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Volume 2 : Appendices

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Synopsis: This report presents the findings and recommendations of the Lake Currimundi Dynamics Study. This study has addressed a range of ecosystem processes and management options for the lake. The approach adopted has been to address processes and issues in the context of an adaptive management framework.

Keywords: Lake Currimundi, adaptive management plan, midge, water quality, stream bank erosion, entrance dynamics, hydrodynamic modelling, berm, coastal processes, community engagement.

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APPENDIX 1 – GLOSSARY OF TERMS

Algae: A collective term referring to several groups of simple photosynthetic plants, mostly microscopic, lacking roots, stems and leaves.

Algal bloom: Extensive growth of algae in or on a body of water. Blooms may occur from excess nutrients in water bodies, or from particular climatic conditions.

Ambient monitoring: Ongoing monitoring of current conditions to establish baseline or background data that can be used to identify changes or trends in conditions.

Ammonia (NH_3): Compound of nitrogen and hydrogen; can form NH_4 (ammonium) if solution is more acidic.

Anaerobic: Living or occurring without oxygen.

Anoxic: Lacking in oxygen; at abnormally low levels of oxygen.

Baseline: A measurement, calculation, or location used as a basis for comparison with future data; also, a type of monitoring program to establish current condition.

Bank: Sloping ground bordering a river, stream or lake forming the sides of the waterway channel.

Berm: The ridge of sand across the entrance to the lake.

Biota: The total group of organisms (living things) in a particular area, including plants, animals, fungi and bacteria.

Bloom: An unusually large number of organisms of one or a few species, usually algae, per unit of water.

Catchment: An area of land that is drained by a stream and its tributaries.

Channel: The section of a stream that contains the main flow.

Chlorophyll: The green pigment in plants that enables them to use the energy of the sun for photosynthesis.

Compliance: A type of monitoring program that assesses whether accepted standards have been met.

Conceptual model: A mental image of a process, object or system that has been written down or drawn to show the relationships, interaction and outcomes of various elements.

Data: Facts or pieces of information used to draw a conclusion or make a decision.

Discharge: The volume of water moving past a given point for a given period of time. Usually measured in cubic metres per second (m^3/s) or megalitres per day (ML/day).

Dissolved oxygen (DO): The amount of oxygen dissolved in water. The unit of measure is milligrams of oxygen per litre of water (mg/L) or the saturation level of water with oxygen (%).

Electrical conductivity (EC): A measure of how well a substance serves as a channel or medium for electricity. The units of measurement are microsiemens (dS) per centimetre (/cm).

Ecosystem: A community of different organisms that is interdependent on each other, and the chemical and physical factors making up their environment.

Erosion: The gradual wearing away or removal of land surface materials by the action of water or wind. In waterways, eroded material is transported by water and deposited at other sites downstream (aggradation).

Estuary: A body of water adjacent to the sea, typically the mouth of a river, in which the tide ebbs and flows and fresh water mixes with the sea water.

Eutrophic: Term used to describe water enriched with nutrients, primarily phosphorus but also carbon and nitrogen.

Export load: The measured amount of a given contaminant leaving a catchment over a given period of time.

Framework: A structured outline that assists in the development and implementation of a strategy or program.

Dissolved reactive phosphate (DRP): The phosphate in a solution; measured using a colorimetric method.

Hydrodynamic Model: A computer model simulating the movement of water describing water velocity and water level

Indicator: A measurement of a physio-chemical, biological or stream or habitat condition. Indicators tracked over time may show trends and can provide quantitative information about the response of an ecosystem to disturbance or change or be used to assess the general state of the environment.

Indurated (Sand): A layer of hardened sand of a dark colour (also known as Coffee Rock)**.**

Instability, bank: Lack of physical stability of the bank due to the processes of erosion and aggradation of bank sediments.

Littoral drift: The movement of sand along a beach caused by wave action.

Nitrate (NO_3): A combination of nitrogen and oxygen found in a dissolved state.
Nitrogen (N): A common non-metallic element that is normally a highly soluble, colourless, odourless, tasteless, inert diatomic gas.

Nutrient: A compound required for growth by plants and other organisms.

Organic matter: Plant and animal material that can enter a stream in the form of fallen leaves, dead animals, animal manure, sewage, or as a component of soil eroded and washed into the stream.

Parameter: A component of environment or water that is being monitored in order to gain information about the condition of the waterway or surrounding environment.

pH: A measure of relative acidity or alkalinity. A value of 7 is neutral, values less than 7 are acidic and greater than 7 are basic or alkaline.

Phosphate (PO_4): A salt or ester of phosphoric acid; provides organisms with phosphorus in a usable form.

Phosphorus (P): An important nutrient for all organisms, usually found as a phosphate.

Pollutant: Any substance that causes pollution, including pesticides, sediment and nutrients, at levels that negatively impact water quality.

Pollution: Any harmful or undesirable change in the physical, chemical or biological quality of air, water or soil as a result of the release of chemicals, radioactivity, heat or large amounts of organic matter or sediment.

Pollution event: Individual occurrences of high levels of contaminants entering a waterway by accident or through negligence, with significant noticeable effects.

Respiration: The process by which animals and plants absorb and use oxygen from the surroundings and release carbon dioxide.

Riparian: Of or pertaining to the banks of a body of water.

Riparian vegetation: Vegetation that is found on the banks of a river or stream and is directly influenced by the presence of water.

Riparian zone: The transition area between a waterway and the surrounding land. The riparian zone occurs between a normal river level and the edge of the flood plain.

Run-off: The portion of rainfall or irrigation water that flows across the land surface rather than soaking into the ground, eventually running into a water body.

Salinity: Concentrations of salts measured in milligrams per litre (mg/L) or microsiemens per centimetre.

Saturation, oxygen: Percentage of oxygen (O2) dissolved in water compared to the theoretical level of dissolved oxygen capable of being held in pure still water.

Storm Cut: The loss of sand on a beach as a result of storm wave action.

Stratification, water: The formation of layers in a body of water due to differences in conditions such as temperature, light or nutrients.

Subcatchment: A continuous area within a catchment, bounded by waterway junctions.

Surface run-off: Water originating from rain, hail, or excess irrigation that flows across land surfaces instead of soaking in.

Suspended sediment: Sediment that is transported by water while held in suspension.

Thermocline: The divide within a body of water between the warm water of the upper layer and the cold water below it.

Tidal prism: The volume of water contained between high and low tide.

Tidal range: The vertical distance between the lowest and highest tides.

Total nitrogen (TN): The total amount of nitrogen in a sample.

Trigger (or threshold) value: A critical point or level at which a major change in condition occurs.

Turbidity: A measure of water clarity, affected by the amount of suspended solids such as clay, silt, sand, algae, plankton, and micro-organisms in the water column. Is measured using a spectrometer.

Water quality criteria: Maximum concentrations of pollutants that are acceptable for water to meet water quality standards.

Water quality standards: Written goals for the quality of water for different uses based on particular use requirements.

Woody debris: Timber submerged or partially submerged within the stream channel; naturally present in the form of tree trunks, limbs and branches. Provides habitat for aquatic life.

APPENDIX 2 – COMMUNITY CONCERNS

1. Internal Stakeholder Workshop August 2006
2. Broader community issues

Caloundra City Council 30/1/03	**MEETING RECORD / ACTION PLAN**	**Document Date:**

Meeting Type / Purpose: Currimundi Think Tank
Meeting Date: 1 August 2006
Meeting Attendees: Andrew Ryan, Chris Allan, Rodger Tomlinson, Darryl James, Gordon Agnew, Nicki Stokes, Michael Erpf, Denise Johnson, Denis Shaw, Cr Dwyer, Leon Rowlands, Lucy Dahl, Jeff Fanton, Cr Smith, Lea Durie, David Allen (CCCG), Cr Wallace, Tracey Sait (minutes)
Guests:
Apologies: Mark Goyder (CCCG)

ITEM NO	RECORD OF DISCUSSION / ACTION REQUIRED	ACTION
1.	Andrew Ryan started off by welcoming everyone and giving an overview of what he was hoping to achieve from this meeting to help us in cohesively managing Currimundi Lake. He then asked everyone to introduce themselves: Chris Allan – Environmental Operations Manager Cr Smith – Councillor for the area and also representative of FOCL Lea Durie – Acting Manager ELR and Principal Landscape Architect working on Lake Bank Management Strategy Rodger Tomlinson – Griffith Uni – working on Dynamics Study for Currimundi Lake Denise Johnson – Waterways Co-ordinator in charge of water quality monitoring and risk management Jeff Fanton – Growth Management – development assessment and engineering assessment Gordon Agnew – Waterways Technical Officer – health of system David Allen – Currimundi Catchment Care Group representative – concerned about water quality and bank erosion Andrew Ryan – Director City Assets which is the division of Council that manages the Currimundi Lake Cr Dwyer – Councillor for Division 9 and interested in overall effect of weir and development on Currimundi Lake Nicki Stokes – Environment Officer Capital Works – ensuring environmental legislative requirements are followed Michael Erpf – Drainage Co-ordinator – drainage issues	

ITEM NO	RECORD OF DISCUSSION / ACTION REQUIRED	ACTION
	Lucy Dahl – Development Engineer – major developments Leon Rowlands – Environmental Engineer – flooding and water quality Darryl James – Landscape Architect – environment and community issues – Lake Bank Strategy Denis Shaw – Coastal Engineer – entrance management and dredging	
2.	Presentation by Denis Shaw – Major occurrences in the development of Currimundi Lake (copy attached with minutes). Questions in relation to this presentation:- David Allen questioned whether there has been a comparison done between the natural opening and closing of Currimundi Lake and Council manually doing this with relation to the midge problem. Chris advised that this info needs to come from Regulatory Services Vector Control Unit. They were unable to have a representative at today's meeting. Cr Dwyer questioned whether it would be possible to get one photo or diagram of the whole area. David Allen questioned whether the flow of water when the new weir is opened will be at the same volume. Jeff Fanton advised that it is set for the same amount. Cr Dwyer questioned if the water is pumped in at a constant regular flow. Jeff Fanton advised that there is 1.8 mega litres of water pumped per day from Mooloolah River into Lake Kawana which is then pumped into Currimundi Lake and the entire volume (of Lake Kawana) is turned over once every 30 days. This is pumped at a set rate. Cr Dwyer also questioned if the water could be pumped through at a faster rate to try to help alleviate the sand plug problem in Currimundi Lake. This is not really possible.	
3.	Rodger Tomlinson gave a brief overview of the work he's doing. He has received and read lots of reports from Council but what's missing from the information we've provided him is information on the way the lake behaves as a tidal system. What does the community want to see there? Is that compatible with where the system is heading now? We need the community behind a sensible management strategy.	

ITEM NO	RECORD OF DISCUSSION / ACTION REQUIRED	ACTION
	Until the weir is connected we won't know how it's going to go as there has been no previous dynamics study. We may not be able to return Currimundi Lake to the way it was (perception issue) Rodger is currently putting together a draft overview of all the information he's received. Cr Wallace questioned monitoring of the water at the head of Tokara Canal. Denise advised that water quality monitoring is done every month. Denise to provide copies to Cr Wallace each month. Cr Dwyer commented that he would like to see community needs and desires based on realities and not perceptions. We need to provide the community with all the details. Cr Dwyer prefers that we let nature take its course where we can. David Allen questioned previous management plans that don't appear to be proper management plans. Chris advised that this is what we are now refining. ICOLLs have been done in draft and have been sent out to external agencies for comments. Cr Smith put forward comments and concerns from his community:- • Midge problems • Erosion • Lake flows • Water colour – have noticed changes since pumps started • Fishing and habitat • Weir height • Water quality • Sedimentation • Water quality when Kawana Island is fully housed • What happens if the water quality of Mooloolah River is bad and is then pumped into Currimundi Lake? David Allen said that the perception on the northern and western sides of the lake are not for a pristine (as in the past) lake but do have the following concerns:- • Concerned about water quality. CCCG have checked Ph levels at different sites and they have been quite high. David reports the results to CCCG every month and also forwards these to FOCL.	Denise

ITEM NO	RECORD OF DISCUSSION / ACTION REQUIRED	ACTION
	• Degradation of system as a whole. Have had reports of no fish in the lake. • Bank erosion and stability. There is a difference between northern and southern sides. More erosion on the northern side. In some areas of Noel Burns Park 4 to 5m has been lost over the last few years.	
4.	Overview from Growth Management staff on the Kawana weir design specifications, intent and development conditions. Jeff Fanton advised that the intent of the weir is that the State Government wouldn't allow any further canal development. To allow Lake Kawana to take place it needed to become a non tidal lake. Development Control Plan 1996 Kawana and consultant submit for review tidal exchange. Original impact assessment used only mean high water spring. Lucy spoke about the design of the weir. It is 60m long, 10m @ RL 0.4m with the remainder @ 0.65m. It is approximately 50% completed. The EPA was involved in the approval. There is an ERA 19 approval for the whole of the Birtinya waterways. Was there modelling on the tidal exchange? Did the flood study look at tidal prism? Max 10% increase in tidal prism at HAT. Do developers need to do more modelling on this? Cr Smith questioned does the weir have sedimentation type trap? Gordon Agnew raised concerns about the ecological health of the whole system and potential issues from the whole catchment. Cr Dwyer questioned turbidity. Is it the case that the flow of the water from the weir will increase the turbidity in the lake? When it's pumped over, that creates turbidity; will that flow that wasn't previously there create the turbidity? Leon advised that this would have a low water quality impact. The basic flow rate is 100mm per hour. It is not the flow that's creating turbidity. What causes the erosion in canals without high currents or flows?	Denise – refer to study

ITEM NO	RECORD OF DISCUSSION / ACTION REQUIRED	ACTION
	David Allen commented on the gradient of canals now and when they were built. Cr Smith commented that banks can naturally become softened when water is up against them for a long time. Kids and dogs running up and down the banks can then attribute to some of the erosion. This is why we need bank stabilisation. Chris will be taking Rodger out in a boat to have a look at the sites. Leon advised that Stockland is obliged to do monitoring before handover of Lake Kawana. Monitoring started in mid 2005. Council has only received one set of water quality monitoring results at this stage. Parameters – N & P, pH, DO, salinity, turbidity faecal coliforms; iron. Stockland have agreed to provide their water quality monitoring results to Council every 3 months. It was suggested that Council monitor in the same sites to compare results. Map of sites to be provided to Denise Johnson to do the full range of tests. On the issue of Ph, Michael Erpf raised the issue of stormwater pipes and the bottom of gully pits being eroded as they run through the acid sulphate soils layer. Andrew Ryan asked if modelling has been done of typical Currimundi Lake water and the impacts of the more brackish Mooloolah River water coming through. Added to this, does salinity then have an impact over fish breeding habitats? Cr Smith questioned whether the pumps should be stopped during the incoming tide. It was advised that the water is not going to stop flowing when the pumps are turned off. Cr Smith raised some further issues from his community:- • Community believes that work on the weir should stop until we know what will happen • Have we the right to say we don't want Lake Kawana water in Currimundi Lake? • Is weir at the right height? • Should we have a moveable weir? • Is it in the right spot?	Jeff Fanton Denise – refer to study

ITEM NO	RECORD OF DISCUSSION / ACTION REQUIRED	ACTION
	Cr Dwyer commented if we stop it now and find there is an ill effect, can we stop it altogether anyway? Make sure we have enough monitoring controls in place through development control processes. David Allen questioned what is the best that can be achieved. This is what we are aiming to find out by employing Rodger. Cr Smith commented on ICOLLs vs estuaries. Part of the FOCL mission statement refers to having a pristine lake.	
	DATE OF NEXT MEETING TBA	

Issue	Details	Status	Activity	Action	Who
Midge	Comparison between the natural opening and closing of Currimundi Lake and Council manually doing this with relation to the midge problem Is the appearance of midge the result of past dredging or development as a whole or other? Option for midge control is dredging of habitat areas, unknown impacts on Lake	Need to monitor Include in brief	Model could be used to test various opening scenarios for change in water levels Model + expert opinion Model can be used to show short term water level and flow velocity changes + expert opinion on long term Changes	Dynamics Study	Regulatory Services
Sand dredging	Unknown effects of past dredging of sand plug and midge habitat on the Lake dynamics and the system as a whole. Can further sand be dredged from entrance?	Include in brief	As above Model of various scenarios of sand removal to show water level changes	Dynamics Study	Consultant
Entrance Management	How has human intervention at the entrance affected the Lake dynamics? How will the constant flow from Lake Kawana affect the entrance of the Lake? What are the ecological impacts?	Include in brief	As above Model can show physical changes. Expert opinion on likely ecological impact + video monitoring of entrance + monitoring of water quality and anecdotal information.	Dynamics Study	Consultant

Erosion & stability	Erosion of banks in Currimundi system, particularly on northern side of lake. Is it a result of: • an altered catchment; • dispersive soils; • old Melaleuca wetlands; • higher runoff velocities; • installation of hard surface (rock walls); • development; • or natural? What's causing erosion in canals?	Include in brief	Expert opinion + model to show velocity changes due to various scenarios Expert opinion	Dynamics Study	Consultant
Fish habitat	Reports of less fish catch in lake and canals. Is this a result of changes in: • tidal regimes; • salinity ranges; • water quality; • loss of habitat; • years of development and lag effects?	Need to monitor	Expert opinion + monitoring	Review existing information Investigate possibility of fish monitoring/study	CCC/Consultant
Ecosystem Health	The effect of Lake Kawana and associated development on the ecological health of Currimundi Lake is generally unknown.	Include in brief Need to monitor	Model to show changes to tidal regime under various entrance scenarios + monitoring	Dynamics Study Review existing information Investigate possibility of ecosystem health monitoring/study	Consultant CCC

Education	Need to provide community with facts so that wants are based on reality not perception. What does the community want and is it achievable	Include in brief Include in brief	Information sheets on components of lake dynamics Environmental values assessment	Communication of facts of critical issues Social Assessment	CCC? Consultant
Vegetation	Reports of vegetation dying along banks of Currimundi Creek and Lake.	Include in brief Need to monitor	Expert opinion + model can show water level changes due to entrance opening	Dynamics Study Review existing information Investigate possibility of vegetation monitoring/study	Consultant CCC
Sedimentation	Effects on water quality and sand plug at lake entrance Sedimentation in canals altering gradient of canals	Include in brief	Expert opinion + monitoring + wq data analysis Model can be used to interpret	Dynamics Study	Consultant
Hydrodynamic changes	Gap on inter-tidal knowledge and modelling. Modelling required for: • tidal exchange; • tidal prism; • weir height and lake flow (1.8mL/day); • volume of water being pumped relative to the volume of water in the lake and is it restricting tidal movements	Include in brief Need to monitor	Model + monitoring	Dynamics Study Water level monitoring and tidal flow measurements prior to and after completion of new weir on Lake Kawana	Consultant CCC/Consultant

Water Quality	Have there been changes to water quality in Currimundi Lake? What is the quality of the water at the Mooloolah River intake and how does this affect the water quality in Lake Kawana and Currimundi Lake; What is the WQ of the Canals and stormwater entering the Lakes and canals? High turbidity and pH levels recorded by Community Groups Will flow from Lake Kawana increase turbidity in Currimundi Lake Water colour & clarity Acid sulphate soils	Need to Monitor/Include in brief CCC (Waterways) currently monitor 11 sites in Currimundi system (pH; DO; Temperature; Conductivity; Salinity; Faecal Coliforms; Nutrients; Turbidity; Suspended solids) Stocklands conduct monitoring at sites (Turbidity; iron; faecal coliforms; nutrients; pH)	WQ data analysis + monitoring	Review of existing water quality data CCC (Waterways) to continue monitoring plus shadow testing at Stockland's sites. Shadow testing with CCC & community groups.	CCC/Consultant as part of Dynamics Study CCC CCC
Impacts of future development in Currimundi catchment	Concern about what the problems will be when the planned future development is finished and populated.	Include in brief Need to monitor	Expert opinion + model scenarios of increased catchment hydrological load	Dynamics Study Review existing information Investigate the possibility of further monitoring	Consultant CCC/Consultant

APPENDIX 3 – ORIGINAL PROJECT TASKS

TASKS

A number of tasks were identified in the original project brief as paraphrased below. These have in general been adhered to, but as a result of the way in which the project has progressed, the results of these tasks will not necessarily be presented in the same format.

a. Analysis of existing water quality data and correlation with environmental parameters and system behaviour

Council has been collecting water quality data since 2001. Community groups have also been collecting data, and an analysis of all historical data will be undertaken to establish any trends and/or correlation with environmental parameters such as rainfall, or with modifications to the waterway. A discrepancy between datasets should also be investigated to ensure that the fullest level of information can be obtained from all sources. A first order model will be developed which relates the water quality outcomes with environmental and other parameters which influence the water quality. Modelling techniques such as neural network analysis are deemed as suitable. An operational system will be established to link with the monitoring system.

The Queensland Water Quality Guidelines 2006 will be used for the analysis to ensure relevancy to the Currimundi system. Specific Water Quality objectives have been produced for Caloundra City under the EPP (Water) 1997, Mooloolah River Environmental Values and Water Quality Objectives, March 2006.

b. Conceptual Models Workshop

A workshop is to be convened with a small group of experts from government, industry or universities to develop a conceptual framework for lake dynamics. It is expected that a consensus view will be established of the various lake responses and inter-relationships. The workshop will be guided by the questions raised at the Think Tank in August 2006 (see Appendix 1). It is anticipated that conceptual models will be developed for processes such as:

- Lake water level fluctuation in response to entrance opening (including sand plug removal) – implications for midge habitat increase, bank erosion
- Water quality change in response to weir and stormwater connections to Lake Kawana
- Berm width and height and natural entrance breakthrough
- Entrance channel location and adjacent beach erosion

c. Monitoring system

A long term monitoring program will be established. Negotiations with Council in regard to integration with or modification of the existing water quality program will be commenced immediately. The desirable components of the system will be:

- Flow regimes measured in real time at one location at the Ahern Bridge. A velocity profile is preferred, but a point measurement can be proposed and justified. Data will primarily be used for first order and hydrodynamic model calibration. Flow conditions at other locations will be inferred from the hydrodynamic model.

- Water level will be measured in real time at the Ahern Bridge, opposite the Lake Kawana weir, within Lake Kawana before the weir and at the upstream end of Tokara Canal. Measurements will be in real-time.
- Physico-chemical water quality parameters (T, pH, DO, Cond.) are to be measured in real time at the 3 sites mentioned above. Cost-effective remote sensing of nutrient levels needs to be considered. Offsetting the additional cost of this by terminating the regular existing sampling program could be considered and justified.
- A catchment monitoring program should be developed. This should incorporate physical and ecological assessments such as bank stability, vegetation condition, in-stream habitat, fish, benthic communities etc. This program should rely on the analysis of historical data along with the collection and collation of current data. If not currently in place, mechanisms to capture and collate such information should be identified. Engaging the support of community groups is important in this context.
- A plan for a targeted program of bore logs to assess soil type and erodibility, and to qualify the extent to which silt derived off the catchment is being deposited at the entrance is to be presented including an assessment of usefulness and cost.
- Entrance channel size and position, and adjacent beach alignments, are to be monitored and quantified if possible. Real-time video capture techniques are preferred.
- All data streams are to be transmitted to a central server at a convenient location – most likely being the Council administration building in Caloundra. Display systems are required which include environmental parameters such as wind, waves, rainfall and tide level.

Recommendations can be made for a staged implementation of the monitoring system to accommodate existing and future budgeting; however, any staged approach must still be able to provide sufficient data for first-order assessment of the efficacy of management actions.

d. Triple Bottom Line (Environment, Social and Economic) Values Assessment and community engagement program

The community shall be asked to provide input to the development of Environmental Values. A list of names and addresses will be provided by Council to assist in this matter.

A detailed plan for the public consultation process will be provided to Council. This may involve preparation of technical working papers such as fact and information sheets. A targeted program of public consultancy is envisaged to capture community values and aspirations for input into the development of the study's objectives. Community consultation will also assist in prioritisng the importance of issues and in ranking management options.

The public consultation process shall be a joint effort with Council. It is envisaged that the consultant shall provide advice and guidance while Council provides the administrative, logistical and marketing support.

Existing data will be assessed against the Queensland Water Quality Guidelines 2006 and the ANZECC Guidelines for Fresh and Marine Water Quality 2000. Specific Water Quality objectives have been produced for Caloundra City under the EPP (Water) 1997, Mooloolah River Environmental Values and Water Quality Objectives, March 2006. This assessment should be complemented by the ecosystem health surveys already undertaken and should be used to inform the establishment of holistic environmental values.

e. *Hydrodynamic Advection - Dispersion model*

A hydrodynamic advection-dispersion model of the Currimundi waterways is required to examine tidal and in-bank stormwater flows. Over-bank flood flow modelling is not required, but the model could be integrated into existing models of this type. In addition to the ocean boundary at the entrance, other boundary conditions/inputs are the constant flow from Lake Kawana, the tidal exchange with Lake Kawana above MHWS and the stormwater connection into Tokara Canal. The purpose of the model is to test scenarios (uncalibrated) of past events and development in the waterway, and to be a tool to support the implementation of an adaptive management framework for future management. The model could initially be uncalibrated, with subsequent calibration and validation once water level and flow data are collected under Task c. A simple dye release exercise should be undertaken to calibrate the advection dispersion component. Provide recommendations with costings for calibrated water quality, sediment transport and ecological process modelling.

A waterway bathymetry survey will be undertaken in areas where the existing survey (undertaken in 2001) is likely to be inadequate. These areas could include the upper reaches where stormwater scouring may have taken place, and near the entrance where there is active sand movement. Survey should be undertaken at a level commensurate with the model requirements.

The model will be used in conjunction with conceptual and first-order models to help address the issues raised in Appendix 1. For example, a range of entrance channel configurations can be estimated from survey, aerial photos or other information and corresponding approximate tidal gradients determined. In the case of the removal of the sand plug in 2004, there are quite detailed surveys of the entrance, which can be used for calibration.

An operational plan including costs should be presented for future use of the model, updating of bathymetry and calibration. It is expected that the model be available to be run “on call” in the event of a modification to the lake configuration due to a natural event, new development, or management action.

f. Entrance options assessment and Cost/Benefit Analysis

The management of the entrance sand berm has a significant influence on the hydrological regime of the Lake and on the exchange of lake water with the ocean. The berm is also an integral part of the beach littoral system, and the extent of the berm and the degree of opening of the entrance affect the stability of the adjacent beaches. A number of options for the management of the entrance conditions have been considered in the past involving the use of hard and soft engineering solutions. These include the construction of a rock wall stabilizing the adjacent beach and berm, and a berm height management strategy. An assessment of the coastal processes influencing the stability of the entrance channel and the height and width of the berm is required, leading to a cost benefit analysis of viable options. These assessments should be informed by model scenario testing as set out in Task 4e. It

is anticipated that the ultimate entrance management option will not be selected until after the completion of the study and the understanding of the lake behaviour is improved through the adaptive management process.

g. Lake Kawana inter-connection options assessment and Cost/Benefit Analysis

The connection of the Lake Kawana system to Currimundi via the weir structure and other connections are seen to be potentially very significant in terms of detrimental change to the Lake Currimundi ecosystem health and dynamics. This will be assessed in Tasks a to f, and should there be a clear indication of negative impacts, an assessment of options for the modification of these connections is to be undertaken. These options may include for example the modification of the weir to be adjustable for variable heights, or other means of modifying the flows from Lake Kawana into Lake Currimundi. A Cost/Benefit Analysis is to be included addressing both the implications for the Lake Kawana development and the state of Lake Currimundi.

h. Implementation plan for Adaptive Management Framework

The aim of this study is to provide relevant information on the dynamics of Lake Currimundi to support the future development of an adaptive management framework for entrance and catchment management. An Adaptive Management Framework (AMF) in this context, and as outlined in Attachment 1, will provide a cost-effective way of maximising the long-term capacity of Council to improve the overall management of Lake Currimundi.

In addition to the establishment of the modelling and monitoring components of this framework, an implementation plan is to be developed for integrating monitoring data, modelling and management action. The plan will set out the procedures for interfacing monitoring data, model outputs and management action. The plan should include operational and maintenance schedules for monitoring systems. It is expected that during the duration of the study, an opportunity will arise to test these procedures for a particular management action. To ensure long-term benefits from the management approach for Council it is expected that training/capacity building will be provided on the key elements of the AMF and on the process of implementation of an operational system. Subsequent regular support for the AMF is to be provided which may include regular (annual) review of the implementation progress, evaluation of the system components (including verification of model outputs and calibration of monitoring system). Council's LEROMP can be used as a basis for the management actions, and a comparison between the findings of the dynamics study and the actions set out in the LEROMP should be undertaken.

APPENDIX 4 – COMMUNITY ENGAGEMENT

1. Environmental values
2. Expert panel workshop – Agenda and Findings
3. Information Sheet
4. Community Survey results, additional comments and respondents
5. Environmental values workshop and findings – December 2007
6. Community Focus Group workshop and findings – March 2008

Environmental Values for South-east Queensland

The many possible wants and values that could be recognised in a waterway are grouped into environmental values. These are described below:

AQUATIC ECOSYSTEMS

Maintaining or improving the health of waterways to protect plants, animals and their ecological interactions

Wildlife Habitat

Protection of water way and riparian wildlife including maintenance of their habitat, food and drinking water. For example, turtles, platypus, seagrass and dugongs.

Human consumption of aquatic foods

Protection of human health for safe consumption of aquatic foods (e.g. fish, crustaceans and shellfish) from natural waterways

Cultural Heritage

Protection of indigenous and non-indigenous cultural heritage. This includes custodial, spiritual, cultural and tradition heritage. For example, hunting, gathering and ritual responsibilities. Cultural heritage includes symbols, landmarks and icons that should be protected such as waterways, dugongs and turtles.

Primary Recreation

Protection of human health from recreation which involves direct contact and a high probability of being swallowed. For example, swimming, wading, surfing, windsurfing, diving and waterskiing.

Secondary Recreation

Protection of human health which involves indirect contact and a low probability of being swallowed. For example, boating, rowing, fishing.

Visual Recreation

Protection of waterways for recreation which does not involve any contact with the water. For example, walking and picnicking.

Industrial Use

Protection of water supply for industrial use. For example, food, beverage, paper, petroleum and power industries. Industry will usually monitor and treat water supplies as required by their individuals needs.

Aquaculture

Protection of environmental health for safe consumption of aquatic foods (e.g. fish, crustaceans and shellfish) from commercial ventures.

Drinking Water Supply

Protection of (raw) drinking water supply, that is, before treatment. This environmental value assumes minimal treatment of water through coarse screening and/or disinfection.

Irrigation

Protection of water supply for irrigation. For example, irrigation of crops, pastures, parks and gardens, and recreational areas.

Stock Watering

Protection of water supplies to maximise the production of healthy livestock.

Farm Water Supply

Protection of domestic farm water supply (other than drinking water). For example, water used for laundry and produce preparation.

Some work was already been completed on developing environmental values for south-east Queensland catchments. This work has identified two environmental goals. That is, sub-divisions of broad environmental goals, described below.

Oysters

Protection of commercial and recreational oystering from faecal contamination

Seagrass

Maintenance or rehabilitation of seagrass habitat through improved water quality.

AGENDA

Lake Currimundi Dynamics Study
Expert panel Workshop

Thursday 18th October 2007
10am – 2.30pm

- Welcome - Introduction of attendees
- Purpose of workshop
  - Aims
  - Outcome
- Background
  - Summary of knowledge as set out in the report to Council by Rodger Tomlinson
  - Update on management activities, community issues etc since January 2007
- Overview of Lake Currimundi Dynamics Study
  - Study team
  - Work plan
  - Adaptive Management Framework
- Working through issues.
  - Panel discussion on:
    - The key management options available to Council, namely entrance management, pollutant source control. Are there other strategies to be considered?
    - Major issues and their relationship with management options and other issues
      - Biting Midge Nuisance
      - Tidal Hydraulics and Entrance Dynamics
      - Bank Erosion
      - Lake Ecosystem Health
      - Influence of Lake Kawana
    - Identify points of agreement and disagreement. Resolve disagreements by consensus.
- Workshop wrap up
  - Summarise consensus view on overall lake dynamics
  - Ratify work plan (with or without modification).

EXPERT PANEL WORKSHOP

An expert workshop was held on October 18, 2007 with CCC, GCCM and University of the Sunshine Coast to discuss the current issues and possible management options and their implications associated with the Lake.

Some of the main points to come from the workshop included:

Midge

- Numbers building due to increase in available habitat
- Closure of entrance needed to reduce/kill midge population
- Different management techniques considered
- 2004 closure successful

Sand Plug/Dredging

- Need to manage entrance to the north with sand movement
- Berm and channel created with natural longshore drift process
- Channel migrates south due to wave direction and longshore drift
- Plug provides major frictional resistance to tide. The removal contribute to tidal range

Bank erosion

- Bank erosion was occurring prior to lake becoming an estuary
- Erosion caused from recreational impacts
- Bank saturation occurs when the entrance is closed

Lake Kawana weir

- Need to monitor flow rates from the weir

Water quality

- Water quality is and remains stable
- Nutrient levels have been dropping
- Water is healthy and fish population is good
- Need for three permanent monitoring systems

Past issues and management strategies for the lake were also discussed.

Currimundi Lake Dynamics Study
- Caloundra -

August 2007

Introduction

In recent years, there has been growing community concern over the state of Currimundi Lake, and the condition of the entrance. These concerns have primarily focused on biting midge problems, water quality, entrance management and bank erosion. Also of concern is the impact of the connection of the artificial Lake Kawana into Currimundi. Before appropriate management strategies can be adopted for the lake, it is important to understand the dynamics of the lake and the changes that have occurred over time.

Management Issues

Midges

Midges are an increasing community problem in the Lake area and mitigation options are being investigated with the aim to achieve a balance between public health and wellbeing and the environment as a whole.

Entrance Dynamics

Understanding the entrance dynamics is important for the future management of the system as a whole.

Bank Erosion

Increasing bank erosion is of concern not only due to the loss of bank vegetation and parkland but also due to the introduction of sediment into the system.

Ecosystem Health

Council and community groups have routinely collected water quality data for some years. It is proposed to analyse the data to determine relationships between environmental factors, entrance regimes and other changes to the lake configuration and the occurrence of water quality deterioration.

Influence of Lake Kawana

Considerable concern has been raised about the impact of the connection to Lake Kawana and its possible effects on the dynamics and ecosystem health of Lake Currimundi. An assessment of management options for this connection plus a cost benefit analysis will be undertaken.

Adaptive Management Action Plan

In order to develop effective management actions for Lake Currimundi it is important to recognise that all the current issues of concern

are inter-related. The study will establish a framework for an adaptive management approach to lake management and set out an implementation plan which is flexible and can be effective initially, but which can be developed into a more sophisticated system.

A few of the tasks to be undertaken include:

1. Analysis of existing water quality data.
2. Long-term Monitoring system including flow, water levels, entrance size and position.
3. Community engagement program.
4. Currimundi waterways model – Examining tidal and in-bank stormwater flows.

So Far…

Preliminary testing on the Lake began in late July by the Griffith Centre for Coastal Management (GCCM) prior to the dune re-profiling work and construction of the wading pool at the entrance of Lake Currimundi.

Background information on the Lake was collected from Caloundra City Council (CCC) and community groups including the history of the Lake, water quality data and past aerial photographs of the entrance. Water flow and velocity data was collected over a two-day period using SonTek Argonaut equipment. Five sites along the lake were analysed and the GPS location of each site was noted as well as the water temperature, depth, and water flow direction. Additional aerial photos of the Lake entrance were taken from The Entrance apartment complex.

Further work was completed on the Lake in conjunction with the opening of the entrance in late October. Water quality measurements were taken in relation to temperature, pH, dissolved oxygen and conductivity. Water flow and velocity data were again measured, this time at two locations near the entrance, as well as measurements in tidal range and movement.

Discussions have been initiated for cameras to be installed by Coastal Watch on the Currimundi Lifeguard Tower and The Entrance apartment block to monitor the movement of the entrance and analyse any changes that may occur. These cameras are an important tool in understanding the dynamics of the entrance.

An expert workshop was held in September with CCC, GCCM and University of the Sunshine Coast to discuss possible management options and their implications associated with the Lake.

A community consultation event to capture community values and aspirations is planned for December 6.

Contact Information

For further information on this project please contact Denise Johnson at Caloundra City Council on d.johnson@caloundra.qld.gov.au or Peta Williams from the Griffith Centre for Coastal Management on peta.williams@griffith.edu.au.

Information in this report taken from Tomlinson, R. (2006) Lake Currimundi Dynamics Report, GCCM. Photos sourced from Griffith Centre for Coastal Management.

Currimundi Lake Dynamics Study
Community Survey

Background

This survey has been formulated for community and stakeholders to complete, with the aim of providing valuable information and feedback on issues related to Lake Currimundi. The survey will also aid researchers involved in the study. By completing this survey you will be providing valuable community feedback.

Your participation in this survey is important and very much appreciated.

Q1. **Do you:** *(please tick one)*

☐ Own a property on Currimundi Lake?
☐ Rent a property of Currimundi Lake?
☐ Reside within the vicinity of Currimundi Lake?
☐ Reside in a neighbouring suburb to Currimundi Lake? Which suburb?
.....
☐ Other.....

Q2. **How many years have you resided in the area?**
(please tick one)

☐ Less than 1 year
☐ 1-2 years
☐ 2-4 years
☐ 4-6 years
☐ Other.....

Q3. **Age group?** *(please tick one)*

☐ Under 18
☐ 19-30
☐ 31-50
☐ 51-70
☐ 70+

Q4. **Gender?** *(please tick one)*

☐ Male
☐ Female

Q5. **Are you a member of a local community group?**
(please circle)

Yes/No

If yes, which one?

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Q6. **Where do you access Currimundi Lake or surrounds and what do you do there?**
e.g. Use the walking tracks via Sunjewel Bld; Use Westaway Pde boat ramp to kayak

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Q7. **How many times per year do you use the Lake or surrounds?** *(please tick one)*

☐ Less than 6 times a year
☐ Once a month
☐ Once a week
☐ Everyday
☐ Other.....

Q8. **Can you identify the main features of the Lake or surrounds that you would consider to be the most important or special?**

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Q9. **Could you please advise what you consider to be the main issues or threats currently facing Currimundi Lake/Creek/Canals?**

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Q10. **Could you please comment on what actions or strategies you would like to see undertaken to best address these issues?**

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Q11. **Do you see opening/closing or moving the entrance as an appropriate and effective management option?** *(please circle)*

Yes/No

Why?

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Q12. **Where do you access information in relation to the current state of and issues for the Currimundi Lake/Creek/Canals?** *(please tick)*

☐ Television
☐ Radio
☐ Newspapers
☐ Internet
☐ Council
☐ Other.....

Q13. **How would you rate the current state of Currimundi Lake/Creek/Canals?**
(Please tick one)

☐ **Good** (of a high standard with little or no quality improvement required)
☐ **Fair** (acceptable quality but may benefit from some improvement in quality)
☐ **Poor** (quality affects but does not limit range of recreational uses and environmental attributes)
☐ **Critical** (state is not acceptable for current recreational use and environmental quality)

Q14. **How do you rate the importance of the following Triple-Bottom-Line Values of Currimundi Lake?** *(please tick the appropriate box for each item)*

		Negligible	Low	Medium	High	Very high
Recreation	Sunbathing, swimming, surfing					
	Dog exercising					
	Walking					
	Non-motorised water activity					
	Motorised water activity					
	Fishing & bait collection					
	BBQ/picnic facilities					
	Other					
Residential	Lake aesthetics					
	Shoreline stability					
	Enhanced property value					
	Other					
Biodiversity	Lake flora & fauna					
	Birds					
	Fish species					
	Crabs					
	Impact of midge					
	Other					
Water quality	Flushing of Lake through entrance					
	Water clarity/colour					
	Stormwater improvement					
	Other					
Links	Link to Lake Kawana					
Economic	Access to shops/cafes/ accom.					
	Car parking					
	Recreational equipment hire					
Others	1					
	2					
	3					

Q15. **In your opinion what are the top 3 priority issues for Currimundi Lake/Creek/Canals?**

1) .....

2) .....

3) .....

Q16. **Do you have any additional comments?**

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Please return this survey in the box provided or return it by December 31, 2007 using the pre-paid, self addressed form on page 6.

For further information please contact:
Denise Johnson
Caloundra City Council
Ph: 07-5499-5135

Peta Williams
Griffith Centre for Coastal Management
Ph: 07-5552-8530

Please return this survey in the box provided

or

Return all pages by December 31, 2007 using the pre-paid, self addressed form overleaf.

No postage stamp required
if posted in Australia

Lake Currimundi Dynamics Study

REPLY PAID 117
Caloundra City Council
PO Box 117
CALOUNDRA QLD 4551

ATTENTION: Denise Johnson, Waterways Operations

FOLD HERE

Name: _____

Address: _____

_____

FOLD HERE

THANK YOU FOR YOUR PARTICIPATION

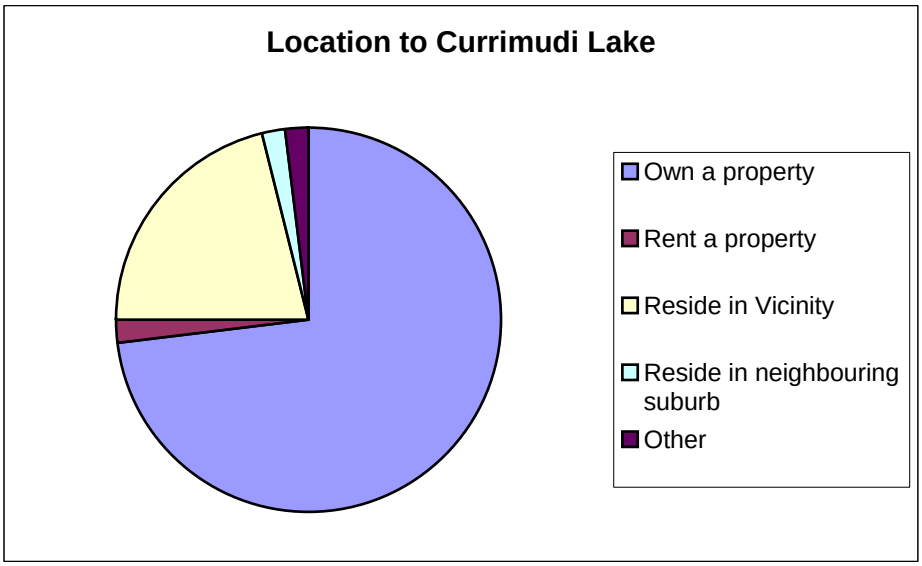
Currimundi Lake Dynamics Study
Community Survey

Background

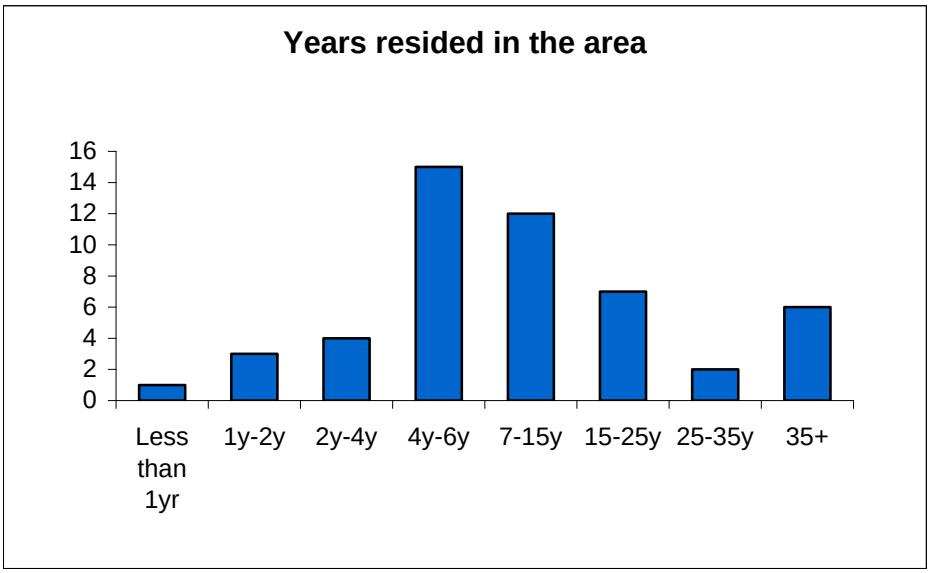
This survey has been formulated for community and stakeholders to complete, with the aim of providing valuable information and feedback on issues related to Lake Currimundi. The survey will also aid researchers involved in the study. By completing this survey you will be providing valuable community feedback.

Your participation in this survey is important and very much appreciated.

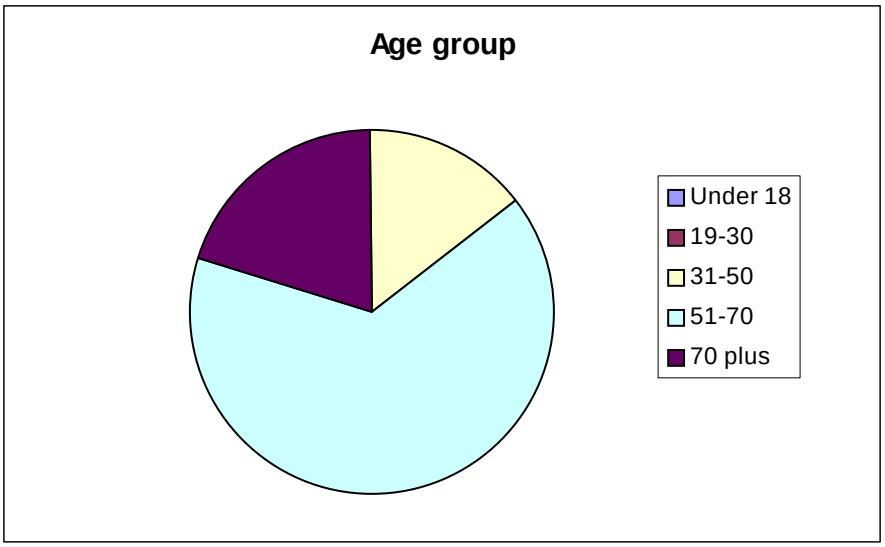
Q1. **Do you:**



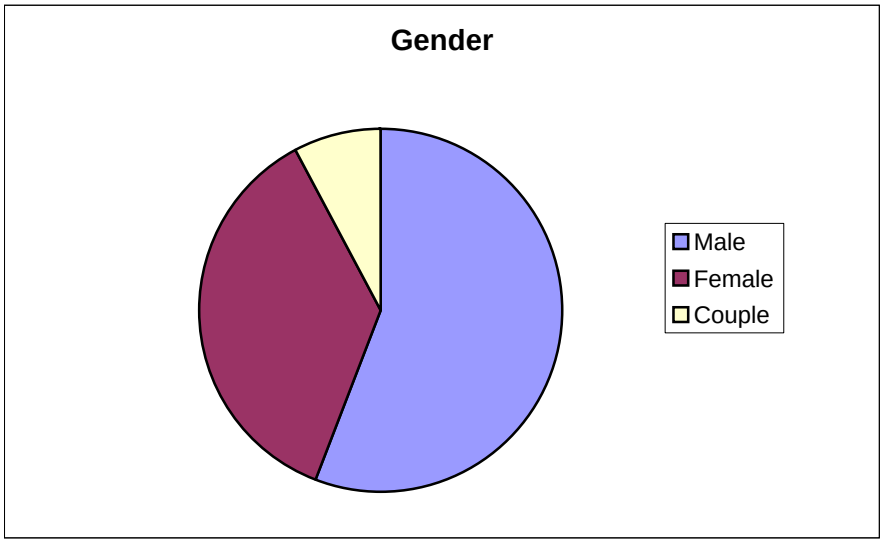
Q2. **How many years have you resided in the area?**



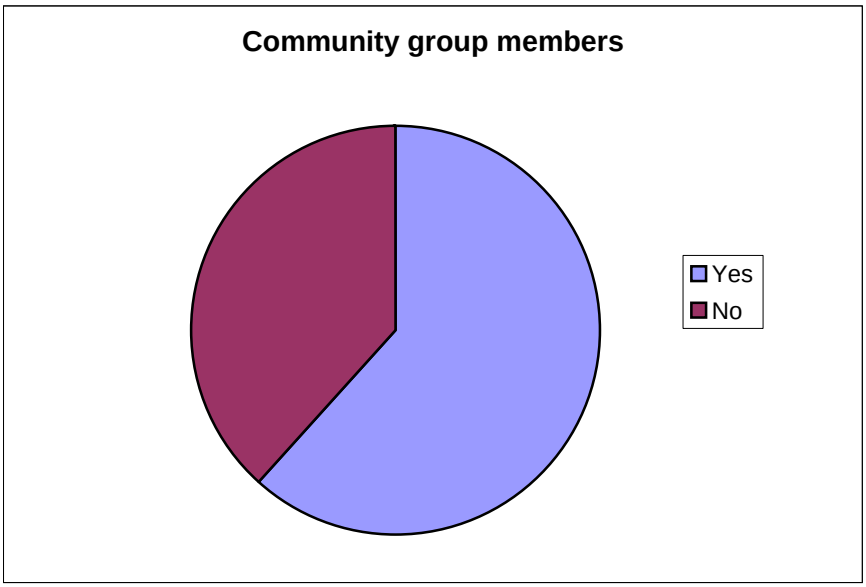
Q3. **Age group?**



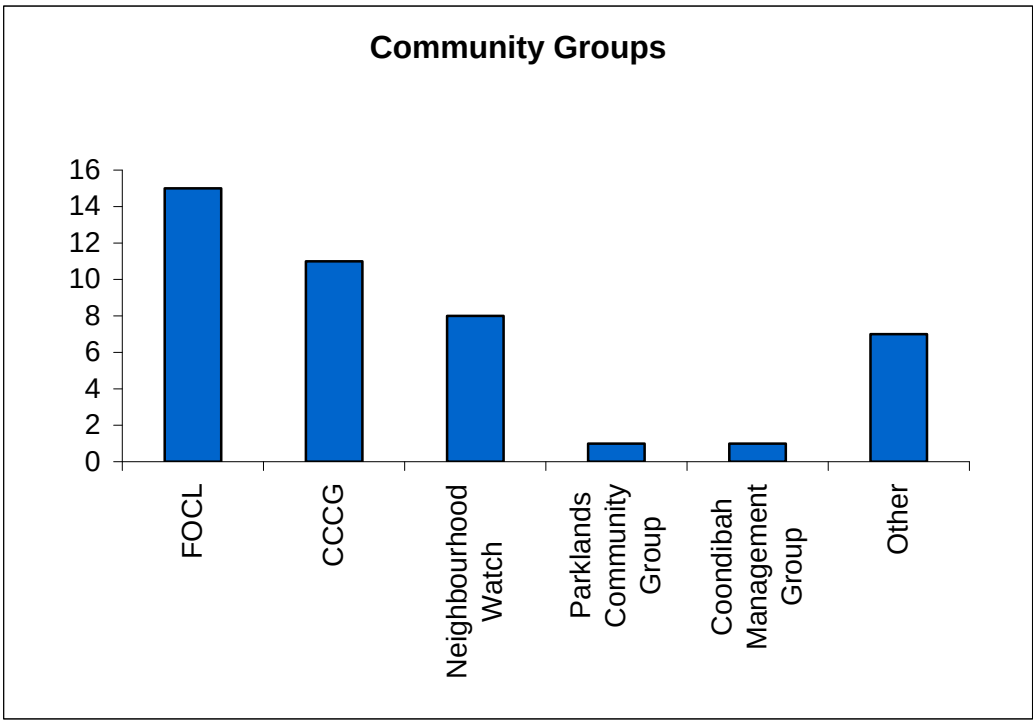
Q4. **Gender?**



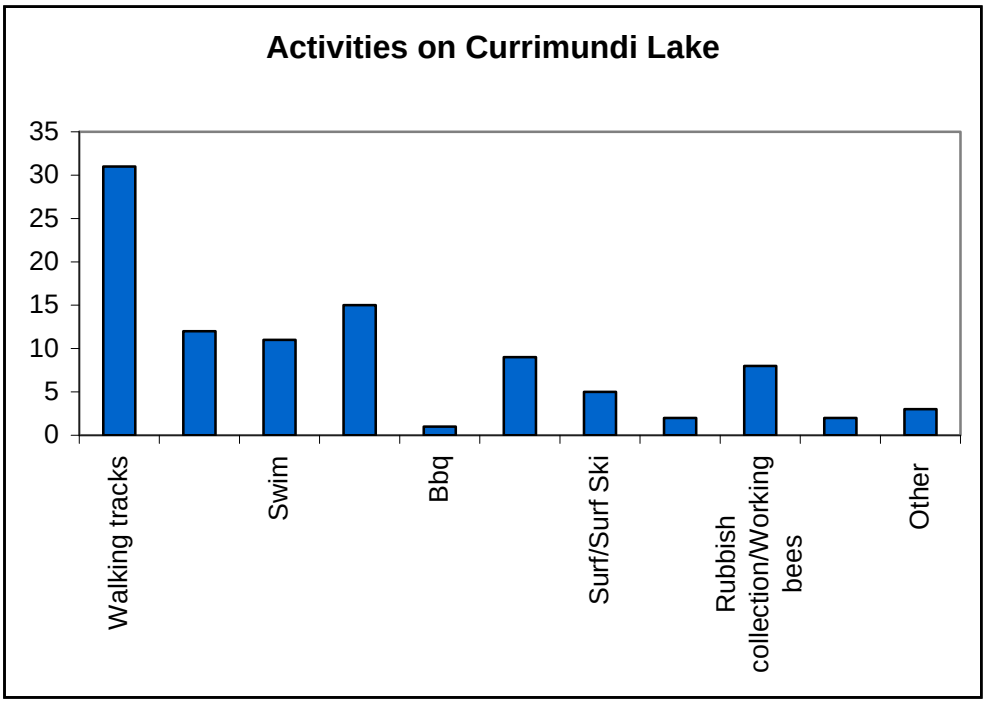
Q5. **Are you a member of a local community group?**

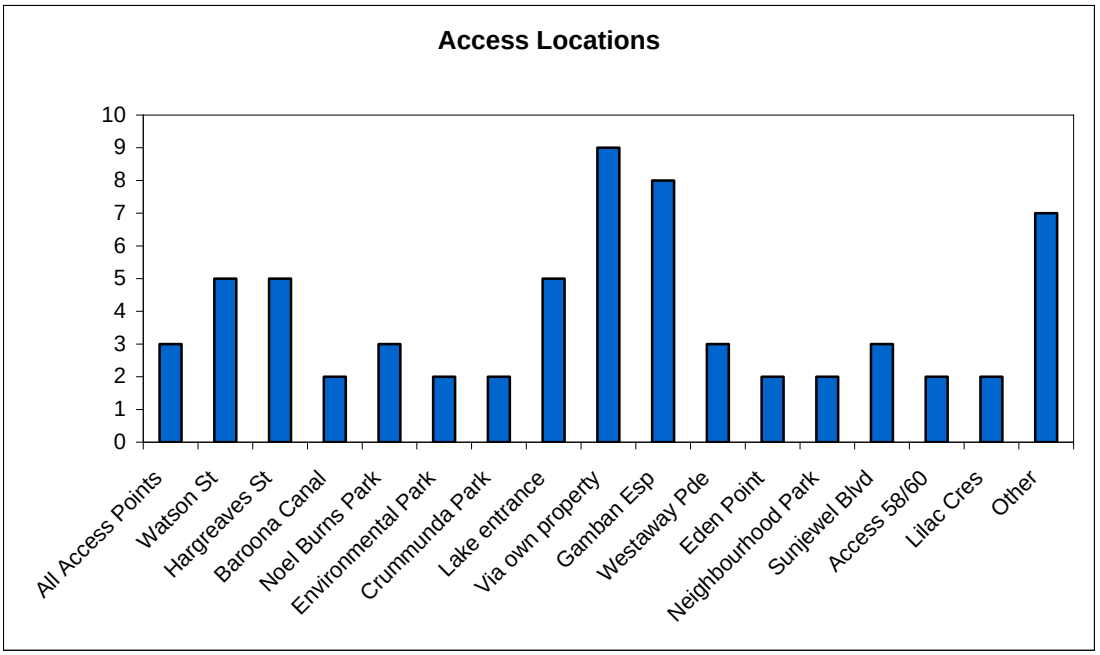


If yes, which one?

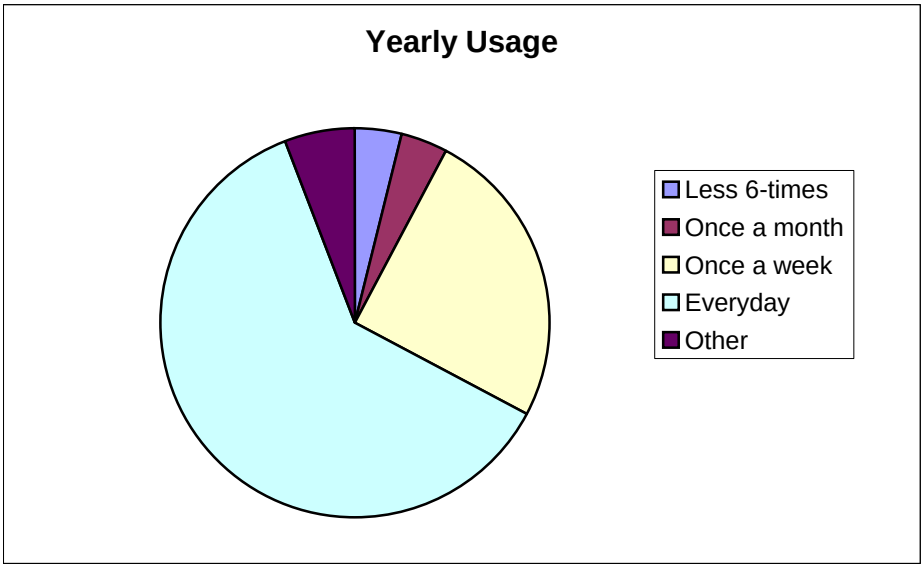


Q6. **Where do you access Currimundi Lake or surrounds and what do you do there?**





Q7. **How many times per year do you use the Lake or surrounds?**

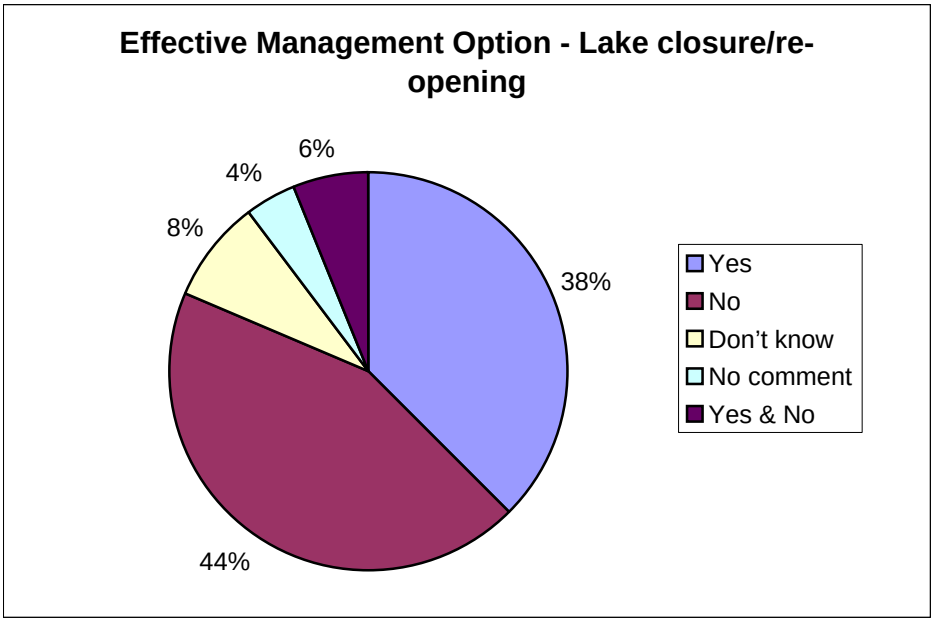


Q8. **Can you identify the main features of the Lake or surrounds that you would consider to be the most important or special?**

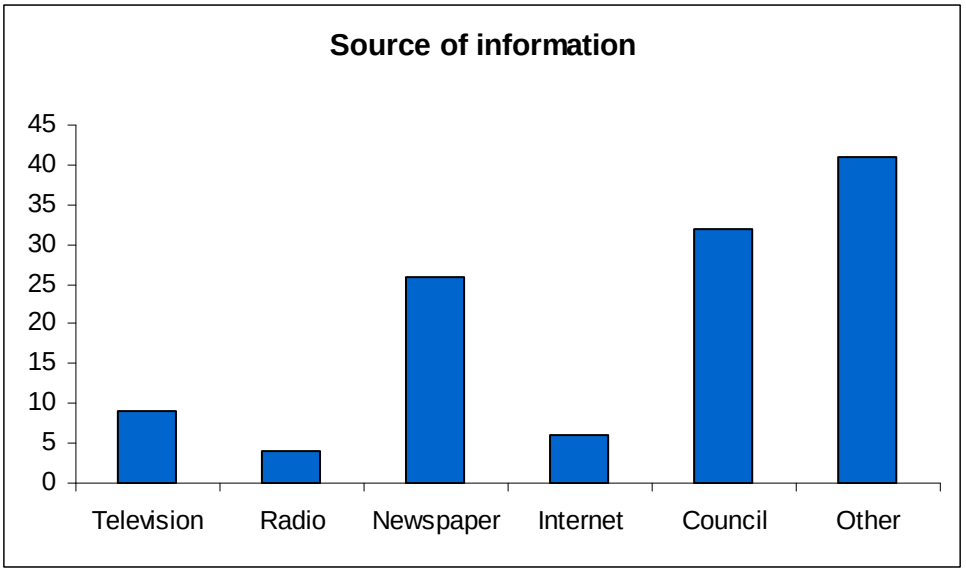
Q9. **Could you please advise what you consider to be the main issues or threats currently facing Currimundi Lake / Creek / Canals?**

Q10. **Could you please comment on what actions or strategies you would like to see undertaken to best address these issues?**

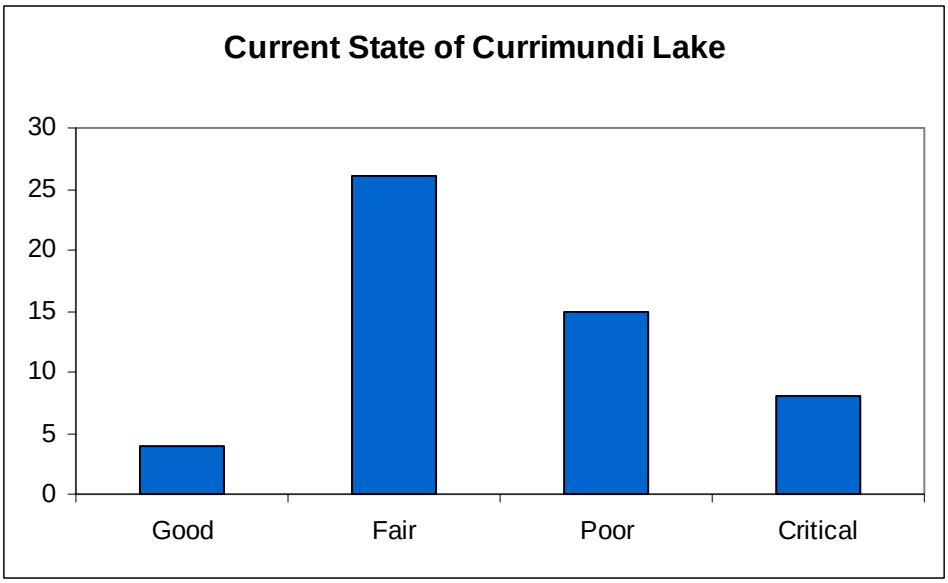
Q11. **Do you see opening/closing or moving the entrance as an appropriate and effective management option?**



Q12. **Where do you access information in relation to the current state of and issues for the Currimundi Lake/Creek/ Canals?**



Q13. **How would you rate the current state of Currimundi Lake / Creek / Canals?**

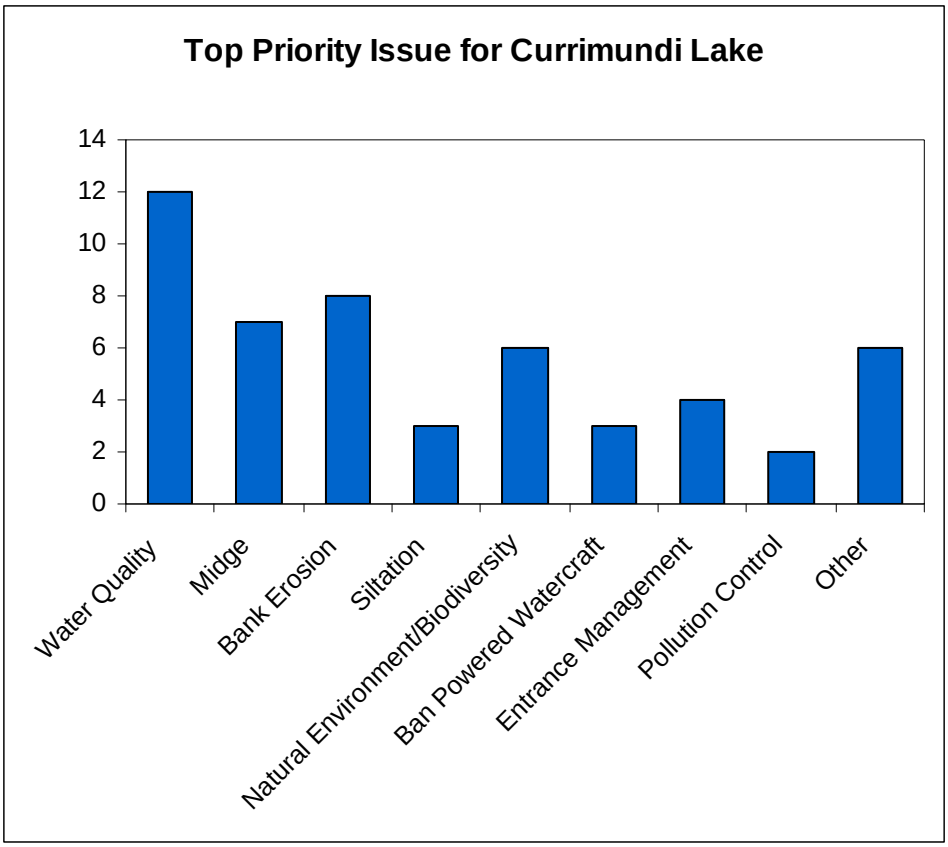


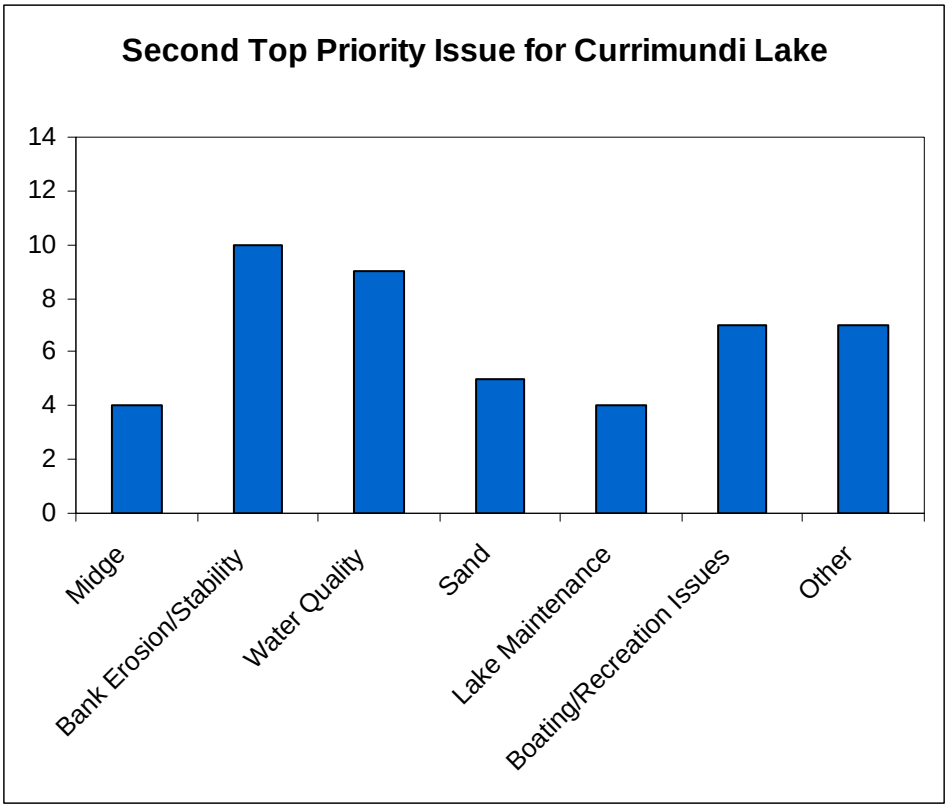
Q14. **How do you rate the importance of the following Triple-Bottom-Line Values of Currimundi Lake?**

		Negligible	Low	Medium	High	Very high
Recreation	Sunbathing, swimming, surfing	1	1	9	22	17
	Dog exercising	5	11	9	17	3
	Walking	1	1	6	20	20
	Non-motorised water activity	3	3	8	14	20
	Motorised water activity	17	20	10	2	2
	Fishing & bait collection	5	7	22	14	2
	BBQ/picnic facilities	1	4	12	22	10
Residential	Lake aesthetics	1		4	12	22
	Shoreline stability	1		7	16	27
	Enhanced property value	6	7	15	11	13
Biodiversity	Lake flora & fauna		1	6	7	34
	Birds			3	12	34
	Fish species		2	4	13	32
	Crabs	1	2	3	12	29
	Impact of midge	3	4	8	10	22
Water quality	Flushing of Lake through entrance	2		9	10	27

	Water clarity/colour	2	5	10	9	26
	Stormwater improvement		4	3	9	33
Links	Link to Lake Kawana	12	8	8	5	15
Economic	Access to shops/cafes/ accom.	11	6	16	12	6
	Car parking	4	16	11	11	9
	Recreational equipment hire	20	18	5	4	2

Q15. **In your opinion what are the top 3 priority issues for Currimundi Lake/Creek/Canals?**




Second Top Priority Issue for Currimundi Lake
14
12
10
8
6
4
2
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Midge
Bank Erosion/Stability
Water Quality
Sand
Lake Maintenance
Boating/Recreation Issues
Other

Additional Comments from the 2008 Currimundi Lake Community Survey

- If you continue to allow development upstream you will have to continually dredge downstream – Reclaim and landscape foreshore
    - Ban dogs from Lake
    - Ban bait collection
    - Link to LK closed
    - Non-motorised water craft from Nicklin Bridge to Sea
- Please use community groups for data gathering and reporting
- Knowledge of Currimundi for 35 years of fishing and surfing – 0413 661 066
- Removal of reeds in 2006 was a great help but more work needs to be done to remove the stinking silt that pollutes the system. This comes from development and lack of resident care
- Council has approved development with little regard to consequences. Canals are no longer constructed apparently but lakes are. There is no difference in what problems they cause to natural waterways.
    - Councils should be proactive. Stop approving man-made waterways (canals/lakes) to prevent the situation that now exists at Currimundi
    - Name change suggestion for Currimundi Lake to "Stocklands Drain"
- Midges need to be controlled by any means necessary
- Surrounds need to be preserved – control of erosion, removal of silt, no more infrastructure, parklands maintained to a high standard, control of weeds, maintenance of Lake entrance
- Urban runoff – Volume and quality must be monitored and managed eg. Channels for over bank flooding, adjusting inflows from Lake Kawana and canals
- From the time the first canal was constructed the changes to the Currimundi catchment system became irreversible. It could be assumed that the canal system will not be returned to the original and therefore man made solutions will have to be continuously implemented for best results. Any effort (and especially monitoring procedures) that maintains the system at optimistic quality will be worthwhile effort
- I think the council needs to recognise that the systems waterways are being degraded by lack of enforcement of procedures to minimise siltation and that human amenity (particularly west of Nicklin Way) does not necessarily fly in the face of natural amenity
- While scientific research is important to make decisions, the observations by local residents provide evidence that is critical to understanding the lake system
- Residents and Council must accept responsibility for the condition of the lake system (and developers must protect the environment as they undertake development)
- Educational programs based on a theme "caring for our waterways" particularly during summer
- Use community groups as partners in such projects
- Undertake a study of the fish species caught in the lake over a few years and monitor changes and identify if these changes relate to particular events impacting on the lake system
- Clean up the dead wood and rubbish along the banks – southern side of the lake
- Stabilise banks (southern side) to prevent vegetation toppling into the lake
- Prevent contaminated stormwater from entering lake by having a pollution control device on EVERY stormwater outlet

- Recent arrivals to the catchment demanding solutions without considering the natural history of the catchment
- Now that the lake can no longer flush itself naturally some human intervention eg sand excavation in swimming areas is necessary on a regular basis
- Better maintained parks with more lawn areas while keeping adequate sedges etc near the lakes edge
- Acres of seagrass beds have been lost between Hargreaves and Alice Sts over the past 50-years
- Huge build up of sand over the years had reduced the recreational value at surf end of lake
- Continuing people pressure for more housing in the upper catchment areas
- Residents should be made more aware of how to reduce man made pollution instead of having the lake open to solve the problem
- Would like to see plantings of Melaleuca to replace ones which have either fallen into lake with subsequence loss of soil or died leaving a gap
- Also like to see more seating for elderly and disabled
- Do not agree with the using of bait nets. Fines are in place if one is caught with an undersize fish but apparently it is all right to have dozens in a bucket classified as bait. The lake is a breeding ground and numbers have depleted drastically over the years… why?
- Perhaps banning of cast or bait nets could be a step in the right direction. Most shops and garages stock and sell a variety of bait in the area
- We enjoy living near the lake and appreciate its natural values and qualities. Work that enhances rather than detracts from these values would be preferable
- While there have been several community planting days in the last couple of years I have never seen any follow up weed control by Council. Plantings near Cliff Hargreaves Park have been covered by weeds just weeks after Currimundi Lake Day this year. It is very discouraging for residents to see their hard work so quickly undermined. Council should be able to easily program in such follow up weeding and a more positive and successful result might mean more people participate in the future rather than saying “what’s the point”
- Maybe Council could consider a less done better approach than spreading their staff thinly over such a large number of community planting projects
- Many of the working bees are during the week and those of us who work full time cannot attend
- Limit motorised craft
- Link to LK should never have happened. Now established water quality but be monitored closely
- Development should be monitored very closely to ensure builders, etc comply with laws/regulations
- Sensible future planning not driven by greedy developers
- No motorised water craft
- Educate fishing people to clean up their mess when leaving sites/stop fishing
- Future development monitored ensuring builders comply with regulations if any
- Continuing education for the community and all levels of schools
- Council notice to householders re garden refuse being disposed of in canals i.e. palm branches, grass pruning and clippings
- Better control of dust prevention concerning developers
- The dredging of the lake made a huge improvement after many years of deterioration which had become most depressing

- We hope that Council will set aside funding annually so that this can be repeated as and when it becomes necessary and is never again allowed to become a barren expanse of sand
- Would like to see stabilisation of banks which are subjected to constant human activity/erosion eg Gamban Esp swimming hole and Westaway Pde
- Since I moved to this area in the early 1990s I have enjoyed the natural appearance of the Currimundi Lake system and Noel Burns Park. I personally took an interest in the park from the time I arrived and started collecting litter and abandoned fishing line, hooks, etc. A few more persons started doing the same thing and eventually the group now known as Currimundi Catchment Care Group (CCCG) was formed.
- CCCG has been responsible for the planting of thousands of plants along the riparian zone in Crummunda, Noel Burns and Sunjewel areas to name a few. These plants help stabilise the parks and central stormwater erosion as well as enhance the aesthetics of the park and improve wildlife habitat.
- Speeding powered watercraft are a menace. Water police and other authorities do not have the resources to enforce regulations. Banning powered watercraft from the entire lake and canal system would enhance public safety and reduce erosion
- Of most concern – Bank erosion, UXOs, weed infestation, litter, lack of parking spaces
- Need more Bbq and picnic tables. Bbq needed at boat ramp Westaway Pde and Hargreaves St
- Cats roaming during day and night
- Private landowners degrading native vegetation and planting/mowing inappropriately
- As a matter of interest I used to photograph wading birds (mainly egrets) feeding in shallow water on southern side of Lake between Hargreaves and boat ramp. Since dredging of lake I these numbers have practically ceased altogether
- This area is in need for a disabled toilet. I know it is in the plan for the area but it is a disgrace that it was not built long ago
- There is a need for a sign showing where dogs are allowed. The one at access 58 is only understood by the person who produced it. There is much confusion especially with visitors trying to understand it
- There is an urgent need to clean up what used to be a garden in Cliff Hargreaves Park. If it were replanted with grass it would be a wonderful shady picnic spot
- There needs to be actual fencing with shade cloth fitted around the point near the tower. This would allow the sand the build up and provide a buffer from the big seas. It worked well for years but the Council seems reluctant to replace it
- There needs to be tables and seats along the shore between Hargreaves St and Bull St
- Better monitoring of the smell from SQIDs. At times it is shocking especially when it comes out of the drains near Cocos
- Regular pruning of the Cottonwoods to prevent the young suckers taking root
- I feel building the man-made canals have adversely affected the natural lake quality
- Currimundi Lake has been turned into a drain and is no longer a self-cleansing lake, which closed periodically. Sand build up has a detrimental effect on swimming areas and forces lake run out onto northern bank which is now subsiding
- The canal is not the same as it was when we first moved in

- The midges where we live No7 Gamban Ave are unbearable at low tides and after very high tides. I am not only speaking of outside in the garden but also up and down streets. All the rest of the lake is done – Racks near the bridge the full length of the north shore (but then I gather our Councillor lives there) and all of Gamban until no.9. There are 14 dead trees in this area and over 40 sticks – a real hazard at high tide. We all pay rates, we all keep the foreshores clean and natural – why do we not receive the same treatment as everyone else.
- As we, inhabitants, along with many others of this area are now very much a part of the environment, we feel that some compromise must be reached with the natural one to allow us the comfort of being as free of midge attack as possible. After all this relatively small area which we desire to have changed has only been formed because of other man made changes to the upstream environment in previous years
- We love the nature of the lake – the high tide changes the look and use of lake to low tide – we enjoy both
- Particularly love the lake's entrance at low tide when the small sandy beach is available with shelter from both trees and vegetation
- Links to LK must be monitored very carefully and regularly as the flow had a big erosion effect in 2005 on the north headland. As nature was trying to close the entrance the water from LK would not let it and this water was forced into the north headland by the natural closing action from the south thus causing massive sand loss on the northern side of the entrance
- This is a beautiful area, takes my breath away when I look along the creek. Due to the size and speed of development of the area it is more important than ever we do what we can to keep the natural environment at its best. If we could make sure we replace the trees/have lost so many in the last couple of years
- Nesting boxes to help the birds
- Controlled burning along the creek during the winter, the shrubs and trees are in very poor condition due to the drought. Could do with a good pep up. The park in summer is a tinder box along Sunjewel to Nicklin way
- Thank you for the opportunity to have a say
- Copy of letter to Council CEO – Actions on the recommendations in this letter are the subject of current correspondence by FOCL with the Council. Would you please investigate and support on comment on this issue
- As we have many man made "improvements" eg canals/weirs, I feel more of the Currimundi Lake needs to be treated as a canal. The only way in my opinion is to start stabilising sections of the waterway that is collapsing at a rapid rate. Rocks need to be placed in the most crucial areas before it is too late. I notice that some rock stabilisation has already been done. That side of the waterway now seems ok while the other side is falling in. Why was this work not continued?
- Currimundi Lake and the canal areas are a beautiful part of the Caloundra area. They are used extensively by a wide variety of people/residents, visitors and tourists for kayaking, surf life saving training, swimming, fishing, bike riding, walking – people of all ages and physical abilities. I competed at the Australasian Masters Games in Adelaide in October. I won 5 gold medals and 1 silver in kayaking – most of my training is on Currimundi Lake and canals. I also train on Lake Kawana. It is very important that the protected area near Cocos is kept as a recreational area for children and families. There should be a lifeguard there during school holidays – at the lake itself
- Currimundi Lake has become an overflow drain for Lake Kawana and canals. Has become a silted up drain

- Ideas and improvement practices should consider the catchment in its totality
- Turbidity levels are a disgrace
- What is the future of the lake? How do we get there? Should we have the Kawana link? What will the overall cost be to the people and the council depending on where the group wants to go and will it be sustainable? What is the most important – People/recreation of lake, a green lake, or a combination of both and if so is it sustainable? Cap people, high-rise and too much infrastructure and maintain/improve vegetation? The dunes/beach needs to be part of the whole plan
- Open and close the lake think about – Council need to plan a time frame (its opens 4days after its closed). The lake has cost the ratepayers a lot of money. Its time to think about our lake. Over the last 3-4years the local councillor has made blunders and plus what a mess and very costly.
- The midge eradication – What a fiasco – What that cost us ratepayers? Maybe our local councillor should have given all residents a can of Aeroguard
- A clean up of the Environmental Park is much needed. It is currently a fire hazard. Catchment Care volunteers and locals have done a great deal, however, Council needs to get involved
- Wildlife encouragement with possum boxes, bat boxes etc would help to encourage native wildlife
- Teenagers making swings off trees and digging clay out of the creek banks are causing an environmental problem as well as a social problem for this area
- We regularly site animals, which show good signs of native breeds in this area eg possums, frogmouth owls, goannas, bats, etc. We have also seen foxes in the Environmental Park
- We have lived here since 2001 and have regular visitors from interstate and overseas – many with young children. They and we are very concerned with the impact of the biting midge that frequently requires children to be either indoors or covered in toxic prophylactic treatments. In many cases while we have enjoyed the amenities of the area, guests have elected not to return siting the biting midge as the major deterrent

Name	Address	Email	Would like further information on the Currimundi Lake Dynamics Study? Y/N	Would you be interested in joining a community focus group for Currimundi Lake? Y/N	Phone Number
Graham Smith	PO Box 1357 Caloundra		Y	N	
K. Blake	54/2 North St Caloundra		Y	N	
Jason Porter	2 Holt St Currimundi	j.m.porter@hotmail.com	Y	N	5493 4316 0413661066
Jenny Allan	8 Piringa St Wurtulla	Allan7@iprimus.com.au	Y	Y	5493 9695
David Allan	8 Piringa St Wurtulla	Allan7@iprimus.com.au	Y	Y	5493 9695
Sylvia Ginty	13/9 Lomandr Drive		Y	N	
Pat Norton	11 Lilac Cres. Currimundi	pat@setu.net.au	Y	N	
Paul McDonald	18 Dominica Place KI		Y	N	
Steve Dobos	6 Tandian Cr. Bellbowrie		Y	N	
Don & Joy Potter	27 Gannawarra St	joypotter@bigpond.com	Y	Y	5493 1990

Name	Address	Email	Would like further information on the Currimundi Lake Dynamics Study? Y/N	Would you be interested in joining a community focus group for Currimundi Lake? Y/N	Phone Number
Danny O'Kearny	33 Coonparr Esp. Wurtulla		Y	Y	
Lorraine Yarrou	10 Gamban Esp Currimundi Lake		Y	Y	
R. J. Yarrou	10 Gamban Esp. Currimundi Lake		Y	Y	
Helen Norman	5 Barwon St Currimundi		N	N	5491 5318
Cliff Hargreaves	17 Hume Pde. Currimundi		N	N	
Bill Alexander	18 Currimundi Rd	rhonbill@bigpond.net.au	Y	Y	5437 6481
Bill Hume	21 Hume Pde Currimundi		Y	Y	
M. Watson	13 Bowman Rd Caloundra		Y	N	
Ron O'Neill	18 Gannawarra St Currimundi	Ron.oneill@raywhite.com	Y	N	0431350592
Cec Munns (?)	11 Watson St Currimundi 4511	Avova.c@bigpond.com	Y	Y	54938251 0414841216

Name	Address	Email	Would like further information on the Currimundi Lake Dynamics Study? Y/N	Would you be interested in joining a community focus group for Currimundi Lake? Y/N	Phone Number
Lorraine Jenkinson	42 Swallow St Wutulla	jenko@bigpond.net.au	Y	Y	
Rob Burnett	29 Lakeshore Pl Little Mountain	rburnett@bigpond.net.au	Y	Y	
Keryn Jones	7 Redwood Court Currimundi	accordelec@hotmail.com	Y	Y	
Dennis Hicks	7/7 Bunya Pl Currimundi Lvl3/132 Bulcock St Caloundra 4551	hicksbd@bigpond .com hicks@sc.placedesigngroup.com	Y	Y	5499 6188 0407385202
Hannah Welch	34 Piringa St Wurtulla	tradedebtors@optusnet.com.au	Y	N	
Peter McKenzie	18 Piringa St Wurtulla		Y	N	
Lesley Porter	2 Holt St Currimundi	lesleypp@bigpond.net.au	Y	N	
Joan Andrews	5 Coongarra Esp Wurtulla		Y	N	
P. J. Poole	4 Karunda St Wurtulla		Y	Y	
Mick Smith	7 Lalwinya St Buddina	smithm@maroochy.qld.gov.au	Y	Y	5441 8430

Currimundi Lake Dynamics Study

Community Environmental Values meeting

Thursday December 6, 2007
The Events Centre, Caloundra

Agenda

6.30pm Welcome and introduction by Chris Allan (CCC) and Councillors

6.50pm Presentation of Currimundi Lake Dynamics Study research findings to date by GCCM team.
Professor Rodger Tomlinson (GCCM)
Introduction and project summary

7.20pm Questions and discussion from community.

7.40pm Where to from here?
Peta Williams (GCCM) and Denise Johnson (CCC)
Survey and formation of working group.
Community members and stakeholders who wish to become further involved in the CLDS by taking part in a working group will be asked to stay behind and provide contact details. It is intended that these people will make up a stakeholder committee / working group to aid in identifying a set of environmental values for Currimundi Lake.

7.50pm Community feedback and survey

8.00pm Tea and coffee provided

Contact Information:
Denise Johnson – Caloundra City Council Ph: 5499 5135
Peta Williams – Griffith Centre for Coastal Management Ph: 5552 8530

CALOUNDRA CITY
University of the Sunshine Coast Queensland, Australia
GCCM Griffith Centre for Coastal Management
Griffith UNIVERSITY

Catchment name: **Currimundi Lake**

Issues / Interests

															
Your choice	**10**	**10**	**10**	**7**	**10**	**9**	**10**	**NA**	**2**	**1**	**1**	**1**	**1**	**2**	**7**
Low				**3**		**2**									
Medium			**2**	**2**	**2**	**1**	**1**			**1**					**1**
High	**10**	**10**	**8**	**2**	**8**	**6**	**9**		**2**		**1**	**1**	**1**	**2**	**6**

Priority

Lake Currimundi Dynamics Study – Focus Group Workshop
12th February & 11th March 2008
6.00pm – 8.00pm
Lake Kawana Community Centre

The purpose of the stakeholder working group is to establish a set of community values (CV) for Lake Currimundi. These can include for example: recreation, water quality, flora & fauna, erosion, education, midge control, or aesthetics. Selecting or determining CVs is fundamental to determining appropriate water quality objectives, direction of management strategies for that waterway and developing knowledge to assess and monitor the performance of those strategies. Stakeholder involvement is essential to this process as it is a visioning exercise to determine what the community values as being important to protect, conserve or enhance.

It was proposed to have two working group meetings, the first being aimed at preliminary formulation of CVs for Lake Currimundi, and the second aimed at finalising these values and the major issues of concern.

CCC and GCCM would like to invite you to attend a series of working group meetings. It is hoped that your involvement will play an integral role in the future adaptive management of Lake Currimundi.

The details of the first stakeholder working group meeting are as follows:
Date: Tuesday 12th February
Time: 6.00pm – 8.00pm
Location: Lake Kawana Community Centre – Meeting Room 1 & 2

The details for the second meeting are as follows:
Date: Tuesday 11th March
Time: 6.00pm – 8.00pm
Location: Lake Kawana Community Centre – Meeting Room 1 & 2
(Light refreshments will be provided at both meetings)

For further information and to RSVP (for catering purposes), please contact Denise or myself on the details provided below.

Thank you for your time and interest, I look forward to meeting with you.

Kind Regards

Peta Williams
Project Manager
Griffith Centre for Coastal Management
Ph: (07) 5552-8530
Denise - CCC: (07) 5499-5135

DRAFT AGENDA
FIRST WORKING GROUP MEETING

6.00-6.20pm* Welcome and Introduction

6.10-6.20pm Aims and outline of workshop

6.20-6.40pm Background, preliminary findings overview, and summary of community survey results. Background of CV process

6.40-7.10pm Question and answers

7.10-7.20pm Formulation of sub-groups/discussion on how groups should be formulated

7.20-7.40pm Issues for preparation of meeting two

7.40-8.00pm Closing issues and discussion of meeting two

** Light refreshments on arrival*

CURRIMUNDI LAKE STUDY

SUMMARY OF PRELIMINARY WATER QUALITY RESULTS FOR CURRIMUNDI LAKE
Summary Sheet 1 – February 2008

Dr Aaron Wiegand, Assoc. Prof. Thomas Schlacher
University of the Sunshine Coast

Introduction

This document provides a synopsis of key points emerging from the preliminary analysis of historical records of water quality measurements in the Currimundi Lake system and associated canals.

Method

Caloundra City Council have taken monthly measurements of water quality indicators in the Currimundi Lake system and associated canals, since 2001. These indicators include temperature, dissolved oxygen (mg per L and %), pH (acidity), conductivity, salinity, faecal coliforms, nutrients (ammonia, nitrogen oxides, reactive phosphorus, total phosphorus), turbidity and suspended solids.

These data were assessed to address two primary questions:

- Does water quality conform to guidelines set out by Queensland EPA?
- Has water quality changed substantially following dredging of the mouth and pumping of fresh water from Lake Kawana since 2004?

The Currimundi system falls into the Qld EPA water quality guidelines under the category of “Mid-estuarine and tidal canals, constructed estuaries, marinas and boat harbours”.

Key Observations

The following observations are not specific to any of the sampling sites, but reflect the general nature of water quality in the system as a whole.

- Since 2001, temperature, salinity and pH measurements were generally within guideline levels;
- Faecal coliforms were generally within guideline limits for secondary exposure, but many observations were significantly higher after events such as storms;
- The systems appears hypertrophic with respect to Nitrogen levels: almost all ammonia, oxidized-N and total-N measurements were above the guideline values;
- The total phosphorus and orthophosphate concentrations were within the guidelines most of the time;
- There is evidence of hypoxia, with dissolved oxygen concentrations being consistently lower than guideline values.

Changes in water quality indicators since 2004

The following table shows that the values for nearly all water quality indicators have improved since 2004.

For all indicators except dissolved oxygen and pH, a decrease (negative percent change in mean magnitude) is a desired outcome.

The percent exceedences denote proportion of measurements that breach guideline values. The “ncv” denotes that “no critical value” is specified in the guidelines.

Indicator	% Change in mean magnitude	% Exceedences before Jan2005	% Exceedences after Jan2005
Temperature	3	ncv	ncv
Dissolved Oxygen (mg per L)	25	ncv	ncv
Dissolved Oxygen (%)	27	100	93
pH	0.3	12	7
Conductivity	-14	ncv	ncv
Salinity	No pre-data	ncv	ncv
Faecal Coliforms	-12	13	13
Ammonia	-24	98	89
Nox	-23	68	56
Total N	2	74	90
Reactive P	-57	21	13
Total P	-43	44	34
Turbidity	-9	29	35
Suspended Solids	-11	98	99

In most cases, improvement in water quality indicators have been enough to significantly reduce the number of exceedences of the guidelines, but several indicators (i.e. suspended solids, total N, dissolved oxygen) regularly breach guideline values, suggesting that water quality is poor and the systems is overly turbid, enriched in nitrogen and starved of oxygen.

Summary

- Water quality indicators show a general improvement in average water quality since the Currimundi mouth was opened and pumping from Lake Kawana commenced;
- Despite the improvement since 2004, several water quality indicators continue to regularly exceed the water quality guidelines;
- The role of external drivers (e.g. significant rainfall events) is likely to be an important factor in determining water quality of the system and how often guideline values are breached. However, the exact relationship between weather and catchment drivers on the receiving water quality in the system has not been quantified to date. Similarly, the influence of tidal flushing is unknown at present.

Currimundi Lake Community Survey
- Caloundra -

January 2008

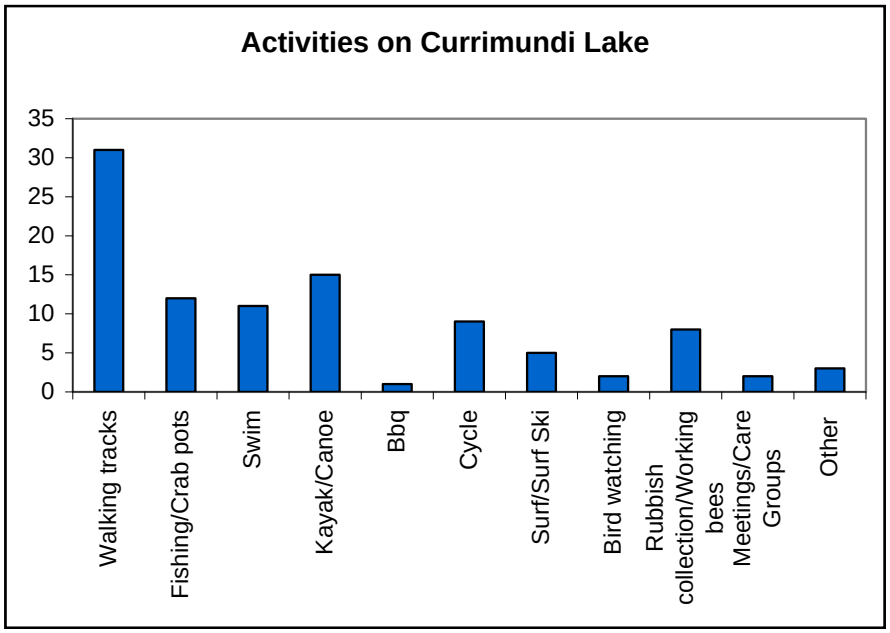
Introduction

Initial consultation with the community on the Currimundi Lake Dynamics Study was undertaken via information sheets and surveys distributed to community members with the Currimundi region. Approximately 120 surveys were distributed (52 completed surveys were returned).

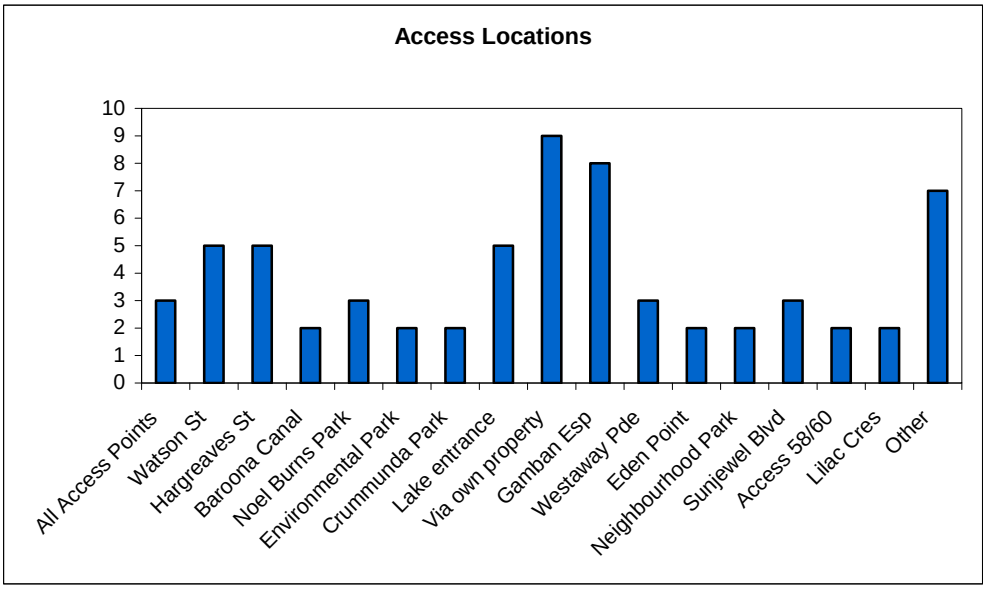
The information and feedback received via the community survey (and the community meeting) provided valuable information on the communities understanding of the health of the lake, their expectations and issues, as well as some information on usage of the lake and surrounding areas. A summary of the results of the survey is given below.

Some Survey Results

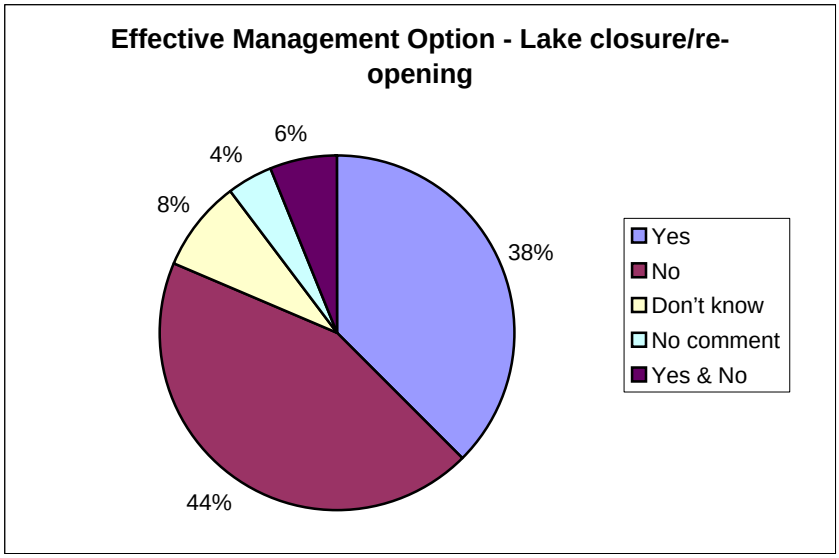
Lake Activities



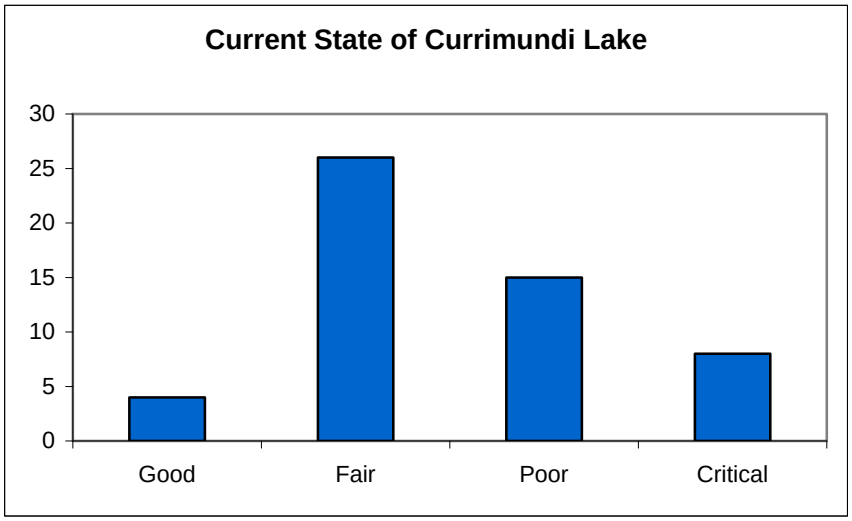
Access Points



Entrance Management



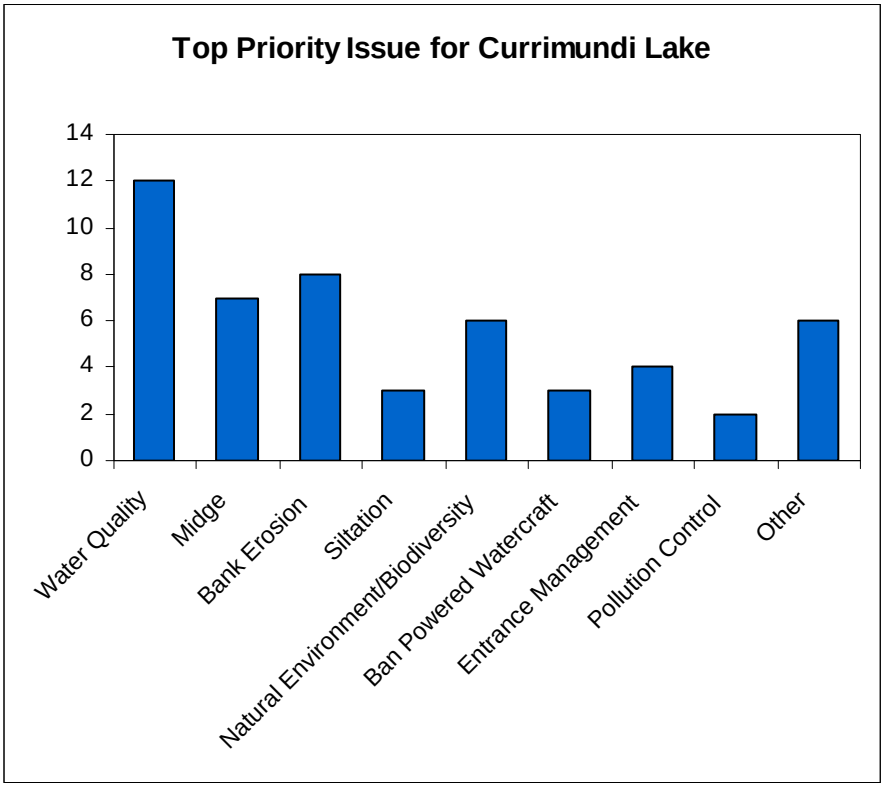
Current State

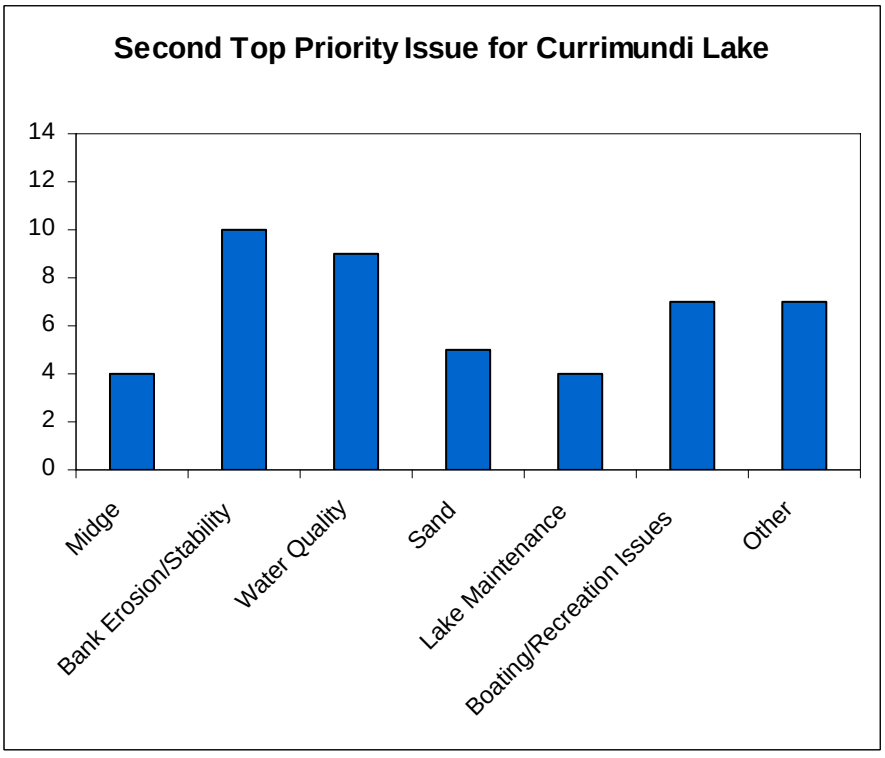


Triple-Bottom-Line Values

		Negligible	Low	Medium	High	Very high
Recreation	Sunbathing, swimming, surfing	2%	2%	18%	44%	34%
	Dog exercising	11%	24%	20%	38%	7%
	Walking	2%	2%	13%	42%	42%
	Non-motorised water activity	6%	6%	17%	29%	42%
	Motorised water activity	33%	39%	20%	4%	4%
	Fishing & bait collection	10%	14%	44%	28%	4%
	BBQ/picnic facilities	2%	8%	24%	45%	20%
Residential	Lake aesthetics	3%	0%	10%	31%	56%
	Shoreline stability	2%	0%	14%	31%	53%
	Enhanced property value	12%	13%	29%	21%	25%
Biodiversity	Lake flora & fauna	0%	2%	13%	15%	71%
	Birds	0%	0%	6%	24%	69%
	Fish species	0%	4%	8%	25%	63%
	Crabs	2%	4%	6%	26%	62%
	Impact of midge	6%	9%	17%	21%	47%
Water quality	Flushing of Lake through entrance	4%	0%	19%	21%	56%
	Water clarity/colour	4%	10%	19%	17%	50%
	Stormwater improvement	0%	8%	6%	18%	67%
Links	Link to Lake Kawana	25%	17%	17%	10%	31%
Economic	Access to shops/cafes/ accom.	22%	12%	31%	24%	12%
	Car parking	8%	31%	22%	22%	17%
	Recreational equipment hire	41%	38%	10%	8%	4%

Top Priority Issues





Contact Information

For further information on this project please contact Denise Johnson at Caloundra City Council on d.johnson@caloundra.qld.gov.au or Peta Williams from the Griffith Centre for Coastal Management on peta.williams@griffith.edu.au.

Catchment name: **Currimundi Lake**

Issues / Interests

															
Your choice	**10**	**10**	**10**	**7**	**10**	**9**	**10**	**NA**	**2**	**1**	**1**	**1**	**1**	**2**	**7**
Low				**3**		**2**									
Medium			**2**	**2**	**2**	**1**	**1**			**1**					**1**
High	**10**	**10**	**8**	**2**	**8**	**6**	**9**		**2**		**1**	**1**	**1**	**2**	**6**

Priority

APPENDIX 5 – BANK EROSION MANAGEMENT OPTIONS

A.5 STREAM BANK EROSION AND ASSOCIATED PROBLEMS

Many stream banks have been greatly altered from their natural condition since Europeans first settled in Australia. Some of these changes include the introduction of grazing, changes to riparian vegetation types and density, changes to water quality and quantity the waterways are required to carry and increased recreational and commercial use of waterways. The results of these changes have affected the relationship of the river to its banks and consequently increased the susceptibility of the banks to erosion (Frankenberg & Tilleard, 1991).

Streambank erosion is a serious natural resource problem that requires effective management techniques (Frankenberg & Tilleard, 1991). Whilst erosion is a natural process it can result in various problems including the following:

- Loss of productive agricultural land and damage or destruction of infrastructure, such as roads and bridges
- Increase in sediment loads that are carried by the water bodies which result in the degradation of their recreational value and aquatic ecosystem health; and
- Changes to flow regimes, with the potential for increased flooding

A.5.1 Bank Stability and the Causes of Erosion

The stability of a stream bank is dependant upon the ability of the bank to resist erosion and the forces acting upon it. The ability of the bank to resist erosion is related to soil type, vegetation and bank profile. The shear strength of the soil can also be influenced by the water quality within the system, dredging, trampling and animal activity. Stresses applied to the stream bank by fluid forces are the most significant. According to White (1988), these forces may take the form of streamflow, tidal activity and wind or boat generated waves. They may result in the removal of individual soil particles or larger aggregates (White, 1988).

Strong shear forces exerted on a stream bank along with weak banks can result in the removal of soil particles. If peak shear stress is greater than stability shear stress, then erosion will occur. Particle removal generally occurs below the rooting zone and can lead to undercutting. An undercut block may eventuate, which will fail once stability passes beyond the critical limit. According to White (1988), the maximum stress exerted on the bank is at the waterline. Boat waves may cause the banks, which lay above the waterline, to experience both wetting and drying. This can accelerate the erosion process of clay type soils. Submerged banks may experience stability loss during periods of drawdown due to buoyancy loss that is usually provided by the water. Failure occurs once the effect of gravity overcomes the tensional strength of the bank material (White, 1988).

A.5.2 Classes of Bank Erosion

Various factors may play a role in bank erosion. Bank erosion processes may be categorised according to the following classes:

1. Sub-arterial erosion – This includes those processes that are not related to the stream (e.g. rill erosion, stock trampling, rain splash, frost heave).

2. Fluvial scour – Where the forces of the water are greater than the ability of the bank to resist those forces. Scour increases with flow velocity and shear stress (a product of depth and slope) and tends to increase at the outside of meander bends.

3. Mass wasting/gravity failure – When large sections or blocks of the bank collapse into the stream.

A.5.3 Role of Vegetation in Bank Stability

Streambank erosion is heavily influenced by the riparian vegetation type and density (Arthington *et al*., 1992). This, in conjunction with increasing environmental and economic concerns, has seen the restoration of many stream ecosystems focus on riparian zone management, due to the positive effects that riparian vegetation has on stream environmental quality and the reduction in costs usually associated with revetment wall construction and maintenance. Riparian management is often used to stabilize banks, recreate habitat, restore natural channel morphology and reduce erosion. Riparian vegetation protects stream banks in three ways:

1. Water velocity is decreased and subsequently the erosive force of the water is reduced. Riparian vegetation slows down the water velocity in the channel during average flows and on the flood plain during associated high flows. As a result, the detachment capability and the transport capacity of the water are greatly reduced.

2. A physical barrier is created between the water and the bank materials. Plants that are able to cover large amounts of the soil surface area or flatten during flow create a physical barrier between the flow and the bank material. As such, the erosive force of the water is dissipated by the barrier created between the bank materials and the vegetation.

3. The soil is bound together by the plant root systems. The root systems of the plants that make up the riparian vegetation bind the soil particles together, reducing its erodibility by mechanically reinforcing the soil.

Riparian vegetation may also influence the cross-sectional shape of the channel and prevent slumping, which may occur when vegetation is not present. Proper management of riparian vegetation may also improve aesthetics, provide wildlife corridors, reduce algal growth by reducing the water temperature and improve water quality through a reduction in turbidity and pollution.

A.5.4 Boat Generated Waves and Stream-Bank Erosion

Erosion from boat wash follows the following mechanism:

1. Soil is removed from the root mat of trees and any emergent plants that may exist close to the banks and from the roots of marginal bank vegetation. Erosion may accelerate rapidly in clay-free areas once the vegetation is removed.
2. Tree lined banks may fail once the soil around the roots is removed and the tree becomes unstable. This will depend upon the depth of the roots and size of the tree.
3. A wave-cut platform extends into the bank.

A study by Nanson *et al.* (1994), on stream bank erosion caused by boat generated-waves illustrated that a number of the measured wave characteristics showed a high association with measured rates of erosion. One of the simplest characteristics associated with erosive energy is wave height. The study found that wave heights greater than 35 cm caused all but the most resistant bank sediments to erode. As shown in Figure A5.1, the erosion rate slowly increased up to wave heights around 25cm. For wave heights greater than 35cm the erosion rate increased rapidly.

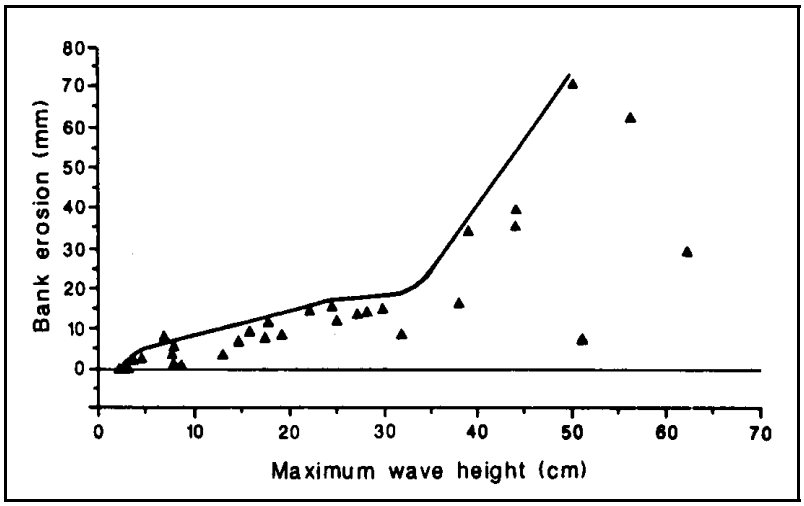


Figure A5.1: Relationship between wave height and bank erosion (Nanson *et al*., 1994).

The study also found a strong correlation existed between wavelength and bank erosion and wave period and bank erosion. Figure A5.2 shows that bank erosion is initiated at wavelengths of 2 metres (m) and increases rapidly at wavelengths above 12m. Figure A5.3 shows that bank erosion may occur at wave periods of 1s with accelerated erosion rates occurring at wave periods above 2.75 seconds (Nanson *et al*., 1994). It can be concluded from the study by Nanson *et al*. (1994), that the rate of erosion of channel banks caused by boat wash is determined by a number of wave characteristics.

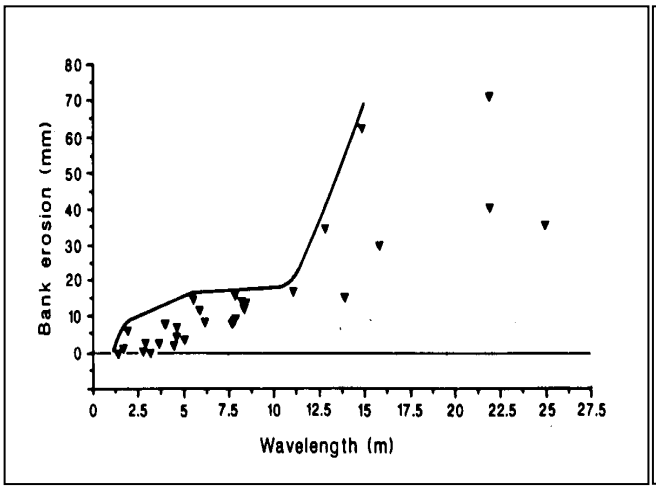


Figure A5.2: Wavelength vs bank erosion

(Nanson *et al*., 1994)

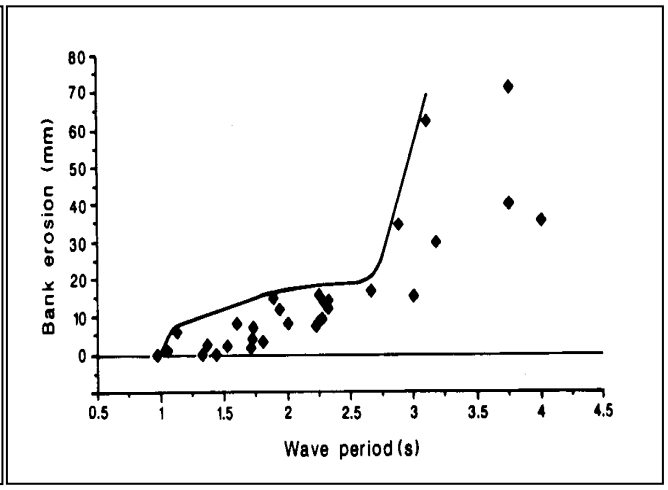


Figure A5.3: Wave period vs bank erosion

(Nanson *et al*., 1994).

A.5.5 Catchment Development and its Effect on Bank Erosion

Urbanisation of a catchment involves sealing the land with impervious surfaces such as pavements and roofs. These impervious surfaces alter all aspects of the hydrologic balance by repelling water away from infiltration, soil moisture, recharge, subsurface storage and base flow. The deflected water creates quick moving runoff that moves down stream systems and out of the landscapes where it originated. Studies of various stream systems have shown that for a given amount of storm precipitation, the flow volumes and velocities within the stream system increased. These increased flow rates result in stream bank erosion and increased water turbidity.

Urbanisation in watersheds can exacerbate channel erosion in two ways:

1. It can lead to increased peak storm flows and thus increased peak velocities.
2. The storm flow volume can be increased and as a result, the time during which the velocity of the water is over an erosive threshold is lengthened. This increases the amount of total erosion and the amount of sediment generated during a storm event.

The high volumes of flow that follow urbanisation tend to extend the times of moderate flow rates due to stormwater detention and this also increases the total amount of erosion.

A.5.6 Dredging and its Effects on Bank Erosion

Dredging a channel and deepening it may result in reduced peak tidal velocities. If the velocity is reduced to such a level that sediment transport cannot occur, accelerated deposition may result and eventually the channel will return to an equilibrium channel depth. Dredging of a channel increases the tidal range within the system and as such, increases the potential for bank erosion to occur. The tidal system attempts to return to a state of energy equilibrium, after the change in tidal prism, by returning the creek to its original cross-sectional area. This is achieved through the deposition of sediment. The sediment may also be obtained from the creek banks, resulting in erosion.

A.5.7 STREAM BANK MANAGEMENT OPTIONS

According to White (1988), stream bank erosion management may be applied in two ways: (i) reduce the forces acting on the stream banks, and/or (ii) increase the ability of the bank to withstand the forces acting on it. Reducing the forces that act on the stream bank may require consideration of the following options:

A.5.8 Reduction of Boat Wash

"The critical factor is the shear stress generated by the wave when it hits the bank compared to the strength of the bank material" (White 1988). Reducing boat wash may be achieved by the following means:

(a) Reduce the speed of the boats - Increases in boat speed result in an increase in wave height and its associated shear stress. A study by Nanson *et al*. (1994), showed that the introduction of a speed limit dramatically reduced the rate of bank erosion. Boat speeds within a channel should be determined by considering the type of bank material, the shape of the bank profile, the amount of protective vegetation and the

channel width and depth. As shown in Figure 16 wave heights increase exponentially with boat speed. Therefore a reduction in boat speed can result in a dramatic decrease in wave height (White 1988). The recommended speed for most small stream systems is currently 6 knots.

(b) Reduce boat proximity to banks prone to erosion - Wave height from a boat reduces with distance (Figure 16). Controlling the distance between boats and the bank could prove to be an effective way of controlling erosion. In most stream systems however, the markers outline the channel where safe passage may be made and it may not be possible to change markers given the narrow width of many streams (White 1988).

(c) Hull design - According to White (1988), there has been little variation shown between wave heights created from various hull designs. Even if improved hull design became a possible erosion control variable, it would be some time before its implementation would have a significant impact, given the life expectancy of most boats today (White 1988).

(d) Boat numbers - reducing the number of boats would obviously lessen the amount of erosion resulting from boat wash. Although studies have shown this to be an effective method in reducing the rate of bank erosion (Nanson *et al*., 1994), it would not be a practical solution for most situations and would undoubtedly prove to be unpopular with recreational boat users (White 1988).

A.5.9 Bank Resistance to Erosion

An option in managing bank erosion involves increasing the ability of the bank to withstand erosive forces. There is a range of options that are available – from hard engineering structures through rehabilitation of the riparian vegetation. In summary the various options can be divided into the following categories which will be discussed in brief.

- Vegetation
- Soft (structural) options
- Hard structural options

A.5.10 Riparian vegetation rehabilitation

A healthy, diverse riparian vegetation alongside a waterway can reduce erosion whilst improving the quality of the water and providing an aquatic habitat. Increasing the density of the bank side vegetation will increase the stability of most stream banks and reduce erosion. Streamside vegetation should be based on locally native species. It should include both the use of trees and shrubs. O'Connell and Wiltshire (2005) make a strong argument that in NSW ICOLLs the main problem has been the restricted capacity for re-colonisation of species that have been affected by erosion or elevated water levels.

According to Lyons *et al*. (2000), woody vegetation (i.e. – shrubs and trees > 2m in height) is more suited for providing bank stabilization in areas where the eroding banks are high (>1m) and steep (>45° angle with water). Grassy vegetation may be more effective in areas where the banks are lower and less steep. A bank that is to be revegetated should be graded to a stable slope having the dimensions of 1 Vertical: 2 Horizontal, or flatter.

In some cases where the stream has deepened either through natural or man-made processes, the use of vegetation to stabilize the banks will not be adequate. In situations where the banks are high and the rooting system of the vegetation does not extend down to the toe of the bank, large vegetation such as trees may increase bank instability if the lower bank is subject to erosion and undercutting.

A.5.11 Soft (structural) options

The are a few techniques which are structural in form, but which provide a "softer" option to rock or concrete revetments. These include the following:

Geotextile Bags

Bags constructed from geotextile fabric can be configured to produce a wall that intercepts and absorbs wave energy before it reaches the bank. Any wave energy that passes over the GeoBag barrier (at high tide or during flood events) will only transport foreshore material back to the base of the GeoBags on the shoreline side, not back into the navigational channel. The Geotextile fabric is significantly softer than concrete so damage to boats and swimmers is greatly reduced. The GeoBags are filled with local soil or sand material which will have a reduced impact on the local environment.

Gravel or cobble fillets on berm

A simple yet effective solution to a wave erosion problem is to install gravel or cobble fillets along the erosion effected bank. Where wave action has eroded the stream bank at the water level, and bank recession has resulted in a shallow underwater bench, a fillet of gravel or cobbles could be placed to prevent further wave attack of the bank. Vegetation can be planted to provide further stability and create a valuable habitat. This method is only applicable where there is a significantly low tide bench and where flood velocities do not exceed 1.5m/sec (Tweed Shire Council, 1998).

Coir mats or logs

Made from 100% biodegradable organic coconut fibre, Coir Logs are an inexpensive solution which can slow and deflect the water flow, holding the soil in place, and serving as a growing medium for the establishment of vegetation along the bank. This method is affective when applied to low flow areas experiencing low to moderate effects of erosion. The Coir Log flexibility allows the coir rolls to be placed along the natural contours of the bank/channel. Following installation the material can be planted with suitable vegetation which once established needs little or no maintenance.

Rock Riprap

Rock rip rap is the most common and economically viable method of stream bank stabilisation. The method involves the deposition of rock on the intertidal zone. Riprap completely eliminates erosion by trapping intertidal material underneath a blanket of rock, all erosive energy is dissipated before contacting sand or soil. Voids within the rocks allow vegetation to grow through it. One obvious problem of rock rip rap is the risk to public safety as it can be difficult to walk on and damage to water craft is also a possibility.

A.5.12 Hard structural options

The most common hard structural option is to construct a revetment wall. As shown in Figure A5.4, a revetment consists of an armour layer, a filter layer and other

possible sub layers. The armour or cover layer may be rigid or flexible depending on the material used for construction. The advantage of a flexible revetment is that it provides for some degree of movement or deformation of the structure as a result of settlement of the underlying material.

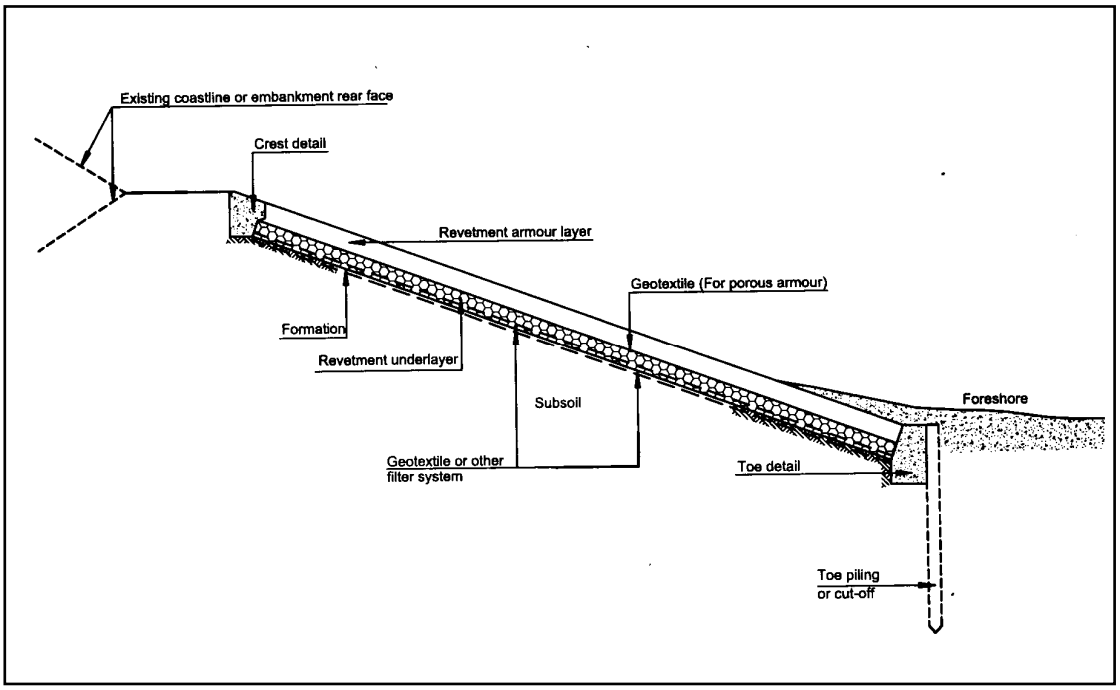


Figure A5.4: Features of a revetment wall (McConnell, 1998).

A permeable or impermeable revetment may be constructed depending upon the choice of construction material. The purpose of the filter layer is to ensure appropriate drainage of the system whilst avoiding the build up of excessive hydraulic pressure and the migration of fine material. It is located beneath the cover layer and is sometimes referred to as the under-layer. Crest details such as crown walls, wave walls or return walls may be built into the design to limit overtopping of the structure. Toe details such as a toe beam, piling, a toe trench or wooden stakes may also be incorporated in the revetment to stabilize the toe and prevent possible scour of the foreshore in front of the structure.

Materials used in Revetment Construction

Various materials may be used in the construction of revetment walls.

Rock

In addition to the rip-rap discussed in the previous section larger rocks similar to that shown in Figure A5.5 can be used.

Figure A5.5: Example of Rock Wall

Concrete Blocks and Slabbing

Concrete blocks may be used as an armour layer in a revetment wall. The blocks may be free, interlocking or integrated through the use of cables or wires. Concrete blocks are often used to form permeable revetments when constructed on coastal or estuarine environments. Using a filter layer with a lower permeability than the armour material should ensure stability of the revetment. Greater stability may be gained by using interlocking blocks.

An example of interlocking concrete block units is the A-Jacks system. A-Jacks are a registered product of Hanson Australia. They are geometrically designed to allow configuration into a wall by interlocking many individual units or they can be randomly placed around a problem area. Their interlocking ability allows interaction between the stream system and the bank whilst stopping intertidal material loss. Problems associated with this method are the A-Jacks can potentially pose threats to people and boats especially at high tide, they are unsightly and unaesthetic, heavy lifting equipment is required to place the units, and the project may also require specialised divers to lay foundation layers.

Asphalt

A range of asphalt mixes, containing various proportions of bitumen binder and sand, exist that can be used to construct revetments.

Various types of asphalt mix are used in revetment construction including the following main types.

- Asphalt Concrete
- Mastic and grouting
- Dense Stone Asphalt

- Open Stone Asphalt
- Lean Sand Asphalt

Gabions
Gabions are formed by stacking rock filled wire containers. Stability is provided by the self-weight of the revetment. The flexibility of the units allows them to conform to small ground surface changes.

Used Tyres
Used automobile tyres have been used successfully as a revetment structure. Closely spaced tyres are placed on the bank or on filter cloth and attached together with chain, wire or rope to create a mat. To reduce floatation problems tyres can be filled with soil, stone or concrete. This type of revetment is unsightly at first but does improve aesthetically once sediment deposits on the tyres and vegetation becomes established.

A.5.13 Summary of appropriate management options

Table A5.1 presents an options assessment developed by Kirkpatrick et al (2008) for Saltwater Creek on the Gold Coast. This location has many similarities with Lake Currimundi, and the suite of options is deemed the most appropriate for consideration here.

A.5.14 References

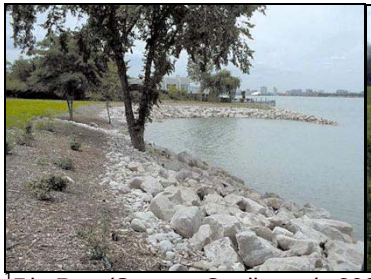
1. Arthington, A.H., Bunn, S.E.. & Catterall, C.P. (1992) "The Ecological Roles of Riparian Vegetation", *The Role of Buffer Strips in the Management of Waterway Pollution from Diffuse Urban and Rural Sources,* – proceedings of a workshop held at International House, University of Melbourne, 9th October.
2. Frankenberg, J & Tilleard, J. (1991) "Protecting River Banks from Erosion", *Australian Planner*.
3. Lyons, J., Trimble, S.W. & Paine, L..K., (2000). "Grass versus Trees: Managing Riparian Areas to Benefit Streams of Central North America", *Journal of the American Water Resources Association*, vol 36 (4): 919-930.
4. Nanson, G..C., Krusenstierna, A., Bryamt, E..A. & Renilson, M.R. (1994). "Experimental Measurements of River-Bank Erosion caused by Boat-Generated Waves on the Gordon River, Tasmania", *Regulated Rivers Research and Management*, vol 9:1-14
5. White, W.R. (1988). *International Conference on RIVER REGIME*. Hydraulics Research Ltd. Wallingford, England.

Table A5.1: Appropriate Erosion Management Options

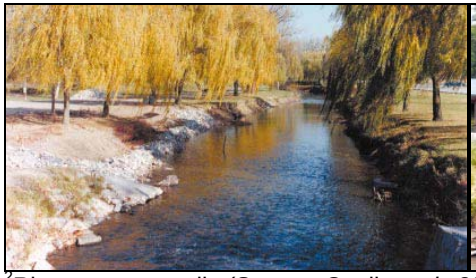
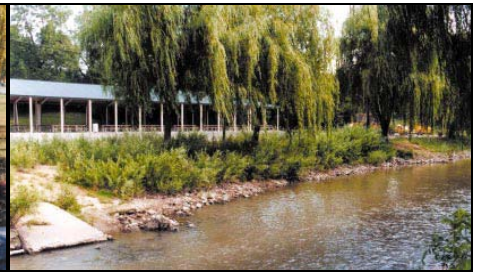
available measure	Description	Installation techniques	Capital Costs	Maintenance cost	Advantages	Disadvantages	Characteristics of site
Revegetation	Use of native plants species, particularly those with extensive and deep root systems	Replanting native species	Approx $7.50/$m^2$	Low However, maintenance may be required for several years to ensure adequate establishment of vegetation	Aesthetic, re-establishment of riparian area, improved fish and wildlife habitat, improved water quality, improved sediment and nutrient control	Not suitable for all sites, particularly those with potential high flow and velocity and those suffering severe erosion and bank instability	Most successful in smaller streams or where banks are reasonably stable (i.e. where banks are not seriously eroded)
Rip rap[1] (rock rubble) + revegetation	Rip rap consists of coarse angular rock of varying sizes, generally up to 1 m max. across the longest flat surface.	1. Excavation 2. Rip rap placed within excavated site at the toe of the eroded bank (rock toe protection can be required) 3. Planting of native species (installation of bush mattress and topsoil may be required)	Land access: Approx $35/$m^2$ Barge access: Approx $55/$m^2$	Low Average $25/$m^2$/yr Regular inspections required, rocks can become displaced during extreme flow	Instant protection, stabilises the bank, flexible, allows for revegetation, improved fish and wildlife habitat, impact on stream flow capacity	Visually harsh until vegetation established, hard structure remains visible Can be undermined if area is prone to bed scour	Areas with bank instability and a lack of riparian vegetation
Rip rap (rock rubble) + geotextile[2] + revegetation	Rip rap consists of coarse angular rock of varying sizes, generally up to 1 m max. across the longest flat surface. Geotextile is a woven fabric used here to reduce erosion of fine underlying sediment	1. Install soil erosion and sedimentation control measure 2. Excavation for the installation of rock toe 3. Geotextile placed in the excavation 4. Rocks placed over geotextile 5.Vegetation to stabilise the area above the rock toe	Land access: Approx $70/$m^2$ Barge access: Approx $90/$m^2$ (with geotextile of 4 m width)	Low Average $25/$m^2$/yr Regular inspections required, rocks can become displaced during extreme flow and geotextile can become exposed and damaged	Instant protection, stabilises the bank, flexible, allows for revegetation, improved fish and wildlife habitat, impact on stream flow capacity	Visually harsh until vegetation established, hard structure remains visible Can be undermined if area is prone to bed scouring	Useful in areas of moderate erosion and existing but damaged vegetation
A-Jacks[3] + geotextile	Concrete armour units of complex geometric shape used in conjunction with bio-stabilisation	1. Toe created with A-jacks 2. Lining stones to backfill 3. Installation a geotextile filter between	Land access: Approx $85/$m^2$	Low Average $25/$m^2$/yr Regular	Efficiency proven, quick installation, instant protection, stabilises the bank, flexible allows for	Visually harsh until vegetation established Hard structure can remain visible although	Useful in areas of erosion and bank instability where vegetation is

available measure	Description	Installation techniques	Capital Costs	Maintenance cost	Advantages	Disadvantages	Characteristics of site
		the rock and exposed soils 4. Vegetation	Barge access: Approx $110/m^2	inspection required	revegetation, improved fish and wildlife habitat, impact on stream flow velocity	to a much lesser extent than rip rap.	damaged
Coir logs[4]	Consist of rolls of coir (Coconut) fibre held together with coir netting. Biodegradable.	1. Coir logs staked and tied into place (becoming very heavy once wet). 2. Vegetation	Approx $30 – 50/m	Low Monitoring using basic photo point monitoring and transects is recommended.	Immediate protection, stabilises the bank, natural appearance, allows for revegetation, traps eroded soils, biodegrades over time as vegetation establishes resulting in no permanent structure	Currently being trialled as a product	Useful in areas of moderate erosion and existing but damaged vegetation,

*Costs of options may vary depending on the severity of the erosion and bank instability




[1]Rip Rap (Source: Caulk *et al*., 2000).

[2]Rip rap + geotextile (Source: Caulk *et al*., 2000).


[3]A-jacks (Source: Unknown)

[3]A-jacks (Source: GCCC)

[4]Coir logs (Source: GCCC)

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APPENDIX 6 – CURRIMUNDI CATCHMENT CARE GROUP SUBMISSIONS

Currimundi Catchment Care Group Inc.

ABN77276084162

1st October 2007

Mr Gary Storch
CEO
Caloundra City Council

Dear Mr Storch

Re: Response to Closure of the entrance of Currimundi Lake

I refer to the letter from Denise Johnson, Waterways Coordinator, on your behalf, dated 20th September 2007 outlining the Caloundra City Council's decision to close the entrance of Currimundi Lake as a control measure to reduce the seasonal biting midge population. We appreciate the time Denise has taken to assemble this very informative and comprehensive information.

The letter outlines the monitoring history of biting midge populations over the last three years, the reasons for closure as a primary control option as opposed to spraying, the evidence of successful reduction of midge populations, the reasons for closing the entrance in September, the actions planned to monitor and maintain water quality within acceptable ranges in the whole system for the duration of and immediately after the closure, and acknowledges the inadequate communication to community members in a timely manner. However, we would like to respond to some pertinent points.

(a) The possibility, even probability, of **increased erosion and scouring of the banks of Currimundi Lake and Currimundi Creeks** has not been mentioned. On record, we support the Council's aim to kill or reduce the biting midge population. However, given that, from considerable debate and investigation, the primary control option was to flood the whole system, now what control options will subsequently be implemented to **reduce erosion** to the areas of the lake and creek west of Nicklin Way? We expect that this problem – natural or man-made - also be given the same degree of debate and investigation it deserves.

(b) We applaud the Council's aim to achieve a balance between public health and wellbeing and the environment as a whole. Some recent actions taken by Council in separate sections of Currimundi Lake **east of Nicklin Way** have caused residents to wonder if the Council actually considers the waterbody **west of Nicklin Way** as part of the environment as a whole. With regard to public health, CCCG members have witnessed the potentially dangerous collapse of banks and trees into the lake after prolonged high water levels. In fact, if the tonnes of dirt,

trees and bushes which fell into the lake from this area in June were actually loaded into a truck and dumped off the shoreline **east of Nicklin Way**, the public reaction to such environmental vandalism, waterways pollution, disturbance of fish habitat and potential danger to walkers, kayakers and swimmers would be immediate. We suspect that the Council reaction would be immediate also!

The Currimundi Catchment Care Group's objectives are to improve water quality, limit erosion and to improve the environment of the Currimundi Catchment area. To meet our objectives, we have initiated and undertaken restoration of the riparian zones in many areas along the banks of Currimundi Lake and Currimundi Creek. Costs associated with these activities have been provided by our volunteers, from various grants and from much appreciated assistance from Council. However, this appears to be the only countermeasure to erosion to have been undertaken west of Nicklin Way.

Therefore, we would appreciate information on the actions Caloundra City Council plans to take in the near future as well as proposals for the long term as countermeasures to erosion caused by the closure of Currimundi Lake.

Yours faithfully,
Jenny Allan
Secretary

8 Piringa Street, Wurtulla Qld 4575
Tele: 07-54939695 email: allan7@iprimus.com.au

Currimundi Catchment Care Group Inc.

ABN77276084162

17th September 2007

Mr Gary Storch,
CEO
Caloundra City Council

Dear Mr Storch,

Re: Closure of the entrance of Currimundi Lake

The closure of the entrance of Currimundi Lake began today and we believe it will remain closed for one month to kill the seasonal biting midge lavae. Some members of our group were informed of this closure yesterday in casual conversation at the Volunteers Day lunch at Crummunda Park. Either as an active environmental group or as individual residents living along and close to Currimundi Lake, we expect that we should have been formally advised of the planned closure by officers of the Caloundra City Council or by Councillors Smith and /or O'Kearney.

We understand that biting midges are a seasonal problem affecting some segments of Currimundi Lake. We support the aim to kill or reduce their development. However, we also support the aims of improved water quality, improved environment and reduced erosion of Currimundi Lake, Creeks and Canals and consider that the closure of the entrance has the potential to minimize one problem but to exacerbate other problems further along the catchment.

We have continuously urged Caloundra City Council Officers and Councillors to view the waterbody of Currimundi Lake Catchment as a whole – not just as separate segments with separate management programs. Action taken in one area can positively or negatively affect other areas or the whole area of the catchment. Reports, observations and photographs indicate that during periods of high levels of water in the Lake, the banks absorb water like a sponge. Within months of the water levels dropping, the banks dry out, split and fall away from the edges resulting in quite significant erosion along Currimundi Lake and Creeks.

In our correspondence over six years with the Caloundra City Council, through our newsletter *Currimundi Lake Catchment News*, through all of our environmental activities and water monitoring programs, in our submission to Roger Tomlinson's *Currimundi Lake Dynamics Brief*, and as recently as the August 7th Friends of Currimundi Lake general meeting, we have highlighted our concerns about the problem of erosion for the banks of Currimundi Lake and Creek, especially after prolonged high water levels have been clearly voiced.

There will be no tidal flushing of Currimundi Lake for one month. Can we assume that the decision made by Caloundra City Council to close the mouth of Currimundi Lake took into account all the other factors that impact on the waterways:

1. Severe bank erosion with the possibility of trees falling into the Lake and Creeks;
2. The continuous flow of brackish water from Lake Kawana weir into Currimundi Lake which cannot be stopped;
3. Siltation run-off from soil and waterway disturbance by new urban developments, road and bridge developments in the catchment area;
4. The possibility of heavy rainfall which would increase turbidity and lower dissolved oxygen, resulting in a reduction of the quality of the water;
5. Hot weather effect on a dormant warm and shallow waterbody;
6. School holiday season being a time of increased use of the waterways for recreational purposes and a time when high water quality is of overriding importance.

We sympathize with residents (some of whom are members of CCCG Inc) who are affected by the seasonal biting midge problem and acknowledge that it has health implications for residents and may impact on tourists who visit the area, with an economic consequence.

However, while the closure of the entrance may be the cheaper action in the short term, it is not necessarily the best environmental solution for the whole of Currimundi Lake. In fact, its impact has a detrimental effect on other sections of the lake.

We believe that any major change to Currimundi Lake system should only be undertaken with a whole-system approach and are very interested in what recommendations will be made in the expansive research by Roger Tomlinson in his *Currimundi Lake Dynamics Study*.

Yours faithfully,
Jenny Allan
Secretary

Attachments: Photo of collapse of Currimundi Lake banks (June 07)

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Currimundi Catchment Care Group Inc.

ABN77276084162

27/01/2008

Mr Chris Allan
Environmental Services & Open Spaces
Operations Manager
PO Box 117
Caloundra Q4551

Dear Chris,

Re: Aspects of continuous erosion along Currimundi Lake

At our AGM meeting on 21st January, a report was given by Dave Holder who is our Team Leader for Noel Burns Park along Currimundi Lake. Dave has lived along the Lake for almost 15 years and is a keen naturalist.

We understand from Cr Danny O'Kearney that, together with Denis Shaw, you have been looking at strategies to prevent and/or reduce bank erosion along Currimundi Lake and Currimundi Creek.

I have attached Dave's report with photos of the erosion problem for Noel Burns Park for your consideration. The general approach of "do nothing because it's natural" means that both the quality and quantity of the parks bordering Currimundi Lake are doomed to severe deterioration such as shown in Dave's report.

Our group looks forward to hearing what strategies are selected and to assisting wherever possible.

Yours faithfully,

Jenny Allan

Jenny Allan
Secretary

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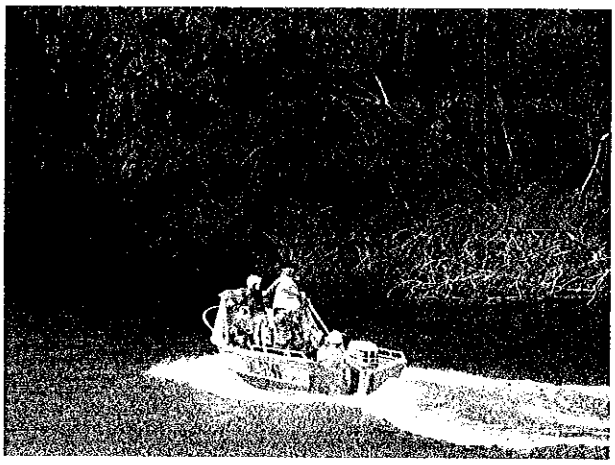
Team Leader Report - Noel Burns Park.

Wash from boats is continuing to undermine the banks. The tree shown below is now doomed, and another much larger tree about 30 meters upstream will be next.

In the above photo, note the tree about to fall, and the larger amount of soil and smaller trees, that has already fallen into the water.



Speeding boats continue to be a problem on the waterway.

Saturday and Sunday, there appeared to be an organized kayak / canoe event on the waterway. It would appear that as in previous years, the officials from this event use power craft and ignore the speed limit and no wash rule. One large craft had a sort of boom net astern, possibly to carry a canoe.

There are a couple of sites where sheet erosion is taking place, in particular the ground near the "Old jumping tree" opposite Dewrang Place, and at the western end of the park adjacent to the end of the canal.

The recent rain has increased the erosion, and coupled with increased pedestrian traffic over the Christmas season, has made the repair and prevention of this erosion an urgent matter.

Note how the stump in the center of this picture is now way above ground level. The point at which the trunk was cut off was once the ground level. The ground was more or less level from foreground to the seat. Many tones of soil have been eroded, and the grade of the remaining ground will ensure a more rapid rate of erosion from both water run off, and pedestrian traffic.

Littering by fisher persons continues to be a problem. Plastic bags, bait bags, lengths of fishing line and hooks are regularly left behind.

Dave Holder,

Team Leader,
Noel Burns Park

21 January 2008.