PURPOSE OF THIS REPORT

This report was commissioned by NRM North's Tamar Estuary and Esk Rivers (TEER) Program to provide independent advice to partners of the TEER program on the potential environmental impacts of developing a barrage on the Tamar River estuary as proposed by Tamar Lake Inc.

The scope of this peer review is to provide an independent assessment of the environmental reports commissioned by Tamar Lake Inc. as at September 2014. Specifically this report aims to identify any gaps in understanding of specific and system wide impacts not addressed in the Tamar Lake Inc. environmental reports; provide recommendations for further study and investigations; and to describe the likelihood and consequence of the potential environmental impacts during the lifespan of the project.

This peer review focuses on the potential environmental impacts of the Tamar Lake proposal in the context of the Tamar River estuary and does not include any direct assessment of the economic or social impacts associated with the Tamar Lake proposal.

This report was commissioned by the TEER program for the purpose of informing program partners in future discussions regarding the potential impacts, costs and benefits of the proposal. No inference should be made regarding the level of endorsement or support for the Tamar Lake proposal by any of the TEER program partners or NRM North as a result of information contained in this report.

Peer Review Report

Assessment of the comprehensiveness of the potential environmental impacts, threats and risks identified in the Tamar Lake Inc. reports.

David Rissik
November 2014

Report for NRM North

Executive Summary

Disclaimer: It is recognized that this review is part of an ongoing body of work aimed at creating a full understanding of the potential impacts and consequences of the proposed Tamar Lake. As such, this review is limited as outlined below and seeks to provide guidance and suggestions which progress the required work in a satisfactory way.

NRM North through the Tamar Estuary and Esk Rivers Program has commissioned an independent peer review to assess the current environmental reports commissioned by Tamar Lake Inc. The aim of the peer review is to provide an independent assessment of these reports in respect of potential environmental impacts of the Tamar Lake proposal and to identify any gaps in understanding of specific and system impacts.

In particular, this peer review focuses on the potential environmental impacts of the Tamar Lake proposal in the context of the Tamar estuary and does not include an assessment of the economic or social impacts associated with the Tamar Lake proposal.

Tamar Lake Inc. has commissioned three environmental assessment reports related to the proposal which have been reviewed in this report. These reports have been predominantly desk-top in nature and vary in the depth to which they have been able to identify and address issues. Whilst they provide a good start for stakeholders to build an understanding of the implications of the proposed barrage, this review posits that they lack sufficient detail to describe the consequence or impact of the issues on the entire system which would enable community debate and informed discussion. This review has also identified a number of critical gaps which were not addressed in the Tamar Lake commissioned reports.

A summary of the major findings from this review are documented below to capture the key environmental issues, key gaps identified in the reports and key recommendations for further investigation.

Water Quality and Hydrology

Key Issues:
Water quality issues in the Tamar River are well recognised particularly in the upper estuary in the more populated urban areas around Launceston. High nutrient, sediment and bacterial loads from both point sources (e.g. Waste water treatment plants WWTPs) and diffuse sources (eg. run off from agricultural, forestry and other landuses) currently result in degraded water quality limiting recreational use in the upper estuary.

Although Tamar Lake Inc. have proposed that WWTPs would be upgraded under a Tamar Lake scenario to allow discharge into a freshwater environment, only 20 to 30% of the nutrients entering the Tamar estuary are from WWTPs. Currently 70% to 80% of the nutrient loads enter the Tamar estuary from the catchment. A key concern is the potential for algal blooms to occur. Algal blooms are already known to occur during the warmer months in both Lake Trevallyn and the Cataract Gorge. Under a Tamar Lake scenario is it likely that algal blooms would occur without significant reduction in nutrient loads from WWTPs and the catchment, and there is potential for blooms of toxic blue green algae to occur which would greatly impact the recreational use and amenity of the proposed Tamar Lake.

The Tamar estuary currently receives significant loads of pathogens (bacteria) in the upper estuary. More than 90% of these loads come from catchment run off, primarily from livestock waste on top of natural loads. Under a Tamar Lake scenario it is likely that the Lake will continue to receive high bacteria loads which will impact on the recreational use of the Lake in certain conditions. Currently, only the upper to mid-upper estuary is unsuitable for primary contact activities due to poor flushing. Under a Tamar Lake scenario it is possible that majority of the

60km Lake would experience high pathogen levels at times, making it unsuitable for primary contact recreational activities, and consequently limiting its potential use and economic value (e.g. for irrigation purposes, potable water supply). It is also possible that current dairy expansion and irrigation intensification of agricultural land in the catchment will contribute higher loads of pollutants to the Lake environment from the Esk river systems.

Key Gaps:
The contribution of diffuse loads of pollutants (nutrients, sediments, pathogens and metals) to the proposed Tamar Lake have not been adequately explored in the environmental reports. Although Tamar Lake has developed the proposal under the assumption that Waste Water Treatment Plants would be required to be upgraded to allow for discharge into freshwater, the majority of the pollutant loads (70-80%) are attributed to diffuse sources transported to the Tamar estuary through the North and South Esk river systems. It is highly likely that the reduced flushing in the Lake environment would result in poor water quality which could limit the social, and economic values of the proposed Tamar Lake. More modelling with respect to these issues would be required in a full feasibility study.

Sedimentation

Key Issues:
Mitigating issues associated with sedimentation of the Tamar estuary has been one of the advantages cited by Tamar Lake Inc. in its proposal for creating a barrage on the Tamar estuary. It is likely that sedimentation under a Tamar Lake scenario will continue to occur with sediment transported to the Lake environment from the North and South Esk river systems. Although flocculation of sediments will not occur in the freshwater Lake, sediment will continue to settle out and may require occasional sediment removal inside the Lake to remove excess sediments over a protracted period of time.

The zone immediately below the barrage is most likely to be impacted by sedimentation as the flocculation zone will be moved to the area below the barrage where freshwater is released from the lock into the salt water. As the freshwater carrying the sediment from the Lake meets the saltwater below the barrage the sediments will clump together into a 'floc' and settle out. Modelling scenarios are required to ensure that sedimentation impacts inside the Lake environment and below the barrage are closely examined. The proposed 3D modelling will help to underpin full feasibility modelling of these issues.

Key Gaps:
Acid sulfate soils are naturally occurring soils found in low lying coastal landscapes. When these soils are waterlogged they remain harmless, however when they are disturbed through excavation or drainage they can release sulphuric acid. The Tamar estuary is known to contain extensive areas of potential acid sulphate soils (PASS).

Any sediment removal within the Lake or construction of the barrage infrastructure will need to consider the impact of Passive Acid Sulfate Soils which have the potential to release acid when exposed to oxygen and consequently result in contamination of the Lake environment. If left untreated this can lead to a range of environmental, engineering, infrastructure and health related impacts.

Ecology

Key Issues:
In 2011 the Tamar estuary was listed by the Australian Government as a High Conservation Value Aquatic Ecosystem (HCVAE). The Tamar Estuary possesses extremely high plant, invertebrate and fish species diversity, and many of these species are not found elsewhere in

Tasmania. The estuarine and coastal ecosystems of the Tamar Estuary and its environs provide many important habitats, including soft muddy and sand bottoms, rocky reefs and soft corals, open ocean environments, wetland communities and sandy beaches.

The site includes species protected under state, national and international instruments. Fifteen threatened fauna species visit or inhabit the Tamar Estuary. These include the humpback and southern right whales (both endangered), the Australian grayling (vulnerable) and the white-bellied sea eagle (vulnerable). A number of threatened vegetation communities also occur along the shores of the Tamar, including the rare or endangered swamp paperbark (*Melaleuca ericifolia*) forest. Protected species include a number of migratory birds protected under international treaties, marine mammals, Syngnathidae (pipefishes, seahorses, sea dragons) and a number of shark species.

Many of the identified nationally listed threatened species will likely be displaced from the Tamar estuary under the proposed Tamar Lake project.

Key Gaps:
In August 2013 *Subtropical and Temperate Coastal Saltmarsh* was officially added to the list of threatened ecological communities under section 181 of the Environment Protection and Biodiversity Conservation Act 1999. The Tamar estuary has extensive coastal saltmarsh (1731 ha mapped) in the low lying tidal flooding zone. Saltmarsh communities that occur within the proposed freshwater Lake area will be displaced.

Gambusia (*Gambusia holbrooki*) is a pest fish species which has colonised a number of areas within the Tamar estuary (Tamar Island Wetlands and adjacent farm dams and drains). This is the only know infestation of Gambusia in Tasmania. Gambusia compete with native fish for food and habitat and they have been linked to the decline of native fish and frog species throughout Australia. To date the spread of the pest fish has been limited due to its isolation in the Tamar Island Wetlands. Under a Tamar Lake scenario the habitat for Gambusia is likely to expand significantly posing a significant risk of infestation of the pest species, particularly via human translocation, to other areas in Tasmania and impacts on native fish and frog species.

Key Recommendations

Risk Assessments
Full risk assessments are recommended to determine the risk to the survival and health of ecological communities present in the Tamar River estuary, particularly the nationally and state listed high conservation value and threatened species and communities. Further detail on specific risk assessments recommended can be found in the issues tables within this report.

Modelling scenarios
Modelling a range of scenarios to determine the impact of a proposed barrage on hydrology, sedimentation and sediment transport, ecology and water quality will be a critical component of future investigations required to assess the viability of the Tamar Lake Inc. proposal. Further detail on specific modelling scenarios recommended can be found in the issues tables within this report.

Monitoring and evaluation
In the event that the development is approved, there is a need for the associated impacts and mitigating management actions to be monitored and reported over the lifespan of the development. It is strongly recommended that data are collected in a highly rigorous manner with sufficient spatial and temporal replication, to enable a statistically rigorous monitoring program to be developed.

Develop a Business Case
Reports reviewed to date describe the advantage of a barrage as a means of mitigating 'siltation'

in the Tamar. The creation of a lake may remove visibility of mud flats however may not mitigate on-going sedimentation of the Lake and will likely increase sedimentation below the barrage. The ongoing potential for water quality issues in the Lake are also likely to limit use of the lake for recreation and its potential economic value if there was a demand for irrigation or potable water supply. Additionally use of a barrage to mitigate flood and climate change risks requires further detailed investigation and modelling before they can be promoted as a case for project development. This review recognizes that any development requires trade-offs between the economic and in this case recreational values and the environmental values but the reports reviewed at this point do not present a robust argument regarding the potential environmental trade-offs and issues against the potential value. A strong business case with respect to these trade-offs, once more fully explored is strongly recommended.

Introduction

The Tamar Estuary is situated on the northern coast of Tasmania. It is one of the State's larger estuaries occupying an area of approximately 100km2 (see figure 1). It extends 70km from the confluence of the South Esk and North Esk Rivers near Launceston to its mouth at Low Head where it enters Bass Strait (Pirzl and Coughanowr 1997). The climate of the region is described as cool temperate with mean daily maximum temperatures ranging from around 12 °C in July to 21-24 °C in February and minimum temperatures ranging from 2-6 °C in July to 12-13 °C in January. Average annual rainfall is approximately 680mm (based on climate averages for Launceston and Low Head weather stations, BOM 2006).

Tamar Lake Inc., is leading a pre-feasibility study for the development of lock and barrage system across the Tamar River estuary in northern Tasmania. The barrage would be created 60km downstream from the city of Launceston at near Rowella at Moriartys Reach (see figure 1). The 800 metre long barrage would create a 60km freshwater lake upstream of the barrage and truncate the tidal estuary to approximately 20km entering Bass Strait.

The proposed development is primarily aimed at managing silt in the upper Tamar, but the proponents argue that a variety of other outcomes will also be achieved. These include a significant fresh water supply, with benefits for agriculture and the regional community, flood mitigation from catchment flows and ultimately from sea-level rise and significant tourism opportunities for the region.

The proponents have funded several technical studies to support their proposal and have identified several environmental, social and economic changes which will result if the proposal goes ahead. They have concluded that the positive effects outweigh the negatives, and have submitted the proposal for further review and evaluation, with a view to seeking support to implement the plan.

NRM North has commissioned an independent review and evaluation of the proposal and a range of associated reports and literature about the Tamar Estuary. The review includes consideration of the comprehensiveness of the environmental issues covered and identification of any gaps. This review is limited to a review of the potential environmental impacts of the proposal and does not include a discussion on the social or economic impacts.

This peer review has included consideration of the following information:

Tamar Lake Inc. reports:

- **Preliminary Technical Assessment** – BMT WBM – Dr. Ian Teakle
- **Natural Values Assessment** – BMT WBM – Dr. Andrew Costen
- **Ecological Assessment of threatened species and potential eco-system impacts** – CDM Smith – Dr. Mark Breitfuss
- **Tamar Lake Inc. Power point presentation by Robin Frith** to the TEER Scientific and Technical Committee, 8 May 2014.

Reports and information provided by NRM North:

- **Gambusia reports**- (various)
- **TEER Water Quality Improvement Plan**- outputs from DSS tool- R. Kelly, A. Locatelli
- **Tamar ecology and biodiversity reports** (various)
- **Impacts of Barrages** (various papers collated by NRM North)
- **Tamar Estuary Sedimentation reports** (various)
- 5 responses to a written questionnaire to the TEER Stakeholders,
- Feedback from face-to-face meeting with a range of TEER Stakeholders on 28 August 2014.
- A site inspection of the Tamar estuary including of the proposed location of the barrage.

The review focussed on:

- Assessing the degree to which previously identified key issues of concern (identified by NRM North and other stakeholders) have been addressed in the Tamar Lake assessment reports.
- Identifying questions that have not been asked or assumptions made by Tamar Lake in their reports.
- Identifying gaps that have not been addressed in the assessment reports.
- Recommending additional investigations/ assessments.

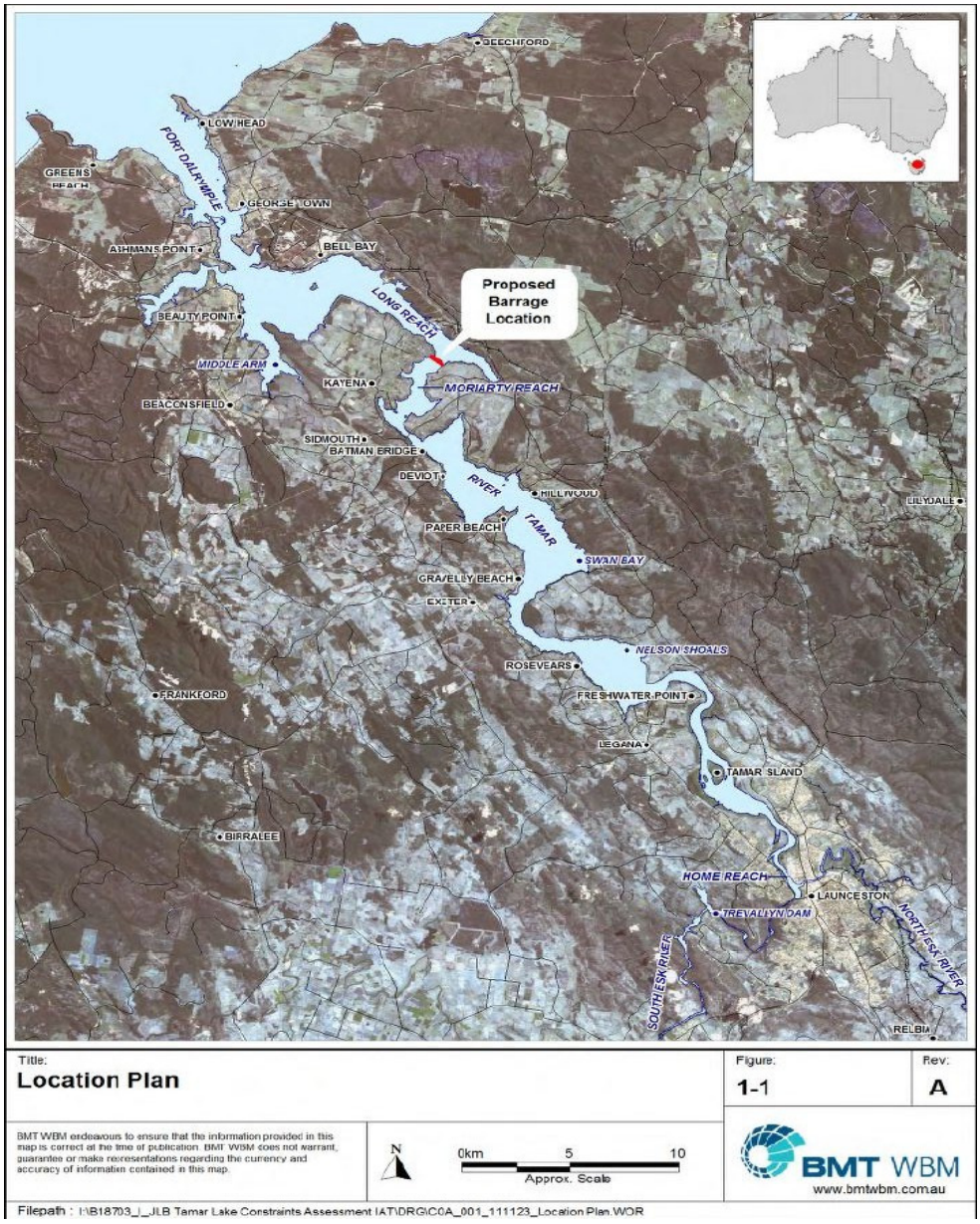

Figure 1: Location map for the Tamar Lake Barrage Concept, Moriartys reach, Rowella, Tasmania.

Assumption

This review has been undertaken with the assumption that in the event of a barrage being developed, the WWTPs responsible for treating sewage that discharges to the estuary will be upgraded to a tertiary water treatment capability, with nutrients (N and P) being removed from the wastewater stream.

Despite this, it is recommended that in any modeling and risk based investigations that are conducted to support the proposed barrage, the proponents clarify exactly what such an upgrade will entail. For example: Will all pathogens and nutrients be removed from the waste stream, what risks remain of overflow, and if any, where will overflows take place? Will all heavy metals and potential toxicants also be removed from the waste stream?

It is also very important that the proponents recognise the implications of diffuse pollutants to the system. These pollutants are important drivers of freshwater and estuarine water quality issues (Leigh et al. 2013). If the proposed development was to be approved diffuse pollutants would need to be managed to reduce implications from nutrients and sediment.

Background to estuaries

Estuaries are bodies of water which form the interface between the freshwater environment and the marine (saltwater) environment. Estuaries are highly variable systems with varying salinity as a result of mixing of marine and freshwater, and because of the movement of tides. Estuaries are very productive areas with important vegetation such as seagrass and saltmarsh. They are also semi-enclosed environments which offer a lot of protection for the organisms that live in them. Because of this, estuaries are very important habitats and have unique species, but also play an important part in the lifecycles of many species. For example providing shelter and food for larval and juvenile fish species. There are a number of different types of estuaries in Tasmania, Australia and in other countries. This is an important feature as not all estuaries are the same.

The variety of habitats associated with estuaries is an important feature. These include open water, saltmarsh, sand and mud flats, wetlands, rocky shores and riparian habitats. Most people in Australia live near estuaries which has led to estuaries being under pressure from nutrient and sediment runoff, loss of habitat, overfishing to name a few. Estuaries are also faced with the potential impacts that may result from climate change, including sea-level rise.

Construction of a barrage across an estuary can substantially change the processes that take place in the estuary. Barriers block the tidal movement associated with estuaries, they reduce the movement of salt water into areas above the barrage changing those areas into a freshwater environment. This can result in changes to the chemistry of the water and sediment and make it unsuitable for many of the species that live there.

Freshwater systems are very simple systems compared with estuaries, they do not support the diversity of organisms or vegetation and have a different character to estuaries. Importantly too, freshwater lakes do not support part of the lifecycles of many marine species which is an important service provided by estuaries.

Overview and structure of the report

The Tamar Lakes Inc. proposal for a barrage to be built across the Tamar Estuary, changing the majority of the estuary to a freshwater system presents a significant challenge to decision makers, stakeholders and the community. The proposal has been developed as a means to address the issue of sedimentation in the estuary, while providing a number of other benefits to

the system, including substantial economic opportunity.

The large size of the Tamar Estuary means that the proposed barrage will have a significant impact on the water quality, the ecology and hydrodynamic processes that take place in the estuary. The proponents intend to change the system from an estuary with a diversity of aquatic and terrestrial habitat driven by tidal and freshwater dynamics with constantly changing water currents, salinity regime and levels of inundation to something that is much more homogenous in nature with a constant salinity (freshwater).

Environmental issues associated with the proposed barrage are presented in four categories including:
1) construction phase,
2) establishment to equilibrium phase,
3) equilibrium phase and
4) future phase.

The risk of a particular effect occurring has been estimated and the consequence rated. In each case categories of high, medium and low have been used. In determining consequences the scale of change has been taken into account. As a significant extent of one of the most important Tasmanian Estuaries will be affected (see Figure 2), the consequences are often determined as high.

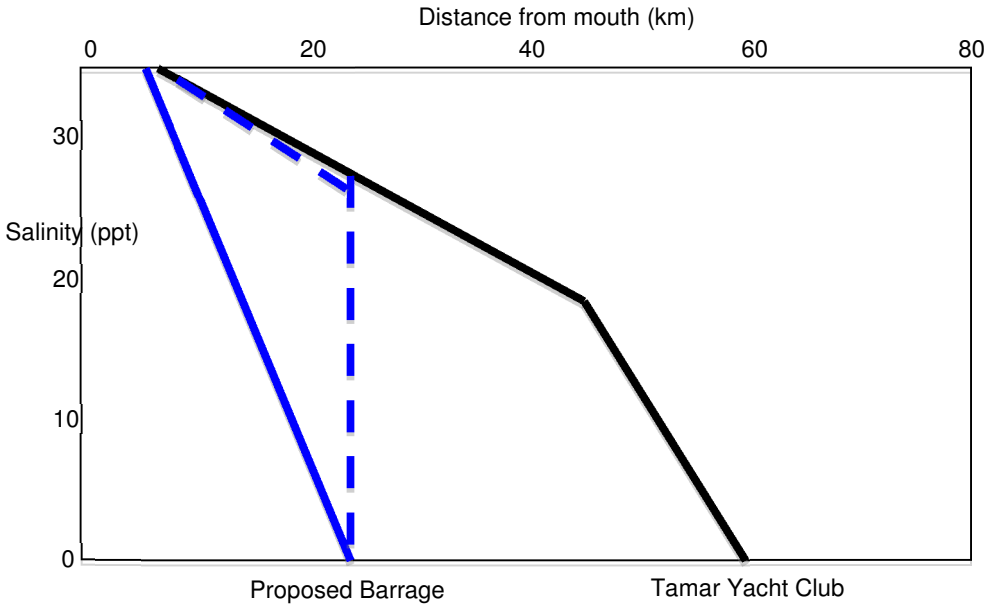

Figure 2. Stylised salinity profiles for the Tamar Estuary without Barrage (black line) and following construction of the barrage (blue lines). The dashed blue line shows the salinity during no flow conditions and the solid blue line shows salinity during high flow conditions. Salinity shown by the black line is based on a figure from BMT WBM 2012. Note that the estuary upstream of the barrage will become freshwater changing the character of the waterway completely. The salinity regime below the barrage will also change substantially.

Figure 2 shows the significant change to the salinity regime of the waterway that will occur under this plan. All the area to the right of the vertical blue line will ultimately become a freshwater system. In addition, this area, which currently undergoes significant tidal variability, will have a stable water level, that will only vary as a management tool to reduce flooding

Construction Phase

Constructing the barrage will be a large and complex operation. Consideration will need to be given to reducing environmental effects during the construction phase. These impacts will be determined through an Environmental Impact Statement and conditions will be outlined if approval for the development goes ahead. It is strongly recommended that issues associated with construction are determined very early on so that the proponents are able to conduct the various studies that will/may be applied early on in a rigorous fashion.

Construction Phase (Colours used to indicate high risk/high consequence, medium risk/medium consequence, low risk/low consequence)			
Issue/threat identified	**Risk and likelihood of occurring**	**Priority or Severity/Consequence**	**Recommendation for additional assessment**
Noise caused during construction could impact birds.	Low risk	Low	Access long-term bird observation data to determine the types of birds and their use of the area surrounding the proposed development over a calendar cycle. Specific attention to be paid to migratory birds or other locally important taxa.
Increased size of roads and use of large trucks could lead to increased sediment runoff at the site of the barrage during construction	Medium risk	Low consequence	Consider the sediment type, and the potential for erosion and sediment runoff from dirt roads in the area.
Depending on the nature of construction, there could be increased turbidity in the area of the construction	Medium risk	Low consequence	Consider the approach to construction and the likelihood that short-term changes to flow resulting from the construction process could have on upstream and downstream erosion and sedimentation.
Mitigating issues related to disturbance of Acid Sulfate Soils. See map from Land Information Systems Tas (LIST) online mapping	Medium risk	Medium consequence	Consider the extent of Passive Acid Sulfate Soils (PASS) in the area and the likelihood of exposing PASS and the resultant implications. Acid Sulfate Soils occur naturally in soils that contain sulfate. When they remain undisturbed and unexposed to oxygen, acid sulfate soils are not a problem and are known as Passive Acid sulphate Soils (PASS). Acid sulfate soils become active when waterlogged soils dry and are exposed to oxygen in the air. This leads to oxygenation of the soils which produces sulfuric acid which can lead to metals such as iron being released from the sediment and can also have direct effects on organisms.
Changes to estuarine hydrology and estuary upstream and downstream water quality and ecology	Medium risk	Medium consequence	The development of a barrier across the estuary can change the hydrology of the system. There is a need to understand what the short-term implications of these changes may be to the hydrology of the system and the upstream and downstream ecology.

			The hydrology or hydrodynamics of an estuary is the movement of water by tidal movement or inflow from rivers. Barriers to flow or to tidal movement can change the nature of water movement and ultimately the chemical composition of the water as salt water above the barrier gets diluted with freshwater.
Local impacts to the ecology of the area under development	Medium	Medium	There is potential for the construction approach to have impacts on the ecosystems near to the development site. There is a need for a detailed inventory to be undertaken of the ecology of the system for 2 km upstream and downstream of the proposed development. This will help to identify ecosystems and organisms that may be impacted during development, which will support a risk analysis and will also underpin a monitoring program should the development go ahead.

Establishment to equilibrium phase

The proposed development will reduce the size of the Tamar Estuary substantially. This is not refuted by the proponents, and is part of their proposal. A significant change to the salinity and hydrodynamics of the estuary will take some time to reach a state of equilibrium where there is a fully freshwater lake and freshwater ecosystems have reached a stable state. It is critical that investigations are conducted to help to fully understand the changes that will take place in the system, the times that these changes may take, to identify any previously unforseen outcomes and risks.

Establishment to equilibrium phase (Colours used to indicate high risk/high consequence, medium risk/medium consequence, low risk/low consequence)			
Issue/threat identified	**Risk and likelihood of occurring**	**Priority or Severity/Consequence**	**Recommendation for additional assessment**
Gradual change from saltwater to freshwater system	High Likelihood	High Consequence	The implications need to be spelled out very clearly and simply and considered against the needs and values of the community. The changes that will occur at various sections of the estuary should be illustrated using conceptual models. The temporal and spatial scales of change should be outlined. Community need to be informed of how long the transition timeframe will take and what to expect e.g. Odour from decaying vegetation.
Loss of saltwater related habitat and species	High Likelihood	High Consequence	The change to a freshwater system and the cessation of tidal fluctuations will have a significant impact on saltwater habitat and species. An assessment should be done to determine and document all floral and faunal communities that will be changed. The assessment should also include an indication of the importance of the current habitat to estuarine ecological processes and to the northern Tasmanian coastal environment. The assessment should include a projection of what communities will replace the lost habitat and what ecological processes will be linked to these changed communities. Decision makers and the community should be able to use this document to clearly understand the significance and extent of the changes and their replaced habitats.
Increased residence times upstream of barrage	High Likelihood	High consequence	The presence of a barrage will prevent tidal flushing in a significant area of the estuary and increase residence times of the water. The proposed 3D physical model should provide an indication of the residence times in the lake under a variety of freshwater flow conditions (high, medium, low, no flow).

			Modelling output should be provided spatially in a manner that clearly indicates where residence times are high, medium or low and tables should indicate the differences between seasons.
Alteration of sediment bacteria and associated processes. Potential release of nutrients and sulphates into water column.	High Likelihood	Medium consequence	The changing salinity regime will result in changes to the microbial communities in the sediment, which will influence the sediment water column processes. Such changes could potentially result in nutrients, sulfates and heavy metals being released into the water column. A study should be done to understand the sediment nutrient interactions that take place at the moment and to provide an indication of the extent of changes that will occur. The study should include a determination of the amount of nutrients and heavy metals that are bound in the sediment under the present regime, and an assessment of how changes to the microbial communities may affect these.
Breakdown of dead and decaying salt tolerant vegetation causes deoxygenation of bottom waters	High Likelihood	Medium-high consequence	Changes to the salinity regime upstream of the barrage will potentially result in the die-off of large expanses of salt tolerant vegetation, which will ultimately settle to the bottom of the estuary. In addition the increased residence times of the water will result in settlement of organic matter from the water column. The breakdown of the organic matter will consume oxygen from the bottom water. This may persist for some time and could lead to a further change in the microbial composition of the sediment, with consequences such as release of nutrients and metals from the sediment. A study should be conducted to estimate the amount of vegetation and organic matter that will break down or settle into the system. These parameters should be included in the 3D modelling work to facilitate an estimation/prediction of the extent and duration of deoxygenation (again under a range of flow conditions). The study should include a risk assessment of where die-off is most likely to occur. For example risk of die-off is reduced in the expanses of the estuary with consistently low salinities.
Rice grass die back as the salinity regime changes, could destabilise and mobilise sediment, releasing nutrients, metal and other contaminants that are bound in the sediment. Mobilised sediment could result in changes to the areas where sedimentation occurs.	High risk that rice grass will die back. Medium risk of contaminants being released	High consequence	Rice grass is intolerant to salinities below 5ppt (Invasive Spartina Project 2011). Work is required to map extent of rice grass and the sediment which they stabilise at present. A comprehensive risk analysis of the effects of destabilising sediment associated with rice grass should be conducted along with an indication of where any mobilised sediment will move to. This may be possible using the 3D model. The risk analysis should include consideration of the contaminant in the rice grass. This could include mapping of rice grass areas according to the concentrations of metals and contaminants in each area. This would facilitate the development of a management plan to mitigate risk should the proposed barrage be developed.
Breakdown of organic matter can result in the production of odours. Where areas with increased odours are close to places where people live or use, the odours may impact liveability and amenity	High risk of odours	Medium consequence	The potential for increased odour resulting from breakdown of organic material must be considered. This can build on work conducted to map extent of vegetation that may die-off as a result of salinity changes. The work should consider mitigation approaches (e.g. use of lime) that may be used if this occurs close to population centres
Rice grass has been present in the Tamar Estuary for long	Medium risk	Low consequence	The role of rice grass areas as habitat for various taxa should be considered and used to assess the implications of the die-off of rice grass on the biodiversity of the system.

periods of time and may provide habitat for a range of estuarine taxa.			
Stratification as remaining salt water sinks to the bottom and is covered by freshwater.	Medium (depending on spatial and temporal scales)	Medium (depending on spatial and temporal scales)	Once the barrage is constructed the salt water will gradually be replaced by freshwater. Salt water is more dense than freshwater and in low flow conditions or in deeper areas of the lake could sink to the bottom and form a layer of salt water covered by a layer of freshwater (known as stratification). Strong pycnoclines (the zone between the freshwater layer and the saltwater layer) which could result are difficult to break down through mixing, and could potentially result in pools of deoxygenated saline waters at the bottom of the freshwater lake. Deoxygenated bottom waters could lead to changes to the bacteria in the sediment and subsequent changes to the form of nutrients being discharged from the sediment. Three dimensional modelling of the estuary before and after the barrage is constructed (supported by detailed bathymetric data) will help to determine where stratification may occur, and over what period any remaining pockets of salt water will remain in the Lake. The modelling can also determine the nature of flows that are required to advect the remaining bottom saline water from the lake. The results from modelling can be used to determine the risk associated with stratification and the likelihood of stratification occurring under different flow regimes.
Salt tolerant zooplankton species and poorly motile marine associated larval fish die off.	High	High	A changing salinity regime will result in die-off of saltwater plankton such as zooplankton and larval fish. The likelihood of die-off will depend on the salinity tolerance of the various taxa. Risk assessment should include a map showing where die-off of these taxa is most likely. A prediction of what freshwater taxa may replace the existing communities should be included.
Loss of estuarine nursery grounds for a variety of fish taxa.	High	High	Estuaries are very important nursery grounds for a variety of fish species including economically important taxa. For example, 110 finfish species occur in the Tamar Estuary (Tasmanian Parks, Wildlife and Heritage 1991). The lower Tamar is also designated a Shark nursery area. Associated with the risk assessment into loss of estuarine habitat, an assessment of the implications of any loss/changes to habitat to fish communities should be done.
Tidal movement ceases, exposure of mud flats becomes less variable. This promotes vegetation growth and colonisation by plants. Feeding habitat for birds is reduced.	High	High	The distribution and extent of tidally exposed mud flats must be documented. The use of these mud flats by feeding birds must be assessed and maps should be produced showing the level of use and hence importance of the various mud flats at different times of the year. For example, >60 species of birds have been identified at Tamar Island (Aquanal and DEPHA 2008), many of these species will rely on mud flats for feeding purposes. Mud flats which may remain exposed at the levels managed through the lake should also be documented. Areas of significance for shorebird feeding may be prioritised for long-term management to ensure they are not colonised by vegetation communities. The infauna associated with the mud flats should be documented and considered against the types of infauna that may be present one the lake ecology has stabilised.
Threats to threatened species associated with the upper estuary. These include	High	High	Initial reports have identified threatened species and communities which inhabit the upper estuary at all or some stages of their life history.

Australian Grayling, Green and Gold Frog, swamp paperbark and saltmarsh communities.			Additional research should include an estimate of the populations of Australian Grayling and Green and Gold Frogs and should discuss the potential effects (negative or positive) that loss of habitat or changing habitats in response to the reduced tidal range and change to a freshwater system will have. It is possible that an increase in the extent of freshwater habitat could have a positive influence on the distribution and abundance of some freshwater taxa. Saltmarsh communities upstream of the barrage will lose their competitive advantage and are likely to be replaced. Mapping of salt marsh is available and should be used to facilitate a risk assessment indicating where changes are likely to occur, and to determine what the implications of these changes are on the system. Discussion should be centred on processes affecting these communities and species, and on the regional significance of the populations, and the long-term ramifications of these changes on a regional and estuarine scale. The Tamar is a stronghold for swamp paperbark in Tasmania. Swamp paperbark communities should be mapped and there should be discussion about the current physical processes that support that community. A risk analysis should be conducted on how changes to any of those processes will affect the swamp paperbarks. Discussion should also include the combination of threatening processes. E.g. loss of certain habitats, changes to physical conditions, changes to food supply, changes to competing communities/ species.
Loss of intertidal organisms and effects on predators of these taxa.	High	High	Stable water levels and a freshwater environment will result in die-off of oyster beds and other intertidal estuarine species upstream of the barrage. The oysters in the Tamar Estuary are Pacific Oysters and die-off of these communities is a positive result. Any native intertidal fauna that is lost through changes to the salinity regime, would be a negative consequence. A study should be conducted to map the distribution and extent of the intertidal fauna and a risk assessment should be conducted on the effects of the barrage on those populations. The risk assessment should also include an understanding of the implications of any changes on other organisms such as higher levels predators.
Loss or changes to other habitats, loss of connectivity between habitats (e.g. Olds et al. 2013)	High	High	Habitat diversity and connectivity between the different habitat types have been shown to be important for maintaining fish populations (Olds et al. 2014). Discussion should take findings such as this into account when determining the implications of changing habitats in response to changes to the physico-chemical regime of the estuary.
Implications to the values of the community.	High	High	The community associated with the Tamar Estuary and Esk River has previously emphasised the importance of the estuary and its surrounding habitat. A significant change to the estuary such as that associated with the proposed Lake would have significant implications for the values of the community. This is extremely important as the community should ultimately determine the type of system they wish to have. A significant study on community values should be considered. This must include all facets of the community along the estuary and upstream. Values of the broader Tasmanian society should also be considered as Tamar is an important estuary for the state.
Changes downstream of the barrage including flocculation zone moving closer to the estuary mouth and associated	High	High	The 3D modelling work that will be conducted should include consideration of where the likely flocculation zones will be under a variety of flow conditions (no flow, low flow, medium flow and high sustained flows). The modelling should also include an estimation of changes to the turbidity of the estuary downstream of the barrage.

increase in sedimentation. Changing to salinity regime of the estuary immediately below the barrage. Potential increase in turbidity for longer periods than has previously occurred.			Any changes of the turbidity should be used to determine how light penetration into the estuary will change and the ramifications of any changes in light penetration on the ecology of the remaining downstream estuary. This should include influence on seagrass and other algae such as those associated with rocky shores.
Changes to salinity regime of the estuary and influence on the distribution and abundance of estuarine biota.	High	High	The construction of a barrage and resultant changes to the estuarine hydrodynamics and salinity regime, will influence the distribution and diversity of organisms in the estuary. Reports should include an estimation of what changes are likely to occur and where organisms will be distributed. This should be done for major taxa and also for the broader communities of biota.

Equilibrium Phase

Sometime after the barrage is constructed, the system will reach equilibrium (determined through running the detailed 3D hydrodynamic model) and a new relatively stable state will be in place. This will essentially be a large freshwater lake as planned and a significantly shorter estuarine environment downstream. There are a variety of considerations about the long-term aquatic health of the lake and estuarine environments which need to be considered.

Equilibrium Phase (Colours used to indicate high risk/high consequence, medium risk/medium consequence, low risk/low consequence)			
Issue/threat identified	**Risk and likelihood of occurring**	**Priority or Severity/Consequence**	**Recommendation for additional assessment**
High nutrients (from diffuse catchment sources and benthic fluxes). Higher light intensity through water column (as a result of clearer less turbid water results in increased likelihood of freshwater blue green algal blooms – potentially harmful varieties. Analysis conducted using the Decision Support System for the TEER Water Quality Improvement Plan estimates that 20-30% of loads for TN and TP come from waste water treatment plants, the rest is diffuse loads from the catchment (A. Locatelli, pers comm., Sept 2014)	High	High	The issue of runoff of diffuse nutrients from the catchment into the lake must be addressed. Nutrient runoff into the lake can increase freshwater algae production in the water column. Rates of productivity will be increased in areas and periods of high residence times, and as a result of the presence of less turbid water. Blue green algae blooms occur in Trevallyn Dam and in all likelihood will occur in Tamar Lake. Blooms of *Anabaena circinalis* can be toxic and have also been associated with reduced amenity, eutrophication and associated fish kills. The report must consider the likelihood of such blooms occurring under a variety of scenarios. Scenarios should include different rainfall conditions, different land uses and farming practices, including those expected by the proponents to enhance the economic output in the region (e.g. through increased access to irrigation water). Blooms are likely to occur during the warmest periods, which will coincide with the highest recreational use of the proposed lake.
High bacterial loading from runoff from livestock waste. This could affect recreational amenity. This reduces the amenity potential of the lake and cost of treating water for potable use.	Medium risk	Medium	The risk of runoff of pathogens associated with livestock waste must be considered. Any proposed increase in the use of livestock in the catchment and increases in irrigation, that may be associated with the proposed lake should be included in a risk assessment of effects on amenity and potable use of lake water.
Lake sedimentation occurs as a result of catchment input of	High	Low to Medium in the short term	Runoff of sediment from the catchment will continue and could increase depending on development and increased agricultural activity in the catchment that is proposed to occur as a result of the development.

sediment and the influence of low flushing times in the lake.		High in the long-term	Studies are required to consider the different sediment loads that may result from different landuses and to consider the fate of these loads in the lake over a long time period. Modelling should cover the lifespan of the proposed barrage.
Sediment of previously estuarine areas contain Passive Acid Sulfate Soils (PASS). Any dredging to reduce lake sediment may expose these soils and result in Acid Sulfate Soils (ASS) with associated implications.	Medium	High	It is likely that as a result of continual sedimentation in the lake, combined with reworking of mobilised existing sediment resulting from changes to vegetation and hydrodynamics, dredging might be required to remove sediment. Where possible modelling should be used to determine the likelihood of this scenario and where this is most likely to occur. Matching this with mapping of PASS, will enable a risk assessment to be done to determine whether dredging could lead to exposure of these soils. A management approach may be required early on to deal with these issues.
Oxygenation of PASS resulting from reduced tidal variation and subsequent drying of sediment	Low	Medium	The proposed barrage will reduce tidal variability and potentially lead to exposure of PASS that may previously have been regularly inundated. Runoff of acid from exposed ASS, will no longer be buffered by salt water and may have a greater effect than at present. An assessment on risk associated with Acid Sulfate Soils should include an assessment of this form of exposure and on the consequences of acid runoff into a freshwater environment. A significant body of information exists in NSW, where barriers have reduced tidal flow in several estuarine areas, with significant impacts. It is essential that any ASS risks associated with the development are considered explicitly and that if risks are deemed high, that the impacts of the acidic waters are considered.
More stable water levels may reduce exposure of mud flats and available habitat for migratory species.	High	High	Estuarine mud flats are affected by and maintained by tidal variability. Once water levels stabilise, these important shore-bird and fish feeding habitats may become colonised by freshwater associated vegetation and will no longer be available to birds. The biota which live in the sediment will also change completely. An assessment of the extent and locations of mudflats should be conducted and an indication of those areas that will be affected by the lake should be provided. This should then be used to undertake a risk assessment of the potential impact on shorebirds, particularly migratory shorebirds. An assessment of the risks of loss of these important areas should be made in a regional context. IE how significant are the mudflats in the Tamar to the regional distribution of shorebirds?
Gambusia (mosquito fish) have access to a significantly greater expanse of waterway as habitat. The proposed increase in recreational activity could potentially lead to a spread of the species to other areas.	High	High	Gambusia is a pest fish species which has colonised a number of areas within the Tamar Estuary (Tamar Island Wetlands and adjacent farm dams and drains). This is the only know infestation of Gambusia in Tasmania. Gambusia compete with native fish for food and habitat and they have been linked to the decline of native fish and frogs species throughout Australia. A risk assessment should be conducted to determine whether stable water levels and the transition to a freshwater system will lead to an expansion of their distribution. The implications of an increase in distribution should be spelled out. The assessment should also consider the risk of translocation of Gambusia to other waterways that could result from an increase in recreational activities proposed to occur with the development of the lake.

Change in flocculation zone in estuary to below the barrage will result in increased sedimentation at this point. *Note that the shape of the estuary and the barrage itself will mean that sediment is not advected upstream during low flow periods.	High	Medium/High (dependent on flushing times and magnitude of flows from above the barrage)	Freshwater flowing out of the barrage will be turbid as a result of sediment input from the catchment. Once the sediment mixes with salt water, the process of flocculation will occur and sediment is likely to settle out onto the floor of the estuary. The flocculation zone is also likely to be more turbid than it has been previously. 3D and sediment modelling should include the identification of the location of the flocculation zone downstream of the proposed barrage under a range of flow scenarios. This modelled output should be used to determine the risk of negative consequences for a variety of habitats including seagrass beds near the mouth (550 ha Aquanal and DEPHA 2008). Light penetration is a driver of seagrass biomass and distribution and reduced light levels for long periods can have negative consequences.
Reduced tidal prism as a result of the barrage, reduces the extent that sediment can be moved by tidal currents with resulting reduced potential to remove sediment, or moving sedimentation issues to different locations in the estuary	High	High	The substantial reduction in the size of the estuary, will reduce the tidal prism with associated effects on the potential for tidal movement of estuarine waters to remove sediment from the estuary. The proposed 3D modelling should consider the changes to the tidal prism and how changes will affect the ability of the estuarine flows to remove sediment from the system. The model should include assessments of flow velocities and sedimentation below the barrage (to the mouth of the estuary) under a variety of flow scenarios. Modelling should cover the lifespan of the proposed change (up to 100 years).
Impacts on biodiversity hotspot at Low Head including potential negative effects on soft coral reefs, seahorse communities, kelp forests etc.	Medium (dependent on flows)	High	Placing the proposed barrage so close to the mouth of the estuary and the associated important marine habitats and biodiversity could have an effect on the nature and ecology of this area of the estuary. The 3D model should consider changes to the salinity regime, water quality and flow dynamics of the estuary below the barrage. The model should include high flows, medium flow and no flow scenarios and incorporate changes that may be associated with a changing climate. The model should be run for the proposed lifespan of the barrage. In order to appreciate the potential risks to habitat and biodiversity, the model may need to incorporate light penetration through the water column. Model outputs can then be used to determine any risks to the habitats and associated biodiversity.
Impacts on shark nursery areas in the lower reaches of the estuary	Medium	High	The lower estuary is an important nursery ground for a range of important shark species. An assessment should be made of the reasons that this area is important for these species. Once this has been done, model outputs should be used to determine the implications of the barrage on these taxa.
Changes to flood risk as a result of hydrological changes	High	High	The proponents suggest that the barrage will have a significant flood mitigation effect for upstream areas. The potential for inland flooding must be a substantial component of the 3D modelling, and must include the reworking of sediment upstream and downstream of the barrage. Because changes to sedimentation can occur over long periods of time, the modelling must be conducted for the lifespan of the proposed barrage.

			Importantly, the modelling must include a range of scenarios including changes to rainfall patterns and sea-level rise associated with climate change. Although not purely an environmental impact. The risk of flooding in Launceston if the barrage mechanism fails during high peak event and coincides with flood tides would be disastrous. Additional modelling to determine if the current levee recently finished to 1/200 year flood could withstand worst case scenario for barrage failure should be modelled and also combined with additional modelling for climate change. Noted: this has been included below in future phase but may still be warranted as a scenario under the current climate.
Permanent wider extent of lake may increase the likelihood of wind driven waves. Increased wind waves can affect bank erosion.	Low	Medium	A stable lake level over long time periods may increase the potential for wind erosion and associated stirring of bottom sediment. In addition, increased use of the lake by recreational and other vessels could also result in wake-derived erosion. An analysis of the risk of these forms of erosion changing from present conditions should be considered.
Changes to the sediment budget of the estuary and lake will change sediment processes. The "demand" for sediment by the system may result in redistribution of sediment and/or increased erosion up or downstream.	Medium	High	Modelling should include a detailed assessment of changes to the distribution of sediment and to sedimentation upstream and downstream of the barrage under a range of rainfall, tidal and flow conditions. Importantly, flooding estimates should include consideration of coincident events such as high rainfall, high tides and storm surge occurring simultaneously. The modelling should include consideration of the impact of changes to the sediment budget of the upstream and downstream systems.

Future Phase

A substantial development such as the proposed barrage has a long-term projected lifespan (>80 years). Over this time period, climate change will begin to have a stronger influence on the system and these influences need to be considered. As mentioned above, the influence of climate change has implications for the Tamar/Esk Region. Considering a single option as a potential solution for certain effects of climate is not an optimal means of approaching the challenge and could lead to unintended consequences.

Climate change is expected to result in increased temperatures for Launceston City of between 2.6°C and 3.3°C. There is likely to be increased frequency and severity of extreme events and increased temperature of surface waters. Average runoff will increase which could enhance erosion and localised flooding. Flows in the Tamar are projected to increase by 5% by mid-century and 19% by the end of century. Flows in the Esk River are projected to increase by 7% by the end of the century. Sea-level rise is projected to increase by 0.82 m by 2100. The current 100-year storm tide event is around 1.9 to 2.0 m above average sea level. Changes to

storm surges by the end of the century will not be as large as sea level rise. Accounting for all effects, the current 100-year event in George Town will be exceeded every 10 to 30 years by 2030, and more frequently than once every 4 years in 2090 under the high emissions scenario (Grose, ACE CRC).

Future Phase (climate change) (Colours used to indicate high risk/high consequence, medium risk/medium consequence, low risk/low consequence)			
Issue/threat identified	**Risk and likelihood of occurring**	**Priority or Severity/Consequence**	**Recommendation for additional assessment**
Barrage constructed to cope with a sea-level rise of 0.8 metres above current levels. This will help to reduce tidal flooding of areas above the barrage.	High	High	The 3D models should include a range of scenarios associated with the effect of climate change, including coincident events. See comments on lack of strategic approach to determining the use of the barrage as an adaptation measure. (page 6 General Comments) Consider a coincident event with high range sea-level rise increase, combined with a storm surge and a high inflow event from the catchment.
Freshwater supply provided by dam could help to ensure water security and food security in the region.	High	Positive consequences under a climate affected future	See comments on lack of strategic approach to determining the use of the barrage as an adaptation measure. (page 6 General Comments)
Barrage has not been designed to deal with climate change effects and a comprehensive planning process to determine the most effective adaptation measures has not been followed.	High	High	See comments on lack of strategic approach to determining the use of the barrage as an adaptation measure (page 6). High potential for maladaptation if planning is not done properly. Climate Change adaptation measures such as the proposed barrage, need to be developed as part of a regional/city based Adaptation Plan, that considers risks and implications of climate change and follows a process to identify, develop and cost options and consider the implications of options on other pressures and on the system as a whole. Options need to be planned using an adaptation pathways approach, which enables continual changes if they are required and does not lock the Council or region into an expensive option that is inappropriate for the problem. Any planning for climate must be done through a specific planning regime.
Long-term climate change is predicted to increase air temperatures which will increase surface water temperatures. Warmer temperatures and warmer lake waters will occur for longer periods than at present	Medium	High	The implications on the potential for freshwater algal blooms resulting from warmer water for longer periods should be considered and could potentially form part of a modelling exercise. Implications for amenity and use of water.
Long-term climate change is predicted to increase rainfall and alter rainfall conditions including the potential for increased erosion	High	High	Risks associated with increased erosion should be assessed. Increased intensity and frequency of events in the catchment are likely to lead to higher catchment erosion and sediment loading of rivers and transported sediment loads to the lake.

Discussion

The Tamar Lakes Inc. proposal for a barrage to be built across the Tamar Estuary, changing the majority of the estuary to a freshwater system presents a significant challenge to decision makers, stakeholders and the community. The proposal has been developed as a means to address the issue of sedimentation in the estuary, while providing a number of other benefits to the system, including substantial economic opportunity for the region.

The reports and documentation prepared to underpin the initial proposal have been predominantly desk-top in nature and many of the issues and challenges associated with the proposal have not been addressed sufficiently or ignored to date. The supporting studies have varied in the depth to which they have been able to identify and address issues, but provide a good start for stakeholders to build an understanding of the implications of the proposed barrage. There is however a long-way to go before the issues associated with the proposal are addressed effectively enough to facilitate a community debate about the proposed barrage.

There is a shortage of detailed ecological, physical and chemical process information, but importantly there is also a concerning lack of a strategic basis to many of the objectives of the proposal. There is also a profound lack of socio-economic information underpinning the document, which although not part of this review, is highly concerning.

The large size of the Tamar Estuary means that a significant area of important estuarine habitat will be lost if the proposed barrage is approved. Developing the barrage will have a significant impact on the water quality, the ecology and hydrodynamic processes that take place in the estuary (upstream and downstream of the barrage). The proponents intend to change the system from an estuary with a diversity of aquatic and terrestrial habitat driven by tidal and freshwater dynamics with constantly changing water currents, salinity regime and levels of inundation to something that is much more homogenous in nature with a constant salinity (freshwater).

Any proposal to alter an estuarine habitat into a freshwater environment needs to be carefully thought through. There are many instances where this has occurred before for a variety of reasons with negative consequences. Most examples in Australia have been at a smaller scale than what is proposed in the Tamar, such as to increase the extent of farming land and reduce tidal flooding of potentially useful farm land (e.g. Yarrahappinni Wetlands in the Macleay Valley NSW (Appendix A)). In many of these cases, there is recognition that the proposed outcomes of the changes have not been delivered, and in many cases work has been undertaken to undo the past changes.

There is a need for a substantial investigation and planning to ensure that if the development does go ahead, it has community support, is based on a good understanding of all the potential outcomes (negative and positive), includes a comprehensive cost-benefit analysis, and is part of an integrated strategy for the region as a whole, not just a fix it for a particular problem (i.e. sedimentation).

One of the main challenges with a review of this nature is the lack of a strategic context for much of what is proposed. The proposal seeks to alleviate a sedimentation issue in the upper Tamar estuary, and suggests that a variety of other outcomes will also be achieved that will benefit the region and make the development cost-effective. There is no strategic context for example, for using a barrage to deal with the impact of climate change, and while it may well be a useful approach in the future if freshwater availability is projected to be an issue, it should have been developed in response to a well thought out strategy for the region, and the benefits should not be hind cast. Climate change adaptation approaches need to be thoroughly worked through and there is a need for an adaptation pathway to be considered together with an options analysis to ensure that outcomes are not maladaptive. Every adaptation option should be considered in the light of other adaptation options, and integrated solutions should be reached.

The proponents accept that their plan will have a variety of environmental effects and have provided documents outlining many of these including a range of hydrodynamic, water quality and ecological issues. The issues they raise and the issues identified in this report and through stakeholder engagement require further investigation. Some may have a low risk of occurring and with monitoring and management procedures in place and appropriately funded, may be mitigated. The proponents have recognized the effects of discharge from the waste water treatment plants (WWTP) into the estuary (proposed lake) and will not proceed with the development without WWTPs being upgraded to tertiary treatment (with nitrogen and phosphorus being removed from the waste stream). There are also substantial nutrient inputs from the catchment system that would be likely to impact negatively on a freshwater lake.

Others require substantial investigation to understand them, and then need to be fleshed out in detail. They will require a comprehensive management plan to be implemented to ensure they do not cause further problems over time.

Others will definitely occur if the development is pursued and a significant extent of the estuary will change completely in terms of character. All stakeholders need to understand this and need to accept and support the changed environment which will be very different. Investigations are required to better understand the ramifications and time frames of what will occur and what ecosystems are likely to replace the previously estuarine reaches.

A number of detailed recommendations are made that are required to support an understanding of the risk associated with the proposed change to the system. These include the need to consider risks associated with the following:

- Water quality
    - High nutrients and potential algal blooms including blue green toxic algae
    - High bacteria loading and loss of recreational amenity
    - Sedimentation of the lake requiring on-going dredging of acid sulphate soils
    - Transition state of lake from estuarine to freshwater resulting in release of sulfur and other elements.
    - Pollutant loads from diffuse sources which will continue particularly in light of irrigation development in the catchment and fast dairy industry expansion.
    - Implications of the possible exposure of Passive Acid Sulfate Soils.
- Ecology
    - Threats to EPBC listed species including (but not limited to); Australian Grayling, Green and Gold Frog, Swamp Paperbark and Saltmarsh communities.
    - Major expansion of habitat for Gambusia (currently isolated in Tasmania at the Tamar Island Wetlands and several adjacent connected waterways).
    - Loss of regularly exposed mudflats to support feeding by shore birds
    - Implications for marine biodiversity hotspot at Low Head including soft coral reefs, seahorses, kelp forests, etc. resulting from a changed flocculation zone to further downstream.
    - Implications on the ecology of the estuary and region resulting from a substantial alteration of the extent of the estuary.
- Hydrology & sedimentation:
    - Ability of the barrage to alleviate sedimentation impacts on the upper estuary and impacts below the barrage due to change in truncated tidal prism and flocculation zone.
    - Potential impacts due to hydrological changes e.g. flood risk
    - Residence time of lake water and potential to 'trap sediment, nutrient and other pollutants'.
- Climate change:
    - Implications of a barrage in relation to predicted climate change projections, sea level rise and expected increased sediment loss from the catchment.
- Geomorphology
    - Increased wind generated wave action causing erosion of banks on lake

- Redistribution of sediments as Lake finds equilibrium. Generally sediments will move and redistribute into the main channel filling in deep areas- infilling of the lake will occur over a protracted time.
- Possible sedimentation downstream of the barrage (?) as sediment flocculate and deposit after the barrage.

The recommendations made in this peer review report include suggestions of appropriate scenarios that should be considered when undertaking modelling and investigations to determine risk.

It is strongly recommended that all data that are collected to underpin the planning and associated risk assessments are collected with sufficient rigour and with appropriate temporal and spatial replication need to underpin a long-term high quality monitoring and evaluation program into the future should the development be approved.

Monitoring and Evaluation

In the event that the development is approved, there is a need for the associated impacts and mitigating management actions to be monitored and reported over the lifespan of the development. The above recommendations in which data are collected to underpin a risk analysis will support the long-term monitoring. It is strongly recommended that data are collected in a highly rigorous manner with sufficient spatial and temporal replication, to enable a statistically rigorous monitoring program to be developed.

Conclusion

The Tamar Lakes Inc. proposal for a barrage to be built across the Tamar Estuary, changing the majority of the estuary to a freshwater system presents a significant challenge to decision makers, stakeholders and the community. The interest and engagement of Tamar Lake Inc. in looking at options to solve the sedimentation issues associated with the estuary is applauded, but their proposed solution is highly invasive, causing a substantial change to the physical and ecological characteristics of the system. It should also be noted that sedimentation would be likely to continue to occur in a freshwater lake system created by the barrage, because diffuse sources of pollution are not addressed in the proposal.

The Tamar Estuary is well known as an important Tasmanian estuary which has been classified by the Australian Government as a “High Conservation Value Aquatic Ecosystem” and this proposal should not be considered without the community and decision makers being made well aware of the implications of the development. The development which would change a large expanse of the Tamar Estuary to a freshwater system, with associated biophysical implications (short, medium and long-term), will also shift the location of the highly turbid zone of the estuary to further downstream, with potential implications for ecological condition, aquaculture, amenity and tourism in the lower estuary.

At present the information provided has been desk-top based and is not sufficient to underpin any decisions. There is a need for a comprehensive risk assessment to be undertaken on water quality, ecology, physical dynamics, geomorphology, and flood assessments

The shortage of detailed ecological, physical and chemical process information is compounded by a lack of a strategic basis to many of the objectives of the proposal. There is also a profound lack of socio-economic information underpinning the document, which although not part of this review, is highly concerning. There is a significant amount of investigation, data collection and modeling that is required to underpin a proposal.

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Appendix A

Yarrahapinni Wetlands National Park was formerly known as Yarrahapinni Broadwater and was a large wetland supporting mangroves, salt marsh, seagrass beds and intertidal mudflats in the lower reaches and freshwater species in the upper reaches.

The wetland was an important cultural site for local indigenous communities Dunghutti and Gumbaynggir nations, linked to the once relative abundance and diversity of food sources within the site and evidenced by the large midden of past food gathering.

In the early 1970s flood mitigation to increase the extent of farm land near to the estuary, stopped regular tidal inundation of the wetland from the Macleay River. The construction of levees, drainage channel and floodgates resulted in the well flushed estuarine wetland becoming a degraded, predominantly dry, marginally freshwater habitat. Drainage resulted in acid sulfate soils being exposed to air and becoming oxidised, and leaching sulphuric acid into the ground and water above killing vegetation and impacting fauna.

The construction of the floodgate and levee had a severe impact on the highly abundant and productive estuarine fauna and flora in the Macleay Estuary, including resulting in the loss of important nursery areas for fish and invertebrates. Outflow of acid from the exposed acid sulphate soils had an impact on oyster production in the estuary.

The site is now being restored at great cost, which has taken considerable community engagement, purchase of nearby farmlands and significant scientific investigation (including an Environmental Impact Assessment).