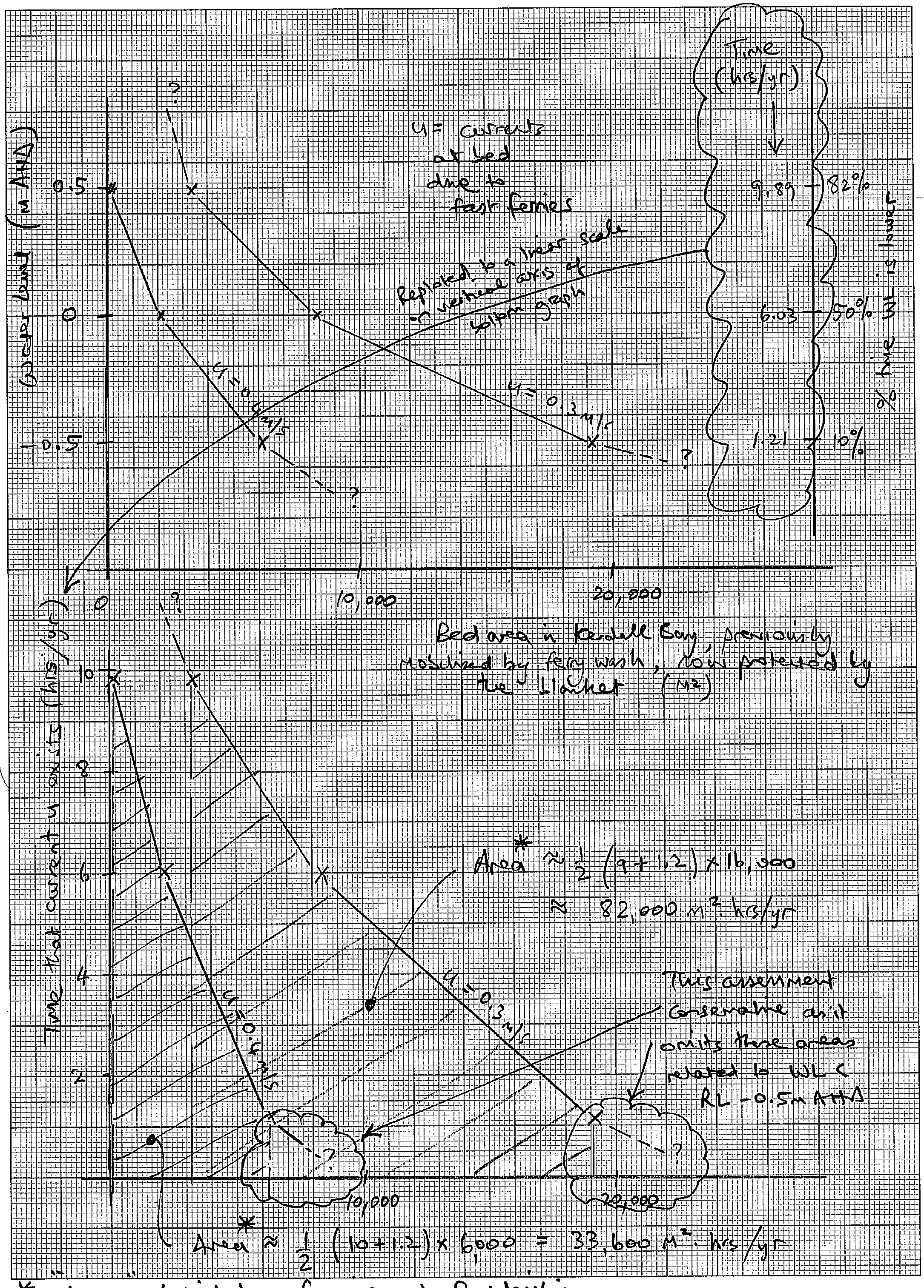
or $\frac{43,435}{3600} = 12.07$ hrs/yr.

% time WL is lower (from p1)	Time $\|U_{max}\|$ equalled or exceeded
82%	$0.82 \times 12.07 = 9.89$ hrs/yr
50%	$0.50 \times 12.07 = 6.03$ hrs/yr
10%	$0.10 \times 12.07 = 1.21$ hrs/yr

07-16

1mm Squares

9/10/09 GPJ



* = Measure of disturbance for given critical velocities

(1.) Over what period of time might the bed be disturbed during construction of the blanket?

Disturbance would be expected when:

1. The geotextile comes to rest on the bed
2. The geotextile is close to the bed whilst being lowered into position such that water velocities are generated in excess of Ucritical (nominally 0.3 m/s) - water being pushed by the physical presence of the geotextile (paddle effect)
3. Fines are squeezed back up and through the geotextile when the rock is placed.

At any point within the footprint of the blanket, we have assumed that the bed would not be disturbed (surface sediment mobilised) for more than a couple of mins (say 120 s) during construction.

If all 56,000 m^2 of blanket footprint is disturbed for 120 s a "measure" of the disturbance (area x time) is 1867 m^2. hrs

(2.) Over what period of time would it take ferry running to generate the same level of disturbance as construction of the blanket?

If we conservatively limit our assessment to WL's between RL 0.5m AHD and RL -0.5m AHD, then ferries are assessed to cause a level of disturbance of 82,000 m^2.hrs/yr for u_{crit} = 0.3 m/s, and 33,600 m^2. hrs/yr for u_{crit} = 0.4 m/s (conservative). Refer p5A.

∴ adopting 0.4 m/s (conservative), period of time it takes ferry running to generate same level of disturbance as construction of blanket

$$= \frac{1867 \text{ m}^2.\text{hrs}}{33{,}600 \text{ m}^2 \text{ hrs/yr}} = 0.056 \text{ yrs or } \sim 2.9 \text{ weeks}$$

Note that for blanket construction disturbance to "equate" to 12 months of ferry movements, the disturbance time at any point within the footprint of the blanket during construction would need to last for ~ 3.6 mins (33,600 M^2. hrs / 56,000 M^2)

APPENDIX F

GEOTECHNICAL APPRAISAL
(DOUGLAS PARTNERS, 2009)

Douglas Partners
Geotechnics • Environment • Groundwater

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MJT:jlb
Project 71235
27 June 2009

BPPL
c/ - TLB Engineers
514 Miller Street
CAMMERAY NSW 2062

Attention: Mr Howard Bersten

email: howard@tlbengineers.com

Dear Sirs

INNER WEST MARINA, KENDAL BAY
CONSOLIDATION SETTLEMENT

1. INTRODUCTION

Following your instructions we have carried out an estimate on the likely consolidation settlement of sediments around the proposed marina due to construction of an erosion blanket. We have based our estimates of settlement on soil classifications given in the URS report which provides generalised descriptions of the bay sediments and some notional engineering properties, probably based upon their engineering experience. The estimate outlined below has been calculated using parameters derived from experience with similar materials to those described by URS.

2. SOIL CONDITIONS

In carrying out this evaluation Douglas Partners has used the information provided in a report titled '*Environmental Risk Assessment for Sediments Adjacent to the former AGL Mortlake site*' prepared by URS dated 31 May 2006. The report contained a generalised sediment stratigraphy as summarised below.

Table 1 – Sediment Stratigraphy

Depth (m)	Lithology
0.0 – 0.02	Surficial sediments comprising brown green mud with broken shell material
0.02 – 0.1	Grey green estuarine mud
0.1 – 1.5	Black to olive grey marine mud, very soft with traces of fine grained sand
> 1.5	Grey to orange sandy clay, firm with fine sand and dispersed shells

In carrying out our assessment we consider that the upper 100 mm of very soft sediments would probably be affected during the placement of the Elcomax 1200 geotextile and the 300 mm thick basalt confining layer. This is based on our experience that it is very difficult to obtain competent samples of this material in any estuarine environment because the material behaves as a high viscosity fluid.

3. ESTIMATED SETTLEMENT

The estimated settlement due to the design load of 3.2 kPa is 5 mm for the very soft mud layer which extends to a depth of 1.5 m below river bed level.

In carrying out the analysis we have ignored the sediments below a depth of 1.5 m. These sediments, based upon the descriptions provided by URS, are much stiffer than the upper sediments and therefore their contribution (if they were to consolidate slightly under the load) is probably negligible compared to the very soft sediments to depths of 1.5 m.

We trust that the above is of assistance but if you have any further questions please contact Fiona MacGregor.

Yours faithfully
DOUGLAS PARTNERS PTY LTD

Reviewed by

for

Michael J Thom
Principal

Fiona MacGregor
Principal