APPENDIX 9 – HYDRODYNAMICS

A9.1 INTRODUCTION

The aim of the Lake Currimundi Dynamics Study is to provide an adaptive management plan for the entrance of the lake. This area has changed considerably over the years due to anthropogenic and/or natural actions. Over the few decades or so, the population has grown considerably and the catchment area has developed with the creation of canals and the latest connection to Lake Kawana. This has raised certain issues within the community including water quality, beach and bank erosion and biting midge nuisances. In order to address these issues a continuous on-going monitoring program was proposed. The field exercises described below were aimed at collecting water quality data, hydrodynamic data and bathymetric surveys of the entrance in order to create a database of information on which a monitoring program could be based, and to calibrate a hydrodynamic model for scenario simulation.

A9.2 PRELIMINARY FIELD EXERCISE – JULY 2007

Preliminary testing began on the lake in late July prior to the dune re-profiling work and construction of the wading pool at the entrance of Lake Currimundi. This presented an opportunity to establish some baseline data to assist in the final design of the monitoring program.

A9.2.2 Results

A hydrographic survey was carried out over a two-day period, 26 and 27 July 2007, using a SonTek Argonaut velocity profiler and other various equipment. Five sites (see Figure A9.1) along the lake were analysed and the GPS location of each site was noted as well as the water temperature, depth and water flow direction.

Additional aerial photographs of the lake entrance were taken from The Entrance apartment complex.

Figure A9.1: Map of Lake Currimundi with field trip no.1 site locations (Source: Google Earth)

Water Level

The water height was measured using the tide board at the boat ramp (see Figure A9.1). Measurements were taken approximately every hour for the days leading up to the sand re-profiling (see Figures A9.2 and A9.3). This was done to see how much influence the tide had on the water levels in the lake.

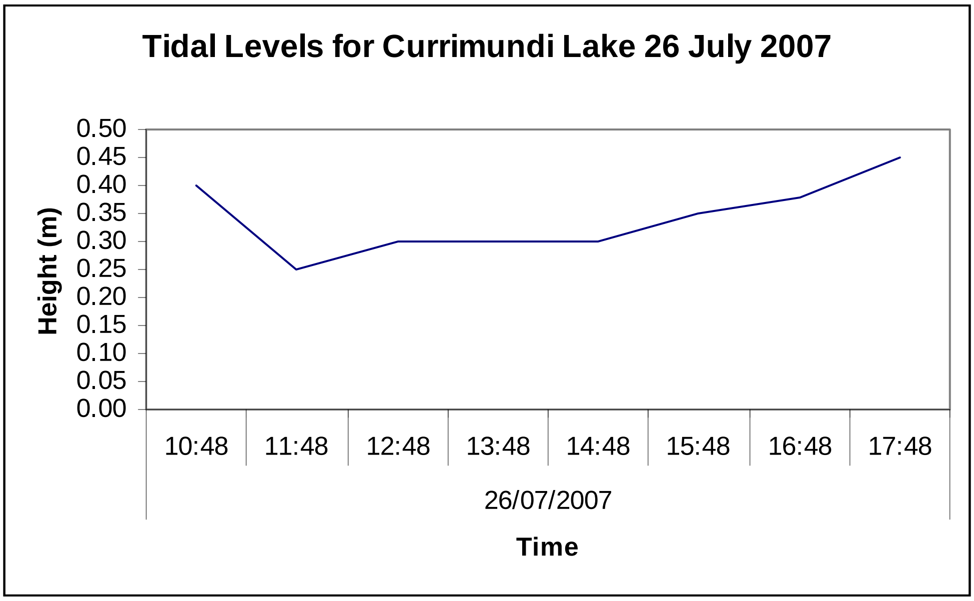


Figure A9.2: Tide levels for Lake Currimundi for 26/07/07

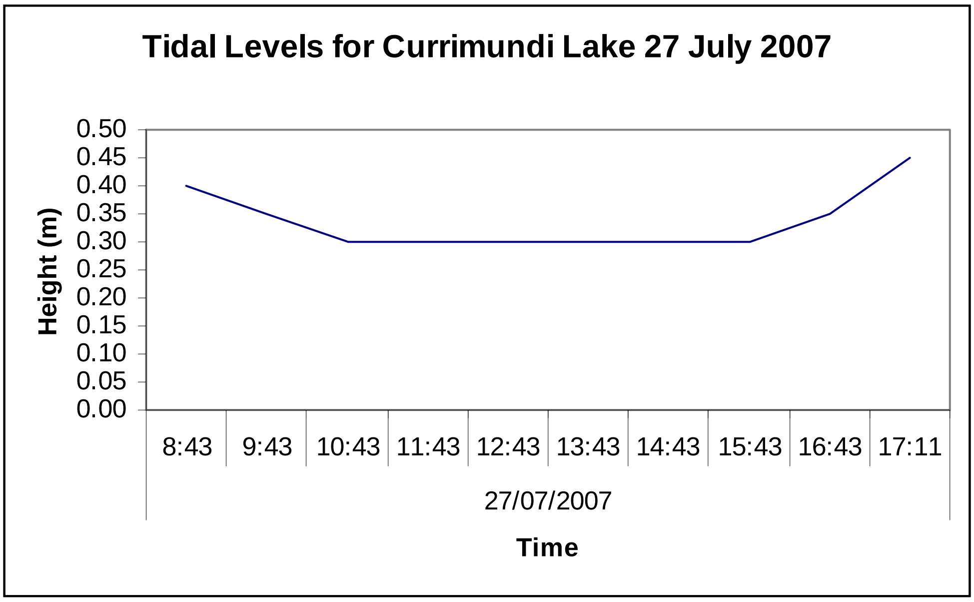


Figure A9.3: Tide levels for Lake Currimundi for 27/07/07

Continuous Velocity Profiling

The Argonaut was launched at 9:32am on 26th July 2007, upstream of the boat ramp under the bridge at a depth of 2.0 m. This location was chosen as the most likely place to identify current flow. The Argonaut was placed in this location for the duration of the study and retrieved at 5:04pm on 27th July 2007. Unfortunately the data was corrupted and is of no use.

Current velocity

Current velocity readings were also taken using a hand-held impellor current meter. Readings were taken in centre-channel at five different sites (see Figure 129) located from the entrance through to the weir. The current invariably was parallel to the channel.

The measured velocity (m/sec) is representative and realistic for a typical estuarine environment. Velocity levels were higher at site 5 located at the Lake Kawana weir (see Figures A9.4 and A9.5).

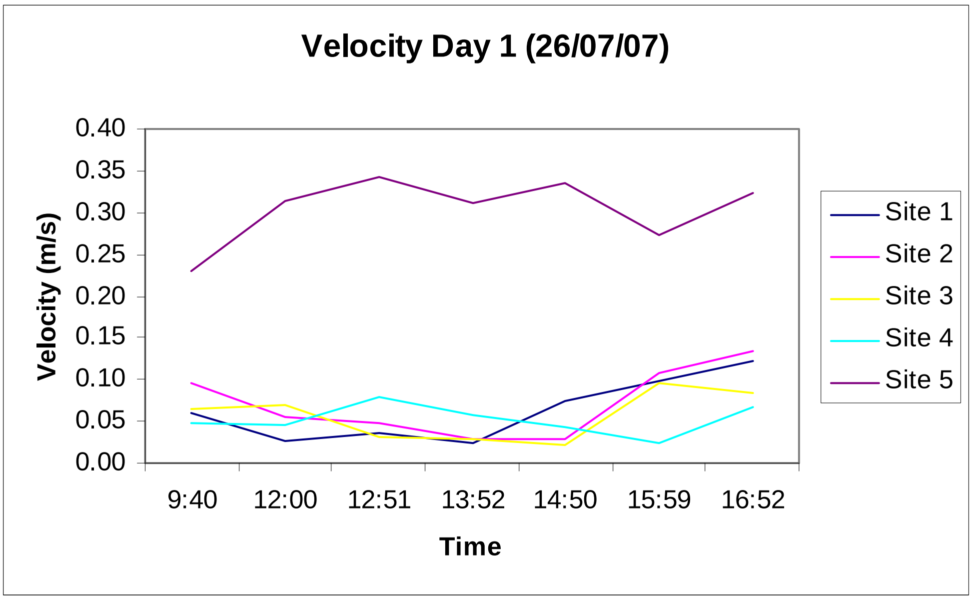


Figure A9.4: Velocity readings for Lake Currimundi on 26/07/07

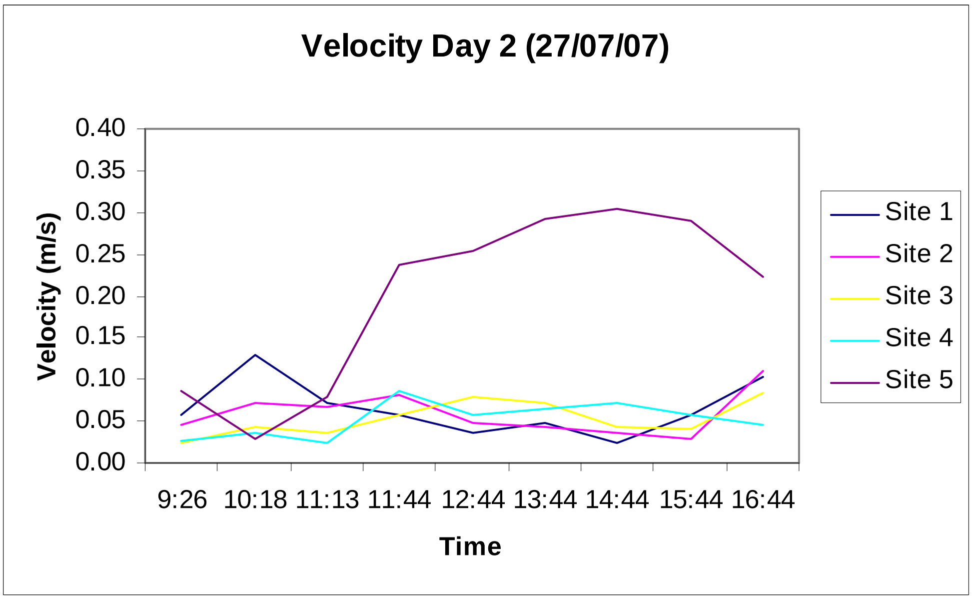


Figure A9.5: Velocity readings for Lake Currimundi on 27/07/07

A9.2.3 Discussion

The main finding of this exercise was that the velocity of tidal flow is relatively low throughout the lake with typical values of 0.05 – 0.1 m/s. Tidal range was also small at around 0.2 m. There was a considerable phase lag (around 4 hours) between the increase in velocity on the outgoing tide at the bridge and at the weir location. Presumably the higher velocity at the weir is a function of the onset of controlled flow over the weir on the outgoing tide. These findings are consistent with a highly constrained entrance.

A9.3 PRELIMINARY FIELD EXERCISE – OCTOBER 2007

Further fieldwork was hastily organized to coincide with an entrance closing and opening cycle to control biting midge. Fieldwork was completed on the Lake from the 24th October to the 29th October 2007, in conjunction with the final stages of the entrance closure to control midge. In particular, the purpose of the exercise was to monitor the changes during and immediately after the opening on the 26th October 2007. Water quality measurements were also taken in relation to temperature, pH, dissolved oxygen and conductivity as part of a preliminary assessment of requirements for a major water quality monitoring planned for 2008. Velocity data were again measured, this time at different locations mainly near the entrance, as well as measurements of tidal range.

Water Level - Pressure Gauges

Pressure gauges were deployed to monitor water level. Gauge No. 1 (see Table A9.1) was located at the boat ramp of Lake Currimundi on the tide board (S 26°45.913, E 153°07.725). The gauge was attached to the tide board using tie wraps, as low as could be managed. Water level was measured from the top of the gauge to the surface of the water and this was noted. The water level was also noted for the tide board so a correlation could be made at later dates. It was left in the water for the entire of the study and removed at 5:00pm on the 29th of October 2007. The absolute level of the tide gauge is yet to be determined by land survey.

Table A9.1: Gauge No.1

At time of installation 10:15 24-10-2007	Total Water Depth	1.20m
	Gauge to Water surface	0.88m
	Tide Board Water Depth	1.01m
At time of removal 16:20 29-10-2007	Gauge to Water Surface	0.39m
	Tide Board Water Depth	0.52m

Gauge No. 2 (see Table A9.2) was located on the pontoon jetty up stream of the boat ramp (S 26°45.667 E 153°06.984). This was near the confluence of the canal developments and the natural waterways. It was attached to the left hand pylon when standing on the bank facing the jetty. The gauge was attached to the pylon using tie wraps, as low as could be managed. Water level was measured from the top of the gauge to the surface of the water and this was noted. The height from the gauge to marks on the pylon was also noted so a correlation could be made at later dates.

Table A9.2: Gauge No.2

At time of installation 14:45 24-10-2007	Total Water Depth	1.39m
	Gauge to Water Surface	1.11m
	Gauge to Pillion Cap	2.85m
	Gauge to RL2.0 Line	2.27m
At time of removal 16:11 29-10-2007	Gauge to Water Surface	0.62m
	Gauge to Pillion Cap	2.85m
	Gauge to RL2.0 Line	2.27m

Water Quality

Using YeoKal and TDS instruments the water quality parameters of dissolved oxygen (ppm) (see Figure A9.6), temperature (°C) (see Figure A9.7), conductivity (ms/cm) (see Figure A9.8) and pH (see Figure A9.9) were measured. These measurements were taken at eight locations through out the lake and canal system (see Figure A9.1). At each site measurements were taken at the surface and then at 1.0 m intervals to the bottom. The measurements were taken both before and after the opening of the entrance on the 26th October 2007.

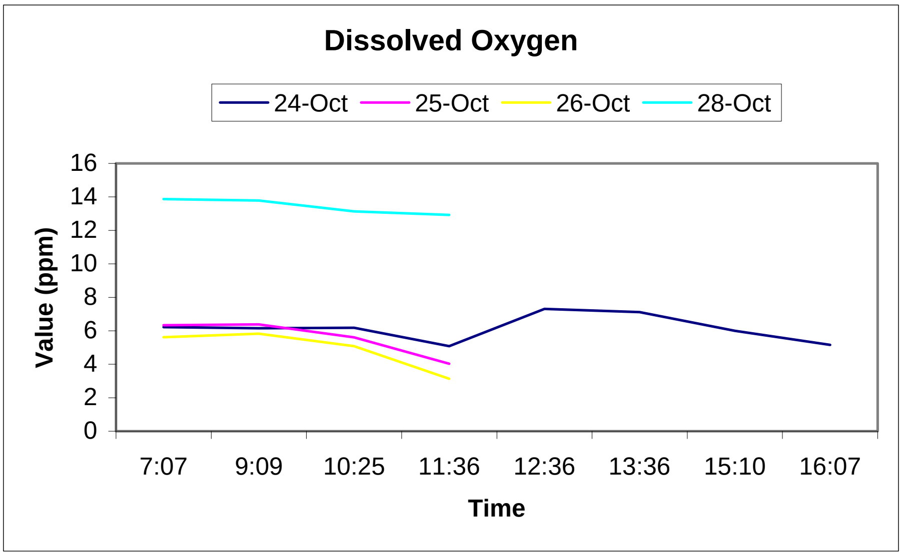


Figure A9.6: Dissolved Oxygen data collected at the Argonaut site using YeoKal

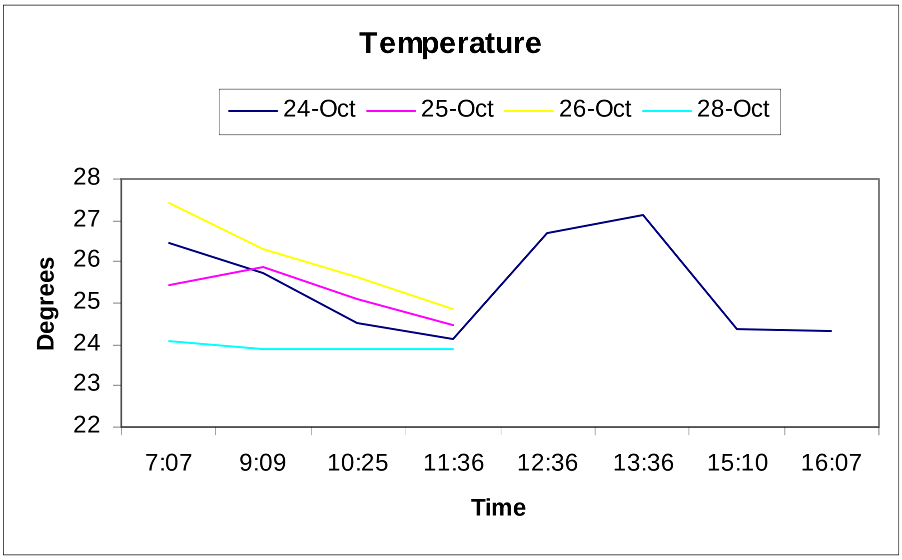


Figure A9.7: Temperature data collected at the Argonaut site using YeoKal

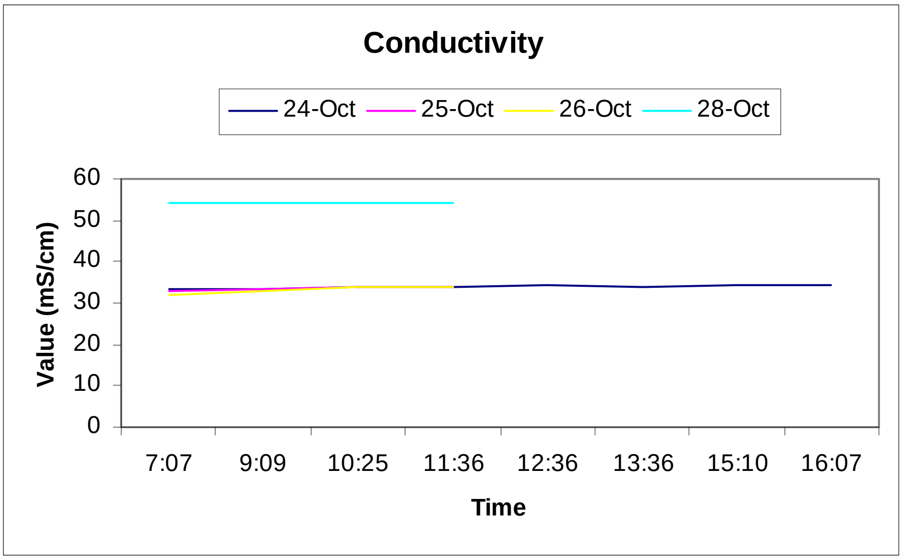


Figure A9.8: Conductivity data collected at the Argonaut site using YeoKal

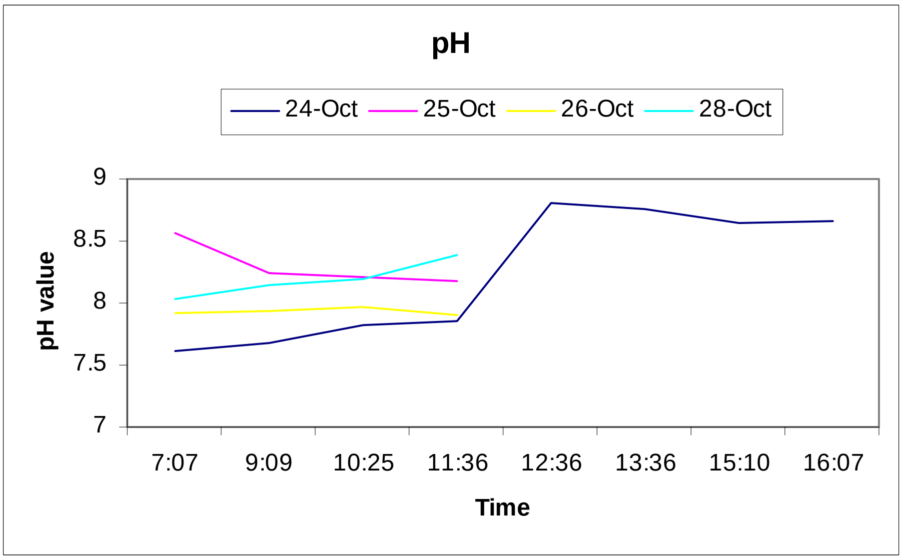


Figure A9.9: pH data collected at the Argonaut site using YeoKal

Water Level

The water level was measured using the tide board at the boat ramp (see Figure A9.1). Measurements were taken approximately every hour for the days leading up to the opening of the entrance and every 30 minutes after the opening. Very little change was expected before the opening because the entrance was closed and the Lake Kawana pumps were not operating for most of the time. It was expected that once there was tidal influence there would be rapidly changing heights (see Figures A9.10, A9.11 and A9.12).

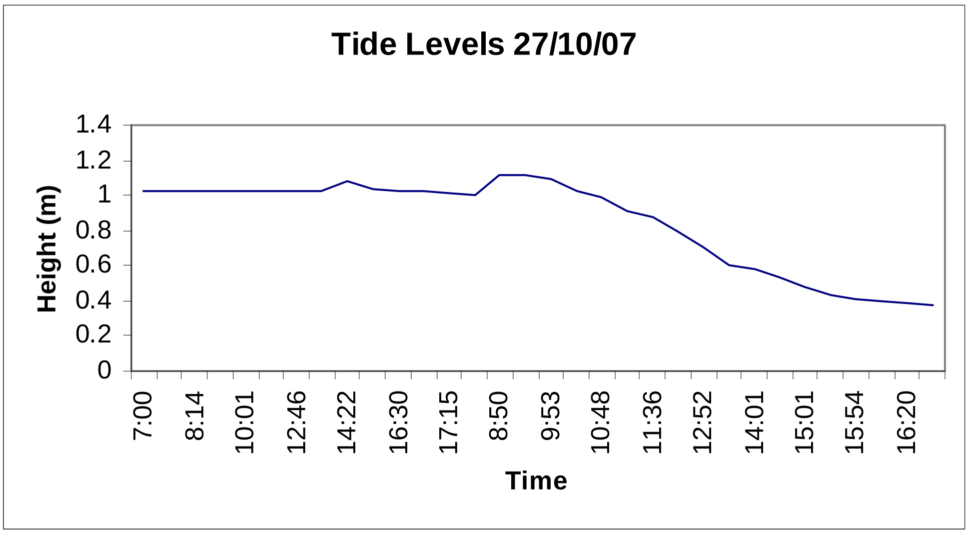


Figure A9.10: Tide levels for Lake Currimundi on 27/10/07

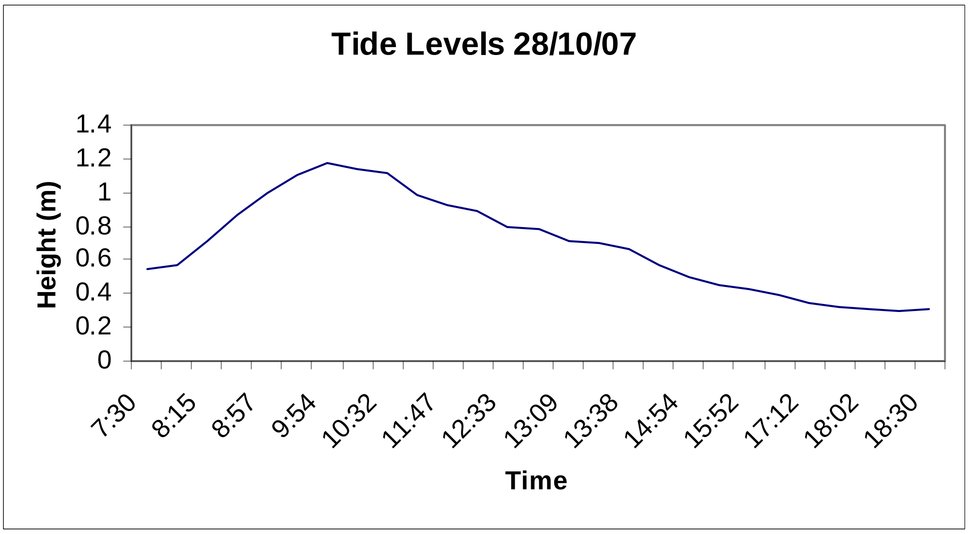


Figure A9.11: Tide levels for Lake Currimundi on 28/10/07

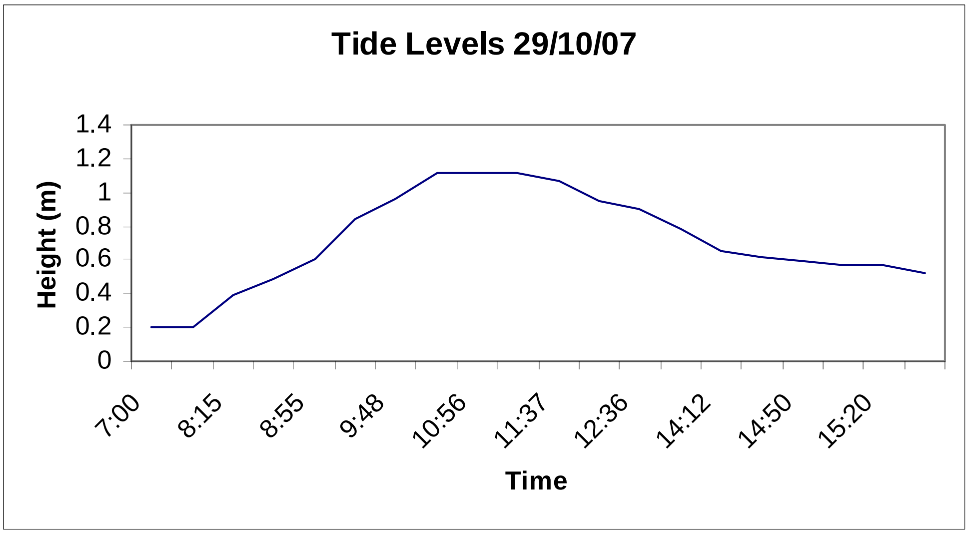


Figure A9.12: Tide levels of Lake Currimundi on 29/10/07

Point Velocity Measurement

Current velocity readings were taken using an impellor current meter. Readings were taken before and after the opening of the entrance. The readings taken before were used to demonstrate that there was very little or no current flow before the opening of the entrance (see Figures A9.13 to A9.21). Once the entrance was opened readings were taken at nine sites (see Figures A9.22a and A9,22b). The sites were located from the entrance through to the weir.

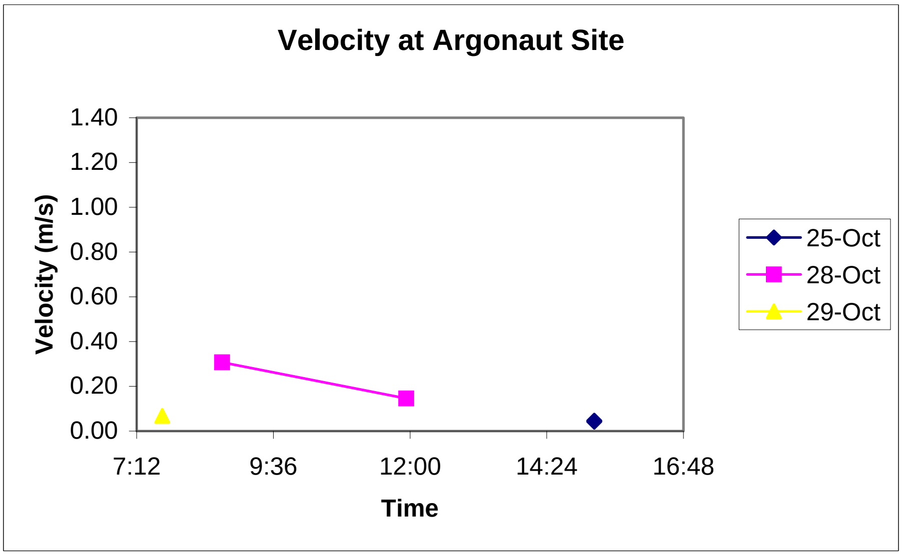


Figure A9.13: Velocity readings for Lake Currimundi at site 1

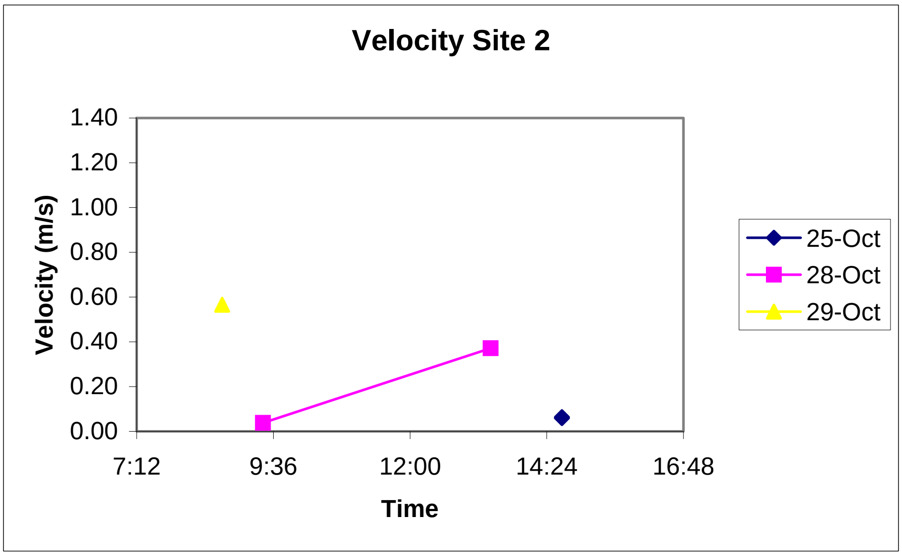


Figure A9.14: Velocity readings for Lake Currimundi at site 2

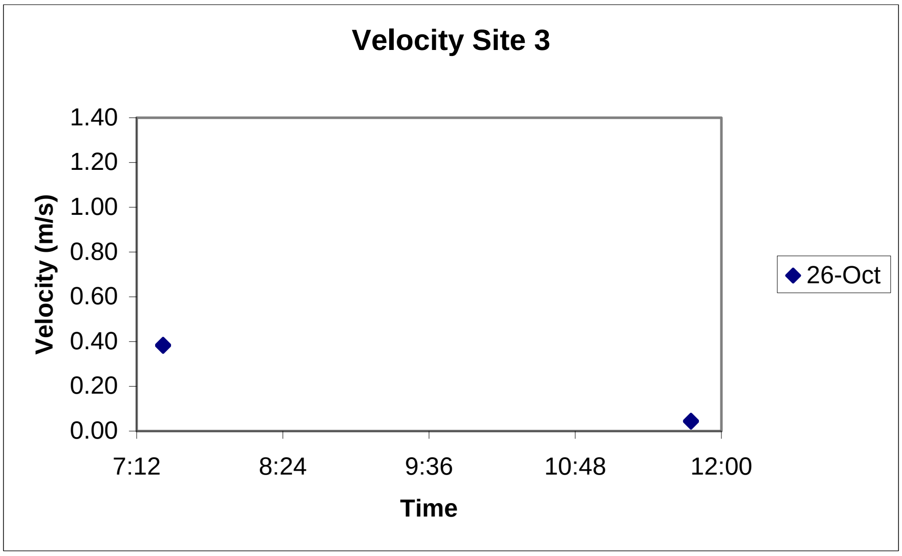


Figure A9.15: Velocity readings for Lake Currimundi at site 3

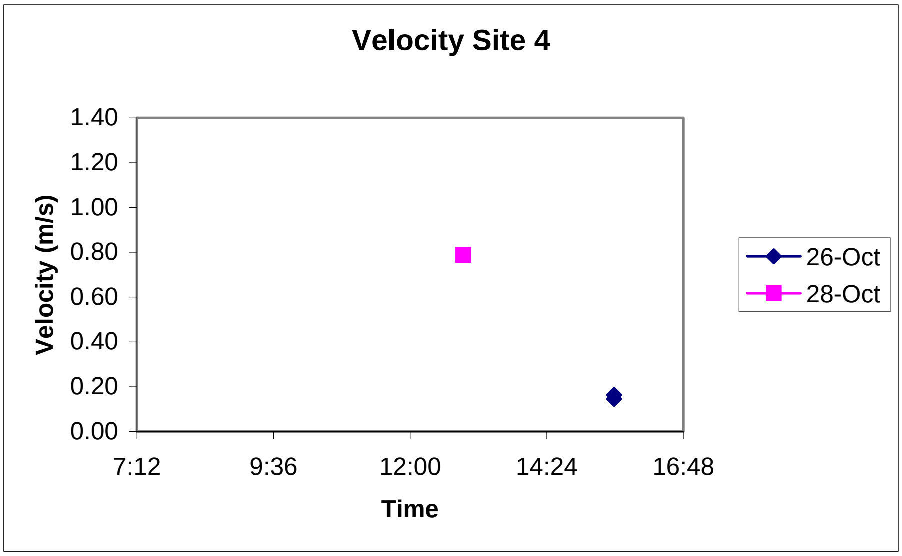


Figure A9.16: Velocity readings for Lake Currimundi at site 4

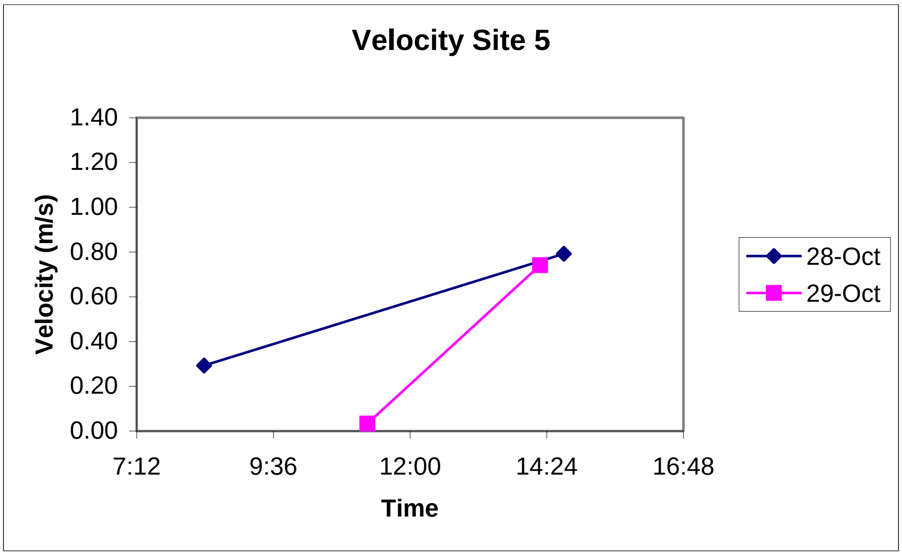


Figure A9.17: Velocity readings for Lake Currimundi at site 5

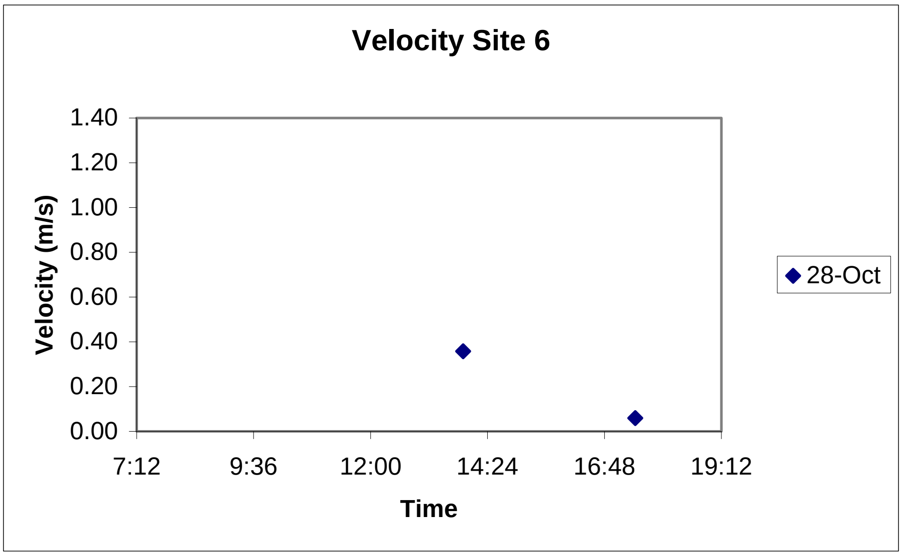


Figure A9.18: Velocity readings for Lake Currimundi at site 6

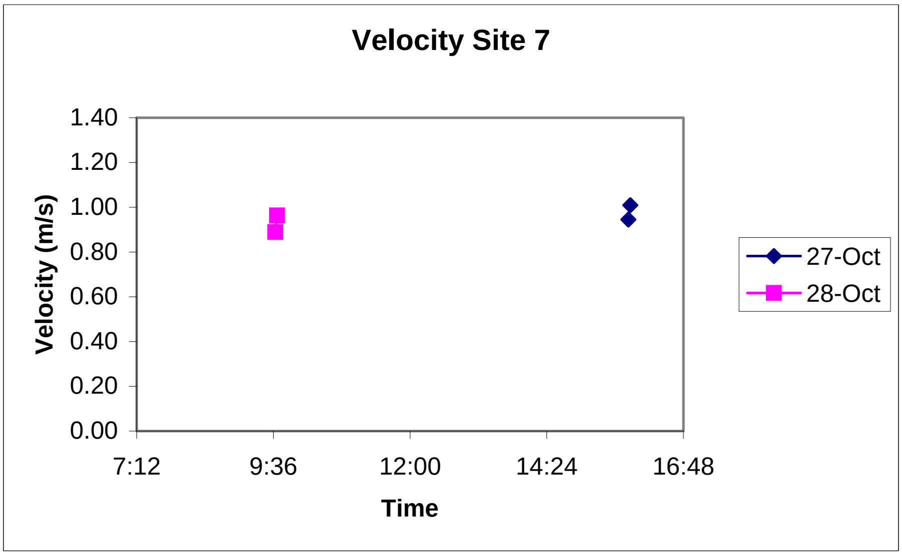


Figure A9.19: Velocity readings for Lake Currimundi at site 7

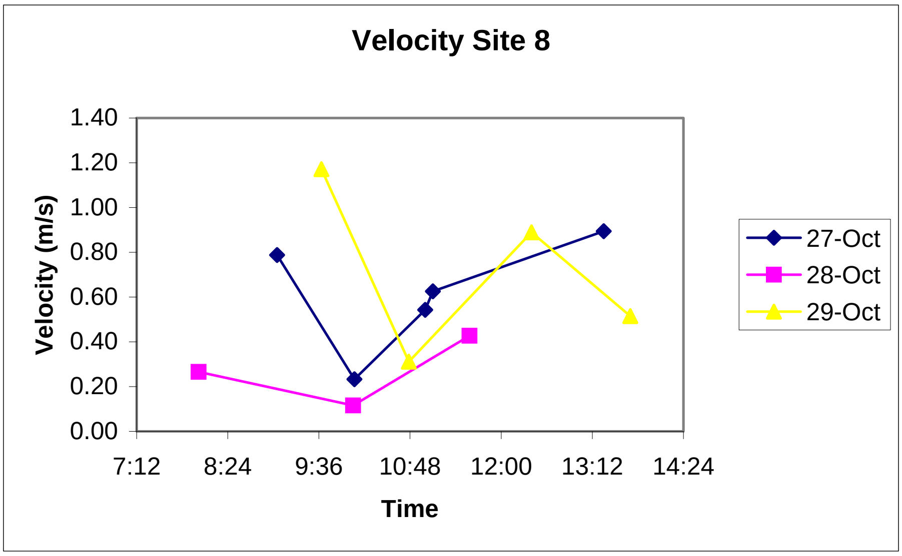


Figure A9.20: Velocity readings for Lake Currimundi at site 8

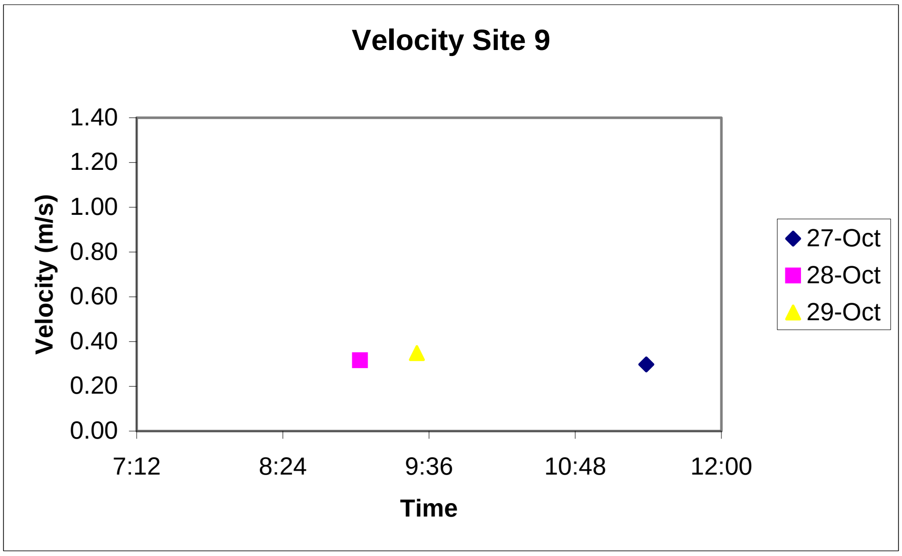


Figure A9.21: Velocity readings for Lake Currimundi at site 9

Figure A9.22a: Map of Lake Currimundi with field trip no.2 site locations (Source: Google Earth) WQ=Water quality sites, Vel=Velocity sites

Figure A9.22b: Map of Lake Currimundi with field trip no.2 site locations (Source: Google Earth) WQ=Water quality sites, Vel=Velocity sites

Continuous Velocity Profiling

The Argonaut current profiler was launched at 11:30am on the 24th of October 2007 upstream of the boat ramp near the middle of the channel (See Figure A9.22a) at a depth of 2.9 m and the most likely place to identify a measurable current flow. The Argonaut was left in this location for the duration of the study and retrieved at 3:57pm on the 29th of October 2007. The results are shown in Figure A9.23 and represent velocity magnitude and direction, and pressure measurement (not converted to water level).

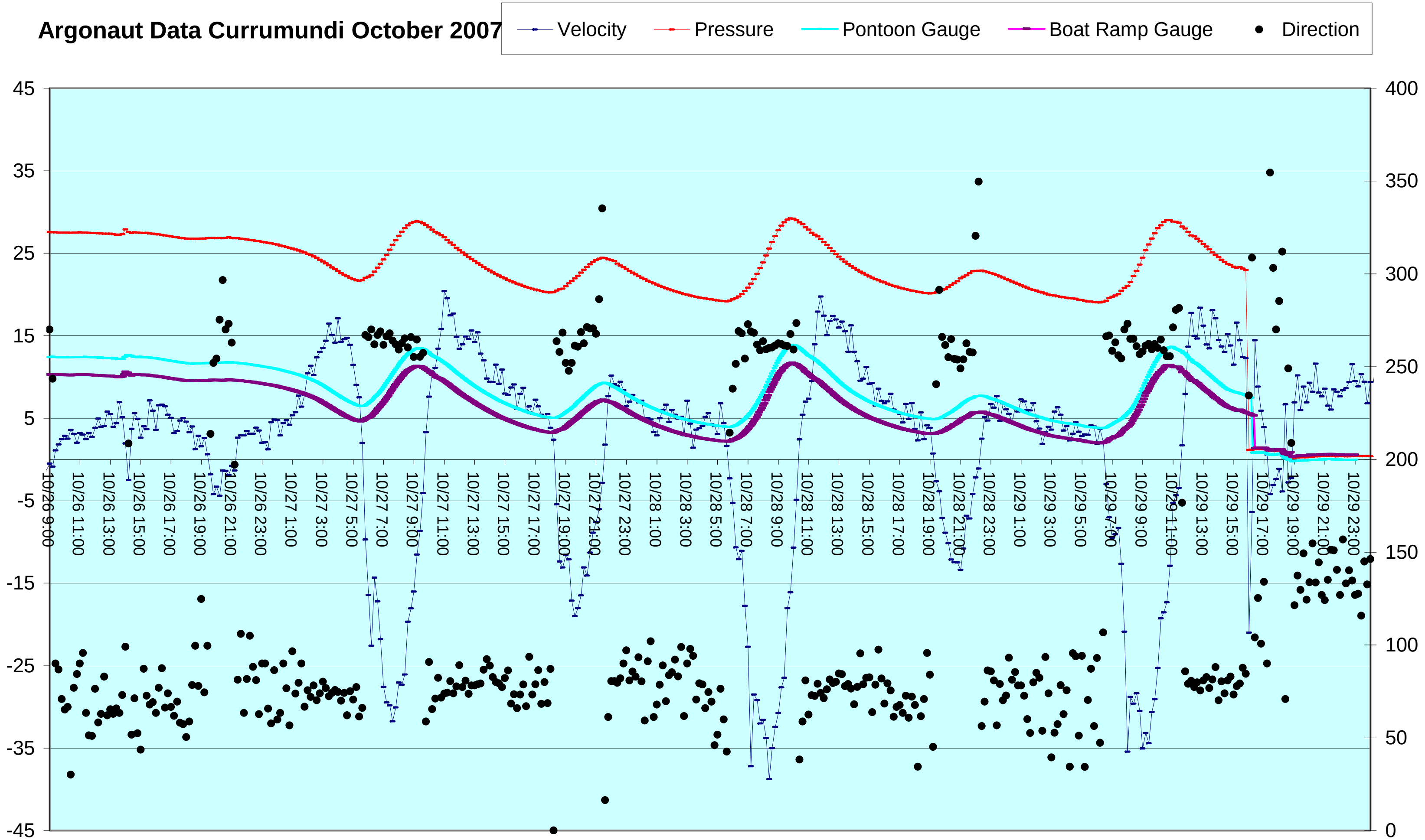


Figure A9.23: Continuous Velocity and Pressure Measurements - July 2007

A9.3.2 Discussion

The main findings from this fieldwork are as follows.

- The lake maintains a strong tidal signal for at least 3 days following the entrance opening
- There is a strong tidal asymmetry typical of estuaries with the flood tide velocity being greater in magnitude than the ebb, but for a shorter period. This asymmetry is the main driver for sand to quickly infill the entrance and cause it to close.
- Following the lake opening, maximum water level is actually higher than that during the closure
- The flow reversals are in phase (or nearly) with the high and low water marks. This suggests that the lake (including the connection to Lake Kawana) is not influenced by tide attenuation due to bottom friction (except most likely for the initial friction loss at the entrance). This means that only one water level monitoring site will be required to describe the dynamics of the system.

A9.4 MAJOR FIELD EXERCISE – MAY TO JULY 2008

Griffith Centre for Coastal Management (GCCM) in collaboration with the University of the Sunshine Coast (USC) conducted a co-ordinated research fieldtrip in relation to the lake dynamics from 22 May to 9 July 2008.

During the month long research period tidal data was recorded continuously and weekly surveys of the lake entrance were conducted in order to understand the entrance movements as set out in Table A9.3. Current velocities were recorded during a two week intensive study period, with water quality measurements being collected by the University of the Sunshine Coast. These water quality data are discussed in Chapter 5.

A9.4.1 Location

Hydrodynamic and water quality data was collected along different sites in Lake Currimundi as shown in Figure A9.24.

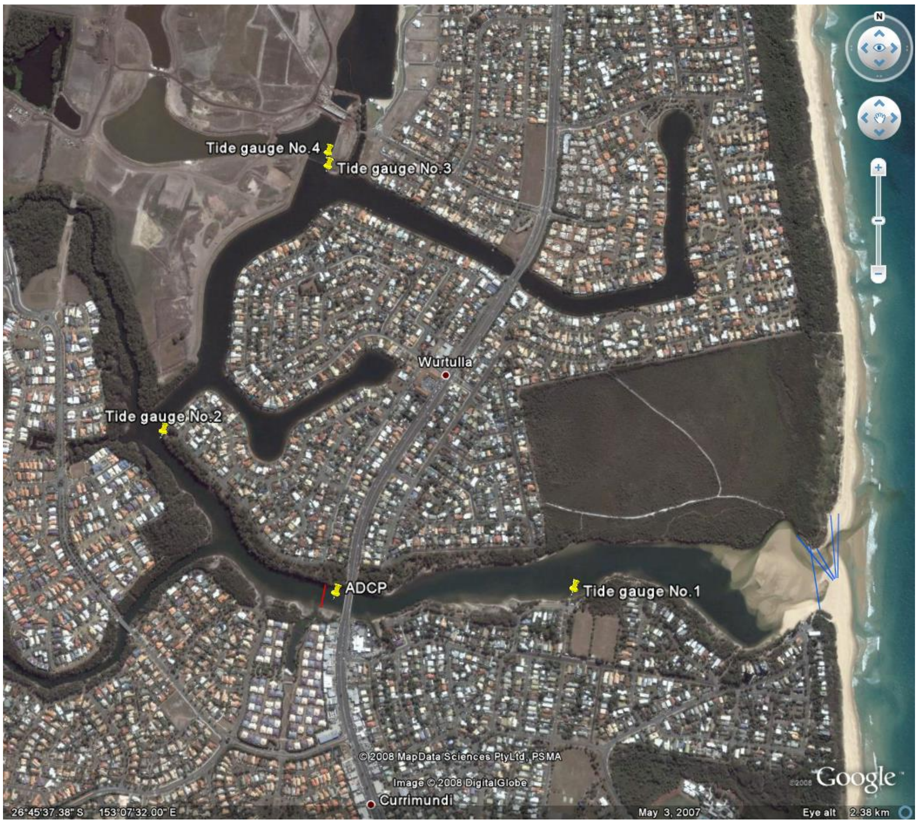


Figure A9.24: Location of the different sites in the lake (Source: Google Earth). The blue lines represent the survey lines at the entrance. The red lines represent the localisation of the transect lines.

Data	Equipment	Location	Duration
Tidal Data	RBR TWR-2058 serial 12537	Lake Kawana next to the weir	22/05/2008 to .9/07/2008
	RBR XR-420 CTD serial 13227	Boat ramp Westaway Parade	22/05/2008 to 9/07/2008
	RBR TWR-2058 serial 12536	Boolagi/Mulloka Pontoon	25/04/2008 to 9/07/2008
	RBR XR-420 CTD serial 13229	Pangali/Tokara Canal next to the weir	22/05/2008 to 9/07/2008
Current Data	SonTek 1.0 Mhz ADCP	Lake Currimundi next to the Lake Currimundi Ahern Bridge	29/05/2008 to 05/06/2008 05-10/06/2008 11-12/06/2008
	SonTek 3.0Mhz Argonaut XR	Lake Currimundi next to the Lake Currimundi Ahern Bridge	04-05/06/2008 Spring tide survey 11-12/06/2008 Neap tide survey
	Impellor Current Meter	Lake Currimundi Ahern Bridge	26-28/05/2008 5/06/2008 10-12/06/2008
Entrance Monitoring	Nikon Total Station DTM-352	Surveys in the entrance of the Lake Currimundi	23/05/2008 31/05/2008 (stopped: too much current) 03/06/2008 06/06/2008 13/06/2008 9/07/2008
Water Quality Data	YSI 6600 V2-2 Multi-Parameter Water Quality Sonde	Lake Currimundi Ahern Bridge	26-28/05/2008 05/06/2008 10-12/06/2008
GPS Data	GPS Handheld	Tide gauges sites	22/05/2008
		Entrance of the lake	22/05/2008
		Lake Currimundi Ahern Bridge (4 sites)	26/05/2008
		ADCP site	29/05/2008
		Transect lines site	04/06/2008

Table A9.3: Data collection from the GCCM during this fieldwork

A9.4.2 Equipment

- Car : GCCM Hillux
- Vessel: Scylla
- SonTek 1.0 Mhz ADCP with a DGPS system (see appendix for its specifications)
- SonTek 3.0Mhz Argonaut XR with anchors, chains, rope and marker buoy (see appendix for its specifications)
- 2 x RBR XR-420 CTD and 2 x RBR TWR-2058 (see appendix for their specifications)
- YSI 6600 V2-2 Multi-Parameter Water Quality Sonde
- Impellor Current Meter with a stopwatch/compass
- Nikon Total Station DTM-352 with a tripod, a measuring tape and a survey staff
- Pegs, mallet and ribbon flagging
- Garmin 76 GPS unit

- Durabook laptop computer and peripherals
- Photography equipment
- Solar panel and 12v battery power supply

Research vessel, Scylla (figure A9.28), was used in conjunction with the SonTek ADP to measure current velocities in order to determine the rate of discharge.

A9.4.3 Current Data

Equipment used to measure current velocity included the SonTek Argonaut and the SonTek ADP.

The measurement of current velocity is based on the principle of Doppler shift. The SonTek equipment has three transducers which generate a beam of sound. The equipment then measures the change in the received frequency from the reflected energy. From this change it can then determine the Cartesian velocities from the orientation of the beams. The SonTek equipment includes an internal compass and tilt sensor to give the velocity in an East-North-Up (ENU) referencing system, which is independent from the beams geometry.

- SonTek Argonaut XR 3MHz

The SonTek Argonaut is used as a stationary device. It includes three transducers which send beams of sound upwards at a frequency of 3 MHz.

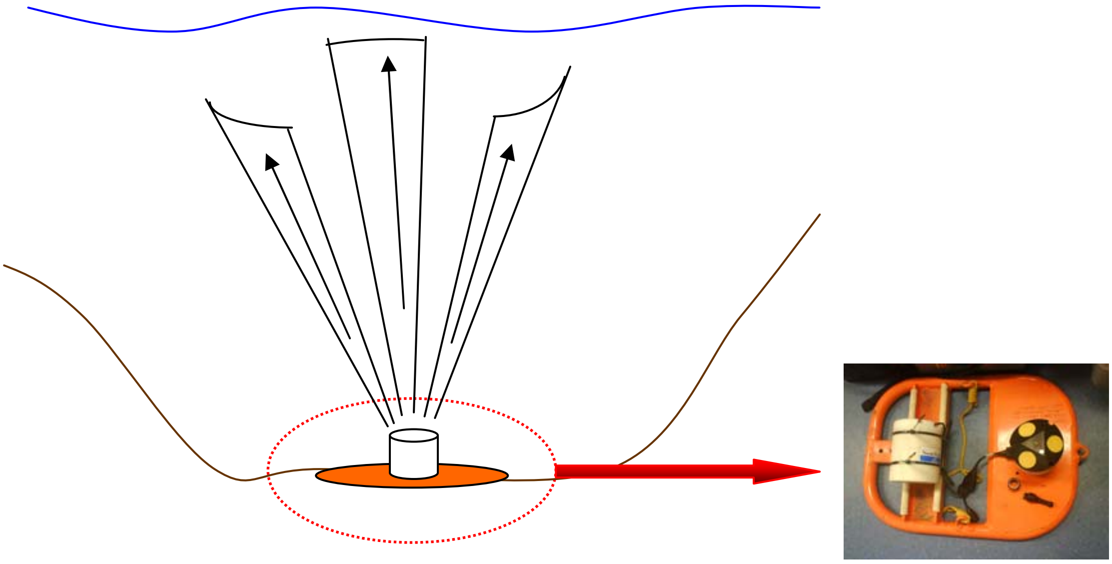


Figure A9.25: Illustration of the Argonaut XR

The SonTek Argonaut XR was placed in the middle of the lake bed (Figures A9.25 and A9.26).

Figure A9.26: Localisation of the SonTek Argonaut XR

The equipment was calibrated with a sixty seconds sampling interval and a ten second averaging interval at sampling rate of 3000 kHz. The Argonaut was placed in a relatively straight section of the lake, downstream from the SonTek ADP cross section location (Figure A9.24), at 4:30 PM on 29 May 2008 while the lake entrance was closed. Waypoints were taken using a handheld GPS.

The Argonaut began recording data at 4:00 PM on 29 May 2008 collecting current velocity, pressure and temperature data. Several significant events were recorded during this period including the opening of the entrance on 30 May 2008, the flooding event occurring between 30 May and 6 June 2008 and a full spring tidal cycle, which was also measured by the SonTek ADP, between 4 June and 5 June 2008. Recording concluded at 8:45 AM on 5 June 2008 when data was extracted and downloaded on the laptop. The data collection resumed at 9:30 AM on 5 June 2008. Data collection again concluded on 7 June 2008 and resumed at 9:00 AM on 11 June 2008, recording hydrodynamic data during a full neap tidal cycle. All Argonaut data collection concluded at 00:45 AM on 12 June 2008.

SonTek ADP 1MHz and the River Surveyor system

The SonTek ADP is used as a mobile device. During the research period it was mounted on the port side of 'Scylla' (Figure A9.27 and A9.28). The top of the ADP was located at the surface of the water due to the low depth of the lake. The transducers were 30 cm under the surface, sending an acoustic beam downward into a water column while travelling in a cross section of the lake.

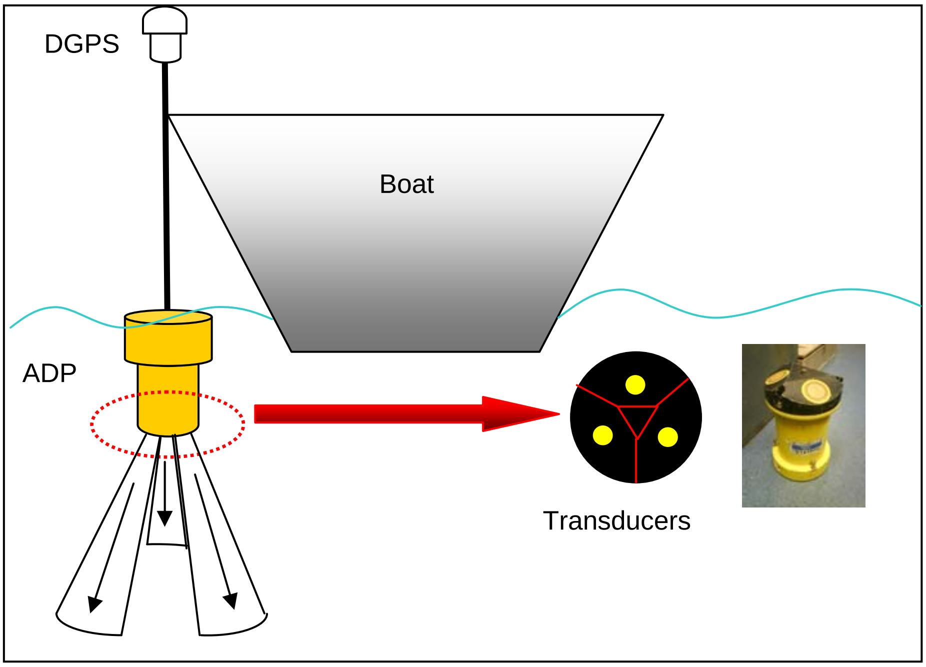


Figure A9.27: Illustration of the installation of the SonTek ADP

Figure A9.28: Scylla Boat with the SonTek ADP

A differential GPS was attached to the SonTek ADP allowing it to record the exact position of each line. The data was collected and recorded using SonTek's River Surveyor software using the "Bottom Tracking" mode due to there being no bed movement. Using the handheld GPS two waypoints were taken at each side of the cross section.

The first spring tide survey line was recorded at 3:09 PM on 4 June 2008 and concluded at 8:05 AM on 5 June 2008 when the current appeared to have changed direction. The lake was crossed every thirteen minutes to one hour. This depended on the current speed over the full tidal cycle. Stationary readings were also recorded in order to check bed movements and record any change in the current direction. A total of 68 lines were recorded with additional stationary measurements.

The first neap tide survey line was recorded at 9:31 AM on 11 June 2008 and concluded at 00:34 AM on 12 June 2008. Using the same method as the spring tidal cycle, a total of 55 lines were recorded with additional stationary measurements. Some technical problems were encountered during the neap tide data collection, explaining the smaller number of performed transects.

Impeller current meter

Measurements were completed with an impeller current meter at the Nicklin Way Bridge. Four measurements were taken at different sites along the bridge. GPS coordinates for these sites were recorded (Figure A9.29).

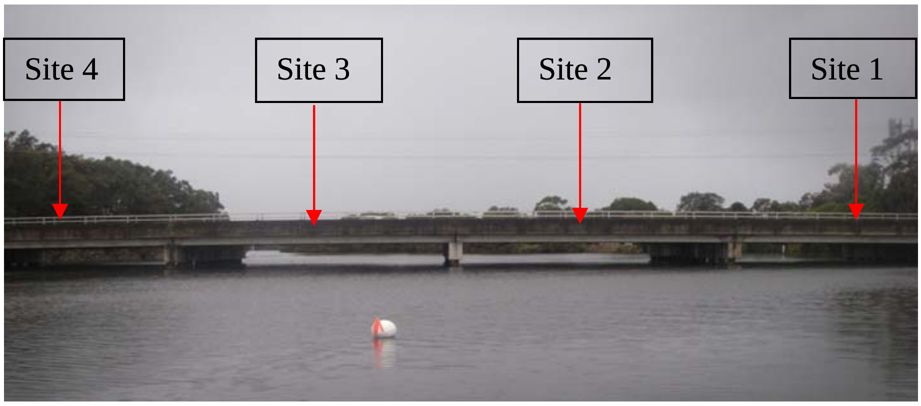


Figure A9.29: Location of the four measurement sites on the bridge

The impellor was placed just below the surface of water, with the number of beeps recorded and the water direction noted. The mean number of beeps was converted into speed using a calibration table (Appendix 10).

A9.4.4 Water Quality Data

In addition to the water quality data collected by USC, measurements were completed using a YSI 6600 V2-2 Multi-Parameter Water Quality Sonde. This equipment was used to measure pressure, salinity, turbidity, temperature and dissolved oxygen. Data was collected prior to and after the opening of the entrance. The sonde was programmed to record a sampling every 30 seconds. Measurements were taken from the Nicklin Way Bridge at one metre intervals starting from the surface (Figure A9.29).

Passing community members showed a keen interest in the research being undertaken, with many stopping to enquire about the equipment and its function.

A9.4.5 Bathymetric Data

During the research period, six entrance surveys were completed in order to map any changes in the entrance morphology. A total station was used and five lines were completed. The first survey was conducted on 23 May 2008 while the entrance to the lake was closed (Figure A9.30). Due to strong water currents and water depths, the second entrance survey was only partially completed. This occurred after the opening of the lake's entrance on 24 May 2008. Following this, four more surveys were conducted in June and a final survey in July (Figures A9.31 to A9.34). The data from the total station was extracted and exported to a surface mapping software. Some maps were plotted using a Google Earth image of the entrance:

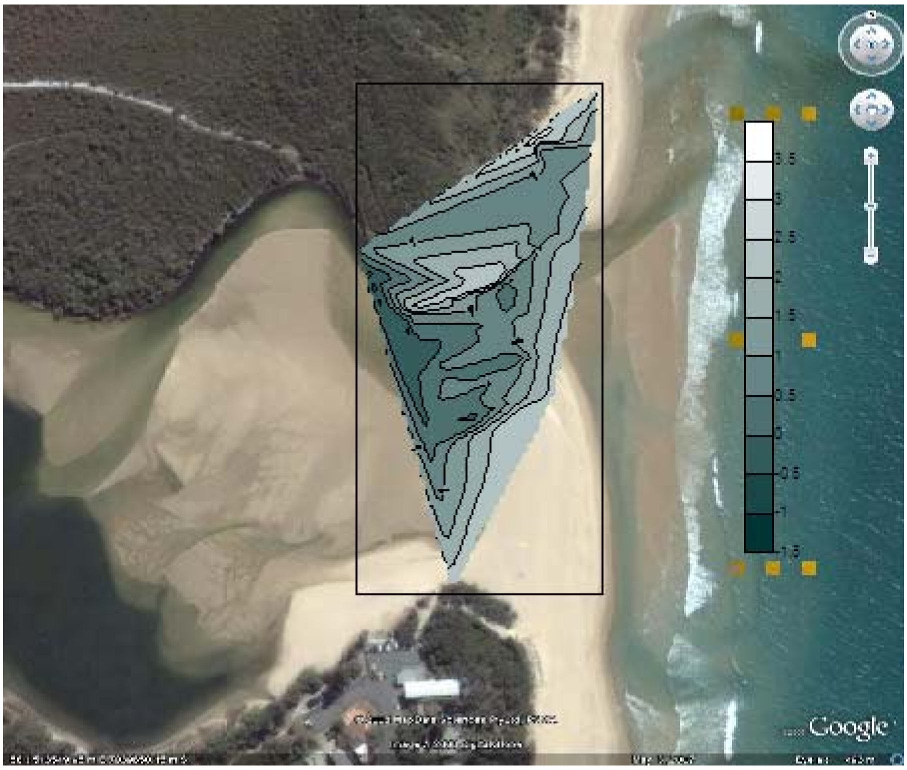


Figure A9.30: First bathymetry of the entrance when the lake was closed

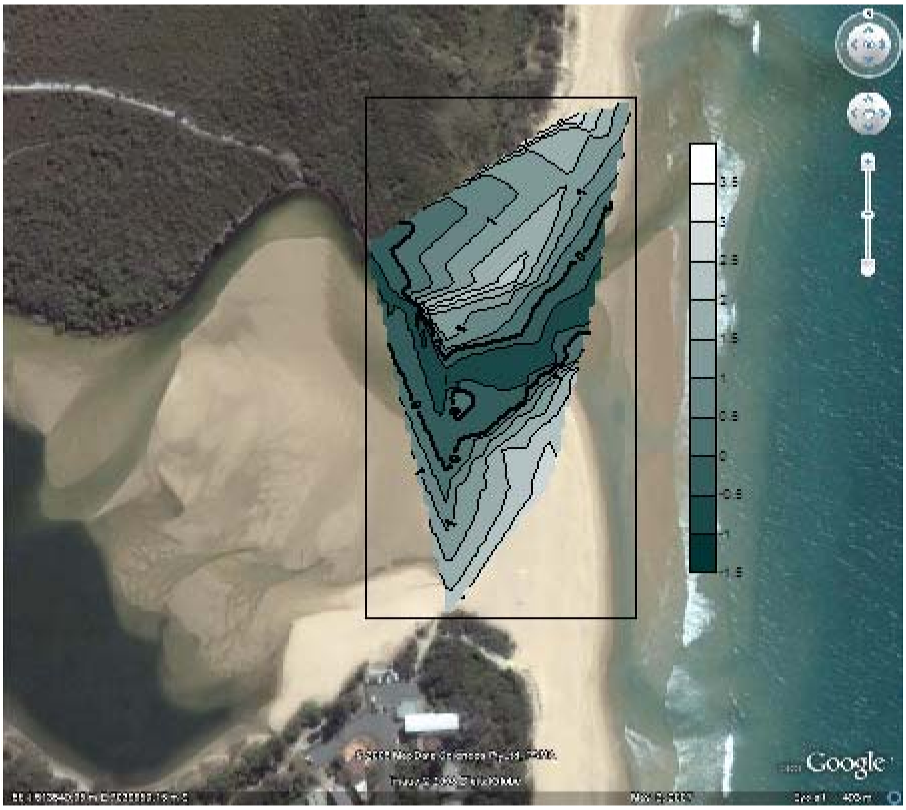


Figure A9.31: The survey of the 3rd of June 2008 after the opening

Figure A9.32: The survey of the 6th of June 2008

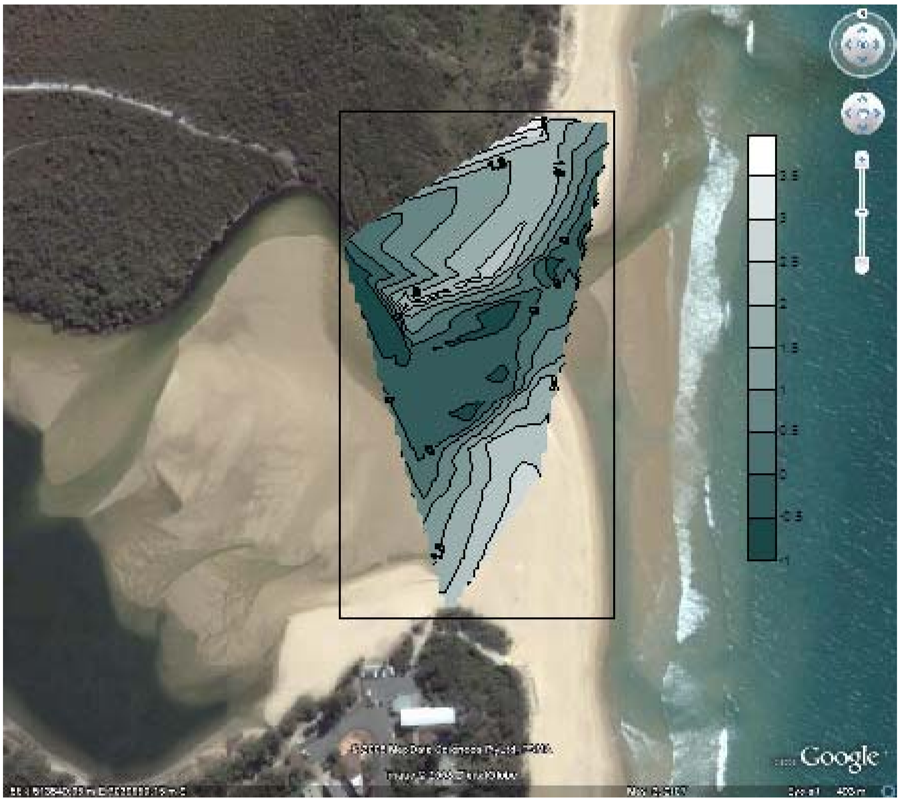


Figure A9.33: The survey of the 12th of June 2008

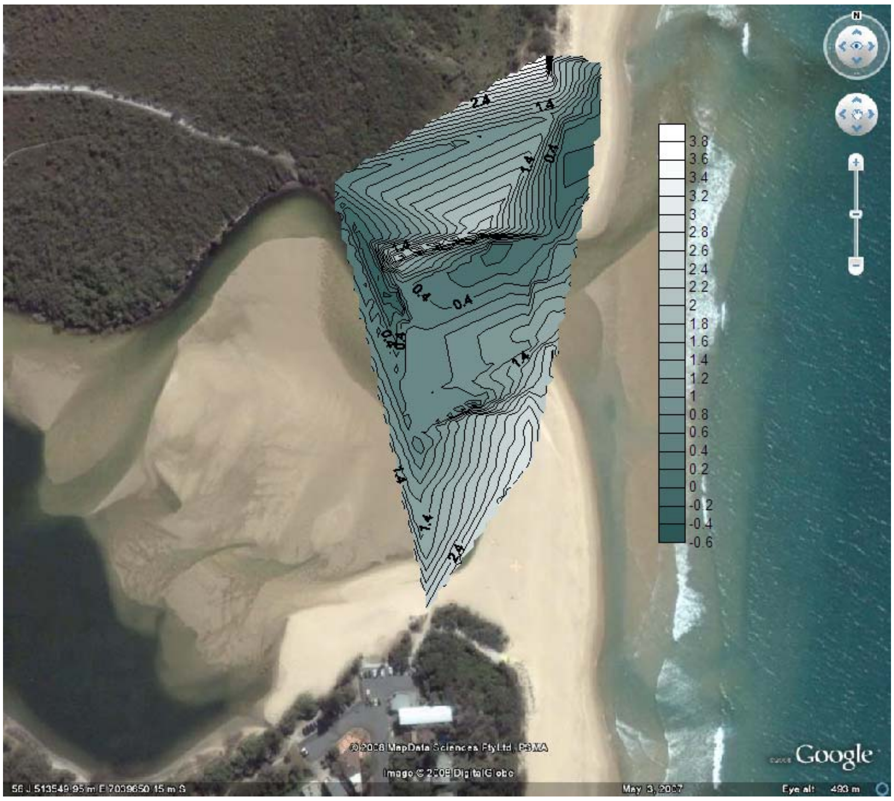


Figure A9.34: The last survey on July 9th 2008

Daily changes in the entrance morphology were noticed and recorded especially after the entrance was opened on 23 May 2008. Some changes noticed included the natural removal of excess sand left after the entrance opening, the ever changing depth and location of the entrance channel and the gradual exposure of rock along the environmental park. During the surveying, community members showed a keen interest in the work being conducted. Many stopped to enquire about the purpose of the research.

A9.4.6 Tidal data

Four tide gauges were placed in various locations in Lake Currimundi (Figure A9.24 and Appendix 10). Two RBR XR-420 CTD tide gauges and two RBR TWR-2058 tide gauges were used. They were programmed to a six minute recording time interval with 10 second averaging interval at a sampling rate of 6 Hz.

The RBR XR-420 CTD tide gauges recorded conductivity, temperature and pressure depth. The RBR TWR-2058 recorded temperature and pressure depth. Windows® software was used to produce the practical salinity of water using conductivity, temperature and depth (Appendix 10). The calculation of depth was based on a UNESCO Technical Paper (Marine Science #44), which uses the latitude of the data collection and the pressure from the logger to give a result. Atmospheric pressure was needed to correct the pressure measurement. This was set to a standard atmospheric pressure of 10.132500 dbar. Climate data (Appendix 10) was sourced from the Bureau of Meteorology. Additional measurements, including salinity and location, were conducted at each tide gauge site location.

Three gauges were placed in Lake Currimundi and one in Lake Kawana on 22 May 2008. These were located at the Westaway Parade boat ramp (Figure A9.35), and

22/05/2008
2:35 PM

09/07/2008
10:41 AM

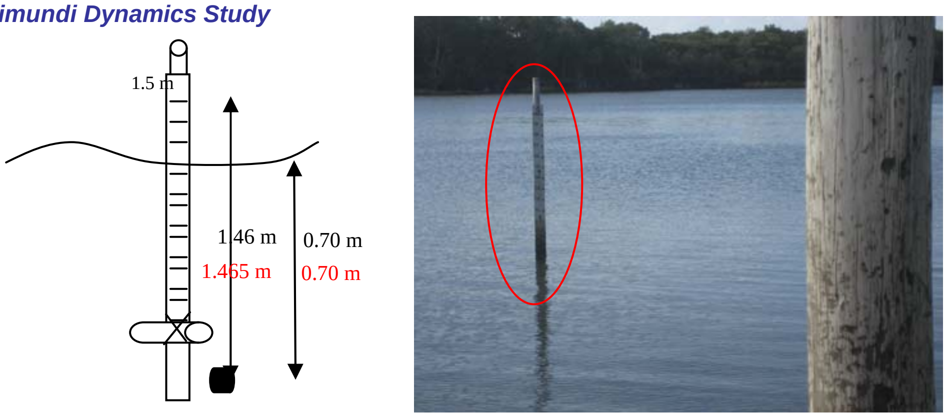


Figure A9.35: Tide gauge No.1 (XR-420-CTD Serial: 13227) near the jetty

25/05/2008

09/07/2008
11:23 AM

Figure A9.36: Tide gauge No.2 (TWR-2050 Serial: 12536) on the Boolagi/Mulloka Pontoon

22/05/2008
3:34 PM

09/07/2008
12:05 PM

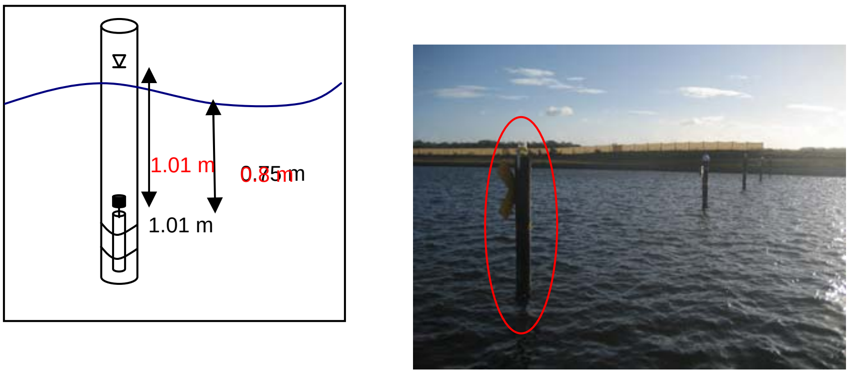


Figure A9.37: Tide gauge No.3 (XR-420-CTD Serial: 13229): Pangali/Tokara Canal next to the weir

22/05/2008
3:27 PM

09/07/2008
11:53 AM

Figure A9.38: Tide gauge No.4 (TWR-2050 Serial: 12537) in the Lake Kawana near the weir

either side of the weir (Figure A9.37 and A9.38). A tide gauge was also placed at the pontoon on 25 April 2008, one month prior to the fieldtrip (Figure A9.36).

Hydrodynamic data was recorded from 22 May until 9 July 2008.

A9.5 POST-PROCESSING AND RESULTS

A9.5.1 Current velocities and discharge during the spring and the neap tides

SonTek Argonaut XR

The data from the Argonaut was analysed using SonTek's View Argonaut software. The magnetic declination was adjusted in function of the place and the time (10.57°). The salinity was 35 ppt and temperature 20 degrees by default. The local bathymetry and the ADCP elevation were inserted into the program which uses a theoretical flow calculation. Results for a spring and neap tide are shown in Figures A9.39 to A9.42.

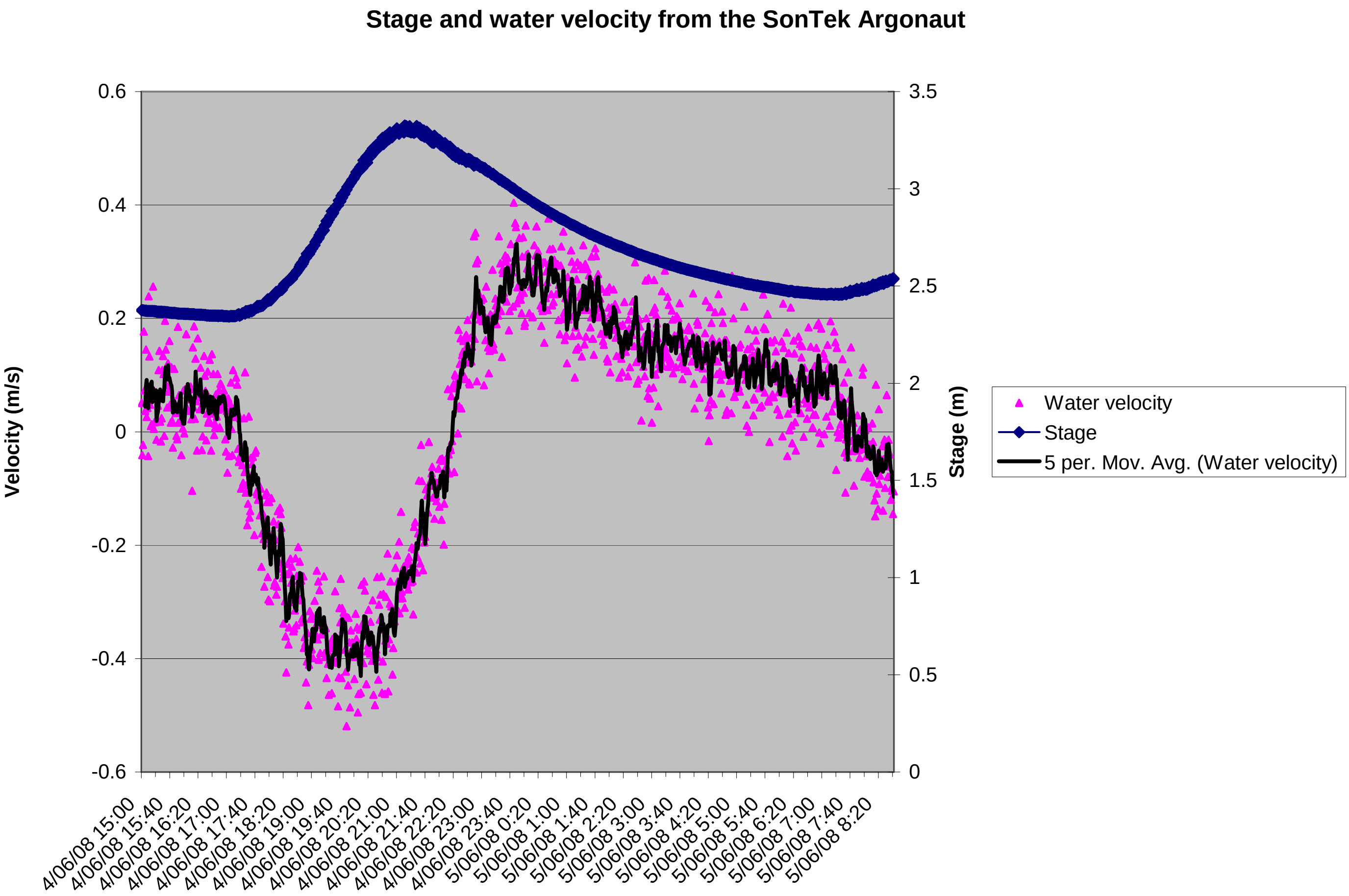


Figure A9.39: Flow Conditions - Spring tide 4 -5 June 2008

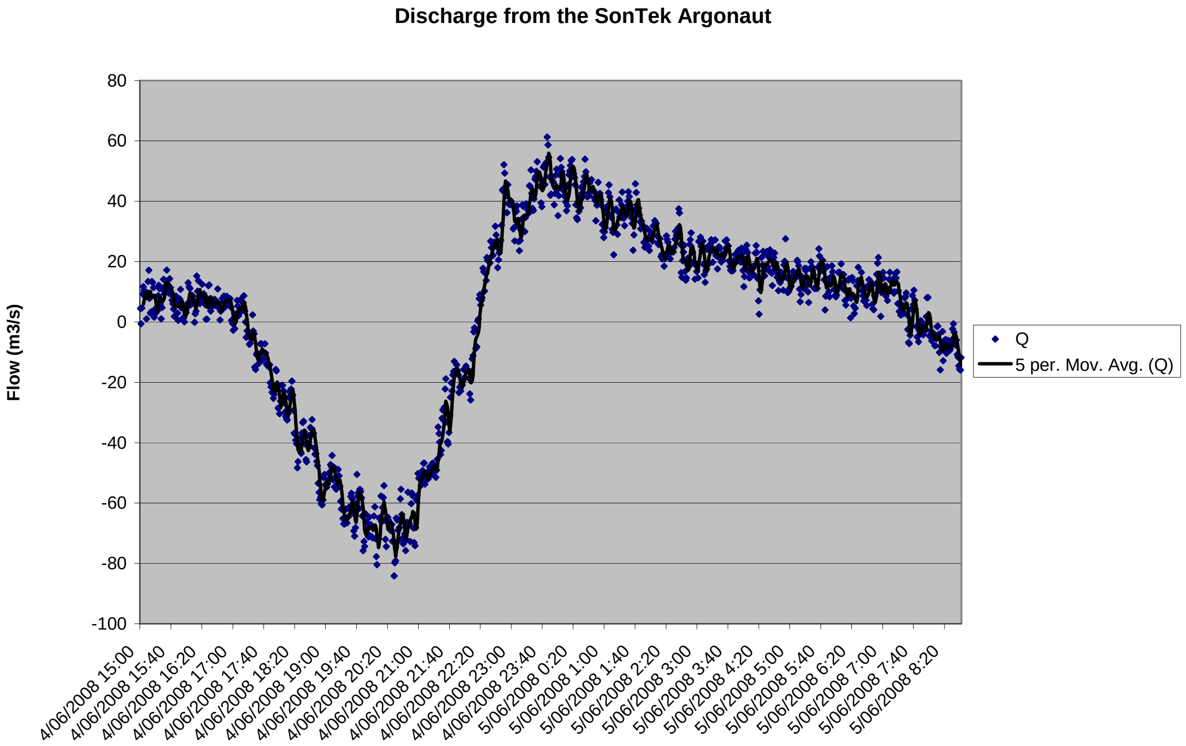


Figure A9.40: Discharge Spring Tide 4 -5 June 2008

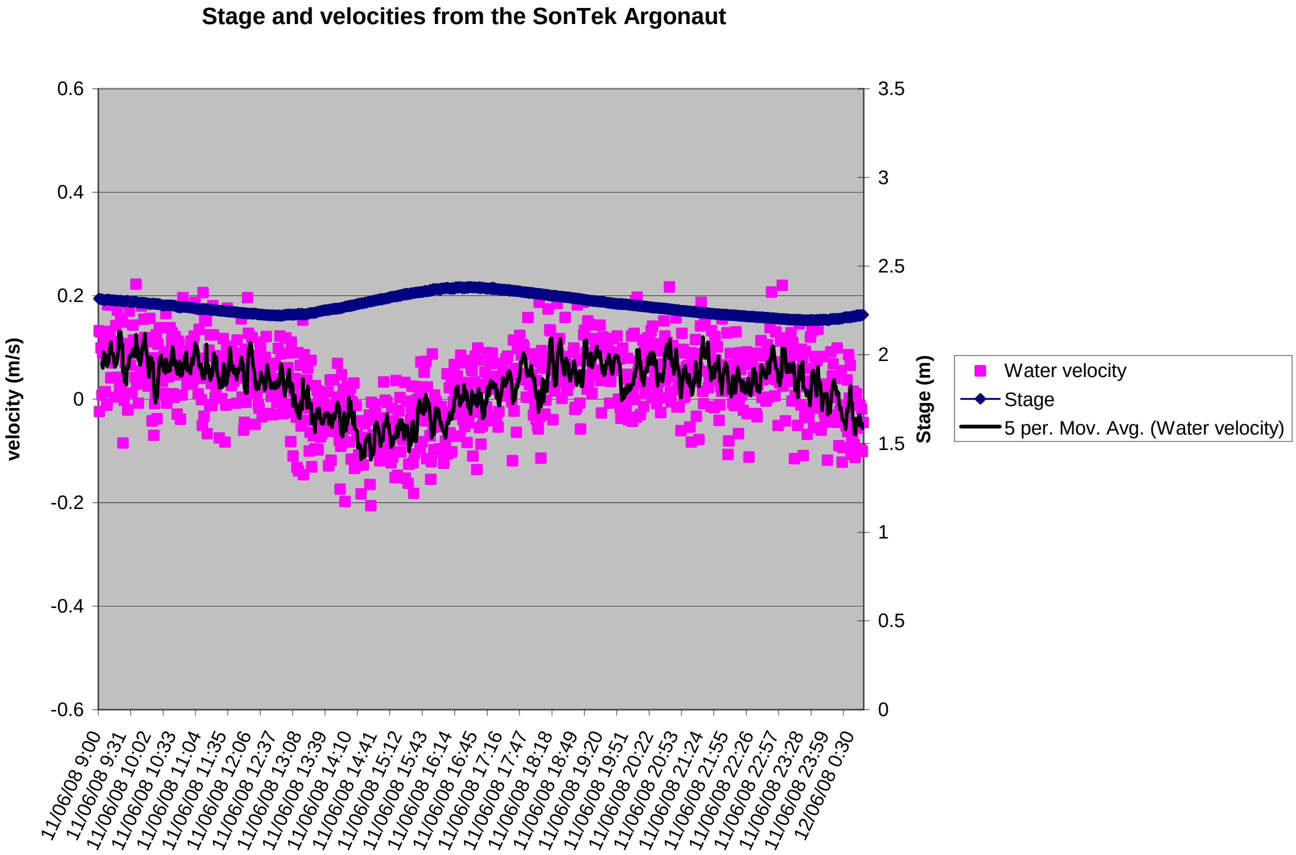


Figure A9.41: Flow Conditions Neap Tide 1 - 12 June 2008

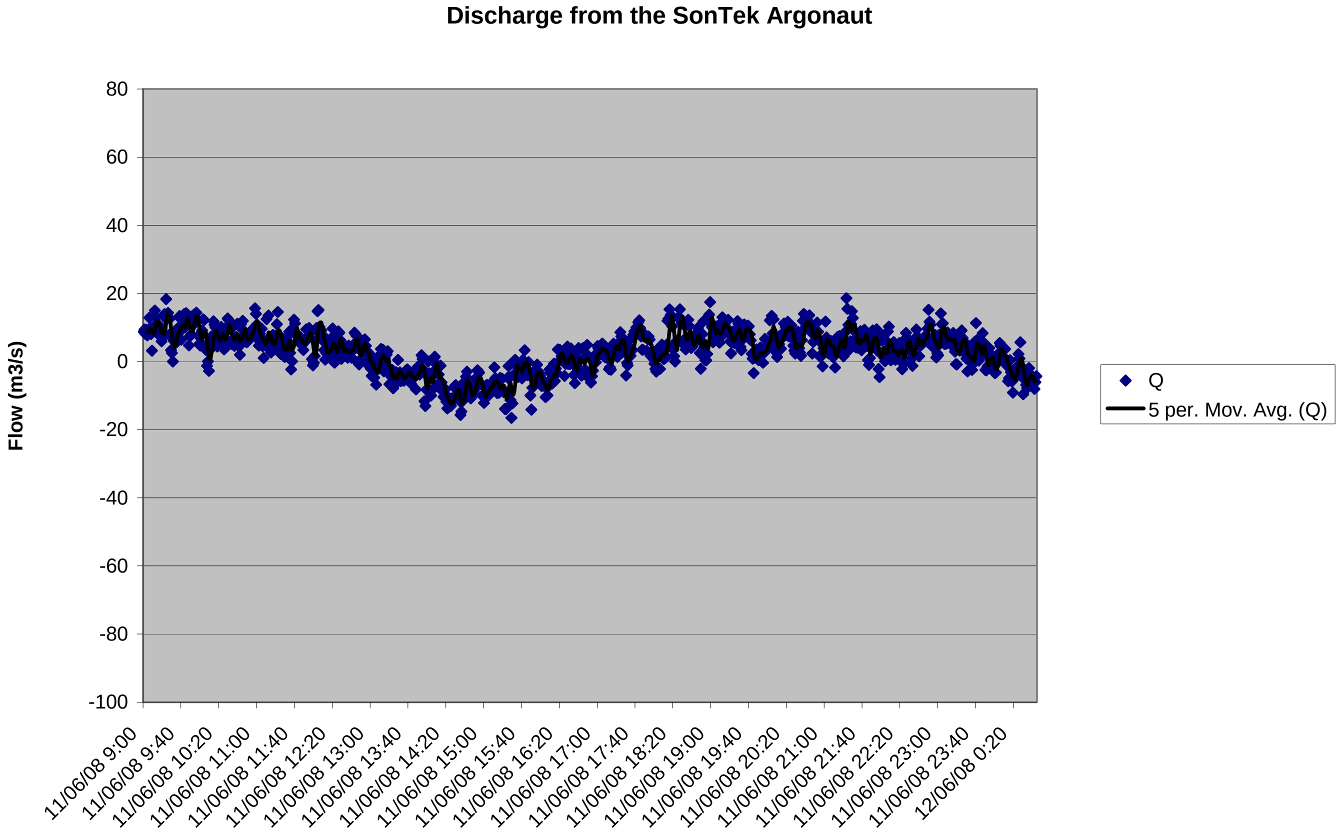


Figure A9.42: Discharge neap Tide 11 - 12 June 2008

SonTek ADP

Data from the SonTek ADP was analysed using SonTek's River Surveyor software. The local magnetic declination and the transducers' depth were inputted (10.57° and 0.3 m) in each file. Each file corresponds to one line.

The velocity reference used during data collection was "Bottom Track" and the velocity coordinate system used was the ENU (East-North-Up) system. Bank measurements and distance to the nearest bank were verified. The profile used for bank discharge was entered in such a way as to be most characteristic of the current water velocity and direction. Discharge and velocity derived from the transects are shown in Figure A9.43 to A9.46.

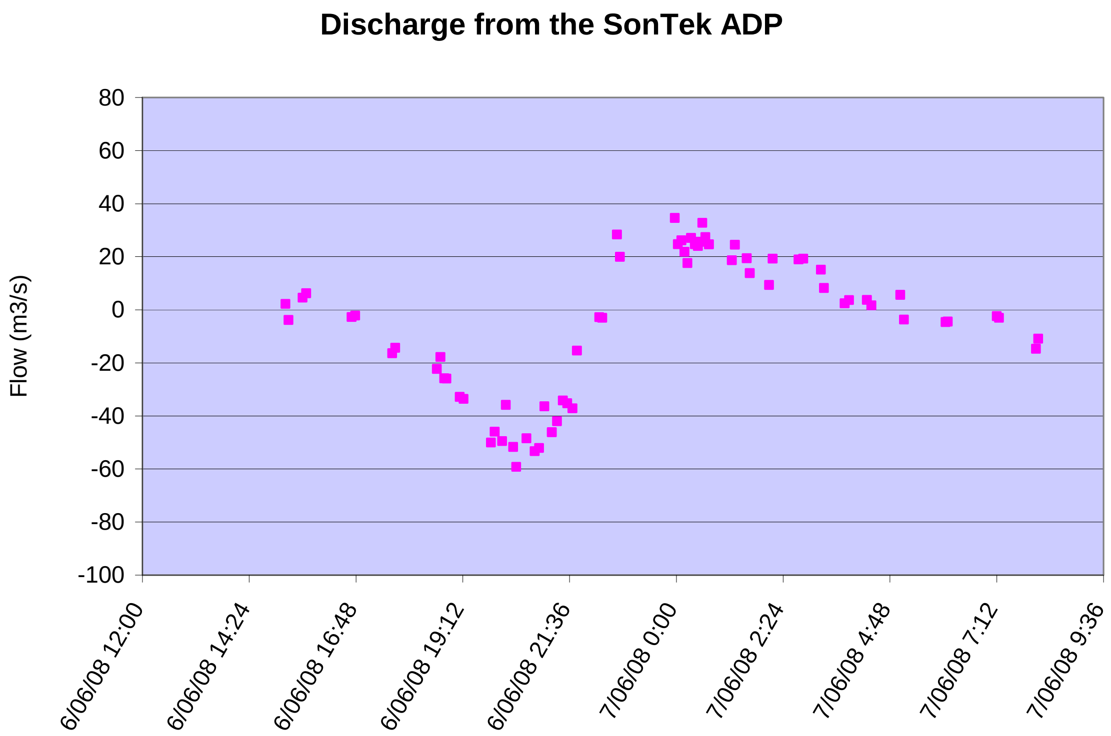


Figure A9.43: Discharge from Transect on Spring Tide 4 -5 June 2008

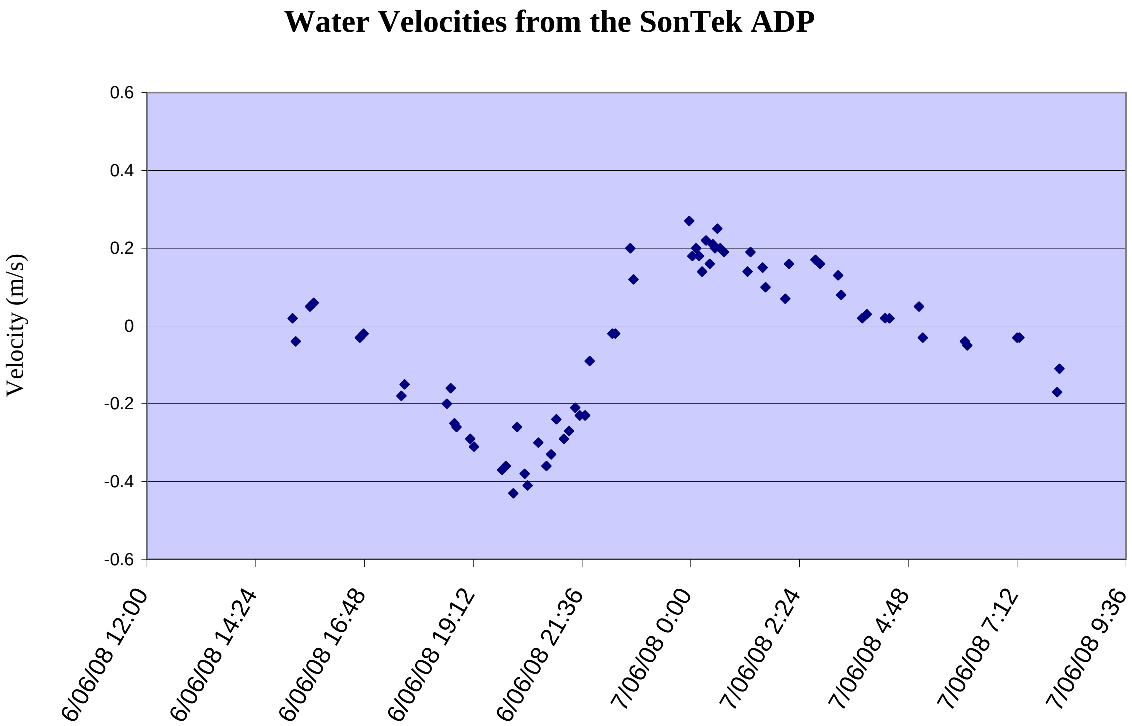


Figure A9.44: Average Velocity form transect Spring Tide 4 - 5 June 2008

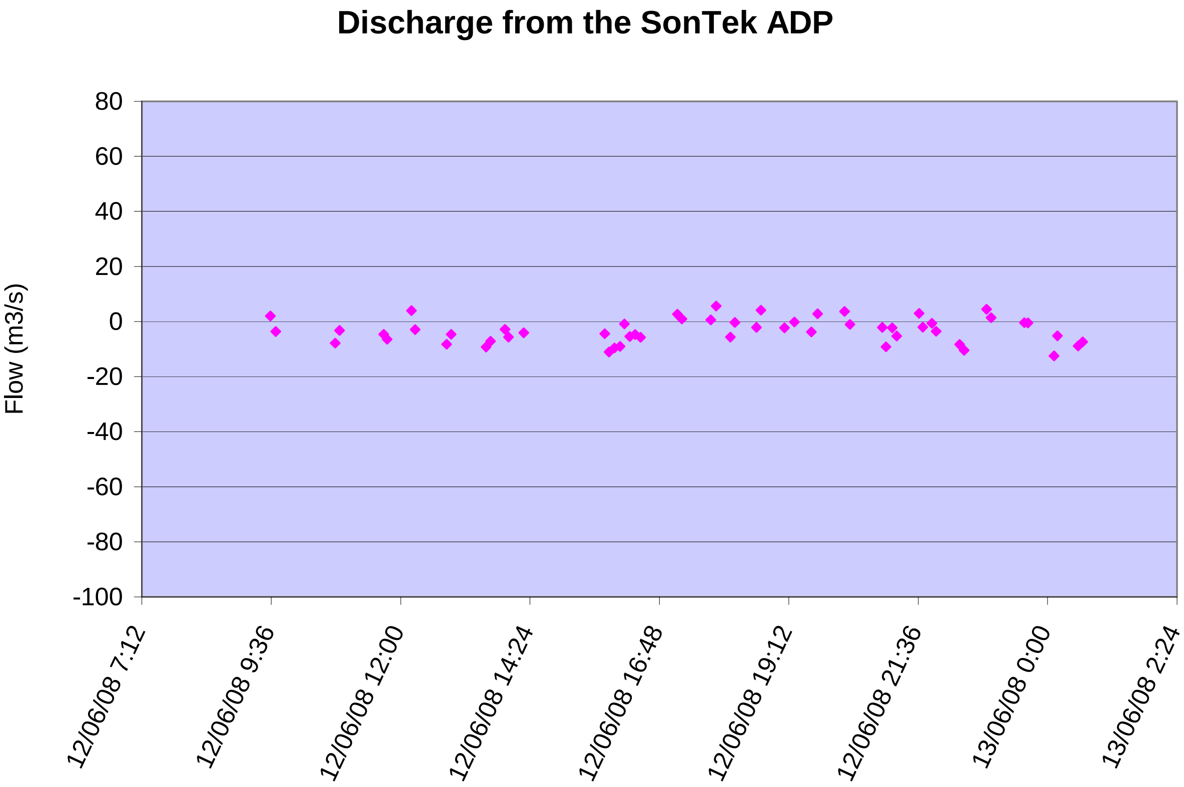


Figure A9.45: Discharge for Transect Neap Tide 11- 12 June 2008

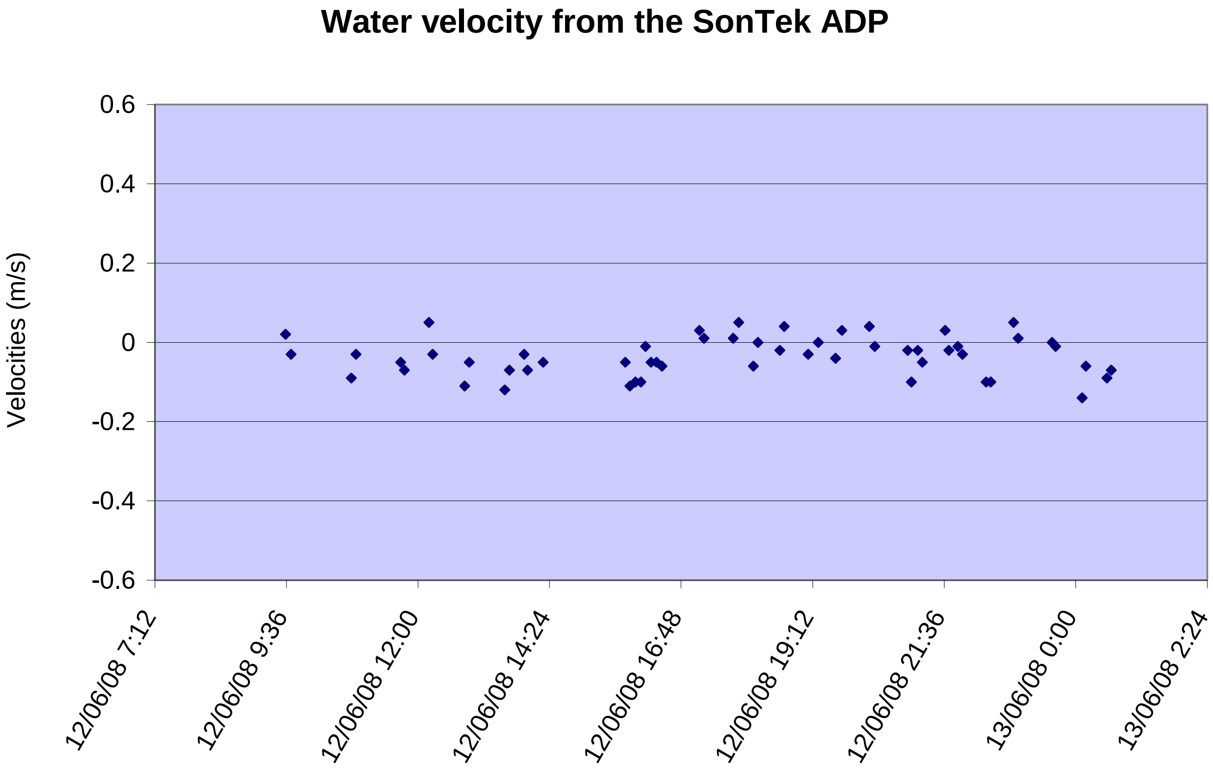


Figure A9.46: Average Velocity on transect Neap Tide 11 - 12 June 2008

Impeller current meter

During the lake's closure no water current was recorded. After the lake's opening, measurements were taken and an equation was used to find the speed of the water current. (Appendix 10)

V (m/s) = 0.012+0.2584*n
n : the mean number of revolutions during 30 seconds divided by 30 seconds.

Table A9.4: Current measurements with the impeller

10/06/2008

	Site 4	Site 3	Site 2	Site 1
Time	17:35	17:43	17:50	17:58
Speed (m/s)	0.06	0.11	0.11	0.07

11/06/2008

	Site 4	Site 3	Site 2	Site 1
Time	13:15	13:19	13:44	17:58
Speed (m/s)	/	/	0.09	0.07

12/06/2008

	Site 4	Site 3	Site 2	Site 1
Time	14:51	15:04	15:16	15:28
Speed (m/s)	0.06	0.13	0.12	0.071

A9.5.2 Water quality data

Temperature, salinity and dissolved oxygen measurements conducted using the YSI 6600 V2-2 Multi-Parameter Water Quality Sonde.

During the lake's closure measurements were constant with higher salinity and temperature recorded near the bottom and higher dissolved oxygen recorded near the surface.

Once the lake was opened additional measurements were taken (Table A9.6 and A9.7).

Water Level Variation

Pressure transducer data was converted into water level using survey data provided by SCRC surveyors and is presented in Figure A9.47.

Table A9.5: Measurements before the opening of the lake

Site 1
S 26°45.936
E 153°07.321

Depth (m)	salinity (ppt)	Temp (°C)	DO (%)
0	27.64	19.45	86.8
1	27.98	18.81	86.3
1.85	28.4	19.61	81.1

Site 2
S 26°45.235
E 153°07.321

Depth (m)	salinity (ppt)	Temp (°C)	DO (%)
0	27.6	19.49	86
1	27.9	18.72	87.6
2	28.8	20.09	65.1
2.2	29.1	20.5	52.9

Site 3
S 26°45.921
E 153°07.322

Depth (m)	salinity (ppt)	Temp (°C)	DO (%)
0	27.57	19.41	87.5
1	27.9	18.82	86.5
2	28.9	20.18	67.6

Site 4
S 26°45.922
E 152°07.322

Depth (m)	salinity (ppt)	Temp (°C)	DO (%)
0	27.5	19.46	89
1	28	18.97	83.8
1.75	28.6	19.79	74.5

Table A9.7: Measurements after the opening of the lake

Sites	1	2	3	4
GPS	S 26°45.936	S 26°45.235	S 26°45.921	S 26°45.922
	E 153°07.321	E 153°07.321	E 153°07.322	E 152°07.322

	Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)
10/06/08	0	21.81	21.11	88.6		0	22.12	20.8	84		0	21.81	20.98	95.3		0	21.7	20.9	91
17:35	1	26.46	20.51	87.8		1	32.96	20.29	94.5		1	26.2	20.41	92.5		1	32.1	20.23	94

	Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)
11/06/08	0	21.13	21.72	94.7		0	21.28	21.42	94.6		0	21.33	21.23	95.5		0	21.28	21.4	94.5
13:20	1	32.16	20.77	89.5		1	32.56	20.68	94.2		1	32.99	20.5	95.2		1	32.9	20.51	93.9
						1.5	33.66	20.39	89		1.3	33.56	20.55	82.4		1.1	33.12	20.53	86.2

	Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)		Depth (m)	Salinity (ppt)	Temp (°C)	DO (%)
12/06/08	0	23.61	22.54	97.3		0	23.62	22.44	99.5		0	23.64	22.39	98.6		0	23.12	21.79	92.5
15:00	1	32.46	21.15	88.1		1	32.59	20.93	96		1	32.52	20.87	97.2		1	32.83	21.14	85
	1.2	33.13	21.12	84.8		1.8	33.47	21.03	82.4		1.65	33.57	21.06	79.1		1.4	33.47	21.15	80.8

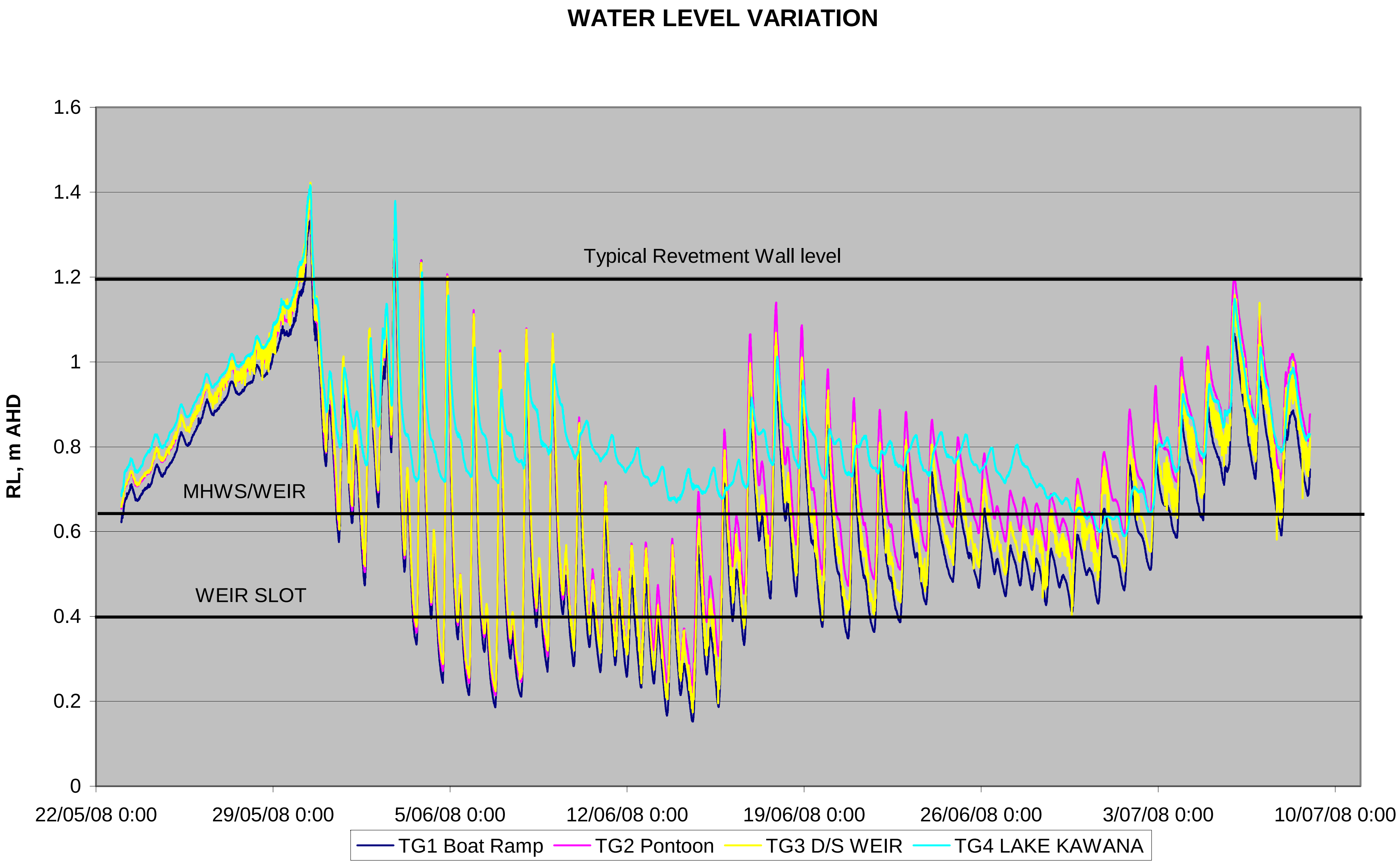


Figure A9.47: Water level variation June/July 2008

A9.6 DISCUSSION

A9.6.1 Tidal influence in the lake

Ocean low tide was predicted at 1:55 PM on 4 June 2008 (Figure A9.47). Pressure recorded by the Argonaut XR recorded a change at 17:19 PM on 4 June 2008 with the lowest speed recorded around 5:00 PM. This shows a time lag of three hours between the ocean tide and the recorded tide in Lake Currimundi. The cross section location was approximately 1.6 km from the entrance of the lake. The recorded high tide in Lake Currimundi was at 9:30 PM, only 45 minutes after the ocean tide. A second recorded low tide in Lake Currimundi was at 7:05 AM, 3 hours and 45 minutes after the ocean low tide.

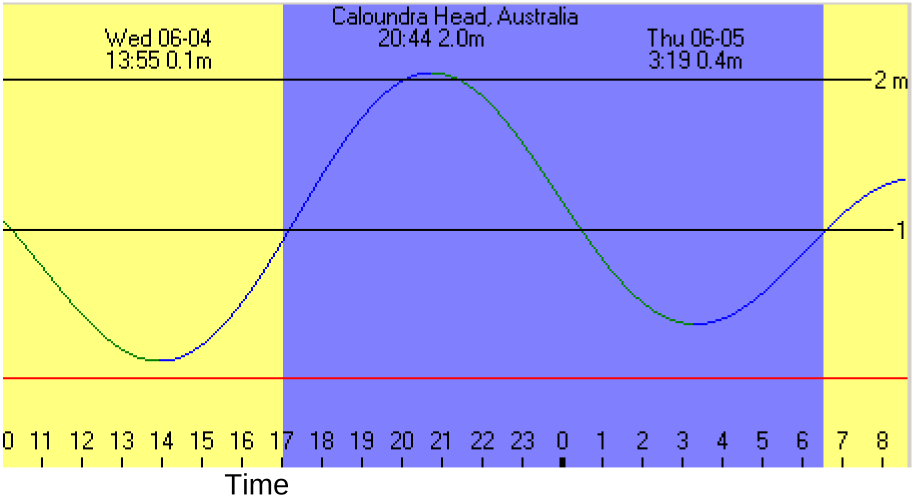


Figure A9.47: Ocean tide in Caloundra during the spring tide measurements 4 – 5 June 2008

Ocean low tide was predicted at 8:44 AM (Figure A9.48) on 11 June 2008. The SonTek recorded a change in the current direction and with no recorded velocity at 12:45 PM in Lake Currimundi. This shows a lag time of four hours after the predicted low tide. High tide was predicted at 15:00 PM and was recorded in Lake Currimundi at 16:45 PM, showing a lag time of 1 hour and 25 minutes. At the conclusion of the full neap tide, the low tide was recorded in Lake Currimundi at 11:45 PM, three hours after the predicted ocean tide.

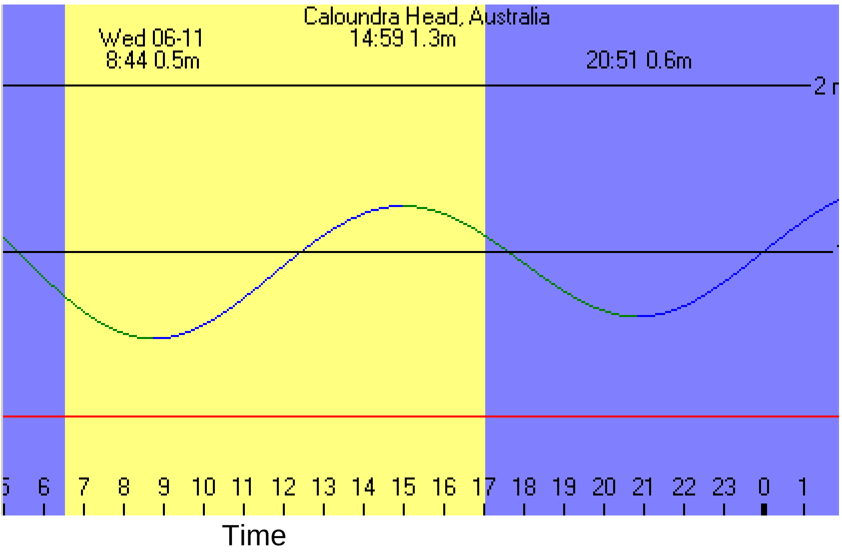


Figure A9.48: Ocean tide in Caloundra during the neap tide measurements 11 -12 June 2008

Results show that there is a difference of three to four hours between the ocean tide and the recorded tide in Lake Currimundi during low tide and a difference of 45 minutes to 1 hour and 30 minutes during high tide.

These results can also been seen with the tide gauge data.

The overall tidal characteristics for the system are shown in Figure 176. Some key findings are:

- The build-up of water level in response to the high rainfall preceding the opening is shown
- The tidal signal remains evident throughout the data collection period
- The attenuation in the tidal signal is evident as the overall tidal exchange reduces

Utilising the tidal discharge relationships it is possible to estimate typical tidal prism values during spring and neap tides. Using the data for the first established tidal signal following the opening (4 June 2008), a tidal prism volume of approximately 910ML was calculated. For a neap tide (11 June 2008) a tidal prism volume of approximately 250 ML was calculated.

For both of these tidal cycles, the entrance was open with a reasonably well defined entrance channel. A more typical condition is one when the entrance is a wide very shallow channel. Under these conditions, the entrance would be classified as closed or nearly-closed from a point of view of there being very limited tidal range in the lake. Measurement using the velocity profilers is not possible under these circumstances. An estimate was made of this base flow during a field inspection in summer 2007, when the entrance channel was estimated at 30m wide and 300mm deep. The average velocity was estimated at 0.8m/s resulting in an estimate tidal prism of approximately 100ML.

Based on the quoted figures for the pumped discharge through Lake Kawana of 82 ML on an average tide, it can be seen that it is most likely that the Lake Kawana flow is responsible for maintaining the entrance “nearly-closed”, rather than closed.

APPENDIX 10 – HYDRODYNAMIC FIELDWORK REFERENCE DATA

Appendix 10.1: Climate Data

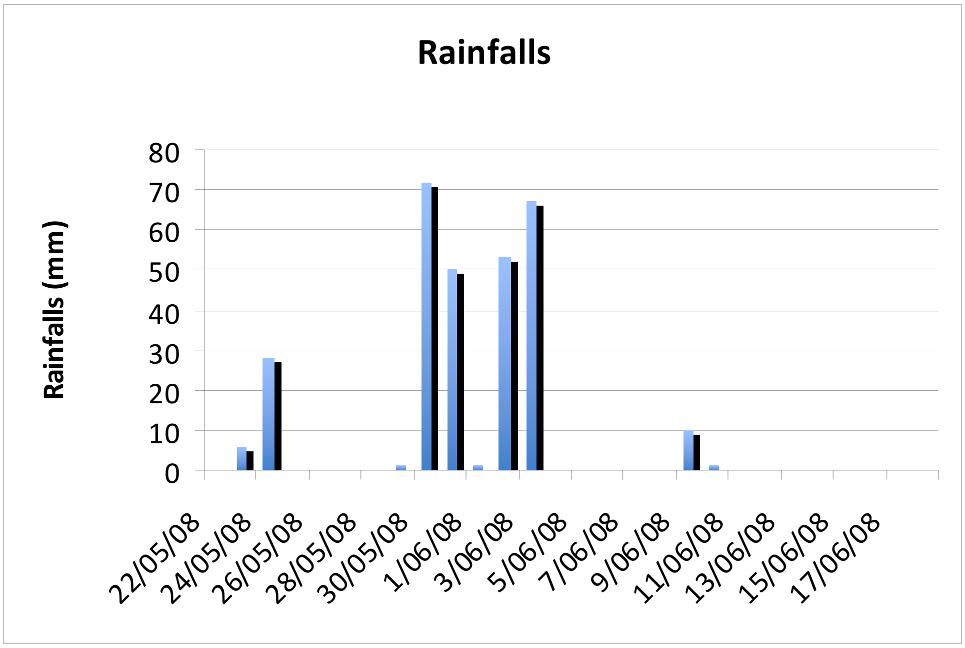


Figure A10.1: Rainfalls on Caloundra from 22/05/2008 to 18/06/2008

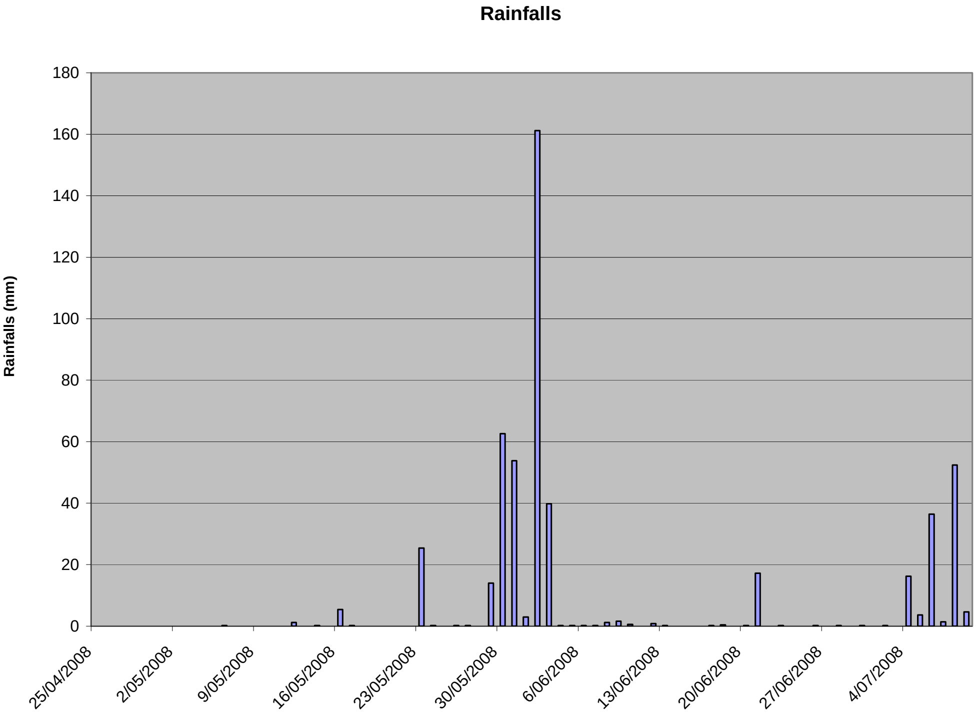
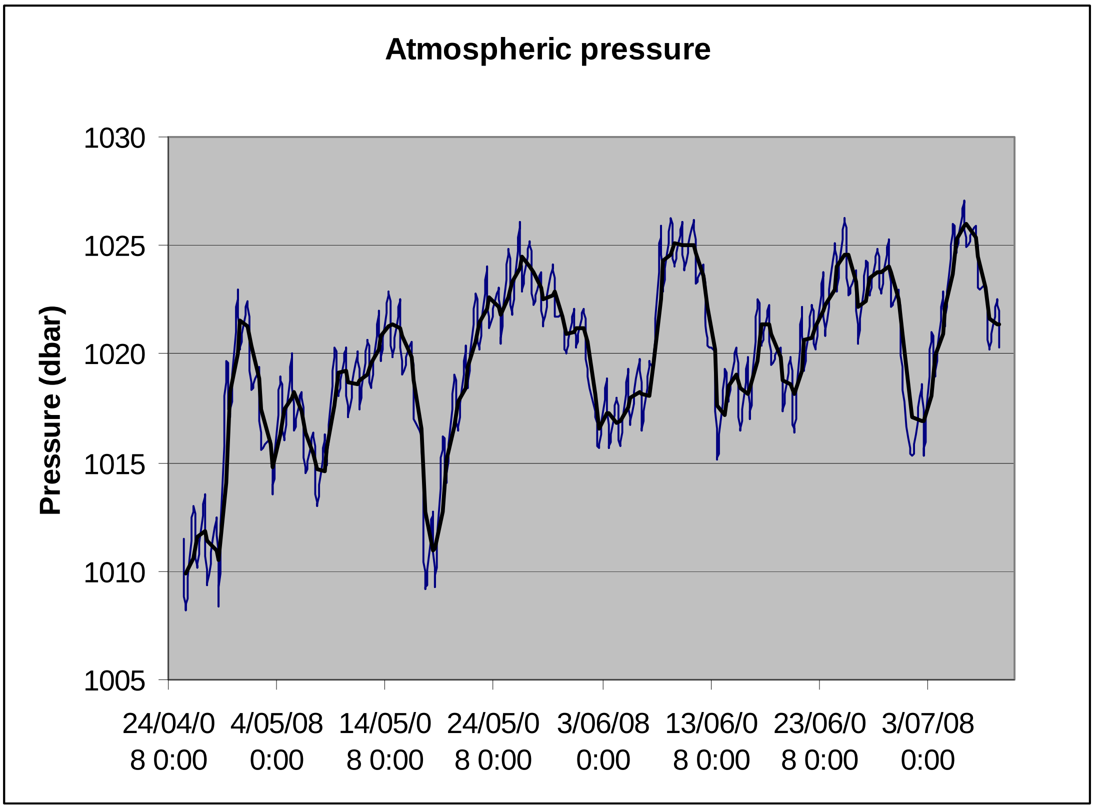
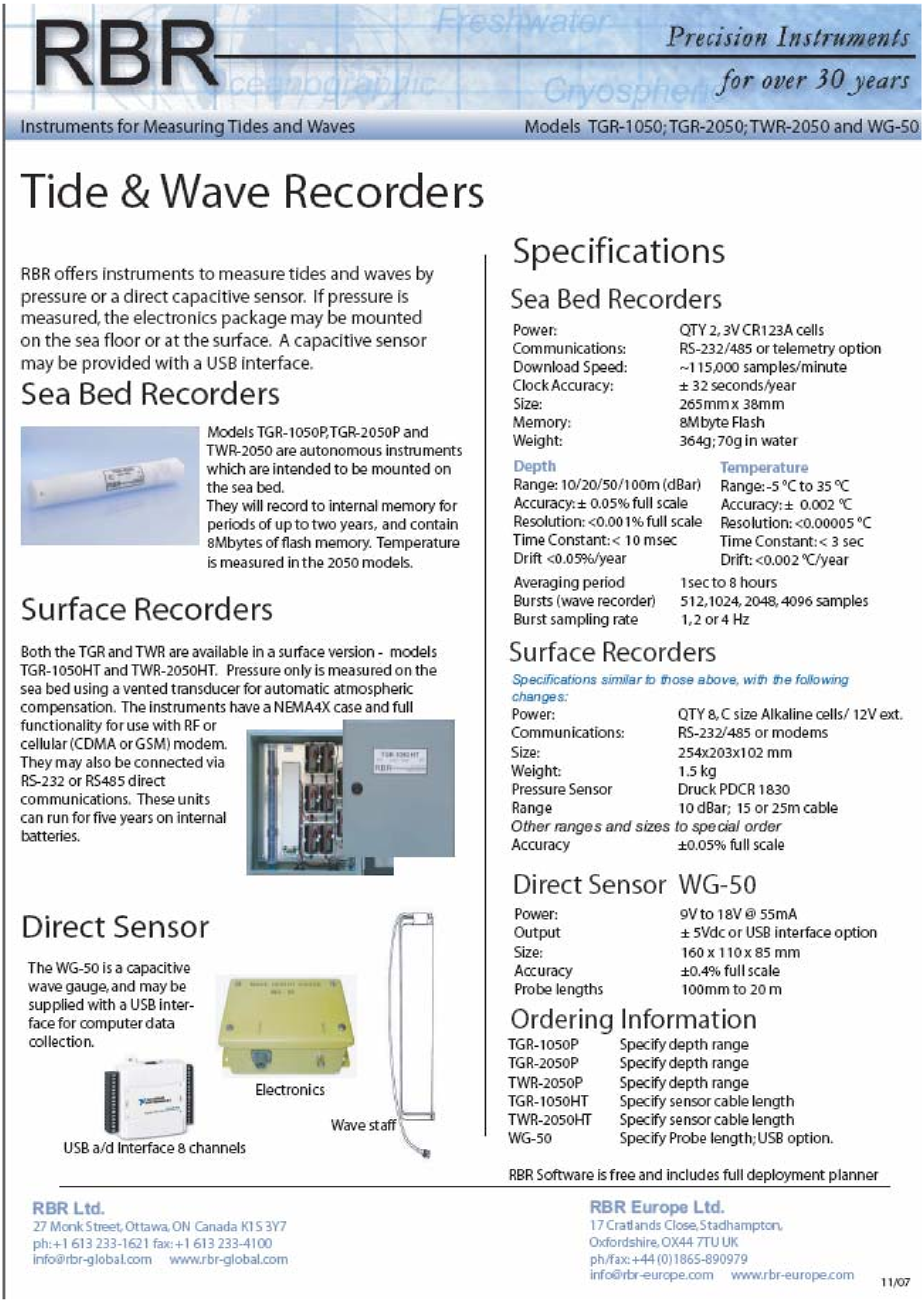


Figure 1 Rainfalls on Maroochydore from 25/04/2008 to 09/07/2008


Atmospheric pressure
Pressure (dbar)
1030
1025
1020
1015
1010
1005
24/04/0 8 0:00
4/05/08 0:00
14/05/0 8 0:00
24/05/0 8 0:00
3/06/08 0:00
13/06/0 8 0:00
23/06/0 8 0:00
3/07/08 0:00

Appendix 10.2: Equipment characteristics

RBR TWR-2050 specifications



RBR

Precision Instruments
for over 30 years

Instruments for Measuring Tides and Waves

Models TGR-1050; TGR-2050; TWR-2050 and WG-50

Tide & Wave Recorders

RBR offers instruments to measure tides and waves by pressure or a direct capacitive sensor. If pressure is measured, the electronics package may be mounted on the sea floor or at the surface. A capacitive sensor may be provided with a USB interface.

Sea Bed Recorders

Models TGR-1050P, TGR-2050P and TWR-2050 are autonomous instruments which are intended to be mounted on the sea bed. They will record to internal memory for periods of up to two years, and contain 8Mbytes of flash memory. Temperature is measured in the 2050 models.

Surface Recorders

Both the TGR and TWR are available in a surface version - models TGR-1050HT and TWR-2050HT. Pressure only is measured on the sea bed using a vented transducer for automatic atmospheric compensation. The instruments have a NEMA4X case and full functionality for use with RF or cellular (CDMA or GSM) modem. They may also be connected via RS-232 or RS485 direct communications. These units can run for five years on internal batteries.

Direct Sensor

The WG-50 is a capacitive wave gauge, and may be supplied with a USB interface for computer data collection.

Electronics

Wave staff

USB a/d Interface 8 channels

Specifications

Sea Bed Recorders

Power:	QTY 2, 3V CR123A cells
Communications:	RS-232/485 or telemetry option
Download Speed:	~115,000 samples/minute
Clock Accuracy:	± 32 seconds/year
Size:	265mm x 38mm
Memory:	8Mbyte Flash
Weight:	364g; 70g in water

Depth	Temperature
Range: 10/20/50/100m (dBar)	Range: -5 °C to 35 °C
Accuracy: ± 0.05% full scale	Accuracy: ± 0.002 °C
Resolution: <0.001% full scale	Resolution: <0.00005 °C
Time Constant: < 10 msec	Time Constant: < 3 sec
Drift <0.05%/year	Drift: <0.002 °C/year

Averaging period	1sec to 8 hours
Bursts (wave recorder)	512, 1024, 2048, 4096 samples
Burst sampling rate	1, 2 or 4 Hz

Surface Recorders

Specifications similar to those above, with the following changes:

Power:	QTY 8, C size Alkaline cells/ 12V ext.
Communications:	RS-232/485 or modems
Size:	254x203x102 mm
Weight:	1.5 kg
Pressure Sensor	Druck PDCR 1830
Range	10 dBar; 15 or 25m cable

Other ranges and sizes to special order

Accuracy	±0.05% full scale

Direct Sensor WG-50

Power:	9V to 18V @ 55mA
Output	± 5Vdc or USB interface option
Size:	160 x 110 x 85 mm
Accuracy	±0.4% full scale
Probe lengths	100mm to 20 m

Ordering Information

TGR-1050P	Specify depth range
TGR-2050P	Specify depth range
TWR-2050P	Specify depth range
TGR-1050HT	Specify sensor cable length
TWR-2050HT	Specify sensor cable length
WG-50	Specify Probe length; USB option.

RBR Software is free and includes full deployment planner

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11/07

RBR XR-420 CTD specifications

RBR

Precision Instruments for over 30 years

Submersible Conductivity, Temperature and Depth Logger

Model XR-420CTD

XR-420 CTD

Conductivity, Temperature and Depth Logger

Features:

- High Accuracy
- Large Memory
- Low Power
- High-speed Data Download

The XR-420 CTD Marine is a small, autonomous data logger designed to monitor conductivity, temperature and depth. High accuracy Speed of Sound and Salinity may be derived from the data.

The normal marine conductivity range of 0 to 70 mS/cm is measured by an inductive cell. RBR uses a three-coil system with a closed loop feedback for superior temperature compensation. The titanium housing provides a depth rating for the cell of 6,600m which can be axial to the logger. It also provides shielding and stable cell geometry. The response time of the inductive cell is better than 0.095 seconds, which, along with a large hole diameter, allows for long-term operation without an additional flow pump.

8MB of nonvolatile flash memory provides sufficient memory for 2,400,000 readings, which can be logged on one set of high-powered 3V lithium batteries. The batteries are common camera batteries (CR123A), which are readily available. Power consumption can vary significantly depending on the sampling rate, and operating temperature. A fresh set of batteries will usually permit collection of a full complement of readings over periods exceeding one year.

For more details, please visit our website: www.rbr-global.com

Software

The XR-420 use fully integrated RBR Windows® software, which is compatible with Windows® 95/98/NT/2000/XP. Please see the "RBR Logger Software" datasheet, or visit the RBR website (www.rbr-global.com) for more information.

Technical

Base Logger

Power:	QTY 4, 3V CR123A cells
Communications:	RS-232/485; logged, cable, or telemetry
Download Speed:	~115,000 samples/minute
Clock Accuracy:	± 32 seconds/year
Size:	400mm x 64mm
Weight (plastic):	1259g (in air); 389g (in water)
Memory:	8Mbyte Flash (2,400,000 samples)
Sample Rate:	1Hz* to 24 hours (programmable)
Calibration:	NIST traceable standards

* see RBR XR-620CTD Profiler for faster sampling rate

Temperature

Range:	-5 °C to 35 °C; extended range to -40 °C
Accuracy:	± 0.002 °C
Resolution:	<0.00005 °C
Time Constant:	depends on probe construction

Conductivity

Range:	0 to 70 mS/cm
Accuracy:	± 0.003 mS/cm
Resolution:	<0.0001 mS/cm
Time Constant:	< 95msec

Depth

Range:	10/25/60/150/250/740/1000/2000/3000/4000/6600 m (dBar)
Accuracy:	± 0.05% full scale
Resolution:	<0.001% full scale

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11/07

Appendix 10.3 : Spring/Neap Current Measurement Methodology

Equipment

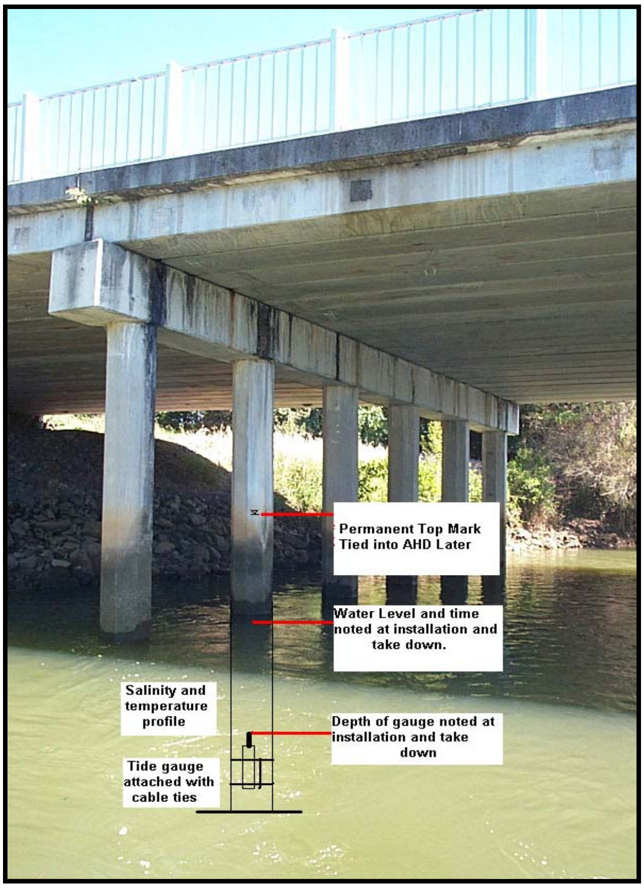
- Truck
- Boat
- Solar panel and 12v battery power supply
- 240V ac Inverter
- 12-24 DC/DC converter
- Sontek or FlowQuest 1.0 Mhz ADCP
- DGPS system
- Handheld GPS system
- Echosounder
- Laptop computer
- Sontek 3.0Mhz Argonaut XR
- Anchors
- Marker buoys

Methodology

Usually 1 hr packing, travel time, 25 hours survey, 1 hour berthing, Travel time, 2 hrs cleaning, 1 hr down loading data. Total 30 hours plus travel time.

- Prior to leaving base, set up Argonaut XR and tide gauge recording at 12 and 6 minute intervals respectively.
- Arrive on site just prior to low water slack, launch boat
- Set up handheld GPS to 1min track log, take WP at jetty.
- Proceed to site, place Argonaut XR in the deepest point just upstream or downstream of the cross section.
- Take WP position of Argonaut XR.
- Tie up boat to large marker buoy and anchor placed centre of channel.
- Take WP position of centre channel marker.
- Set up Sontek River Surveyor software, DGPS, Echosounder
- Start a record hopefully catching low water slack.
- Monitor the velocities and once they exceed 1.0 m/s start cross sections.
- Set up Left or Right bank (Left is traditionally on your left when facing upstream). Take WP position.
- Start line. Proceed across the channel ensuring speed within limits and heading changes minimised. End line. Take WP position.
- If the start and end of each line is obvious or markers are placed in position, only one WP is needed for each location.
- Start next line and repeat from Right to Left i.e. two runs.
- Repeat every ½ hour until velocity falls to below 1.0m/s, say 1hr prior to high water
- Once velocities less than 1 m/s, tie up to centre float and record over high water slack to get accurate time of HW slack.
- Repeat exercise again down to low water slack
- Repeat exercise again back up to high water slack
- Repeat exercise again down to low water slack
- Once current velocity >1 m/s take one more double cross-section.
- Retrieve Argonaut XR, anchors and floats
- Return to jetty. Retrieve boat.
- Back to boat shed, wash down boat, store
- Wash down equipment
- Download data and tidy up

Appendix 10.4: Tide Gauge Installation and Take Down methodology



Methodology

- Arrive on site and choose suitable permanent tide gauge location point that has reasonably easy visual access from the shore.
- If using a boat, drop anchor upstream and pay out the anchor rope till adjacent to the mark. Use a side rope to loosely tie off on the tide gauge location point
- Check depth (>1m Low Water) using survey staff.
- Once satisfied location is good, make a permanent mark (PM) on the chosen post using a scratching devise or permanent marker. This is later tied into a local datum.
- Attach cable ties onto tide gauge and lower to swimmer in the water.
- Swimmer fastens cable ties around post prior to lowering to the bottom, ensuring sufficient slack on cable ties to clear growth and obstructions on post.
- Swimmer lowers tide gauge as deep as possible, firmly secures attaching cable ties and then threads a 3rd cable tie between the two attaching ties to use leverage tightening.
- Distance then measured from top of the gauge to the PM and noted in the log. The difference between this measurement and the one taken at take down gives an indication as to the stability of the gauge during the survey period.

- Noting the time and distance from the PM in the log does a water level check. It is good practice to ensure the time the water level is taken coincides with the time the tide gauge is taking a reading. A 12-hour Van de Castillo test should ideally be done sometime during the survey period.
- A salinity and temperature profile is taken at the site on installation and preferably ever week thereafter.
- Dismantling is just a reverse procedure of the installation with the cable ties being severed using side snips or a sharp knife.

Appendix 10.5: Water Velocity Impellor methodology

Method for use

1. Put red plug into +VOA socket and black plug into –com socket
2. Turn multimeter switch
3. Rotate impellor to check if working (will beep, if not replace the batteries)
4. Lower impellor into the water (just below surface) keeping it level
5. Start stopwatch and count the number of beeps in 30 seconds
6. Notes results
7. Using compass, record the current direction

GCCM Current Metre Calibrations

Calibration limits – 0.028 – 6.064 m/s
Minimum response speed 0.028 m/s
Maximum response speed 6.064 m/s

Range of impellor revolutions n revs/s		Equation for speed of flow V m/s
Minimum	Maximum	
0.06	0.54	V = 0.012+0.2584 n m/s
0.54	13.35	V = 0.002+0.2773 n m/s
13.35	18.29	V = 0.0.29+0.2753 n m/s

The uncertainty of repeatability (at 95% confidence level) of calibration varies with the speed of flow within the limits stated below.

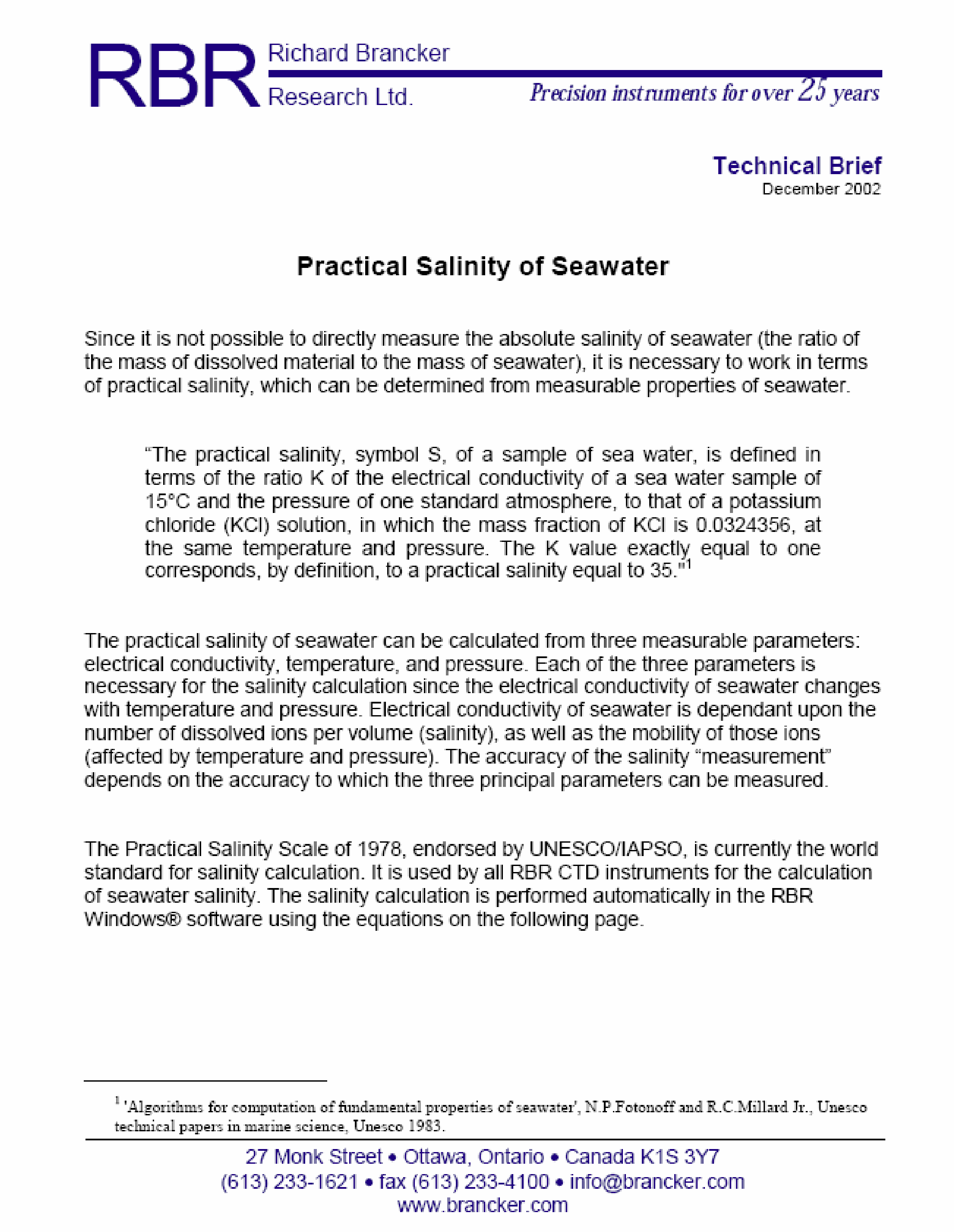
Flow Speed m/s	0.03	0.10	0.15	0.25	0.50	>0.50
Uncertainty %	20	5	2.5	2	1	1

The above values represent variation of +/- 0.005 m/s up to 0.5 m/s.

Equation

n = rev/30 seconds

Appendix 10.6: Calculation of the salinity by the RBR software



RBR Richard Brancker
Research Ltd.

Precision instruments for over 25 years

Technical Brief
December 2002

Practical Salinity of Seawater

Since it is not possible to directly measure the absolute salinity of seawater (the ratio of the mass of dissolved material to the mass of seawater), it is necessary to work in terms of practical salinity, which can be determined from measurable properties of seawater.

> "The practical salinity, symbol S, of a sample of sea water, is defined in terms of the ratio K of the electrical conductivity of a sea water sample of 15°C and the pressure of one standard atmosphere, to that of a potassium chloride (KCl) solution, in which the mass fraction of KCl is 0.0324356, at the same temperature and pressure. The K value exactly equal to one corresponds, by definition, to a practical salinity equal to 35."[1]

The practical salinity of seawater can be calculated from three measurable parameters: electrical conductivity, temperature, and pressure. Each of the three parameters is necessary for the salinity calculation since the electrical conductivity of seawater changes with temperature and pressure. Electrical conductivity of seawater is dependant upon the number of dissolved ions per volume (salinity), as well as the mobility of those ions (affected by temperature and pressure). The accuracy of the salinity "measurement" depends on the accuracy to which the three principal parameters can be measured.

The Practical Salinity Scale of 1978, endorsed by UNESCO/IAPSO, is currently the world standard for salinity calculation. It is used by all RBR CTD instruments for the calculation of seawater salinity. The salinity calculation is performed automatically in the RBR Windows® software using the equations on the following page.

---

[1] 'Algorithms for computation of fundamental properties of seawater', N.P.Fotonoff and R.C.Millard Jr., Unesco technical papers in marine science, Unesco 1983.

27 Monk Street • Ottawa, Ontario • Canada K1S 3Y7
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www.brancker.com

Practical salinity, S, is calculated using the following equation(s)
(IEEE Journal of Oceanic Engineering, Vol. OE-5, No. 1, January 1980, page 14):

$$S = a_0 + a_1 R_T^{1/2} + a_2 R_T + a_3 R_T^{3/2} + a_4 R_T^{2} + a_5 R_T^{5/2} + \Delta S$$

where

$$\Delta S = \frac{(T-15)}{1+0.0162(T-15)} * (b_0 + b_1 R_T^{1/2} + b_2 R_T + b_3 R_T^{3/2} + b_4 R_T^{2} + b_5 R_T^{5/2})$$

T is the in-situ temperature (International Temperature Scale 1968 or ITS-68). Since RBR loggers are calibrated to the more recent ITS-90 scale, the conversion to ITS-68 for salinity calculation is performed automatically in the RBR Windows® software.

$$R_T = \frac{R}{R_p r_T}$$

RBR Conductivity sensors measure R, which is the ratio of the conductivity of the sample of seawater, to the conductivity of standard seawater at S = 35, T = 15ºC, and p = 0. Conductivity(35,15,0) = 42.914mS/cm.

$$R = \frac{Conductivity(S,T,P)}{Conductivity(35,15,0)} = R_T R_p r_T$$

R_P and r_T are calculated to adjust for in-situ temperature and pressure:

$$R_P = 1 + \frac{p(e_1 + e_2 p + e_3 p^2)}{1 + d_1 T + d_2 T^2 + (d_3 + d_4 T)R}$$

$$r_T = c_0 + c_1 T + c_2 T^2 + c_3 T^3 + c_4 T^4$$

p is the in-situ pressure measured in bars.

Coefficients

	a	b	c	d	e
0	0.0080	0.0005	0.6766097		
1	-0.1692	-0.0056	$2.00564e^{-2}$	$3.426e^{-2}$	$2.070e^{-4}$
2	25.3851	-0.0066	$1.104259e^{-4}$	$4.464e^{-4}$	$-6.370e^{-6}$
3	14.0941	-0.0375	$-6.9698e^{-7}$	0.4215	$3.989e^{-12}$
4	-7.0261	0.0636	$1.0031e^{-9}$	$-3.107e^{-3}$	
5	2.7081	-0.0144			

APPENDIX 11 – IMPLEMENTATION PLAN FOR MODELLING AND MONITORING

1. INTRODUCTION

The successful implementation of an Adaptive Management Framework requires appropriate monitoring and modelling. The following sections set out the requirement for monitoring as recommended in the main report; costs asscoicated with each component; a process for monitoring data to be integrated with modelling; and a process for both the monitoring data and modelling output to be integrated within the adaptive management guidelines (LEROMP).

2 MONITORING PROGRAM

The monitoring program needs to provide the information to support effective adaptive management. The following key monitoring activities are required:-

1. Velocity measurements
2. Water level / tide gauging
3. Entrance Video monitoring
4. Water sampling
5. Bank stability
6. Ecological surveys

The details of each activity and associated costs are included in this section Monitoring strategies and likely data analysis are also recommended with the required budget. To monitor the performance of important monitoring programs performance criteria, corrective action and performance indicators are detailed.

2.1 Velocity Measurements

Background:
Current velocities within the main Currimundi channel are effectively negligible during period of near closure of the entrance. During flood flow and entrance openings, the velocities increase and respond to tidal variation. During these times there is flushing of the lake system.

Objective:

- To obtain a thorough understanding of the response to entrance opening.
- To calibrate a numerical model

Monitoring strategy:

- During flooding or entrance opening events, take velocity measurement at one site.
- If possible continue measurements until the entrance closes, or for at least one week

Data analysis:

- Download data at the end of each event monitoring.
- Analyse velocity data and correct pressure data to local datum to produce the equivalent water level.
- Estimate cross-sectional discharge from velocity data.
- Input velocity and water level data into numerical modelling for calibration.
- Compare results with previous events, and prepare a relationship between parameters associated with the entrance opening : - volume dredged (if relevant), tide height at opening; antecedent rainfall; height of the berm; duration of opening; duration of tidal influence in the lake system.

2.2 Water Level / Tide Gauging

Background:
The dominant parameter in lake management is the water level. During periods of closure it remains fairly static, but will increase during freshwater flows. The water level impacts on biting midge, bank stability and property freeboard. The relative water level between lake kawana and Lake Currimundi influences the weir discharge throughout the tidal cycle. During period when the entrance is open, tidal fluctuations are experienced in lake Currimundi, and if during spring tides, in Lake Kawana.

Objective:
- To provide reference data for a range of lake management parameters.
- To provide calibration data for numerical modelling.

Monitoring strategy:
- Install water level meters at 2 locations – near the bridge and at the upper end of Lake Kawana.
- Telemeter data real-time to SCRC offices.
- Obtain short term measurements at a number of locations (as used in the June 2008 field exercise) during events monitoring exercises.

Data analysis:
- Analyse data and correct to equivalent water level.
- Compare with predicted levels.
- For opening event monitoring, compare results with previous events, and prepare a relationship between parameters associated with the entrance opening : - volume dredged (if relevant), tide height at opening; antecedent rainfall; height of the berm; duration of opening; duration of tidal influence in the lake system.
- For real-time records develop a relationship between water levels in both lakes and rainfall, tide level, changes in water quality, bank stability and biting midge numbers.
- Input water level data for events into numerical modelling for calibration.

2.3 Entrance video monitoring

Background:
Video (or digital still) records provide a record of features, shoreline changes and reveal coastal processes which are otherwise difficult to measure. A permanent monitoring station at the Currimundi surf tower offers the added advantage of providing up to date information on beach and surf conditions. A video imaging system provides an extremely cost effective tool to address a wide range of environmental, social and economic issues. Digital analysis of video images obtained can provide both quantitative and qualitative information on the movement of the entrance channel and shoals in response to natural forcing and artificial opening.

Objective:
- To provide a cost effective means of monitoring the entrance channel movement
- To monitor useage of the entrance environment

Monitoring strategy:
- Install 1 robotic video camera on the Currimundi surf tower which can monitor the entrance channel and shoals on a daily (low tide) basis and to also provide surf and beach condition images.
- Set-up the system (video camera + computer) to ensure snap shot images every low tide, and timex and variance images of the beach.
- Download data via modem for analysis by GCCM.

Data Analysis:
- Measure daily entrance channel and shoals shoreline changes
- Correlate channel position with other parameters such as berm height, antecendent wave climate conditions, freshwater flow, Lake Kawana discharge.
- Integrate output into the adaptive management framework by modifying adaptive action related to entrance opening to ensure that the entrance channel remains to the north.

2.4 Water Sampling

Background:
For the works associated with dredging and beach nourishment some local impact on water quality is possible. Contaminant re-suspension and turbidity are expected to be minor in relation to the overall waterway system. However in keeping with the precautionary principle, water quality monitoring should occur to ensure that there are no contaminants in these areas above the recommended ANZEC limits.

Objective:
- To monitor changes in water quality in response to closed entrance conditions and to events such as flooding or entrance opening.

Monitoring Strategy:

- Routine monitoring on a monthly basis at the suite of existing sites to be undertaken by the Currimundi Catchment Care Group under guidance form SCRC personnel.
- Undertake event monitoring before known flooding and entrance opening events, and for a period of a least one week following the event. Sampling frequency will depend on the magnitude of the event, but should be at least every 2 days. In event of limited resources being available at least one site in the main channel near the bridge should be sampled as the system is well mixed under these conditions.
- Automatic monitoring of water quality is also an option depending on coast (se later section).
- Monitoring parameters are set out in the main report.

Data Analysis:
- Test water quality samples from all sites.
- Compare water quality with relevant standards.
- Undertake comparative control tests between community and Council measured data.
- Correlate water quality trends or features with other dynamic parameters such as atmospheric conditions, Lake Kawana discharge, rainfall runoff, entrance opening.
- Test LEROMP actions against water quality outcomes.

2.6 Bank stability

Background:
Bank stability/erosion issues occur from time to time, and are observed by community and Council officers. These anecdotal observations provide the best method for monitoring the extent of bank erosion problems.

Objective:
- To determine the relationship between bank erosion and other lake parameters.

Monitoring strategy:
- Collaborate with the community groups to establish a database of observations.
- Record all observations.

- Establish monitoring of erosion rates at locations where erosion is persistent. Simple measurements from a fixed reference point, and photographic record.

Data analysis:

- Correlate these observations with other lake parameters such as rainfall, entrance opening, water level.
- Compare results with historical and previous measurements records.
- Develop simple relationship between water level and bank stability.
- Use data to support a foreshore erosion management plan implementation.

2.6 Ecological Survey

Background:

Biting midge has been identified as the key issue of concern for many of the community. Other concerns include fish stock and changes in aquatic flora.

Objective:

- To enhance the midge control programs.
- To monitor aquatic health of the waterway.

Monitoring strategy:

- Collaborate with the community groups to establish a database of observations of flora and fauna.
- Record all observations.
- Continue SCRC's biting midge control and research program.

Data analysis:

- Correlate these observations with other lake parameters such as rainfall, entrance opening, water level.
- Compare results with historical and previous measurements records.
- Develop simple relationship between biting midge and other lake parameters; and between recreational fish abundance and water quality, entrance opening and flooding.
- Test LEROMP actions for biting midge against other relationships for flora and fauna.

3. MODELLING

3.1 Numerical Hydrodynamic Modelling

Background:

Hyrdodynamic modelling can provide a better understanding of the dynamics of the Lake during natural events and artificial entrance openings. Either through simulation of a range of possible scenarios, or by real-time modelling following specific events, a database of output can be obtained from which various operational parameters such as flushing time, and extent of entrance opening can be assessed.

Objective:

- To define the hydrodynamic characteristics of the Lake system during natural events and artificial entrance openings.

Modelling strategy:

- On notice of an upcoming event, the modelling team should be put on standby.
- If possible pre- and post-event bathymetry should be obtained at the entrance.

Data Analysis:

- Model outputs to be analysed for flushing time: impact on Lake Kawana level; peak water levels throughout the system; peak velocities.

- Correlate the numerical output with other lake parameters as above.

3.2 First-Order relationships

Background:
Exact relationships between parameters of concern in Lake Management do not exist, or are not amenable to cost-effective numerical modelling. A better approach is to develop first-order relationships (or conceptual models) to identify trends and causal factors. Through the sections above reference is made to correlating various parameters, which over time will provide sufficient data to develop such models.

Objective:

- To define in a broad sense – relationships between various lake parameters.

Modelling strategy:

- Apply various data manipulation techniques, such as Bayesian Networks and General Additive Modelling to all data sets obtained (including simulated data from numerical models).

Data Analysis:

- Analyse the results of these manipulations for trends.
  Integrate the analysis into the LEROMP actions where appropriate modification is required.

4. Adaptive Management Framework

The overall objective of this project was to develop an adaptive management framework for the management of the Lake Currimundi system. The findings of the report suggest that there is no simple process or management action which will meet all stakeholders concerns, or which will provide optimum outcomes for all issues.

Under these circumstances it has been recommended that an adaptive approach be adopted where new knowledge is gained following each event or action. This new understanding needs to be integrated into the existing adaptive management protocol – the LEROMP. Guidance for doing this has been given in Chapter 10 of the main report.

The process to achieve more effective management could follow these steps.

1. Pre-event or management action monitoring
2. Event or management action.
3. Post-event or action monitoring and modelling
4. Data analysis and development of improved relationships
5. Steering Committee workshop on outcomes of system response to event or management action.
6. Collaborative decision on the need for modification to LEROMP prescribed action, or routine treatments.
7. Establish new monitoring and action plan protocols in preparation for next event or action.

5. Monitoring systems for Lake Currimundi

In the following section, a couple of options are costed and detailed for the installation water level monitoring systems, monitoring of hydrodynamics data during an event, and an automated water quality monitoring at one site.

Specific details of traditional water quality data collection have not been dealt with here, as the cost and methods are well known.

5.1 Water Level Monitoring

This system includes 2 water level gauges – on at the bridge and one at the upper end of Lake Kawana.

Details and Cost estimates

Atmospherically compensated Depth sensor, Conductivity and Temperature (Includes self recording data logger at tide recording site)	$ 9,900.00	
Tide board and Aluminium wall mounting.	$ 1,700.00	
Radio Telemetry Field Station (client can choose dial up or wireless)	$ 3,750.00	
Total for Tide Gauge 1		$15,350.00
Total for Tide Gauge 2		$15,350.00
Radio Telemetry Base Station (to clients desk top)		$ 3,250.00
Software to run telemetry system		$ 5,500.00
Installation and basic training (client to provide AHD datum level at site)		$ 4,500.00
Total estimate		$43,950.00

Note. Field housing provided by client. See ideas below

Suggested ongoing maintenance

- Daily checks against vandalism and transducer fouling
- Fortnightly cleaning of the transducer heads
- Monthly field check against a salinity standard
- Regular spot height checks on the tide board.
- Annual back to manufacturer clean-up and re-calibration

5.2 Event Monitoring Exercise

An estimate of the cost of an event monitoring exercise is given below for hydrodynamics data.

Day Rates

MOB		$ 1,200.00
Scientist	$ 1,000.00	
Assistant	$ 750.00	
Sontek Argonaut ADCP	$ 700.00	
YSI CTD sonde	$ 120.00	
2 x wave and tide sonde	$ 120.00	
TOTAL		$ 2,690.00
DEMOB		$ 1,200.00

Note

Currimundi is known to be a high risk and aggressive location as equipment has been lost on previous exercise. The instrumentation was dumped on the shore with anchor and chains stolen and both tyres were deflated on the boat trailer whilst parked at the apartments.

This risk has not been reflected in the estimates.

5.3 Automated Water Quality and Velocity measurement

Preferred location

Figure 1. Plan of Currimundi Bridge

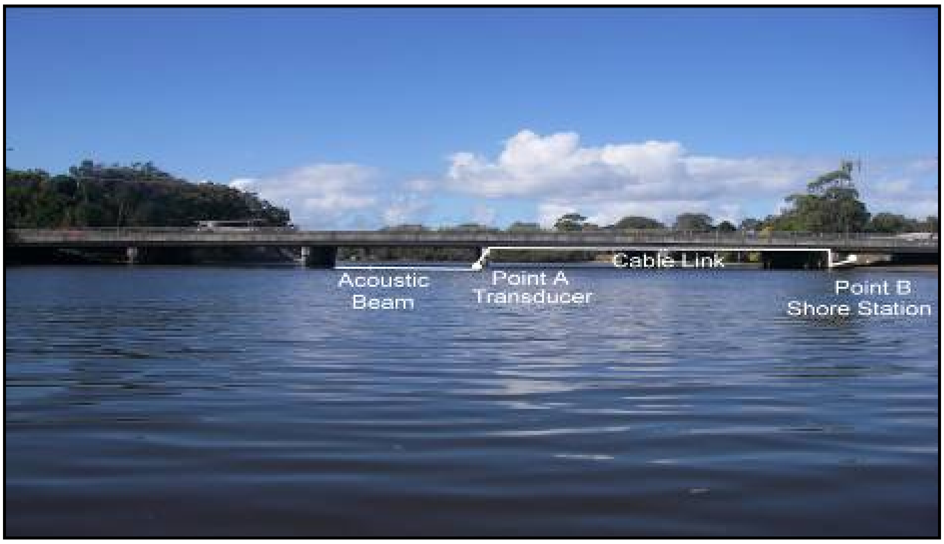


Figure 2. Side View of Currimundy Bridge

Suggested Methodology and Set Up
Point B is a shore based, flood and vandal proof cabinet that houses a solar panel driven data logging system permanently linked to the internet for real time display anywhere on the planet.

Optional parameters that can be recorded at point B and then stored on the data logging system every six minutes could be but not limited to

- Air temperature and humidity
- Wind speed and direction
- Barometric pressure
- Rainfall
- Solar radiation

Point A is a bridge wall mounted sensor assembly designed for easy cleaning and maintenance from a boat, negating the need for divers, linked to the shore based cabinet at Point B via a SDI 12 data cable assembly.

Optional parameters that can be recorded at point A and stored by the data logging system every six minutes at Point B could be but not limited to

- Water level
- Water conductivity
- Water temperature
- Water turbidity
- Water velocity
- Dissolved Oxygen

Within the cabinet there is also a water sampling station that can be triggered by various chosen events such as extremes in water level, rainfall, water velocity or turbidity for example.

The water samples stored can subsequently be tested in a NATA approved laboratory for various event specific parameters determined by the client.

Typical equipment example
Not including say weather station mast and solar panel power supply.

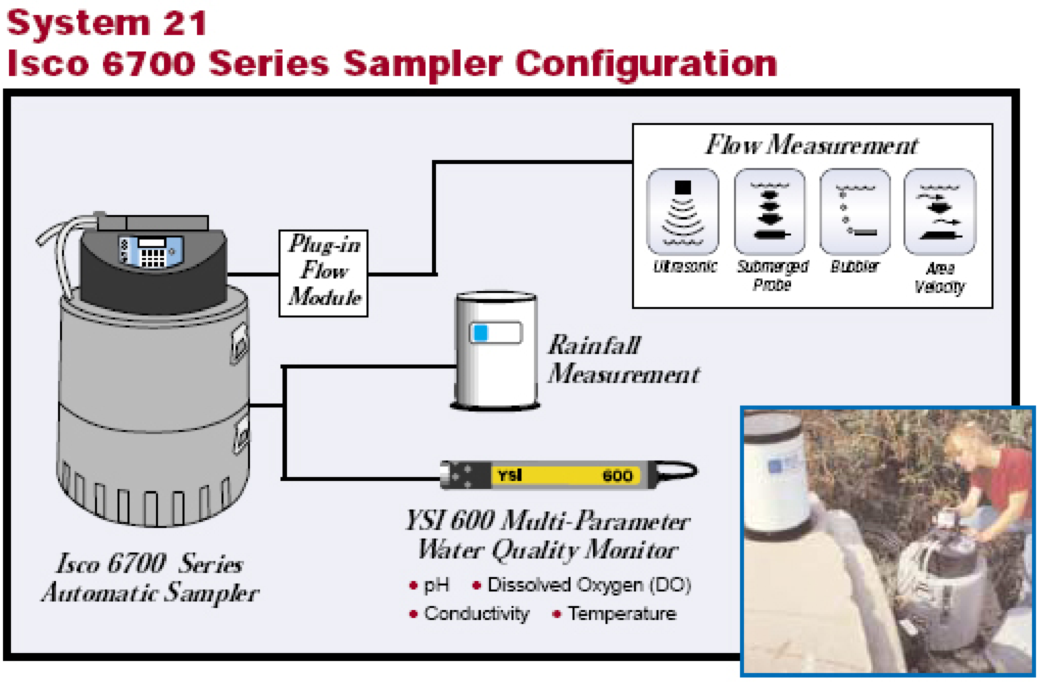


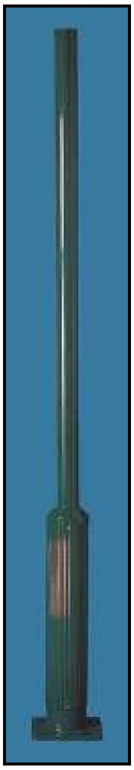
Figure 3. Water monitoring example and equipment overview

Costing

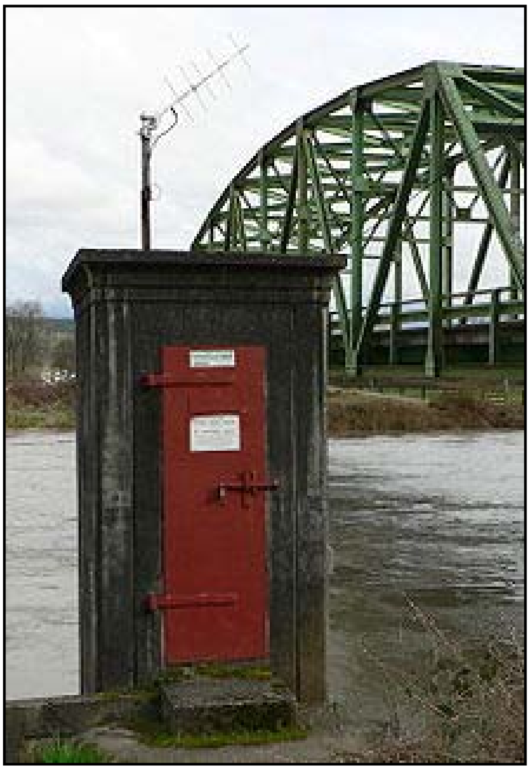
The table below gives estimated costs on a system that could be chosen by the client to monitor the Lake Currimundi system on a full time basis with real time internet display and an inbuilt capacity to collect water samples during extreme events for subsequent laboratory analysis.

A	1	6600-02	YSI model 6600 water quality sonde with two (2) optical sensor ports, internal memory and battery chamber for unattended monitoring, and supplied with medium depth sensor, conductivity and temperature sensor,	$11,770.00	
B	1	EAOS	Weather station wind, temp, rainfall, BP	$4,750.00	
C	1	006092	100m Field Cable	$2,880.00	
D	1	006130	Self cleaning sensor - Turbidity probe	$3,900.00	
E	1	606150	Self cleaning sensor - Optical DO probe	$3,545.00	
F	1	Sontek	Sontek Argonaut SL 3000 water velocity sensor	$7,400.00	
G	1	68-6710-070	ISCO model 6712 Portable water Sampler with internal data logger, digital I/O, connection for flow meter, rain gauge, selection of plug-in modules, SDI-12 connection for water quality sondes etc.	$6,545.00	
H	1	68-6700-006	24 x 1 Litre poly bottle Configuration for 6712 Sampler	$500.00	
I	1	68-6700-050	ISCO model 730 Bubbler Flow Module with 1/8 inch x 25 ft. vinyl bubble line. Uses built-in compressor technology and does NOT require supply of bottled gas such as nitrogen.	$4,425.00	
J	1	EAOS	Flood and vandal proof cabinet and footings	$5,500.00	
K	1	EAOS	Software and Internet connection	$3,500.00	
L	1	GCCM	Installation, mobilisation, checks and calibration	$10,500.00	
M		GCCM	Consumables, nuts, bolts and miscellaneous items	At cost	
			Total suggested hardware supply and installation	**$65,215.00**	
N		GCCM	Annual monthly site visits, sensor cleaning and field calibrations	**$24,500.00**	

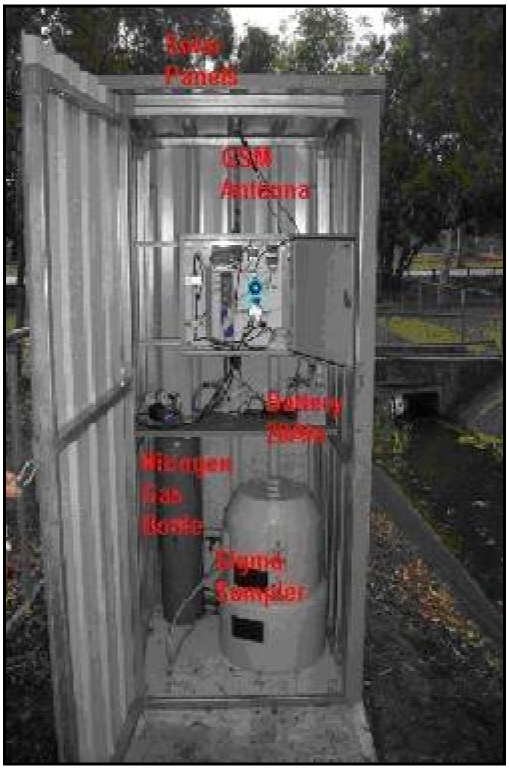
Ideas for Enclosures and Housings



Light Pole



Basic Enclosure



Typical Enclosure Contents

Shed Example

Simple Pole Assembly

APPENDIX 12 – GEOTECHNICAL INVESTIGATION OF DUNAL SYSTEM

Golder Associates

TECHNICAL MEMORANDUM

DATE 12 November 2009 **PROJECT No.** 097682053-001-TM-Rev0

TO Mr Denis Shaw
Sunshine Coast Regional Council

CC Cess Munns

FROM Ashley Davey **EMAIL** adavey@golder.com.au

WATSON STREET, CURRIMUNDI – SAND DUNE STABILITY ASSESSMENT PRELIMINARY REPORT

At the request of Sunshine Coast Regional Council, Golder Associates Pty Ltd (Golder) has undertaken the following works as part of a geotechnical assessment of sand dune stability at Watson Street, Currimundi:

- Desk-top study (Stage 1): Review of published maps, historical aerial images and previous geotechnical reports by Golder on other sites in the local area.
- Site investigation (Stage 2): Walk-over survey on 30 October 2009 followed by subsurface borehole investigation on 4 and 5 November 2009.

This technical memorandum includes a preliminary report on the findings of the above described works, together with recommendations for further geotechnical investigation and an outline of possible sand dune stabilisation measures. It is intended that a more detailed report on findings from the above work would be presented in a final report following the completion of the additional stages of investigation.

Desk-Top Study

Published geology[1] indicates that the site is underlain by Quaternary (Pleistocene to Holocene) age beach ridges.

Historical aerial photographs show that the sand dune east of Watson Street has experienced periods of advance and retreat over a number of years, as evidenced by the extent of vegetation. There appears to have been a westward retreat of the vegetation line from a maximum eastward position around 1996 to the current situation.

Our records indicate that Golder has conducted three geotechnical investigations within approximately 100 m (west) of Watson Street (Ref. 89680056, 92680229 and 95680258). Those investigations encountered dense to very dense indurated sand ('coffee rock') from about 1 m depth, then extending to depths of up to approximately 5 m.

Site Investigation

The results of our site investigation generally confirm the findings of our desk top study. In summary, the site investigation determined the following:

- Anecdotal evidence indicates that in 1974 there was substantial beach erosion associated with Cyclone Wanda. This event formed a scarp along the current main sand dune line approximately 10 m to 15 m east of the existing properties. We understand that residents observed outcrops of indurated sand at places along the toe of this erosion scarp at that time. Between 1974 and 1996 there was a period of sand dune advance, during which time low fore dunes developed further east of the current fore dune (in the order of 20 m). In 1996 there was again a substantial weather event that eroded the fore dunes

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[1] 1 100,000 Nambour Special, Geol. Map, DME, 1999

to a position just east of the current line. Heavy seas in early 2009 further eroded the fore dune to its current position.

- Eight boreholes (designated BH1 to BH8) were drilled by hand auger at locations between the toe of the main dune and the current fore dune scarp. Dynamic cone penetrometer (DCP) testing was undertaken adjacent to, and within, each borehole after augering to various depths. Figure No. 1 attached shows the borehole locations. Note that the eastern extent of vegetation has retreated in the order of 5 m to 10 m westwards since the aerial image shown in Figure No. 1 was recorded, particularly to the south of borehole BH6. The borehole reports are attached along with explanatory notes.
- Boreholes BH1 to BH4 were drilled along the toe of the main dune and encountered:
  - Very loose grading to medium dense sands; then
  - The upper interface of an indurated sand layer between approximately RL 1.7 m and RL 0 m AHD.
- Boreholes BH5 to BH8 were drilled along the scarp at the rear of the beach (adjacent to the eastern edge of the fore dune) and encountered loose grading to dense sands to the depth of investigation (approximately RL -1 m AHD). No indurated sand was encountered in these boreholes.
- Indurated sand is exposed along the northern bank of Currimundi Creek, to the north of the site. The upper interface of the indurated sand is at about RL 1.5 m AHD, and the layer is at least 2 m thick (possibly extending to greater thickness below ground surface).

Comments and Recommendations

The results of our investigations indicate that it is likely that a layer of indurated sand, probably at least 2 m thick, exists beneath the main sand dune slope to the east of the existing residential properties along Watson Street (i.e. 10 m to 15 m east of the property boundaries). As outlined in our proposal P97682168, the stability of many coastal sand dunes in the Sunshine Coast region is enhanced by the presence of indurated sand, which essentially underpins the slope.

Provided that the indurated sand layer is relatively continuous under the primary sand dune (excluding the lower fore dune), and at least 2 m thick, it is unlikely (in the short-term) that erosion at the toe of the dune by seawaters could cause instability extending more than 5 m horizontally westwards of the crest of the dune slope. Consequently, it is unlikely that sand dune instability could affect the existing residential properties in the short-term. This assessment considers the position of the main sand dune slope relative to the property boundaries, the likely presence of indurated sand under the dune, and the extent of erosion caused by Cyclone Wanda (generally considered to be a 1 in 100 year weather event).

Essentially, the likely presence of indurated sand under the dune provides a ‘buffer’ should a significant weather event occur in the near future (e.g. a near–shore cyclone and associated storm surge). Should such an event occur, the indurated sand should limit the westward extent of erosion and enable sufficient time to implement measures to protect the residential properties. One option could comprise the construction of a seawall involving the placement of marine rock armour along the edge of the indurated sand stratum. The seawall could be constructed so as to enable burial of the structure if the fore dune area naturally regenerates during periods of stable weather activity.

In order to confirm our assessment of the sand dune stability, and the options for management of that stability, further investigation is required to confirm the extent and thickness of the indurated sand.

Further Investigation

In our original proposal P97682168, dated 11 September 2009, we recommended four stages of investigation. Stages 1 and 2 have been completed. Our proposed Stage 3 comprised geophysical investigation and proposed Stage 4 involved additional borehole drilling by hand auger. Considering the results of Stages 1 and 2 of the investigation, particularly the extent and depth of very loose sand, we now propose a Stage 3 investigation comprising borehole drilling only which would replace the original scope for Stages 3 and 4.

Borehole drilling provides direct physical data regarding subsurface conditions, whereas geophysical investigation is a non-intrusive process that comprises interpretation of remotely obtained data to assess stratigraphy.

For Stage 3, we now propose to drill boreholes along the crest of the sand dune behind the residential properties at approximately 20 m intervals (22 boreholes in total) using a buggy-mounted (skid steer) drill rig. We anticipate that the boreholes would be taken to an average depth of 15 m in order to confirm the thickness of the indurated sand. In situ standard penetration testing (SPT) would be selectively carried out to confirm the density of the sand and indurated sand. Costs for this revised scope of work will not exceed those outlined in our original proposal. We will provide a revised fee proposal under separate cover to confirm the amended scope of work.

Your attention is drawn to the document "Limitations", which is attached to this technical memorandum

Regards,

ADavey

Ashley Davey RPEQ 8159
Senior Geotechnical Engineer

Attachments:	Figure No. 1, Site Plan Reports of Boreholes & Explanatory Notes Limitations

ACD/DJQ/acd

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Scale - 1:1,500 (Approx.)

Scale - 1:3,000 (Approx.)

LEGEND

BH1 DENOTES APPROXIMATE BOREHOLE LOCATION

19° DENOTES APPROXIMATE SLOPE ANGLE & DIRECTION

INTERPRETIVE ONLY
DO NOT SCALE

Golder Associates

CLIENT	Sunshine Coast Regional Council	PROJECT	Dune Stability Assessment - Watson Street, Currimundi
DRAWN DJP	DATE 10-11-2009	TITLE	SITE PLAN
CHECKED ACD*	DATE 10-11-2009		
SCALE As Shown	A3	PROJECT No 097682053	FIGURE No 1 REVISION No 0

NOTE: THE * DENOTES THAT THE ORIGINAL DRAWING WAS SIGNED BY THAT RESPECTIVE PERSON.

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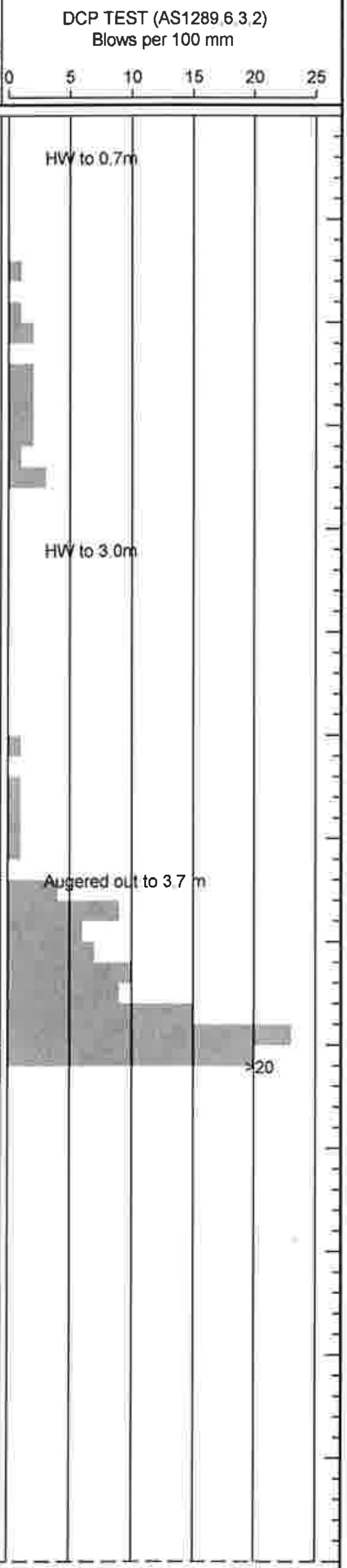
REPORT OF BOREHOLE: BH1

CLIENT: Sunshine Coast Regional Council	COORDS: 513553 m E 7039419 m N MGA94	SHEET: 1 OF 1 DRILL RIG: Hand Auger	
PROJECT: Sand Dune Stability Assessment	SURFACE RL: 5.71 m DATUM: AHD71	DRILLER: DJJ	
LOCATION: Watson Street, Currimundi	INCLINATION: -90°	LOGGED: DJP	DATE: 4/11/09
JOB NO: 097682053	HOLE DIA: 45 mm HOLE DEPTH: 4.70 m	CHECKED: ACn	DATE: 12/11/09

Drilling					Sampling	Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA		GROUNDWATER SEEPAGE ENCOUNTERED AT 4.5 m	0.0	0.10 5.61				SP	SAND fine to medium grained, grey and pale brown becoming pale grey	D D-M M	VL MD
			4.5	4.50 1.21				SM	Indurated SAND fine to medium grained, dark brown, weakly indurated	W	D
				4.70 1.01					END OF BOREHOLE @ 4.70 m PRACTICAL REFUSAL		

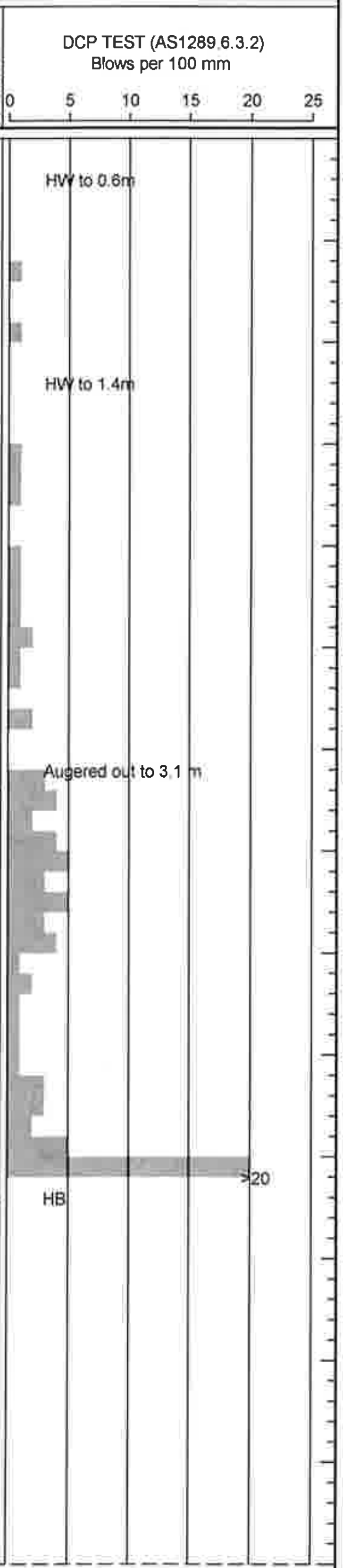


This report of borehole must be read in conjunction with accompanying notes and abbreviations. It has been prepared for geotechnical purposes only, without attempt to assess possible contamination. Any references to potential contamination are for information only and do not necessarily indicate the presence or absence of soil or groundwater contamination.

REPORT OF BOREHOLE: BH2

CLIENT: Sunshine Coast Regional Council	COORDS: 513571 m E 7039366 m N MGA94	SHEET: 1 OF 1 DRILL RIG: Hand Auger	
PROJECT: Sand Dune Stability Assessment	SURFACE RL: 6.79 m DATUM: AHD71	DRILLER: DJJ	
LOCATION: Watson Street, Currimundi	INCLINATION: -90°	LOGGED: DJP	DATE: 4/11/09
JOB NO: 097682053	HOLE DIA: 45 mm HOLE DEPTH: 5.20 m	CHECKED: ALD	DATE: 12/11/09

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA			0.0	6.79				SP	SAND fine to medium grained, pale grey and pale brown	D	VL
				0.90 5.89					becoming pale grey	D-M	
											L-MD
										M	
		GROUNDWATER SEEPAGE ENCOUNTERED AT 5.1 m	5.0	5.10				SM	Indurated SAND fine to medium grained, dark brown, weakly indurated	W	D
				5.20 1.59					END OF BOREHOLE @ 5.20 m PRACTICAL REFUSAL		



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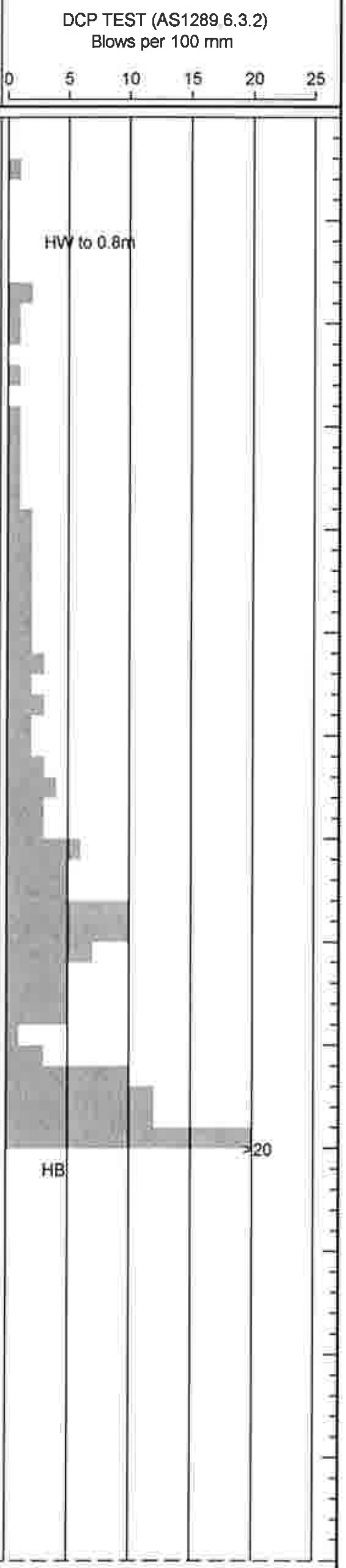
REPORT OF BOREHOLE: BH3

Golder Associates

SHEET: 1 OF 1

CLIENT: Sunshine Coast Regional Council	COORDS: 513595 m E 7039225 m N MGA94	DRILL RIG: Hand Auger	
PROJECT: Sand Dune Stability Assessment	SURFACE RL: 4.82 m DATUM: AHD71	DRILLER: DJJ	
LOCATION: Watson Street, Currimundi	INCLINATION: -90°	LOGGED: DJP	DATE: 4/11/09
JOB NO: 097682053	HOLE DIA: 75 mm HOLE DEPTH: 5.00 m	CHECKED: AUD	DATE: 12/11/09

Drilling					Sampling		Field Material Description					
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY	DCP TEST (AS1289 6.3.2) Blows per 100 mm
HA			0.0	4.82				SP	SAND fine to medium grained, grey and pale brown	D	VL	
			0.5	0.50 4.32					becoming pale grey	D-M		
			2.0								L-MD	
			3.5								MD	
			4.0	4.10 0.72					becoming pale grey and pale brown, trace of fine to medium gravel	M-W		
		▽ GROUNDWATER SEEPAGE ENCOUNTERED AT 4.6 m	4.5	4.70 0.12					becoming brown, grey and pale grey	W		
				4.90				SM	Indurated SAND fine to medium grained, dark grey and dark brown, weakly indurated	D		
			5.0	5.00 -0.18					END OF BOREHOLE @ 5.00 m PRACTICAL REFUSAL			



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REPORT OF BOREHOLE: BH4

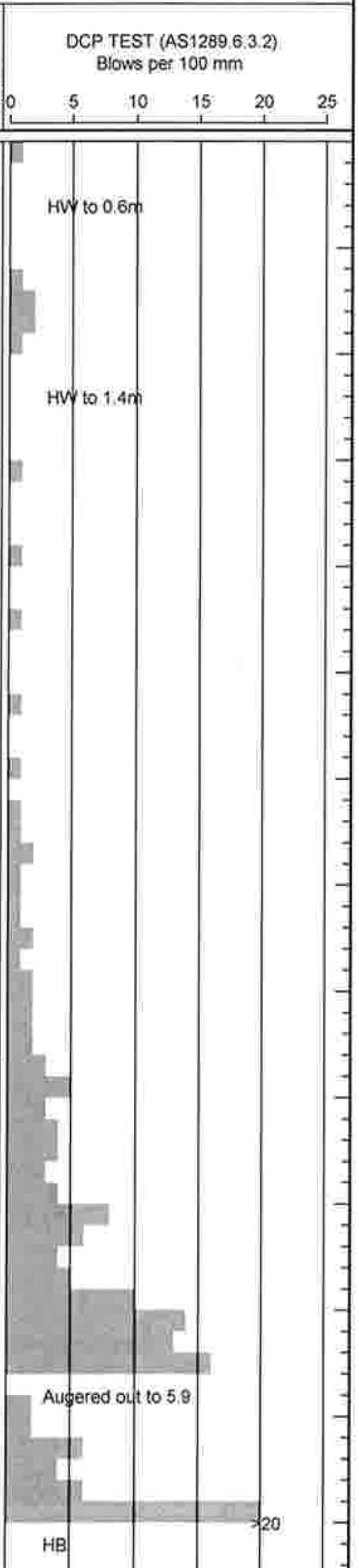
SHEET: 1 OF 1

CLIENT: Sunshine Coast Regional Council
PROJECT: Sand Dune Stability Assessment
LOCATION: Watson Street, Currimundi
JOB NO: 097682053

COORDS: 513594 m E 7039125 m N MGA94
SURFACE RL: 6.39 m DATUM: AHD71
INCLINATION: -90°
HOLE DIA: 45 mm HOLE DEPTH: 5.95 m

DRILL RIG: Hand Auger
DRILLER: DJJ
LOGGED: DJP DATE: 4/11/09
CHECKED: ACD DATE: 12/11/09

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA			0.0	6.39				SP	SAND fine to medium grained, grey and pale grey	D	VL
			0.40	5.99					becoming pale grey	D-M M	VL MD
		GROUNDWATER SEEPAGE ENCOUNTERED AT 5.5 m	4.70	1.69					becoming fine to coarse grained, trace of fine to medium gravel	M M-W W	MD
			5.95	0.44					END OF BOREHOLE @ 5.95 m PRACTICAL REFUSAL		



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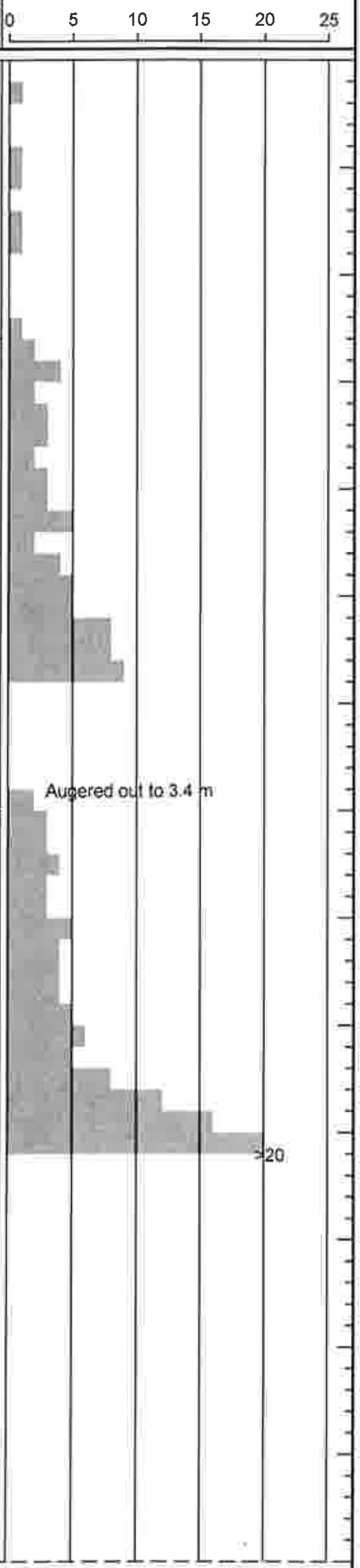
REPORT OF BOREHOLE: BH5

CLIENT:	Sunshine Coast Regional Council	COORDS: 513589 m E 7039439 m N MGA94	SHEET: 1 OF 1
PROJECT:	Sand Dune Stability Assessment	SURFACE RL: 3.9 m DATUM: AHD71	DRILL RIG: Hand Auger
LOCATION:	Watson Street, Currimundi	INCLINATION: -90°	DRILLER: DJJ
			LOGGED: DJP DATE: 5/11/09
JOB NO:	097682053	HOLE DIA: 45 mm HOLE DEPTH: 3.50 m	CHECKED: ALD DATE: 12/11/09

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA		GROUNDWATER SEEPAGE ENCOUNTERED AT 3.2 m	0.0	3.90			⁚⁚	SP	SAND fine to medium grained, pale grey	D	VL
			1.60	2.30			⁚⁚	SW	becoming fine to coarse grained	M	L-MD MD
		▽	3.2							W	
			3.50	0.40					END OF BOREHOLE @ 3.50 m PRACTICAL REFUSAL BOREHOLE CAVING BELOW 3.2m		

DCP TEST (AS1289.6.3.2)
Blows per 100 mm



Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0

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REPORT OF BOREHOLE: BH6

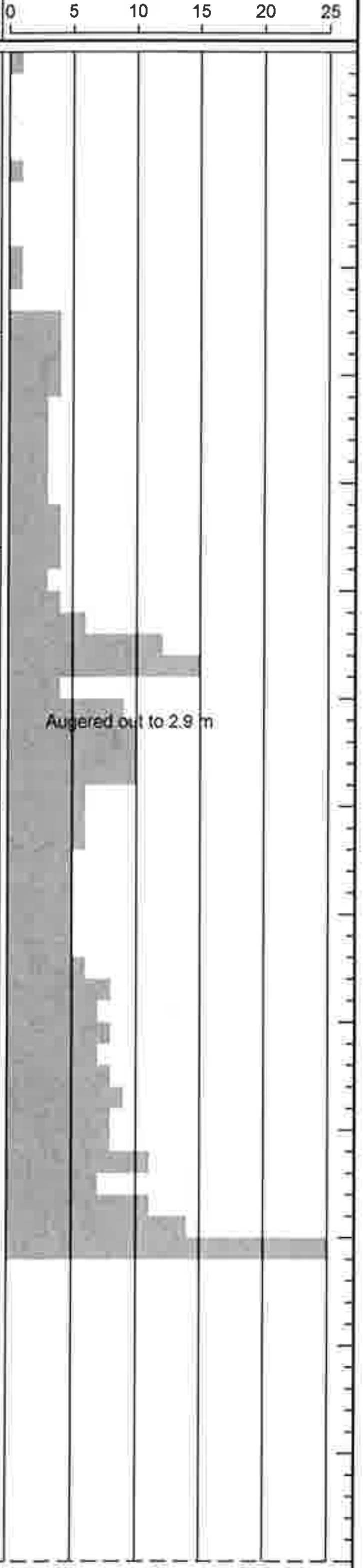
CLIENT: Sunshine Coast Regional Council
PROJECT: Sand Dune Stability Assessment
LOCATION: Watson Street, Currimundi
JOB NO: 097682053

COORDS: 513594 m E 7039360 m N MGA94
SURFACE RL: 3.75 m DATUM: AHD71
INCLINATION: -90°
HOLE DIA: 45 mm HOLE DEPTH: 3.50 m

SHEET: 1 OF 1
DRILL RIG: Hand Auger
DRILLER: DJJ
LOGGED: DJP DATE: 5/11/09
CHECKED: ACD DATE: 21/11/09

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA		▽ GROUNDWATER SEEPAGE ENCOUNTERED AT 3.2 m	0.0	3.75				SP	SAND fine to medium grained, pale grey	D M	VL L-MD MD
			3.20	0.55				SW	becoming fine to coarse grained, trace of fine to medium, rounded gravel	W	
			3.50	0.25					END OF BOREHOLE @ 3.50 m PRACTICAL REFUSAL BOREHOLE CAVING BELOW 3.2m		

DCP TEST (AS1289.6.3.2)
Blows per 100 mm



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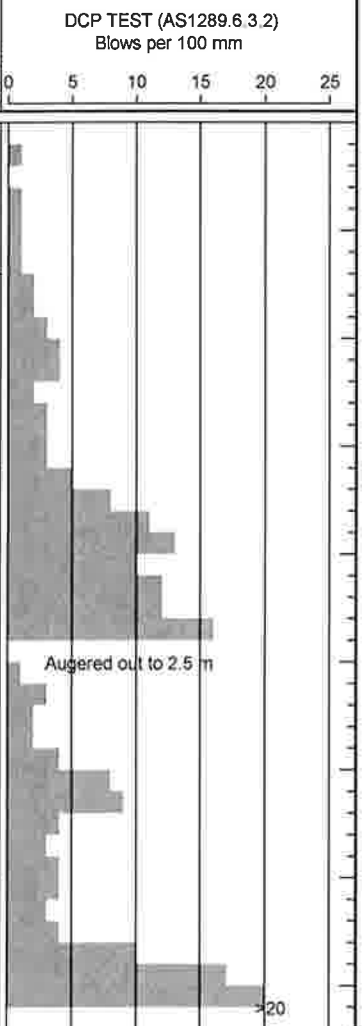
REPORT OF BOREHOLE: BH7

SHEET: 1 OF 1

CLIENT:	Sunshine Coast Regional Council	COORDS: 513602 m E 7039229 m N MGA94	DRILL RIG: Hand Auger
PROJECT:	Sand Dune Stability Assessment	SURFACE RL: 2.8 m DATUM: AHD71	DRILLER: DJJ
LOCATION:	Watson Street, Currimundi	INCLINATION: -90°	LOGGED: DJP DATE: 5/11/09
JOB NO:	097682053	HOLE DIA: 75 mm HOLE DEPTH: 3.50 m	CHECKED: DATE: 12/11/09

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA		GROUNDWATER SEEPAGE ENCOUNTERED AT 2.2 m	0.0	2.80				SP	SAND fine to medium grained, pale grey	D M	VL L-MD MD
			2.10	0.70				SW	becoming fine to coarse grained, trace of fine to medium, rounded gravel	W	MD
			3.50	-0.70					END OF BOREHOLE @ 3.50 m PRACTICAL REFUSAL BOREHOLE CAVING BELOW 2.2m		



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REPORT OF BOREHOLE: BH8

SHEET: 1 OF 1

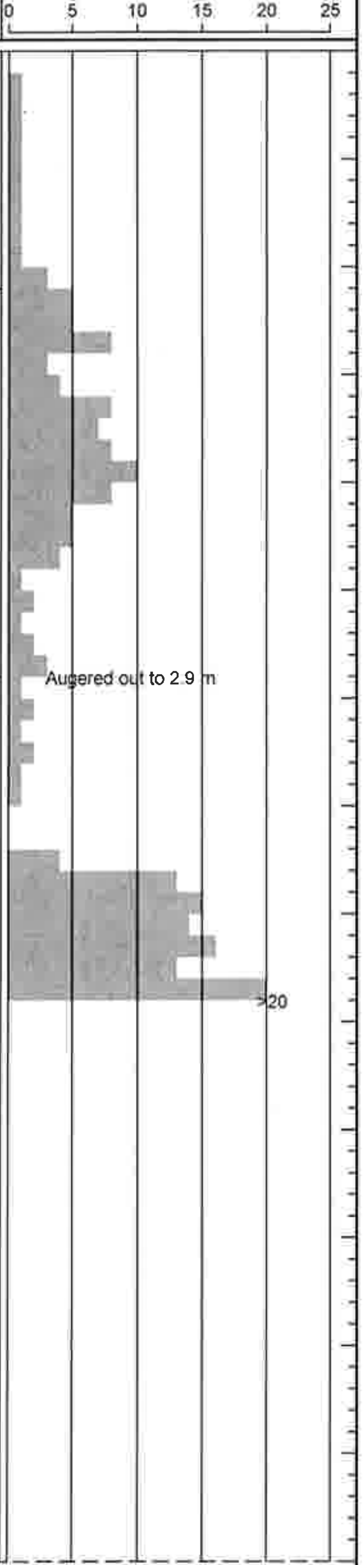
CLIENT: Sunshine Coast Regional Council
PROJECT: Sand Dune Stability Assessment
LOCATION: Watson Street, Currimundi
JOB NO: 097682053

COORDS: 513595 m E 7039128 m N MGA94
SURFACE RL: 2.8 m DATUM: AHD71
INCLINATION: -90°
HOLE DIA: 75 mm HOLE DEPTH: 2.90 m

DRILL RIG: Hand Auger
DRILLER: DJJ
LOGGED: DJP DATE: 5/11/09
CHECKED: AED DATE: 12/11/09

Drilling					Sampling		Field Material Description				
METHOD	PENETRATION RESISTANCE	WATER	DEPTH (metres)	DEPTH RL	SAMPLE OR FIELD TEST	RECOVERED	GRAPHIC LOG	USC Symbol	SOIL / ROCK MATERIAL DESCRIPTION	MOISTURE	CONSISTENCY DENSITY
HA		GROUNDWATER SEEPAGE ENCOUNTERED AT 2.6 m	0.0	2.80				SP	SAND fine to medium grained, pale grey	D	VL
											MD
										M	
				2.60 0.20				SW	Gravelly SAND fine to coarse grained, pale grey and brown, fine to medium, rounded gravel	W	
				2.90 -0.10					END OF BOREHOLE @ 2.90 m PRACTICAL REFUSAL BOREHOLE CAVING BELOW 2.0m		

DCP TEST (AS1289.6.3.2)
Blows per 100 mm



Depth scale: 0.0, 0.5, 1.0, 1.5, 2.0, 2.5, 3.0, 3.5, 4.0, 4.5, 5.0, 5.5, 6.0, 6.5, 7.0

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EXPLANATION OF NOTES, ABBREVIATIONS & TERMS USED ON BOREHOLE AND TEST PIT REPORTS

DRILLING/EXCAVATION METHOD

AS*	Auger Screwing	RD	Rotary blade or drag bit	HQ	Diamond Core - 63 mm
AD*	Auger Drilling	RT	Rotary Tricone bit	NMLC	Diamond Core - 52 mm
*V	V-Bit	RAB	Rotary Air Blast	NQ	Diamond Core - 47 mm
*T	TC-Bit, e.g. ADT	RC	Reverse Circulation	BH	Tractor Mounted Backhoe
HA	Hand Auger	PT	Push Tube	EX	Tracked Hydraulic Excavator
ADH	Hollow Auger	CT	Cable Tool Rig	EE	Existing Excavation
DTC	Diatube Coring	JET	Jetting	HAND	Excavated by Hand Methods
WB	Washbore or Bailer	NDD	Non-destructive drilling		

PENETRATION/EXCAVATION RESISTANCE

L **Low resistance.** Rapid penetration possible with little effort from the equipment used.

M **Medium resistance.** Excavation/possible at an acceptable rate with moderate effort from the equipment used.

H **High resistance** to penetration/excavation. Further penetration is possible at a slow rate and requires significant effort from the equipment.

R **Refusal or Practical Refusal.** No further progress possible without the risk of damage or unacceptable wear to the digging implement or machine.

These assessments are subjective and are dependent on many factors including the equipment power, weight, condition of excavation or drilling tools, and the experience of the operator.

WATER

▽	Water level at date shown	◁	Partial water loss
▷	Water inflow	◀	Complete water loss

GROUNDWATER NOT OBSERVED	The observation of groundwater, whether present or not, was not possible due to drilling water, surface seepage or cave in of the borehole/test pit.
GROUNDWATER NOT ENCOUNTERED	The borehole/test pit was dry soon after excavation. However, groundwater could be present in less permeable strata. Inflow may have been observed had the borehole/test pit been left open for a longer period.

SAMPLING AND TESTING

SPT	Standard Penetration Test to AS1289.6.3.1-2004
4,7,11 N=18	4,7,11 = Blows per 150mm. N = Blows per 300mm penetration following 150mm seating
30/80mm	Where practical refusal occurs, the blows and penetration for that interval are reported
RW	Penetration occurred under the rod weight only
HW	Penetration occurred under the hammer and rod weight only
HB	Hammer double bouncing on anvil
DS	Disturbed sample
BDS	Bulk disturbed sample
G	Gas Sample
W	Water Sample
FP	Field permeability test over section noted
FV	Field vane shear test expressed as uncorrected shear strength (s_v = peak value, s_r = residual value)
PID	Photoionisation Detector reading in ppm
PM	Pressuremeter test over section noted
PP	Pocket penetrometer test expressed as instrument reading in kPa
U63	Thin walled tube sample - number indicates nominal sample diameter in millimetres
WPT	Water pressure tests

Ranking of Visually Observable Contamination and Odour (for specific soil contamination assessment projects)

R = 0	No visible evidence of contamination	R = A	No non-natural odours identified
R = 1	Slight evidence of visible contamination	R = B	Slight non-natural odours identified
R = 2	Visible contamination	R = C	Moderate non-natural odours identified
R = 3	Significant visible contamination	R = D	Strong non-natural odours identified

ROCK CORE RECOVERY

TCR = Total Core Recovery (%)

$$= \frac{\textit{Length of core recovered}}{\textit{Length of core run}} \times 100$$

SCR = Solid Core Recovery (%)

$$= \frac{\sum \textit{Length of cylindrical core recovered}}{\textit{Length of core run}} \times 100$$

RQD = Rock Quality Designation (%)

$$= \frac{\sum \textit{Axial lengths of core} > 100\,\textit{mm}}{\textit{Length of core run}} \times 100$$

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METHOD OF SOIL DESCRIPTION USED ON BOREHOLE AND TEST PIT REPORTS

FILL	CLAY (CL, CI or CH)
GRAVEL (GP or GW)	ORGANIC SOILS (OL or OH or Pt)
SAND (SP or SW)	COBBLES or BOULDERS
SILT (ML or MH)	

Combinations of these basic symbols may be used to indicate mixed materials such as sandy clay.

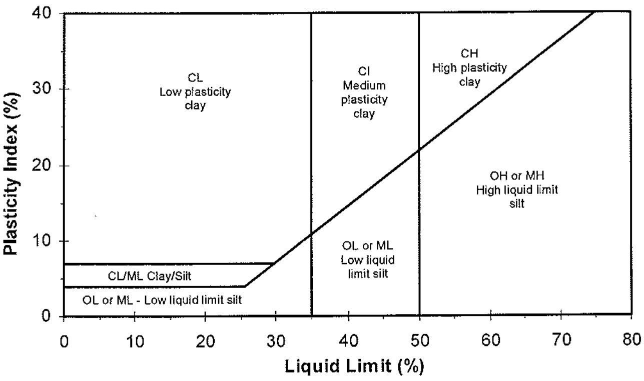
CLASSIFICATION AND INFERRED STRATIGRAPHY

Soil and Rock is classified and described in Reports of Boreholes and Test Pits using the preferred method given in AS1726 – 1993, (Amdt1 – 1994 and Amdt2 – 1994), Appendix A. The material properties are assessed in the field by visual/tactile methods.

Particle Size

Major Division	Sub Division	Particle Size
BOULDERS		> 200 mm
COBBLES		63 to 200 mm
GRAVEL	Coarse	20 to 63 mm
	Medium	6.0 to 20 mm
	Fine	2.0 to 6.0 mm
SAND	Coarse	0.6 to 2.0 mm
	Medium	0.2 to 0.6 mm
	Fine	0.075 to 0.2 mm
SILT		0.002 to 0.075 mm
CLAY		< 0.002 mm

Plasticity Properties



MOISTURE CONDITION

AS1726 - 1993

Symbol	Term	Description
D	Dry	Sands and gravels are free flowing. Clays & Silts may be brittle or friable and powdery.
M	Moist	Soils are darker than in the dry condition & may feel cool. Sands and gravels tend to cohere.
W	Wet	Soils exude free water. Sands and gravels tend to cohere.

CONSISTENCY AND DENSITY

AS1726 - 1993

Symbol	Term	Undrained Shear Strength
VS	Very Soft	0 to 12 kPa
S	Soft	12 to 25 kPa
F	Firm	25 to 50 kPa
St	Stiff	50 to 100 kPa
VSt	Very Stiff	100 to 200 kPa
H	Hard	Above 200 kPa

Symbol	Term	Density Index %	SPT "N" #
VL	Very Loose	Less than 15	0 to 4
L	Loose	15 to 35	4 to 10
MD	Medium Dense	35 to 65	10 to 30
D	Dense	65 to 85	30 to 50
VD	Very Dense	Above 85	Above 50

In the absence of test results, consistency and density may be assessed from correlations with the observed behaviour of the material.

SPT correlations are not stated in AS1726 – 1993, and may be subject to corrections for overburden pressure and equipment type.

LIMITATIONS

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11 September 2009 Proposal No. P97682168

Mr Denis Shaw
Sunshine Coast Regional Council
By e-mail: denis.shaw@sunshinecoast.qld.gov.au

PROPOSAL FOR GEOTECHNICAL ASSESSMENT OF SAND DUNE STABILITY WATSON STREET, CURRIMUNDI

Dear Sir

1.0 INTRODUCTION

Following our recent discussions (Shaw/Davey), Golder Associates has pleasure in submitting our proposal to conduct a geotechnical assessment of sand dune stability along the foreshore behind Watson Street, Currimundi. We understand that local residents have raised concerns with Council regarding the potential for instability of the sand dunes, particularly during storm surge (cyclone) events, and of the potential for such instability to affect property.

2.0 BACKGROUND

Watson Street runs parallel with the coastline (north/south) extending southwards from Currimundi Lake. Published geology[1] indicates that the site is underlain by a north/south trending Quaternary to Pleistocene age sand dune. Our previous experience indicates that the site may be underlain by loose dune sands and dense indurated sands ('coffee rock') with a water table 'perched' along the interface between these strata.

Based upon our desk-top review of publicly available Council records (CalMap), we have determined the following:

- There are approximately 20 residences located along the eastern side of Watson Street (i.e. adjacent to the coastline), over a lineal distance of approximately 400 m.
- These existing residences are generally located at the crest of a sand dune, where the ground surface elevation ranges from approximately RL 9 m AHD the north up to RL 10 m to RL 11 m AHD in the south.
- The eastern face of the sand dune is about 5 m to 6 m high and slopes from the crest to the toe (approximately RL 5 m AHD) over a distance of about 10 m to 20 m. This area appears to be generally well vegetated.
- From the toe of the sand dune, the beach area slopes gently down to the waterline over a distance of approximately 50 m.
- Historical aerial images from the mid 1990's to present do not show any significant erosion of the beach zone, nor do they show any exposures of 'coffee rock'.

We are advised that anecdotal evidence provided to Council by local residents indicates that significant beach erosion occurred in the area during the Cyclone Wanda event (circa 1974), and that 'coffee rock' was exposed on the beach in places at that time.

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[1] 1:100,000 Nambour Special Geol. Map, DME, 1999

3.0 MECHANISM OF DUNE INSTABILITY/EROSION

Based upon our experience with similar sand dunes in the Sunshine Coast Region, the primary mechanism for large scale dune instability is undercutting of the dune toe caused by erosion from seawaters during abnormal weather events. Other mechanisms for dune instability include the removal of vegetation, which can also be related to natural erosion, and the introduction of concentrated stormwater flows (e.g. pipes discharging into the slope).

The stability of many coastal sand dunes in the region is enhanced by the presence of 'coffee rock' at relatively shallow depth (around RL 0 m AHD, or above), which essentially underpins the slope. Where 'coffee rock' is not present, there is a greater risk of dune instability, dependent on topography and other influencing factors (e.g. man-made structures). The extent of 'coffee rock' is therefore a critical factor when determining sand dune stability.

Considering the above, we have formulated the following proposed scope of work for the geotechnical assessment at this site.

4.0 SCOPE OF WORKS

Our proposed approach is to conduct the assessment in stages, which enables the development of a geotechnical model for the site. One benefit of this approach is the minimisation of costs; i.e. if ground conditions are found to be unfavourable at any stage, the scope of the assessment could be reduced (Ref. Stage 2 below for further details).

Desk-Top Study (Stage 1)

Prior to conducting any fieldwork, an experienced geotechnical engineer would conduct a desk-top review of available data including:

- Geological and acid sulfate soil maps;
- Historical aerial images; and
- Report on previous investigations held by Golder Associates.

Site Investigation (Stage 2)

Stage 2 site investigations would comprise the following:

- Walk-over survey by an experienced geotechnical engineer to map the terrain and other surface features across the site (e.g. including ground slopes, vegetation cover, geological exposures); and
- Approximately eight (8) hand augered boreholes, taken to depths of up to 6 m, or shallower refusal. Dynamic cone penetrometer (DCP) testing would be conducted adjacent to each of the boreholes, and within the boreholes after augering to various depths. Boreholes would be drilled by a team of two technicians over a two (2) day period at the same time as the walk-over.

Should no 'coffee rock' be discovered during the Stage 2 works, it may be decided not to continue with further stages of investigation. The results of the Stage 2 investigation would be utilised to calibrate the results of geophysical testing proposed in Stage 3.

Geophysical Investigation (Stage 3)

Geophysical testing enables the appraisal of subsurface conditions over long distances, and can be used to interpolate point data from intrusive subsurface investigations (e.g. boreholes). Given the size and sensitivity of the site, we propose to conduct a non-intrusive geophysical investigation. Based upon our understanding of the likely subsurface conditions, our proposed methodology for the geophysical investigation is to conduct seismic refraction and ground penetrating radar (GPR) surveys.

We propose one (1) day each of seismic refraction and GPR surveys. The calibration runs will be done preferentially where the depth of coffee rock is known, such as near boreholes or outcrop. The GPR survey will cover the total lineal distance of the sand dune toe (approximately 400 m), with approximately two to three (2 to 3) 90 m long seismic refraction surveys allowed for (i.e. 180 m to 270 m total length).

Detailed descriptions of the seismic refractions and GPR methodologies are provided below.

Seismic Refraction methodology

The seismic refraction method is the most widely applied geophysical methodology to assist in geotechnical investigations. The seismic refraction method utilises the P-wave (first arrival) signal of the seismic record. The P-wave velocity is directly controlled by the parameters of elasticity (moduli) and density of the subsurface strata. The seismic refraction method can yield the subsurface P-wave velocity structure, which can be use to help model subsurface stratigraphic and structural characteristics. Where significant change in P-wave velocity occurs (e.g. soil/rock interface), estimates of the depth to layers interface can be determined for assessing depth to bedrock and thickness of overburden.

Seismic P-waves are generated on the surface by an energy source such as a sledge hammer or explosives or weight drop source allowing P-waves to propagate through the soil and rock. An array of geophones is placed along the survey line (spread) and an engineering seismograph is used to record the travel-times of the seismic signals.

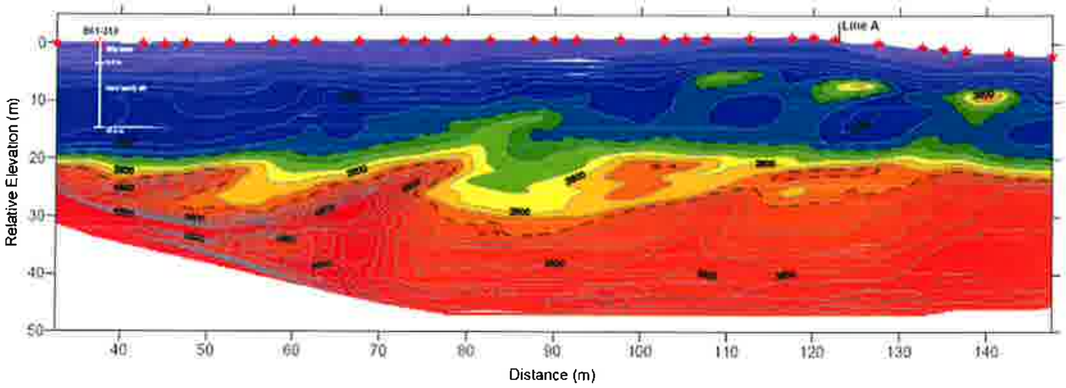

Figure 1: Example of interpreted seismic refraction results

To meet the objectives of this investigation we propose to undertake a detailed seismic refraction study using 4 m geophone spacing, and source spacing of 12 m with common shotpoint locations. A minimum of three (3) offsets shall be obtained for each seismic line. Seismic energy for the refraction study will be provided by striking a sledge hammer on a steel plate sufficient times to obtain clear first arrivals. All data will be acquired digitally using a 24 channel engineering seismograph. Assessment of data during acquisition will be performed to ensure data quality is adequate for reliable interpretation.

Equipment Specifications:

Seismograph: Seismic Source DAQ Link 2 System, 24 bit engineering seismograph

Receivers: 24 X 10 Hz geophones with 75 mm taped spikes

Seismic Source: Sledge Hammer and Steel Plate

We assume the following regarding use of this method:

- Maximum depth of investigation is 30 m;
- Sledge hammer and steel plate is sufficient for depth of investigation;
- Required resolution achieved by 4 m geophone spacing;
- 4x4 vehicle access to all seismic lines;
- Ground surface is appropriate for moving along the lines to place geophones;
- No significant extraneous noise (power lines, vibration from large trucks, drilling rigs, and underground utilities) that interferes with the geophysical measurements; and

- Minimal surface noise from rain and winds which may create vibrations that will make interpretation difficult.

In order for the processing of the seismic data to commence some survey information is required. We propose undertaking an elevation survey of all shot point and geophone positions using abney level and stave method prior to departure from site. Labelled pegs will be staked at the ends of the spreads for later pick by surveyor.

The seismic data will be analysed using the commercially available SeisImager 2D software. The tomographic inversion method is proposed to be utilised for data interpretation. A check of the seismic interpretation will be done using the reciprocal method in the software Refract. The accuracy of seismic layer thickness and depth is expected to be in the order of 10% of depth. The seismic interpretations will be compared with geotechnical borehole information to improve precision of interpretation.

The interpreted data will be presented as 2D interpreted seismic sections relative to the surface profile at specified scale consistent with other project drawings. A plan map showing the locations of seismic alignments will be provided based on the survey positions provided. The report shall include details of the field procedures, data processing and interpretation. The report will also include discussions on interpreted P-wave velocities as well as depth and nature of soils, weathering and bedrock ('coffee rock') profile.

Ground Penetrating Radar

The GPR system consists of two antennae (transmitter and receiver), a control console and a computer for real-time, graphic display and data recording. In reflection profiling mode, the antennae, separated at a fixed distance, are moved stepwise along a traverse and readings are taken at discrete intervals. At each step, pulses of radar frequency electromagnetic energy (megahertz range) are transmitted and reflections received from subsurface horizons. The reflecting horizons occur where there is an abrupt change in the subsurface material dielectric permittivity such as at the interface between saturated and unsaturated materials (water table), stratigraphic horizons, and interfaces between natural and man-made materials. The amplitude of received radar energy is recorded as a function of time, processed in real-time for display purposes, and the raw data recorded digitally for later processing and presentation.

GPR sections are presented as time-sections, with the position (in metres) of each trace recorded as the horizontal axis across the top of the section and the GPR travel time (in nanoseconds, increasing downward) as the principal vertical axis. A second vertical axis is included to provide an estimate of depth or elevation and is calculated assuming a constant GPR velocity for the subsurface. The example below (Figure 2) is presented to demonstrate the type of information that can be obtained. In this example, the GPR section shows rock level below silica sands.

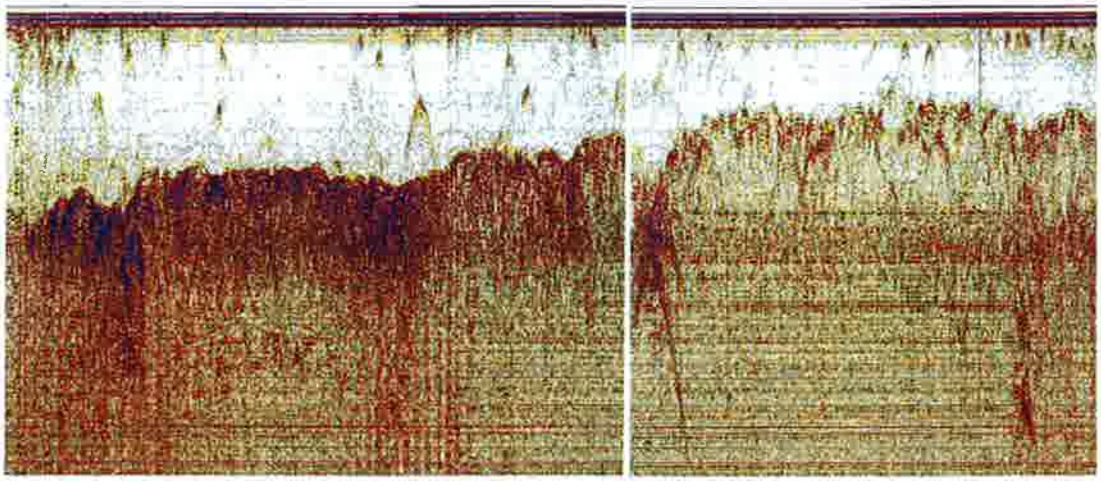

Figure 2: Example GPR profile

Equipment:

Mala unit with 250 MHz and 500MHz antennas, on hand pushed cart.

Interpreted GPR time sections will be presented in the geophysical report, along with the results of the seismic refraction surveys.

Site Investigation (Stage 4)

In order to enable the assessment of any 'holes' in the 'coffee rock' (if present) and to target areas identified during the geophysical investigation, approximately ten (10) additional hand augered boreholes would be taken to 3 m to 4 m depth, or shallower refusal, along the toe of the sand dune. DCP testing would be conducted for all boreholes. Stage 4 boreholes would be drilled by a team of two technicians over a two (2) day period.

Project Management, Engineering Assessment & Reporting

The project would be managed by Mr Ashley Davey, a senior geotechnical engineer and RPEQ from our Maroochydore office with more than 14 years of experience. Project management activities would include the coordination of Golder Associates staff and sub-contractors, preparation of health and safety plans, and liaison with Council on project matters.

Utilising the results of the intrusive (boreholes) and non-intrusive (geophysical) investigations, we would develop a geotechnical model for the site, also incorporating topographical and built environment data (e.g. house positions). We have assumed that data regarding potential storm surge sea levels, including allowance for predicted sea rise levels, would be provided by Council at no cost to Golder Associates for use in our assessment. The geotechnical model would then be used as the basis to prepare a map delineating potential sand dune instability hazard areas.

Our report would include:

- A description of the method and results of the intrusive and non-intrusive investigations;
- Presentation of our geotechnical model (colour plans and sections);
- Presentation of our preliminary sand dune instability hazard map (colour plan); and
- Recommendations for management of sand dune stability.

Depending on the results of the assessment, further investigation may be required. As such, our hazard mapping will be of a preliminary nature. Advice on further investigation requirements (if any) would be provided to Council progressively, as the assessment proceeds.

5.0 COSTS, TIMING AND CONDITIONS

We offer to carry out the geotechnical assessment for a fixed fee of **$55,700 (excluding GST)**. The break-down of this fee is presented below:

Table 1: Break-Down of Cost

Component of Work	Cost (Excluding GST)
Stage 1	
- Desk-top study	$1,500
Stage 2	
- Senior engineer walk-over	$1,700
- Boreholes (2 technicians, 2 days)	$4,000
Stage 3	
- Geophysical investigation	$32,000
- Survey (licensed surveyor)	$3,000
Stage 4	
- Boreholes (2 technicians, 2 days)	$4,000
Project management, engineering & reporting	$9,500
TOTAL	**$55,700**

Following receipt of authorisation to proceed, fieldwork could commence within one week. The whole programme of fieldwork would take three to four weeks. Our report would be compiled about two weeks after completion of fieldwork. Therefore, the time for completion of the project would be about six to seven weeks from the date of commissioning. Preliminary advice would be provided during the fieldwork.

We will contact you at significant milestones during the course of the project, these will likely be:

- Prior to commencement of fieldwork
- On completion of fieldwork
- Following submission of our report

Our proposal terms are based on acceptance of Council's terms and conditions as the basis for a contract. If engaged for this work we look forward to finalising the contract terms. The above work would be performed in accordance with the attached Special Conditions.

Written confirmation from the client **(person responsible for payment)** of our engagement and agreement of the conditions must be received prior to any fieldwork.

The price given herein is valid for a period of 3 months from the date of this proposal. Each stage of the fieldwork will be invoiced upon completion, with claims also made upon submission of our draft and final reports (80% and %20 of project management/reporting sum, respectively). Terms for payment of our invoices will be 30 days.

We trust that this proposal meets your requirements and look forward to working with you on this project should we be successful.

Please contact the undersigned should you wish to discuss any aspect of this proposal.

Yours Faithfully

GOLDER ASSOCIATES PTY LTD

Ashley Davey RPEQ 8159
Senior Geotechnical Engineer

ACD/GAH/acd

Attachments:	Client Authorisation Special Conditions

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CLIENT AUTHORISATION

Client Name on Invoice: ______________________________ Phone : ____________

Address: ______________________________ Mobile: ____________

______________________________ Fax : ____________

______________________________ Email : ____________

PROJECT:

Geotechnical Consultancy Services – Sand Dune Stability Assessment Watson Street, Currimundi

We hereby authorise Golder Associates Pty Ltd to conduct the work detailed in proposal number P97682168 dated 11 September 2009 for the amount of $55,700 (ex GST) and in accordance with the attached Special Conditions.

Signed (person authorising payment):

Signed:______________________________

Name:______________________________

Dated this __________ day of _______, 2009.

SPECIAL CONDITIONS

Additional work outside of the scope described in this proposal (e.g. attendance at meetings, site inductions and responses to information requests after our report has been submitted) would be undertaken at the following rates (all excluding GST):

- Associate: $250 per hour
- Senior Geotechnical Engineer: $200 per hour
- Geotechnical Engineer: $135 per hour
- Geotechnician: $120 per hour
- Mileage: $1 per km

We will provide one draft report for comment (PDF by e-mail), then 1 hard bound copy and one PDF copy on CD of the final report. Please note that any additional hard copies required will be charged at a rate of $85 per hour (excluding GST) for administration plus photocopying expenses (charged at cost plus 15%, excluding GST).

The work will also be performed in accordance with the following conditions relating to fieldwork:

1) Access onto and across the site will be available during normal working hours

2) Any necessary arrangements or documents will be made or supplied by the client, such as unlocking gates, informing tenants of our work and clearing structures/vegetation or providing permits for vegetation clearance, riverine work etc.

3) Boreholes will be backfilled on completion and sealed with excess spoil mounded at the surface.

4) Samples recovered during investigations will be stored for maximum period of three months from the date of submission of the final report. Longer storage can be arranged for a charge of $50 per month (excluding GST).