Refining the Gippsland Lakes Future Directions and Actions Plan

A scoping study undertaken for the Gippsland Lakes Task Force by:

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Cover photo:
Chinaman's Creek at Metung, courtesy of the Gippsland Coastal Board.

EXECUTIVE SUMMARY

The Gippsland Lakes Task Force (GLTF) is charged with implementing the Gippsland Lakes Future Directions and Actions Plan 2002, which seeks to achieve a 40% reduction in nutrient entering the Gippsland Lakes by 2022 in order to reduce the frequency and severity of nuisance algal blooms that affect ecosystem values associated with the Lakes. The GLTF seeks to ensure that the priorities stated in the Future Actions Plan remain applicable in light of predictions related to changed climatic conditions and other regional factors that might affect the condition and ecology of the Lakes and its catchments. Knowledge of such factors will assist in the development of a business case for the Future Actions Plan for 2009 and beyond.

This scoping study identifies issues and actions to be considered by the GLTF as it refines its business case for the Future Action Plan. It has been based on:

- A review of relevant State, regional and local policy and management strategies and plans for the Lakes and their catchments;
- A limited review of relevant scientific and technical information on the Lakes and their interaction with their catchments and adjacent marine areas;
- Consultation with key stakeholder organisations (including a workshop of staff from the Gippsland Coastal Board, Department of Sustainability & Environment, Department of Primary Industries, Environment Protection Authority, West Gippsland Catchment Management Authority and East Gippsland Catchment Management Authority in July 2008).

Many issues, questions and actions were considered in relation to the taxa of algae that occur in the Lakes, nutrient loads and associated nutrient reduction options, links with complementary NRM activities and institutional arrangements. The potential for factors associated with climate change to result in a change in the state of the Gippsland Lakes from a freshwater-brackish to a more open marine system were also considered. While the ecological response(s) of the Lakes to a change in state are likely to be unpredictable, the importance of managing nutrients loads and algae still remains. The GLTF will play a key role in managing the condition of the Lakes in the event that it transitions to a more open marine system. Planning for such an eventuality will be assisted by a review of the environmental indicators required to assess ecosystem responses to new conditions as they unfold.

In summary, it is recommended that the GLTF:

- Retain its focus on nutrient load reduction in the Future Actions Plan, as this remains relevant and important.
- Continue its support for the implementation of BMPs already identified by the Future Actions Plan and subsequent investigations. It will also be important that the GLTF consider new approaches to both land and waterway management.
- Review its membership in light of restructuring of some organisations (e.g. DSE was being restructured at the time of writing) and to assess if additions could be made to bolster the work of the GLTF.

- Review the objectives and environmental water requirements of the Lakes (once developed) to determine the implications for nutrient reduction options in the future.
- Review the vision and objectives set for the Future Actions Plan along with that of other policies and obligations set for the Gippsland Lakes (e.g. SEPP, Ramsar) with the expectation that the state of the Lakes will shift to a marine system in the foreseeable future.

Discussions with stakeholders have identified the following as high priority considerations for the GLTF as it refines its business case for the Future Actions Plan.

Future role of the GLTF and development of a Future Actions Plan business case:

- Confirm the membership of the GLTF and development of a business case to put to the Expenditure Review Committee.

Algae and in-lake nutrients:

- Use of a conceptual model of algal bloom formation in the Gippsland Lakes and scientific literature to develop a framework or tool to predict the timing, likely taxa and severity of algal blooms.
- Identify if there are deposition 'hotspots' (e.g. via tracer studies or similar) that might then be the target of management actions to reduce the amount of nutrients subsequently mobilised from bottom sediments.
- Review of measures that can be applied to reduce nutrient availability in receiving waters.

Catchment nutrient generation and management:

- Continue to implement Best Management Plans (BMPs) for the priority nutrient sources identified in the Future Actions Plan.
- Undertake an economic study to evaluate marginal returns and the cost-effectiveness of increasing levels of adoption of BMPs.
- Confirm the level of nutrient generation from various land uses and reduction associated with current BMPs under different climate change scenarios, including more episodic events.
- Consider the feasibility of setting nutrient reduction targets for various land uses (e.g. irrigated land, urban land), calculating the level of nutrient reduction expected or required per unit area of a particularly land use, and assessing the relative contribution different land uses are likely to make to overall nutrient reduction targets.
- Develop a tool for identifying high risk nutrient export areas (e.g. overlay of topography, soil type, soil erodability, fire risk) and setting targets for reforestation or other sediment and nutrient management measures.
- Undertake an Ecological Risk Assessment to explore the relative benefits and risks of nutrient reduction measures in comparison with waterway health or rehabilitation measures.
- Use existing communication and community engagement practices to reinforce the long-term nature of addressing eutrophication and algal blooms.

Complementary activities:

- Review the objectives and recommendations for environmental water requirements for the Gippsland Lakes once developed, both from a nutrient load and broader ecosystem health perspective.
- Review the vision and objectives of Future Actions Plan, SEPP and Ramsar listing in light of a change in the state of the Gippsland Lakes. Identify indicators from which to measure ecosystem response to a change in state.
- Use existing communication and community engagement practices to reinforce the long-term nature of addressing eutrophication and algal blooms. Explore the potential for collaboration with existing community and industry groups to bolster communication efforts.

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1 INTRODUCTION

The Gippsland Lakes Task Force (GLTF) is charged with implementing the Gippsland Lakes Future Directions and Actions Plan 2002 (The Future Actions Plan, DNRE 2002). The Future Actions Plan seeks a 40% reduction in nutrient entering the Gippsland Lakes by 2022 in order to reduce the frequency and severity of nuisance algal blooms that affect ecosystem values associated with the Lakes. The Future Actions Plan provides a blueprint for action and guidelines for future investment in the wellbeing of the Lakes. It includes a vision for the Lakes and provides strategic direction to achieve that vision:

- *The Lakes will continue to be a local, regional, national and international icon where everyone, individually and collectively, will be working to achieve common, community-owned objectives for the Gippsland Lakes and catchment.*

The Future Actions Plan is complemented by a range of State and regional strategies and plans (Figure 2), such as the Victorian Coastal Strategy (Victorian Coastal Council 2002), the West and East Gippsland Catchment Authority's Regional Catchment Strategies (RCS), the East & West Gippsland River Health Strategies, the Gippsland Fire Operations Plans, the Gippsland Estuaries Coastal Action Plan (GCB 2006), the Gippsland Lakes Shore Erosion & Revegetation Strategy (Crossco Engineering and Environmental Consultants et al. 2002), and responds to issues raised by the Gippsland Lakes Environmental Audit and Gippsland Lakes Environmental Study (Harris et al. 1998, Webster et al. 2001). The Future Actions Plan acknowledges that most of the effective management activities required to achieve the objective of improving water quality in the Gippsland Lakes will have a long period of implementation and possibly an even longer period before benefits start to become apparent; it may be many years before there are visible signs of improvement in the ecology of the Lakes, and even longer before trends become measurable and algal blooms are diminished.

1.1 Project Objectives and approach

The GLTF seeks to ensure that the priorities stated in the Future Actions Plan remain applicable in light of predictions related to climate change and other regional factors that might affect the condition and ecology of the Lakes and its catchments. The following tasks were undertaken to meet this objective:

- Assessment of the appropriateness of current actions and strategic directions in achieving the stated objectives in the Future Actions Plan, taking into account the likely impacts of any significant changed circumstances that will have an impact on the Gippsland Lakes and its catchment;
- Identification of any new actions or strategic directions required to meet the vision and objectives of the Future Actions Plan;
- Collation and prioritisation of actions and strategic directions required to meet the objectives of Future Actions Plan.

The activities associated with the tasks identified above included:

- Review of relevant State, regional and local policy and planning strategies;

- Review of relevant management strategies and plans for the Lakes and their catchments;
- Review of relevant scientific and technical information on the Lakes and their interaction with their catchments and adjacent marine areas;
- Consultation with key stakeholder organisations (including a workshop of staff from the Gippsland Coastal Board, DSE, DPI, EPA, WG CMA and EG CMA in July 2008);
- Identification of potential future scenarios as the basis for more detailed fore sighting activities;
- Preparation of a report that summarises the above (this report).

1.2 Study Area

The study area includes the catchments of the Latrobe, Thomson, Macalister, Avon, Mitchell, Nicholson and Tambo Rivers, as well as the lakes system (Lakes Wellington, Victoria and King) (Figure 1).

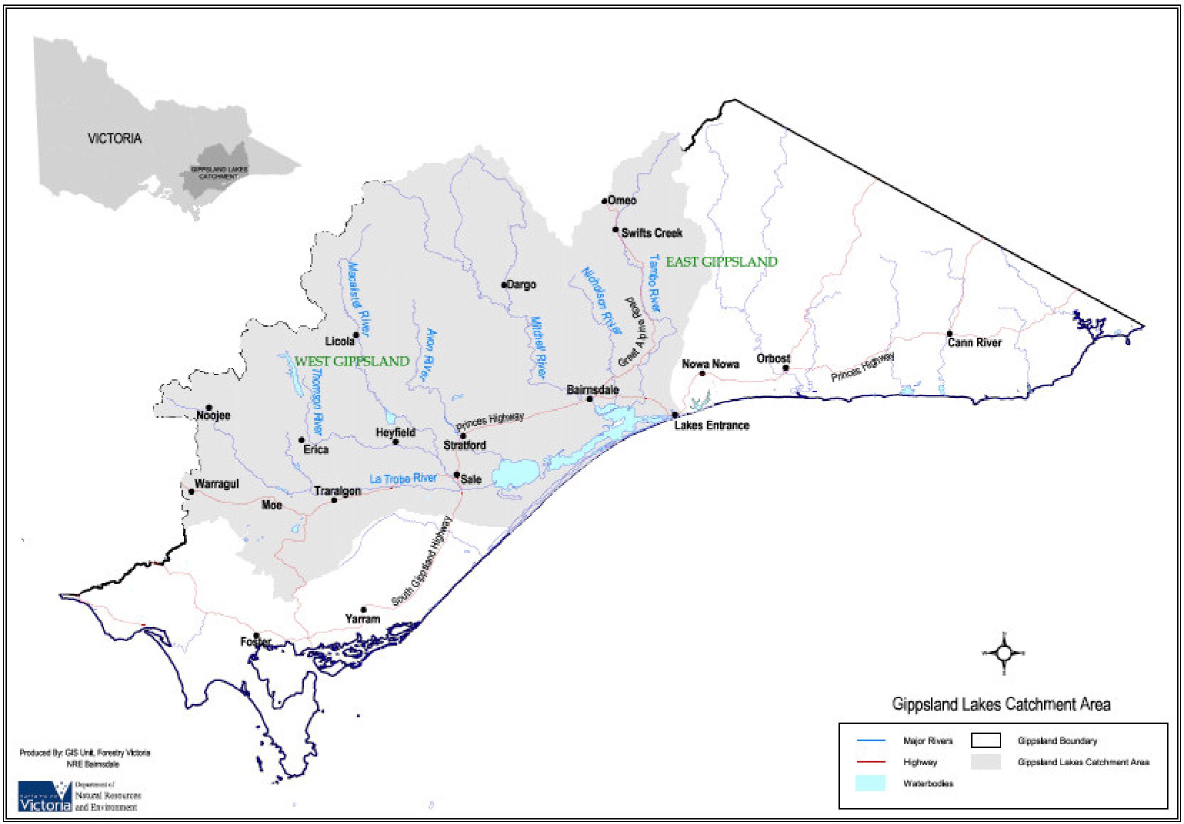

Figure 1: Map of the study area.

1.2.1 Values

The Gippsland Lakes and adjacent hinterland have long been recognised for their natural, cultural, social and economic values. A significant portion of the coastal dune systems, woodlands and heathlands, and waterbodies of the Gippsland Lakes and its hinterland are included in the Gippsland Lakes National Park and the Gippsland Lakes Coastal Park, both of which are listed on the Register of the National Estate in recognition of their significant natural values (DSE 2003, Parks Victoria 1998). The significance of the natural values of Gippsland Lakes system is also reflected in its listing under the Ramsar convention as a wetland system of international importance (DSE 2003). Because of its many natural values, the Gippsland Lakes and adjacent Ninety Mile Beach are highly valued for recreation (e.g. fishing, camping, sailing) and a very important component of the regional economy.

2 OVER VIEW OF THE GIPPSLAND LAKES FUTURE DIRECTION AND ACTIONS PLAN

The Future Actions Plan is based on a framework of five management themes:

- Nutrients and sediments;
- Water management;
- Capacity building;
- Wetlands biodiversity;
- Planning, monitoring and evaluation.

A number of projects and actions were identified within each theme in order to guide investment. In undertaking the works associated with each theme, the GLTF has been mindful to achieve the desired outcomes using existing NRM programs, and achieve multiple benefits (i.e. more than just nutrient reduction) in the short as well as long-term. The relationship between the Future Actions Plan and other regional and local NRM initiatives is outlined in Figure 2. While the GLTF is charged with implementing the Future Actions Plan, it has no direct role in implementing any other strategy or plan, although it will seek to support other initiatives where these complement the Future Actions Plan.

The GLTF has implemented a science-based approach to planning based on a set of guiding principles that provide a regional, national and international context for the Gippsland Lakes Future Directions and Actions Plan. They are:

- Adherence to the precautionary principle when considering the impact of management actions;
- Management of the Gippsland Lakes in accordance with Ramsar objectives and Victoria's Biodiversity Strategy;
- Consideration of economic, environmental and social implications and measures;
- Definition of shared outcomes to enable shared decision making;
- Facilitation of broad community ownership;
- Use of adaptive management principles.

The science-based approach and guiding principles will remain relevant and applicable to the activities of the GLTF in the future.

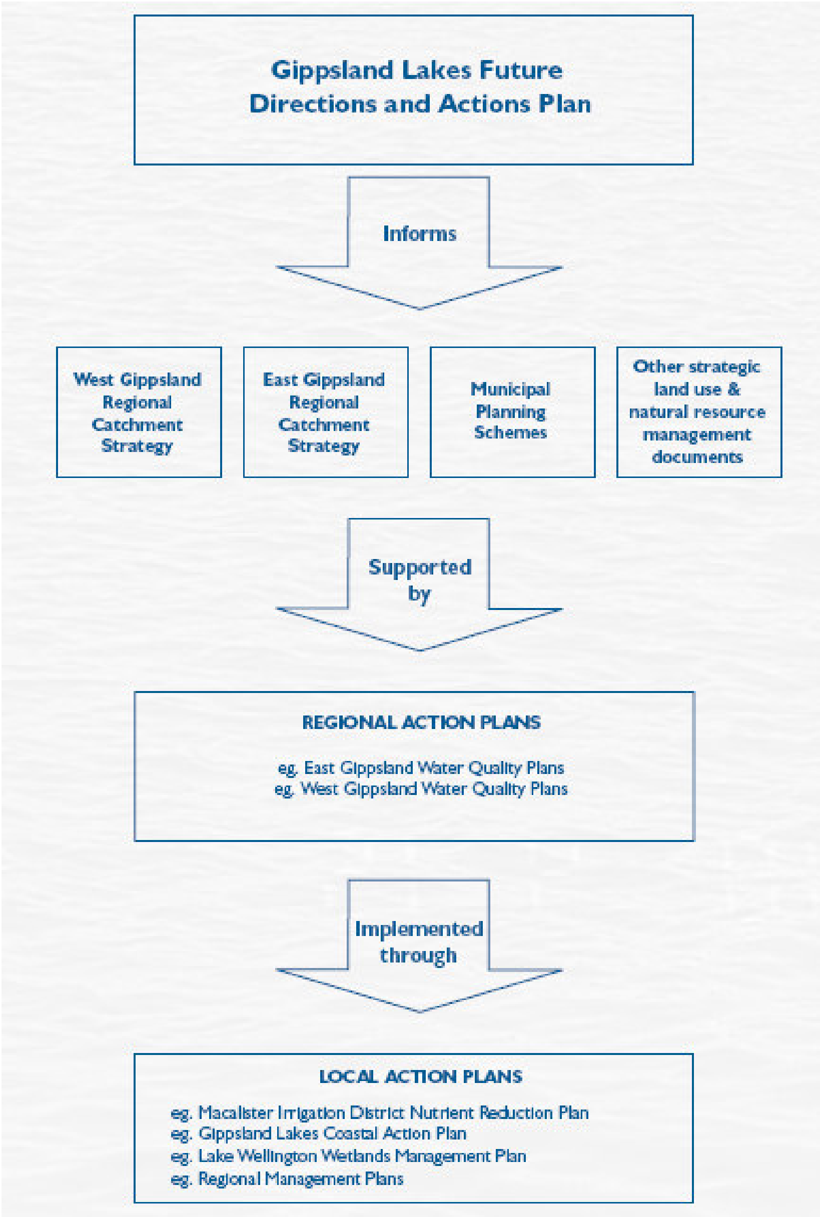

Figure 2: Relationship between the Future Actions Plan and other regional strategies and plans (DNRE 2002).

2.1 Future Actions Plan outcomes

The programs, objectives and outcomes of activities associated with each of the themes of the Future Actions plan are summarised in Table 1. In addition, investigations undertaken on behalf of the GLTF have emphasised the following:

Table 1: Summary of outcomes from activities undertaken for the Future Actions Plan

Theme	Program	Objective	Outcomes	Lead and Partner Agencies	Future Considerations
Nutrients & Sediments	Agriculture Nutrient Reduction	To minimise controllable nutrient sources from dryland and irrigated agriculture in the Gippsland Lakes catchment.	• Macalister Irrigation District Land & Water Management Plan (MID L&WMP) developed and being implemented. • Other priorities for nutrient reduction identified.	• WGCMA, SRW, DPI, EPA	• Continued implementation of the MID L&WMP. • Review of landscape-scale nutrient load reduction measures.
	Forestry and Public Land Sediment Reduction	To reduce sediment and nutrient loads from public land and forestry.	• Survey and prioritisation of road and track stream crossings • Track and stream crossing control where required.	• DSE • DSE	• Review in light of recent bushfires and floods.
	Waterways Erosion Control	To minimise sediment loads to the Gippsland Lakes by targeting actively eroding waterways in priority catchments.	• Gully and stream erosion prevention/control and riparian zone revegetation programs being delivered via CMA programs. • Preparation of shore erosion and revegetation strategy for the Gippsland Lakes.	• WGCMA EGCMA DPI • GCB	• Continued implementation of erosion control and revegetation programs as part of RHSs and the Shore Erosion and Revegetation Strategy.
	Urban and Industrial Nutrient	To support the implementation of Urban Stormwater	• Wastewater management systems for Banksia Peninsula,	• East Gippsland Water, Gippsland Water	• Ongoing GLTF support for implementation of these systems

Theme	Program	Objective	Outcomes	Lead and Partner Agencies	Future Considerations
	Reduction	Management Plans and manage point source urban and industrial sources according to Environment Protection Authority requirements.	Loch Sport and Seaspray. • Implementation of components of stormwater management plans for Sale, Bairnsdale and Lakes Entrance.	• East Gippsland Water, Wellington, Baw, Baw and Latrobe Councils	• Ongoing GLTF support for implementation of SMPs
	Gippsland Lakes and Hinterland Nutrient Reduction	To implement a nutrient reduction program to combat sources in the Gippsland Lakes that are significant to the wider community in terms of direct contribution by Gippsland Lakes users and stakeholders.	• Completion of composting toilet program. • Enforcement of boat sewage pump-out requirements. • Foreshore erosion control.	• GCB and DSE • EPA • DSE, East Gippsland Shire and GCB	• Continued implementation or maintenance of control measures.
Water management	**Hinterland Environmental Flows**	To deliver water regimes that restore and conserve the ecological values of the Lakes hinterland.	• Methodology for determining environmental watering requirements developed and awaiting implementation.	• Parks Vic, WGCMA, EGCMA	• Funding to apply method and determine environmental water requirements for the Lakes.
Capacity Building	**Community Awareness**	To improve the capacity of the catchment community to understand and participate in actions and changes necessary to reach the objectives of the *Gippsland Lakes*	• Community capacity building. • Gippsland Lakes and catchment fact sheets. • Gippsland Lakes atlas.	• EGCMA, WGCMA, DSE, GCB	• Continued implementation of a communication strategy.

Theme	Program	Objective	Outcomes	Lead and Partner Agencies	Future Considerations
		Future Directions and Actions Plan.			
	Schools Awareness	To lay the basis for the generational change needed to sustain long term actions that address the problems of the Gippsland Lakes.	• Gippsland Lakes atlas • Additional Waterwatch materials and coordinators.	• Water watch	• Maintain commitment to community programs such as Waterwatch.
Wetlands Biodiversity	**Wetlands Protection**	To ensure the medium term survival of the wetlands of the Gippsland Lakes while longer term water quality improvements take effect.	• Stock grazing exclusion. • Pest plant and animal control. • Revegetation.	• DSE, Parks Vic • Private landowners	• Continued protection and enhancement of GL wetlands
Planning, Monitoring and Evaluation	**Lakes System Water Quality Monitoring**	To establish and operate a Lakes and Wetlands Water Quality Monitoring Network that underpins assessment of long term trends and the effectiveness of management actions.	• Integrated monitoring, evaluation and reporting arrangements for the Gippsland Lakes in place.	• GCB, DSE, EPA	• Investigate dynamics of sediment transport and deposition in and through the Lakes.
	Lakes catchment monitoring	To establish and operate a catchment monitoring network that provides assessment of long term trends and the effectiveness of management actions.	• Monitoring network established to evaluate trends over time.	• GCB, DSE, EPA	• Review effectiveness of monitoring arrangements following recent bushfires, floods and projected increases in storm frequency and intensity.
	Planning, evaluation and adaptation	To model, analyse and evaluate the results of monitoring. To adapt	• Annual reporting of algae status and nutrient load evaluated	• GCB, DSE	• Ongoing commitment to this activity.

Theme	Program	Objective	Outcomes	Lead and Partner Agencies	Future Considerations
		future management actions in response to better understanding of the effectiveness of past activities.	and used to direct targeted investigations.		

- Nutrient load reduction of between 12-20% may be expected with implementation of current measures (Cottingham et al. 2006). Thus the objective of achieving a 40% reduction in annual nutrient loading to the Gippsland Lakes will not be realised with these current measures alone.
- Evaluation of the second entrance option concluded that the limited potential benefits in terms of reduced risk of algal blooms and hypoxia events in the lakes were outweighed by social, economic and environmental risks.
- Evaluation of natural wetlands as potential nutrient sinks identified that long-term nutrient retention was unlikely (wetlands could even become a source of nutrients) and diversion of nutrient-rich water posed an environmental risk to the wetlands, many of which are part of the system nominated under the Ramsar convention and protected by the EPBC Act.
- Nutrient and algal monitoring has provided valuable information that will help guide objectives and actions in the future. Particularly important have been findings related to recent algal blooms and loads generated and transported to the Lakes following successive bushfire and flood events.
- Potential changes due to climate change (e.g. increased temperature, lower rainfall-runoff, dryer catchment conditions but with more frequent high intensity rainfall events, increased storm surges and rising sea levels) increase the likelihood that the coastal barrier will be breached and that the long-term shift from a freshwater-brackish system to a more estuarine-marine system will be accelerated.

In relation to the themes of the Future Actions Plan:

- While there has been significant progress, the implementation of nutrient reduction options as part of the **Sediment and Nutrients theme** should continue;
- Activities related to the **Water Management theme** are largely complete but remain to be integrated into the Gippsland SWS;
- Activities related to the **Capacity Building theme** are ongoing;
- Activities related to the **Wetlands Biodiversity theme** have been implemented but may require review in light of increased salinity;
- A range of activities related to the **Planning, Monitoring and Evaluation theme** have been completed but ongoing commitment is required in face of drivers such as climate change, and the potential for the state of the Gippsland Lakes to shift to a more marine system.

The delivery of the various activities under each of the major themes included in the Future Actions Plan was reviewed in 2005 (URS 2006). The review concluded that there was strong evidence that the investment Future Actions Plan has been well managed and wisely spent.

The findings and issues described above and in Table 1 will be considered in more detail in Chapters 3 and 4.

2.2 Algal bloom update

Over 20 major blooms of harmful algae have been recorded in the Gippsland Lakes since 1965 (Davies 2008, Stephens et al. 2004):

- 14 cyanobacteria (including genera *Nodularia, Microcystis, Anabaena* and *Synechococcus*, each of which have been reported to produce toxins to various degrees);
- 5 dynoflagellates (including genera *Gymndinium* (toxin-producing), *Noctiluca* (ammonia-producing));
- 2 blooms whose constituents are unknown.

Blooms of the cyanobacteria *Nodularia spumigena* and *Microcystis aeruginosa* have been particularly troublesome in the Gippsland Lakes, resulting in warnings about primary contact and restrictions on activities such as fishing.

Interestingly, the most recent cyanobacteria bloom has been of S*ynechococcus,* a genus often associated with estuary and marine systems (e.g. Beardall 2008, Johnson and Sieburth 1979, Waterbury et al. 1979, http://www.whoi.edu/science/B/people/ewebb/Syne.html) that has not been recorded in large numbers previously. This may raise the question as to the extent of the shift to a more marine state for the Gippsland Lakes, whether such a shift in state is permanent, and what implications this might have for nutrient reduction objectives and for preventing or managing algal blooms in the future.

Researchers from the Water Studies Centre, Monash University, and the Marine and Freshwater Research Institute, Queenscliff, are currently investigating the factors that contribute to the development of algal blooms in the Gippsland Lakes. Their findings will be captured in a conceptual model of the events that lead to algal blooms and hypoxia events in the Lakes. The conceptual model is likely to consider three important phases (Cook et al. 2008):

- Phase 1 - Flood. Fresh water enters the lakes carrying high nitrate and phosphorus loads. This triggers an algal bloom, often dominated by diatoms.
- Phase 2 – Stratification. Freshwaters sit on top of a layer of salty water in the lakes; this salty layer nearly always remains, even after large floods. Detritus from the initial algal bloom falls to the bottom of the water column and sediments, feeding respiration and consuming bottom water oxygen. Changed redox conditions can in turn lead to a large release of phosphorus from the sediments into the bottom waters.
- Phase 3 - Cyanobacterial bloom. The exact trigger for a cyanobacterial blooms is unclear, however it most likely coincides with an event that mixes phosphorus from the bottom water into the surface water, as well as warm temperatures and salinities <25 ppt.

Conceptual models such as that described above, as well as insights from algal bloom formation in lakes and reservoirs across southeastern Australia (e.g. Lawrence et al. 2000) can be used to develop a predictive capability of the type of alga likely to develop depending on antecedent conditions. Approaches such as Bayesian belief networks have also been used to develop semi-quantitative and quantitative models that can capture new learning over time. Such a predictive capability would allow the GLTF to develop management responses tailored to particular taxa. Remote sensing approaches have been used overseas to detect algal bloom formation and behaviour (e.g. Baltic Sea, North

Sea, Gulf of Mexico). This in combination with studies of the factors that favour individual taxa could also increase the predictive capability available to the GLTF.

The GLTF may also wish to consider questions such as the extent to which it might be possible to manage conditions to favour one taxa over another (presuming that if a bloom is inevitable that some taxa are preferred over others – e.g. prefer green algae to cyanobacteria, if cyanobacteria then prefer *Synechococcus* to *Nodularia* – and that conditions can be manipulated at the appropriate scale). For example:

- Are there options for retaining oxidised nitrogen in water entering and so reduce the competitive advantage of nitrogen-fixing cyanobacteria over more benign taxa?
- Is it feasible or cost-effective to prevent hypoxia of bottom water and so reduce the amount of phosphorus released from sediments that sustains algal blooms (e.g. aeration of the water column)?

Issues to consider in relation to algal bloom formation are summarised in Table 2.

2.3 Nutrient load update

The 40% nutrient load reduction objective is based on the nutrient load (average annual load of 2250 t/yr TN and 250 t/yr TP) entering the Lakes, algae response and hypoxia estimates modelled as part of the Gippsland Lakes Environmental Study (Webster et al. 2001). Subsequent calculations by Grayson (2006) estimated average catchment-generated loads of 2400 t/yr TN and 330 t/yr TP. The EPA is currently finalising its evaluation of nutrient loads entering the Gippsland Lakes for 2006/07 using data and information generated by a dedicated water quality monitoring program (Davis and Martinez 2008). This work is expected to highlight the following:

- 2100 tonnes of TN and 245 tonnes TP were estimated to have been discharged to the Gippsland Lakes for the year.
- The majority of the nutrient load (>80%) occurred during flood events of June-July 2007.
- The eastern catchments contributed more of the nutrient load than did the western catchments of the Gippsland Lakes, presumably due to increased loads in runoff from catchments affected by recent bushfires.
- The nutrient loads entering the Lakes in 2006/07 were higher than in preceding years, presumably due to previous year's lower rainfalls and the combined effects of bushfires in many upper catchment areas, followed by heavy rain and floods.
- It is possible that a considerable amount of sediment and nutrients were deposited in Lake Glenmaggie during the flood events of June-July 2007, significantly reducing the nutrient load that might otherwise have been discharge from the Macalister River. This is an issue currently being investigated by Southern Rural Water.
- Recent annual nutrient loads (2004/05, 2005/06) to the Gippsland Lakes have been lower than the long-term average (e.g. Grayson et al. 2001) due to lower rainfall and runoff associated with ongoing drought.

Interestingly, EPA water quality monitoring in the Gippsland Lakes suggests that much of the water column remained stratified during the June-July 2007 floods, raising the possibility that a significant portion of the nutrient load entering the Lakes during the flood events remained in the surface waters and were discharged from the Lakes to Bass Strait (EPA 2008). It was also noted that the some water quality monitoring stations were knocked out of action during the floods (L. Radcliff, EPA, pers. comm.), highlighting the difficulty of collecting data and samples for further analysis during such events.

Questions to consider in relation to the fate of nutrients[1] entering the Lakes include:

- What else is required to accurately measure nutrient loads entering the Lakes and nutrient dynamics within the Lakes?
    - ➢ Stratified sampling of the water column to confirm the extent of surface water mixing during large inflow events.
    - ➢ Determining nutrient outflows through the entrance as well as inflows.
    - ➢ Tracer studies to identify if there are defined sediment and nutrients deposition zones (hot spots) that may disproportionately affect the amount of nutrients mobilized to support algal growth (e.g. as seeding populations that may expand to large areas of the Lakes).
- To what extent is the sorption of dissolved inorganic phosphorus (DIP) affected by salinity?
- Should there be defined sediment/nutrient deposition sites, is it feasible or cost-effective to reduce the amount of phosphorus that may become available to support alga growth – for example using propriety compounds such as Phoslock?

Issues to consider in relation to the fate of nutrients entering the Lakes are summarised in Table 2.

[1] Other aspects such as nutrient load retained in catchments with changed land use or BMPs will be discussed in later chapters.

Table 2: Summary of considerations for the Future Actions Plan in relation to algal bloom formation and the fate of nutrients entering the Gippsland Lakes

Requirement	Actions to consider	Anticipated outcome
Additional information on the estuarine-marine algae taxa likely to enter the Lakes	• Review the autecology of Synechococcus (e.g. salinity and Identify taxa that may enter from Bass Strait and if they have the potential to form harmful algal blooms. • Identify additional marine taxa that may enter the Lakes from Bass Strait. • Review autecology of those additional species.	• Information that can be used to assess relative risk of potentially harmful marine taxa and factors that lead to blooms.
Development of capability to predict algal blooms	• Use of the conceptual model of algal bloom formation in the Gippsland Lakes and scientific literature to develop a framework or tool to predict the timing, likely taxa and severity of algal blooms. • Investigate the feasibility of applying remote sensing techniques to predict algal bloom development and behaviour.	• Development of a capability to predict the onset, severity and likely taxa of harmful algal blooms based on antecedent conditions.
Assessment of benefits and feasibility of options to manipulate in-lake conditions that favour benign taxa over those that form harmful algal blooms	• Cost-benefit analysis of options (e.g. water column aeration) for manipulating in-lake conditions related to algal bloom formation. • Update management plans (e.g. algal bloom response plans) to deal with different taxa.	• Information from which to tailor management response to the taxa predicted to occur.
Accurate information on the loads entering and leaving the Gippsland Lakes during large events	• Review of water quantity and quality monitoring to evaluate lessons from the June-July 2007 floods. • Evaluate the feasibility of measuring the nutrient load discharged from the Gippsland Lakes to Bass Strait during large events.	• Adjustment of the current monitoring program to account for large events. • Knowledge of the likely nutrient load retained within the lakes system following large events.
Information on the extent of water column mixing	• Identify additional sampling of the water column to confirm the extent of mixing during large flow events.	• Confirmation of the extent to which the water column remains stratified during large events.
Knowledge of the likely impact of salinity on DIP sorption	• Investigate DIP sorption (potential phosphorus availability) under varying salinity conditions.	• Knowledge of how salinity affects nutrient availability

Requirement	Actions to consider	Anticipated outcome
Information on the deposition of sediments and nutrients entering the Gippsland Lakes during large events	• Identify if there are deposition 'hotspots' (e.g. via tracer studies or similar) that might then be the target of management actions to reduce the amount of nutrients subsequently mobilised from bottom sediments.	• Identification of sites that may lend themselves to in-lake manipulation or management to reduce the availability of nutrients.
Assessment of the feasibility for limiting remobilisation of nutrients from the bottom sediments following large events	• Review the feasibility and cost-effectiveness of using materials purported to retain nutrients in bottom sediments. • Design a trial of such materials to determine that there are no adverse environmental or ecological affects (should such measures be deemed feasible and cost-effective).	• Evaluation of potential measures for limiting nutrient release from bottom sediments.

3 POTENTIAL FUTURE STATES OF THE GIPPSLAND LAKES SYSTEM

3.1 Drivers of system state and condition

European settlement in the region since the 1840's and has resulted in modification to both the catchments of the Gippsland Lakes as well as to the state of the Lakes themselves. The modifications have changed catchment hydrology, increased the amount of sediment and nutrients delivered to the Lakes (e.g. Grayson et al. 2001), and the opening of a permanent entrance in 1889 has resulted in the system state shifting from freshwater-brackish lakes, wetlands and lagoons to a more estuarine-marine system (Webster et al. 2001). It is likely that the ecology of the Lakes continues to adjust to changing hydrological and catchment conditions.

A number of existing and emerging drivers of ecosystem condition have the potential to influence the state and condition of the Gippsland Lakes in the medium to long term. These include:

- Climate change,
- Land use change,
- Water availability,
- Shoreline erosion,
- Land subsidence.

These drivers of ecosystem condition are described in sections 3.1 to 3.5 and implications for the Future Actions Plan considered in section 3.6.

3.1.1 Climate change

The potential changes to climate conditions have received considerable attention over the last 10 years. A number of factors related to climate change have the potential to influence the condition of the Gippsland Lakes and its catchments, including:

- Increased temperature and reduced rainfall, leading to drier catchments (higher fire risk), less runoff and reduced river flows.
- More frequent extreme events, leading to more frequent or longer droughts and intense rainfall events. This increase the likelihood that sediments and nutrients will be transported to the Gippsland Lakes in large events, such as the floods of June-July 2007.
- Sea level rise that increases the risk of breaching of the coastal dune barrier and greater incursion of sea water into the Lakes system.
- Increased wind strength and larger storm surges, which increased the risk of inundation of low-lying areas and the risk of shoreline erosion.

Summaries of potential climate change impacts for both West and East Gippsland have been collated by DSE (2004a and b), based on investigations undertaken by the CSRIO (e.g. McInnes et al. 2005a and b, Freij-Ayoub et al. 2007). These summaries are presented in Table 3. Of particular note is the potential for climate change to influence catchment conditions and the delivery of sediment and nutrients to the Lakes, as well as contribute (through sea level rises and storm surges) to the breaching of the coastal barrier system, resulting in a greater influence of seawater on the ecology of the Lakes. The implications of these factors for the Future Actions Plan are considered in more detail in section 3.6.

Table 3: Summary of projected climate changes for West and East Gippsland (adapted from DSE 2004a and b)

West Gippsland	East Gippsland
Temperature: • Annual warming of 0.3 to 1.6ºC by 2030 and 0.8 to 5.0ºC by 2070 • Day time maximum temperatures and night time minimum temperatures will warm at a similar rate • Warming will be similar throughout the seasons • A 10 to 40% increase in the number of hot summer days (over 35ºC) by 2030 and a 30 to 400% increase by 2070 • A substantial reduction in the number of frost days by 2030 and a possible loss of all frost days by 2070 in coastal areas	**Temperature:** • Annual warming of 0.2 to 1.4ºC by 2030 and 0.7 to 4.3ºC by 2070 • Day time maximum temperatures and night time minimum temperatures will rise at a similar rate • Warming will be similar throughout the seasons • A 10 to 100% increase in the number of hot summer days (over 35ºC) by 2030 and a 30 to 400% increase by 2070 • A substantial reduction in the number of frost days by 2030 and a 40 to 100% decrease in frost days by 2070.
Precipitation: • Annual precipitation change uncertain (annual changes of +10 to -10% by 2030 and +25 to -25% by 2070) • Extreme heavy rainfall events may become more intense	**Precipitation:** • Annual precipitation decreases likely (+3 to -10% by 2030 and +10 to -25% by 2070) • Extreme heavy rainfall events may become more intense
Drought: • Dry conditions that currently occur on average one in every three years may halve in frequency or as much as double in frequency by 2070, depending on average rainfall changes • When droughts do occur, they are likely to be more intense due to hotter conditions	**Drought:** • Droughts are likely to become more frequent and longer, particularly in winter-spring • Dry conditions that currently occur on average one in every five winter-springs may increase to up to one in three years by 2030 • Due to hotter conditions, droughts are also likely to be become more intense
Water resources and fire: • Decreased alpine area with an average of at least one day of snow cover per year • Increased evaporation rates • Drier soil likely, even if precipitation increases • Hotter, drier conditions likely to increase bushfire risk • Decreased average run-off in streams	**Water resources and fire:** • Decreased alpine area with an average of at least one day of snow cover per year • Increased evaporation rates • Drier soil likely, even if precipitation increases • Hotter, drier conditions likely to increase bushfire risk • Decreased average run-off in streams
Winds, storms and sea level rise: • Winds are likely to intensify in coastal regions of Victoria, particularly in winter as a result of more intense low pressure systems. Low pressure systems off the east coast of Australia may become more frequent • Sea level rise of 7 to 55cm by 2070 (0.8 to 8.0cm per decade)	**Winds, storms and sea level rise:** • Winds are likely to intensify in coastal regions of Victoria, particularly in winter as a result of more intense low pressure systems. Low pressure systems off the east coast of Australia may become more frequent • Sea level rise of 7 to 55cm by 2070 (0.8 to 8.0cm per decade)

3.1.2 Land use change

Private land

Private land use across the region is dynamic and will continue to evolve in response to factors such as climatic condition, water availability and cost, as well as market and economic settings. Overall, it will be important to consider the effect of land use change on sediment and nutrient loads entering waterways, both for existing climatic conditions and under climate change scenarios. For example, future decreases in water availability (e.g. under a climate change scenario or ongoing drought) or increased cost for water is likely to result in shifts such as from irrigated pasture for dairy production to irrigated horticulture. Forest plantations (development of which will be driven primarily by market conditions and land availability) may result in altered hydrology and sediment and nutrient generation in sub-catchments, as can urban[2] and tourism development. The implications for nutrient loads generated and transported to waterways have not been evaluated in detail (e.g. to what extent might nutrient loads from agricultural areas increase in response to more frequent intense storm events? To what extent will forest plantation affect water yield and nutrient yields from sub-catchments?). The continued promotion and adoption of BMPs (e.g. via whole farm plans for agriculture and via water sensitive urban design for urban areas) will be important for reducing nutrient loads to the Gippsland Lakes, under both existing and future land use conditions. However, it is not clear how the performance of BMPs might be affected by factors affected by climate change.

Public land

Much of the public land in the catchments of the Gippsland Lakes is forested. Recent bushfires have highlighted the potential for increased sediment and nutrient loads being delivered to streams and ultimately the Lakes when forest fires are followed soon after by heavy rains. The scale and unpredictability of large forest fires and large storm events makes the application of sediment transport mitigation efforts at landscape scales very difficult and costly. While it is possible to implement measures at small scales (e.g. managing sediment transport from unsealed access tracks in -affected areas), this is likely to have only a relatively minor affect on sediment loads reaching the Gippsland Lakes (Sheridan and Noske 2005).

Implications for the Future Actions Plan of land use and management dynamics on both private and public land are considered in Chapter 4.

3.1.3 Water availability

Changed climatic conditions and increased demand for water for agriculture, industry and human consumption can affect the water available for the environment. Changes to water availability can have implications for environmental values and ecosystem processes in the Gippsland Lakes. Inflows affect factors such as nutrient load, retention time, the extent of mixing and the salinity regime of the Lakes (Webster et al. 2001), which in turn can affect the conditions required for algal growth and the taxa that might predominate. A study to define the environmental water requirements for the Gippsland Lakes is underway and will inform the Gippsland Lakes Sustainable Water Strategy. To date, the methodology for

[2] While urban land contributes only a relatively small proportion of the nutrient load entering the Gippsland Lakes, stormwater drainage systems are a direct connection between urban areas and waterways. Urban areas around the Lakes have the potential to be a disproportionate risk in terms of delivery of nutrients at local scales around the Lakes.

developing environmental water recommendations has been established and is awaiting implementation.

3.1.4 Shoreline erosion

Much of the coast near the Gippsland Lakes, including the dunes of the coastal barrier, is highly erodible (Ethos NRM and Water Technology 2008). This makes this section of the Victorian coast susceptible to the influence of large storm surges and potentially climate-induced sea level rise. Breaching of the coastal barrier raises the prospect of opening new entrances to the Gippsland Lakes, increased tidal influence and exchange with Bass Strait, and increased salinity in the southwest areas of the Lakes (e.g. Lake Wellington and adjacent wetlands). A sustained breach in the coastal barrier is most likely should there be a succession of large storm surges such that the eroded beaches and dunes do not have an opportunity to reform. In such circumstances, coastal erosion and subsequent inundation of low-lying areas would have the potential to affect a large range of environmental, socio-economic and cultural values.

3.1.5 Land subsidence

The lowering of regional aquifers due to water extraction for agriculture and industry has raised the prospect of land subsidence and increased risk of inundation with storm surges (Freij-Ayoub et al. 2007, Gippsland Coastal Board 1998). An investigation of inundation potential due to subsidence, based on a digital elevation model and GIS, failed to detect significant levels of subsidence near the Gippsland Lakes and concluded that the risk of inundation due to subsidence was minor compared with the risk posed by storm surges (Freij-Ayoub et al. 2007). While land subsidence was predicted to occur over the next 50 years, this centred on the area near Golden Beach some distance to the southwest of the Gippsland Lakes.

3.2 Potential future state of the Gippsland Lakes

A mix of factors, such as sea level rise, more severe storm surges and increased shoreline erosion predicted with climate change, raise the prospect of the coastal dune barrier being breached. The rate of seawater intrusion to the Lakes system will accelerate should this occur, resulting in the completion of a state change from a freshwater-brackish system to an estuary-marine system that has been occurring since the opening of the permanent entrance to the Lakes in 1889. The increase in salinity is likely to be most pronounced for Lake Wellington and surrounding wetlands, as saltwater intrusion via the Entrance has already seen salinity in Lakes Victoria and King climb towards that of Bass Strait. A system that is more open to the sea is likely to resemble systems such as Corner Inlet near Wilson’s Promontory (Figure 3) or Moreton Bay in Queensland.

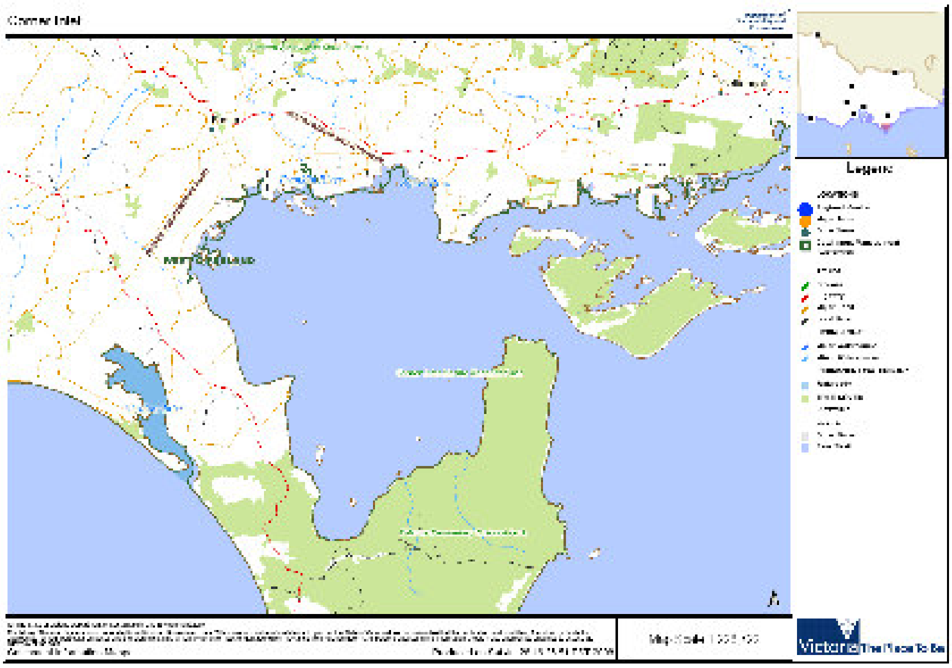

Figure 3: Map of Corner Inlet

There are many potential environmental, social and economic impacts that may ensue from sea level rise, increased coastal erosion and changed coastal processes, including:

- Large scale modification to coastal landforms;
- Increased tidal intrusion into estuaries, rivers and coastal embayments;
- Increased flooding of low-lying areas;
- Altered inundation frequencies for fringing estuarine wetlands;
- Irreversible change to those aspects of the Lakes ecosystem unable to tolerate a marine environment;
- Modified distribution of fauna and sea grass species;
- Increased risk to private, commercial and public infrastructure;
- Changes to recreation and amenity opportunities in low lying areas.

A shift in the state of the Gippsland Lakes raises important questions as to the implications for managing nutrient loads and algal blooms:

- Is the current focus on reducing nutrient loads entering the Lakes still relevant?
- Given the possible changes to the Lakes system, what additional aspects should the GLTF focus on?

Insights may be gained from considering eutrophication and hypoxia issues from similar coastal systems, both in Australia and overseas. Even a very cursory examination of the scientific and technical literature can identify numerous instances highlighting eutrophication and hypoxia issues in estuarine and marine waters:

- In Australia, eutrophication and hypoxia remain serious management issues for coastal estuary systems such as Moreton Bay in Queensland (Moore et al. 2006, Elmetri 2003), Lake Macquarie and Lake Illawarra in new South Wales (e.g. Brown and O'Gorman 1986, Nichols 1999), and the Swan-Canning estuary in Western Australia (e.g. Hamilton et al. 2001, Swan River Trust 2000).
- USA examples include Chesapeake Bay, Gulf of Mexico, Neuse River – Pamlico Sound (Chesapeake Bay Program 2006, Sharpley 1999).
- European examples include the Baltic Sea and North Sea (e.g. EEA 2001).

Experience elsewhere suggests that a shift to a marine system would not lessen the need to manage eutrophication, algal blooms and hypoxia events in the Gippsland Lakes.

Thus the current focus on nutrient load reduction in the Future Actions Plan will remain relevant and important.

However, such a shift in state, and the drivers underpinning it, does pose very important questions in relation to regional NRM policies and strategies. For example:

- What does change in state mean in terms of values and beneficial uses? What are implications of increased tidal influence on southern and western Lakes? Do the objectives of the State Environment Protection Policy (SEPP) as applied to the Gippsland Lakes need to be refined?
- What are the implications for Ramsar and Flora and Fauna Guarantee listing? Does the new state go beyond defined 'limits of acceptable change' that are important features of Ramsar listing?
- What philosophies might apply (e.g. protect, mitigate, abandon) as the system continues its transition to a marine system? Will different portions of the Lakes system require different philosophies and approaches (e.g. protect freshwater wetlands adjacent to Lake Wellington, mitigate the effects of salinity in Lake Wellington, and allow Lakes Victoria and King to become marine systems)?

How the GLTF might respond to the challenges associated with the drivers and potential change in state of the Gippsland Lakes is explored further in Chapter 4.

4 MANAGEMENT RESPONSE TO POTENTIAL FUTURE STATES OF THE GIPPSLAND LAKES

Previous reviews (Cottingham et al. 2006, Grayson 2006, Ladson and Tilleard 2006) found that the implementation of BMPs already identified in the Future Actions Plan were capable of achieving a 12-20% decrease in nutrient load to the Gippsland Lakes, still short of 40% reduction objective. Given the potential for a change in state to a marine system, a workshop attended by scientific experts with an extensive knowledge of the Gippsland Lakes was held in May 2007 to consider whether the objective of a 40% reduction in nutrient load was still valid. The workshop concluded that efforts to reduce the nutrient load entering the Lakes were still valid for controlling eutrophication and hypoxia events, and that there was no compelling reason to abandon the objective of a 40% reduction in nutrient load (see also section 3.6).

The GLTF is, therefore, encouraged to continue its support for the implementation of BMPs already identified by the Future Actions Plan and subsequent investigations. It will also be important that the GLTF consider new approaches to both land and waterway management.

However, as the current BMPs will not achieve the objective of a 40% reduction in nutrient load, additional measures will be required in the future, including:

- Confirmation of an appropriate vision for the Gippsland Lakes, and the terms of reference and representation on the GLTF to ensure continued commitment to the delivery of the Future Actions Plan;
- Promoting an integrated approach to developing adaptation strategies for dealing with potential climate change impacts;
- Investigation of potential nutrient reduction options to complement existing BMPs, with an emphasis on management options and approaches that can be applied at large scales;
- Contribution to planning and activities complementary to the Future Actions plan, including planning for a change in the state of the Lakes and identifying indicators from which to assess ecological responses to changed state.

The issues and activities listed above are considered further in the sections 4.1 to 4.4 and summarized in section 4.5.

4.1 Role of the Task Force

4.1.1 Task Force terms of reference

The current terms of reference for the GLTF include:

- Develop and implement priority projects;
- Annual plan and advice to the Minister;
- Strategic communications and media plan to inform the community;
- Integration and coordination of key government actions related to the health of the Gippsland Lakes;

- Integrated monitoring and assessment program to supply information on the condition of the Gippsland Lakes and its catchment;
- Update the Actions Plan based on adaptive management principles;
- Identify information gaps required for the ongoing management of the Gippsland Lakes and its catchment;
- Provide specific advice to the Minister on the condition and management of the Gippsland Lakes.

In addition, the GLTF has regard to the precautionary principle when considering the implementing its current terms of reference.

Parties to the GLTF have acknowledged the important role it plays, particularly in terms of providing strategic advice and recommending priorities for action; it is therefore important that the GLTF continues this role in the future. The GLTF is comprised of representatives from organisations with responsibility for implementing NRM initiatives across the region.

While this is appropriate, it is recommended that membership be reviewed in light of restructuring of some organisations (e.g. DSE was being restructured at the time of writing) and to assess if additions could be made to bolster the work of the GLTF, for example with regards to community engagement.

The changes predicted to occur with climate change are pervasive and pose challenges for organizations charged with developing and implementing regional NRM policies and strategies. Meeting such challenges will require a whole of government response. While it is important that the Future Actions Plan is integrated with other river and lake health initiatives, it is also important that the GLTF is clear about its terms of reference and activities, so that its focus on achieving its objectives and associated ecological outcomes is not distracted. For example, a change in state to a marine system has implications for the SEPP and Ramsar listing of the Gippsland Lakes that may prompt a review of values and beneficial uses set for the Lakes. Such a change in state also raises questions related to the ecological response(s) of the Gippsland lakes and the extent to which additional management actions might be required over and above actions required to manage issues related eutrophication. The GLTF, as it includes representatives from the main NRM agencies in the region, can play a key role in terms of dealing with a relatively unpredictable and unstable system as the Lakes transition to a more open marine system.

Delivering the Future Actions Plan will require a mix of dedicated actions and investigations commissioned to inform future GLTF decisions (i.e. small projects managed by the GLTF) as well as implementation of nutrient reduction activities and other river and lake health initiatives (i.e. large programs and projects managed by the appropriate partner(s) of the GLTF). A business case for the next round of funding will require:

- A summary of NRM programs and activities occurring across the region and how the Future Actions Plans is integrated with these;
- A summary of outcomes expected with the continued implementation of the Future Actions Plan;
- A summary of what will happen should the Future Actions Plan not proceed;

- A summary of issues that should be considered in relation to a change in state of the Gippsland Lakes as a result of breaching of the coastal barrier;
- A person or persons at a suitable level to champion the Future Actions Plan through the Expenditure Review Committee process.

4.1.2 Adaptation strategies for dealing with climate change impacts

Individual NRM agencies have used recent climate change predictions (DSE 2004a and b, McInnes et al. 2005a and b) in reviewing their risk and responsibilities, and will no doubt soon commence development of adaptation strategies in view of the identified risks. For example, Wellington Shire is currently developing and applying a planning overlay to control coastal development in low lying areas. Benefits are likely to arise if there is cooperation and coordination between the parties to the GLTF in terms the development and implementation of climate change adaptation strategies. This would not require any new body to achieve, as a network for considering climate change already exists as part of the Gippsland Integrated NRM Forum (GINRF).

4.2 Continued implementation of Future Actions Plan

As indicated previously, the continued implementation of the current Future Actions Plan is a high priority for the GLTF. Cottingham et al. (2006) recommended a number of activities to assist the ongoing implementation of the Future Actions Plan, including:

- Applying existing BMPs to the priority nutrient sources of irrigated land in the MID, point sources in the Western sub-catchments and hotspots of stream bank erosion in the Western sub-catchments and the Lower Mitchell and Upper Tambo.
- Review the relative contribution of stream erosion in the Upper Mitchell sub-catchment to sediment and nutrient loads, and their contribution to the Lakes.
- Investigating in greater detail the costs of applying BMPs to specific locations, starting with the priority areas identified above, and factors that may promote or constrain the effectiveness or adoption of BMPs at specific locations.
- Review any emerging technologies that may lead to new BMPs, particularly those that may be applied to diffuse sources such as dryland/grazing and forest land uses.
- An economic study to evaluate marginal returns and the cost-effectiveness of increasing levels of adoption of BMPs.

An important consideration will be how climate change and other drivers affect nutrient reduction activities that are based on average or typical conditions. Thus there is also a need to:

- Confirm the level of nutrient generation from various land uses and reduction associated with current BMPs under different climate change scenarios;
- Use fore-sighting or scenario analysis to evaluate socio-economic trends and predict likely land use change over next 10, 20, 30 years;
- Consider the feasibility of setting nutrient reduction targets for various land uses (e.g. irrigated land, urban land), calculating the level of nutrient reduction expected or required per unit area of a particularly land use, and assessing the relative contribution different land uses are likely to make to overall nutrient reduction targets.

4.2.1 Use of wetlands

Use of natural wetlands as a means of reducing nutrient loads entering the Lakes has been reviewed and ruled out because of the potential impacts on the environmental values and because such wetlands will not necessarily be long-term nutrient sinks (Boon et al. 2005). Constructed wetlands are more likely to reduce nutrient loads but Boon et al. (2005) considered that the amount of land required to reliably trap and retain a significant portion of the nutrient load entering the Lakes from large inputs (e.g. major rivers) makes this option unfeasible. However, constructed wetlands and other features such as vegetated swales are likely to feature prominently at a local level as part of water sensitive urban design (WSUD) options that should be applied to any future urban or commercial developments.

4.2.2 New entrances to the Lakes

SKM (2005) undertook an evaluation of the potential benefits and risks of opening a second permanent entrance to the Lakes in order to reduce the incidence and severity of hypoxia events. They concluded that the limited water quality benefits of this option were outweighed by environmental, social and economic considerations. While the GLTF does not intend to pursue this option, factors such as sea level rise and erosion may in the future result in breaching of the coastal barrier and the formation of new entrances to the Lakes. It is recommended that the GLTF, in consultation with stakeholders, review such a scenario and identify potential remedial or protection measures that might be required. This should include important considerations such as:

- The implications for the values and objectives of existing policies and strategies;
- Confirmation of the medium and long-term values and objectives that will underpin management responses (e.g. will management objectives be the same for entire Lakes system or will there be different objectives for different components of the system?);
- Confirmation of potential management strategies and where they apply (e.g. protection, remediation, abandonment).

4.3 Additional sediment and nutrient load reduction measures

Recent bushfire and flood events (1998 floods, 2003 alpine fires, 2007 Gippsland fires and 2007 Macalister River flood) have emphasised the episodic nature of sediment and nutrient loading to the Lakes. These occurrences have also reinforced awareness of potential issues related to climate change: an increased frequency of such large (in some cases extreme) events may add to the difficulty of achieving the long-term nutrient reduction objective set for the Future Actions Plan. Given that fully implementing existing BMPs[3] alone will not achieve the 40% nutrient load reduction objective, there is a need to explore additional measures, including those that may be applied at landscape scales and can be adapted to address loads associated with stochastic events.

4.3.1 Landscape-scale nutrient reduction measures

Existing BMPs have focused on defined sources such as the MID and point sources discharges. To complement this activity, it is recommended that the GLTF now review the

[3] Existing BMPs predominantly apply to defined (e.g. point) sources of nutrient.

potential for managing sediment and nutrient generation and transport at large (often landscape) scales. In addition to identifying approaches that can be applied to diffuse sources of nutrient, this will provide the GLTF with information about possible management responses appropriate for stochastic events and dynamic conditions. Factors to consider include:

- The potential for reforestation or other changes in land use[4] (e.g. conversion of existing agricultural land to less intensive uses) to affect nutrient loads and water yield, and over what spatial and temporal scale. Identification of changes in nutrient and water yield that might be expected from changes such as reforestation or urbanization (with WSUD) of sub-catchments can be used to estimate the nutrient load retained per unit area of land. Market instruments (see section 4.3.2) might then be considered to try and influence where in the landscape reforestation might be promoted, assuming this can be done without affecting other environmental values (e.g. due to reduced streamflow or groundwater recharge, see also section 4.3.3).
- The relative generation and transport of nutrient loads from forested public land affected by wildfire versus that affected by controlled burns. When supplemented with information on the nutrient load retained in biomass as burnt catchments revegetate, this could be used to assess any nutrient retention benefits from regrowth per unit area of land affected by controlled burns.
- The development of a tool for identifying high risk nutrient export areas (e.g. overlay of topography, soil type, soil erodability, fire risk) and setting targets for reforestation or other sediment and nutrient management measures. This will inform decisions such as where in the landscape to apply different packages of measures and when evaluating options such as the purchase, retirement and revegetation of marginal farmland (e.g. as used in the upper Tambo catchment following the 1998 floods).
- Ensuring that WSUD principles are enforced for all urban and commercial developments and that towns fringing waterways and the Lakes are sewered.

4.3.2 Market based instruments

Once the utility and feasibility of landscape scale management actions have been assessed, it is recommended that the GLTF review the mix of market instruments that might be applied to influence the adaption of BMPs and land use change across the region. This will be informed by having clear medium-long term nutrient reduction targets set for subcatchments.

4.3.3 Ecological Risk Assessment

An ecological risk assessment (ERA) is recommended to explore the relative benefits and risks of different management controls. For example, while regrowth associated with forest plantations or after fires can reduce water yield and associated contaminant load, the reduced water yield could result in decreased flushing (turnover rate) of the Lakes, which may in turn increase the risk of algal blooms. An ERA can also be used to explore the relative nutrient reduction benefits from BMPs under ‘normal’ conditions and with episodic events.

[4] The need for landscape scale initiatives is also recognized in the current Victorian green paper - Land and biodiversity at a time of climate change (DSE 2008).

4.4 Complementary activities

4.4.1 Environmental water requirements

While not the direct responsibility of the GLTF, establishing the environmental watering requirements for the Gippsland Lakes does have implications for some of the nutrient reduction options that might be considered in the future (e.g. reforestation or controlled burning and their relative impact on water yield).A methodology is under development for determining the environmental water requirements of the Lakes,. This work will be important for developing the Gippsland Sustainable Water Strategy and its linkages with the Central Sustainable Water Strategy. The ecosystem objectives and the related environmental water required will be important considerations when developing nutrient reduction targets and options in the future.

It is recommended that the GLTF review the objectives and water requirements once developed to determine the implications for nutrient reduction options in the future.

4.4.2 Planning for a change in state and ecological health of the Gippsland Lakes

As noted previously, breaching of the coastal barrier (e.g. due to large storm surges, sea level rise, erosion) will affect the state of the Gippsland Lakes. How this change in state might affect the ecological condition and stability of the Lakes, and over what temporal and spatial scales, is unclear.

It is recommended that the GLTF review the vision and objectives set for the Future Actions Plan along with that of other policies and obligations set for the Gippsland Lakes (e.g. SEPP, Ramsar) with the expectation that the state of the Lakes will shift to a marine system in the foreseeable future.

Such a review will also provide the basis for identifying environmental indicators that can be used to assess ecosystem responses (e.g. contraction of river estuaries and ensuing changes to hydrodynamic and ecological processes, or the distribution of key flora and fauna) to any future change in state.

4.4.3 Socio-economic considerations

Factors such as the drought, the availability of water, energy costs and other market forces contribute to trends in population and land use. Market forces have the potential to affect the level of adoption of BMPs by impacting on farm inputs costs, such as for energy and fertilizers. The fore-sighting exercise identified in section 4.2 will be important for considering future trends in population and land use change across the region. Identifying such trends will provide valuable insights that may guide where and when different BMPs and other nutrient reduction measures might be applied.

4.4.4 Community engagement

Access to water quality and algae monitoring information is a key feature of current community engagement and communication efforts. It is essential that these activities are maintained in the future, especially given recent local initiatives to promote tourism and development based on the natural features and beauty of the Gippsland Lakes. It will be important to reinforce to the community that there are no quick fixes for problems associated with eutrophication and algal blooms. The region will have to continue to live and adapt to the occurrence of algal blooms for some time to come. Identifying opportunities (e.g. links to community and industry groups) is an important consideration for improving the effectiveness of communications about the Future Actions Plan and its outcomes.

4.5 Summary of actions

The issues and activities described in sections 4.1 to 4.4 are summarised in Table 4.

Table 4: Summary of considerations for the Future Actions Plan in relation to algal bloom formation and the fate of nutrients entering the Gippsland Lakes

Requirement	Actions to consider	Anticipated outcome
Development of a business case for the ongoing work of the GLTF.	• Review membership in light of recent organisational restructures and to identify any additional representation that might bolster the work of the GLTF. • Summarise regional NRM programs and activities and how the Future Actions Plans is integrated with these. • Summarise the outcomes expected with implementing the Future Actions Plan; • Summarise what will happen should the Future Actions Plan not proceed. • Identify a person or persons to champion the Future Actions Plan through the Expenditure Review Committee process.	• Renewed commitment to the Future Actions Plan by party organisations • Clear business case for the Future Actions Plan to put to the ERC.
Integration of climate change adaptation strategies.	• Cooperation in developing climate change adaptation initiatives through GNIRF.	• Coordinated response to climate change across different levels of government.
Continued implementation of the current Future Actions Plan.	• Continue to apply existing BMPs to the priority nutrient sources. • Review the relative contribution of stream erosion in the Upper Mitchell sub-catchment to sediment and nutrient loads, and their contribution to the Lakes. • Investigate in greater detail the costs of applying BMPs to specific locations, and factors that may promote or constrain the effectiveness or adoption of BMPs at specific locations. • Review any emerging technologies that may lead to new BMPs, particularly those that may be applied to diffuse sources such as dryland/grazing	• Realisation of nutrient load reduction anticipated with current BMPs. • Improved understanding of BMP performance under climate change scenarios. • Evaluation of how trends in population and land use change might affect nutrient load objectives and the relative effectiveness of the current mix of BMPs.

Requirement	Actions to consider	Anticipated outcome
	and forest land uses. • Undertake an economic study to evaluate marginal returns and the cost-effectiveness of increasing levels of adoption of BMPs. • Confirm the level of nutrient generation from various land uses and reduction associated with current BMPs under different climate change scenarios, including more frequent episodic events. • Use fore-sighting analysis to evaluate socio-economic trends and predict likely land use change over next 10, 20, 30 years. • Consider the feasibility of setting nutrient reduction targets for various land uses (e.g. irrigated land, urban land), calculating the level of nutrient reduction expected or required per unit area of a particularly land use, and assessing the relative contribution different land uses are likely to make to overall nutrient reduction targets.	
Develop contingency plans for the effects of new entrances should the coastal dune barrier be breached.	• Engage with stakeholders to consider implications for the values and objectives of existing policies and strategies. • Identify medium and long-term values and objectives that will underpin management responses. • Confirm the potential management strategies and where they apply (e.g. protection, remediation, abandonment).	• Whole of government response to the issue of breaching of the coastal barrier and subsequent acceleration of the shift to a marine system.
Identity and evaluate additional nutrient reduction measures, with an emphasis on management options	• Assess the potential for reforestation to affect nutrient loads and water yield, and over what spatial and temporal scale.	• Evaluate a mix of large-scale options for managing diffuse sources of nutrient and stormwater from urban areas.

Requirement	Actions to consider	Anticipated outcome
that may be applied at large scales.	• Assess the relative generation and transport of nutrient loads from forested public land affected by wildfire versus that affected by controlled burns. • Develop a tool for identifying high risk nutrient export areas (e.g. overlay of topography, soil type, soil erodability, fire risk) and setting targets for reforestation or other sediment and nutrient management measures. • Review of the feasibility and cost-benefit of applying large-scale sediment control measures in at-risk catchments. • Ensure that WSUD principles are enforced for all urban and commercial developments and that towns fringing waterways and the Lakes are sewered.	
Identify a mix of market-based instruments to achieve desired levels of adoption of nutrient reduction options.	• Review the mix of market instruments that might be applied to influence the adaption of BMPs and land use change across the region. This will be informed by having clear medium-long term nutrient reduction targets set for subcatchments.	• Market-based options available to complement the work of government NRM agencies.
Ecological risk assessment of potential competing management and protection measures	• An ERA to explore the relative benefits and risks of nutrient reduction measures in comparison with waterway health or rehabilitation measures.	• Understanding of the potential conflict of new nutrient load reduction measures with other environmental protection and management measures.
Acknowledgement of environmental watering requirements for the Gippsland Lakes.	• Review the objectives and recommendations for environmental water requirements for the Gippsland Lakes once developed, both from a nutrient load and ecosystem health perspective.	• Understanding of how nutrient load reduction measures may complement or put at risk the objectives of the environmental water delivered to the Lakes. Broader understanding of the role of river inflows to the overall condition of the Gippsland Lakes
Planning for a change in state and	• Review vision and objectives for Future Actions	• Ability to recast vision and policy

Requirement	Actions to consider	Anticipated outcome
ecological health of the Gippsland Lakes	Plan, SEPP, Ramsar etc. in light of a change in state. • Identify indicators from which to measure ecosystem response to change in state.	objectives and assess ecological responses should the state of the Lakes change.
Understanding of socio-economic drivers and implications for adoption of BMPs for nutrient reduction.	• Use fore-sighting analysis to evaluate socio-economic trends and predict likely land use change over next 10, 20, 30 years.	• Information on future trends that may affect the ability of landholders to adopt nutrient BMPs.
Community engagement	• Use existing communication and community engagement practices to reinforce the long-term nature of addressing eutrophication and algal blooms. • Explore the potential for collaboration with existing community and industry groups to bolster communication efforts.	• Increased public awareness of long-term management issues.

5 HIGH PRIORITY CONSIDERATIONS FOR THE FUTURE ACTIONS PLAN BUSINESS CASE

Discussions with stakeholders and with those who attended the July 2008 workshop highlighted the following actions from Tables 2 and 4 as high priorities for the GLTF as it develops a business case for the Future Actions Plan:

Role of the GLTF and the Future Actions Plan business case

- Confirm the membership of the GLTF and development of a business case to put to the ERC.

Algae and in-lake nutrients

- Use of the conceptual model of algal bloom formation in the Gippsland Lakes and scientific literature to develop a framework or tool to predict the timing, likely taxa and severity of algal blooms.
- Identify if there are deposition 'hotspots' (e.g. via tracer studies or similar) that might then be the target of management actions to reduce the amount of nutrients subsequently mobilised from bottom sediments.
- Review of measures that can be applied to reduce nutrient availability in receiving waters.

Catchment nutrient generation and management:

- Continue to implement BMPs for the priority nutrient sources identified in the Future Actions Plan.
- Undertake an economic study to evaluate marginal returns and the cost-effectiveness of increasing levels of adoption of BMPs.
- Confirm the level of nutrient generation from various land uses and reduction associated with current BMPs under different climate change scenarios, including more episodic events.
- Consider the feasibility of setting nutrient reduction targets for various land uses (e.g. irrigated land, urban land), calculating the level of nutrient reduction expected or required per unit area of a particularly land use, and assessing the relative contribution different land uses are likely to make to overall nutrient reduction targets.
- Develop a tool for identifying high risk nutrient export areas (e.g. overlay of topography, soil type, soil erodability, fire risk) and setting targets for reforestation or other sediment and nutrient management measures.
- Undertake an ERA to explore the relative benefits and risks of nutrient reduction measures in comparison with waterway health or rehabilitation measures.
- Use existing communication and community engagement practices to reinforce the long-term nature of addressing eutrophication and algal blooms.

Complementary activities:

- Review the objectives and recommendations for environmental water requirements for the Gippsland Lakes once developed, both from a nutrient load and broader ecosystem health perspective.

- Review vision and objectives for Future Actions Plan, SEPP and Ramsar listing in light of a change in the state of the Gippsland Lakes. Identify indicators from which to measure ecosystem response to a change in state.
- Use existing communication and community engagement practices to reinforce the long-term nature of addressing eutrophication and algal blooms. Explore the potential for collaboration with existing community and industry groups to bolster communication efforts.

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