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Turbid Plume Measurements – Port of Brisbane Corporation Dredgers 'Amity', 'Ken-Harvey' and 'Alan M'

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Turbid Plume Measurements - Port of Brisbane Corporation Dredgers 'Amity', 'Ken-Harvey' and 'Alan M'

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Title :	Turbid Plume Measurements - Port of Brisbane Corporation Dredgers 'Amity', 'Ken-Harvey' and 'Alan M'
Author :	Brad Hiles, Craig Morgan
Synopsis :	Summary of turbidity measurements undertaken before, during and after operations of the PBC dredgers 'Amity', 'Ken Harvey' at Fisherman Islands and the bed leveller 'Alan M' at the Maritime Wharf at Hamilton.

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CONTENTS

LIST OF FIGURES

LIST OF TABLES

1 INTRODUCTION

1.1 Background

The Port of Brisbane Corporation (PBC) operates dredging vessels to maintain navigable water depths within declared shipping channels and berths within the Port of Brisbane (the Port). PBC has developed a fleet of dredging vessels and dredging equipment to accommodate both capital and maintenance dredging requirements for the Port. The fleet includes the self-propelled cutter-suction dredger *'Amity'*, the clamshell bucket dredger *'Ken Harvey'* and the bed-levelling barge *'Alan M'*. This report summarises the measurements of plume turbidity surrounding the operation of each of the above dredgers, whilst operating at various locations in the Brisbane River.

All dredging plant results in the re-suspension of bed material, usually resulting in visible turbid plumes of water, which are advected down-current of the working area by tidal currents. The turbid plumes have the potential to result in aesthetic nuisance and may also impact upon estuarine or marine plant or fauna communities *via* light limitation or smothering if the plumes are intense and long-lived.

PBC commissioned BMT WBM to measure and describe the spatial and temporal patterns in the distribution and extent of turbid plumes generated by the dredging and bed levelling operations. The results of this investigation, which are documented in this report, will be used by PBC to manage potential risks associated with turbid plumes generated by their dredging operations.

1.2 Study Aims and Objectives

The broad aim of this study is to assess the spatial and temporal characteristics of the turbid plumes generated by operations of the dredgers *Amity* and *Ken Harvey*, and the bed leveller *Alan M*. The specific objectives of this study are as follows:

- Undertake measurements of the water turbidity within the initial plume created by dredging and within the plume of turbid water discharged from the dredger's hoppers;
- Undertake measurements of the movement of the turbid plume(s) as indicated by drogue(s) using differential GPS;
- Undertake measurements of the water turbidity within the centroid of the turbid plume(s) at regular intervals for a period of approximately 3 hours following their creation or until the plume(s) are no longer evident;
- Collect corresponding water samples from the turbid plume(s) for laboratory analysis of suspended solids concentrations within the dredge plume and from there determine any quantitative relationship between the two parameters; and
- Identify the influence of other factors on local turbidity values within the vicinity of the dredgers.

1.3 Description of the Dredger and Bed Leveller Operations

1.3.1 Dredger *Amity*

The *Amity* is presently engaged in long-term capital dredging of mud, sand and gravel shoals at the mouth of the Brisbane River for deepwater berth development and future port reclamation. The completed works will ultimately result in the major extension of berth areas at the seaward end of Fisherman Islands and the reclamation of adjoining impounded tidal areas for future port development purposes.

The *Amity* is equipped with a large cutter section head deployed from the bow with pilotage near the bow, stores and accommodation amidships and large dredging and booster pumps positioned aft. It has a continuous dredged material handling capacity of approximately 750m^3/hour and is the largest of the dredgers examined in this report. Dredged sediments are delivered directly to the adjoining future port reclamation area *via* a 650mm diameter-floating pipeline. Once discharged to the impounded area, the dredged sediments are allowed to settle via a network of wet storages with the excess water ultimately being discharged to Moreton Bay.

At the time of reporting, the dredger was slowly progressing in a seaward direction adjacent to the recently created future port expansion alignment with the approaches to the berth and berth development-dredging programme scheduled for completion in 2010. The *Amity* is positioned by stern spuds and manoeuvres over the shoal dredging area using port and starboard side anchors to swing in arcs up to approximately 100m wide across the dredging area. The existing water depth over shoal areas adjoining the future port expansion area is approximately 1-1.5m below datum with a design dredging depth of 16m below datum being created within the newly formed berth areas.

1.3.2 Dredger *Ken Harvey*

The *Ken Harvey* is a smaller barge equipped with a bow-mounted crane and clamshell grab with aft accommodation and hydraulic and electrical power packs. It is typically used on smaller short-term projects to dredge confined or shoal areas in close proximity to the riverbank or other obstructions, which prohibit the use of larger dredgers. It is pushed to the dredging location using a tug and manoeuvres over the dredging area using a series of port and starboard side anchors as well as head and stern anchors. *Ken Harvey* has a 3.25m^3 bucket with a dredged material handling capacity of approximately 50-80m^3/hour. Dredged material is loaded into a waiting bottom-dump or split-hull hopper barge moored alongside the dredger. When the moored barge is full with sediment, a tug is used to push the loaded barge to the sediment disposal site whilst a second barge is pushed into place adjoining the *Ken Harvey* so that dredging is a more or less continuous process. At the time of turbidity measurements *Ken Harvey* was undertaking capital and maintenance dredging of a new berth area for a general-purpose wharf being constructed at the landward (city) end of the Fisherman Islands reach of the Brisbane River. The material being dredged consisted principally of fine mud. The existing water depths were approximately 7m below datum with a design dredging depth of 11m below datum for the new berth.

1.3.3 Bed Leveller *Alan M*

The bed leveller *Alan M* is the smallest item of dredging plant reviewed. It is a 12m long barge equipped with a stern-mounted blade, which is used to grade and level the bed sediments adjoining existing piles and wharf areas. It is pushed and positioned using the small tug *Seahorse*. The blade is similar in shape and function to that found on conventional earthmoving equipment such as a road grader, in this instance with the depth and angle of the blade being controlled from the wheelhouse of the *Seahorse*.

Together the *Alan M* and *Seahorse* work to grade the berth face areas such that the blade is lowered angled and pushed forward and along the face of the wharf into the prevailing tidal currents. In plan view, the plant describes a number of consecutive ‘C’ shaped dredging cycles to remove the accumulated sediments from the quayline of a berth. The lower section of the ‘C’ represents the travel path moving into the berth where the bed levelling blade is lowered to the correct depth, the middle section of the ‘C’ represents the distance along the quayline from which the sediment is graded and the upper section of the ‘C’ represents the departure from the quayline where the material accumulated against the blade is typically moved offshore into an over-dredged pocket, awaiting future dredging by larger dredging plant. *Alan M* has a dredged material movement capacity of approximately 100-150m^3/hour, whilst operating in fine silt and mud.

2 METHODOLOGY

2.1 Study Areas and Sampling Conditions

Given that the dredging locations (and potentially sediment types), and type and operational characteristics of each dredger (eg. size, capacity, mobility, pattern of dredging, duration of dredging cycle, duration of dredging, method of sediment handling) differed, it was expected that each item of plant would result in different and distinctive spatial patterns of turbid plume generation. For this reason, each dredger was considered separately in this investigation.

The dredging (and turbid plume monitoring) areas for each of the three dredgers were dictated by PBC's dredging schedule. Figure 2-1 illustrates the dredging locations within the Port of Brisbane for each of the dredgers. Field conditions and timetables of dredging/monitoring undertaken for the dredgers *Amity*, *Ken Harvey* and bed leveller *Alan M* are illustrated below in Tables 2-1 to 2-3.

Locality Map

Figure 2-1

2.1.1 Dredger *Amity*

Field conditions and timetables of dredging/monitoring undertaken for the dredgers *Amity* are summarised in Table 2-1. Dredging and monitoring of the dredge plume about the *Amity* was undertaken on the morning of Tuesday 5th June 2007 at Fisherman Islands Berth 10 with a light wind forecast and neap flood tidal conditions. Weather conditions on the day were initially fine with increasing cloud cover becoming moderately overcast during the mid to late morning. Light easterly winds of less than 5 knots were experienced until approximately 1030 hours, after which slightly stronger southeasterly winds were evident. (Note that turbidity measurements conducted later the same day about the PBC dredger *Brisbane* whilst it was dredging in the Outer Bar Cutting of the Brisbane River are the subject of a separate report (WBM 2007)). The predicted range of the flooding tide was 1.0m.

The shoal dredging area for the *Amity* at Berth 10 (see Figure 2-2) consisted of a mixture of fine-grained muds, silts and sand with occasional gravel and cobble-sized shell and stone material. The *Amity* commenced dredging at approximately 0715hrs, and was fully operational for approximately 1 hour 45 minutes on the flooding tide before the start of turbidity measurements. That is, sufficient time was allowed for the formation of a steady-state turbid water plume about the dredger, prior to the commencement of monitoring.

Table 2-1 Schedule of Plume Turbidity Measurements for *Amity*: 5th June 2007

Time	Event	Comments	Field Condition
06:45	Low water – 0.7m	Predicted flood tide range at the Brisbane bar of 1.0m	Generally overcast conditions with east to southeast winds at 5-10 knots
08:30	Arrived and boarded the *Amity* to discuss the monitoring operation with the vessel master.	*Amity* started dredging at approximately 0715 hrs	
09:00	Reference (up-current) turbidity profile and water clarity measurements, and water sample collection	Turbidity measurements collected approximately 70m up-current of the dredger	Remnant shoal areas up-current of dredger have an approximate depth of 1.5m. Dredged areas have a depth of approximately 16.5m.
09:15	Deploy drogue 1		
09:32	Drogue moving shoreward towards Fisherman Islands and is likely to strand.		
09:41	Drogue 1 removed	Drogue had not progressed down current	
09:48	Deployed drogue 2	Turbidity measurements and water samples taken adjacent to drogue whilst tracking drogue movement until 11:56	
12:00	Conclusion of turbidity measurements		
12:10	High water – 1.7m	*Amity* continued dredging operation	
13:00	Aerial photos captured of the *Amity* whilst en-route to the dredger *Brisbane*		Note: No sediment sample of dredged material was collected due to cobbles obstructing closure of Van Veen Grab.

2.1.2 Dredger *Ken Harvey*

Field conditions and timetables of dredging/monitoring undertaken for the dredger *Ken Harvey* are summarised in Table 2-2. Monitoring of the turbid water plumes about the dredgers *Ken Harvey* and *Alan M* was undertaken on Friday 31st August 2007. Weather conditions on this day were fine with generally calm to light northeasterly wind conditions in the morning, with an afternoon northeasterly sea breeze of approximately 10-15knots. A flooding tide occurred in the morning, with the ebb tide beginning at approximately 1145-1200hrs, subject to location.

Monitoring about the *Ken Harvey* was initiated on the flooding tide at 0940hrs, approximately 1 hour 40 minutes after the commencement of dredging (see Figure 2-3). Dredging by *Ken Harvey* was conducted in close proximity (20-30m) to the Fisherman Islands foreshore where there was a large amount of heavy earthmoving was equipment being operated to prepare the adjoining land for development of the general purposes wharf. The adjoining construction equipment included scrapers, haul trucks, water trucks and long-reach excavators, which were actively involved in the placement of rock and fill materials into the tidal and sub-tidal extension of the foreshore (see Figure B-10). These concurrent construction activities resulted in their own turbid plume adjoining that created by operation of *Ken Harvey*. At the time of monitoring, the dredged material being loaded into the barge *Hercules* by the *Ken Harvey* consisted of fine textured silts and mud.

Table 2-2 Schedule of Plume Turbidity Measurements for *Ken Harvey:* 31st August 2007

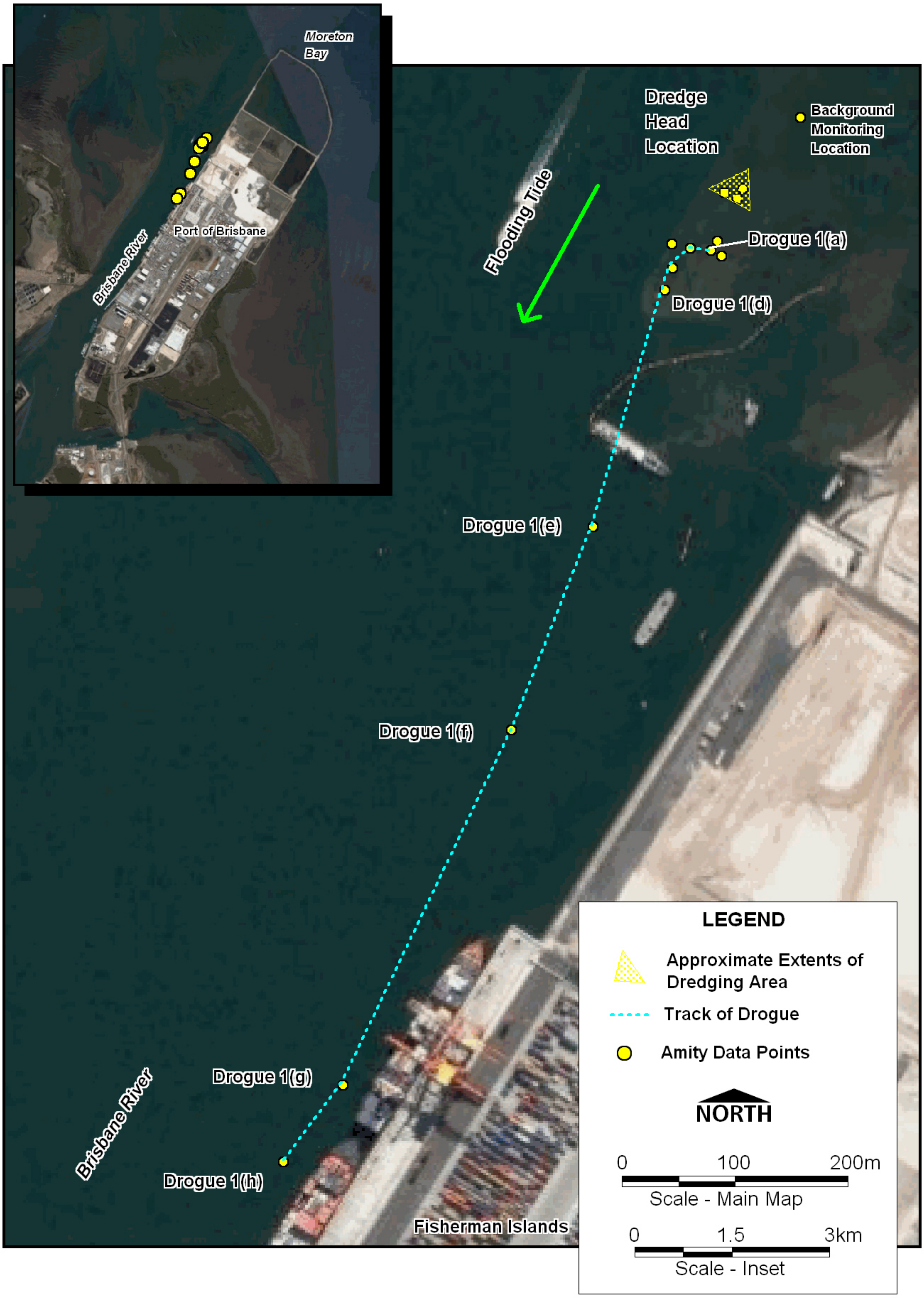
Time	Event	Comments	Field Condition
05:32	Low water – 0.2m	Flooding tide through to 1129hrs, predicted high water at the Brisbane Bar of 2.1m	Fine weather with slight northeasterly winds at 5 knots
08:00	*Ken Harvey* begins dredging operation		
09:39	Reference (up-current) turbidity profile measurements and water samples collected		
10:06	Deploy drogue one and two	Drogues deployed at the stern of the *Ken Harvey* (i.e. downstream of the bucket movement area).	Unable to deploy drogues near the bow of *Ken Harvey* due to safety issues (swinging bucket).
10:23	Turbidity measurements and water sample tracking of plume movement until 1043hrs	Since both drogues stranded on the near-by shoreline, follow up turbidity measurements were undertaken at selected distances downstream from the dredger.	Large amount of earth works along the shoreline for construction of the general-purpose wharf. Shore based activities creating turbid plume close to shore i.e. in the vicinity of the drogue tracks.
10:43	Conclusion of turbid plume measurements.		Note: Aerial photos were taken on the 5th June 2007 whilst enroute to the PBC dredger *Brisbane*. A sediment sample to determine particle size was collected from the barge *Hercules*. No aerial photos were taken during the dredging/monitoring operation.

2.1.3 Bed Leveller *Alan M*

Field conditions and timetables of dredging/monitoring undertaken for the bed leveller *Alan M* are summarised in Table 2-3. Monitoring of the dredge plume about the *Alan M* was undertaken on an ebbing tide during the afternoon of 31st August 2007 at the Maritime wharf in the Hamilton Reach of the Brisbane River (see Figure 2-4). Monitoring down-current of the dredger was initiated at approximately 1340 hours after the completion of 6 dredging cycles to allow time for the formation of a steady state turbid plume. Bed levelling works undertaken by the *Allan M* commenced at the western end of the Maritime wharf and progressed in an easterly direction to the decommissioned section of wharf. Bed levelling and monitoring works focussed on those dredging cycles completed towards the eastern end of the wharf, since this is where most sediment accumulation was evident. By its nature, a proportion of turbid plume generated by dredging undertaken by the *Alan M* is often inaccessible since the plume moves below the wharf area being dredged. The dredged material at the Maritime wharf consisted of fine textured mud containing silt and clays.

Table 2-3 Schedule of Plume Turbidity Measurements for *Alan M:* 31st August 2007

Time	Event	Comments	Field Condition
12:03	High water – 2.2m	Ebbing tide with predicted ebb tidal range of 1.9m at the Brisbane Bar.	Fine weather conditions, northeasterly winds 10-12 knots
12:55	Collect reference (up-current) turbidity measurements and water sample		
13:06	*Alan M* begins bed levelling operation at the western of Maritime wharf	Dredging (bed levelling) progressed in an easterly direction towards decommissioned area of Maritime wharf.	
13:40	Begin downstream turbidity monitoring program	Wait for *Alan M* to complete approximately 6 dredging cycles through berth until localised turbid plume has been created and is suitable for turbidity measurements	
13:46	Deploy drogue 1 into stern wake of *Alan M*	Undertake turbidity and water clarity measurements and water samples, until drogue begins to move towards decommissioned wharf area	Drogue 1 strands below wharf at approximately 1400hrs.
14:10	Collection of drogue from under decommissioned area of Maritime wharf	At approximately 14:00hrs the drogues appears to be missing and was subsequently relocated under Maritime wharf	
14:15	Conclusion of bed levelling operations by *Alan M*	A sediment sample was collected from *Alan M* blade to describe the nature of local sediments.	
14:25	Conclusion of turbid plume measurements.		Note: No aerial photos were taken during the dredging/monitoring operation.

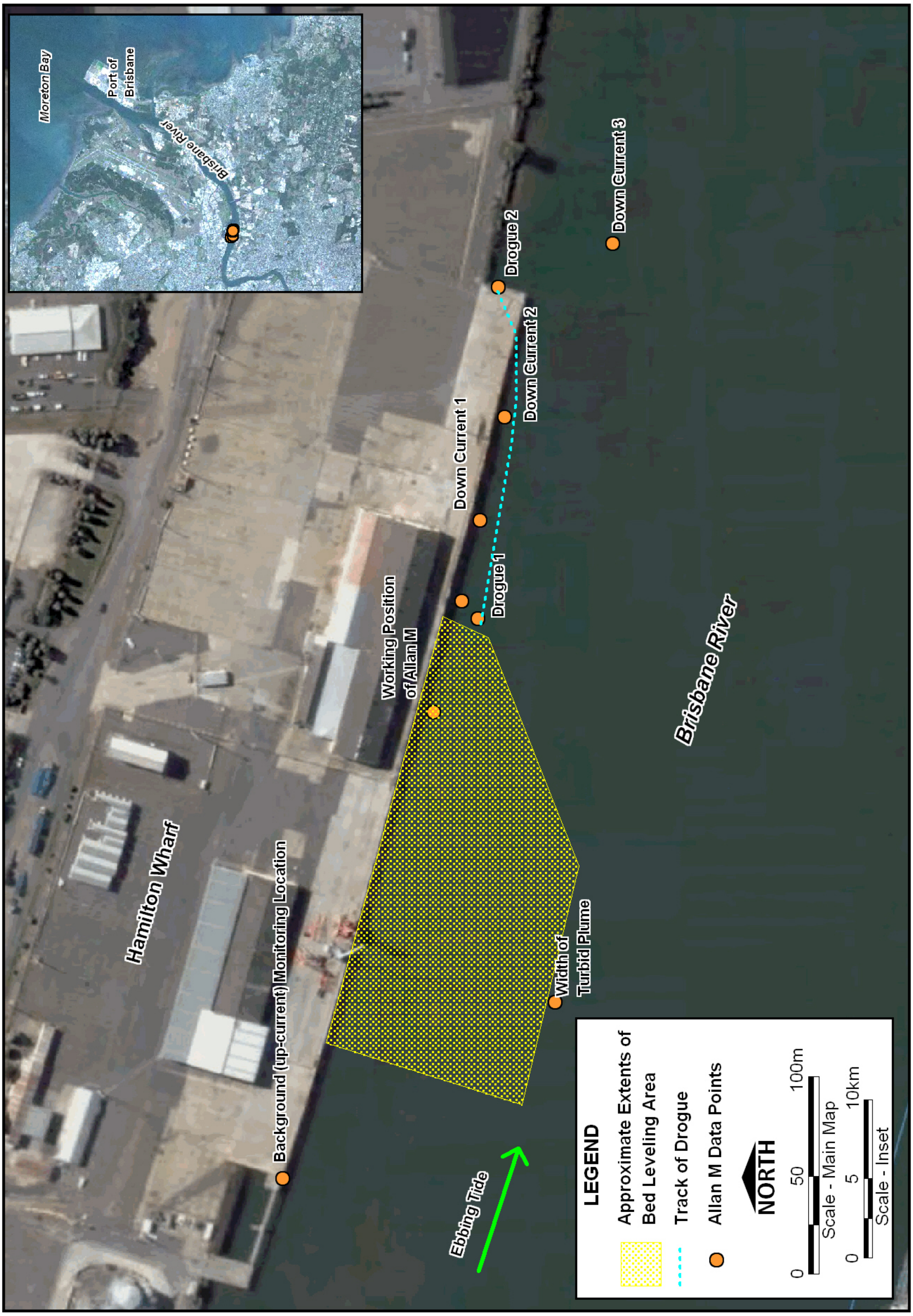


Dredging and Turbidity Monitoring Area - "Amity" - 5th June 2007

Figure 2-2

Dredging and Turbidity Monitoring Area - "Ken Harvey" - 31st August 2007

Figure 2-3



Bed Levelling and Turbidity Monitoring Area - "Allan M" - 31st August 2007

Figure 2-4

2.2 Survey Logistics

Prior to each of the monitoring dates, the masters of the dredgers *Amity, Ken Harvey and Alan M* were briefed by PBC personnel on the proposed turbidity measurement exercises and were requested to execute dredging following standard procedures and work methods.

Turbidity measurements were undertaken from the survey vessel *Resolution II* which was able to communicate and co-ordinate measurement and sampling activities with the dredgers *via* VHF marine radio. For the turbid plume monitoring undertaken about the *Amity* on the 5th June 2007, aerial overflights and oblique aerial photography of the dredging operation and turbid plumes residual from dredging were co-ordinated by mobile phone with BMT WBM personnel at Flight Charter Australia (Gemair Pty Ltd) at Archerfield airport. Aerial photographs of the *Amity* were collected opportunistically on this date from a single engine fixed wing aircraft (Cessna 172RG) as a part of the aerial overflight and photography of turbid plumes arising from dredging of the Outer Bar Cutting by the PBC dredger *Brisbane* (WBM 2007). Aerial photography of the *Amity* was captured enroute to the Outer Bar Cutting prior to the start of dredging by the *Brisbane*.

Some oblique aerial photography was also captured on the 5th June 2007 in the vicinity of the new general purpose wharf (dredging area for the *Ken Harvey*) (see APPENDIX B), though this was recorded several months prior to the date of turbid plume measurements about the *Ken Harvey.*

2.3 Turbid Plume Measurements

Since the dredgers *Amity* and *Ken Harvey* were stationary or generally constrained in their ability to manoeuvre during dredging, whilst the bed levelling plant (*Alan M* and *Seahorse)* was quite mobile, slightly different sampling approaches were required for evaluating the turbid plume characteristics of each dredger.

The measurement of plume intensity was generally based upon the near-field measurement of plume turbidity close to the dredger and then again within the plume down-current of the dredger on several occasions. The plume turbidity was then compared with turbidity immediately upstream of the dredger. This allowed a comparison of turbidity within the plume to 'control' turbidity measurements outside the influence of the plume. The plume position was indicated at distances away from the dredger by one or more drogues initially deployed into the plume close to the dredger (Figure 2-5). Additional complications for measurements about the *Amity* and *Ken Harvey* particularly, included the number of supporting vessels and/or other vessel traffic whilst above water obstructions (such as old piles or wharfs) made the task of tracking the plume indicating drogues difficult for both the *Ken Harvey* and *Alan M* dredging and monitoring exercises.

To begin each plume measurement exercise the survey vessel, *Resolution II* was positioned up-current of the dredger to collect background surface water clarity (as indicated by Secchi disc), turbidity profile measurements and water samples for total suspended solids (TSS) analyses. Subsequently, near-field and far-field water clarity, turbidity profiling measurements and water samples were collected within the plume as indicated by the position of the drogue(s). These down-current measurements were often separated by a return to the up-current measurement station to get corresponding measurements of the potentially changing turbidity of water entering the dredging area.

To minimise the potential risks associated with collision of the drogues to either the dredgers or surrounding vessel traffic, small sacrificial tube type drogues were used as reference markers for turbid plume measurements. The drogues denoting the turbid plume location were initially deployed astern of the dredger or in the case of the *Alan M* shortly before the dredger turned away from the quayline of the wharf. Subject to the constraints of surrounding vessel traffic, bathymetry or above-water obstructions, each of the drogues was tracked for a period until the turbid plume generated by dredging was no longer visible or evident from the turbidity measurements (i.e. turbidity was similar at the control locations and at the location of the residual 'plume'). In some situations, for example when monitoring turbidity about the *Alan M* at the Maritime wharf, drogues could not be reliably tracked since they repeatedly stranded below the wharf. In these circumstances turbidity profiles were undertaken at several distances downstream of the dredging operations to provide information on the reduced intensity of turbidity downstream of the dredger.

All sampling and analysis procedures were undertaken in accordance with the Queensland Environment Protection Agency (1999) water quality sampling manual. Turbidity profile measurements from the water surface to depths close to the bed were recorded using a using a YSI model 6600 water quality instrument connected to a YSI Model 650MDS multi-parameter display unit. The instrument's turbidity sensor was two point calibrated before use in distilled water (0.0 NTU) and in a AMCO 100 NTU polymer bead solution. On each profile, water depth and turbidity were measured at 5-second intervals as the sonde was lowered in 1m depth increments to the seabed. A Secchi disc deployed from *Resolution II* was used to record the surface water clarity.

To provide an indication of the relationship between turbidity and suspended solids in the vicinity of the dredging operations, background and dredging plume water samples were collected for suspended solids analysis coincident with turbidity measurements at a specific depth (usually 1.0m depth). A 2.2L Van Dorn water sampler (Wildlife Supply Co.) was used to collect water samples from the water column.

Queensland Health Scientific Laboratory (QHSS)[1] at Coopers Plains was engaged to analyse water samples collected at the various dredging locations for the total suspended solids (TSS) concentrations. Two up-current reference and 6 plume water samples were collected during the measurement exercise about the *Amity.* Three reference and 8 plume water samples were collected about the *Ken Harvey*. Three reference and 5 plume water samples from the Maritime berth were analysed from the *Alan M* monitoring exercise.

[1] NATA certified laboratory

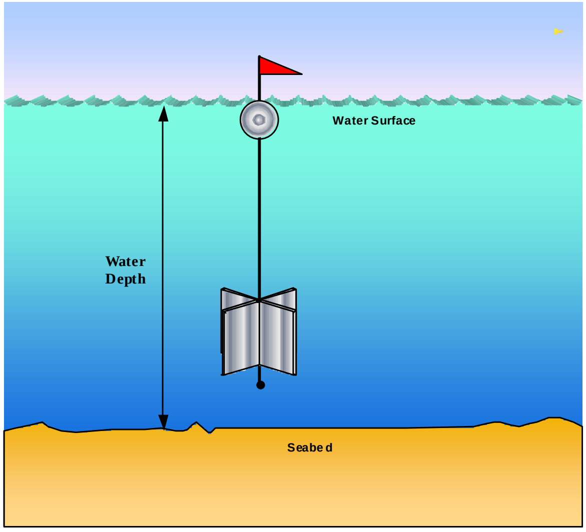


Figure 2-5 Typical Drogue Configuration

2.4 Statistical Analysis

2.4.1 Box and Whisker Plots

Box and whiskers plots were prepared to examine patterns in turbidity levels in time and space. Box and whiskers plots were generated to illustrate turbidity values within three sections of the water column: surface (upper 1 m of the water column), near-bed (lower 1 m of the water column) and mid-depth (all depths between surface and near measurements), over time. Note that due to the configuration of the various dredging operations, background/control measurements (located upstream of the dredger) could in some instances only be undertaken in sub-tidal shoal environments (where water depths <2m), which differed from the area downstream of the dredgers where water depths were up to 16m below datum. Box-plots were also generated to show depth-averaged turbidity values over time (i.e. all water depths were pooled). Box-plots were generated using the statistical software package Statview Version 5.0.1.

The key statistics incorporated into box and whiskers plots are shown in Figure 2-6. These include:

- 90^{th} percentile: 90% of the values fall below this mark, while 10% of the values exceed this value
- 75^{th} percentile: 75% of the values fall below this mark, while 25% of the values exceed this value
- 50^{th} percentile: 50% of the values fall below this mark, while 50% of the values exceed this value
- 25^{th} percentile: 25% of the values fall below this mark, while 75% of the values exceed this value
- 10^{th} percentile: 10% of the values fall below this mark, while 90% of the values exceed this value
- Outliers: values that exceed the 90th percentile or are below the 10th percentile
- Median: the value that corresponds to the middle case when all individual scores are arranged in order by score; the value that divides the cases into two halves of equal frequency.

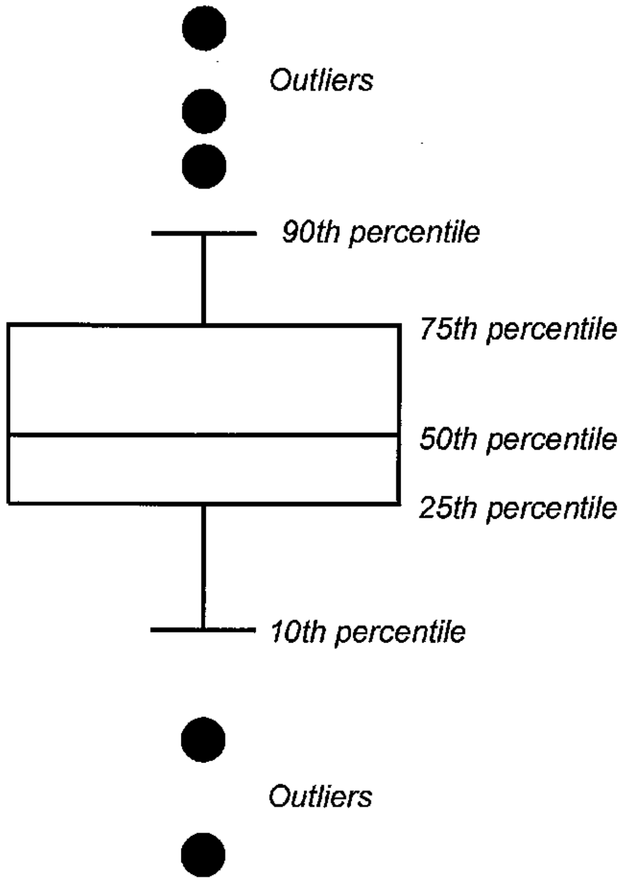


Figure 2-6 Key features of the box and whiskers plots generated in the present study

2.4.2 Relationship between Turbidity and Suspended Solids

As discussed in Section 2.3, water samples were collected concurrently for measurements of total suspended solid concentrations (TSS) and turbidity (NTU). This allowed empirical estimates of the relationship between these two variables, based on simple linear regression analysis.

Average turbidity values were calculated for each depth and site at which TSS samples were collected. Separate regression analyses were then undertaken for each dredger. Regression analysis was undertaken using the statistical software package Statview Version 5.0.1.

3 RESULTS

3.1 Dredger *Amity*

A summary of turbidity measurement results for the flood tide dredging of Port of Brisbane berth 10 by the *Amity* on the 5th June 2007 is presented in Table 3-1.

Table 3-1 Dredger *Amity* Plume Measurements – Flood Tide – 5th June 2007, Fisherman Islands Berth 10

Before and During Dredging	Time (Up-current Measurements)	Total Depth (m)	Depth	Turbidity (NTU)	Secchi Disc Visibility (m)
	09:02-09:05	1.5	Surface	6	1.3
			Mid-depth	N/A	
			Bed	10.0-11	
	10:22-10:23	1.7	Surface	3.6-3.9	1.7 (total depth)
			Mid-depth	N/A	
			Bed	N/A	
	11:29-11:30	1.8	Surface	4.7-5.4	1.8
			Mid-depth	N/A	
			Bed	N/A	
During Dredging	**Time (Down-current Measurements)**	**Total Depth (m)**	**Depth**	**Turbidity (NTU)**	**Secchi Disc Visibility (m)**
	9:14-9:19 (D1)	15.3	Surface	6.9-19.8	1
			Mid-depth	10.4-19.4	
			Bed	6.5-109	
	9:32-9:36 (rd1)	15.8	Surface	9.8-19.8	N/A[2]
			Mid-depth	17.7-32.6	
			Bed	30.2-51.3	
	9:48-9:52 (rd1a)	15.8	Surface	6.3-16.7	N/A
			Mid-depth	20.6-74.0	
			Bed	66.6-81.6	
	10:12-10:16 (rd4a)	16	Surface	6.7-16.0	N/A
			Mid-depth	8.6-16.8	
			Bed	7.7-8.9	
	10:44-10:50 (rd5a)	16.1	Surface	8.9-12.7	N/A
			Mid-depth	9.2-15.1	
			Bed	13.0-18.1	
	11:12-11:16 (rd6a)	16.1	Surface	9.4-12.9	N/A
			Mid-depth	8.9-13.5	
			Bed	8.6-9.7	
	11:36-11:40 (rd7a)	16.1	Surface	8.1-13.1	1.2
			Mid-depth	9.3-13.6	
			Bed	5.9-6.9	
	11:49-11:52 (rd8a)	16.4	Surface	8.5-10.2	N/A
			Mid-depth	6.1-11.3	
			Bed	6.4-9.4	

[2] N/A = no measurements taken

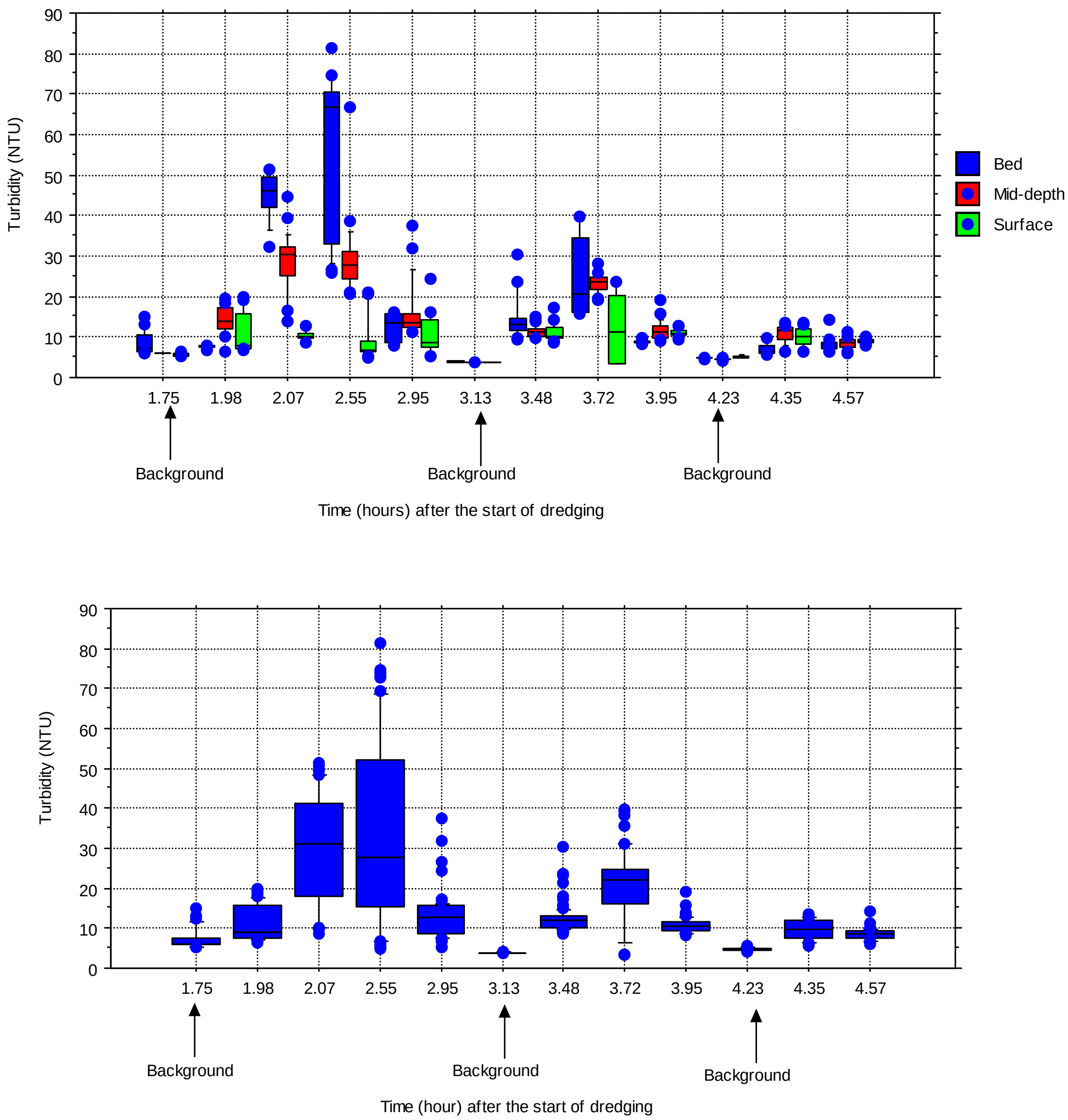


Figure 3-1 Box plots showing Control (up-current) and plume (down-current) turbidities about the dredger *Amity* - 5th June 2007, Fisherman Islands Berth 10. Values are shown for each depth interval (upper plot) and depth averaged (lower plot)

Figure 3-1 contains two box plots illustrating the control/background turbidity levels up-current of the dredger *Amity* whilst it was operating at Berth 10 and the dredging plume turbidities within and beyond the berth areas. The turbidity measurements are shown relative to the time from the start of dredging (approximately 0715hrs) and monitoring (approximately 0900hrs), and include measurements from surface and bed sections of the water column.

Patterns in turbidity levels among depths varied inconsistently among sites/times. Median near-bed turbidity levels were higher than surface and mid-water levels at interval 1.75 (background), 2.07 and 2.55 (commencement and approximately half an hour after the commencement of dredging), but were relatively similar among depths at other times.

Background median turbidity values were <10 NTU overall. Turbidity levels were higher than background (control) levels in the period immediately following dredging (within 1 hour, sampling intervals 2.07 and 2.55) at near-bed and mid-depth sections of the water column. Turbidity levels then remained within the range of background levels until sampling interval 3.72, when levels increased at all water depths (median overall turbidity = ~23 NTU). At sampling interval 3.95, median turbidity levels then returned to near background (~11 NTU), although an outlier value of 20 NTU was recorded. Turbidity levels then remained within the range of background levels for the remainder of the monitoring exercise (<15 NTU).

Figure 3-2 depicts the total suspended solids (TSS) concentrations at reference (up-current) and plume (down-current) locations about the dredger *Amity* on the 5th June 2007. The TSS analysis results are shown relative to the time from the start of dredging (approximately 0715hrs) and monitoring (approximately 0900hrs), which includes measurements at depths of 1.0m and 10.0m. Consistent with patterns in turbidity, TSS concentrations measured down-current of the *Amity* were approximately twice as high as background measurements.

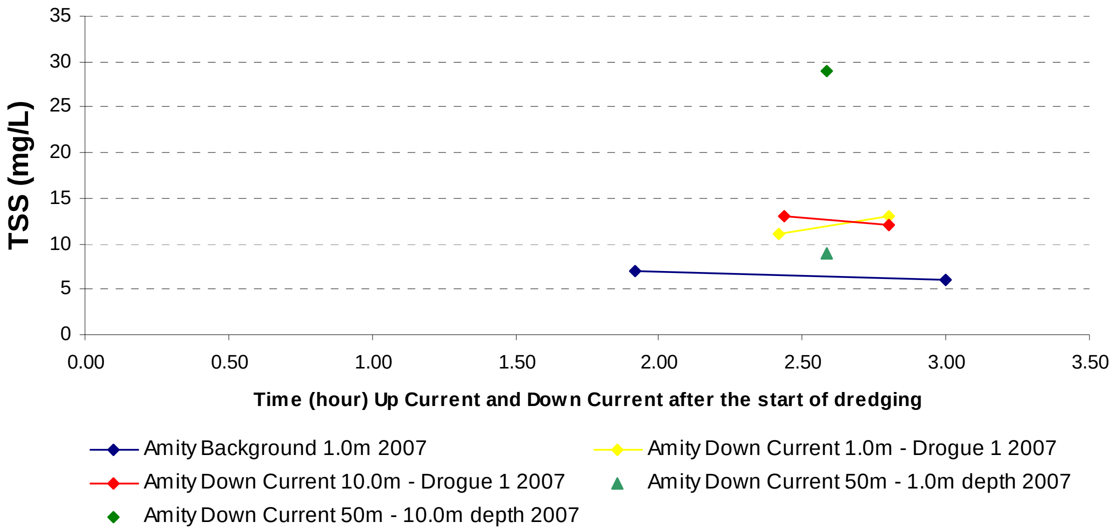


Figure 3-2 Control (up-current) and plume (down-current) TSS measured adjacent to the dredger *Amity* - 5th June 2007, Fisherman Islands Berth 10

Figure 3-3 shows that there was a positive linear association between turbidity and TSS. This relationship was highly statistically significant (p = 0.0001), with regression analysis (APPENDIX A) suggesting that ~93% of variation in turbidity was explained by TSS. The equation describing the line of best-fit (Y = 1.212 * X + 0.245) suggests an approximate 1.2 (TSS): 1 (turbidity) ratio.

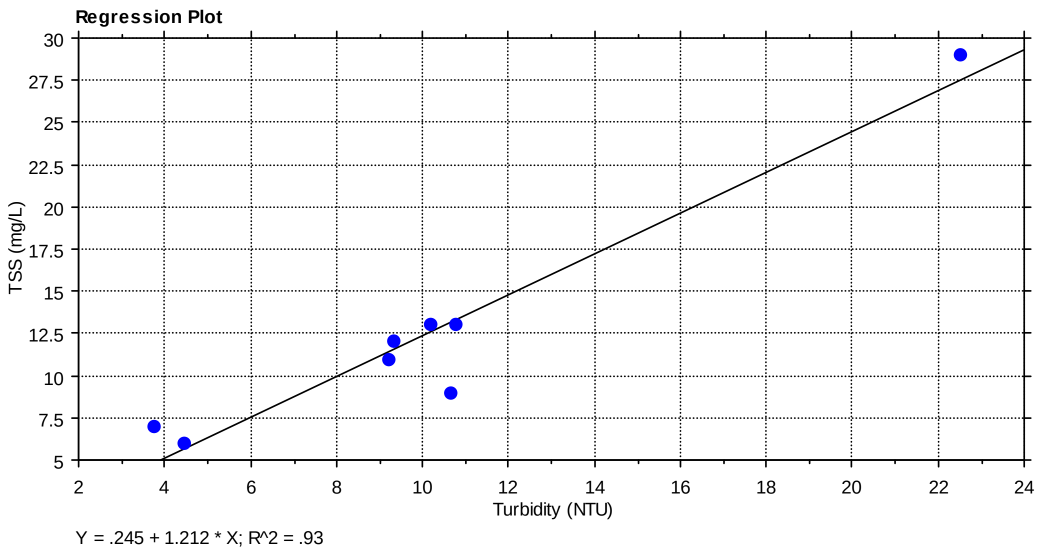


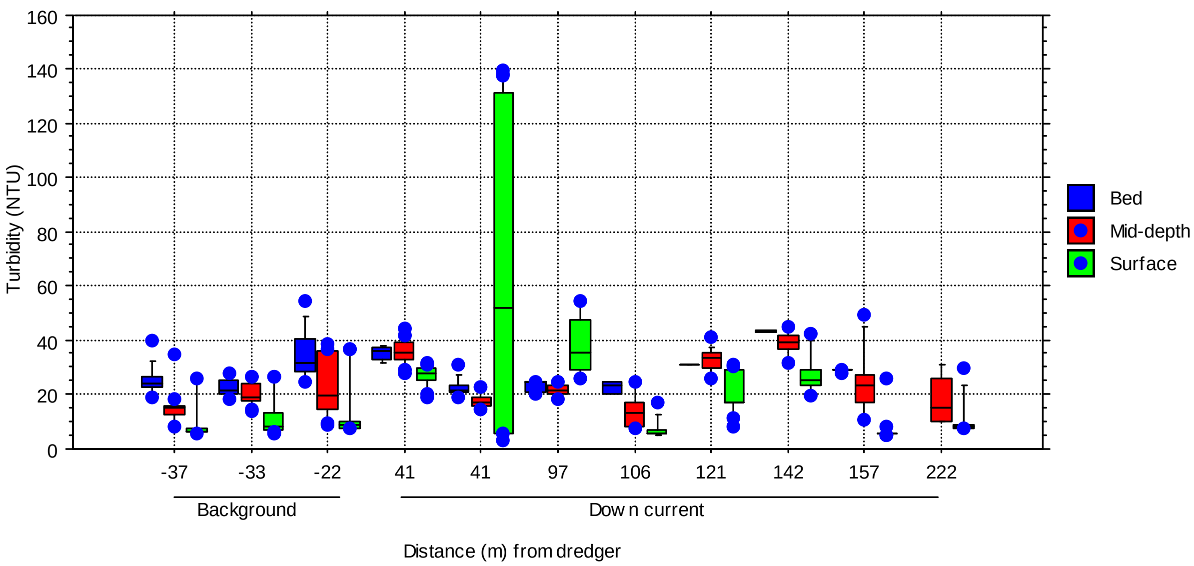
Figure 3-3 Regression plot on average turbidity (NTU) and total suspended solids concentrations – Dredger *Amity* - 5th June 2007, Fisherman Islands Berth 10

3.2 Dredger *Ken Harvey*

A summary of the turbidity measurement results for the flood tide dredging of the new general-purpose berth by the *Ken Harvey* on the 31st August 2007 is presented in Table 3-2.

Table 3-2 Dredger *Ken Harvey* Plume Measurements - Flood Tide - 31st August 2007, General Purpose Berth

Before and During Dredging	Time (Up-current Measurements)	Total Depth (m)	Depth	Turbidity (NTU)	Secchi Disc Visibility (m)
	9:40-9:42	7.0	Surface	7.6-10.2	1.2
			Mid-depth	10.5-16.1	
			Bed	17.5-30.9	
	9:55-9:58	13.6	Surface	7.5-14.6	1.6
			Mid-depth	15.8-24.9	
			Bed	18.2-26.8	
	11:26-11:31	12.1	Surface	6.2-9.3	1.7
			Mid-depth	10.2-23.4	
			Bed	22.4-27.5	
During Dredging	**Time (Down-current Measurements)**	**Total Depth (m)**	**Depth**	**Turbidity (NTU)**	**Secchi Disc Visibility (m)**
	10:08-10:12 (Stern of Barge)	7.4	Surface	19.2-29.2	0.4
			Mid-depth	32.0-42.1	
			Bed	31.8-37.7	
	10:15-10:17	8.0	Surface	25.8-44.0	0.6
			Mid-depth	18.3-24.3	
			Bed	20.1-24.6	
	10:24-10:27	7.8	Surface	11.7-31.1	0.7
			Mid-depth	32.0-41.2	
			Bed	26.0-30.9	
	10:28-10:31	4.0	Surface	20.1-27.8	0.4
			Mid-depth	29.9-39.3	
			Bed	42.1-44.9	
	10:32-10:37	3.3	Surface	7.5-19.5	1.2
			Mid-depth	10.1-10.2	
			Bed	15.0-31.2	
	10:45-10:47 (115m down current of dredge operation)	6.0	Surface	5.1-8.0	1.6
			Mid-depth	10.7-28.1	
			Bed	29.4	
	10:55-10:56 (70m down current of dredge operation)	4.0	Surface	5.3-7.5	1.6
			Mid-depth	7.4-17.5	
			Bed	18.5-25.2	
	11:03-11:06 (Stern of barge)	7.0	Surface	24.2-39.7	0.5
			Mid-depth	14.7-22.6	
			Bed	19.2-31.1	



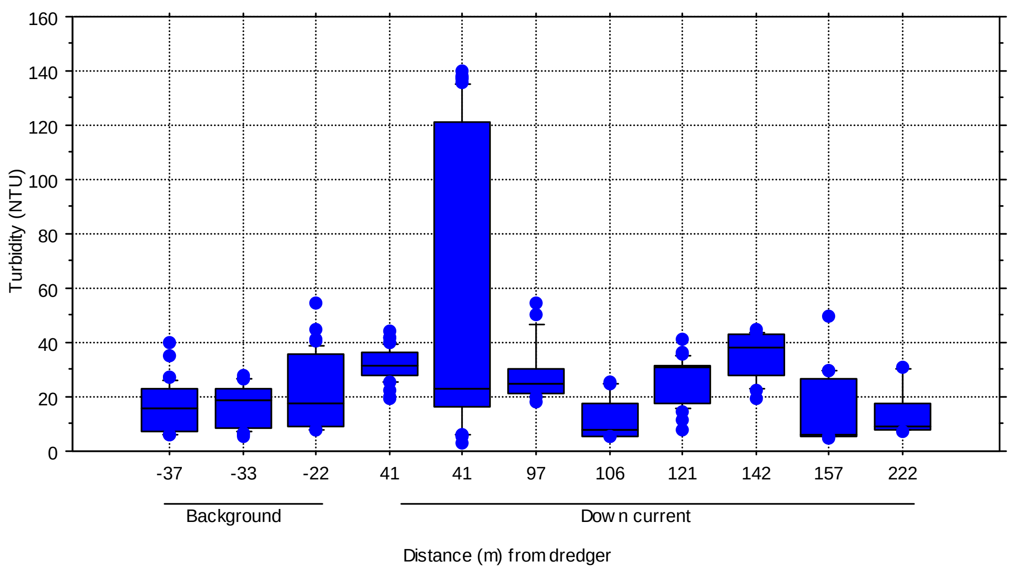


Figure 3-4 Box plots showing control (up-current) and plume (down-current) turbidities about the dredger *Ken Harvey* – 31st August 2007, Fisherman Islands General Purpose Berth. Values are shown for each depth interval (upper plot) and depth averaged (lower plot)

Figure 3-4 contains two box plots illustrating the control/background turbidity levels up-current of the dredger *Ken Harvey* whilst it was operating at the new general purposes berth and the plume turbidities downstream of the dredger. The turbidity measurements are shown relative to the distance in metres up-current (negative numbers) and down-current (positive numbers) and include measurements from surface, mid-depth and near-bed sections of the water column.

Patterns in turbidity levels among depths varied inconsistently among sites/distances downstream. Median surface turbidity levels were initially higher than mid-water and near-bed levels downstream of the dredger, but were relatively similar among depths further downstream.

Background median turbidity values were <20 NTU overall. Median turbidity levels were higher (>30NTU) than background (control) levels immediately downstream of the dredger (40m downstream). Turbidity levels generally remained within the range of background levels further downstream of the dredger.

Figure 3-5 illustrates the reference or background Secchi disc water clarity up-current of the dredger *Ken Harvey* whilst it was operating at the general purposes berth and the down-current Secchi disc measurements within the turbid dredge plume within and beyond the berth area. The Secchi disc measurements are shown relative to the distance up-current and down-current of dredging.

The surface water clarity as indicated by Secchi disc visibility varied between 1.2 and 1.7m upstream of the dredger. The surface water clarity was much reduced immediately downstream of the dredger (to approximately 0.4m at 40m downstream of the dredger) before steadily increasing to within the range of background measurements within 100 to 200m downstream of the dredging operation.

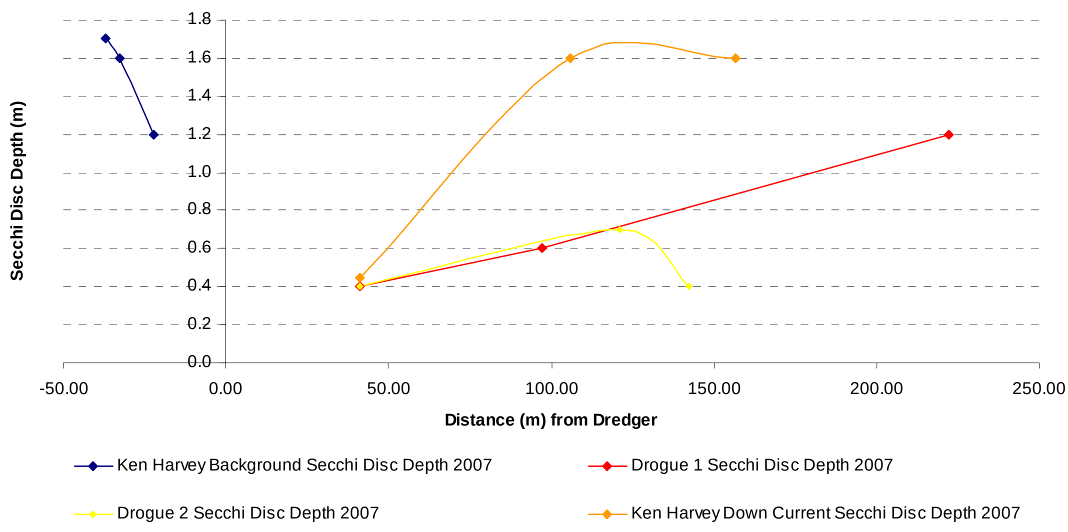


Figure 3-5 Reference (up-current) and plume (down-current) Secchi disc visibilities about the dredger *Ken Harvey* – 31st August 2007, Fisherman Islands General Purpose Berth

Figure 3-6 depicts the maximum water turbidity measured at reference (up-current) and plume (down-current) locations about the dredger *Ken Harvey* on the 31st August 2007. The turbidity measurements for surface column water are shown relative to the distance up-current and down-current of dredging. The maximum turbidities measured up-current of the *Ken Harvey* were approximately 9-15NTU, whilst those measured downstream of the dredger were in the range 30-40NTU at a distances of 40-100m down-current of the dredger. Within the near-surface horizon of the water column, the maximum measured turbidities reduced to within the range of background (up-current) turbidities within 100m downstream of the dredger.

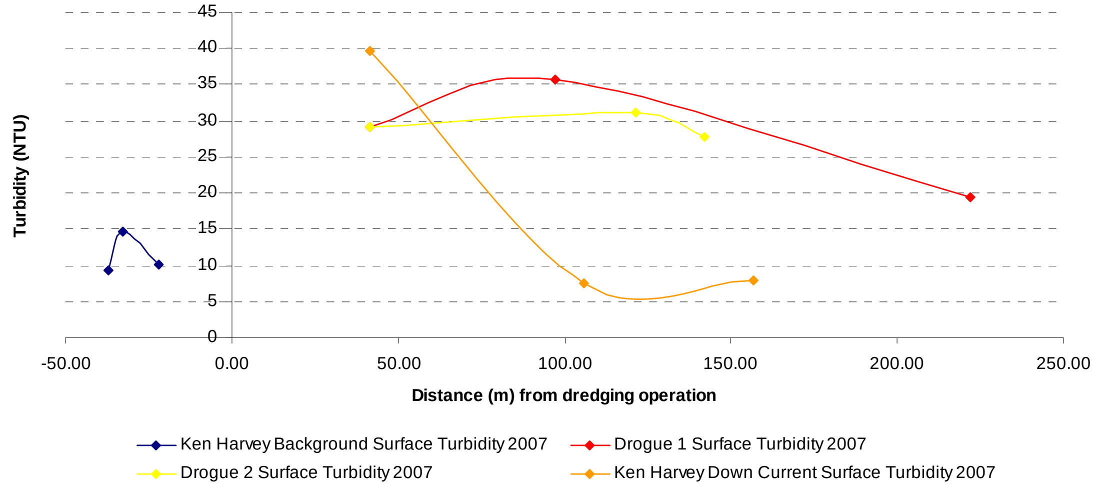


Figure 3-6 Reference (up-current) and plume maximum water turbidity measurements about the dredger *Ken Harvey* – 31st August 2007, Fishermans Island General Purpose Berth

Figure 3-7 shows total suspended solids (TSS) results at reference (up-current) and plume (down-current) locations about the dredger *Ken Harvey* on the 31st August 2007. The TSS results are shown relative to the distance up-current and down-current of dredging. (Note that water clarity, turbidity and TSS results for dredger *Ken Harvey* were plotted against distance rather than time, since drogues used for indicating turbid plume movements stranded quite quickly following deployment).

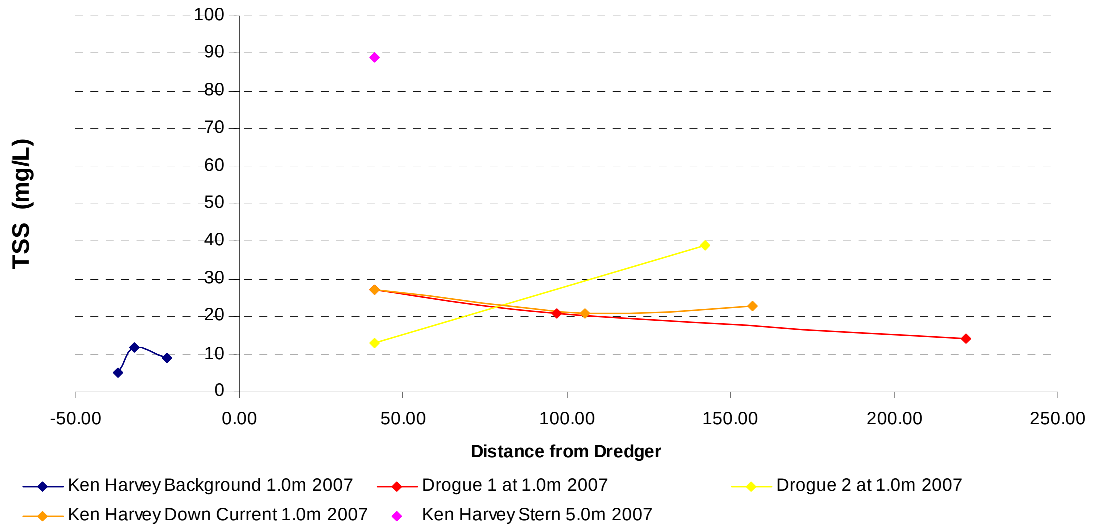


Figure 3-7 Reference (up-current) and plume (down-current) TSS about the dredger *Ken Harvey* – 31st August 2007, Fisherman Islands General Purpose Berth

Figure 3-8 depicts the turbidity verus total suspended solids relationship for the sediments at the New General Purpose berth based upon the analysis of 10 water samples including 3 background (reference samples) and 7 dredging plume samples. There was no significant association between TSS and turbidity with the regression analysis (see APPENDIX A) suggesting that ~ 3.6% of variation in turbidity was explained by TSS.

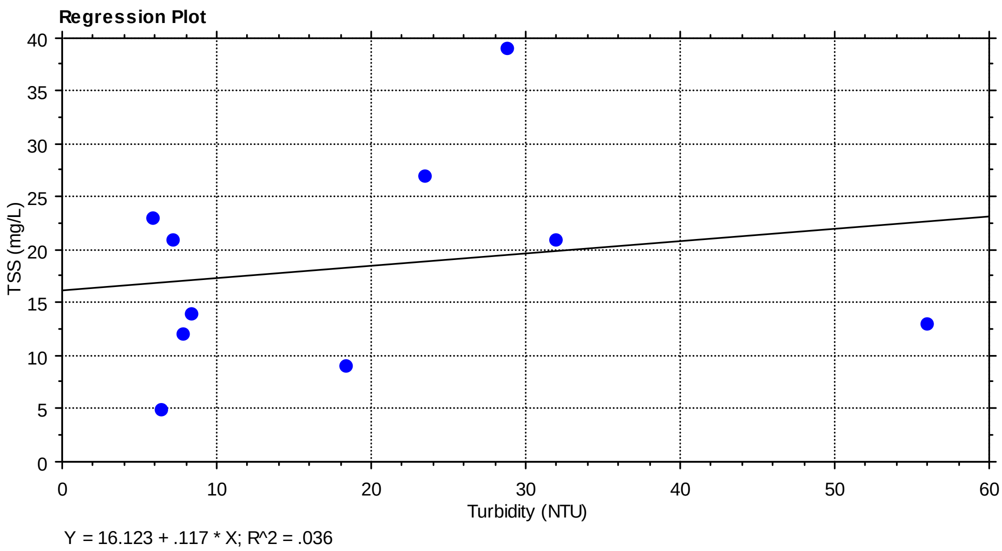


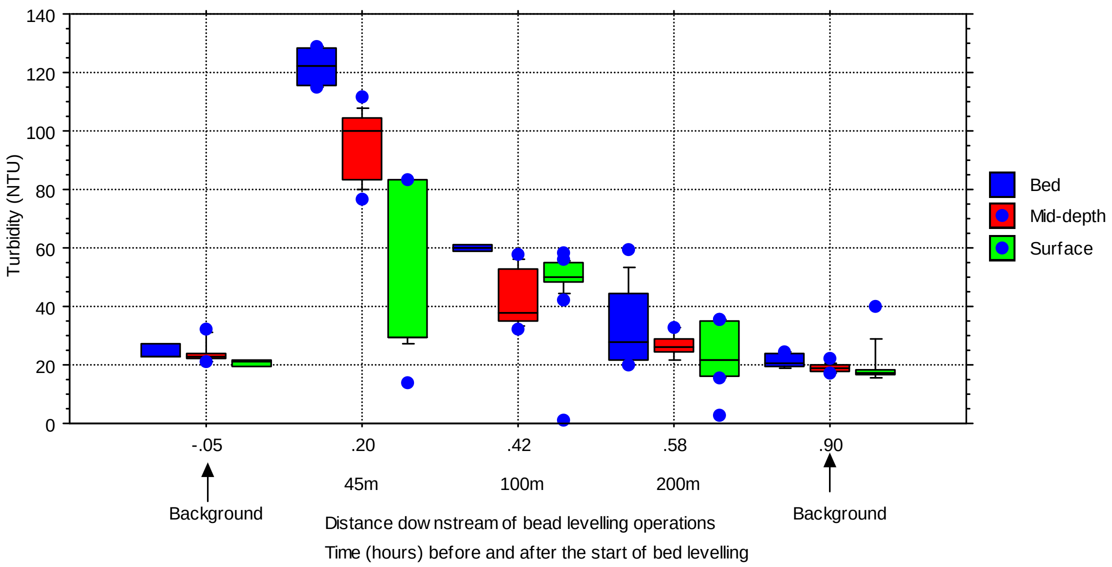
Figure 3-8 Regression plot on average turbidity (NTU) and total suspended solids concentrations – Dredger *Ken Harvey* 31st August 2007 New General Purpose Berth

3.3 Bed Leveller *Alan M*

A summary of turbidity measurement results for ebb tide levelling of sediments at the Maritime Berth at Hamilton by the *Alan M* on the 31st August 2007 is presented in Table 3-3.

Table 3-3 Bed Leveler *Alan M* Plume Measurements – Ebb Tide - 31st August 2007, - Maritime wharf

Before and During Dredging	Time (Up-current Measurements)	Total Depth (m)	Depth	Turbidity (NTU)	Secchi Disc Visibility10 (m)
	12:52	11.9	Surface	19.0-21.0	0.8
			Mid-depth	22.5-24.0	
			Bed	23.0-29.0	
	13:49-13:51	10.1	Surface	15.7-19.3	0.7
			Mid-depth	17.0-20.1	
			Bed	18.9-24.5	
During Dredging	**Time (Down-current Measurements)**	**Total Depth (m)**	**Depth**	**Turbidity (NTU)**	**Secchi Disc Visibility (m)**
	13:07-13:10 (45m Down current)	9.6	Surface	14.0-83.9	0.3-0.4
			Mid-depth	83.3-104.4	
			Bed	104.2-2439.8	
	13:20-13:22 (100m Down current)	9.7	Surface	37.9-50.2	0.3
			Mid-depth	32.2-47.8	
			Bed	54.8-62.0	
	13:30-13:33 (200m Down current)	10.9	Surface	15.4-26.3	0.6
			Mid-depth	20.0-32.8	
			Bed	23.6-981.3	



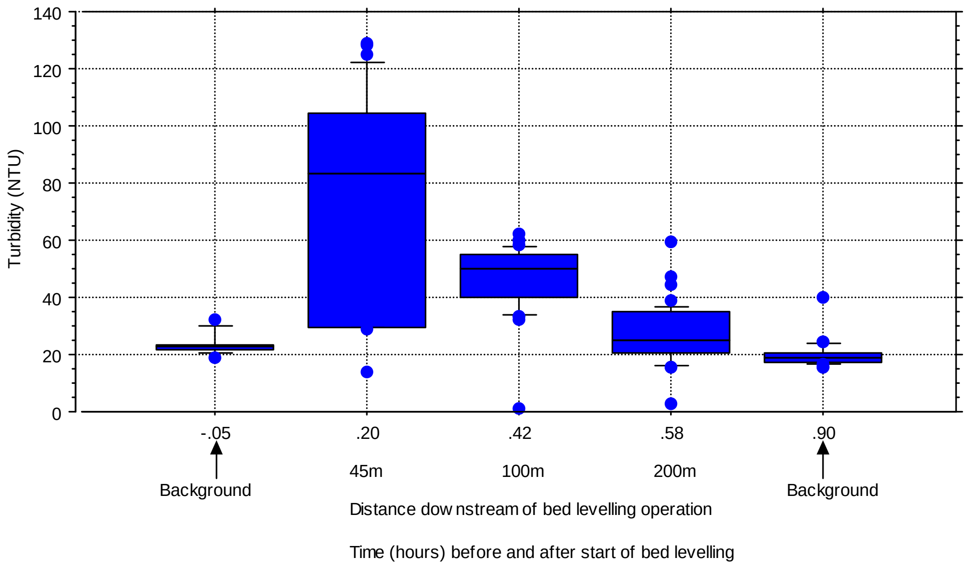


Figure 3-9 Box plots showing control (up-current) and plume (down-current) turbidities about the bed leveller *Alan M* – 31st August 2007, Maritime Berth Hamilton. Values are shown for each depth interval (upper plot) and depth averaged (lower plot)

Figure 3-9 depicts the water turbidity at reference (up-current) and plume (down-current) locations about the bed leveller *Alan M* on the 31st August 2007. The turbidity measurements are shown relative to the distance up-current and down-current of bed levelling.

Figure 3-10 shows total suspended solids (TSS) results at reference (up-current) and plume (down-current) locations about the bed leveller *Alan M* on the 31st August 2007. The TSS results are shown relative to the distance up-current and down-current of bed levelling with measurements taken at 0.7m, 2.0m and 5.0m depth intervals. (Note that turbidity and TSS results for the bed leveller *Alan M* were plotted against distance as well as time, since drogues originally deployed for indicating the turbid plume movements were quickly stranded below the adjoining wharf). Total suspended solids concentration measurements were consistent with patterns in turbidity, with the concentration increasing immediately after dredging. Concentrations spiked at 0.4 hours after the commencement of dredging before steadily decreasing, however remaining above reference concentration measurements.

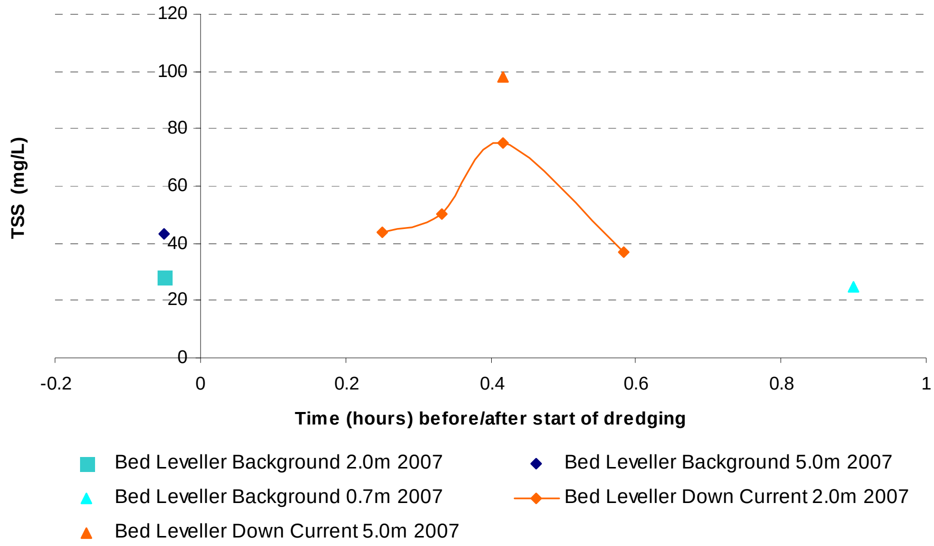


Figure 3-10 Reference (up-current) and plume (down-current) TSS about the bed leveller *Alan M* – 31st August 2007, Maritime Berth Hamilton

Figure 3-10 illustrates the relationship between turbidity and TSS of sediments at Maritime wharf based upon the analysis of 8 water samples, including 3 background (reference samples) and 5 plume samples. There is a positive however not statistically significant linear relationship between turbidity and TSS ($p = 0.0775$) with regression analysis (APPENDIX A) suggesting that ~43% of variation in turbidity was explained by TSS. The equation describing the line of best-fit (Y = 6.132 * X + 1.523) suggests an approximate 1.5 (TSS): 1 (turbidity) ratio.

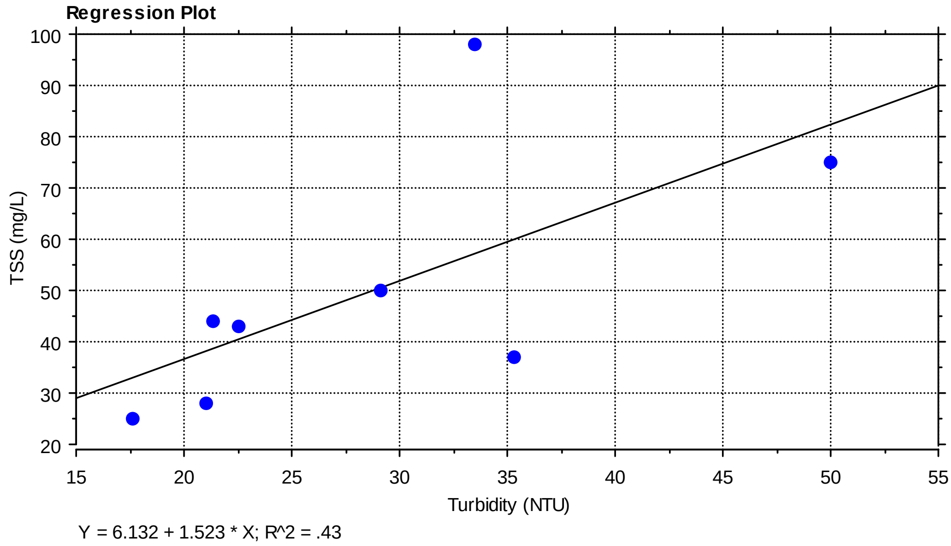


Figure 3-11 Regression plot on average turbidity (NTU) and total suspended solids concentrations – Dredger *Alan M* 31st August 2007 Maritime wharf

4 DISCUSSION

4.1 Dredger *Amity*

Visual observations of plume formation at the time of measurements suggest that:

1 The turbid water plume arising from operation of the *Amity* covers the full width of the dredging arc (approximately 80-100m wide) created by the dredger *Amity* as it dredges material from the shoal banks to create the berth and channel approach areas. It appears that the principal component of dredging related turbidity is generated by the fretting of sediment at the interface of the freshly exposed batter slope created by the dredger and it's subsequent entrainment into the water column on the flooding tide. That is, the tidal velocity of water flowing across the shoal flats was sufficient to mobilise the finer fractions of dredged material at the face of the substrate exposed by the dredger.

2 The surface turbidity plume apparently from the dredger as indicated by the movement of the drogues was evident for a comparatively large distance down current of the dredger (minimally, 500m to perhaps up to 1km downstream of the dredger).

3 Tidal stages influenced the turbidity/TSS concentration measurements recorded. Whilst turbidities/TSS were above control or background levels during the middle stages of the tide (when drogue tracking was undertaken) due to comparatively strong tidal velocities passing over the shallow shoal areas, the turbidities measured downstream of the dredger *Amity* were much reduced near high water. This was likely due to the combined effects of the rising tide, which was to increase the depth of water over the shoal areas thereby reducing the associated water velocity over the shoal areas, and also as the tidal phase neared high water there was also a commensurate decrease in the flooding water velocity.

These general observations were supported by the plume turbidity measurements (refer to Figure 3 - 1) where the surface turbidities remained elevated above background (i.e. up-current levels) for a considerable distance (up to 1km) down-current of the dredger. At the dredger location the water turbidity increased from a background of less than 10NTU to 20NTU and was slow to reduce to levels approximating up-current background level. Almost 2 ½ hours were required for turbidities measured downstream of the dredger to approach up-current background turbidity levels.

The comparative total suspended solids (TSS) concentrations were approximately 7mg/L up-current of the dredger which increased to approximately 13mg/L at the point of dredging. Consistent with the observed trend of an elevated turbidity concentration well down-current of the dredger, both the surface (1.0m depth) and sub-surface (10m depth) TSS concentrations remained elevated well above the reference up-current TSS concentrations some 40 minutes past the point of dredging.

At the time of measurements it was not apparent why turbidity values remained above background for a comparatively large distance (and long time) downstream. This was particularly unusual since the fast flowing water covering the shoals immediately up-current of the dredger, whilst entraining sediments at the point of dredging then progressed into comparatively deep (16-17m depth) quiescent water. It was considered that the deep water downstream of the dredger should have assisted the settlement of suspended sediments, resulting in a less extensive plume than measured here.

A review of aerial photography (gathered en-route to monitoring of the PBC dredger *Brisbane*) provided a possible explanation for the elevated turbidities. The aerial photography indicated that there was a stream of more turbid water close to shore (apparently due to shore-based earthworks and revetment works), which appeared to be directed into the tidal water downstream the dredger (refer to Figure B-3). Thus on the date of measurements, the water turbidities immediately downstream of the dredger were likely to have been influenced not only by the dredger's turbid plume but also by the plume of more turbid water close to shore, which when mixed with the dredger's plume required a comparatively large distance downstream for settlement. Notwithstanding the above it was considered that the primary source of turbid water downstream of the dredger was associated with the *Amity's* dredging operation.

4.2 Dredger *Ken Harvey*

General observations of plume formation at the time of measurements suggest that:

1. There was a plume of very turbid water adjoining the general shore-based construction activities taking place at the new general-purpose wharf development area at Fisherman Islands on the morning of the 31st August 2007. The shore-based turbid water plume was estimated to extend approximately 10-15m seaward of the shoreline in the vicinity of the dredger *Ken Harvey* and this construction-related plume was evident down-current for an estimated distance of at least several hundred metres.

2. The dredger *Ken Harvey* was positioned close to shore (20-30m from the riverbank) and was dredging the shoreward batter slope of the General Purpose berth pocket. The proximity of the dredger to shore and the associated shore-based excavation and revetment works meant that the dredging plume from the *Ken Harvey* was to some extent affected by and difficult to differentiate from the turbid plume generated by shore-based construction activities.

3. Drogues that were released into the turbid plume immediately downstream of the dredger become stranded on the nearby shoreline after only a comparatively short time. Hence turbidity and water clarity measurements collected adjacent to the drogues (particularly in the later stages of their track) were compromised by the elevated construction related turbidities adjoining the shore and so these later measurements (close to shore) were not presented.

4. The need for plume turbidity measurements, which were representative of the dredger, and not unduly affected by the near-shore turbidity plume, prompted the collection of a second set of turbidity measurements at varying distances downstream of the dredger. These were obtained by anchoring the survey vessel *Resolution II* within the visible plume at varying distances downstream of the dredger. The turbid plume from the *Ken Harvey* (as distinct from the shore-based construction related turbid plume) was visible at the water surface for a distance of approximately 150-200m downstream of the dredger. The initial width of the surface plume was estimated at approximately 12–15m, subject to the swinging arc of the clamshell and the amount of sediments spilled from the barge. The initial size and density of the turbid plume was not consistent, with the plume consisting more a series of connected patches or splodges of turbid water than as a consistent plume of uniform size and density.

Turbidity measurements shown in Figure 3-4 suggest a considerable variability in the turbidity immediately downstream of the *Ken Harvey*; and this was likely due to the range of factors influencing the water turbidity during dredging, most notably including the impact of the bucket with the bed, penetration and withdrawal of the bucket from the water column, the amount of water surcharged from the bucket following withdrawal from the water column and the spillage of sediments onto and from the adjoining hopper barge.

Background surface turbidities measured up-current of the dredger were less than 10NTU. Immediately (40m) downstream of the dredger, the surface water turbidities ranged between background levels and 120NTU, with a median turbidity above 50NTU. The broad range of turbidity measurements reflected the time varying influences on sediment re-suspension and plume formation described above. Surface turbidities were quickly reduced with distance downstream and were close to background concentrations approximately 150-220m down-current of the dredging operation.

4.3 Bed Leveller *Allan M*

General observations at the time of measurements were as follows:

1. Bed levelling was undertaken shortly after high water on the ebbing tide. Monitoring down-current of the dredger was initiated after the completion of 6 dredging cycles to allow time for the formation of a steady state turbid plume.

2. From the survey vessel, the turbid plumes resultant from operation of the bed leveller were apparent at the water surface as a series of linear patches or bands of turbid water (each approximately 10-15m wide) emanating from the quayline of the wharf and projecting at an acute angle to the wharf face approximately 80-100m towards the centreline of the River. Subject to the speed of the ebbing current and the cycle time of the bed leveller, an approximate distance of 60-80m of comparatively clear water separated each turbid band resulting from each cycle of the bed leveller.

3. Because the drogues released into the turbid plume immediately downstream of the bed leveller were quickly stranded below the Maritime wharf, turbidity and water clarity measurements were subsequently recorded at varying distances (45m, 100m, and 200m) downstream of the bed leveller. The measurements were recorded during the passing of turbid patches of water, resulting from the bed levelling operations.

The turbidity and water clarity measurements downstream of the *Alan M* indicated the following:

- at a distance of 45m downstream of bed-levelling operations, the surface turbidity increased approximately 4-fold, from a background of approximately 20NTU to approximately 80NTU. Large turbidity increases were evident at all depths, with the near-bed concentrations increasing up to 6 TIMES above background levels.
- By 100m distance downstream, the surface turbidity was reduced to approximately 2.5 times above background (approximately 50NTU).
- At a distance of 200m downstream of the bed leveller, the median surface turbidity was close to background (20NTU), though the range of surface measurements included values up to 30NTU.

Mid-depth and near- bed turbidity levels remained somewhat elevated above the background turbidity levels.

Turbidity and water clarity measurements and general observations suggest that the visible plume created by the bed leveller whilst operational at the Maritime wharf at Hamilton was contained within an approximate distance of several hundred metres downstream of the dredger. The visually apparent effect of its operation on the surface turbidity was to produce a series of narrow turbid plumes which dissipated several hundred metres downstream of the area of operation.

5 REFERENCE

Queensland Environment Protection Agency (1999) 'Water Quality Sampling Manual. For use in testing for compliance with the Environmental Protection Act 1994.' Queensland EPA, Brisbane.

APPENDIX A: REGRESSION ANALYSIS STATISTICS

Amity Data

Regression Summary
TSS (mg/L) vs. Turbidity (NTU)

Count	8
Num. Missing	0
R	.964
R Squared	.930
Adjusted R Squared	.918
RMS Residual	2.049

ANOVA Table
TSS (mg/L) vs. Turbidity (NTU)

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	334.813	334.813	79.758	.0001
Residual	6	25.187	4.198		
Total	7	360.000			

Regression Coefficients
TSS (mg/L) vs. Turbidity (NTU)

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	.245	1.552	.245	.158	.8797
Turbidity (NTU)	1.212	.136	.964	8.931	.0001

Ken Harvey Data

Regression Summary
Total Suspended Solids vs. Turbidity

Count	10
Num. Missing	1
R	.191
R Squared	.036
Adjusted R Squared	•
RMS Residual	10.356

ANOVA Table
Total Suspended Solids vs. Turbidity

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	32.353	32.353	.302	.5978
Residual	8	858.047	107.256		
Total	9	890.400			

Regression Coefficients
Total Suspended Solids vs. Turbidity

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	16.123	5.283	16.123	3.052	.0158
Turbidity	.117	.213	.191	.549	.5978

Alan M Data

Regression Summary
TSS (mg/L) vs. Turbidity (NTU)

Count	8
Num. Missing	0
R	.656
R Squared	.430
Adjusted R Squared	.335
RMS Residual	20.194

ANOVA Table
TSS (mg/L) vs. Turbidity (NTU)

	DF	Sum of Squares	Mean Square	F-Value	P-Value
Regression	1	1845.334	1845.334	4.525	.0775
Residual	6	2446.666	407.778		
Total	7	4292.000			

Regression Coefficients
TSS (mg/L) vs. Turbidity (NTU)

	Coefficient	Std. Error	Std. Coeff.	t-Value	P-Value
Intercept	6.132	21.822	6.132	.281	.7881
Turbidity (NTU)	1.523	.716	.656	2.127	.0775

APPENDIX B: AERIAL PHOTOGRAPHS

Figure B-1 5th June 2007 – *Amity* dredging along berths 10 and 11 of Fisherman's Island, illustrating floating dredge pipeline pumping sediments to shore for reclamation works

Figure B-2 5th June 2007 – *Amity* and Associated Dredge Plume

Figure B-3 5th June 2007 – Turbidity plume caused by earth works within dredging operation

Figure B-4 31st August 2007 – Turbidity plume associated with the dredge operation of Ken Harvey along the general-purpose wharf construction site

Figure B-5 31st August 2007 – Turbidity plume associated with the dredge operation of Ken Harvey along the general-purpose wharf construction site

Figure B-6 31st August 2007 – Turbidity plume associated with the dredge operation of Ken Harvey along the general-purpose wharf construction site

Figure B-7 31st August 2007- Ken Harvey dredger and Hercules barge

Figure B-8 31st August 2007 – Dredging operation at general purpose wharf, showing the dredger Ken Harvey, the tug Turtle and barge Hercules

Figure B-9 31st August 2007 – Clamshell bucket of the dredger Ken Harvey loading dredge material on to the Hercules

Figure B-10 31st August 2007 – Earthwork operation along shoreline of the general purpose wharf construction site

Figure B-11 31st August 2007 –Earthworks operations along berth area

Figure B-12 31st August 2007 – Dredger Alan M

APPENDIX C: SAMPLE ANALYSIS RESULTS FROM QLD HEALTH

18 JUN 2007

CDM

Queensland Government

Queensland Health

SCIENTIFIC SERVICES

Enquiries :D. Wruck

Phone :(07)32749062

Our Ref :06EN12172/12194:ST

ANALYTICAL REPORT

CLIENT BMT WBM PTY LTD
PO BOX 203
SPRING HILL Q 4004

CONTACT : CRAIG MORGAN

CLIENT PROGRAM : B16530 - P OF B DREDGE MONITORING

DATE RECEIVED : 06/06/2007

SAMPLE TYPE : WATER.

The results relate to samples as received.

The responsibility for sampling rests with the client.

The results for the above samples are attached.

The following methods were used :-

Tot.Suspended Solids Method Number QIS 16624

.... 14/06/2007
S. Turner, Chemist.

070606CM_WBMO_B16530

Your Ref.		Our Ref	Total Suspended Solids mg/L
070605 Amity 1	1.0m depth Upstream 10:25 5/06/2007	EN12172	7
070605 Amity 2	1.0m depth D/stream @ RD5A 10:55 5/06/2007	EN12173	11
070605 Amity 3	10m depth D/stream @ RD5A 10:56 5/06/2007	EN12174	13
070605 Amity 4	1.0m depth 50m D/stream 11:05 5/06/2007	EN12175	9
070605 Amity 5	10m depth 50m D/stream 11:05 5/06/2007	EN12176	29
070605 Amity 6	1.0m depth D/stream @ RD6A 11:18 5/06/2007	EN12177	13
070605 Amity 7	10m depth D/stream @ RD6A 11:18 5/06/2007	EN12178	12
070605 Amity 8	1.0m depth Upstream 11:30 5/06/2007	EN12179	6

Queensland Health
Pathology and Scientific Services
Queensland Government

Enquiries : Mara Fedczina
Phone : (+61 7) 3274 9058
Fax : (+61 7) 3274 9181

CLIENT (HWBMOC) : WBM Oceanics Australia
PO Box 203
Spring Hill Qld 4004

CONTACT : Craig Morgan

Package No. : SSP0010180
Client Order No. : CRAIG_MORGAN
Date Sampled : 31-Aug-2007
Date Received : 04-Sep-2007
Date Started : 17-Sep-2007
Date Completed : 19-Sep-2007
QHSS Ref. : 07NA7075-07NA7093 : MFP5

ANALYTICAL REPORT

24 SEP 2007 CDM

Number of Samples Received : 19

QHSS Ref.	Client Reference	Description
07NA7075	1	Marine Water - Marine
07NA7076	2	Marine Water - Marine
07NA7077	3	Marine Water - Marine
07NA7078	4	Marine Water - Marine
07NA7079	5	Marine Water - Marine
07NA7080	6	Marine Water - Marine
07NA7081	7	Marine Water - Marine
07NA7082	8	Marine Water - Marine
07NA7083	9	Marine Water - Marine
07NA7084	10	Marine Water - Marine
07NA7085	11	Marine Water - Marine
07NA7086	12	Marine Water - Marine
07NA7087	13	Marine Water - Marine
07NA7088	14	Marine Water - Marine
07NA7089	15	Marine Water - Marine
07NA7090	16	Marine Water - Marine
07NA7091	17	Marine Water - Marine
07NA7092	18	Marine Water - Marine
07NA7093	19	Marine Water - Marine

Report 07NA7075-07NA7093 : MFP5 Continued:

Lab. Ref.			07NA7075	07NA7076	07NA7077	07NA7078	07NA7079	07NA7080
Client Reference			1	2	3	4	5	6
Sample			Water Marine	Water Marine	Water Marine	Water Marine	Water Marine	Water Marine
Method	**Analyte**	**Units**						
18211	Total Suspended Solids	mg/L	9	12	27	21	39	14

Lab. Ref.			07NA7081	07NA7082	07NA7083	07NA7084	07NA7085	07NA7086
Client Reference			7	8	9	10	11	12
Sample			Water Marine	Water Marine	Water Marine	Water Marine	Water Marine	Water Marine
Method	**Analyte**	**Units**						
18211	Total Suspended Solids	mg/L	23	21	89	13	5	28

Lab. Ref.			07NA7087	07NA7088	07NA7089	07NA7090	07NA7091	07NA7092
Client Reference			13	14	15	16	17	18
Sample			Water Marine	Water Marine	Water Marine	Water Marine	Water Marine	Water Marine
Method	**Analyte**	**Units**						
18211	Total Suspended Solids	mg/L	43	44	50	98	75	37

Lab. Ref.			07NA7093
Client Reference			19
Sample			Water Marine
Method	**Analyte**	**Units**	
18211	Total Suspended Solids	mg/L	25

.... **19-Sep-2007**

Mara Fedczina
Chemist

07NA7075-07NA7093 Note: This report shall not be reproduced except in full, or used in any way for advertising purposes, without the written approval of the laboratory. The results relate to the sample(s) as received. Responsibility for sampling rests with the client.

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80504-1282 Printed: 13:11 19-Sep-07 mfp5

APPENDIX D: SEDIMENT SAMPLE ANALYSIS RESULTS

Australian Geomechanical Laboratories Pty Ltd
ABN 25 065 630 506
1/29 Finchley Street, Milton, Qld. 4064
P.O. Box 434, Paddington, Qld. 4064
Telephone: (07) 3217 5535
Facsimile: (07) 3217 5311
Email: aglabs@bigpond.net.au

PARTICLE SIZE DISTRIBUTION TEST REPORT

Test Method: AS1289 3.6.1, 2.1.1

Client:	W.B.M Pty Ltd	Report No.	709012-G
Project:	B16530	Test Date:	08/09/07
		Report Date:	10/09/07

Sample No.	709012	709013
Client ID:	Hamilton	Fisherman Island
Depth (m):	-	-
Moisture (%)	162.0	101.3

AS SIEVE SIZE (mm)	**PERCENT PASSING**	
19.0		
9.5		
4.75		
2.36		
1.18	100	100
0.600	98	99
0.425	96	98
0.300	95	96
0.150	93	93
0.075	90	89

Sample/s supplied by the client

Authorised Signatory

J. Russell

Manager

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BMT WBM Denver	**14 Inverness Drive East, #B132** **Englewood Denver Colorado 80112 USA** **Tel +1 303 792 9814 Fax +1 303 792 9742** **Email wbmdenver@wbmpl.com.au** **Web www.wbmpl.com.au**
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