

AQUATIC PARADISE CANAL ESTATE

Siltation Study—Final Report

Prepared for:

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Summary

This report has been prepared for Redland Shire Council to present the findings of a siltation study at the Aquatic Paradise Canal Estate in Birkdale. The study has been commissioned in recognition of the fact that the siltation rates in the development are significantly higher than anticipated at the outset of the project.

The primary objectives of the siltation study have been to determine the sources of the siltation, the long term maintenance dredging requirements and costs and the nature of any measures that can be adopted to mitigate such costs.

The study has primarily been conducted as a desk-top review utilising survey data provided by Council and prior reports on both Aquatic Paradise and adjacent developments. Current measurements and a petrographic analysis were however undertaken to supplement the existing data.

The study has been presented in the form of a review of the existing data, a description of the additional studies and finally an assessment of dredging options and costs.

The key issues identified in the report are:

- The original 1982 coastal engineering study by the University of New South Wales Water Research Laboratory provides a reasonable insight into the overall siltation behaviour of the development. It did not however predict the high concentration of material at the inshore end of the access channel.
- There is clear evidence to suggest that the majority of the siltation in the access channel and canals derives from offshore in the form of wave mobilised suspended sediment. The evidence supporting this conclusion includes:
 - suspended sediment sampling in Waterloo Bay in 1989 which clearly demonstrated that the bay does not typically receive high suspended loads from the adjacent catchment;
 - the survey records which illustrate that the build up of material adjacent to the drain outlets is only minor;

- the petrographic analysis which shows only limited association between the bay sediments and the adjacent creeks sediments; and
- the results of theoretical calculations based on the as found waves, currents and material types.
- On the basis of Council's historical surveys the estimated total volumes of silt in the canal estate and access channel (above the as dredged bed level) at July 1997 were:

Access Channel	46,700 m ³
Canals	27,800 m ³

- The corresponding annual siltation rates were:

Access Channel	15,200 m ³ /year
Canals	3,400 m ³ /year

- These estimates indicate that an initial a catch-up volume of 56,000 m³ must be dredged from the channel and canals to bring the volume of sediment down to the annual siltation rate of 19,000 m³ (ie to a volume that can be handled by the proposed long term maintenance system).
- Two options are available to remove the catch-up volume of 56,000 m³. They are either to remove it bit by bit over the first (say) 5 years of operation to onshore settling ponds or secondly to remove it in one hit to an offshore disposal ground in Moreton Bay. The Port of Brisbane Corporation have indicated that they would not object to the latter 'one off' disposal option subject to Council obtaining all approvals. This option is therefore favoured. The estimated costs for both options is around \$800,000.
- The recent introduction of strict environmental controls on offshore dumping has greatly restricted the option for maintenance dredging. The current thrust for onshore disposal has resulted in a change of philosophy whereby frequent small dredging programmes are now finding favour in place of previous infrequent major works.
- Four options have been developed for the excavation, storage and ultimate disposal of the silt material generated in the canal estate and access channel. All involve either near shore or onshore disposal and all are based on the assumption that an initial one off volume of at least 56,000 m³ can be dumped offshore in Moreton Bay.

- The options and their respective costs are:

Option 1—Groyne and dragline with onshore spoil receiving ponds

Development Cost	\$3,300,000
Annual running cost	\$485,000

Option 2—Dredge with foreshore spoil ponds

Development Cost	\$1,450,000
Annual running cost	\$700,000

Option 3—Dredge with onshore spoil ponds - Three Year Cycle

Development Cost	\$990,000
Annual running cost	\$295,000

Option 4—Dredge with onshore spoil ponds - Annual Cycle

Development Cost	\$700,000
Annual running cost	\$315,000

- The favoured option is Option 4 ie. a small dredge resident at the site for 6 months per year and discharging to a restricted area of onshore landscaped ponds.
- The issue of further periodic use of offshore disposal sites was raised with the Port of Brisbane Corporation. The advice received was that subsequent approvals would become less and less likely and therefore that the option should be discounted from any maintenance dredging strategies.

→ where would you set up the dredge ponds?
where would you dispose of the spoil?



1 Introduction

This report has been prepared by Kinhill Pty Ltd to present the findings of a siltation study at the Aquatic Paradise Canal Estate in Birkdale. The study was commissioned by Redland Shire Council in July 1997.

Since the completion of the canal estate in 1987/88 it has been recognised that the siltation rates at some locations in the development and in particular in the access channel near the low water mark, have been higher than anticipated at the outset of the project. This has resulted in an increased dredging requirement (Council is currently re-dredging the access channel on a four year cycle) and an associated increased cost to the ratepayers.

Also since the completion of the development, environmental controls have been instigated which have major implications for dredging works.

The siltation study was commissioned within the context of the above in order to:

- determine the sources of silt in the canal system and the contribution each source makes to the cost of dredging;
- determine the long term, expected frequency of dredging in the various parts of the canal system and hence the long term maintenance costs;
- determine whether there are any works which could reduce the cost of dredging and the nature and approximate cost of those works;
- determine whether there are any possible improvements to the method of dredging which could reduce the cost of the dredging, and the nature of such works.

Redland Shire Council's Terms of Reference for the study are contained in Appendix D.

The methods adopted to achieve the study objectives include:

- petrographic analysis of sediment samples taken from the canal estate, the entrance channel, Waterloo Bay and the creeks flowing into Waterloo Bay;
- a review of the insitu densities of the materials on the floor of Waterloo Bay;
- an examination of historical dredging data and channel surveys;
- a current monitoring exercise to establish current patterns within Waterloo Bay;
- a desk top analysis to establish the relationship between the theoretical and actual entrapment potential of the various channels; and
- a review of earlier coastal engineering reports for both this and adjacent developments.

2 Site description and existing information

2.1 SITE DESCRIPTION

The general layout of Aquatic Paradise and its relationship to Waterloo Bay is illustrated in Figure 2.1. Figure 2.2 provides a detailed layout of the various canals within the estate and also identifies the various drainage paths into the canals.

The estate was constructed over the period 1987 to 1989 and comprises approximately 3,000 m of inshore canals and a 2,800 m long access channel to deep water. The inshore canals were formed in the dry using conventional earthmoving equipment. The implication of this is that the original floor level of the canals can be established with considerable confidence. The access channel was formed by cutter-suction dredge with a resulting decrease in the bed profile accuracy limits.

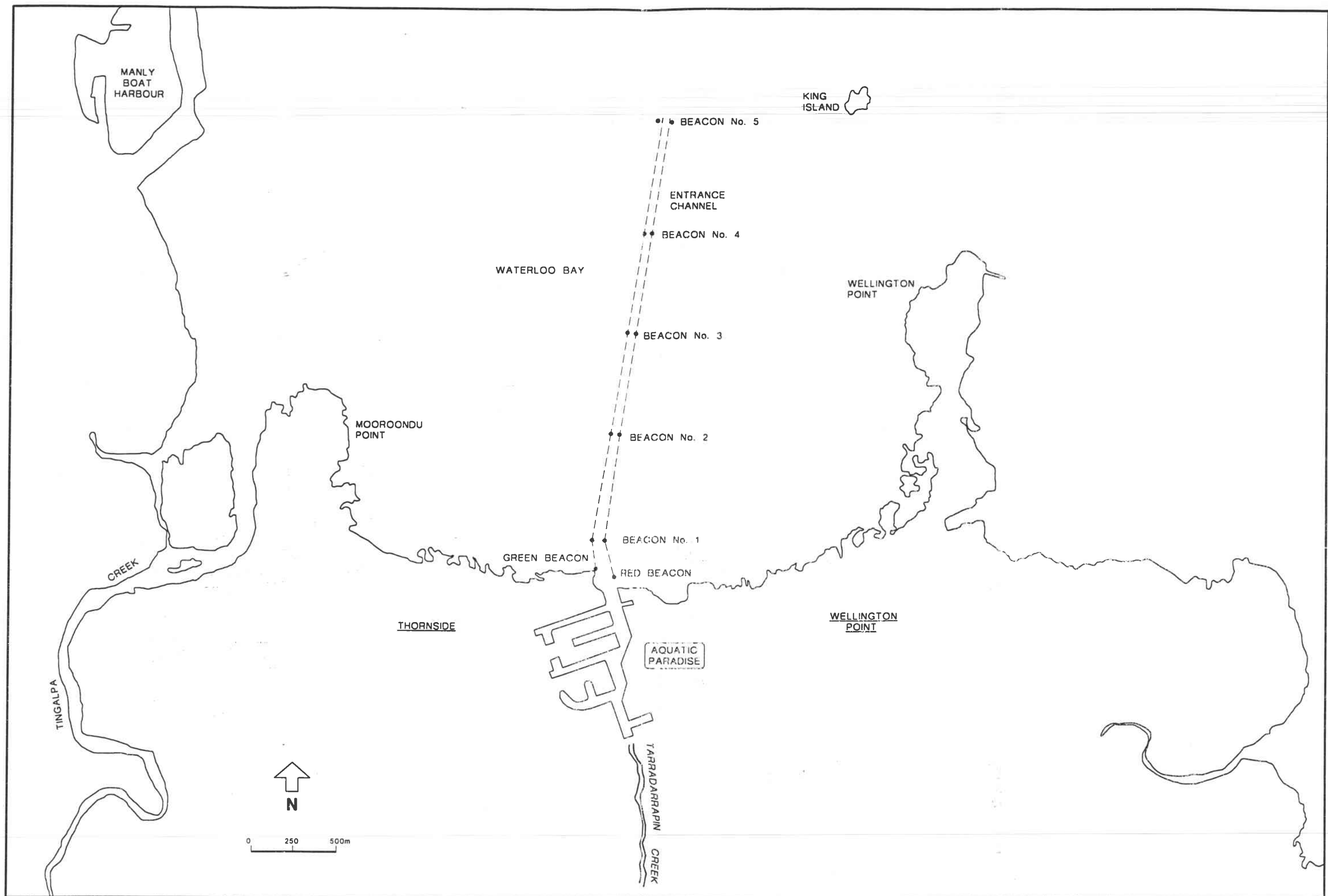
As illustrated in Figure 2.2 the canals receive stormwater inflows from a variety of sources including Tarradarrapin Creek, which flows into the system at the junction of Wood and Laidlaw Canals, and through three large pipes on Woodgate Canal. It is understood that sediment build-up occurs at the mouth of Tarradarrapin Creek despite a large sediment trap, but that erosion occurs on the bed of Woodgate Canal following heavy rain. It is postulated that this latter erosion occurs due to the velocity of the water coming through the pipes as they appear to service a larger catchment area than Tarradarrapin Creek but inflow through a smaller opening.

The insitu materials that form the sides and bed of the canals and access channel are understood to be relatively firm clays. The surface materials of the bay (particularly below the low water mark) however comprise of poorly consolidated fine sediments, which are susceptible to being brought into suspension by wave action.

2.2 PREVIOUS REPORTS

A number of studies have been carried out by Riedel and Byrne Consulting Engineers, Kinhill and the University of New South Wales Water Research Laboratory (WRL) over the course of the last 15 years with the aim of understanding the sedimentation dynamics of Waterloo Bay. A summary of the key relevant observations from these reports are as follows:

- The results of the WRL study, commenced in 1982, (Reference 1) provided extremely broad sedimentation prediction rates of between 30 mm and 320 mm per year along the access channel. This corresponds to a total volume of between 2,500 m³/yr and 27,500 m³/yr. These results comprise a very wide band of possibilities, however when compared with the actual measured sedimentation volumes in the channel of around 15,200 m³/yr, they are found to be reasonably



accurate. They do not however allow for the increased concentration of sediment that occurs near the low water mark and which has instigated the need for periodic dredging.

In summary we believe, the WRL report provides a reasonable insight into the future sedimentation behaviour of the development. While the predicted sedimentation volumes were extremely broad, the results are within the accepted accuracy ranges of the sedimentation prediction theories available at that time.

- During 1988 and 1989, Riedel & Byrne carried out both field measurements and calculations to attempt to determine the likely sedimentation characteristics of a proposed channel to be sited immediately to the east of the Aquatic Paradise channel (Reference 3 and 4). The study component concentrated exclusively on the fall out of suspended sediment from the water column. The results of these reports are extremely useful in examining sedimentation rates at Aquatic Paradise as the theory employed is both sound and relevant.

NB → A major finding of the Riedel & Byrne reports was that after periods of heavy rain and thus large flows in the creek systems, the concentration of sediments recorded in Waterloo Bay was low (9 samples all less than 20 mg/l). This result clearly indicates that Waterloo Bay does not typically receive high suspended loads from rainfall runoff.

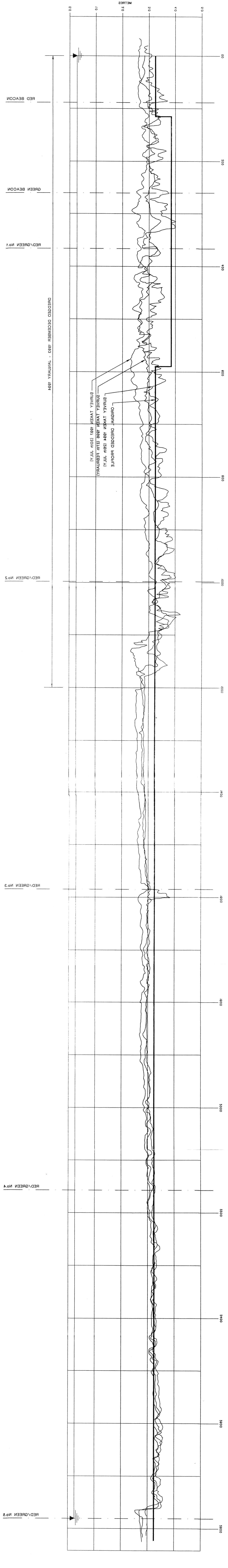
NB → It is acknowledged that occasional significant inflows of sediment may have occurred when heavy rainfall has coincided with major civil works in the catchment. The material generated by such events, when considered across the total area of the bay, is however unlikely to be of major significance.

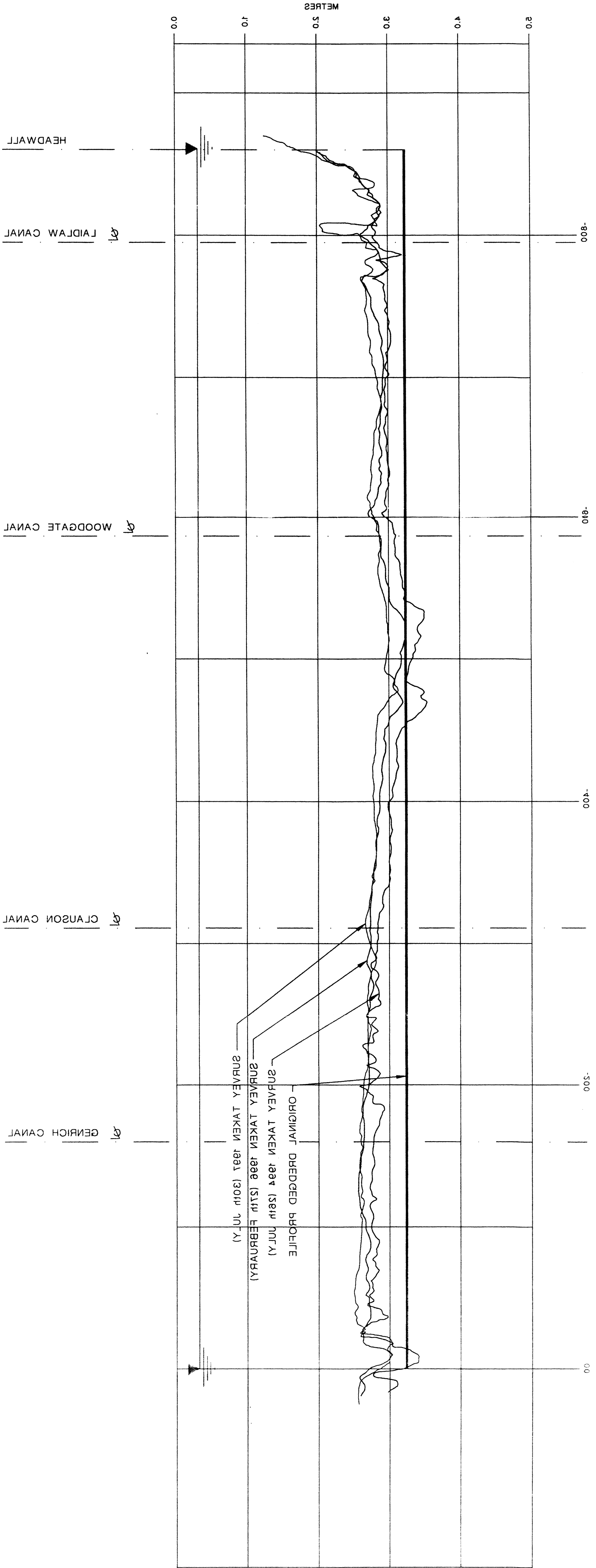
2.3 EXISTING DATA

The specific data and background information available to this study included the following material.

2.3.1 Survey records

The canal system and access channel were formed in the period 1987 to 1989. A general water depth of 1.80 m below Lowest Astronomical Tide (-3.24 m AHD) was provided throughout the system except for a short length of channel at the entrance to the canal estate which was dredged to a depth of 2.3 m (-3.84 m AHD) as a siltation trap. As a consequence of the siltation problems it has been necessary for Council to undertake periodic surveys of the waterway. These surveys, although relatively crude, provide an excellent visual representation of the progressive accumulation of sediment and also provide an approximate method of quantifying the annual volumes. Figures 2.3 and 2.4 have been prepared from Councils surveys for this purpose. Figure 2.3 shows the build up of sediment in Wood Canal as represented by surveys in 1994, 1996 and 1997 and Figure 2.4 shows the same data for the access channel. The original surveys for the remainder of the canals are included in Appendix C in their as provided form. It should be noted that the profiles shown on Figures 2.3 and 2.4 exclude the dredging works that were conducted between October 1993 and January 1994 in the vicinity of the silt trap. The sedimentation volumes in this area are consequently significantly greater than inferred by comparing the 1997 profile





with the original channel bed. A further issue of note on the figures is the frequent cross-over of the bed profiles. **This would suggest that the accuracy of this form of survey is approximately ± 150 mm.**

In addition to the survey data Council also provided a table detailing the siltation history of the various channels. The data provided by Council has been combined with the latest survey plot and the original development drawings to produce best estimate figures for both the annual and the catch-up maintenance dredging requirement. This information is provided as Table 2.1.

As illustrated in the table the estimated total annual maintenance dredging volume for both the canal estate and access channel is $18,600 \text{ m}^3$ and the catch-up maintenance dredging requirement at July 1997 is $75,000 \text{ m}^3$. (The catch-up maintenance dredging requirement is the volume of material to be removed to achieve the original post construction bed profiles.)

We note the following additional issues in respect of the siltation.

- It was we understand, thought that the high sedimentation rates may have been due to sediment from the construction works falling out into the channel. However sedimentation since the maintenance dredging carried out in late 1993 is still high and thus it would appear that the sedimentation being experienced is a permanent and natural phenomenon.
- The spoil area for the maintenance dredging was well away from the site and in deep water. Thus re-sedimentation of the channel as a result of dredged material being pushed back into the channel is not a consideration.
- The sedimentation in the access channel and canal system can be broken down into four areas described as; deep offshore zone, shallow offshore zone, tidal zone and canal zone. The history of the sedimentation of these areas based on Councils surveys is as follows:

Deep offshore zone

Based on the 1997 survey data on the channel centre line, an average of approximately 350 mm of sediment has accumulated in the access channel between chainages 1,100 and 2,300 in the period 1989 to 1997. This equates to an average of around 35 mm per year.

Within the accuracy of the surveys there appears to have been little sedimentation beyond chainage 2,200.

Shallow offshore zone

As described previously the seabed in the area offshore of the mean low water mark (chainage 300 to 1,100) consists of poorly consolidated fine sediments which can easily be moved by the action of waves and currents into the channel. It is therefore not surprising that high sedimentation is occurring in this area. Comparison of the 1994, 1996 and 1997 surveys suggests a maximum of 600 mm and an average of approximately 300 mm per year in this area.

Table 2.1 Estimated siltation volumes

Name of canal	Portion	Bcd Area (m ²)	Depth of siltation (mm)	Period since dredged (Years)	Annual sedimentation mm/yr	Annual volume (m ³)	Catch-up volume (m ³)
Wood	— Headwall to Wood Gate	5,200	400	10	40	210	2,100
	— Wood Gate to Clauson	11,250	300	10	30	340	3,400
	— Clauson to Glenrich	7,650	550	10	55	420	4,200
	— Glenrich to CH 0.00	7,650	600	10	60	460	4,600
Laidlaw	All	3,200	400	4	100	320	1,300
Wood Gate	— Main Channel	7,600	200	9	20	150	1,500
	— Side Canal	2,800	300	9	30	80	800
Clauson	— Main Canal	6,800	250	9	30	200	1,700
	— Side Canal	2,200	150	9	20	50	300
Glenrich	* All	5,200	400	7.5	55	290	2,100
John Goleby	— Main Canal	8,000	550	8	70	560	4,400
	— Side Canal	2,400	250	8	30	70	600
Pat Gay	All	1,000	800	3.5	230	230	800
Totals						3,380	27,800
Access Channel	— CH 1,100 to 2,200	49,500	350	10	35	1,700	17,000
	— CH 300 to 1,100	36,000	600*	3	300	10,800	21,600
	— CH 0 to 300	13,500	600	3	200	2,700	8,100
Totals						15,200	46,700

* Depth of 600 mm assumes silt trap is neglected.



Tidal zone

Higher up the foreshore (in the intertidal area) deposition would be expected to decrease somewhat since the seabed sediments have been in place for a longer period and have been consolidated to a higher bulk density through repeated tidal movements. This assumption is supported by the average measured rate of around 600 mm over 3 years or 200 mm per year.

Canal zone

As demonstrated by the survey data in Appendix C the degree of sedimentation of each individual canal appears to be dependent upon its proximity to either the entrance channel or the outlet of Tarradarrapin Creek. Generally however the measured sedimentation rates are between 37 and 63 mm per year away from these two sources of sediment inflow.

It is also apparent that the build up around the mouth of Tarradarrapin Creek is relatively localised whereas the build up at the entrance to the canal estate is far more gradual and extensive. Hence it is concluded that the majority of the sediment enters the canal estate via the main channel. The 1997 sounding for Clausen Canal (Appendix C) provides possibly the best illustration of this effect.

2.3.2 Seabed materials

Data on the seabed materials in Waterloo Bay close to the site is available from analysis carried out by WRL and Riedel & Byrne in the 1980s (References 1 and 3).

* Both sets of data point to the material being generally very fine silts and sands with DN50 of between 53 and 140 microns and a DN90 of between 260 and 790 microns. This is supported by the results of the petrographic analysis carried out in the course of this study.

While the behaviour of the seabed material would suggest some cohesion when excavated, the particle size would suggest that it may be able to be analysed as a generally non-cohesive seabed. This simplification vastly improves our ability to model the behaviour of the seabed.

The shallow intertidal seabed slopes were sampled by Riedel & Byrne at four locations immediately to the east of the channel location. The results indicated that the insitu bulk density of the seabed material is estimated to be between 1660 kg/m³ and 1820 kg/m³. These bulk densities are quite high and would indicate that seabed sediments in the sampled area have been in place for a long period of time.

Disturbed seabed samples were also taken from the shallow seabed slopes further offshore and below low water level. The seabed at this location was found to consist of very fine material of low bulk density which could be readily moved and resuspended by wave action.

For the purpose of the analysis undertaken in this study an estimate of the mass of solids per cubic meter of sediment on the seabed below low water level was made assuming a settled density of 1.55 t/m³. This equates to a voids ratio of 68 % and a solid mass of 850 kg per cubic metre.

2.3.3 Shoreline movements

Historical aerial photographs were examined in detail by Riedel & Byrne to assess the historical movements of the shoreline of Waterloo Bay. No significant shoreline movement was noted in the vicinity of Aquatic Paradise leading to the belief that the shoreline is currently quite static.

Some recession was noted at the eastern end of Waterloo Bay, however it was concluded that this was a local effect related to foreshore improvements carried out in the immediate area.

2.3.4 Tides

The following tidal planes for the Wellington Point area are available from the Queensland Transport 1997 Tide Tables (Reference 6) as a secondary Port to Brisbane.

Table 2.2 Tidal planes

		To LAT Datum	To AHD Datum
Highest Astronomical Tide	(HAT)	2.82	1.49
Mean High Water Springs	(MHWS)	2.25	0.92
Mean High Water Neaps	(MHWN)	1.83	0.50
Australian Hight Datum	(AHD)	1.33	0.00
Mean Low Water Neaps	(MLWN)	0.78	-0.55
Mean Low Water Springs	(MLWS)	0.31	-1.02
Lowest Astronomical Tide	(LAT)	0.00	-1.33

2.3.5 Currents

We were unable to find any prior current data for Waterloo Bay. It was however reported that a large clockwise gyre exists in the bay. As sedimentation rates can be strongly influenced by currents a series of measurements were undertaken as part of this study.

Refer Section 3 and Appendix A for the results of these current investigations.

2.3.6 Winds

Ambient wind data at the site was available from earlier reports by Riedel & Byrne, and Kinhill, Riedel & Byrne. The data was obtained from the following two sources:

- Wind records for Brisbane Airport between 1952 and 1992; and
- Wind data for one year supplied by the international forecasting group Weathernews.

The information supplied from these two sources was consistent and indicated the following wind speed breakdown from each direction.

Table 2.3 Wind speeds as a percentage of time

Direction	Wind Speed (knots)				
	5	10	15	20	25+
W	2.81 %	2.40	1.51	0.51	0.38
NW	2.32	0.51	0.17	0.07	—
N	6.16	4.66	3.49	1.40	0.24
NE	2.81	1.34	0.58	0.03	—
E	5.34	5.10	5.34	2.71	0.34%

Calms or no fetch wind conditions 49.8%.

The results of these earlier investigations are interesting in that they show that the five year period 1987 to 1992 was noticeably windier than any other period over the last forty years. This finding applies for all wind directions but is particularly apparent for onshore winds. This wind data does not however demonstrate a long term upward trend and no real conclusion can be drawn as to future wind strengths on this data.

The above wind data was used to hindcast waves for the theoretical analysis of sedimentation volumes (refer Section 3).

2.3.7 Measured sediment concentrations

Field measurements were undertaken by Riedel and Byrne and Soil Surveys and Exploration Pty Ltd (Reference 3) as part of an earlier investigation of an adjacent site. Suspended sediment measurements were taken over a range of wind speeds and directions (and consequently over a range of corresponding wave conditions) at locations to the east of the access channel. Values of suspended sediment concentrations were then interpolated and extrapolated to other wind speeds and directions based on an assessment of fetch lengths and depths. The results are presented in the following table:

Table 2.4 Sediment concentration vs wind speed

Wind Speed (knots)	Wind Direction				
	W	NW	N	NE	E
5	20 mg/l	30	36	36	25
10	45	75	90	90	45
15	65	125	140	140	65
20	95	200	240	240	80
25+	120	200	240	240	80 mg/l

For calm and offshore wind directions concentrations in the range 6 to 15 mg/l were measured. Therefore a background suspended sediment level of 10 mg/l was deemed appropriate for Waterloo Bay.

* Suspended sediment samples were also taken following several days of heavy rain. Nine samples were taken in all for analysing. Eight of these had suspended concentrations of 10 mg/l or less while the ninth sample showed a level of 19 mg/l. This would indicate that Waterloo Bay does not receive high suspended sediment

loads from rainfall run-off. Wave action is therefore thought to account for most of the suspended sediment load.



3 Additional studies

This section describes the additional studies that were carried out under this commission, and the objective of each study.

3.1 PETROGRAPHIC ANALYSIS

Petrographic analysis was carried out by Geochempet Services of Maleny on samples collected by Kinhill personnel in the field. The aim of the analysis was to attempt to gain an understanding of where the existing seabed material in the canals and Waterloo Bay originated. The report from Geochempet Services is contained in Appendix B.

The results of the study were unfortunately only partially conclusive due to the large percentages of clay in the samples (generally around 95%). The petrographic procedures used to examine the sediment could not determine the source of the clay because it is common for adjustments in clay mineralogy to occur during various stages of erosion, transport and deposition.

The study was however able to determine that at least a portion of the non-clay material residing in the access channel had in all probability come from Tingalpa Creek. However, as the percentage of non-clay material represented only around 5% of the total retrieved sample, it was inferred that Tingalpa Creek is not a major contributor to the sedimentation of the channel or canal estate. Similarly, the study was able to determine that the build-up of sediment at the junction of Laidlaw and Wood Canals (ie. around the outlet of Tarradarrapin Creek), was in part, due to sediment carried by Tarradarrapin Creek. However, this sediment did not appear to distribute itself to a large extent around the canal system, and appeared to remain concentrated around the outlet.

These observations, when coupled with the fact that low concentrations of sediment are found in Waterloo Bay after periods of heavy rain, and silty water is most often found in Waterloo Bay during periods of large waves, suggests that it is likely that the majority of the sediment in filling to the access channel and canal estate comes from within Waterloo Bay.

In summary, it is inferred that the bay contains a large volume of fine silt material, which is available to be brought into suspension by the waves, and will, when in suspension, preferentially settle out in the deeper (quieter) waters of the access channel and canals.

It is further inferred that the total volume of this material is relatively static with losses offshore, and to areas such as Aquatic Paradise being balanced by inflows from



the creek systems. We note that an imbalance would be apparent in either erosion or accretion of the foreshore.

The elevated sedimentation rate at the start of the access channel is attributed to the increased exposure to wave action that exists near the low water mark, and also the larger difference in depth between the natural ground level and the bottom of the access channel (ie. the effect of the channel is greatest at this location).

3.2 WAVE ANALYSIS

A detailed sedimentation analysis was undertaken to establish if calculation would support the conclusion that the majority of the sediment in the canal and access channel was derived from offshore as a result of wave and current action.

As a prerequisite to this analysis, the design wave climate in the bay was established utilising the wind data contained in the earlier reports.

The effects of swell were neglected, and it was also assumed that the majority of large waves reaching the site resulted from winds blowing from between the north-east and north-west.

Based on the results of the 1989 Riedel & Byrne reports (Reference 3 and 4), winds blow from between the north-east and the north-west approximately 20–25% of the year. The average wind strength from these directions over the period 1952 to 1992 was approximately 9 knots. The fetch length to the north of the site is a maximum of 42 km, although considerable energy will be taken from the waves due to friction as the wave fronts pass over the shallow areas between Fisherman and St Helena Islands. To be conservative, the effects of this friction were neglected.

Using the wave height prediction curves from the US Army Corps of Engineers 1977 Shore Protection Manual (Reference 5) produces an average significant design wave of $H_s = 0.4$ m, with a period of 2.5 seconds. (This wave was derived from the 9 knot breeze blowing over a 42 km fetch with a water depth of between 3 m and 10 m). This represents an 'average' wave condition. Similarly, design waves were calculated for three other representative wind speeds from the north (5, 12.5 and 20 knots), and these, when coupled with the percentage of time that each occurs, were used as a check on the sensitivity of the results to wave distribution. The additional wave heights were:

- Wind = 20 knots, $H_s = 0.8$ m, $T = 3.0$ s
- Wind = 12.5 knots, $H_s = 0.45$ m, $T = 2.5$ s
- Wind = 5 knots, $H_s = 0.25$ m, $T = 2$ s.

We note that the above wave heights are based on a fetch length of 42 km (ie. wind blowing from due north). If the wind was to blow from the north-east or north-west then the fetch length would be reduced, and thus a large wind speed would be required to produce the same wave height. The analysis in this report takes account of this effect.

3.3 CURRENT MEASUREMENT PROGRAM

Sediment will be carried under the action of currents, and hence they can have significant impact on sedimentation rates. As no prior current data could be found for the site, a series of tethered buoy investigations were carried out. The measurements were taken at a time when the winds and waves were typically low and the tide range was average. The results of the current data are shown in Appendix A as a series of plots through a full tidal cycle.

As can be seen from the current plots, the current moves both inshore and offshore, in response to the tide (as would be expected), but there is a definite east to west influence on both the rising and falling tide. This would tend to support the observation that there is a clockwise gyre in the bay. The implication of this is that the current will act to bring additional material into the influence of the channel. The currents measured on 25/07/97 were found to range between 0.05 m/s and 0.1 m/s.

The WRL report in contrast suggested peak tidal currents of between 0.14 m/s and 0.19 m/s, with currents as high as 0.3 m/s.

On the basis of the above, an average tidal current of 0.1 m/s would seem reasonable for input to the sedimentation study.

3.4 SEDIMENTATION STUDY

3.4.1 Canal estate

The sediment entering the canal system can come from three sources:

- Via the access channel
- Via Tarradarrapin Creek or other culverts
- Via surface runoff from the development.

One of the purposes of this study was to examine the former sediment source to establish if calculations would support the hypothesis that the majority of the sediment is derived from offshore.

Sediment from offshore can move into the canals from the access channel either as suspended sediment or as bed load. As the net tidal velocities at the entrance of the canal estate will be similar for both ebb and flood tides and the inflow of fresh water will result in a net movement of water out of the canal system, rather than in, it can be assumed that no net bed load sediment transport into the canal estate from Waterloo Bay exists.

Suspended sediment will, however, be transported into the canals on the flood tide, and it can be hypothesised that some of this sediment will be dropped out before the ebb tide removes the water from the canals.

The amount of suspended sediment being carried in Waterloo Bay has been observed to increase with an increase in wave height. With this being the case, it is possible to relate the offshore wave climate to the ingress of sediment using the previously derived wind speed/sediment rating relationship (Table 2.4), and the material properties established in Reference 3.

Assuming an average canal width of 45 m at MSL and a total approximate length of canal of 3,000 m, the total surface area of the canals is around 135,000 m². Tidal planes for Wellington Point indicate that the spring tidal range is 1.94 m, and the neap is 1.05 m, giving an average tidal range of 1.50 m. This gives an average tidal exchange volume of around 207,000 m³.

Assuming a background level of suspended sediment of 10 mg/L and a suspended sediment concentration of 90 mg/L (ie. for a 10 knot wind as given in the Riedel & Byrne report), and a drop out rate of 85% (and 70%—refer later discussion), the total load of sediment predicted to drop out in one year (with 10 knot winds from the north 25% of the time and two tides per day) is:

- $80/1,000,000,000 * 0.85 * 1,000 * 207,000 * 2 * 365 * 0.25 = 2,570 \text{ t per year.}$

Allowing for this material to settle on the bed of the canals (ie. over an area of 3,000 x 25 = 75,000 m²) at a density of 850 kg/m, corresponds to a depth reduction of around 40 mm/yr. Similarly, a drop out rate of 70% provides a depth reduction of about 33 mm/yr. Allowing for periodic sediment inflow via the creeks and drainage pipes, these values provide a very close approximation to the measured range of between 37 mm/yr and 63 mm/yr.

The above analysis, although relatively crude, therefore clearly tends to support the hypothesis developed from the petrographic analysis and the earlier field measurements, that the bulk of the sediment derives from offshore. These values compare well with the measured volume of sedimentation per year when averaged over the whole planer area of the canal estate. However, they are somewhat less than the measured maximum values of 63 mm at the John Goleby canal, 143 mm at the Laidlaw canal and 269 mm at the Pat Gay canal. These differences are most likely due to localised introduction of silt to the canals from the entrance channel and Tarradarrapin Creek. The volume of material entering the canal system from runoff and Tarradarrapin Creek is difficult to quantify, as it will vary dramatically with the state of the catchment area draining to the canals. For example, should a major storm coincide with a period of construction in the catchment area, then the amount of sediment being carried by the creeks is likely to be dramatically higher than the norm.

One of the key variables in the above analysis is the assumed sediment drop out rate. The firm of Lawson & Treloar (as cited in Reference 3) proposed 70% for Raby Bay, however, the WRL 1982 report (Reference 1) proposed 8 mm/s, therefore implying that almost all the material would fall out each tidal cycle. The value of 85% was therefore selected as an average figure, and 70% as the anticipated minimum.

3.4.2 Access channel

The primary siltation mechanisms in the access channel are:

- suspended sediments which fall out due to the greater 'quietness' provided by the channel, and once there, remain as the increased depth reduces the likelihood of re-suspension by waves;
- bed load and near bed sediments which are moved into the channel by currents, and once there, are trapped as the current velocity is reduced due to the increased depth.

As identified previously, the source of the majority of the material that is available for these processes is believed to be the bottom sediments in Waterloo Bay.

Sedimentation theories

A number of theories can be used to predict the likely sedimentation due to the actions discussed above. Three commonly accepted formulae are CERC, Bijker and Van Rijn. CERC is generally used for sand/beach application, and was therefore deemed unsuitable for this case, given the likely causes of the sedimentation at the site and the nature of the seabed material. Van Rijn's formulae were considered to be the most applicable as the grain size of the seabed material, and the general site characteristics are very similar to those used by Van Rijn in his investigations. Van Rijn's formulae cover specific theory that calculates the sedimentation performance of channels under small wave and current conditions. Bijker's formulae was used as a check on Van Rijn's, particularly for bed load movement.

Analysis

The analysis of the sedimentation in the channel was based on firstly calculating what the sediment at the site would be without a channel, and then calculating what proportion of this sediment ends up being trapped in a channel.

The analysis was also based on an average case to cover the whole range of wave and current climates resident at the site over a year. The following parameters were used for this average case:

- Water depth at equivalent seabed position mid-way along channel length (ie. not in channel) = 2 m (natural seabed at -0.5 m to LAT Datum, plus an average tide of 1.5 m).
- Depth averaged current velocity of 0.1 m/s travelling perpendicular to the channel.
- Significant wave height of 0.4 m.
- Peak wave period of 2.5 s.
- D50 of seabed material of 100 microns.
- D90 of seabed material of 500 microns.
- Ds of seabed material of 60 microns.
- Current and Wave friction factors for use in Van Rijn's analysis method assumed to be 0.01 m, based on the assumption that the seabed surface is likely to be a layer of fluidised muddy material which would be similar in nature to sheet flow conditions in sand and cause little friction. The 1982 WRL report suggests an observed ripple height of 10 mm in certain portions of Waterloo Bay. We have assumed that such ripples would generally occur in areas that have a higher sand or silt content, and are not necessarily consistent throughout the whole of the bay. Further inaccuracies in the theoretical analysis may occur due to the presence of seagrass in Waterloo Bay which may dramatically effect friction.
- Sea temperature of 19°C.
- Salinity of 35 promile.



- Sediment density 2.65 t/m³.
- Silt density 1.55 t/m³.
- Bijker's factor (b) 5.

Van Rijn's method

The results of Van Rijn's analysis for sediment movement under the effects of waves and currents suggest that true bed load (as opposed to near bed load) only contributes approximately 2% of the total sediment movement in the direction of the current (this is the important direction as the current is assumed to be roughly perpendicular to the alignment of the channel), with the other 98% coming from suspended sediment movement. With this being the case the total predicted sediment movements are:

- due to currents 9.9 g/sm
- due to waves 2.1 g/sm.

As the channel is approximately parallel to the direction of the waves, it can be assumed that the wave generated sediment movement will not have a great impact on the channel, and can be neglected in channel sedimentation calculations.

The above figures can be combined and converted to a concentration per litre to check the accuracy of this analysis, with measured concentration levels from the Riedel & Byrne report of October 1989. To do this, a cube of water 1 m by 1 m by 1 m was adopted and, it was assumed that it takes ten seconds to completely fill this cube with sediment laden water (current is 0.1 m/s). As the above sediment movement figures are based on a 2 m depth, they will be divided by two. Thus, the concentration can be predicted by:

- $(9.9 + 2.1) \times 10/2 = 60 \text{ mg/L}$.

This figure compares reasonably with the measured concentrations under a 9 knot wind of 80 mg/L.

Bijkers method

Bijker's method was used specifically to check the predicted bed load movements from Van Rijn's analysis. The results of the Bijker formula indicate that the predicted bed load movement is around 1.1 g/ms. This does not compare particularly well with the Van Rijn prediction of combined current and wave bed load movement of 0.3 g/ms for the same parameters, however, it does support the theory that bed load is likely to contribute little to the overall sediment transport at the site.

Trapping of sediment in channel

To estimate what percentage of sediment is trapped in the channel, Van Rijn's paper titled 'Sedimentation of Dredged Channels by Currents and Waves' (Reference 7) was used. An overall channel width of around 65 m, a particle fall velocity of 3 mm/s (as calculated in Van Rijn's theory), and a trapping efficiency of around 20% were assumed. (A trapping efficiency of 30% applies for low wave climates and around 20% for higher wave climates hence, as the majority of sediment transport occurs during the larger wave climates, an average trapping efficiency of 20% was assumed).

Thus, the yearly sediment volume trapped in the access channel, assuming a seabed density of 1.55 t/m^3 (ie. 68% voids), with mass of solids = 850 kg/m^3 , and the waves to generate the 9.9 g/ms sediment movement figure occurring for approximately 25% of the year, is:

- $(9.9 \times 60 \times 60 \times 24 \times 365 \times 0.25 / 850 / 1,000 / 65) \times 0.2 = 280 \text{ mm/yr}$ decrease in water depth in channel.

Sensitivity analysis

Wave climate

As a check on the sensitivity of the above, Van Rijn's analysis was also carried out using the wave climates associated with three different winds (ie. greater than 20 knots, 10–15 knots and winds of 5 knots). A full fetch length of 42 km was used for winds from the north, while for winds from the north-east and north-west, a reduced fetch length of only 6 km was adopted. This led to the conclusion that waves of only around 0.25 m typically reach the site from the north-east and north-west, except under extreme conditions, while the vast majority of waves greater than this will originate from a northerly wind. Using the percentages of wind speeds shown in the Riedel & Byrne (Reference 3), the following distribution of waves was adopted for the check case:

- $H_s = 0.8 \text{ m}$; $T_p = 3 \text{ s}$ occurs 1.4 % of the time
- $H_s = 0.45 \text{ m}$; $T_p = 2.5 \text{ s}$ occurs 8.2 % of the time
- $H_s = 0.25 \text{ m}$; $T_p = 2 \text{ s}$ occurs 14 % of the time.

Once again, with K values of 0.01, these results produce an annual sediment movement rate of $169,577 \text{ kg/yr}$ which equates to around $200 \text{ m}^2/\text{yr}$ or 3.0 m/yr for a 65 m wide channel. Assuming a trapping efficiency of 20%, this equates to a decrease in channel depth of around 610 mm/yr.

Roughness coefficient

With the roughness coefficient increased to 0.02 m under the bounds of the previous discussion, the overall depth reduction in the channel due to sedimentation is predicted to be around 520 mm/yr.

Thus, the Van Rijn analysis is dependent on the selected roughness coefficient and wave climate, however, notwithstanding this sensitivity, the estimated figures are consistent with the average amount of material being dredged from the channel each year, and are within the bounds of accuracy expected by analysis.

Summary

- In summary, Van Rijn's theory predicts that the annual channel sedimentation will be between 280 mm and 610 mm. This compares reasonably well, if not a little high, with the measured average values of 70 mm, 320 mm and 250 mm, depending on the position within the channel, and the maximum individual recorded value of 600 mm/yr. It also suggests that the vast majority of sediment movement in Waterloo Bay is due to suspended sediment as opposed to bed load.

4 Dredging

4.1 PAST DREDGING WORKS

Two major dredging exercises have been undertaken at Aquatic Paradise in the past; the access channel formation in 1987 and the maintenance works in the vicinity of the siltation trap in 1993/94. In both instances the dredged material was dumped offshore at a recognised spoil disposal site. It is understood that the capital works were undertaken by cutter suction dredge and the maintenance works by a grab hopper barge.

Australia (and therefore by association, Queensland) as a signatory to international pollution control agreements, is now obliged to adhere to strict environmental guidelines in respect of offshore dumping. The implication of this legislation is that Port Authorities, who were in the past relatively willing to allow their spoil disposal sites to be used by others, are now highly protective of their resource, and indeed are seriously looking for alternative spoil disposal options themselves. In summary it must therefore be recognised that the era of offshore spoil disposal is drawing to an end and current maintenance dredging strategies must provide for the efficient and environmentally sound use of the won material.

Discussions with the Port of Brisbane Corporation provide strong support to this as they have indicated that any future dumping into POB's disposal sites in Moreton Bay will only be considered on a case by case basis.

4.2 FUTURE MAINTENANCE DREDGING OPTIONS

In the context of the above legislative climate the options that are now available for spoil disposal are generally restricted to onshore disposal and near shore reclamations. Accordingly the long term options proposed in this Section have been directed towards addressing this style of solution. We note that a further casualty of the legislation are options that seek to 'keep the material moving' hence we have excluded both liquidation and fluidisation based schemes from our review. The authorities reactions to the use of a vessel to mobilise the material are unclear hence the options has been retained as a possible amelioration measure.

4.2.1 Estimated dredging volumes

The following maintenance dredging requirements have been estimated for the site on the basis of the surveys and historical data provided by Council (Refer Table 2.1).



- Access Channel
 - Annual maintenance requirement 15,200 m³
 - July 1997 catch-up maintenance requirement to achieve the original bed profile along the full length of the channel 46,700 m³
 - Canal Estate
 - Annual maintenance requirements 3,400 m³
 - July 1997 catch-up maintenance requirement to achieve the original canal profiles 27,800 m³
- ie. the current accumulated material in the access channel represents approximately three years build-up and the material in the canals eight years build-up

4.2.2 Dredging philosophy

In the past, the normally adopted maintenance dredging philosophy was to allow the material to build-up until it became a nuisance and to then remove it in bulk. The major benefits of this arrangement were:

- the high mobilisation costs of the dredge were distributed over a large volume, and
- temporary amelioration measures could be instigated to remove local shallow areas thereby prolonging the duration between dredging.

In the present environment however where the thrust is for onshore disposal, the most rational philosophy appears to be to undertake small dredging programs at frequent and regular intervals. The clear benefit being the reduced size of the receiving facility. The key elements in the proposed program for Aquatic Paradise are accordingly perceived to be the minimisation of both the initial installation costs and the subsequent mobilisation costs.

We note in this regard that Council is currently faced with the problem of what to do with the large volume of accumulated sediment in the access channel and the canals. In the light of the above argument we perceive that two options are available to remove the initial 56,000 m³ (75,000 - 19,000) of catch-up material. They are:

- firstly to incorporate a proportion of the catch-up material into the annual maintenance program such that it is gradually removed over the first 4 or 5 cycles; or
- secondly to remove all of the 56,000m³ in a "one hit" operation with dumping being to an agreed location in Moreton Bay.

Initial Annual Maintenance Program

An example of the yearly volumes that would be involved in the former option is shown in the Table below. The example shows an initial maintenance dredging volume of approximately 30,000 m³ reducing to match the sedimentation rate over five years.



Year No.	Starting/ Volume	Removed Volume	Sedimentation Volume	Remaining Volume
1	75,000	30,000	19,000	64,000
2	64,000	30,000	19,000	53,000
3	53,000	30,000	19,000	42,000
4	42,000	30,000	19,000	31,000
5	31,000	31,000	19,000	19,000
6	19,000	19,000	—	—

The overall costs involved in the removal of the 151,000 m³ over the five year interval shown is estimated to be around \$2,300,000 or around \$460,000 per year. This assumes a land based spoil receiving facility such as that described in Section 4.2.4, Option 3 is adopted. After the initial five year period the costs are likely to be as per the Section 4.2.4 estimates.

Removal of all Catch-up Volume in One "Hit"

This option involves the dumping of all of the catch-up material in Moreton Bay in one of the Port of Brisbane's dumping grounds. The likely grounds are at either Mud Island or Raby Bay.

Initial discussions with both Port of Brisbane (POB) and Department of Environment (DOE) representatives have been encouraging with POB indicating that they would be willing to allow one of their dumping grounds to be used for the one-off disposal of approximately 56,000 m³ of material. They would however require that all necessary approvals are obtained by the Council (with the exception of Section 86 which has already been obtained by POB).

Port of Brisbane noted that any future dumping of dredge material would have to be considered on a case by case basis and could not guarantee use of the dumping grounds in the future. No charge applies to the use of the POB dumping grounds.

Both of the dumping grounds suggested by POB are a considerable distance from the Aquatic Paradise estate. Thus the use of cutter suction style dredges would probably not be feasible due to the long lengths of pipe and the need for numerous booster stations at intervals along the pipe. A grab dredge is therefore thought to be the most likely choice of dredge. Given the experience of the 1993 / 94 dredging programme it would also be prudent to follow the initial dredging works with a bed leveller (basically a large beam dragged behind a tug) in order to knock off peaks in the finished bed profile. POB presently utilise a bed leveller which may be available for the works. If not a number of other Contractors in South-East Queensland also have access to bed levelling devices.

The overall costs involved in the removal of the 56,000 m³, if it was carried out by the above method is estimated to be around \$ 800,000. Thereafter the annual estimates described in Section 4.2.4 would apply.

The contact at Port of Brisbane is Mr Peter Nella.

3258 4888

4.2.3 Standard rates

In order to be able to draw realistic comparisons between the various maintenance dredging options, the following construction rates have been assumed. The rates are primarily based on Kinhill's previous experience in projects of this nature.

• Groyne Construction (Revetment both sides)	\$2,000/m
• Foreshore Based Bunded Wall Construction (Revetment one side)	\$1,200/m
• Imported General Fill	\$15/m ³
• Imported Quality Fill / Sand	\$20/m ³
• Cut to Fill on Site	\$10/m ³
• Excavator (Long arm)	\$140/hr
• Drag Line	\$200/hr
• 1,600 hp Tug plus Works Barge	\$400/hr
• 10 tonne rough terrain truck (sealed tray)	\$40/hr
• Imported Amour Rock	\$45/m ³
• Trucking Dry Spoil to Dump (Round trip 30 km)	\$5/m ³
• Mobilisation / Demobilisation of Dredge to Site	\$30,000
• Dredging & Carting Spoil from Site to Ponds on Shore/Foreshore	\$6/m ³
• Dredging & Carting Spoil from Site to POB Dumping Ground	\$12.50/m ³

4.2.4 Alternatives

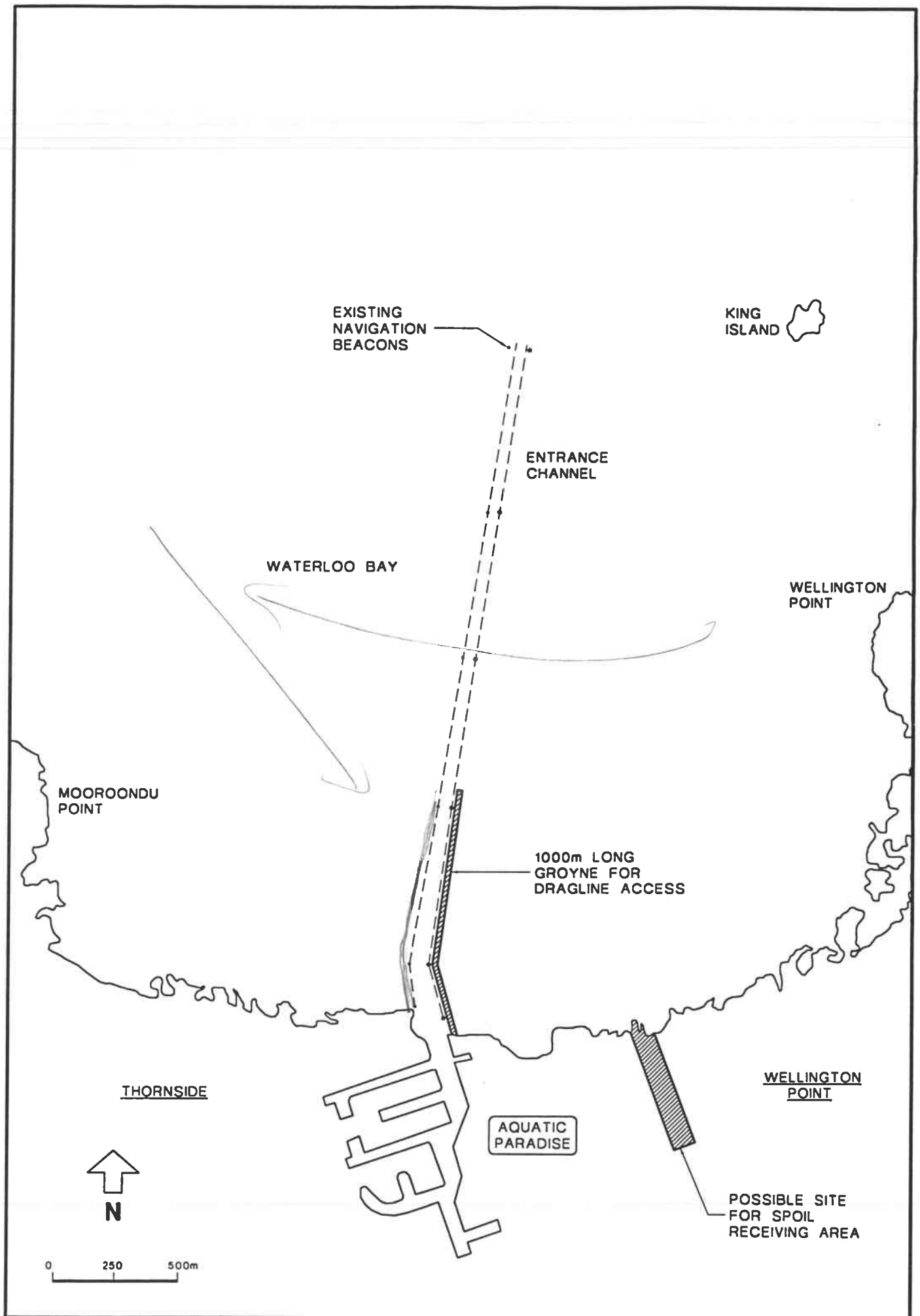
Based on the above limitations and costs, the following alternative long term dredging solutions are proposed as viable options for the Aquatic Paradise development (all options have been developed on the assumption that an initial catch-up volume of 56,000 m³ will be disposed of offshore):

Option 1—Construction of Groyne for the Use of Land Based Excavation Techniques

This option which is illustrated in Figures 4.1 and 4.2, involves the construction of a single groyne on the eastern side of the access channel. A drag line would be operated from the groyne and would load the excavated material directly into trucks which would then transport the spoil to a purpose built spoil receiving area for drying. Long arm excavators would subsequently excavate the 'dry' material from the spoil receiving area and load it into trucks for ultimate disposal at a designated dumping area. Figure 4.1 illustrates a plan of this option while Figure 4.2 shows a cross-section of a typical groyne structure.

Advantages:

- Uses land based equipment;



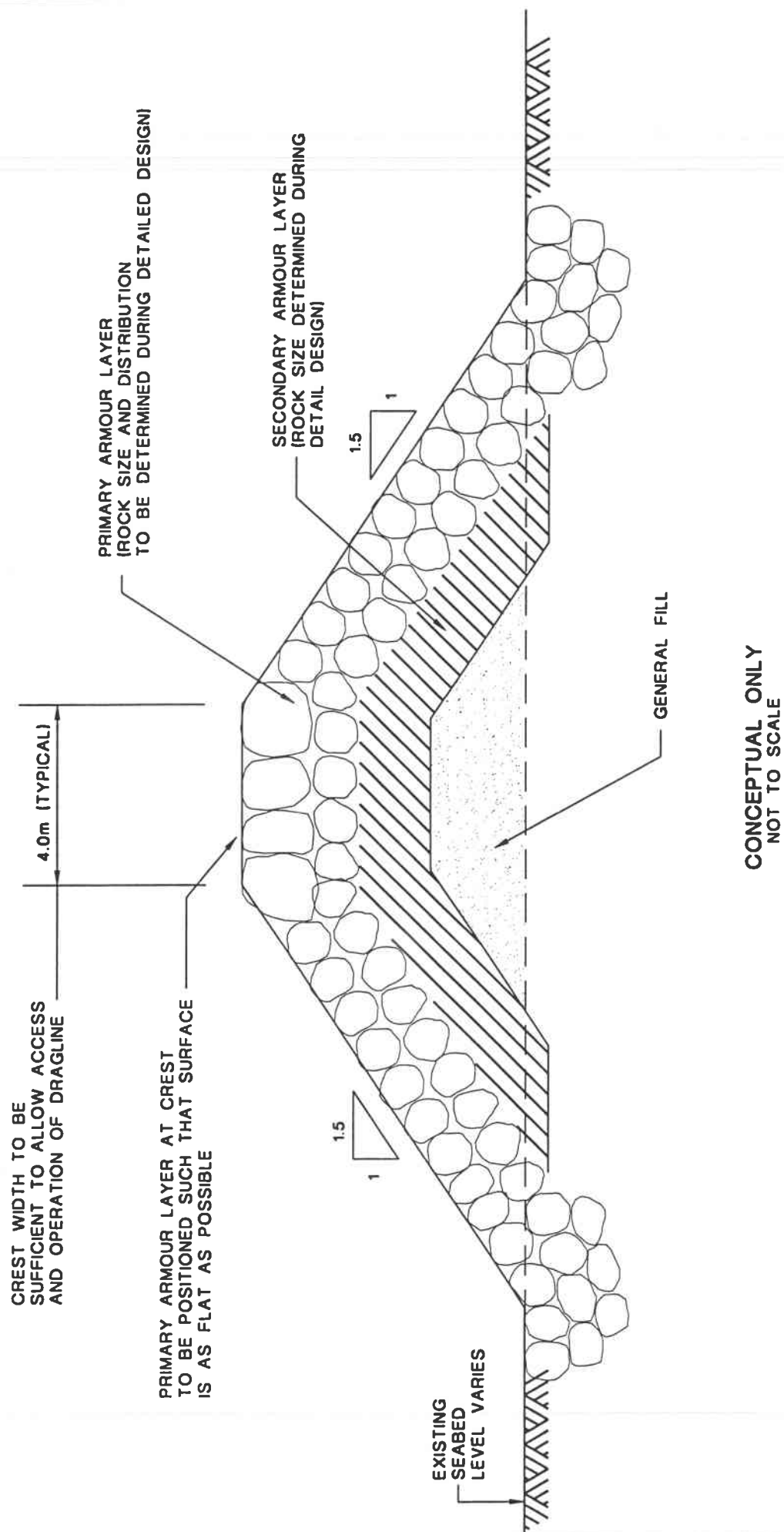


Figure 4.2
**AQUATIC PARADISE
ROCK GROUYNE
TYPICAL CROSS SECTION**

- Excavated spoil is more solid than dredged spoil and thus relatively small settling ponds on land should be sufficient;
- The groyne construction should reduce the level of siltation in the access channel by restricting the flow of silt laden seawater across the channel.

Disadvantages:

- High capital costs associated with the construction of the groyne;
- A dredge would still be needed from time to time in order to clear the canal estate and the access channel area seaward of the end of the groyne. This material would then require a disposal site;
- Some smells may result from the storage of the dredge spoil;
- Public safety would need to be seriously considered due to the hazardous, 'quicksand' like nature of the ponded spoil. High quality security fences would be needed as an absolute minimum.
- This option involves significant 'double handling' of spoil material (ie crane to truck to pond excavator to truck to dump);
- Heavy, land based machinery will need to be in constant operation during the dredging phase. This will create a disturbance for the public and raise safety concerns for both land traffic, pedestrians and boating;
- The groyne will have to extend above the high water mark and will therefore have significant visual impact.
- Sedimentation of the access channel, seaward of the groyne, may increase due to the natural currents of Waterloo Bay pushing more sediment laden water in this direction.

The spoil receiving area would need to be constructed to allow the excavated material to be dried out. Assuming the dredged material is around 30% water, then around 18,000 m³ would need to be stored per year.

The estimated costs for this option are:

Capital Costs

• Groyne Construction (1,000m long)	\$2,000,000
• Temporary Road etc...	\$20,000
• Spoil Receiving Area	\$100,000
• Fencing, Vegetation and Associated Structures	\$80,000
• Road Upgrade to Spoil Receiving Area	\$100,000
Total Estimated Capital Cost	\$3,300,000

Operating costs (per Year)

• Drag Line and trucks (50 days per year)	\$200,000
• Trucking Spoil from Dragline to SRA	\$30,000



• Long Arm Excavator Loading Trucks at SRA (1 months)	\$50,000
• Trucks Carting 'dry' Spoil from SRA to Dump	\$75,000
• Dredging of Canals Every 8 Years	\$100,000
• Additional Small Scale Dredging Every Year	\$20,000
• General Maintenance and Supervisor	\$15,000
Total Estimated Operating Cost	\$485,000/yr

The above costs assume that the land for the spoil recital area is provided free of charge.

Option 2—Foreshore Bunding of Spoil Material

This option, which is illustrated in Figure 4.3, involves using the dredged spoil to progressively create reclamation areas in front of the estate, and assumes the use of a small cutter section dredge.

The planer area of the holding ponds has been selected to allow sediment to drop out of suspension, thus filling the ponds with sediment while the cleaner water is drawn off from the last pond and returned to the sea. As one holding pond fills to an acceptable level with sediment, it would need to be decommissioned from use, capped with good quality fill and an additional pond would then need to be constructed. The capping of the ponds with good quality fill or sand should improve the overall compaction and general properties of the underlying dredged spoil. Vegetation should then be planted on top of the capping fill, to improve the long term stability of the filled pond.

Once the overall stability of the decommissioned ponds has been assured they could be used for recreational purposes or the like. It is initially estimated that an extra bunded pond, such as that shown on Figure 4.3, would be required approximately every two years.

Advantages

- No rehandling of dredged spoil is required (ie spoil can be pumped straight to the pond). Furthermore dredging costs would be lower than most other options due to the shorter distance over which the dredged spoil needs to be transported;
- Provided it was found to be geotechnically stable, the reclaimed land could be developed by the Council into a general purpose recreational area;
- As a result of the reclamation process, the length of channel subject to major siltation due to wave action in Waterloo Bay would be steadily reduced as the reclaimed area is moved seaward, thus reducing the level of future dredging required;
- The use of land based excavation equipment is kept to a minimum, thus reducing disruption and safety concerns for the public.

Disadvantage

- The construction of the bunded spoil areas will involve high capital costs;

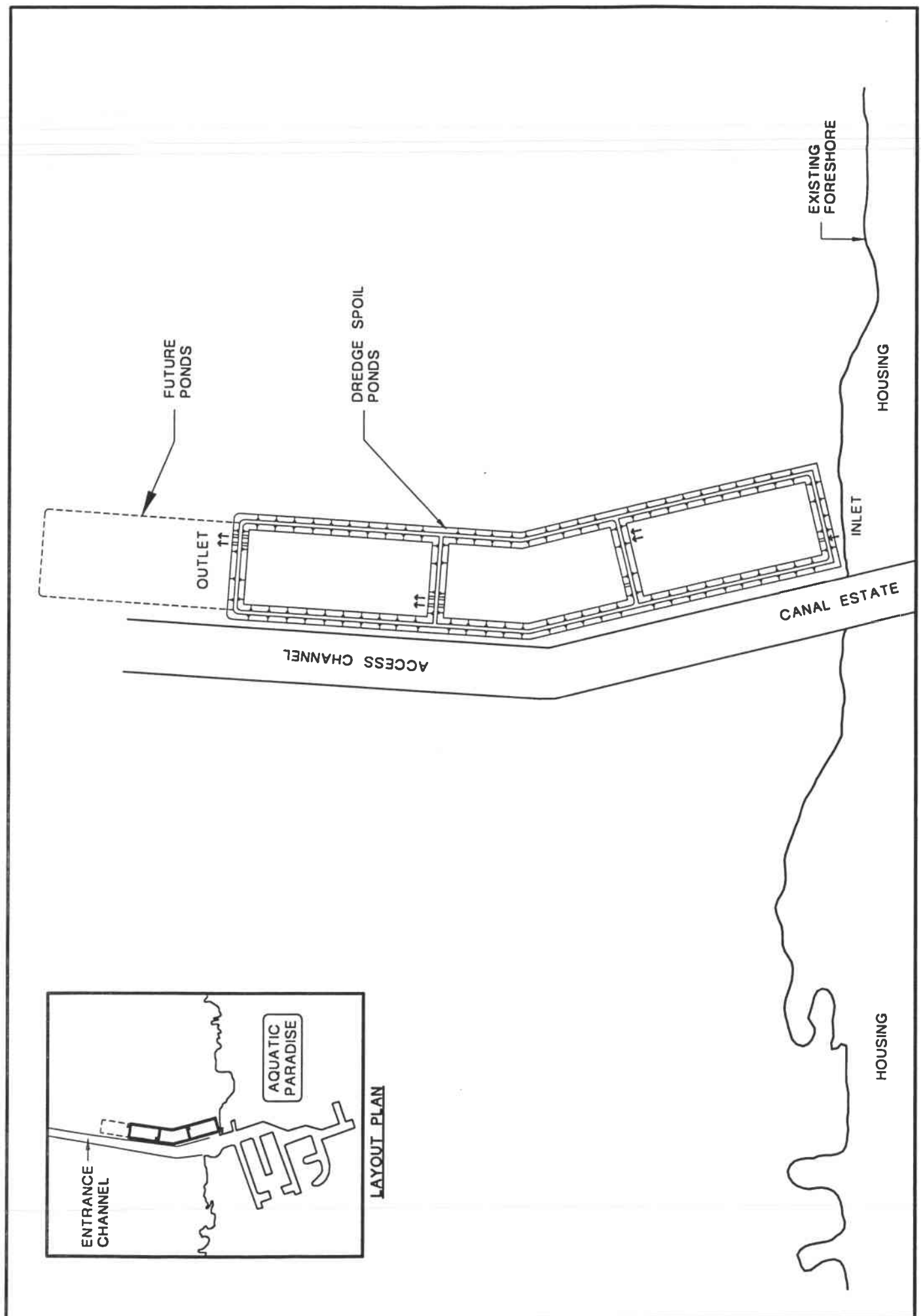


Figure 4.3
**AQUATIC PARADISE
OPTION 2
FORESHORE SPOIL PONDS**

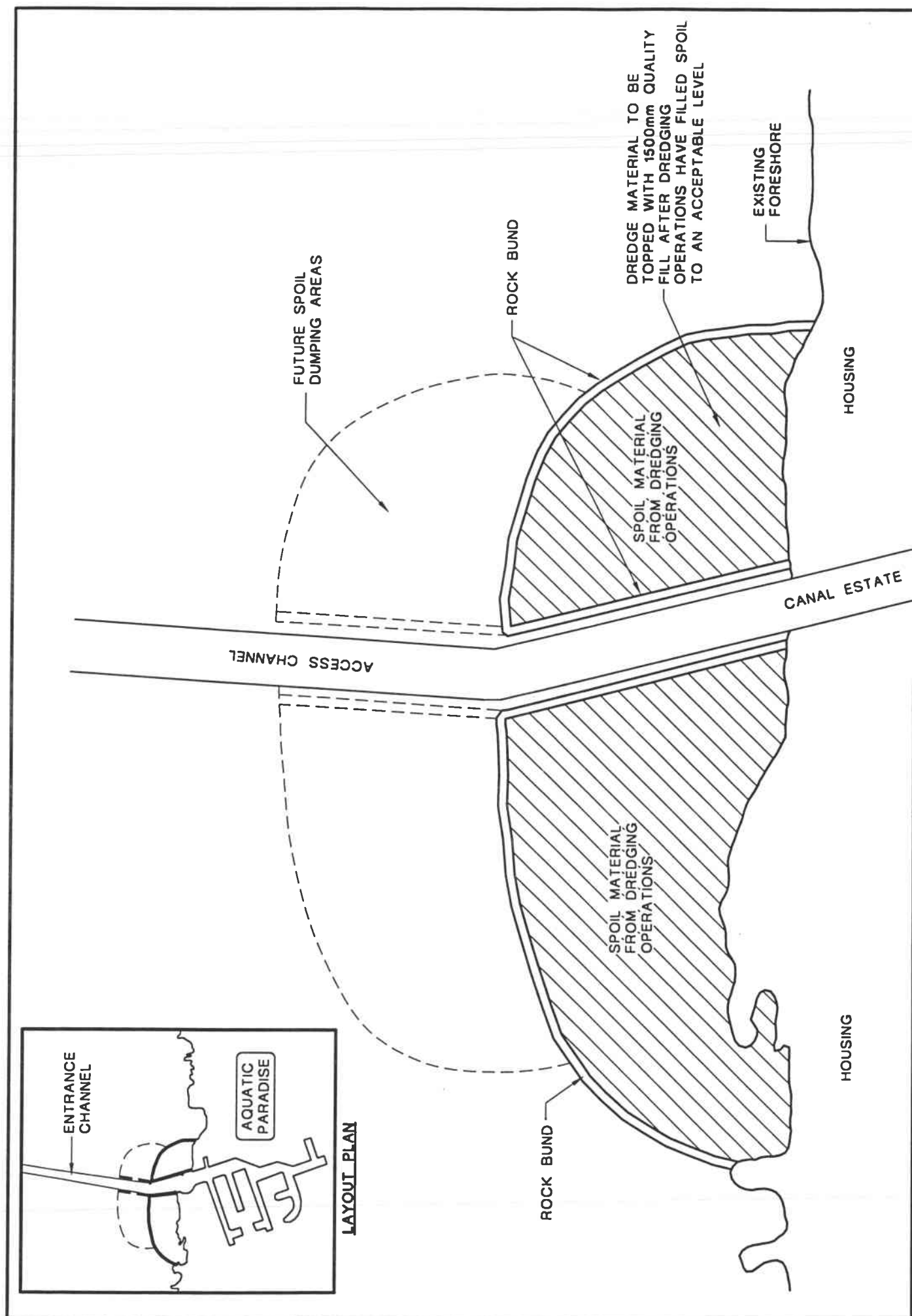


Figure 4.4
**OPTION 2 - ALTERNATIVE
LARGE SCALE FORESHORE PONDS
POSSIBLE ARRANGEMENT**

- The capital costs will be ongoing as fully filled bunded areas will require decommissioning and new ponds will have to be constructed as time passes;
- The project would essentially involve the reclamation of the foreshore hence the environmental implications will be significant;
- The foreshore ponds may be aesthetically displeasing to both residents and the public;
- The quality of the reclaimed area will be low due to the generally poor long term nature of the muddy spoil material;
- Public sentiment may be against any future reclamation of Waterloo Bay;
- Some smells may result from the storage of the dredge spoil;
- Public safety would need to be seriously considered due to the hazardous, 'quicksand' like nature of ponded spoil. High quality security fences would be required as an absolute minimum.

The estimated costs for this option are:

Capital Costs

• Sea-based bunded walls	\$1,200,000
• Internal bunds not subject to wave action	\$50,000
• Access roadworks	\$100,000
• Fencing, Vegetation and Roadworks	\$100,000
Total Estimated Capital Cost	\$1,450,000

Operating Costs (per Year)

• Dredging Operation (every year)	\$115,000
• Capping & Demobilising Pond (every 2 years)	\$170,000
• Construction of New Pond (every 2 years)	\$400,000
• General Maintenance and Supervisor	\$15,000
Total Estimated Operating Cost	\$700,000/yr

Some savings on long term costs could be achieved by initially constructing much larger ponds that would last for say, ten years, before requiring decommissioning and replacement with a new pond. A possible arrangement for these larger ponds is shown on Figure 4.4.

Similarly it may prove to be more cost effective to maintain a series of say, three ponds, which are regularly excavated at the end of each dredging cycle. This would negate the need to construct additional ponds in the future, however would also lead to the creation of large amounts of construction traffic moving through the Aquatic Paradise estate in order to facilitate the removal of the 'dried' spoil material.

Option 3—Ponding of Dredged Spoil on Land - Three Yearly Cycle

This option which is illustrated in Figure 4.5, would involve the use of land based ponds located in the vacant area of land to the east of the Aquatic Paradise development. The ponds would be of sufficient size to handle the volumes of material likely to be dredged from the channel and canal estate every three years. The ponds would be of such a size to be able to handle the full amount of dredged material which can be allowed to dry out in the ponds before the 'dried' spoil is removed to the dump. Under this option, no further pond construction would be required in the future.

Clean water would be either drained out to the sea or evaporated into the atmosphere as the end product.

Advantages

- Low capital costs due to all construction being on land;
- Position of spoil ponds away from the foreshore and thus able to be discreetly hidden behind earth bunds covered in trees and other vegetation;
- Construction / operational traffic can be kept to designated areas away from public dwellings and the Aquatic Paradise estate;
- Dredge pipes can be buried and left in place;
- No rehandling of dredged spoil is required (ie spoil can be pumped straight to the pond). Dredging costs can be restricted by minimising the distance over which the dredged spoil is pumped;
- No future construction of handling ponds is required.

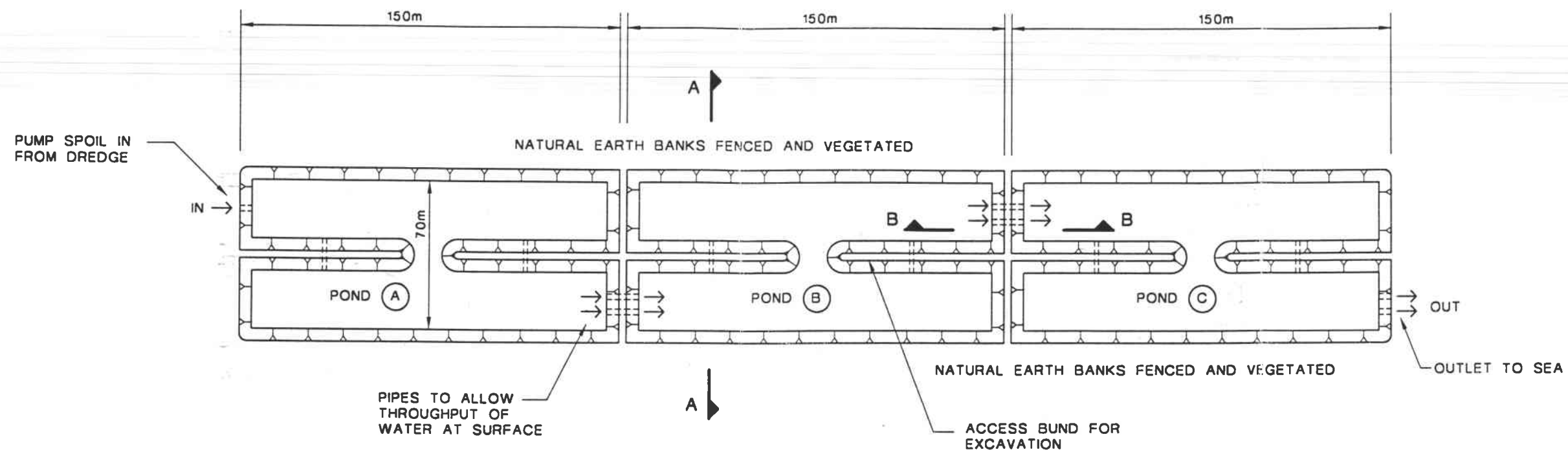
Disadvantages

- The ponds must be sited nearby otherwise dredging becomes unviable. As illustrated in Figure 4.5 the existing vacant land to the east of the site would be ideal;
- Public sentiment may be against locating the spoil ponds on land and close to housing;
- Some smells may result from the storage of the dredge spoil;
- Public safety would need to be seriously considered due to the hazardous, 'quicksand' like nature of ponded spoil. High quality security fences would be essential as an absolute minimum.
- Need to dispose of end product from ponds to a land based dump.

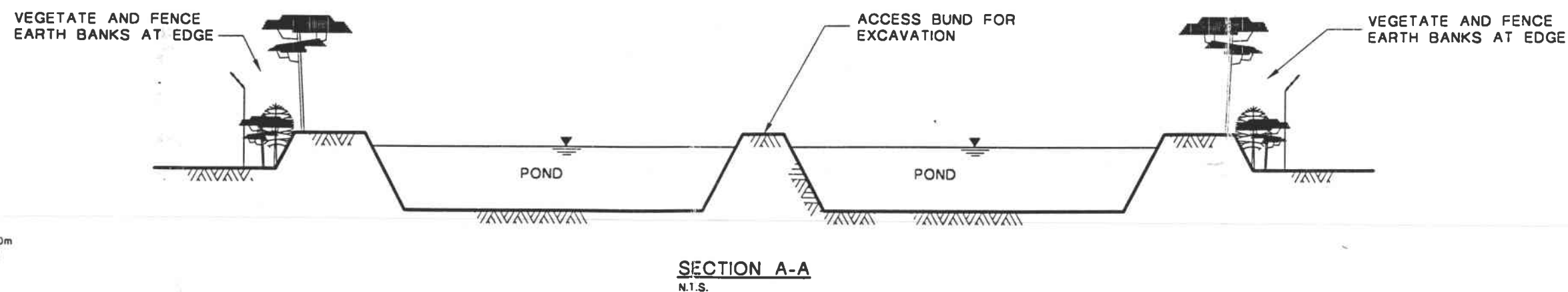
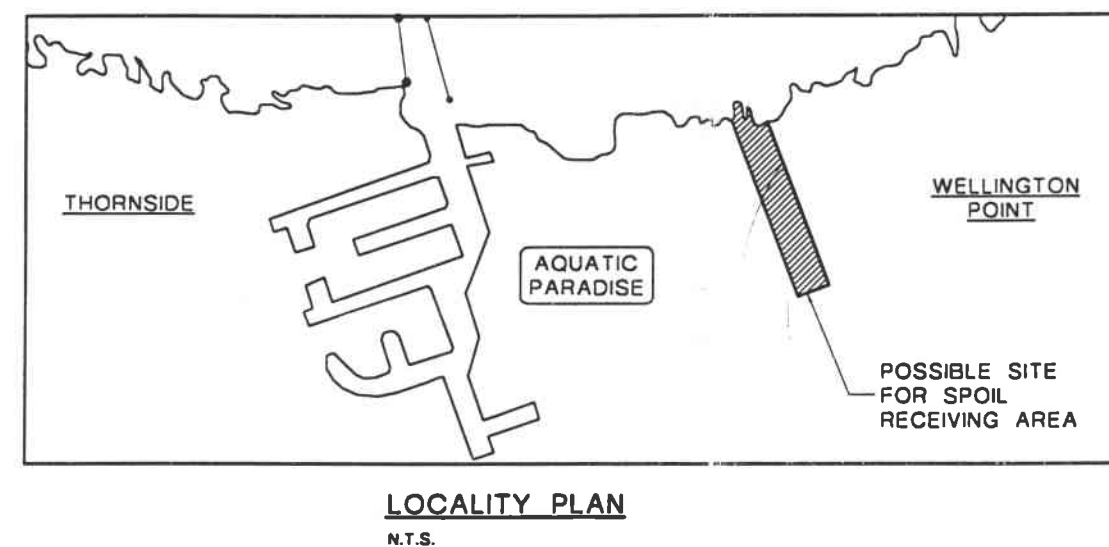
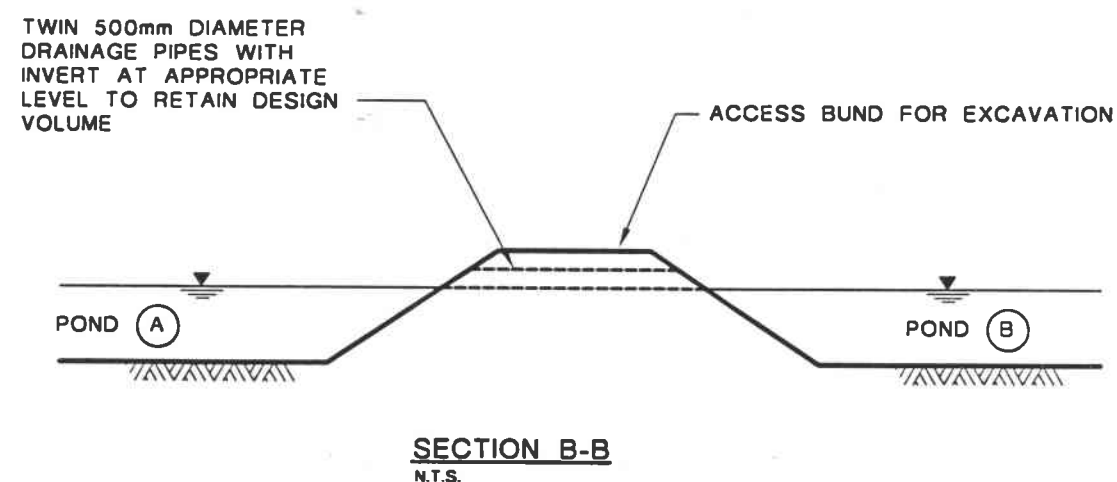
The estimated costs for this option excluding the costs of the land are:

Capital Costs

• Land Based Bunds with Clay Core and Lining	\$750,000
• Vegetation, Pipes, Structures, Fencing, Pump Station	\$150,000



GENERAL ARRANGEMENT
SCALE A



0 200 80m
SCALE A

• Outlet to Sea and Foreshore Stabilisation	\$30,000
• Roadworks	\$60,000
Total Estimated Capital Costs	\$990,000

Operating Costs (per Year)

• Dredging Operation (Once every three years)	\$130,000
• Excavator and Support Trucks	\$90,000
• Truck from SRA to Dump	\$60,000
• General Maintenance and Supervisor	\$15,000
Total Estimated Operating Costs	\$295,000/yr

Option 4—Ponding of Dredged Spoil on Land - Annual Cycle

This option, which is illustrated in Figure 4.6, would involve a similar system to that described for Option 3, except that the ponds would be significantly smaller to allow for the reduced dredging volumes obtained from an annual cycle.

As a consequence of the smaller ponds, the handling facility would need to be more complex with three main components; the Settling Ponds, the Evaporation Pond and the Final Drying Platform. Figure 4.6 shows a preliminary detail for these components. The sizing of the facility has been based on a 6 months per year dredging regime, every year. It is estimated that a small dredge (around 100mm pipe size) would need to be stationed in the estate or access channel for the full 6 months and pump dredged spoil to the ponds at around 50m³ per hour in order to deliver the full 19,000m³ of insitu channel / canal sediment to the ponds in that time. It is thought likely that a booster pumping station will be required halfway along the pipe route to the ponds.

The sizing of the ponds is based on an assumed dredge spoil density of 1.2 t/m³, an insitu channel / canal sediment of 1.55 t/m³, an Evaporation Pond spoil density of 1.8 t/m³ and a Final Drying Platform spoil density of 1.9 t/m³.

The delivery pipe carrying dredged spoil to the facility would be split into three inlet pipes in order to assist in maintenance and excavation of dredged spoil from around the inlets into the settling ponds. Four settling ponds are shown in the typical arrangement developed for this option. The length of flow for the spoil laden water is at least 250 m and in the time it takes for the flow to travel this distance (around ten days) it is expected that the majority of the sediment would drop from the water, thus providing effluent at the outlet of sufficient quality to pass the required guidelines. A series of filter cloth sections may be required at the bends in order to retard the flow and assist in settling the sediment. The exact sizing and nature of the Settling Ponds will need to be checked in the detailed design phase of the project.

Following the sediment dropping out of suspension and on to the floor of the Settling Ponds, it would be excavated and dumped into the Evaporation Pond for drying. A crust will then form on the surface of the Evaporation Pond, which will be excavated and dumped on the Final Drying Platform where it will remain until it is dry enough to load into trucks and cart to an agreed dumping ground.



Advantages

- Small area required for the facility (around 2 ha);
- Low capital costs due to all construction being on land;
- Position of spoil ponds away from the foreshore and thus able to be discreetly hidden behind earth bunds covered in trees and other vegetation;
- Construction / operational traffic can be kept to designated areas away from public dwellings and the Aquatic Paradise estate;
- Dredge pipes can be buried and left in place;
- No future construction of handling ponds is required.

Disadvantages

- The ponds must be sited nearby otherwise dredging becomes unviable. As illustrated in Figure 4.6 the existing vacant land to the east of the site would be ideal;
- Public sentiment may be against locating the spoil ponds on land and close to housing;
- Some smells may result from the storage and rehandling of the dredge spoil;
- Public safety would need to be seriously considered due to the hazardous, 'quicksand' like nature of ponded spoil. High quality security fences would be essential as an absolute minimum.
- Need to dispose of end product from ponds to a land based dump;
- More rehandling of spoil is required in this option than for Option 3.

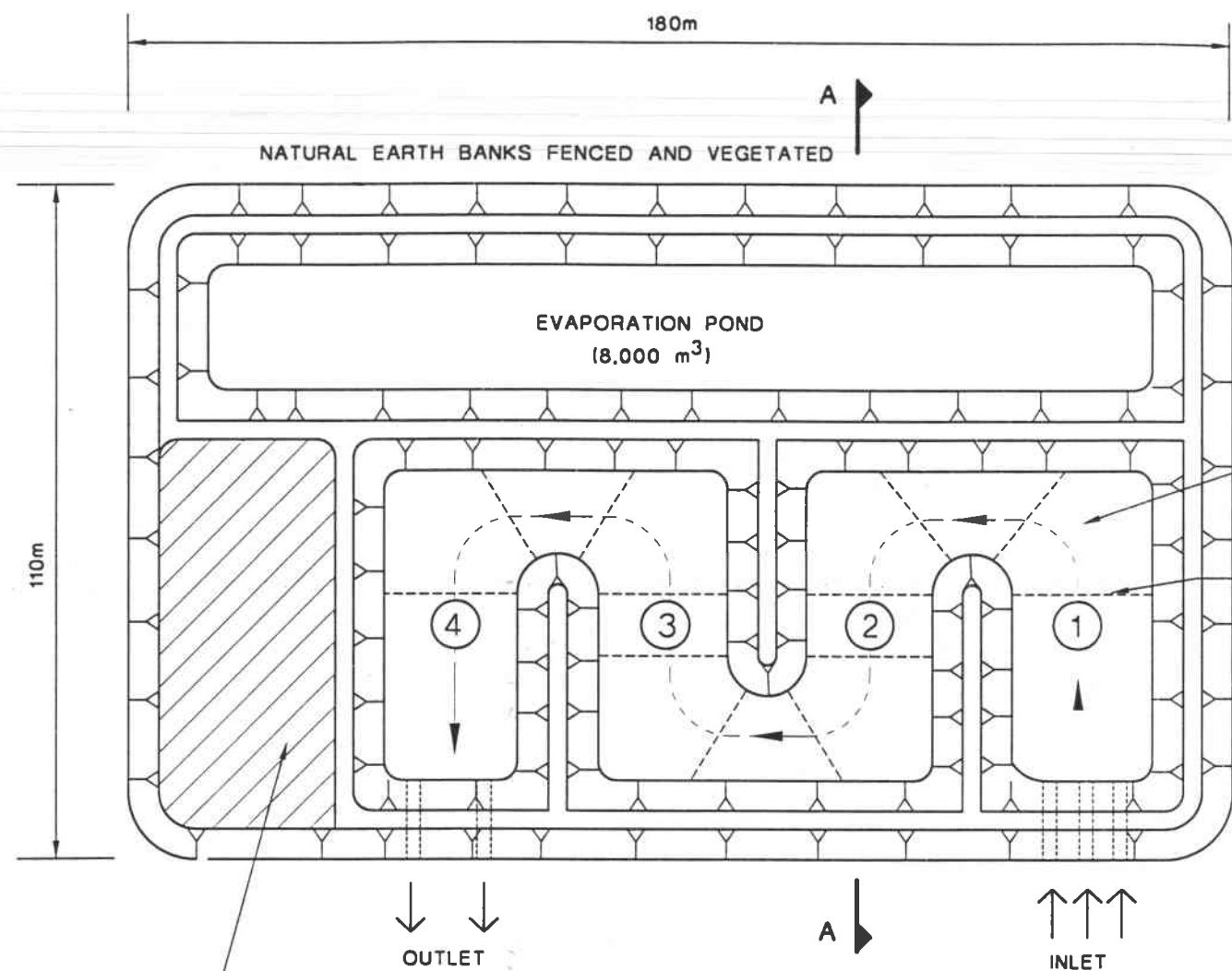
The estimated costs for this option excluding the costs of the land are:

Capital Costs

• Land Based Bunds with Clay Core and Lining, Sand under E.P.	\$440,000
• Vegetation, Pipes, Structures, Fencing, Pump Station	\$170,000
• Outlet to Sea and Foreshore Stabilisation	\$30,000
• Roadworks	\$60,000
Total Estimated Capital Costs	\$700,000

Operating Costs (per Year)

• Dredging Operation (six months per year)	\$140,000
• Excavator and Trucks (2 day per week)	\$110,000
• Truck from SRA to Dump	\$50,000
• General Maintenance and Supervision	\$15,000
Total Estimated Operating Costs	\$315,000/yr



GENERAL ARRANGEMENT
N.T.S.

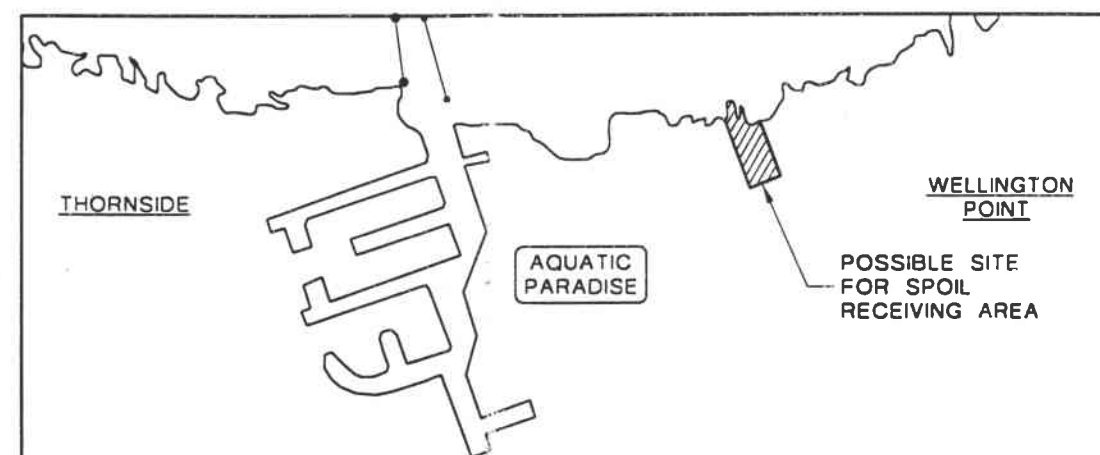
FILTER CLOTH TO
IMPEDE FLOW OF
SEDIMENT AND RETARD
FLOW AROUND CORNERS

SETTLING PONDS
(10,000m³)

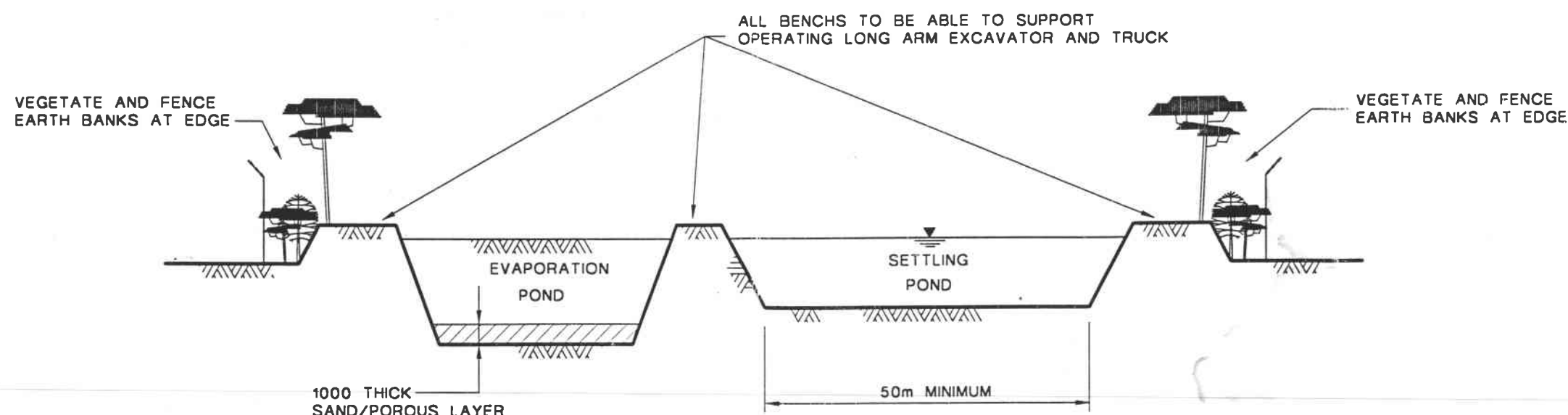
FINAL DRYING
PLATFORM
(3,000m³)

OUTLET

INLET



LOCALITY PLAN
N.T.S.



SECTION A-A
N.T.S.

* EPA (MP+W) - only like spoil going
to a designated spoil site.
'Miles Yates'

4.3 AMELIORATION MEASURES

As identified earlier in the report amelioration measures have generally been used in the past to delay the onset of dredging. Given the current environmental restrictions such alternatives have become less attractive as the displaced material has still generally to be removed from the system.

* Given the high concentration of siltation that currently develops between chainages 300 and 1,100 some form of amelioration in the form of temporary spreading could still be attractive. The suggested options and their likely costs are:

Option A—Prop Wash

It would be possible to pass a powerful vessel such as a tug up and down the access channel on an ebb tide to assist in re-distributing sediment away from the current 'high -build' zone. The effectiveness of the measures are almost impossible to quantify and as noted previously the displaced material would still have to be removed from the system. The anticipated cost of a two day visit by a tug is \$6,500.00.

Option B—Extend Access Channel Groynes

Possible the best way to effectively reduce the amount of sedimentation in the channel is to cut off the flow of sediment laden water into the channel. This can only efficiently be achieved by constructing cut off walls or groynes along the sides of the channel. The costs involved in such an operation are high as the channel is presently exhibiting sedimentation characteristics out to around 2 km from shore. Furthermore the construction of groynes or cut-off walls will not totally prevent sedimentation of the access channel in the area between the groynes. As is presently the case for the canals, tidal exchange will introduce sediment laden water to the access channel area and thus some sedimentation will still result from this process. As an estimate it would be reasonable to assume that the levels of this sedimentation would be similar to that presently experienced in the canal estate.

Figure 4.1 shows an option for the construction of a single groyne and a typical cross-section is shown in Figure 4.2. The same details would apply to a double groyne option.

The capital cost of two groynes is broadly estimated to be around \$4 million based on a rate of \$2,000 per metre.

Option C—Bed Levelling

It would be possible to re-distribute some of the sedimentation in the access channel using a purpose built bed leveller which would basically comprise a heavy beam dragged behind a powerful vessel such as a tug. As for Option A the effectiveness of such measures is totally unquantifiable and the material would still have to be removed from the system. The cost of two days tug and beam hire is estimated at \$8,500.00.

Option D—Improved Silt Traps

In the canals, some reduction of silt entering the system may be achieved through careful maintenance or improvement of the silt traps currently in place. It should be stressed however, that while this will reduce localised areas of sedimentation such as at the outlet of Tarradarrapin Creek, it is not expected to vastly reduce the current sedimentation levels experienced in the canal estate. To vastly improve these levels, the flow of sediment laden water into the canal estate from Waterloo Bay would have to be restricted and due to the nature of the canals, this is not thought to be a practical option.

*Need docking gates?
to minimise sediment laden
water entering the canals.*

4.4**RECOMMENDATIONS**

On the basis of the preceding reviews it is apparent that onshore ponding in conjunction with a small dredge provides the most attractive option (whether it be Option 3 or Option 4 of Section 4.2.4). The major difficulty with the scheme is however likely to be the negative response from the adjacent property owners. Strong protests on the grounds of safety, smells and increased traffic would be anticipated. In particular Councils attention should be drawn to the safety issues relating to land based ponds of this nature. Similarly major negative public comment could be anticipated for any form of offshore bunding and/or reclamation.

Notwithstanding the above public objections we believe that near shore or onshore disposal is inevitable and would strongly recommended Councils early identification of an appropriate site.

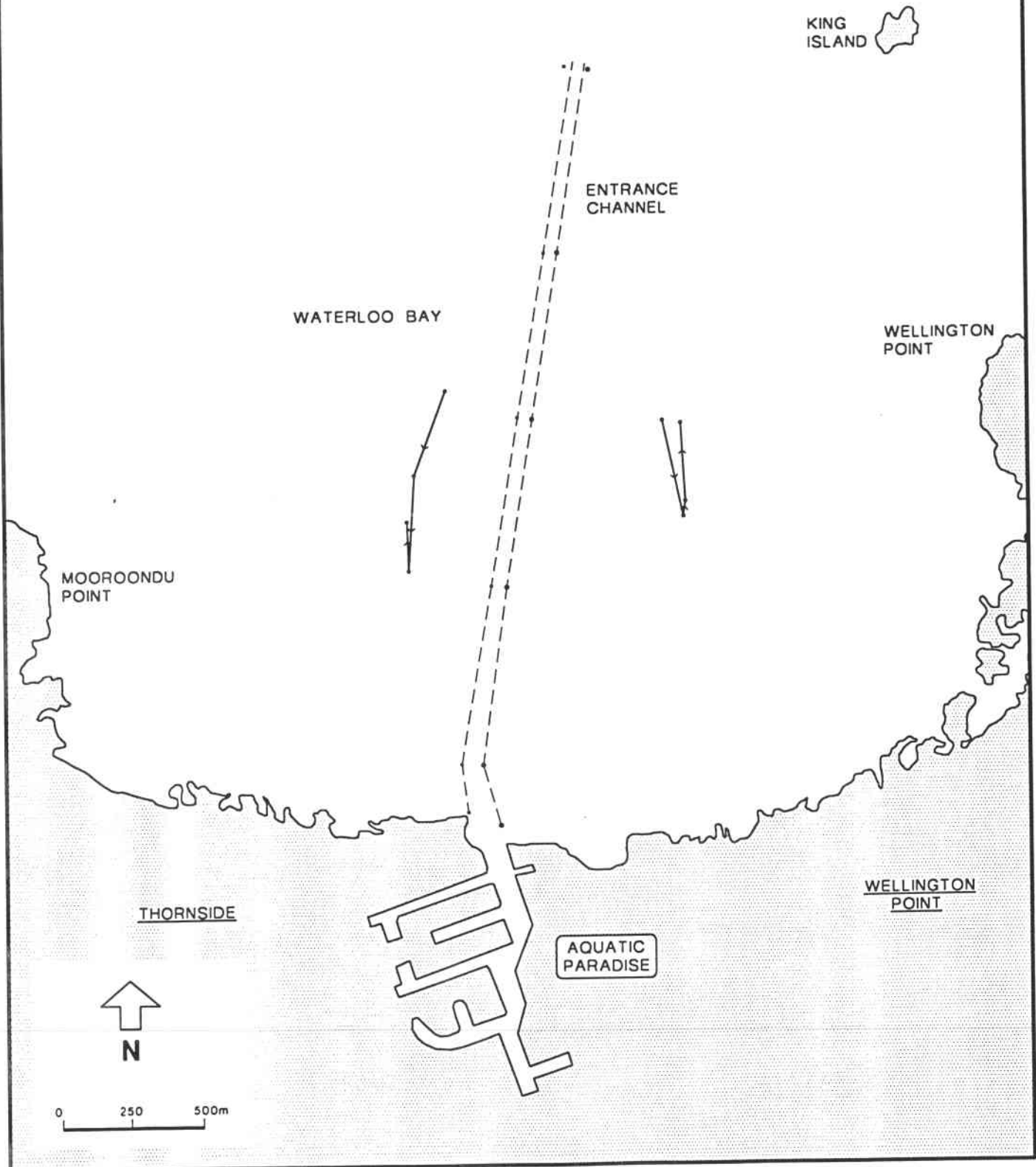
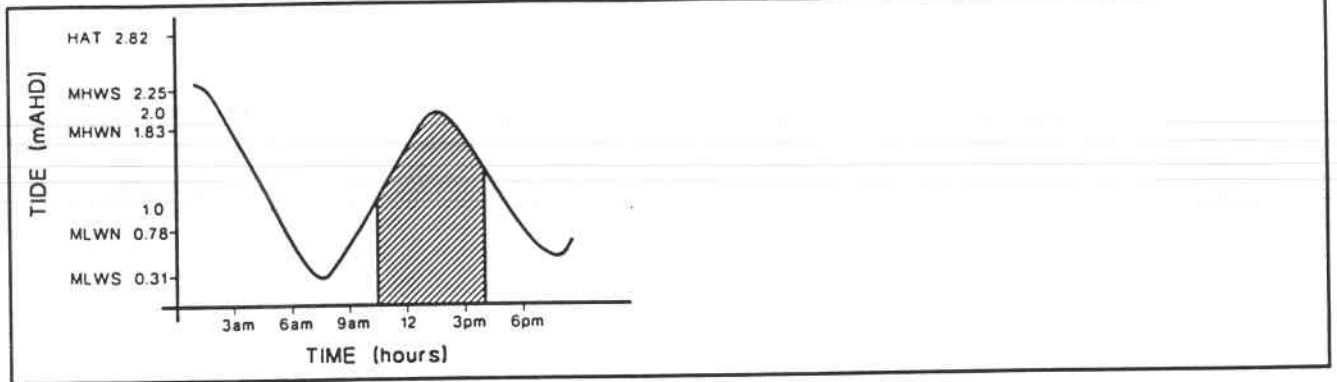
Our recommended dredging strategy is to employ small scale equipment operating on an annual basis with the catch-up maintenance material being removed in one initial hit to an offshore disposal area. The major benefits of this latter strategy are that the onshore facility can be kept small and the quantities of material to be handled on an annual basis at any one time are minimised. The exact size of the ponds and nature and configuration of the dredging operation will be determined in the detailed design phase of the project.

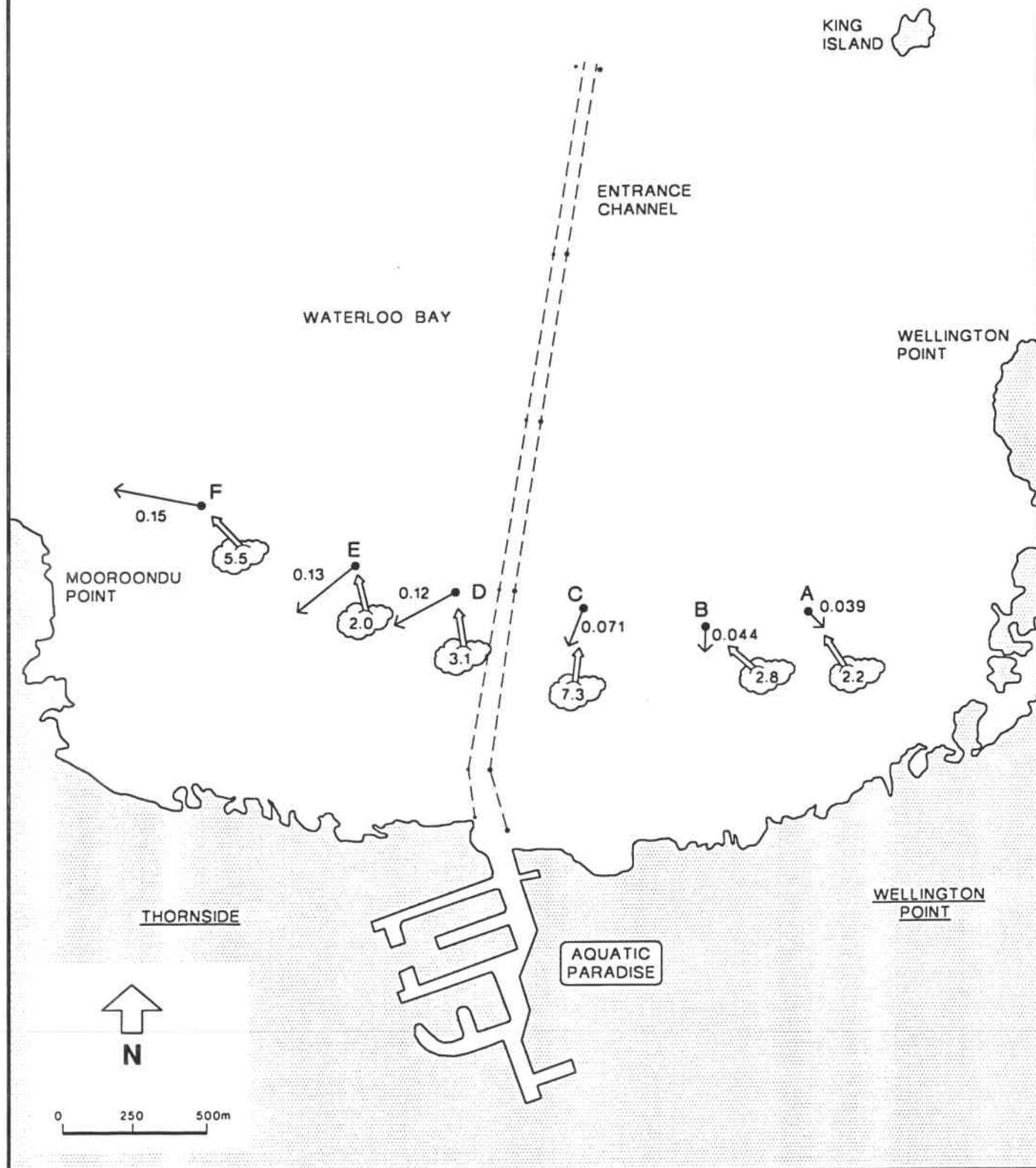
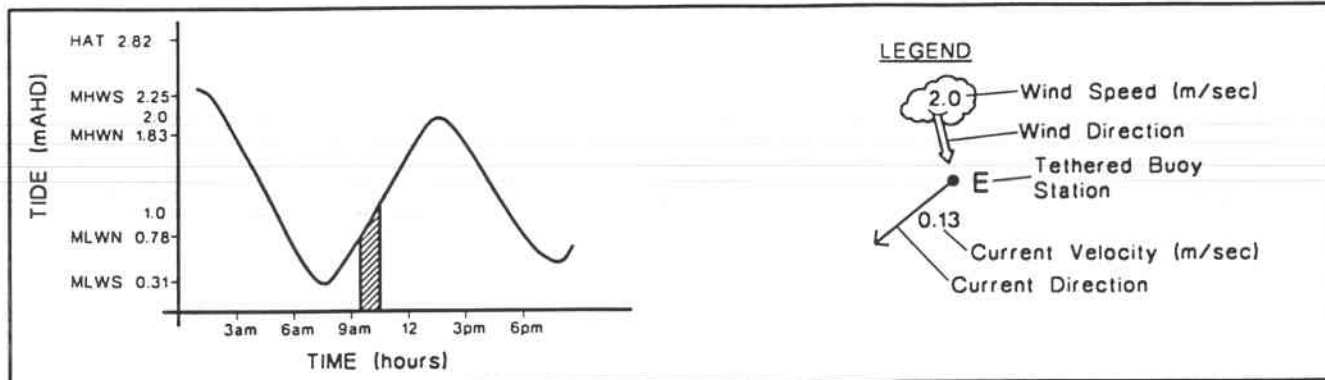
5 References

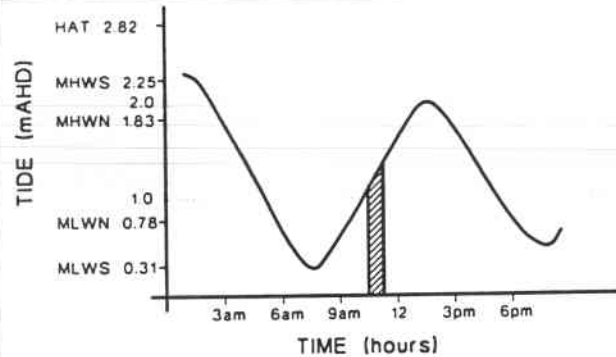
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2. Kinhill Riedel & Byrne. Wellington Harbour Canal Estate. Preliminary Design Report. Report BC3928-500 Rev 2. September 1995.
3. Riedel & Byrne Consulting Engineers Pty Ltd. October 1989. Waterloo Bay Canal Estate, Siltation Studies. Report R350.
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5. C.E.R.C. 1977. Shore Protection Manual. US Army Coastal Engineering Research Centre, fort Belvoir, Virginia, 3 Volumes, 3rd Edition. 1977.
6. Queensland Transport. 1994. Queensland's Official Tide Tables and Boating guide. Queensland Department of Transport.
7. Van Rijn, L.C. 1986. Sedimentation of Dredged Channels by Currents and Waves. Journal of Waterway, Port, Coastal and Ocean Engineering. Volume 112.

Appendix A

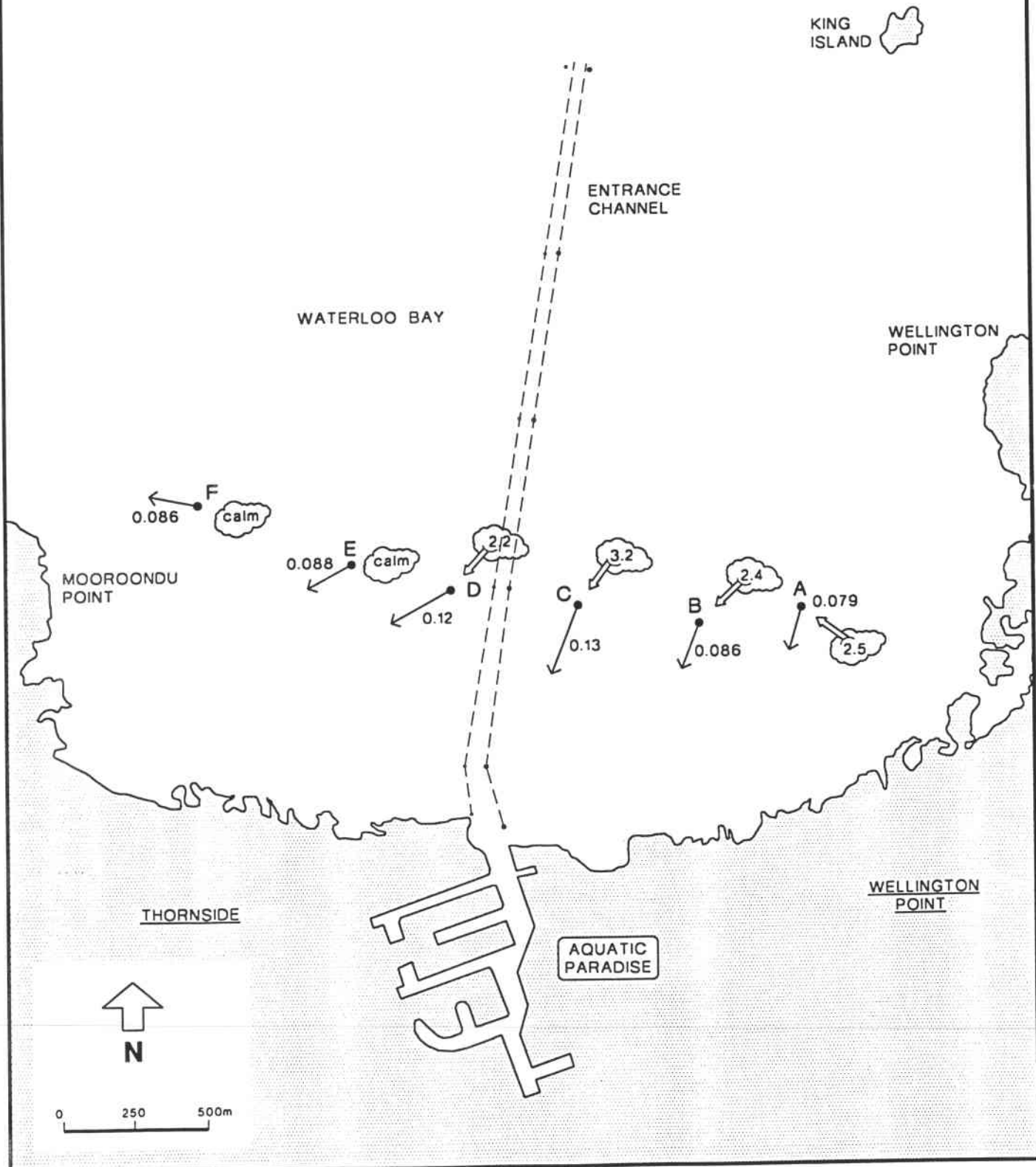
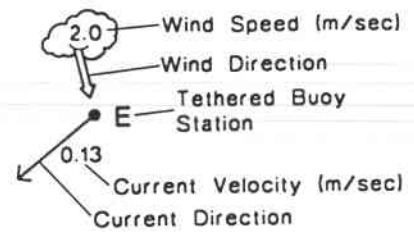
CURRENT MEASUREMENTS



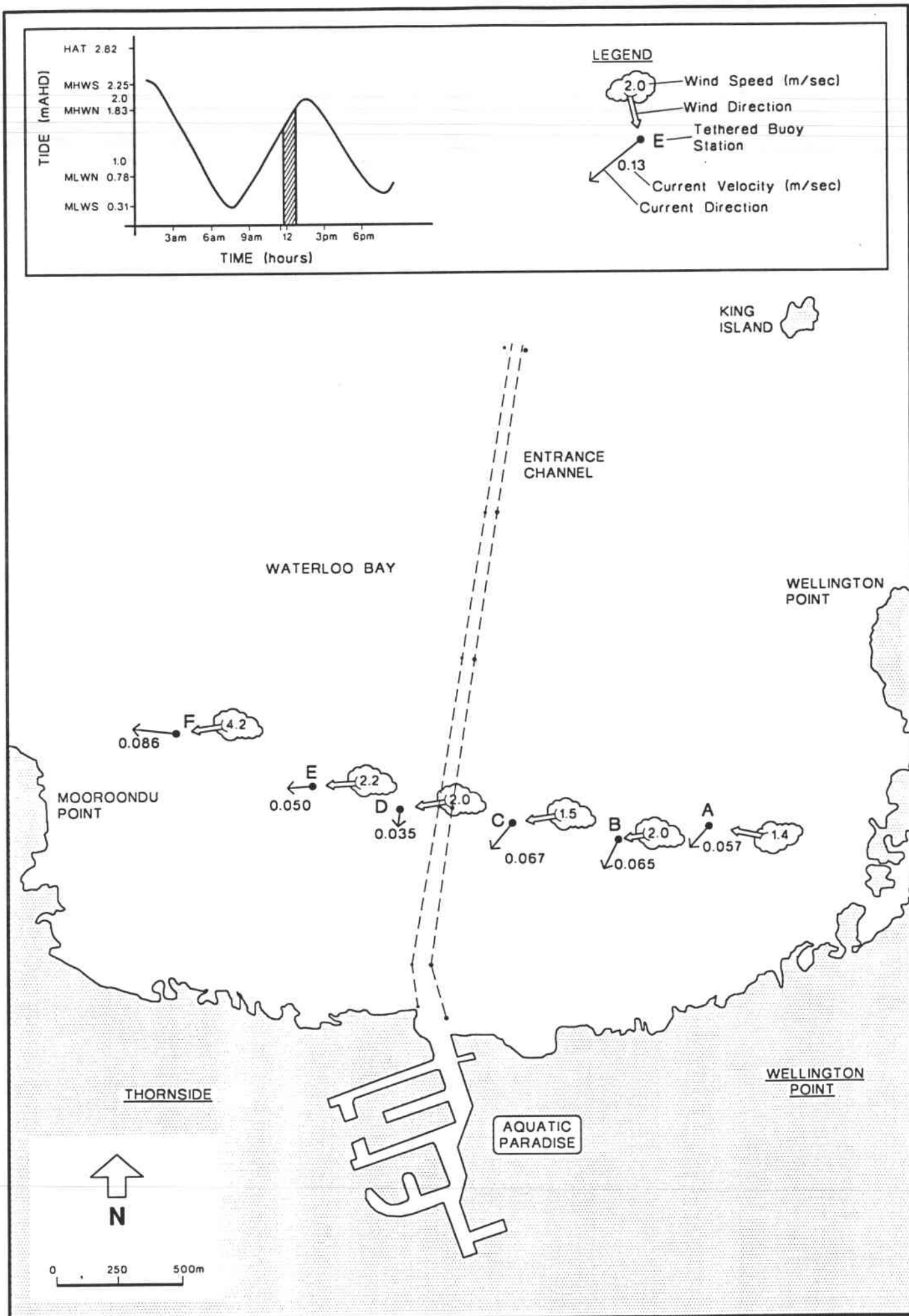




LEGEND







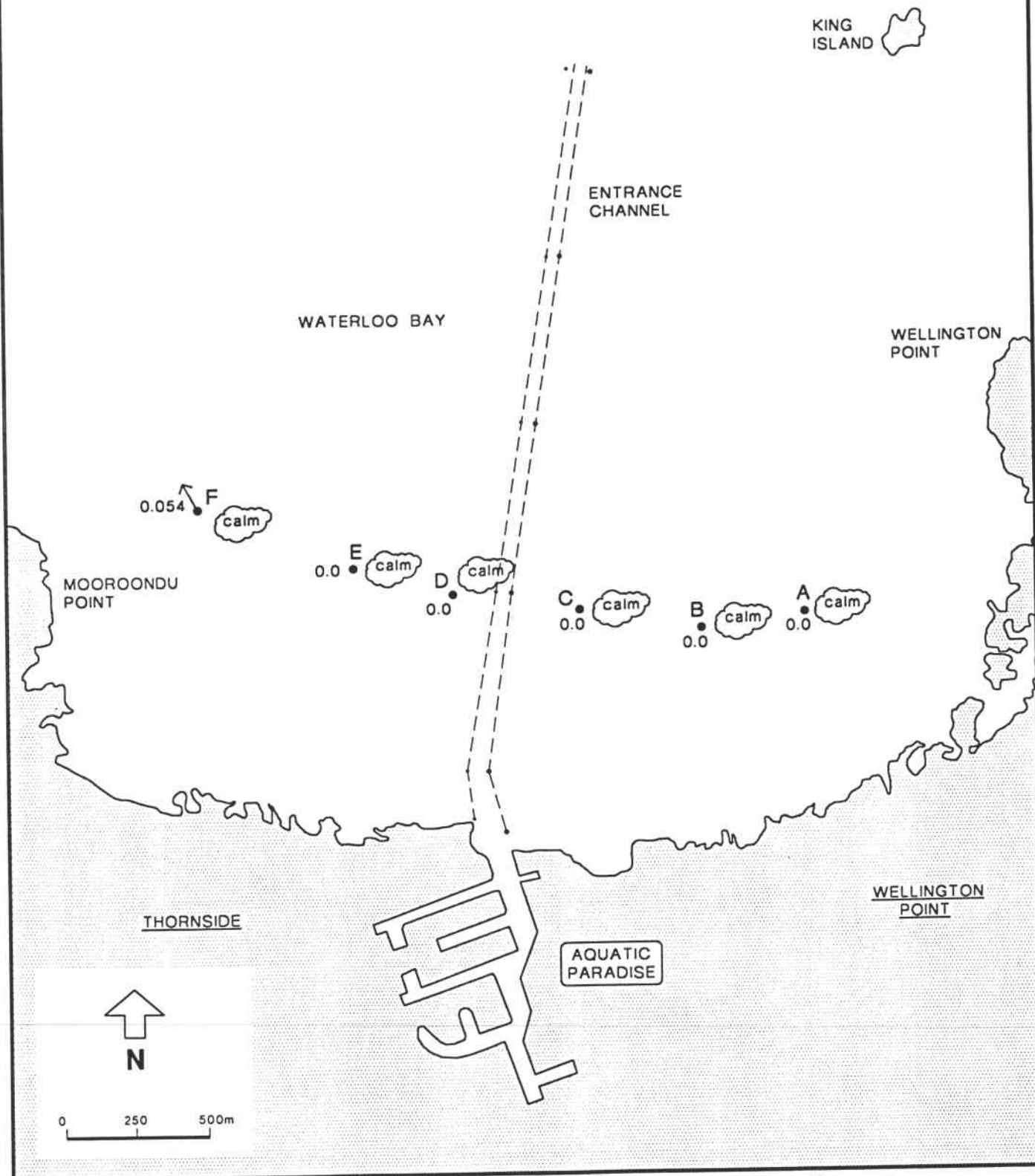
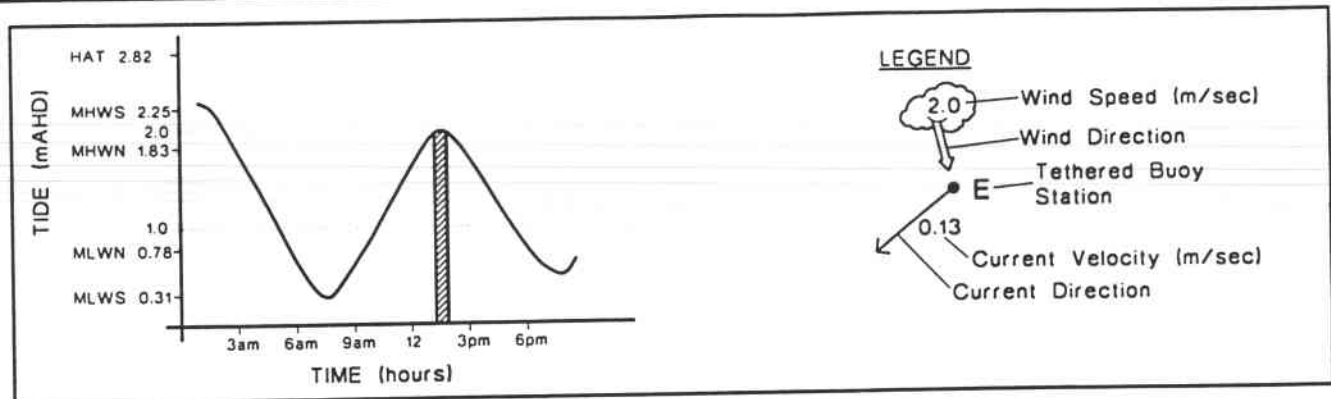
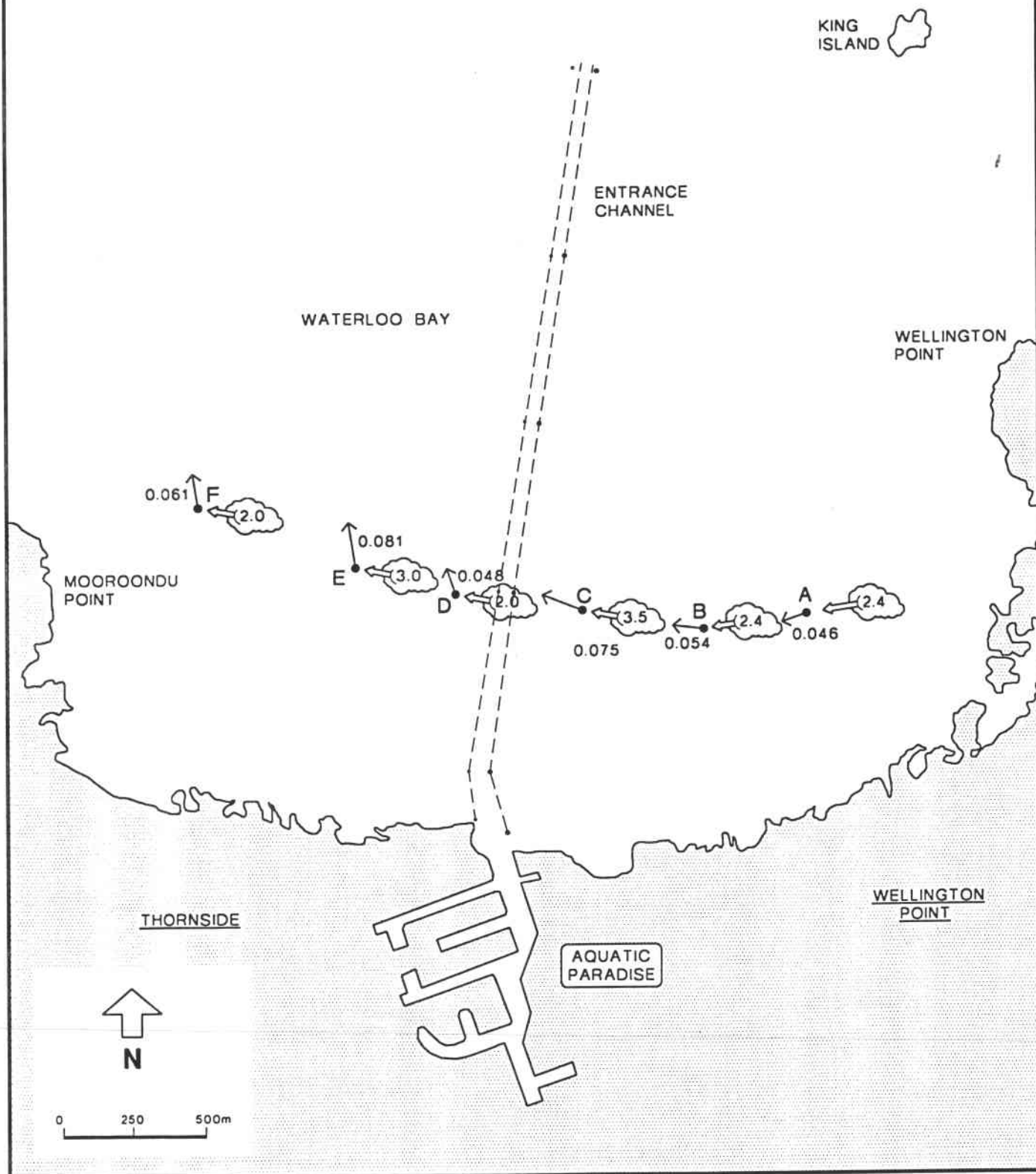
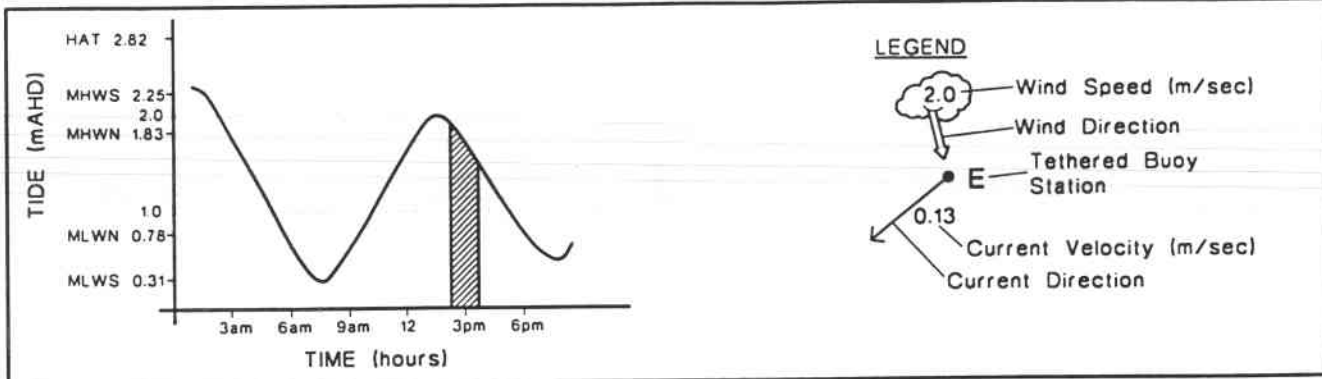
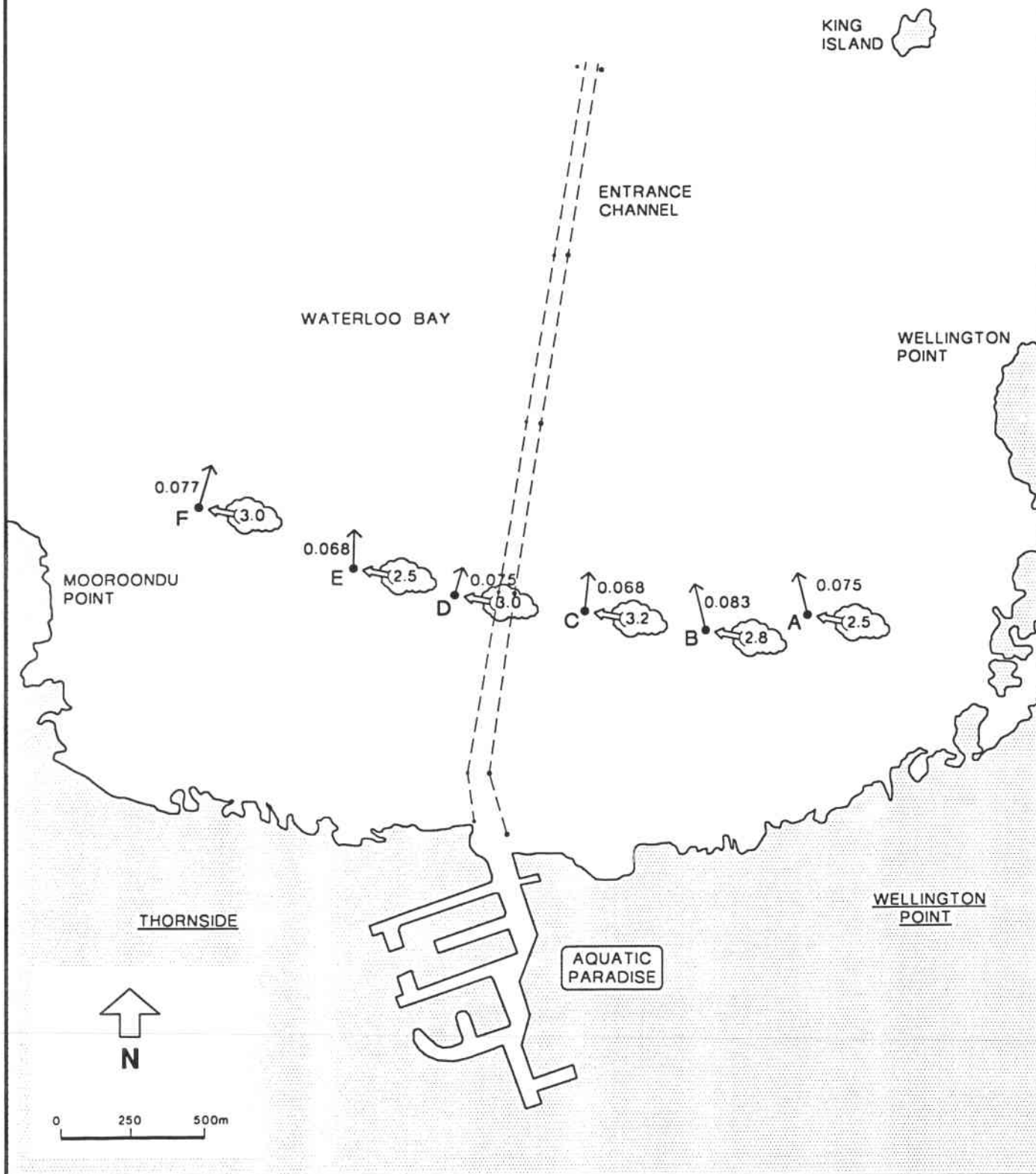
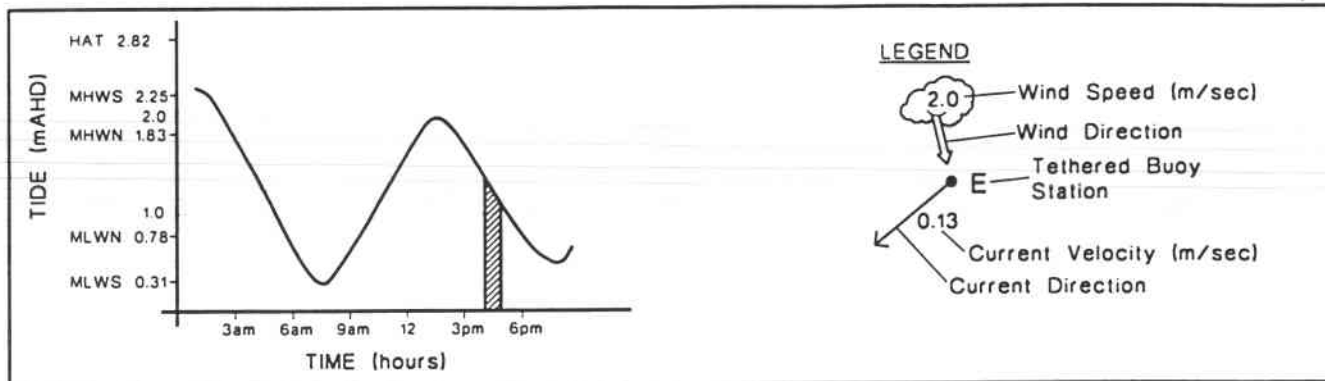


Figure 5
**AQUATIC PARADISE
TETHERED BUOYS**







Appendix B

REPORT ON THE PETROGRAPHIC ANALYSIS

GEOCHEMPET SERVICES, MALENY

PETROGRAPHIC REPORT ON SAMPLES PERTINENT TO ESTABLISHING THE LIKELY ORIGIN OF SEDIMENT IN THE AQUATIC PARADISE CANAL ESTATE

WORK REQUESTED

Petrographic analysis of twelve supplied samples of sediment has been requested with a view to establishing the likely origin of sediment within the Aquatic Paradise Canal Estate.

Two samples (labelled 1 and 2) have been collected from sediment within canals at Aquatic Paradise, two samples have been collected within the entrance channel (3 and 4) and two samples have been collected adjacent to the entrance channel (5 and 6).

Samples labelled A to D have been collected from sediment in creeks which discharge into Waterloo Bay. Three of them (C, D and E) relate to sediment which is expected to discharge to Waterloo Bay via Tarradarrapin Creek and via the entrance canal at Aquatic Paradise: the other two samples (A and B) represent two tributaries which converge to discharge into Waterloo Bay via Tingalpa Creek several kilometres west of Aquatic Paradise. Another sample (labelled 7) has been collected at the mouth of Tingalpa Creek. The precise positions of the samples are shown on supplied maps reproduced as Appendix I.

METHODS

Each sample was inspected in the wet condition in which it was received. An attempt to isolate a silt and sand-sized fraction from subsamples by wet sieving was abandoned when it was found impractical to adequately disperse within a sieve the sticky mud which characterised most of the sediment samples. Therefore, more aggressive, turbulent washing within a bucket, with repeated brief settling and decanting, was used to isolate a mainly silt and sand sized fraction for each subsample to permit preparation of thin sections suitable for detailed microscopic examination in transmitted polarised light. It was considered that no useful purpose would be served by trying to retain the clay and fine organic fractions in the thin sections.

Some information on the amount and nature of the clay and organic fractions has been obtained by binocular examination of other unprocessed subsamples and by attempted disaggregation and sieving of dried oven-dried subsamples.

RESULTS AND COMMENTS

Individual petrographic reports are presented in Appendix II. The results may be summarised as follows.



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2.

Sample 1 (which was collected within the Aquatic Paradise Canal Estate, but close to the input from Tarradarrapin Creek) is dominated by clay, but an estimated 5% of the sediment consists of sand and pebbles, subordinate decomposing plant fragments and very few carbonate shells. It contains only a trivial amount of silt.

The estimated 5% of material coarser than clay size extracted from Sample 1 contains similar detritus to that observed within the equivalent fraction for samples C, D and E from the Tarradarrapin Creek system. It is noteworthy that Sample 1 contains only a trivial amount of silt, a characteristic which is in common with samples C and E from the Tarradarrapin Creek; Sample D contains more silt, but it was collected from a very small tributary of Tarradarrapin Creek.

Samples C, D and E from the Tarradarrapin Creek system differ from the canal Sample 1 in containing much less clay; samples D and E contain more decomposing plant matter and Sample C contains more sand and pebbles.

Sample 2 (canal sediment sample taken from towards the middle of Aquatic Paradise) is dominated by clay, but less than an estimated 5% consists of other components (silt, a similar amount of carbonate shells, about half as much sand and a few plant fragments).

The quite small amount of sand reporting in Sample 2 (from near the middle the Aquatic Paradise canal system) has some characteristics in common with the more abundant (though still quite minor) sand in Sample 1 (from the most inland reach of the canal system), which, in turn appears similar to the sand component of Tarradarrapin Creek. The more prominent, though still quite minor, components of quartz silt and carbonate shells in Sample 2 indicate a transition in character towards the type of sediment represented by the offshore samples 3, 4, 5 and 6.

Sample 3 (from the entrance channel close to the Aquatic Paradise canals) is dominated by clay: an estimated 5% consists of other components (silt, a few plant fragments and trace amounts of carbonate shells and sand).

Whilst it must be conceded that at least some of the major clay present in Sample 3 may have been contributed from Tarradarrapin Creek via the canals of Aquatic Paradise, the mineralogy of the silt component (featuring plagioclase and a heavy mineral suite in addition to quartz) suggests that at least some of the silt has been derived from elsewhere.

Sample 4 (sediment from the entrance channel at a distance estimated to be about 800 m offshore from Aquatic Paradise) is dominated by clay: an estimated 5% consists of other components (silt, minor generally coarser carbonate shells and a very few plant fragments).

The mineralogy of the silt component in Sample 4 is similar to that seen in Sample 3 which is also from the entrance channel, but from much closer to the Aquatic Paradise canals. It is also similar to the silt in the adjacent, offshore, non-channel samples 5 and 6.

3/...

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3.

Samples 5 and 6 (non-channel, offshore samples collected close to the offshore channel sample 4) are dominated by clay, but one carries an estimated 15% of other components and the other carries about 10%. The other components are relatively coarse carbonate shells and subordinate silt (estimated to be 1-2% silt in one sample and 3% in the other).

In relation to the nearby Sample 4 (from within the offshore entrance channel) Sample 5 and 6 are characterised by more shells and less silt; all three are dominated by clay. The silt has a heavy mineral and feldspar component in addition to dominant quartz.

Samples A, B and 7 represent sediment feeding to Waterloo Bay several kilometres west of the Aquatic Paradise canals via Tingalpa Creek and its tributaries. The two main tributaries to Tingalpa Creek are represented by **Samples A and B**; sediment from the mouth of Tingalpa Creek is represented by **Sample 7**.

Sample B (from the tributary known as Coolnwynpin Creek), is dominated by clay, but contains about 10% of other components which comprise sand, pebbles and quite minor amounts of plant matter and silt). The presence of a suite of sand-sized, heavy mineral grains in Sample B may be noteworthy, in view of the presence of heavy minerals in the silt-sized fraction of the offshore samples 4, 5 and 6.

Samples A and 7 (from upstream Tingalpa Creek and from its mouth, respectively) are dominantly sandy sediments. In addition to sand clasts of quartz and of various rock types, they also carry sand grains of feldspar and of heavy minerals which may have some relevance to the source of feldspar grains and heavy minerals observed to occur in the silt fractions of the offshore samples 4, 5 and 6.

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4.

CONCLUSIONS

The sediment within the canals of Aquatic Paradise consist mainly of clay. The petrographic procedures used to examine the sediment cannot determine the source of the clay: it is also doubtful that detailed mineralogical examination of the clay (e.g. by X-ray diffraction analysis) would be able to determine the source of the clay because it is common for adjustments in clay mineralogy to occur during the various stages of erosion, transport and deposition.

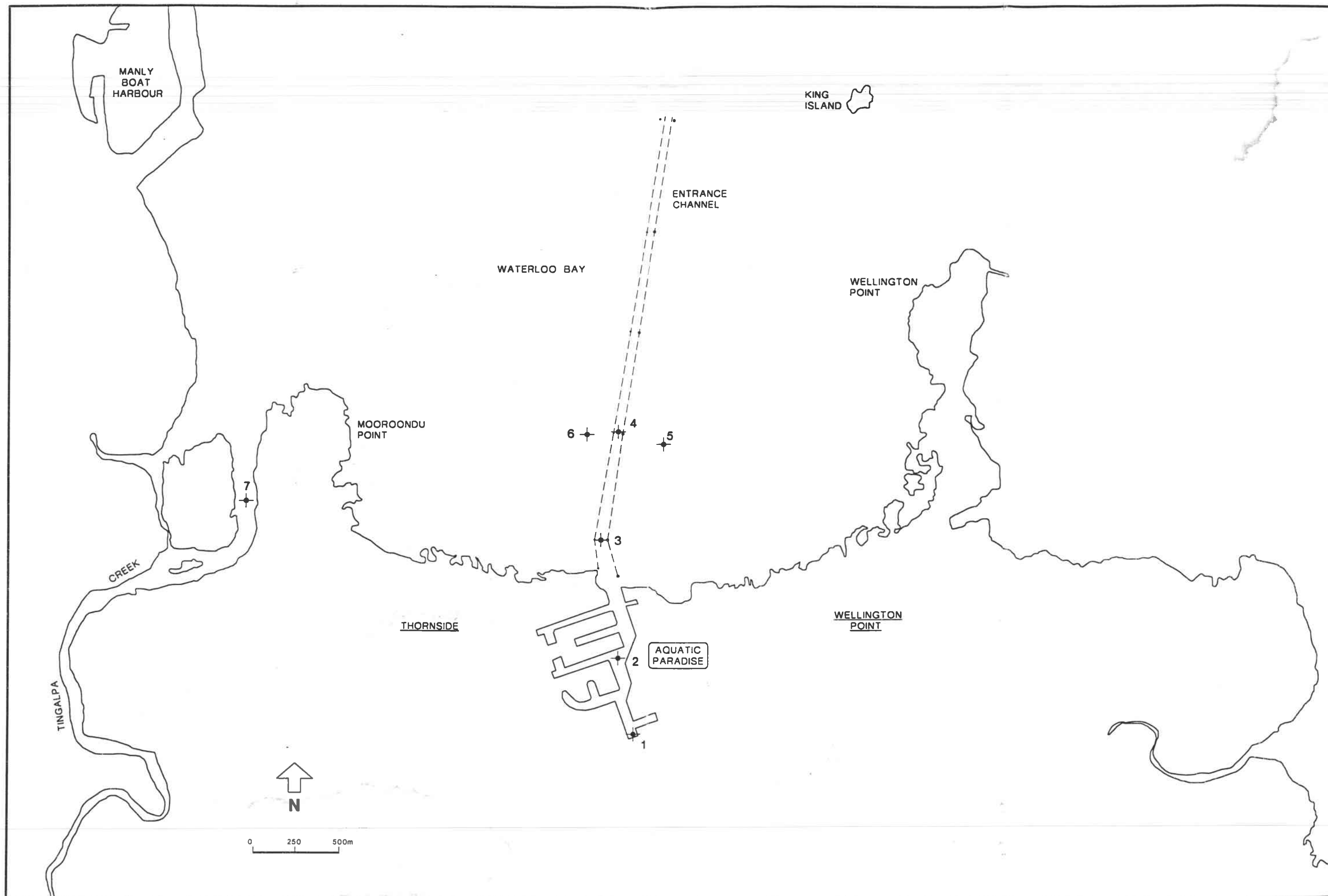
Petrographic examination of a sediment sample from within a canal of Aquatic Paradise close to the input from Tarradarrapin Creek (Sample 1) does contain some sand and pebbles, subordinate decomposing plant fragments, analogous to detritus of equivalent or coarser size within samples C, D and E from the Tarradarrapin Creek system, but the amount of such detritus amounts to only an estimated 5% of canal Sample 1. Two of the sediments samples from the Tarradarrapin Creek system differ from canal Sample 1 in carrying much more decomposing plant matter; the third sample contains more sand and pebbles.

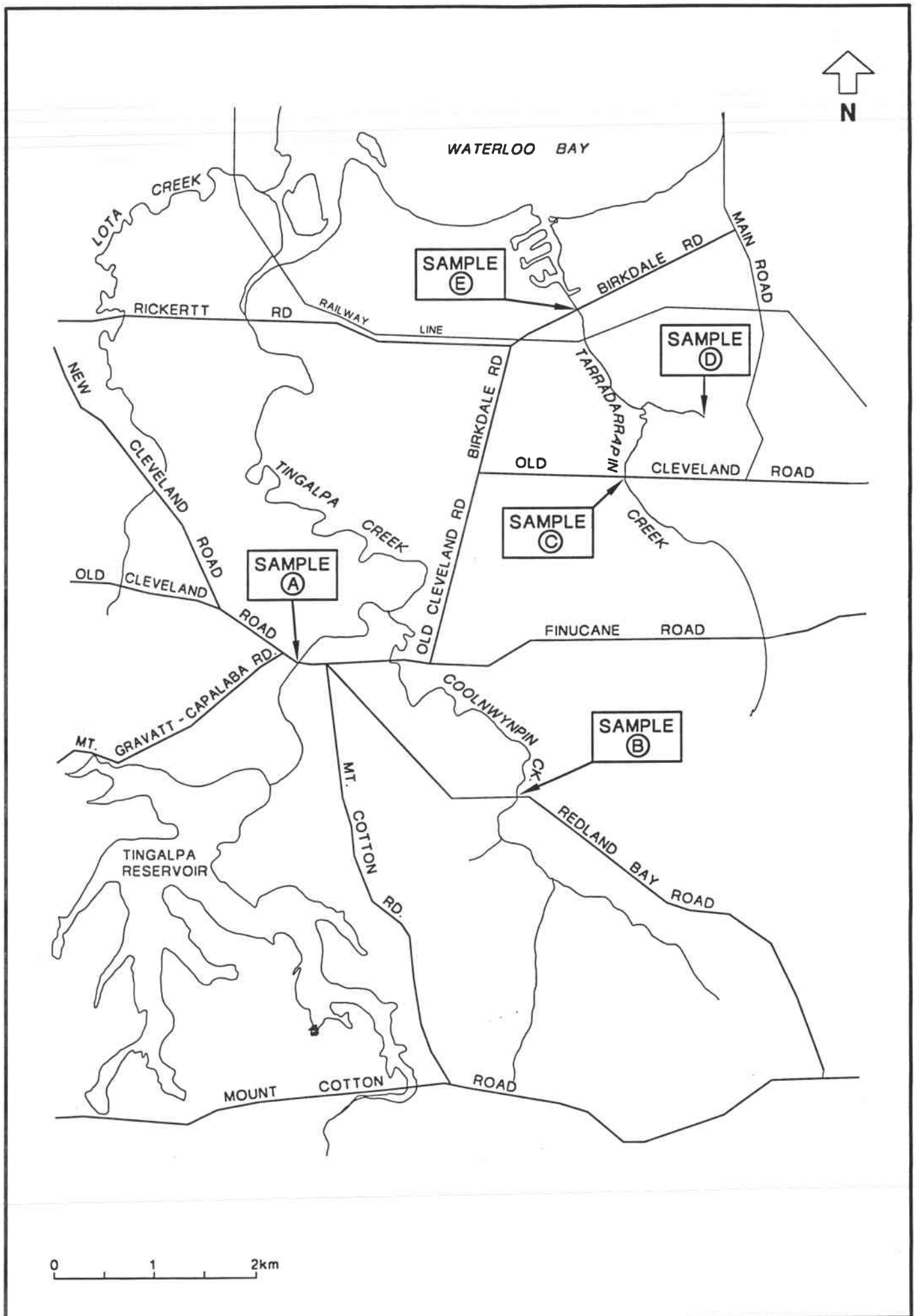
Samples taken progressively further along the canal system and along the offshore entrance channel are also thoroughly dominated by clay. They show a progressive disappearance of sand with distance away from the input of Tarradarrapin Creek and a concomitant increase in the abundance of minor silt which consists not only of quartz, but also of feldspar and heavy detrital minerals analogous to minor components observed as sand grains in sand-dominated sediment which is being discharged to Waterloo Bay via Tingalpa Creek. The slightly silty, dominantly clay mud samples from offshore sample sites in Waterloo Bay near the entrance channel to Aquatic Paradise also carry subordinate, but conspicuous component of carbonate shells.

In short, sedimentation within the Aquatic Paradise canal estate involves deposition of mainly clay, some of which may well be sourced from Tarradarrapin Creek, but other components of which may be entering with tidal flow from Waterloo Bay; it seems possible that there may be supplementation also by local run-off from the estate itself. Silt, sand, plant fragments and carbonate shells are minor components of the sedimentation, but they are trivial in comparison with the accumulation of clay.

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APPENDIX I SAMPLE LOCATIONS







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APPENDIX II INDIVIDUAL PETROGRAPHIC REPORTS

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Sample Label : 1. (Canal sediment sample within Aquatic Paradise at a location close to the input of Tarradarrapin Creek)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with about 5 % of other components (sand and pebbles, subordinate decomposing plant fragments, a very few carbonate shells and a trace of silt).

Description :

The sample consisted of an estimated kilogram of water-saturated, quite fine mud which was streaky dark grey (Munsell colour N3) and light brown (5 YR 5/6) when received: it dried to a dark yellowish brown colour (10 YR 4/2).

Attempted wet sieving and attempted dry sieving both failed to yield meaningful results. For example, 82% of the dried subsample was retained on a +1.18 mm sieve, even after gentle crushing, but binocular microscopic examination revealed that the +1.18 mm fraction consists mainly of now consolidated clay. The aggressively washed subsample yield quite minor sand, an angular pebble of quartzite and a 40 mm x 15 mm piece of brown bottle glass. It is estimated that within the original sample clay-sized material amounts to 95% and the sand and coarser fragments to 5%; the silt content is trivial.

In thin section the fraction coarser than clay size, concentrated by aggressive washing and decanting to remove most of the clay is seen to be dominated by sand and pebble-sized clasts, but with minor plant fragments (mainly woody), a few carbonate shells and a trace of quartz silt. There are indications of fine, diagenetic pyrite and the sample also carries diagenetic siderite.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- 40% quartz of sand size, occurring as free unstrained or mildly strained single grains (32%), moderately strained grains (1%) or as simple crystalline aggregates of several quartz grains (7%)
- 17% quartzite lithic clasts (19% represented by pebbles)
- 7% chert lithic clasts
- 7% basalt lithic clasts (very weathered)
- 2% slate lithic clasts
- 3% trachyte lithic clasts (fresh)
- 4% ferruginized and/or ferricreted fragments

Mineral and rock fragments of silt size

- < 1% quartz of silt size



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2.

Shells

1 % carbonate shells

Plant fragments

19% plant fragments

Comments and Interpretations :

Sample 1 is dominated by clay, but an estimated 5% of the sediment consists of sand and pebbles, subordinate decomposing plant fragments and very few carbonate shells. It contains only a trivial amount of silt.

The minor coarser than clay fraction extracted from Sample 1 (which was collected within the Aquatic Paradise Canal Estate, but close to the input from Tarradarrapin Creek) contains similar detritus to that observed within the equivalent fraction for samples C, D and E from the Tarradarrapin Creek system. It is noteworthy that Sample 1 contains only a trivial amount of silt, a characteristic which is in common with samples C and E from the Tarradarrapin Creek; Sample D contains more silt, but it was collected from a very small tributary of Tarradarrapin Creek.



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Sample Label : 2. (Canal sediment sample towards the middle of Aquatic Paradise)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with less than about 5 % of other components (silt, a similar amount of carbonate shells, about half as much sand and a few plant fragments).

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, fine mud which was dark grey (Munsell colour N3) with light brown streaks (5 YR 5/6) when received. It dried to a dark yellowish brown (10 YR 4/2) and formed some light brown (5 YR 5/6) iron stains beneath individual dried cakes.

Attempted sieving failed to yield meaningful results. Binocular microscopic examination revealed that the sediment is mainly of clay size, but it is difficult to disperse while wet and it cakes when dried. The aggressively washed subsample yielded quite a small amount of silt and sand-sized material. It is estimated that within the original sample clay-sized material amounts to more than 95 % : the rest consists of around 2 % silt, <2 % coarser shells, 1 % sand and a few plant fragments.

In thin section the sand/silt fraction concentrated by aggressive washing and decanting to remove clay is seen to consist of silt, some small carbonate shells and subordinate sand grains. There are indications of fine, diagenetic pyrite.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- 13% quartz of sand size, occurring as free unstrained or mildly strained single grains
- 6% basalt lithic clasts
- 2% feldspar grains (plagioclase)
- 3% ferruginized and/or ferricreted fragments

Mineral and rock fragments of silt size

- 39% quartz of silt size

Shells

- 35% carbonate shells

Plant fragments

- 2% plant fragments

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2.

Comments and Interpretations :

Sample 2 is dominated by clay: less than an estimated 5% consists of other components (silt, a similar amount of carbonate shells, about half as much sand and a few plant fragments).

The quite small amount of sand reporting in Sample 2 (from near the middle the Aquatic Paradise canal system) has some characteristics in common with the more abundant (though still quite minor) sand in Sample 1 (from the most inland reach of the canal system), which, in turn appears similar to the sand component of Tarradarrapin Creek. The more prominent, though still quite minor, components of quartz silt and carbonate shells in Sample 2 indicate a transition in character towards the type of sediment represented by the offshore samples 3, 4, 5 and 6.

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Sample Label : 3. (sediment from the entrance channel close to the Aquatic Paradise canals)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with about 5% of other components (silt, a few plant fragments and trace amounts of carbonate shells and sand).

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, fine mud which was dark grey (Munsell colour N3) with light brown streaks (5 YR 5/6) when received. It dried to a dark yellowish brown (10 YR 4/2) and formed some light brown (5 YR 5/6) iron stains beneath individual dried cakes.. The sediment in Sample 3 is very similar in appearance (both wet and dry) to the sediment in Sample 2.

Attempted sieving failed to yield meaningful results. Binocular microscopic examination revealed that the sediment is mainly of clay size, but it is difficult to disperse while wet and it cakes when dried. The aggressively washed subsample yielded minor, mainly silt-sized material. It is estimated that within the original sample clay-sized material amounts to about 95% : the rest consists of silt, a few plant fragments and trace amounts of carbonate shells and sand.

In thin section the sand/silt fraction concentrated by aggressive washing and decanting to remove clay is seen to consist of silt, a few plant fragments and quite sparse sand grains and small carbonate shells. There are indications of fine, diagenetic pyrite within clay.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- < 1 % quartz of sand size, occurring as free unstrained or mildly strained single grains
- 1 % ferruginized and/or ferricreted fragments

Mineral and rock fragments of silt size

- 83 % quartz of silt size
- 7 % feldspar grains of silt size (plagioclase and rare microcline)
- 3 % ilmenite grains of silt size
- 2 % hornblende grains of silt size
- < 1 % other mineral grains of silt size (including epidote, pyroxene, zircon and leucoxene)

Shells

- < 1 % carbonate shells

Plant fragments

- 4 % plant fragments

GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample 3 is dominated by clay: an estimated 5% consists of other components (silt, a few plant fragments and trace amounts of carbonate shells and sand).

Whilst it must be conceded that at least some of the clay present in this sample may have been contributed from Tarradarrapin Creek via the canals of Aquatic Paradise, the mineralogy of the silt component (featuring plagioclase and a heavy mineral suite in addition to quartz) suggests that at least some of the silt has been derived from elsewhere.

GEOCHEMPET SERVICES, MALENY

Sample Label : 4. (sediment from the entrance channel at a distance of about 800 m offshore from Aquatic Paradise)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with about 5 % of other components (silt, minor carbonate shells and a very few plant fragments).

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, fine mud which was dark grey (Munsell colour N3) with light brown streaks (5 YR 5/6) when received. It dried to a dark yellowish brown (10 YR 4/2) and formed some light brown (5 YR 5/6) iron stains beneath individual dried cakes.. The sediment in Sample 4 is very similar in appearance (both wet and dry) to the sediment in samples 2 and 3.

Attempted sieving failed to yield meaningful results. Binocular microscopic examination revealed that the sediment is mainly of clay size, but it is difficult to disperse while wet and it cakes when dried. The aggressively washed subsample yielded minor, mainly silt-sized material. It is estimated that within the original sample clay-sized material amounts to about 95 % : the rest consists of silt, minor carbonate shells and a very few plant fragments.

In thin section the relatively coarse fraction concentrated by aggressive washing and decanting to remove clay is seen to consist of silt, sparse small carbonate shells and a very few plant fragments). There are indications of fine, diagenetic pyrite within clay and within cavities in shells. There are also some green clasts (variously free or within shell cavities) which may be diagenetic glauconite.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

Nil

Mineral and rock fragments of silt size

75 % quartz of silt size
7 % feldspar grains of silt size (plagioclase and rare microcline)
1 % ilmenite grains of silt size
1 % hornblende grains of silt size
2 % other mineral grains of silt size (including leucoxene and zircon)
1 % ferruginized fragments
3 % probable glauconite

Shells

9 % carbonate shells

Plant fragments

1 % plant fragments



GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample 4 is dominated by clay: an estimated 5% consists of other components (silt, minor generally coarser carbonate shells and a very few plant fragments).

The mineralogy of the silt component is similar to that seen in Sample 3 which is also from the entrance channel, but from much closer to the Aquatic Paradise canals. It is also similar to the silt in the adjacent, non-channel samples 5 and 6.

GEOCHEMPET SERVICES, MALENY

Sample Label : 5. (sediment from Waterloo Bay just east of Sample Point 4 which was taken within the entrance channel at a distance of about 800 m offshore from Aquatic Paradise)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with about 15% of other components (carbonate shells and minor silt).

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, fine mud which was dark grey (Munsell colour N3) with light brown streaks (5 YR 5/6) when received; it carries numerous carbonate shell fragments. It dried to a dark yellowish brown (10 YR 4/2). The sediment in Sample 5 appears to differ from the sediment in Sample 4 primarily in carrying large amounts of carbonate shell material.

Attempted sieving failed to yield quantitatively meaningful results. Binocular microscopic examination revealed that material retained on a 1.18 mm sieve is a mixture of carbonate shells and caked mud. The aggressively washed subsample yielded minor silt-sized material and plentiful coarser shell fragments. It is estimated that within the original sample clay-sized material amounts to about 85% : the rest consists of carbonate shells and minor silt.

In thin section the sand/silt fraction concentrated by aggressive washing and decanting to remove clay is seen to be dominated by relatively coarse carbonate shells, but there is also an obvious silicate silt component. There are indications of fine, diagenetic pyrite within clay and especially within cavities in shells. There are also a few green clasts (variously free or within shell cavities) which may be diagenetic glauconite.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

Nil

Mineral and rock fragments of silt size

8% quartz of silt size
1% ilmenite grains of silt size
< 1% other mineral grains of silt size (including epidote)
< 1% ferruginized fragments
1% probable glauconite

Shells

90% carbonate shells

Plant fragments

Nil

GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample 5 is dominated by clay: an estimated 15% consists of other components (relatively coarse carbonate shells and perhaps 1 to 2% silt).

In relation to the nearby Sample 4 (from within the offshore entrance channel) Sample 5 is characterised by more shells and less silt, characteristics which it shares with Sample 6 (a non-channel sample on the other side of Sample 4).

GEOCHEMPET SERVICES, MALENY

Sample Label : 6. (sediment from Waterloo Bay just west of Sample Point 4 which was taken within the entrance channel at a distance of about 800 m offshore from Aquatic Paradise)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with about 10% of other components
(about two-thirds carbonate shells, one-third silt and rare sand grains).

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, fine mud which was pale brownish grey (Munsell colour 5 YR 5/1) when received; it carries obvious, but small carbonate shell fragments. It dried to a moderate yellowish brown (10 YR 5/2). The sediment in Sample 6 appears similar to the sediment in Sample 5, but it carries fewer carbonate shells.

Attempted sieving failed to yield quantitatively meaningful results. Binocular microscopic examination revealed that material retained on a 1.18 mm sieve is a mixture of carbonate shells and caked mud. The aggressively washed subsample yielded a smaller quantity of silt-sized material and shell fragments than Sample 5. It is estimated that within the original sample clay-sized material amounts to about 90% : the rest consists of carbonate shells, about half as much silt and rare sand grains.

In thin section the sand/silt fraction concentrated by aggressive washing and decanting to remove clay is seen to be dominated by carbonate shells, but there is also some silicate silt and rare sand grains. There are indications of fine, diagenetic pyrite within clay and especially within cavities in shells. There are also a few green clasts (variously free or within shell cavities) which may be diagenetic glauconite.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- < 1 % quartz of sand size, occurring as free unstrained or mildly strained single grains
- < 1 % ferruginized and/or ferricreted fragments

Mineral and rock fragments of silt size

- 32 % quartz of silt size
- 1 % feldspar grains of silt size (plagioclase and rare microcline)
- 1 % ilmenite grains of silt size
- 1 % other mineral grains of silt size (including leucoxene)
- 1 % ferruginized fragments
- 1 % probable glauconite

Shells

- 63 % carbonate shells



GEOCHEMPET SERVICES, MALENY

2.

Plant fragments

Nil

Comments and Interpretations :

Sample 6 is dominated by clay: an estimated 10% consists of other components (about two-thirds carbonate shells, one-third silt and rare sand grains).

In relation to the nearby Sample 4 (from within the offshore entrance channel) Sample 6 is characterised by more shells and less silt, characteristics which it shares with Sample 5. Sample 6 carries fewer shells than Sample 5.

GEOCHEMPET SERVICES, MALENY

Sample Label : 7. (sediment from within the mouth of Tingalpa Creek)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Sandy sediment with several percent of clay and quite minor carbonate shells, plant fragments and silt

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, muddy and mainly sandy sediment which had mixed pale brown (Munsell colour 5 YR 5/2) and medium dark grey (N 4) colours when received. It dried to a dark yellowish brown colour (10 YR 4/2).

The dried sample crumbles readily and sieving indicated about 12% coarser than 1.18 mm, 68% between 1.18 and 0.300 mm and about 20% finer than 0.300 mm. That is, most of the sediment is of sand size. The aggressively washed subsample readily yielded plentiful sand. It is estimated that the clay content amounts to several percent.

In thin section the sand/silt fraction concentrated by aggressive washing and decanting to remove clay is seen to be dominated by sand, but there are quite minor carbonate shells, plant fragments and silt. There are some black specks which seem likely to represent fine, diagenetic pyrite formed within cavities in shells and within wood fragments.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size

- 75% quartz of sand size, occurring as free unstrained or mildly strained single grains (69%), moderately strained grains (1%) or as simple crystalline aggregates of several quartz grains (5%)
- 14% quartzite lithic clasts
- 3% chert lithic clasts
- 1% jasper lithic clasts
- < 1% basalt lithic clasts
- 1% slate lithic clasts
- 2% feldspar grains (plagioclase, orthoclase and microcline)
- < 1% heavy mineral grains (including epidote, tourmaline, pyroxene, chlorite, ilmenite and rutile)
- < 1% ferruginized and/or ferricreted fragments

Mineral and rock fragments of silt size

- 1% quartz of silt size

Shells

- 2% carbonate shells

Plant fragments

- 1% plant fragments

GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample 7 (from the mouth of Tingalpa Creek) consists predominantly of sand, but it also carries several percent of clay and quite minor carbonate shells, plant fragments and silt.

Like Sample B (from the upstream tributary Coolnwynpin Creek), Sample 7 carries a suite of sand-sized, heavy mineral grains (and feldspar grains) which may be noteworthy, in view of the presence of similar minerals in the silt-sized fraction of the offshore samples 4, 5 and 6.

GEOCHEMPET SERVICES, MALENY

Sample Label : A. (sediment from Tingalpa Creek between the reservoir and the junction with Coolnwynpin Creek)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Sandy sediment with around 15% plant matter, around 5-10% clay and quite minor silt

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, muddy and dominantly sandy sediment which contains plentiful plant matter (including twigs and decomposing leaves). The sediment was greyish brown (Munsell colour 5 YR 3/2) with subordinate dark grey colour (N3) when received. It dried to a dark yellowish brown colour (10 YR 4/2).

Incomplete disaggregation was achieved, but dry sieving gave a broad indication that about 59% is coarser than 1.18 mm, 33% is between 1.18 and 0.300 mm and not much more than 8% is finer than 0.300 mm. The aggressively washed subsample readily yielded a sand fraction with minor plant matter and less silt.

In thin section the sand/silt fraction concentrated by aggressive washing and decanting to remove much of the clay is seen to be dominated by sand, but there is minor quartz silt (some of it still locked within clay lumps) and numerous decomposing plant fragments. There are some fine black specks which seem likely to be fine, diagenetic pyrite on plant surfaces, on some sand grains and dispersed through clay lumps.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- 66% quartz of sand size, occurring as free unstrained or mildly strained single grains (56%) or as simple crystalline aggregates of several quartz grains (10%)
- 8% quartzite lithic clasts
- 2% chert lithic clasts
- 1% jasper lithic clasts
- 2% basalt lithic clasts
- < 1% slate lithic clasts
- 2% feldspar grains (orthoclase)
- 1% heavy mineral grains (hornblende)

Mineral and rock fragments of silt size

- 4% quartz of silt size

Shells

None seen



GEOCHEMPET SERVICES, MALENY

2.

Plant fragments

14% plant fragments

Comments and Interpretations :

Sample A is a sandy sediment with around 15% plant matter, around 5-10% clay and quite minor quartz silt.



GEOCHEMPET SERVICES, MALENY

Sample Label : B. (sediment from Coolnwynpin Creek which is a tributary to Tingalpa Creek)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Clay sediment with about 10% of other components (sand, pebbles and quite minor amounts of plant matter and silt)

Description :

The sample consisted of an estimated kilogram of water-saturated mud which was greyish brown (Munsell colour 5 YR 3/2) when received and apparently rich in decomposing plant matter. It dried to a moderate yellowish brown colour (10 YR 5/2).

Neither wet nor dry sieving achieved adequate disaggregation to permit a quantitative report on particle size distribution, but it is apparent that much of the sediment is of clay size. The aggressively washed subsample did yield a sand fraction and several pebbles. It is estimated that about 90% of the primary sample is clay: the rest consists of sand, pebbles and quite minor amounts of plant matter and silt.

In thin section the fraction concentrated by aggressive washing and decanting to remove much of the clay is seen to be dominated by sand, but there are also some pebbles and minor silt and decomposing plant fragments. There are some black specks which may represent diagenetic pyrite.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) **for the fraction of the sediment which is of silt size or coarser:**

Mineral and rock fragments of sand size or coarser

- 70% quartz of sand size, occurring as free unstrained or mildly strained single grains (67%) or as simple crystalline aggregates of several quartz grains (3%)
- 16% quartzite lithic clasts (14% represented by sparse pebbles)
- 1% basalt lithic clasts
- 1% slate lithic clasts
- 1% heavy mineral grains (including epidote, tourmaline, pyroxene, muscovite, ilmenite and rutile)
- 6% greenstone lithic clasts (5% represented as sparse pebbles)

Mineral and rock fragments of silt size

- 2% quartz of silt size

Shells

None seen

Plant fragments

- 3% plant fragments

GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample B is dominated by clay, but contains about 10% of other components which comprise sand, pebbles and quite minor amounts of plant matter and silt).

The presence of a suite of sand-sized, heavy mineral grains may be noteworthy, in view of the presence of heavy minerals in the silt-sized fraction of the offshore samples 4, 5 and 6.



GEOCHEMPET SERVICES, MALENY

Sample Label : C. (sediment from Tarradarrapin Creek where it is crossed by Old Cleveland Road)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Sandy and pebbly sediment with about 10% clay, subordinate plant fragments and a trace of silt.

Description :

The sample consisted of an estimated 1.5 kg of water-saturated, coarsely sandy mud which was light to moderate brown (Munsell colours 5 YR 5/6 to 5 yr 4/4) when received and rich in decomposing plant fragments. It dried to a pale yellowish brown colour (10 YR 6/4).

Incomplete disaggregation was achieved, but dry sieving gave a broad indication that about 65 % is coarser than 1.18 mm, about 25 % is between 1.18 and 0.300 mm and at least 10% is finer than 0.300 mm. The aggressively washed subsample readily yielded a fraction rich in sand and pebbles.

In thin section the fraction concentrated by aggressive washing and decanting to remove much of the clay is seen to be dominated by sand and pebbles, but there is also a small amount of silt (some of it still locked in clay lumps) and some decomposing plant fragments.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- 36% quartz of sand size, occurring as free unstrained or mildly strained single grains (25%), moderately strained grains (1%) or as simple crystalline aggregates of several quartz grains (10%)
- 54% quartzite lithic clasts (38% represented by pebbles)
- 5% chert lithic clasts
- 1% feldspar grains (plagioclase)

Mineral and rock fragments of silt size

- 1% quartz of silt size

Shells

None seen

Plant fragments

- 3% plant fragments

GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample C (from an upstream location in Tarradarrapin Creek where it is crossed by Old Cleveland Road) is a sandy and pebbly sediment with about 10% clay, subordinate plant fragments and a trace of silt.

The components observed in the fraction coarser than clay size extracted from Sample C (the sample taken well upstream from Sample E in Tarradarrapin Creek, and upstream from the confluence with the tributary sampled by D) have characteristics in common with the equivalent size fractions from samples D and E and from Sample 1 (which was collected within the Aquatic Paradise Canal Estate, but close to the input from Tarradarrapin Creek). Sample C differs primarily in being coarser grained and less carbonaceous.

GEOCHEMPET SERVICES, MALENY

Sample Label : D. (sediment from a small tributary which joins Tarradarrapin Creek downstream from the site of Sample C)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Sediment dominated by decomposing plant matter, but containing about 5 % clay and 5 % of other components (sand, pebbles, silt and a few carbonate shells).

Description :

The sample consisted of an estimated kilogram of water-saturated mud which was greyish black (Munsell colour N 2) when received and rich in decomposing leaves and other plant matter. It dried to a dark yellowish brown colour (10 YR 4/2).

Insufficient disaggregation was achieved to permit quantitative reporting on size distribution. The aggressively washed subsample did yield a sandy and pebbly fraction. It is estimated that about 90 % of the primary sample consisted of decomposing plant fragments: about half of the remainder is clay and the rest is sand, pebbles, silt, and a few shells.

In thin section the fraction concentrated by aggressive washing and decanting to remove much of the clay is seen to contain pebbles, sand, silt, many plant fragments, many lumps of silty clay and a few carbonate shell fragments. There are indications of some fine, diagenetic pyrite, especially associated with the plant fragments.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) **for the fraction of the sediment which is of silt size or coarser:**

Mineral and rock fragments of sand size or coarser

- 11 % quartz of sand size, occurring as free unstrained or mildly strained single grains (9 %) or as simple crystalline aggregates of several quartz grains (2 %)
- 42 % quartzite lithic clasts (19 % represented by pebbles)
- 5 % chert lithic clasts
- 5 % basalt lithic clasts
- 5 % ferruginized and/or ferricreted fragments

Mineral and rock fragments of silt size

- 9 % quartz of silt size

Shells

- 2 % carbonate shells

Plant fragments

- 21 % plant fragments



GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

Sample D is dominated by decomposing plant matter, but it contains about 5% clay and 5% of other components which comprise sand, pebbles, silt and a few carbonate shells.

The components observed in the fraction coarser than clay size extracted from Sample D (a small tributary of Tarradarrapin Creek) are similar to the components in equivalent fractions extracted from Sample E (further downstream in Tarradarrapin Creek) and from Sample 1 (which was collected within the Aquatic Paradise Canal Estate, but close to the input from Tarradarrapin Creek).



GEOCHEMPET SERVICES, MALENY

Sample Label : E. (sediment from Tarradarrapin Creek at Birkdale Road, i.e. close to where it enters the Aquatic Paradise canals)

Work Requested : Petrographic analysis as part of a set of samples intended to establish the likely origin of sediment depositing within the Aquatic Paradise Canal Estate.

Identification : Sediment dominated by decomposing twigs and leaves, but containing about 5% of other components (sand, minor carbonate shells, clay and a trace of silt).

Description :

The sample consisted of an estimated kilogram of water-saturated, putrid mud which was black (Munsell colour N 1) when received and dominated by decomposing leaves and twigs. It dried to a dark yellowish brown colour (10 YR 4/2).

Fair disaggregation was achieved by dry sieving. It indicated about 91% coarser than 1.18 mm (observed to be mainly decomposing twigs and leaves), about 6% between 1.18 and 0.300 mm, and only about 3% finer than 0.300 mm. An aggressively washed large subsample did yield a sand/silt fraction (still rich in plant fragments). It is estimated that about 95% of the primary sample consisted of decomposing plant fragments.

In thin section the fraction concentrated by aggressive washing and decanting to remove much of the clay and fine organic matter is seen to contain sand, silt, many plant fragments, many lumps of silty clay and some carbonate shells. There are indications of fine, diagenetic pyrite, especially associated with the plant fragments and scattered through clay.

Microscopic identifications at 100 random points falling within sectioned clasts, but excluding clay and similarly fine carbonaceous matter revealed the following composition (volume % of clast types) for the fraction of the sediment which is of silt size or coarser:

Mineral and rock fragments of sand size or coarser

- 36% quartz of sand size, occurring as free unstrained or mildly strained single grains (32%) or as simple crystalline aggregates of several quartz grains (4%)
- 6% quartzite lithic clasts (19% represented by pebbles)
- 2% chert lithic clasts
- 2% slate lithic clasts
- 1% trachyte lithic clasts

Mineral and rock fragments of silt size

- 1% quartz of silt size

Shells

- 5% carbonate shells

Plant fragments

- 47% plant fragments



GEOCHEMPET SERVICES, MALENY

2.

Comments and Interpretations :

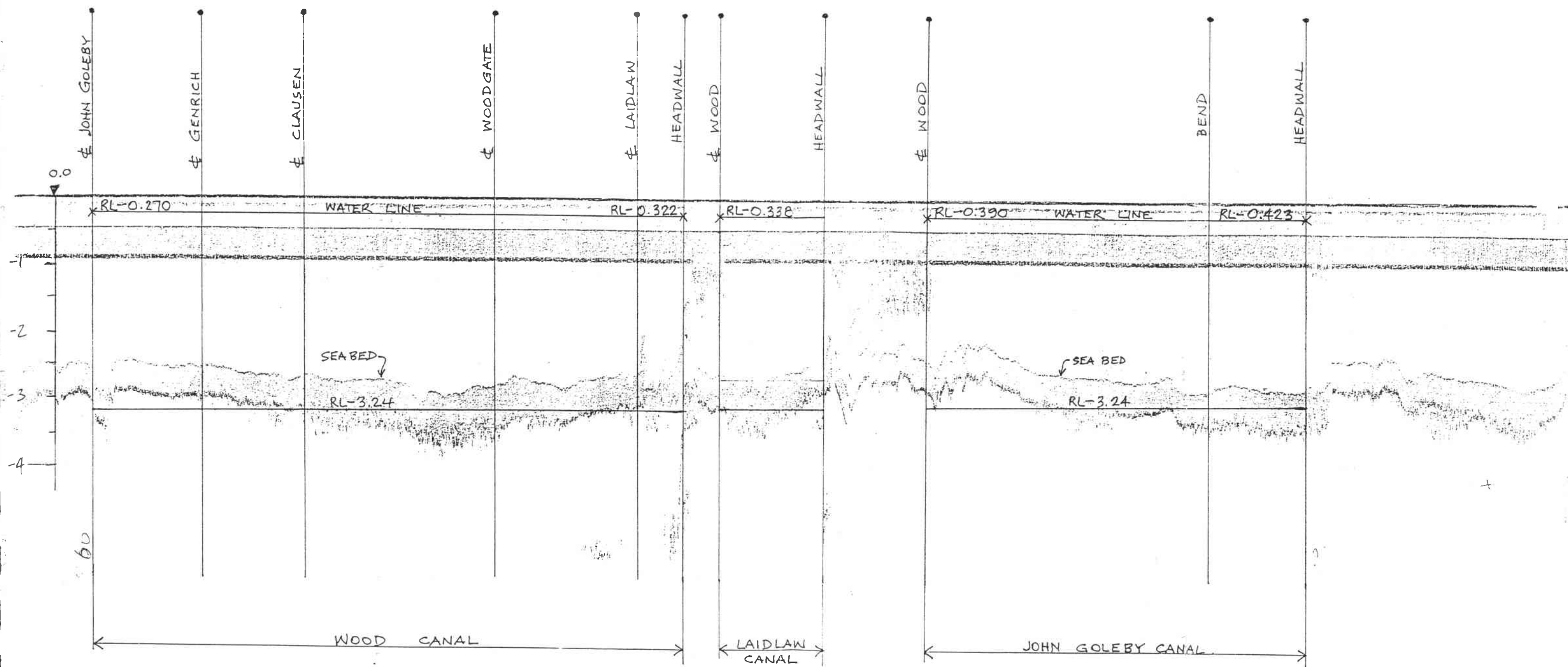
Sample E is dominated by dominated by decomposing twigs and leaves, but contains about 5 % of other components which comprise sand, minor carbonate shells, clay and a trace of silt.

The components observed in the sand fraction extracted from Sample E are similar to the sand components observed in Sample 1 (which was collected within the Aquatic Paradise Canal Estate, but close to the input from Tarradarrapin Creek).



Appendix C

1997 SURVEY OF THE CANALS



REDLAND SHIRE COUNCIL
AQUATIC PARADISE CANALS

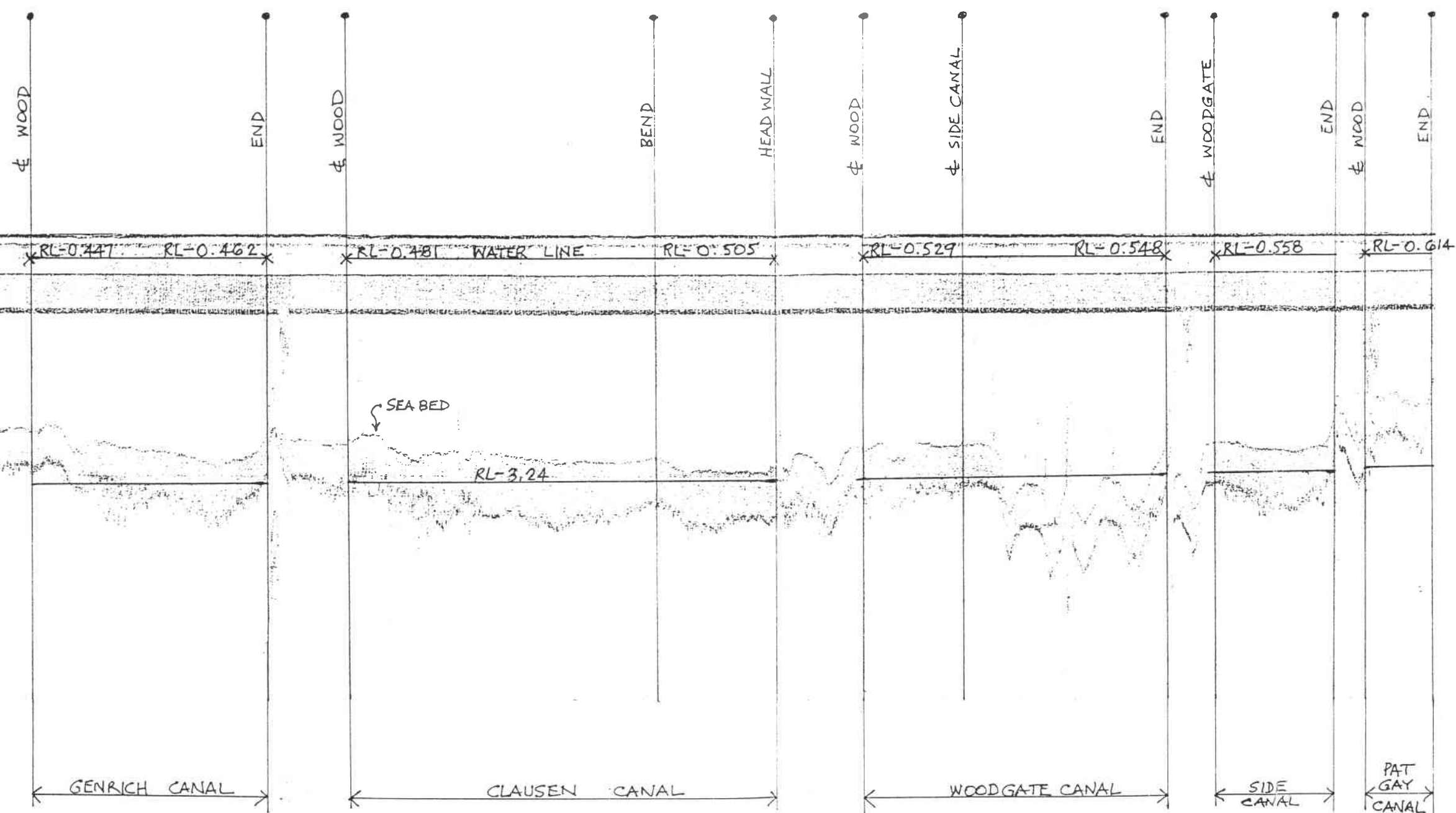
SOUNDINGS TAKEN 30TH JULY 1997. AM.

TIDE MOVEMENT - EBB

DATUM - BM. TOP OF TIDE GAUGE = RL 1.485 AHD.

DEPTH SOUNDER - AWA AQUAPROBE 100.

SURVEYED BY N.T. GOUGH.



REDLAND SHIRE COUNCIL
AQUATIC PARADISE CANALS

SOUNDINGS TAKEN 30TH JULY 1997. A.M.

TIDE MOVEMENT - EBB.

DATUM - BM. TOP OF TIDE GAUGE = RL1.485 AHD.

DEPTH SOUNDER - AWA AQUAPROBE 400

SURVEYED BY N.T. GOUGH.

Appendix D

REDLAND SHIRE COUNCIL'S TERMS OF REFERENCE FOR THE STUDY

TERMS OF REFERENCE AND CONSULTANTS BRIEF



REDLAND SHIRE COUNCIL

TENDER NO. WO16/018

AQUATIC PARADISE CANAL ESTATE
TERMS OF REFERENCE

INTRODUCTION

Redland Shire Council is calling for Fee Proposals from suitably qualified Consultants to undertake a study into and report on the causes of canal siltation and actions that may be taken to reduce the rate of siltation at Aquatic Paradise, Birkdale.

BACKGROUND

The Aquatic Paradise Canal Estate is situated at Birkdale. The estate was cut from natural land and an access channel was cut some 3,000 metres out in to Moreton Bay.

The canals and access channel are subject to regular siltation and require dredging approximately every four years. The main problem areas appear to be at the entrance to the estate from the bay and where the stormwater drains and the creeks; particularly Tarradarrapin Creek, meet the canal system. Location and development site plans are attached for your information.

At the inception of the development in 1982, Water Research Laboratory, University of New South Wales in conjunction with Christopher Miller Consultants Pty Ltd completed a sedimentation and wave penetration study for the development. The study has addressed the geological and geotechnical nature of sediments, likely sediment movement phenomena (siltation estimates), canal stability and wave penetration.

In summary of the study indicates an estimate of the siltation volume per year, likelihood of siltation at the initial phase as a result of relative low tidal velocities compared to that of stable canals in South East Queensland and unlikelihood of significant wave penetration activities.

It seems the current siltation rate is comparatively high. As more than a decade has passed since the completion for the development, whether the initial siltation referred in the report in relation to canal stability could have substantially taken place or not is another concern. The Works Operations Program of Council has some idea of the current siltation rates. Accordingly, dredging has to be carried out on a four year cycle. As this means a substantial expense to the ratepayers, the objectives of the study are as follows:

- To determine the sources of silt in the canal system and the contribution each source makes to the cost of dredging the canal system.

- To determine the long term, expected frequency of dredging in the various parts of the canal system and hence the long term maintenance costs.
- To determine whether there are any works which could reduce the cost of dredging and the nature and approximate cost of those works.
- To determine whether there are any possible improvements to the method of dredging which could reduce the cost of dredging, and the nature of those improvements.

TERMS OF REFERENCE

The following terms of reference have been adopted for this study:

Summary Document

Write summary Document

Deliverables

This Proposal will outline the scope of the study including methodology and timing.

The outcome of the main part of the study is expected to be a report outlining:

- the findings of any inspections, surveys etc;
- the results of any analytical work;
- an assessment of the sources of siltation and the expected frequency of dredging; and the contribution each source makes to the cost for dredging; and
- recommendations for works or methods of dredging which in the opinion of the Consultant will reduce the cost of maintaining the canal system.

PROPOSAL

Consultants' proposals shall include the following details:

- Full details of the study methodology and procedures.
- Full details of the presentation of the results.
- Details of the staff to be included on the project, the Project Director and any sub-consultants.

SECTION E

TERMS OF REFERENCE AND CONSULTANTS BRIEF

SELECTION CRITERIA

Your proposal will be assessed based on the following selection criteria.

	MERIT MARKS
Methodology (How project is to be tackled, scope of work)	45%
Price (Value for money)	20%
Technical Skills (People, systems, specific abilities)	10%
Relevant Experience and Track Record (Previous work of this type)	15%
Time Performance (as proposed for project - likelihood of meeting it)	7%
Enhancement of capabilities of Local Business	3%

SUBMISSIONS

Submissions marked "Redland Shire Council Aquatic Paradise Canal Estate" and "Private and Confidential" are to be lodged with:

The Chief Executive Officer/Shire Clerk
Redland Shire Council
P O Box 21
CLEVELAND QLD 4163

by 11:30 am. Tuesday 13th. May 1997.

FURTHER INFORMATION

The investigation needs to be completed and a final report to be submitted with recommendations as soon as practicable. If you have queries with these terms of reference, please contact Mr Gary Soutar, Manager Works Operations (Telephone 3286 8528) or Mr Kamal Ranaweera, Design Engineer (Telephone 3286 8753) Redland Shire Council.

