Dispersal patterns and quantities of sediment discharged from the Markham River, Papua New Guinea.

Thesis submitted by

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In Christ Jesus, the Eternal One

To my mother, late Imila Uakai and father, Renagi Puele

My wife Ila and children

Ronald, Lisa Thomas and Jeremiah

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Abstract

The Markham River is a small river draining a tropical mountain range with altitudes between 1000 to 3000 m. The river has an estimated sediment load of 12 $Mtyr^{-1}$ and discharges directly into a submarine canyon. The estuary is located offshore, with a mixing zone outside the river channel. Profiles of salinity and suspended sediment concentrations (SSC) show that sediment is dispersed via a plume with components at both the surface, intermediate depth along isopycnal surfaces and along the steep seabed slopes in the Markham canyon. The dispersal pattern of the surface freshwater plume is largely determined by the buoyancy force. However strong northwesterly winds create upwelling along the fringes of the northern coast. During a high discharge event, the discharge was 1600 kgs^{-1} which amount to a daily load of 0.14 Mtons. Estimates of the horizontal sediment flux gradient of the surface plume along the estuary axis suggested that about 80% of the sediment discharge was lost to subsurface waters within a radial distance of 2 km from the river mouth. The layers of sediment within the water column contained about 0.03 Mtons which is about 30% of the daily discharge. The amount of suspended sediment accumulating in thick layers over the seabed is estimated to be about 0.4 Mtons which is about 4 times the daily discharge. Particle fall velocities estimated from the vertical flux indicate values less than those of highly flocculated material but particles will settle up to 100 m in a day. High SSCs observed near the seabed indicated sediment falling through the water column into a bottom boundary nepheloid layer. SSCs over the seabed did not exceed 1000 mgl^{-1} indicating continuous downslope flow of sediment. Sediment at this layer was either directly transported from the river mouth or from the seabed slopes where previously deposited fine material have been resuspended and transported along the seabed. Some of the sediment is transported by advection to form layers of high SSC at isopycnal surfaces. SSCs near the seabed of between 250 and 1000 mgl^{-1} suggest that layers of significantly elevated density existed near the seabed, moving under the influence of gravity down steep seabed slopes of the Markham canyon. The SSC data confirms that Markham River is a high yield river suitable for studying sediment transport mechanisms analogous to systems during low stand sea levels.

The application of the modified hydrodynamic Princeton Ocean Model (POM) has been successful for the Markham estuary. The model simulates surface plume distribution patterns under varying discharge and wind conditions which are comparable with measured data. The model clearly shows the behavior of the surface plume that tends to mix slowly along the fringes of the coast compared to the mixing of plume direct to open sea. The effect of the strong northwesterly wind that caused upwelling, have been well represented by the plume. The model proves to be suitable for predicting plume behavior for further studies on e.g. influence of changing river mouth features caused by weather patterns e.g. the El Nino cycle and the effects of the new tidal basin (700 m x 400 m x 14 m depth) development for the Lae Port Authority which will be dredged out from the swampy land adjacent to the Milford Haven Bay.

A new instrument called the Triple differential pressure sensor (TDPS) for measuring small (<100 mgl^{-1}) amounts of depth averaged suspended sediment concentrations (SSC) has been designed and a prototype built. The new instrument measures SSC directly without the calibration problems that can be associated with optical instruments. Although the specification of the differential pressure sensor indicate that resolutions of up to 10 mgl^{-1} can be reached, the prototype TDPS had resolutions of 100 mgl^{-1}. The low resolution can be attributed to the fabrication process where air pockets may have been trapped within the tubing channels of the device. Nevertheless, there is potential to improve the sensitivity of the instrument. The instrument can be used in coastal waters, rivers and lakes.

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Contents

Abstract 4

Acknowledgements 6

Contents 7

List of Figures 11

1 Introduction 21

1.1 Brief history of sediment transport studies 22

1.2 Focus on small rivers in New Guinea 24

1.3 Current Research 25

1.3.1 TROPICS 25

1.3.2 MARGINS Source-to-Sink 26

1.4 Focus on the Markham River 27

1.4.1 Basin and discharge properties 27

1.4.2 Plume transport effects of industrial developments 28

1.4.3 Plume transport effects on natural ecosystems 28

1.5 Hydrodynamic Model of the Lae Harbour 29

1.6 Instrumentation for measuring small changes in SSC in -situ 29

1.7 Objective of this study 29

2 Study Area 31

2.1 Markham River 31

2.2 The Study Site - The Markham Estuary 33

2.3 Regional Tectonics 33

2.3.1 Geology 33

2.3.2 Collision Margin 36

2.4 Local weather patterns 36

2.5 Observed sediment dispersal patterns in the Markham estuary 37

2.5.1 Dispersal by surface and subsurface plumes 38

2.5.2 Changes in river mouth morphology 38

3 Methods 40

3.1 Wind, tidal heights and waves 40

3.2 River height and discharge 41

3.3 Time series suspended sediment concentration (SSC) 42
3.4 Current Measurement 42
3.5 Water Column Observations 44
3.6 Sampling for OBS calibrations 44
3.7 Data Processing and Reduction 46
4 Results 47
4.1 Time series river height, tidal and wind activity 47
4.1.1 River Height 47
4.1.2 River and sediment discharge during the 2006 and 2007 field trips 47
4.1.3 The winds 49
4.1.4 The tidal levels 50
4.1.5 Wave activity 50
4.2 Time-series SSC data 51
4.3 Current Data 54
4.3.1 Current profiles at site 1 54
4.3.2 Drogue Results 57
4.3.3 Currents and SSC at site 4 58
4.3.4 CTDS profiles in the river and in close proximity outside of the river mouth 59
4.4 Water Column Observation 62
4.4.1 CTDS shallow profiles 62
4.4.2 Surface turbidity and salinity distribution 63
4.5 Deep CTDS Profiles (High Discharge) 66
4.5.1 High SSC and mixing at 30-50 m depth on 26/01/06 66
4.5.2 Deep profiles showing SSC layers along a isopycnal surface 68
4.5.3 Diverging plumes out of the river mouth 68
4.5.4 Deep profiles taken in 2007 69
4.6 Deep Profiles (Intermediate Discharge) 73
4.7 Depth profiles showing thermal activity 75
5 Analysis and Discussion 77
5.1 The river characteristics 77
5.1.1 The river flow and discharge 77
5.1.2 The bedload transport 78

5.2 Estuarine Characteristics ... 78
5.2.1 Riverine forcing ... 78
5.2.2 Separation of sediment at turbulent mixing zone ... 79
5.2.3 Surface Plume Characteristics ... 80
5.2.3.1 Surface plume flow regime ... 80
5.2.3.2 Degree of Stratification ... 81
5.2.4 Subsurface Water Column Structure ... 81
5.2.4.1 Density structure ... 81
5.2.4.2 Layers of sediment over the seabed ... 82
5.3 Variations in Plume SSC ... 82
5.3.1 Dispersal by surface plumes ... 82
5.3.1.1 The high discharge event and its influence ... 83
5.3.1.2 The tidal influence ... 83
5.3.1.3 The wind influence ... 83
5.3.1.4 Upwelling occurring along northern coast ... 84
5.4 Sediment budget ... 87
5.4.1 Percentages dispersed between surface and subsurface pathways ... 87
5.4.2 Sediment delivery to subsurface waters ... 91
5.4.2.1 Mass of sediment layers over isopycnal surfaces. ... 91
5.4.2.2 Sediment mass in layers close to the seabed ... 92
5.5 Summary of dispersal patterns and quantities dispersed ... 95
6 Numerical model of the Markham Estuary ... 97
6.1 Introduction ... 97
6.2 The POM Model ... 97
6.2.1 Description of the model ... 98
6.2.2 Major governing equations ... 99
6.3 Application to Markham Estuary ... 100
6.3.1 The model grid system ... 100
6.3.2 The model parameters and initial conditions ... 102
6.3.3 The boundary conditions ... 102
6.4 Results of Model ... 103

6.4.1 Salinity distributions during northwest winds and changing river discharge 103
6.4.2 The surface currents during northwesterly and high discharge 105
6.4.3 Salinity distributions during zero wind and southeast wind 106
6.5 Qualifying the authenticity of the model 108
6.5.1 Correlation between model and field salinity data 108
6.5.2 Comparing the model surface plume thickness against measured values 110
6.6 Other applications of the model 112
6.6.1 Results of current patterns predicted for the tidal basin 113
6.6.2 The changing river mouth 114
6.7 Discussions 115
7 Instrumentation for measuring suspended sediment concentration (SSC) 118
7.1 Introduction 118
7.2 The Principle of Design 119
7.3 Instrument 122
7.4 Methods 124
7.5 Results of sensor voltage output against concentration 125
7.6 Discussion 126
8 Conclusion 128
8.1 Markham estuary 128
8.2 Sediment dispersal patterns and quantities 129
8.3 The hydrodynamic model for the Markham estuary 129
8.4 Triple Differential Pressure Sensor for measuring SSC 130
References 131
Appendix A – Additional Results 142
Appendix B – Specifications for Differential Pressure Sensor 149

List of Figures

Figure 2.1 Map of PNG showing the Markham River. The study area is the estuary where the Markham River discharges. Other large rivers on the Island are also shown. 32

Figure 2.2 Google-Earth photo showing the Markham Estuary, the study site. Lae City port is 1 km away from the river mouth. A mangrove swamp (known as the Labu Lakes) is in the vicinities of the Markham River channel. 34

Figure 2.3 Map of PNG showing the tectonic boundaries along the Ramu-Markham fault between the Australian plate and the South Bismark plate. The lower region of the Markham River runs along the Ramu-Markham fault and discharges into the inner Huon Gulf (borrowed from Liu et al. (1995)). 35

Figure 2.4 A detailed bathymetry (m) after Buleka et al (1999) showing steep slopes of the Markham canyon. The average slope is 13^{o} only 30 m away from the mouth. The slopes decrease to 8^{o} about 4 km out of the river. The northern seabed slopes at 14.9^{o} and there are regions of 45^{o} slopes at the tectonic plate collision zone at 350 m water depth. The location of the Butibum River is also shown. 37

Figure 2.5 River mouth features changing with seasonal weather patterns (a) Google Photo in Jan. 1999, (b) observed in Aug. 2003 (c) of a Google map captured in Nov. 2003 (d) observed in Jan. 2006 (e) observed in March 2007. 39

Figure 3.1 Map of the study site showing deployment sites (black bold rings with numbers) for Optical Backscatter (OBS) sensors that measured time series SSC. Sites E, A and F were initial positions of drogues that where used for measuring surface and subsurface (10 m) currents. **WS** was the site for the weather station that measured wind speed and direction. 41

Figure 3.2 Enlarged map of the river mouth showing the bathymetry inside and just outside of the mouth. 43

Figure 3.3 Map of study site showing shallow CTDS profiles sites (+) used for determining surface SSC and salinity distributions and (x with letters besides) are sites where deep CTDS profiles were taken. 45
Figure 3.4 Calibration curves for (a) the OBS (n827) and (b) the SSC sensor for the Falmouth CTDS Profiler. 45
Figure 4.1 Time series Time series of (a) river height, (b) wind direction and (c) wind speed, (d) tide levels, (e) significant wave height (H_s) taken during the field trip in 2006. CTDS profiling was carried out on days indicated by the shaded strips. 48
Figure 4.2 Graphs showing (a) the correlation between river discharge and height. The correlations is used to determine the discharge activity for Jan. – Feb. 2006 trip (b) for the Mar. 2007 trip (c). CTDS profiling was carried out on days indicated by the shaded strips. 49
Figure 4.3 Graphs showing (a) correlation curve between sediment discharged and river height. The correlation is used to determine sediment discharge during 2006 (b) and 2007 (b) field trips. CTDS profiling was carried out on days indicated by the shaded strips. 50
Figure 4.4 Wave spectrum data for 18:01 hrs burst taken on 18/01/06. (a) Wave energy spectrum showing two types of waves. (b) The direction 'from' which the waves came. Wave type (I) represent swells coming from the southerly direction and type (II) represent waves generated by the local northeasterly sea-breeze. 51
Figure 4.5 Time series SSC data at (a) site 1 surface, (b) site 1 near seabed, (c) site 2 surface (d) site 2 near seabed, (e) site 3 near seabed (f) site 5 near sea bed (g) site 6 near seabed. (Note differences in the y-axis scale). Shades indicate days on which CTDS profiles were taken. 53
Figure 4.6 Time series current taken at site 1 for velocity (a) and direction (b) for cell 7 (sea surface) about 7.45 meters from the seabed, and velocity (c) and direction (d) for cell 1 which was 0.45 m from the seabed 55
Figure 4.7 Profiles of 1 m vertical bins at site 1 during low tide taken on 01/02/06 showing current (a) velocity (b) direction. The currents were coming from east to west with velocities of 0.1 ms^{-1}. Current

velocities at the lower 3 m of the water column were less than 0.05 ms^{-1}. The horizontal bars represent errors of velocity taken as the standard deviation of 5 to 6 different velocity readings for profiles taken during the single low tide period. 56

Figure 4.8 Profiles of current (a) velocity (b) direction taken at site 1 on 01/02/06 during high tide showing currents to the east at the surface and to the southwest near the bottom. The velocities are around $0.05ms^{-1}$. 56

Figure 4.9 Current profiles at site 1 taken during high tide and a strong north-westerly wind on 02/02/06 showing (a) velocities and (b) direction to the west at the surface and to the south a depths below 6 m............ 57

Figure 4.10 Velocity vectors for surface and subsurface (10 m depth) drogues drifting on 15/02/06 between 1030 and 1130hrs at transect I near the river mouth, between 1310 and 1340 hrs at transect III, between 1400 and 1430 hrs at the transect II. The wind changed direction from northwest to southeast at 1330 hrs. 58

Figure 4.11 InterOcean S4 current meter (current direction and velocity), SSC and tidal height at site 4 taken on (a) 31/01/06 (b) 01/02/06 during rising tides (c) 20/02/06 and (d) 22/02/06 during falling tides. 60

Figure 4.12 Depth profiles of (a) salinity, (b) temperature, (c) SSC taken in the river showing no upstream flow of seawater and (d) salinity, (e) temperature and (f) SSC taken 10m seaward off the river mouth taken on 14/03/07 showing ambient seawater properties below the discharge point. 61

Figure 4.13 Profiles of (a) salinity, (b) temperature and (c) SSC taken 14/03/07 and 40 m away from the river mouth indicating a well mixed layer between 4 and 16 m water depth. Changes in salinity and temperature at 17 m depth indicates a surface of a different layer of water body.. 62

Figure 4.14 Shallow CTDS data recorded on 20/01/06 showing (a) near surface SSC profiles at sites (a) A, (b) B and (c) C. Concurrent (d) salinity (ppt), (e) temperature (^{o}C) and (f) sigma-t' (kgm^{-3}) profiles are also shown. 63

Figure 4.15 Contours of SSC estimated from profiles (sites indicated by +) taken on 31/01/06 showing a radial distribution in the estuary. 64
Figure 4.16 Contours of salinity estimated from profiles taken on 31/01/06 showing a distribution with a wide area of plume of salinities between 12 – 14 ppt extending towards the port area. 65
Figure 4.17 Contours of surface SSC (mgl^{-1}) estimated from profiles taken at sites (+) on 08/02/06 showing a distribution with extended area of SSCs between 200 – 300 mgl^{-1} near the port area................................ 65
Figure 4.18 Surface salinity (ppt) contours estimated from profiles taken on 08/02/06 showing surface plumes with less than 16 ppt edging along the shorelines. High salinity (~22 ppt) was observed in the Milford Haven Bay indicating effects of upwelling............................. 66
Figure 4.19 Map showing sites G, H, I and J where deep profiles were taken on 26/01/06.. 67
Figure 4.20 SSC profiles taken on 26/01/07 along the nearshore zone of the northern coast at sites G, H, I and J showing high SSC layers below 25 m depth. This is a thick layer of SSC transported along isopycnal surface. The profiler did not reach the seabed. 67
Figure 4.21 Salinity and temperature profiles taken at site G, H, I and J on 26/01/06 showing stratification above 40 m water depth where the salinity values are less than 34.5 ppt. 68
Figure 4.22 (a) SSC (mgl^{-1}) profiles for sites A, B and C (Fig. 4.14) along the river axis, (b) concurrent salinity (ppt), temperature (^oC) and sigma-t' (kgm^{-3}) all recorded on 20/01/06 during a period of high discharge. The arrows indicate an isopycnal surface where layers of high SSC (1000 mgl^{-1}) existed. 69
Figure 4.23 CTDS profiles taken on 20/01/06 during high discharge period. (a) SSC Profiles at site D, A and E (site locations in figure 4.19) representing a section across the river mouth. Note that profiles reached the seabed and the high SSC near the seabed indicate accumulation of settling sediment (b) Concurrent salinity (ppt), temperature (^oC) and sigma-t' (kgm^{-3}) for each site. 71

Figure 4.24 Depth SSC profiles taken in March 2007 at sites C, K, L and M during (a) intermediate discharge (b) 2 days after a high discharge event (c) 5 days after the same high discharge.................................... 72

Figure 4.25 SSC profile taken on 30/03/07 at site N (Fig. 4.19) near to the northern coast at 150 m depth showing near-zero SSC in the water column indicating that sediment layers with high SSC (Fig. 4.24) are maintained in the canyon.. 73

Figure 4.26 Profiles of (a) SSC (mgl^{-1}) at site A, B and K along the river axis showing relatively lower SSC in the water column. (b) Concurrent salinity (ppt) and temperature (^{o}C), all recorded on 06/02/06 during a period of low discharge showing well-mixed layers at the surface and between 5 and 10m indicating the halocline and below 20m depths indicating a different water body..................................... 74

Figure 4.27 Deep SSC profile recorded at site C on 23/03/07 during a intermediate discharge period showing existence of high SSC layers above the seabed... 75

Figure 4.28 Depth profiles taken at site F of (a) SSC (b) salinity (c) temperature and (d) sigma-t' for the down-cast while (e), (f), (g) and (h) show respective parameters for the up-cast profiles. This data indicates a possible thermal event... 76

Figure 5.1 Google Earth photo showing standing waves (circled) indicating an outflow with a densimetric Froude number equal to 1 in the shallow parts of the river mouth... 77

Figure 5.2 An along-river section of the mouth showing sediment laden river water interacting with seawater just off the river mouth. Mixing occurs between the seawater and the river water interface and lifts off over the ambient sea water. Sediment and freshwater largely separate at this point and water with high SSC is formed and moves downslope... 80

Figure 5.3 Correlation between wind direction and SSC at site 1 (a) and site 2 (b) showing higher SSC during southeasterly winds compared to lower SSC during northwesterly winds. Correlations between northwesterly wind speed and SSC for site 1 (c) and for site 2 (d) show low SSC during high northwesterly wind speeds compared to high SSC during low wind speeds. This indicates that buoyancy forces dominated wind stress during weak NW winds forcing the plume towards the northern coast. 84

Figure 5.4 Correlation between wind direction and SSC at site 5 (a) and site 6 (b). SSC was relatively higher during northwesterly winds compared to SSC during southeasterly winds. Correlations between northwesterly wind speed and SSC are shown for site 5 (c) and for site 6. These graphs indicate that buoyancy forces were again dominant during weak NW winds forcing the plume towards the western coast. 85

Figure 5.5 A photo showing (arrows towards green water body in the bay) as remnants of upwelling caused by strong northwesterly winds. The surface plumes from the river move slowly into the bay as the wind subsides. 86

Figure 5.6 Photo showing clean seawater in the northern coast of the Milford Haven Bay as a result of upwelling caused by strong northwesterly winds. The surface plume off the Markham River is parallel to the north coast and edges towards the coast as the winds subside. Inset: showing the plan of the camera view 86

Figure 5.7 Schematic diagram of the estuary showing changes in vertical flux and load loss within 2 km distance of the river mouth. Estimates of suspended sediment fall velocities are also shown. 89

Figure 5.8 Correlation between surface SSC and salinity. Curve I represents a conservative mixing curve with no sediment lost from suspension. The points (**x**) represents the actual salinity and SSC values estimated from data recorded on 08/02/06 along the river axis. At a section of the estuary where the salinity is 22 ppt, approximately 70% of material in the surface plume was lost to the sub-surface layers. 90

Figure 5.9 Contours of SSC in the water column obtained by applying the Kriging function to SSC profiles taken on 20/01/07 (Fig. 4.22(a)) showing sediment layers with ~ 900 mgl^{-1} at 75 m water depth. 92

Figure 5.10 The dashed enclosed trapezium shape is the estimated area over which the subsurface plume spreads. The area (Area I) is used to

determine the quantity of sediment existing over isopycnal surfaces. Area II is used to estimate mass of sediment accumulated over the seabed. 93
Figure 5.11 Contours of SSC in the water column during an intermediate discharge on 23/03/07. 94
Figure 5.12 Contours of SSC of the water column from data collected 2 days after a high discharge event. 94
Figure 5.13 Contours of SSC in the water column 5 days after a high discharge event a clear water above with high SSC layers near the seabed.......... 95
Figure 6.1 Grid points in the harbour. The dark lines in the north and west indicate the shoreline and the colored lines represent the bathymetry (m). The boundary adjacent to the river is called the river-mouth boundary. 102
Figure 6.2 Salinity distribution during the northwest winds and low freshwater discharge (250 m^3s^{-1}) from the Markham River end. Notice the high salinity region in the Milford Haven Bay and close to the Lae coastline caused by upwelling when the north-westerly winds drive the surface plume seaward. The shoreline is represented by the black lines to the north and the west. 104
Figure 6.3 Salinity distribution with northwest wind (10 $kmhr^{-1}$) and freshwater intermediate discharge of 520 m^3s^{-1}. 104
Figure 6.4 Salinity chart for northwesterly wind high discharge 1200 m^3s^{-1} showing extension of the surface plumes further seaward................. 105
Figure 6.5 Surface current patterns concurrent with salinity chart (Fig. 6.4) for northwesterly winds and high discharge (1200 m^3s^{-1}).................. 106
Figure 6.6 Salinity distributions for the surface layer (***k*** = 1) at intermediate level of discharge, which is approximately 520 $m^{-3}s^{-1}$. Zero wind has been applied here. The plume extends further seaward compared to plumes during periods of low discharge. 107
Figure 6.7 Salinity distribution of the ***k*** = 2 layer which is at depths of (0.018*total water depth). Zero wind was supplied here. This distribution shows that the clear seawater of 35 ppt is further up the river axis indicating that the thickness of the surface plume is very thin, consistent with field measurements (Fig. 4.14). 108

Figure 6.8 Salinity chart for intermediate discharge (520 m^3s^{-1}) and southeasterly wind showing strong mixing in the Milford Haven Bay. The surface mixed layer moves south even during the southeasterly winds. 109
Figure 6.9 Surface currents patterns for southeasterly wind and intermediate discharge (520 m^3s^{-1}).. 109
Figure 6.10 Correlation between measured surface salinity on 30/03/07 (Fig. A6) and model salinity distribution (Fig. 6.8) for southeasterly wind and intermediate discharge. Conditions of discharge and wind effects applied to model were similar to actual conditions on 30/03/07.. 110
Figure 6.11 Isohalines of the surface plumes prepared from model data plotted for ***k*** layers up to 4 m depth with radial distance from the river mouth. It can be seen that further than 2000 m from the mouth boundary, the thickness of the plume is greater than the thickness of the top model layer. 111
Figure 6.12 Comparing salinity data with distance from the river mouth (a) for raw model surface results against measured salinity at sites along the river axis. The raw data are higher than the measured data. (b) corrected model surface salinity determined by taking the salinity at ***k*** =1 layer as the average value between ***k*** = 1 and 2 and taking the difference of two values from the average value. 112
Figure 6.13 The plan area of the tidal basin (700 m x 400 m x 14 m depth). The area will be dredged to 14 m depth and the waste will be pumped and dumped at 25 m depth 500 m from the river mouth....... 113
Figure 6.14 Surface current patterns during southeasterly wind (10 $kmhr^{-1}$) and intermediate discharge (520 m^3s^{-1}) conditions showing currents directed into the tidal basin. 114
Figure 6.15 Currents at ***k***4 depth (0.071 of water depth) showing subsurface currents directed out of the tidal basin. 115
Figure 6.16 Surface current patterns during northeasterly and intermediate discharge conditions indicating very low (< 0.05 ms^{-1}) flow in the tidal basin while currents are directed seaward outside of the Milford Haven Bay. 116

Figure 7.1 Design of the system with a differential pressure sensor to measure small changes in pressure as sediment falls in enclosed water column. 123
Figure 7.2 A linear relationship between the pressure sensor output voltage and concentration. 125
Figure 7.3 Graph showing the relationship between the raw logger units the pressure sensor voltage when in response to increasing mass in the water column. 126
Figure 7.4 Graph showing relationship between raw logger units and concentration for small increments in concentration. 1 logger unit is equal 100mgl^{-1}. 126
Figure A 1 Surface SSC (mgl^{-1}) contours produced from shallow CTDS profiles taken on 16/02/06. The data for each site (+) profiled was taken as the average SSC of the top 0.5 m of the profile. 142
Figure A 2 Concurrent surface salinity (ppt) contours produced from shallow CTDS profiles taken on 16/02/06. The data for each site (+) profiled was taken as the average salinity of the top 0.5 m of the profile. 143
Figure A 3 SSC surface contours for profiles taken on 14/03/07 during intermediate discharge.. 143
Figure A 4 Concurrent salinity contours for profiles taken on 14/03/07 144
Figure A 5 Surface SSC contours estimated over the harbour with profiles taken on 30/03/07. 144
Figure A 6 Concurrent salinity contours for profiles taken on 30/03/07 145
Figure A 7 Map showing sites for deep profiles which are shown in the rest of the appendix A. 145
Figure A 8 Deep SSC profiles taken on 17/01/06 taken at sites O, P, Q, R, S, T, U, V and W (Fig. A7) showing large subsurface SSC layers beyond 30 m depths with higher values near the river mouth and decreases with distance from the river mouth. 146
Figure A 9 Profiles taken near the river mouth at sites A and D (Fig. 3.3) along the river axis taken on 30/01/07 during high discharge event showing high (~ 500 mgl^{-1}) in the water column. 147

Figure A 10 SSC profiles near the river mouth and along the river axis taken on 23/03/07 during intermediate discharge showing low SSC at sites A and B (Fig. 3.3) closer to the river mouth. However, in deep waters at site C, there were layers of sediment with high SSC indicating presence of fluid mud. 147

Figure A 11 SSC profiles taken at site Y (Fig. A7) on 20/01/06 showing a 20 m thick fluid mud layer over the seabed. 148