



Fiddamans Creek Sustainability Assessment
Report
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EXECUTIVE SUMMARY

This Sustainability Assessment report is based on results from the Coastal Lake Assessment and Management (CLAM) tool for Fiddamans Creek. This tool was developed as part of the Northern Rivers Catchment Management Authority (CMA) funded project entitled 'Ensuring sustainable development in coastal lake catchments of NSW Northern Rivers (CLAM project)'.

The report summarises the quality of data in the Fiddamans Creek CLAM for each node and also provides an assessment of key data gaps identified by Verity Rollason (WBM Oceanics) in putting the Fiddamans Creek CLAM together. These gaps are:

- Flora and fauna – A flora and fauna mapping exercise for the ~40 ha between the caravan park and SEPP14 Wetland (as noted in the CLAM). The true value of this area needs to be defined and protection given. Ideally a monitoring/ periodic remapping program should be implemented.
- Aquatic vegetation and fauna – absolutely no data on aquatic vegetation or fauna currently exist.
- Riparian vegetation – a riparian condition assessment is required.
- Water quality – data is currently collected at one site by Council but given that the creek is closed due to poor water quality further data is required.
- Hydrodynamics – A hydrodynamic study which provides an assessment of how often the creek closes, estimates the tidal prism and depth and volume of the creek is required.
- Source of pathogens – assessment of the likely sources of pathogens is required in particular an audit of septic systems in upstream properties.
- Economic studies – estimates of economic values especially recreation values associated with the creek.

Four scenarios in the Fiddamans Creek CLAM are analysed in this report, as recommended in a workshop with the Coffs Harbour City Council and other stakeholders on 22 May 2007:

- Urban development and stormwater in combination;
- Riparian zone management; and
- Agricultural management.

These are a small number of the total scenario options available in the CLAM but provide a useful insight into the Fiddamans Creek CLAM and the management of the lake. Key conclusions from this analysis are summarised below.

Urban development and stormwater management

Ten scenario options were explored within the combined analysis of urban development and stormwater scenarios. The results showed:

- Urban development options impact on a large range of catchment values.
- The development of 40 ha of forested land with no erosion, sediment or ASS controls or stormwater treatment has a large negative impact upon income, aboriginal values, flooding, erosion, TSS inputs, gross pollutants, terrestrial, wetland and riparian habitat area, ASS runoff, fish and aquatic fauna, sedimentation, social amenity and threatened terrestrial flora and fauna. Interestingly the CLAM model indicates a large reduction in pathogen inputs under this option. This is possibly because the forested areas are assumed to be habitat for many animals. When these are removed by urban development the pathogen load is then lowered.
- Reducing the forest area developed to 10ha and Implementing erosion, sediment and ASS controls and stormwater treatment improves the outcomes of this development from large to moderate negative impacts. The successful implementation of the stormwater levy and

follow on stormwater management works also improves the outcomes from developing the forested lands.

- The largest differences between scenario options occurred for TSS inputs, sedimentation of waterways and aquatic habitat. The implementation of stormwater management options improved the aquatic habitat value for all urban development scenarios

Riparian zone management

The predicted impact of implementing riparian buffer zone management is moderate to large although a similar level of impact is shown with 20 metre and 40 metre buffer rehabilitation. The results show:

- overall there are large impacts (beneficial) as a result of rehabilitation of both 20 and 40 metre buffers with both showing similar probabilities of change for all the values that they impact upon;
- Increases in riparian and wetland habitats are predicted under all options, as are increases in fish and aquatic fauna number or health;
- there was no impact on water quality inputs such as TN, TP or TSS and only negligible impact on pathogen inputs; and
- there was a moderate decrease to agricultural productivity for all riparian buffer management options and this was the only negative impact shown.

Agricultural land management

Three options were investigated for agricultural land management with a small to moderate impact on the catchment as a whole. Targeted options such as BMP for erosion, resulted in large changes to the target nodes such as erosion off the catchment. Although the regeneration of 10ha of agricultural land shows a decrease in agricultural productivity, there is an increase in income of the local economy. This is most likely due to an increase in the scenic quality and social amenity, which also impacts upon the local economy.

1 INTRODUCTION

This Sustainability Assessment report is based on results from the Coastal Lake Assessment and Management (CLAM) tool for Fiddamans Creek. This tool was developed as part of the Northern Rivers Catchment Management Authority (CMA) funded project entitled 'Ensuring sustainable development in coastal lake catchments of NSW Northern Rivers (CLAM project)'. The CLAM approach was developed in a joint effort by the Australian National University and the Department of Environment and Climate Change. Its objective was to fill the need for Sustainability Assessments of coastal lake systems identified in the Healthy Rivers Commission Independent Inquiry into Coastal Lakes. It is considered to be a key tool to assist in management and planning processes such as the Local Environmental Planning review and development of Estuary Management Plans.

Scenarios presented in this report were identified as an important primary focus during workshops held with Council staff and other stakeholders in May 2007. These scenarios represent a relatively small subset of the complete range of options available in the CLAM tool and are intended to:

- document the quality of data used in the Fiddamans Creek CLAM and key data gaps which are a priority for data collection
- provide a useful analysis of options of first concern to Council and other key stakeholders which can be incorporated in decision making and other planning activities on these issues; and,
- illustrate the way in which the CLAM tool can be used to show the trade-offs involved in managing the lake system.

This report is not a management plan and cannot take the place of activities associated with the development of such a plan. In particular this report did not include scope for comprehensive community consultation. It can however be used to inform such a planning process. When this occurs, results in this report must be critically evaluated and open to criticism from members of the public. This needs to occur within the context of the supporting documentation provided in the input pages of the CLAM tool. These pages provide comprehensive documentation of the assumptions underlying the data used to derive the results in this report. This information is provided to allow users to assess for themselves the varying quality of data sources underlying the CLAM tool and its relevance to the decisions being made.

1.1 What is CLAM?

The Coastal Lake Assessment and Management (CLAM) tool was developed to allow stakeholders to assess the social, economic, environmental and ecological trade-offs associated with development, remediation, and use options for coastal lakes and estuaries. A population shift towards the coastal fringe in NSW has seen substantial pressures being placed on these coastal systems. Catchment areas are subject to a variety of activities including urban developments, forestry and agricultural activities, recreation and tourism, and fishing and aquaculture activities. Remediation of impacts through better controls on developments and estuary activities, as well as replanting of riparian areas and fringing wetlands, are frequently being considered by State and Local authorities.

The CLAM tool shows the multitude of impacts arising from such pressures and potential remediation measures. It is most appropriate for strategic planning purposes such as the development of estuary management plans or coastal zone management plans. It delivers a high level of community participation and an open and transparent modelling tool, which provides full detail of assumptions made and data used in its population.

The CLAM approach is based on the concept of Bayesian networks but provides additional decision support through tailored interfaces and in-model documentation of model

assumptions and design process. More details on the development and use of CLAM models can be found in Merritt *et al.* (2007), Brydon *et al.* (2007) and Ticehurst *et al.* (2006, 2007).

There are six main benefits which the CLAM is able to capture for strategic decision making and management activities:

- It allows integration of existing data sets and reports;
- It documents in a transparent way data and assumptions available to be used in making a decision;
- It allows such data and assumptions to be applied repeatedly over many (often 100,000's) iterations in a consistent manner to improve the consistency and rigour of decision making;
- It provides a sound prioritisation of key data and information gaps in the management of a lake system through open documentation of data used in the CLAM system and analysis of the implications of the uncertainty of this data for decision making;
- It plays an education role, providing a tool for people to focus on learning more about the interactions between human actions and social, environmental and economic outcomes in the system;
- It provides a focus for negotiations and discussions about preferred management actions. The CLAM approach encourages people to verbalise and document why they agree or disagree with model results. This type of discourse can form a key component of any negotiation about preferred options and the nature of impacts on the system. Improved understanding and knowledge developed through such discussions and studies which come out of them can be used to update the knowledge in the CLAM system.

1.2 Context for the CLAM and this Sustainability Assessment

The Coastal Lake Assessment and Management (CLAM) approach was developed as part of a NSW Government project focused on the coastal zone, the Comprehensive Coastal Assessment. In response to the Healthy Rivers Commission's Independent Inquiry into Coastal Lakes (2002), a Statement of Intent (SOI) was released by the Cabinet Office in February 2003 stating the Government's commitment to the implementation of the *Coastal Lakes Strategy* (reported in Rissik *et al.*, 2003). The Healthy Rivers' Report recommended the development of Sustainability Assessment and Management Plans for coastal lake systems. The CLAM approach was developed as a Sustainability Assessment tool to assist in the development of such plans. This report also classified all coastal lakes in NSW according to the level of protection and management they required. Classifications were as follows:

- Comprehensive protection – all natural ecosystem processes restored and preserved;
- Significant protection – critical natural ecosystem processes restored and preserved;
- Healthy modified condition – key natural and/or highly valued modified ecosystem processes rehabilitated and retained;
- Targeted repair – habitat conditions for selected key species established.

The first stage of the SOI was to fund the development of sustainability assessments and management strategies of eight priority coastal lakes in NSW. These were Cudgen, Myall, Wollumboola, Burrill, Narrawallee, Coila, Merimbula and Back Lakes. The main aim of the project was to ensure that there is "*no further deterioration or that there is an improvement, in the condition of coastal lakes whilst detailed assessments are conducted (if required) and Lake Management Plans developed and implemented.*" (Rissik *et al.*, 2003).

The CLAM method was developed to enable interim management frameworks to be developed rapidly using the best available knowledge to inform short-term decisions while also providing the opportunity for more information to be collected and used to inform future longer-term decisions and plans. The approach also had to be transferable to other coastal lake systems.

The Fiddamans Creek CLAM has been developed as part of a project funded by the Northern Rivers Catchment Management Authority (NRCMA) entitled "Ensuring sustainable development in coastal lake catchments of NSW Northern Rivers". This project was part of the Northern Rivers Catchment Management Authority (NRCMA) Coastal Management program. It addressed the draft Catchment Action Plan (CAP) Management Target C2: "By 2016 maintain and improve the condition of estuaries and coastal lakes through: completion of management plans for all estuaries (65% by 2009), and sustainability assessment and management plans for all coastal lakes (65% by 2009); and implementation of all priority NRM activities within those plans (65% by 2009)". The project was funded by the Australian Government's Natural Heritage Trust Strategic Reserve 2004-05.

As part of this project CLAMs have been developed for sixteen systems in the Northern Rivers CMA as shown in Figure 1.



Figure 1. Location of the lake systems for which a CLAM tool was developed

This Sustainability Assessment report provides a summary of impacts relating to four key scenarios and their impacts, as recommended at the Fiddamans Creek CLAM workshop with the Coffs Harbour City Council and other stakeholders on 22 May 2007. These impacts affect the social, economic and environmental sustainability of the lake system.

This report is primarily intended for key decision makers in the Fiddamans Creek system, including Council and CMA staff, members of the Estuary Management Committees and those in relevant State Government Agencies. It is also expected to be useful to those people involved in the development of environmental impact statements associated with future developments such as urban release areas. The report is likely to be of interest to a wider audience, particularly those likely to be affected by changes to the management of the lake system. As a companion to the Fiddamans Creek CLAM, this report is useful in demonstrating the ways in which the CLAM can be used and results from it interpreted for management purposes. As such it is recommended to any user of the Fiddamans Creek CLAM.

It should be noted that the scenarios presented in this report are not exhaustive. Additional scenarios are presented in the Fiddamans Creek CLAM and should also be considered when a Sustainability Assessment and Management Plan is developed.

1.3 How should the CLAM tool and results in this Sustainability Assessment Report be used?

The Fiddamans Creek CLAM tool and the results provided in this Sustainability Assessment report should be used sensibly. As with all models, results from the CLAM must be critically evaluated for their appropriateness before being used to make decisions. All assumptions used in populating the CLAM and any expert review of the data are documented in the input pages found with the CLAM model (refer to Workshop manual). This information must be very carefully considered when using results to make decisions or recommendations. Users should ask:

- Does the CLAM consider the specific scenarios you are interested in?
- Do the impacts look reasonable? If not, why not? If yes, why?
- Do you trust the data used to populate the model? Why/why not?
- Is there other better data available that could be used in the model or used to review/validate the results?

The CLAM has a strong potential to be used in negotiations between catchment stakeholders on management actions. It is also useful in an educational and capacity building role.

2 FIDDAMANS CREEK

Fiddamans Creek is located behind Emerald Beach, approximately 20 km north of Coffs Harbour. The Creek and catchment is located between Moonee Creek to the south and Hearnese Lake to the north. The area is a small village, with low density urban residences to the east of the Pacific Highway, servicing the scenic Emerald Beach, and a number of rural residential properties to the west of the Highway. Some low intensity agriculture and high intensity horticulture (banana and blueberry plantations) also occurs in the catchment, west of the Highway. The catchment contains a large SEPP14 Wetland between the beach and the highway and north of Emerald Beach Caravan Park (CP). Also between the CP and this Wetland exist a large (~40 ha) area of swamp land supporting a number of endangered ecological communities. This land is of high environmental value, however it is currently zoned low density urban residential (2A), which would permit it to be developed in the future. The lake and its catchment are shown in Figure 2.

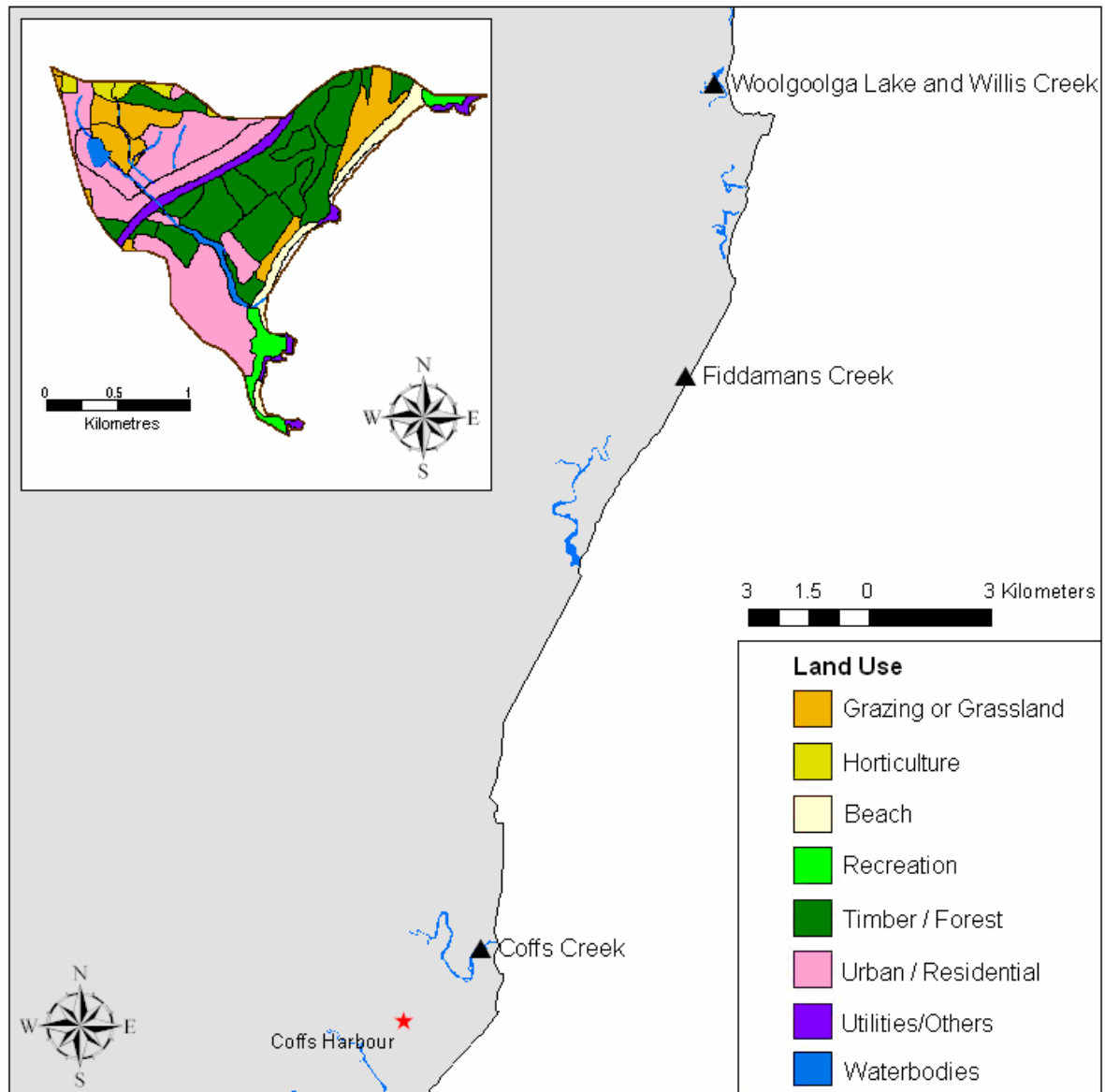


Figure 2. Fiddamans Creek and its catchment

Land use is predominately timber/forest (29.3%) and low density urban (26.1%). Grazing of unimproved pastures and grasslands make up 12.9% of the catchment, while median density urban (8.1%), utilities (6.4%), recreation (6.3%) and horticulture (5.8%) are other significant land uses. The remainder of the catchment includes beach and waterways.

Fiddamans Creek lies within Gumbaynggir territory. The Garby Elders Corporation represents the Gumbaynggir people of the north east of Gumbaynggir country, that is, the area from Moonee Creek north to the Clarence and west to Glenreagh. Garby means Swamp Wallaby. (CEE, 2000). A known indigenous heritage site exists on the Pacific Highway, Emerald Beach near the Coffs Harbour Gun Club. This site is said to have low significance. (CEE, 2000)

The Coffs Harbour area has the highest annual rainfall of anywhere in NSW averaging 1700 – 1800 mm/year. There is said to be slightly less rainfall in urban areas compared with rural areas. Maximum annual evaporation in the Coffs coastal strip is 1760 mm/year, or around 1200ML/day (CEE, 2000). There is estimated to be: 40-50% runoff of rainfall in banana plantations and undulating urban areas; and 50-70% runoff of rainfall in hilly residential areas

and commercial areas. As a result, flow rates in the creeks increase quickly after rainfall, then decrease quickly after rainfall ceases. There is a small base flow from groundwater into the creeks. The remainder of base flow comes from agricultural runoff (including banana plantations which are typically on steep ground) or garden watering in urban areas (CEE, 2000). Part of the Fiddamans catchment is flood prone, with a 1 in 100 year flood level of 3.4 m AHD (PBP, 1995).

Fiddamans Creek entrance to the ocean has been relatively stable in position over the last 50 years. The stability is likely due to an outcropping of bedrock in the beach and foreshore zone which forms a "hard edge" along the right bank (as viewed downstream) over at least the lower 100m of creek channel. The exposed bedrock protrudes to a height of 2 m opposite the entrance to the Creek (PBP, 1995) forming a natural training wall. The creek entrance is currently untrained.

The water quality in Fiddamans Creek is considered poor and the creek is currently closed for human contact due to pollution related to the consistently high pathogens concentrations. Estimated TN loads from the catchment are 2,000 kg/year, or 1.5 – 9.3 kg/ha/year and TP loads are estimated at 200 kg/year, or 0.09 – 1.2 kg/ha/year (CEE, 2000). Pesticide inputs are associated with the historical use of pesticides on banana plantations, which are typically located on the steeper escarpment slopes and which runoff into nearby creeks. Past spraying of weeds in drainage channels has also had a significant impact upon pesticides in upper creek reaches (CHCC, 2004).

There is generally limited information on terrestrial habitats in Fiddamans Creek. A small area of Moonee Beach Nature Reserve (NR) exists in the Fiddamans Catchment, on both the southern and northern headlands of Emerald Beach and including SEPP14 Wetland 318. There is one extensive SEPP14 Wetland (No. 318) located in the catchment. Adjacent to this SEPP14 Wetland is a large area of swamp habitat. These areas combined contain the majority of endangered ecological community habitat in the Fiddamans catchment.

An analysis of endangered ecological communities (EEC) showed that 63.1 % of vegetation in Fiddamans Catchment is part of an EEC.

2.1 Pressures

- Fiddamans Creek is said to be in a critical condition in relation to the health of the aquatic ecosystem (CHCC, 2006). At present, the Creek is closed to human contact due to poor water quality.
- An important area of habitat, containing endangered ecological communities and SEPP14 Wetland habitat, is currently zoned 2A to allow urban development. While CHCC has suggested that this land is unlikely to be developed (pers. comm., Martin Rose, CHCC, March 2007), development applications continue to be lodged for this land. The land should be rezoned (to environment protection or the like) to ensure that the valuable habitats contained within it are preserved into the future.
- The removal of undergrowth (scrub) and grazing on private land is placing pressure upon endangered ecological communities. This includes SEPP14 Wetlands where they are located near buildings. The removal of large trees in urban areas is also placing pressure on the ecological health of catchments. (CHCC, 2006)
- Sediment pollution is said to be placing pressure on the creek. It is believed to be because urban development is not always conducted with adequate sediment and erosion control (CHCC, 2006).
- Within the Coffs Harbour LGA, 661 ha of Koala habitat was removed/lost in 2005/2006.

3 FIDDAMANS CREEK CLAM

3.1 Conceptual framework

The Fiddamans Creek CLAM model is underpinned by the conceptual framework shown in Figure 3. This diagram shows the probable dependencies between scenarios (actions) and state variables (values or impacts). This demonstrates, for example, the way in which ecological outcomes such as algal blooms are dependent on water quality parameters such as total nitrogen or total phosphorus. These in turn depend on actions such as implementing stormwater treatment. Definitions for all nodes in this conceptual framework are provided in Appendix 1.

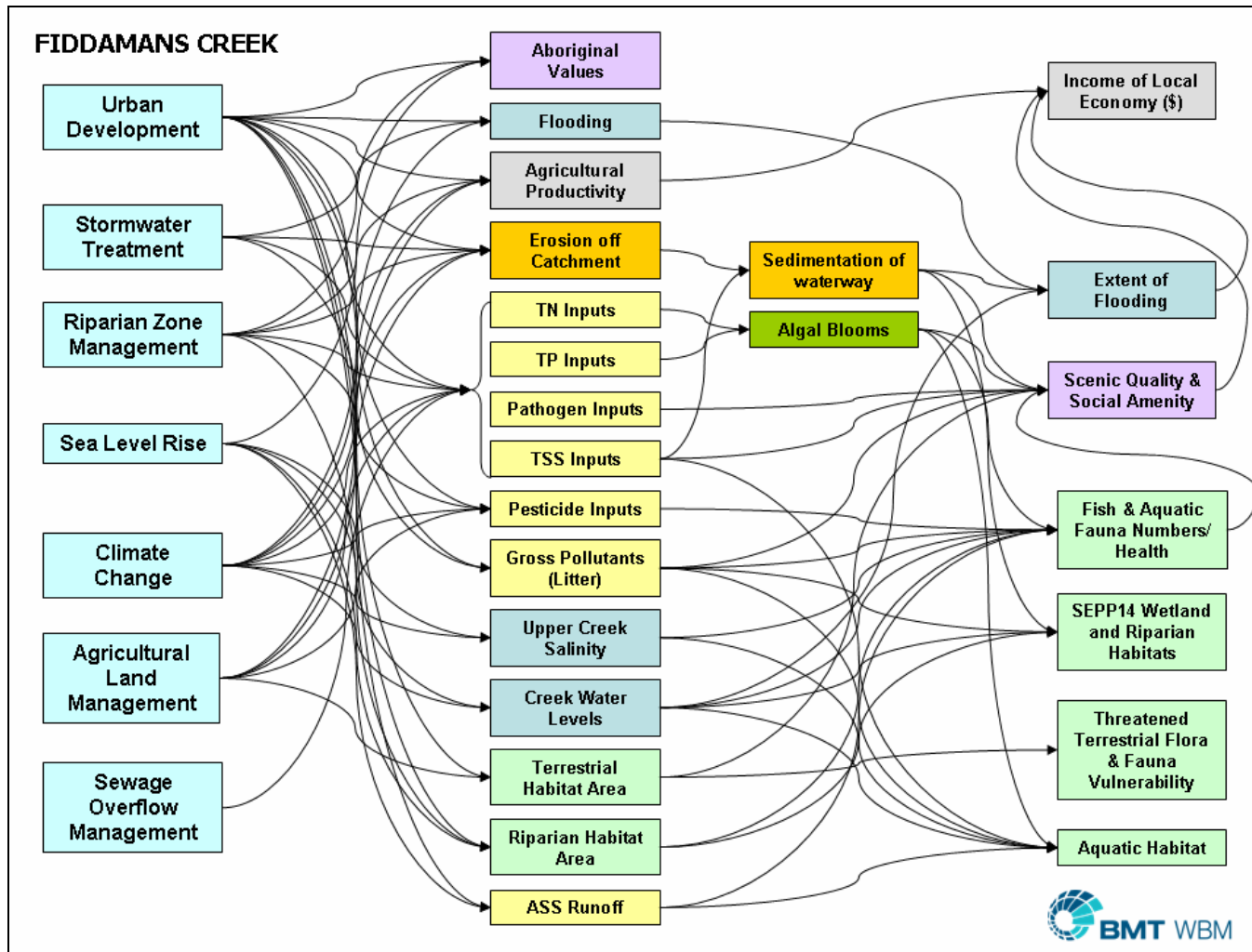


Figure 3. Fiddamans Creek conceptual framework used to underpin the Fiddamans Creek CLAM. Arrows show dependency between nodes. Light blue boxes represent scenarios which are actions, such as stormwater treatment, or potential future drivers of the system, such as climate change.

3.2 Consultation undertaken to develop the Fiddamans Creek CLAM

The framework and scenarios contained in the Fiddamans Creek CLAM were developed in consultation with various stakeholder groups. The conceptual framework, scenarios, scenario options and state variables for Coffs Creek have been based on discussions with various stakeholders including Daniel Rodger (CHCC), Martin Rose (CHCC), Alexandra Williams (CHCC - Strategic Planner), Glenn O'Grady (Coffs Water), David Greenhalgh (SIMP Authority), Cherelle Brooke (CHCC - Landscape Architect), Jenny Mulchrone (Coffs Harbour Regional Landcare), Dr Richard Faulkner (National Marine Science Centre) and Malcolm Robertson (CHCC - Water Quality).

A second major source of feedback was the Project Reference Group which consists of representatives of the Northern Rivers Catchment Management Authority (CMA), the Department of Natural Resources, the Department of Planning, the Department of Primary Industries and NSW Marine Parks Authority.

The CLAM user training workshops held in May 2007 provided an opportunity for feedback on the Coffs Creek CLAM. Attendees at this workshop included Council staff, members of the Estuary Management Committee, staff from State Government Agencies and community members.

3.3 An assessment of data quality

The CLAM model relies on a set of conditional probabilities to define the relationship between variables. An example of a conditional probability is as follows: there is a 30% chance of rain tomorrow if it has rained today. That is, a conditional probability is the probability of event B (rain tomorrow) given that event A (rain today) has occurred.

Thus for every arrow in Figure 3, a set of conditional probabilities must be defined which estimates the nature of the relationship between the two variables. The data used to derive these conditional probabilities comes from a variety of sources. These include literature assumptions, calibrated and uncalibrated models, expert and local knowledge and observed data. For such a broad system a variety of data quality is to be expected. This section provides an assessment of data quality for each node (i.e. each box in Figure 3). A statement of priority data collection needs for Fiddamans Creek is then given. This statement was provided by Verity Rollason (WBM Oceanics) who put together the data for the Fiddamans Creek CLAM.

Table 1 provides a qualitative assessment of data quality for each node in the Fiddamans Creek CLAM.

Table 1. Subjective assessment of the quality of data used in the Fiddamans Creek CLAM

Node	Quality of Data	Reason	Suggested improvements
Aboriginal values	Average	Based on literature reviewed aboriginal values and model developed by iCAM.	Expert and local review
Agricultural productivity	Average	Based on assumptions and iCAM combination model using some local data	Expert and local review

Algal blooms	Average	Based on assumptions and iCAM combination model with some local data	Expert review and increased knowledge of the interactions between nutrients and algae or phytoplankton response in Fiddamans or similar systems.
Aquatic habitat	Poor	Based on assumptions and iCAM combination model	Data for this catchment extremely limited. Expert review and assessment of aquatic habitat interactions would strengthen this node.
ASS runoff	Average	Based on assumptions and iCAM combination model with some local data	Expert review
Creek water levels	Average	Based on assumptions and iCAM combination model with some local data	Expert review
Erosion off catchment	Average	Based on assumptions and iCAM combination model with some local data	Expert review
Extent of flooding	Poor	Based on assumptions and iCAM combination model	Expert review and flood study for Fiddamans creek.
Fish and aquatic fauna	Poor	Based on assumptions and iCAM combination model	Expert review and more information on fish and other aquatic species and habitat for Fiddamans creek.
Flooding	Average	Based on assumptions and iCAM combination model and local data	Expert review and flood study for Fiddamans creek.
Gross pollutants	Average	Based on assumptions and iCAM combination model and data from similar catchments	Expert review
Income of the local economy (\$)	Good	Simple conversion of percentage change to dollar value based on regional data	Expert review and catchment specific data (for quantitative estimation)
Income of the local economy	Average	Based on assumptions and iCAM combination model with some regional data	Expert review and local catchment specific income/economic data.
Pathogen inputs	Average	Based on simple uncalibrated model derived from other situations. Model run with local data	Expert review and more comprehensive local data collection, use of local data for calibration and implementation of the more comprehensive model.
Pesticide inputs	Average	Based on assumptions and iCAM combination model and some local data	Expert review and local data on pesticide fate in Fiddamans Creek.

Riparian habitat area	Average	Based on assumptions and iCAM combination model with some local data	Expert review and more information on riparian habitat for Fiddamans creek.
Sedimentation of the waterway	Poor	Based on assumptions and iCAM combination model	Expert review and local data on runoff and sedimentation dynamics.
SEPP 14 wetland and riparian habitats	Average	Based on assumptions and iCAM combination model with some local data	Expert review and more information on wetland and riparian habitat and pressures for Fiddamans creek.
Social amenity and scenic quality	Average	Based on assumptions and iCAM combination model with some local data	Expert review
Terrestrial habitat area	Average	Based on assumptions and iCAM combination model with some local data	Expert review and more information on terrestrial habitat for Fiddamans creek catchment.
Threatened terrestrial flora and fauna	Poor	Based on assumptions and some local data	Expert review and more information on habitat requirements and pressures on threatened terrestrial flora and fauna.
TN inputs	Average	Based on a simple uncalibrated iCAM water quality model. Local data were used to run this model	Expert and local review. Could be improved more robust modelling tools using detailed local data.
TP inputs	Average	Based on a simple uncalibrated iCAM water quality model. Local data were used to run this model	Expert and local review. Could be improved more robust modelling tools using detailed local data.
TSS input	Average	Based on a simple uncalibrated iCAM water quality model. Local data were used to run this model	Expert and local review. Could be improved more robust modelling tools using detailed local data.
Upper creek salinity	Average	Based on assumptions and iCAM combination model with some local data	Expert review and more information salinity dynamics in the upper creek.

Excellent: Models based on local data, supported assumptions, expert review and calibrated/verified with measured (local) data. For direct changes in measured areas where derived from ground-truthed GIS interpretation. Simple yes/no output models.

Very good: Models based on local data, supported assumptions, expert review and calibrated/verified with measured (local) data which may be limited in extent

Good: Models supported by expert review or local data. May be calibrated/verified with measured (local) data which may be limited in extent or show some areas for improvement of model fit.

Average: Uncalibrated models or based on assumptions with some supporting local data or expert review.

Poor: Based on untested assumptions with little or no supporting local data or expert review.

Priority data collection areas identified by Verity Rollason (WBM Oceanics) are:

- Flora and fauna – A flora and fauna mapping exercise for the ~40 ha between the caravan park and SEPP14 Wetland (as noted in the CLAM). The true value of this area needs to be defined and protection given. Ideally a monitoring/ periodic remapping program should be implemented.
- Aquatic vegetation and fauna – absolutely no data on aquatic vegetation or fauna currently exist.
- Riparian vegetation – a riparian condition assessment is required.
- Water quality – data is currently collected at one site by Council but given that the creek is closed due to poor water quality further data is required.
- Hydrodynamics – A hydrodynamic study which provides an assessment of how often the creek closes, estimates the tidal prism and depth and volume of the creek is required.
- Source of pathogens – assessment of the likely sources of pathogens is required in particular an audit of septic systems in upstream properties.
- Economic studies – estimates of economic values especially recreation values associated with the creek.

4 SCENARIOS

In order to develop this Sustainability Assessment analysis a relatively small subgroup of scenario combinations were selected from the 3200 available in the Fiddamans Creek CLAM. It was decided to focus on the following scenarios:

- Urban development and stormwater management in combination;
- Riparian zone management; and
- Agricultural management.

Urban development and stormwater are considered in combination. Riparian zone management and agricultural management are considered in isolation to each other. The impacts focused on are the likely consequence of the scenario options (i.e., the highest probability outcome). The descriptions below for these scenarios are taken from the Fiddamans Creek CLAM tool. Other scenarios available in the CLAM tool are described in Appendix 2.

4.1 Urban development

There is currently a large (40 ha) area of swamp habitat between Emerald Beach, Emerald Beach caravan park, the Pacific Highway and SEPP 14 Wetland No. 318 which has been zoned for urban development (2A). This land contains valuable endangered ecological communities (EECs), namely freshwater wetlands on coastal floodplains EEC, littoral rainforest EEC, swamp oak floodplain forest EEC and swamp sclerophyll forest EEC (as per mapping provided by CHCC, April 2007, refer photos in CLAM). The EECs contained on this land connect to the adjacent SEPP 14 Wetland No. 318. Council has advised that this land is unlikely to be developed as it contains swamp, is liable to flood and would be difficult to construct upon (pers. comm., Martin Rose, CHCC, March 2007). In spite of the apparent difficulties for construction, development applications continue to be lodged for this land (around 1 per year).

At present, a large block of rural (1A) land behind the southern headland of Emerald Beach and adjacent to the Pacific Highway is being investigated for urban development as part of the CHCC (2006) Draft "Our Living City" Settlement Strategy (refer Map 5a of plan). Of this land, 12.7 ha exists in Fiddamans Catchment (with the remainder in Moonee Catchment).

Any development on agricultural land is assumed to preserve any components of terrestrial habitat which exist on that land. Riparian zones are preserved where Environment Protection zoning, DCPs and/or other relevant planning stipulations exist. Where zoning or planning controls do not exist, riparian zones are also assumed to be developed. Sediment & erosion control refers to compliance with an Erosion and Sediment Control Plan as would typically be approved by CHCC. The use of Water Sensitive Urban Design (WSUD) is strongly encouraged by the CHCC (2006) Draft "Our Living City" Settlement Strategy (refer p 47). Rural residential development has not been explored, as such developments outside lands currently zoned for this are discouraged in the Mid North Coast Regional Strategy (DP, 2006) and the CHCC 2006 Draft "Our Living City" Settlement Strategy (refer p 47).

Scenario options

1. Do nothing
2. Development of 25 ha of rural land *without* erosion and sediment controls, ASS runoff controls or stormwater treatment
3. Development of 25 ha of rural land *with* erosion and sediment controls, ASS runoff controls and stormwater treatment (WSUD)
4. Development of 40 ha of forested land adjacent to Emerald Beach Caravan Park (CP) *without* erosion and sediment controls, ASS runoff controls or stormwater treatment
5. Development of 10 ha of forested land *with* erosion and sediment controls, ASS runoff controls and stormwater treatment (WSUD)

These options will be explored in combination with the stormwater treatment options outlined in Section 4.2.

4.2 Stormwater treatment

This scenario explores the management and treatment of stormwater following the review of existing stormwater treatment and management to determine any "hot spots". Works may include the installation of treatment devices (such as pits) or repair as required at "hot spots" in the urban catchment or from the Pacific Highway. Works may also include the maintenance of any existing outlets and the creek (removal of rubbish, erosion repair, improved bins provision and collection etc from stormwater drains and surrounding mangroves).

Use of both proprietary and non-proprietary (e.g., vegetated swales, bioretention, infiltration, sand filters, ponds) styles of stormwater treatments has been assumed as part of further works.

Scenario options

1. Do nothing
2. Successful implementation of stormwater levy and follow on stormwater management works to value of \$600 000 per annum (for entire LGA)

4.3 Riparian zone management

This scenario assesses the impact of riparian zone management. Options 2, 3 and 4 below comply with the Northern Rivers Catchment Management Authority (NRCMA) Catchment Action Plan (CAP) Management Target W1: "*By 2016, rehabilitate and protect the stream health...of 60% of stream length*". This refers to all estuarine systems in the NRCMA region.

Option 5 below evaluated the impact of controlling access to swampland adjacent to the caravan park. This area contains a number of endangered ecological communities, namely freshwater wetlands on coastal floodplains EEC, littoral rainforest EEC, swamp oak floodplain forest EEC and swamp sclerophyll forest EEC (according to mapping provided by CHCC, April 2007). This swampland and its associated EECs connect to the adjacent SEPP 14 Wetland No. 318.

The riparian buffer widths outlined in options 2, 3 and 4 refer to one side of the stream e.g. a 20 m buffer on each side of stream, totalling 40 m. Improvements to riparian vegetation are also supported in the CHCC (2006) Draft "Our Living City" Settlement Strategy (refer p 53).

Scenario options

1. Do nothing.
2. Fence 20 m riparian buffers on rural land
3. Rehabilitate 20 m riparian buffers on rural land
4. Rehabilitate and fence 40 m riparian buffers on rural land
5. Control access (by humans and domestic animals) into SEPP14 Wetland No.318 and adjacent swampland (located between Wetland No. 318 and Emerald Beach Caravan Park).

4.4 Agricultural management

This scenario assesses the impact of agricultural land management practises. Options 2, 3 and 4 below comply with the Northern Rivers Catchment Management Authority (NRCMA) Catchment Action Plan (CAP) Management Targets as follows:

- Soil/Land Resource Management Target L1 – Soil Health: *"By 2016, 500 000 ha or agricultural land is actively managed to improve soil health"*. This includes issues associated with sheet and minor rill erosion and use of best practise guidelines to manage erosion and other soil health issues. Coffs Harbour is noted as an initial priority area for this target, as it is a *"district of intensive agricultural use"*.
- Biodiversity Management Targets: B1 – Secure Conservation Management (of 40,000 ha of native terrestrial and aquatic ecosystems by 2016); and B6 – Habitat Rehabilitation and Revegetation (of 10 000 ha of native terrestrial and aquatic ecosystems by 2016). Both targets outline rehabilitation/revegetation activities to enhance and restore native terrestrial and aquatic ecosystem functions and health.

Rehabilitation of degraded agricultural (particularly banana) lands and the use of best practise land management are supported in the CHCC 2006 Draft "Our Living City" Settlement Strategy (refer p 49 and p 47 respectively).

Scenario options

1. Do nothing
2. Best practise fertiliser and pesticide use (as per NRCMA CAP Management Target L1)
3. Regenerate native habitat on 10 ha of unproductive agricultural land (as per NRCMA CAP Management Targets B1 & B6)
4. Best practise land erosion management practises used (as per NRCMA CAP Management Target L1)

5 RESULTS FROM SCENARIO RUNS

5.1 Urban development and stormwater options

Urban development options were run in combination with the options for stormwater outlined in sections 4.1 and 4.2 and their impacts considered for all nodes. Table 2 summarises the impacts of urban development, with no change to stormwater, on all nodes for which there was an impact. Table 3 summarises the impacts of urban development, with implementation of the stormwater option, on all nodes for which there was an impact. This impact is a qualitative assessment of the relative magnitude and direction of change in the variable compared to the 'do nothing' option. Thus a 'small increase' means that the variable is likely to have a value that is a bit bigger than it would have been under the 'do nothing' option.

Table 2. Impacts of urban development options (with no change in stormwater management) on likely state values for impacted nodes

Values	Develop 25 ha of rural land		Develop 40 ha of forested land	Develop 10 ha of forested land
	no erosion, sediment or ASS controls or stormwater treatment	with erosion, sediment or ASS controls or stormwater treatment	no erosion, sediment or ASS controls or stormwater treatment	with erosion, sediment or ASS controls or stormwater treatment
Income of the Local Economy	moderate decrease	moderate decrease	large decrease	moderate decrease
Aboriginal Values	moderate decrease	no change	large decrease	large decrease
Flooding	moderate increase	moderate increase	large increase	moderate increase
Erosion Off Catchment	moderate increase	no change	large increase	moderate increase
Agricultural Productivity	large decrease	large decrease	no change	no change
TN Inputs	moderate decrease	very small decrease	moderate increase	very small increase
TP Inputs	very small decrease	very small decrease	moderate increase	negligible
TSS Inputs	small decrease	no change	large increase	small increase
Pathogens Inputs	negligible	negligible	large decrease	negligible
Pesticide Inputs	moderate decrease	large decrease	no change	no change
Gross Pollutants (Litter)	moderate increase	moderate increase	large increase	moderate increase
Terrestrial Habitat Area	no change	no change	large decrease	moderate decrease
Riparian Habitat Area	no change	no change	large decrease	moderate decrease
ASS Runoff	moderate increase	no change	large increase	moderate increase
Algal Blooms	moderate decrease	small decrease	small increase	very small increase
SEPP14 Wetland and Riparian Habitats	small decrease	small decrease	large decrease	moderate decrease
Fish and Aquatic Fauna Numbers or Health	negligible	small increase	large decrease	moderate decrease
Sedimentation of the Waterway	moderate increase	negligible	large increase	moderate increase
Extent of Flooding	moderate increase	moderate increase	large increase	moderate increase
Social Amenity and Scenic Quality	moderate decrease	small decrease	large decrease	large decrease
Threatened Terrestrial Flora and Fauna	no change	no change	large decrease	large decrease
Aquatic Habitat	very small decrease	very small decrease	moderate decrease	moderate decrease

Table 3. Impacts of urban development combined with the successful implementation of stormwater levy and follow on stormwater management works to the value of \$600 000 per annum (for entire LGA) on likely state values for impacted nodes

Values	No change in urban development	Develop 25 ha of rural land		Develop 40 ha of forested land	Develop 10 ha of forested land
		no erosion, sediment or ASS controls or stormwater treatment	with erosion, sediment or ASS controls or stormwater treatment	no erosion, sediment or ASS controls or stormwater treatment	with erosion, sediment or ASS controls or stormwater treatment
Successful implementation of stormwater levy and follow on stormwater management works					
Income of the Local Economy	moderate increase	small increase	moderate increase	small decrease	moderate increase
Aboriginal Values	no change	moderate decrease	no change	large decrease	large decrease
Flooding	moderate decrease	moderate decrease	moderate decrease	moderate increase	moderate decrease
Erosion Off Catchment	moderate decrease	no change	moderate decrease	moderate increase	moderate decrease
Agricultural Productivity	no change	large decrease	large decrease	no change	no change
TN Inputs	moderate decrease	large decrease	moderate decrease	small decrease	small decrease
TP Inputs	moderate decrease	moderate decrease	moderate decrease	small decrease	small decrease
TSS Inputs	moderate decrease	large decrease	moderate decrease	moderate decrease	moderate decrease
Pathogens Inputs	negligible	negligible	negligible	large decrease	negligible
Pesticide Inputs	no change	moderate decrease	large decrease	no change	no change
Gross Pollutants (Litter)	large decrease	moderate decrease	large decrease	no change	large decrease
Terrestrial Habitat Area	no change	no change	no change	large decrease	moderate decrease
Riparian Habitat Area	no change	no change	no change	large decrease	moderate decrease
ASS Runoff	no change	moderate increase	no change	large increase	moderate increase
Algal Blooms	moderate decrease	large decrease	large decrease	moderate decrease	moderate decrease
SEPP14 Wetland and Riparian Habitats	moderate increase	moderate increase	moderate increase	moderate decrease	small increase
Fish and Aquatic Fauna Numbers or Health	large increase	large increase	large increase	moderate decrease	small increase
Sedimentation of the Waterway	moderate decrease	moderate decrease	moderate decrease	moderate increase	moderate decrease
Extent of Flooding	moderate decrease	moderate decrease	moderate decrease	moderate increase	moderate decrease
Social Amenity and Scenic Quality	large increase	moderate increase	large increase	very small decrease	moderate increase
Threatened Terrestrial Flora and Fauna	no change	no change	no change	large decrease	large decrease
Aquatic Habitat	large increase	large increase	large increase	negligible	large increase

Unimpacted nodes were upper creek salinity and creek water levels.

The table shows:

- Urban development options impact on a large range of catchment values.
- The development of 40 ha of forested land with no erosion, sediment or ASS controls or stormwater treatment has a large negative impact upon income, aboriginal values, flooding, erosion, TSS inputs, gross pollutants, terrestrial, wetland and riparian habitat area, ASS runoff, fish and aquatic fauna, sedimentation, social amenity and threatened terrestrial flora and fauna. Interestingly the CLAM model indicates a large reduction in pathogen inputs under this option. This is possibly because the forested areas are assumed to be habitat for many animals and when these are removed because of the urban development, lowering the pathogen loads.
- Reducing the forest area developed to 10ha and Implementing erosion, sediment and ASS controls and stormwater treatment improves the outcomes of this development from large to moderate negative impacts. The successful implementation of the stormwater levy and follow on stormwater management works also improves the outcomes from developing the forested lands.
- The largest differences between scenario options occurred for TSS inputs, sedimentation of waterways and aquatic habitat. The implementation of stormwater management options improved the aquatic habitat value for all urban development scenarios

Figure 4 shows the impacts of a range of scenario options on TSS inputs. Interestingly the model suggests that the greatest reduction in TSS input is for urban development of 25ha of rural lands with no runoff and erosion controls, but with stormwater management option. This is counter-intuitive as one might expect that erosion and runoff controls would further reduce the TSS input. Table 1 shows that this was generated using a simple uncalibrated iCAM model and it is recommended that expert review is undertaken. This result results warrants further investigation. The largest increase in TSS inputs is shown for the development of 40 ha of forest to urban, with no runoff, sediment or stormwater controls.

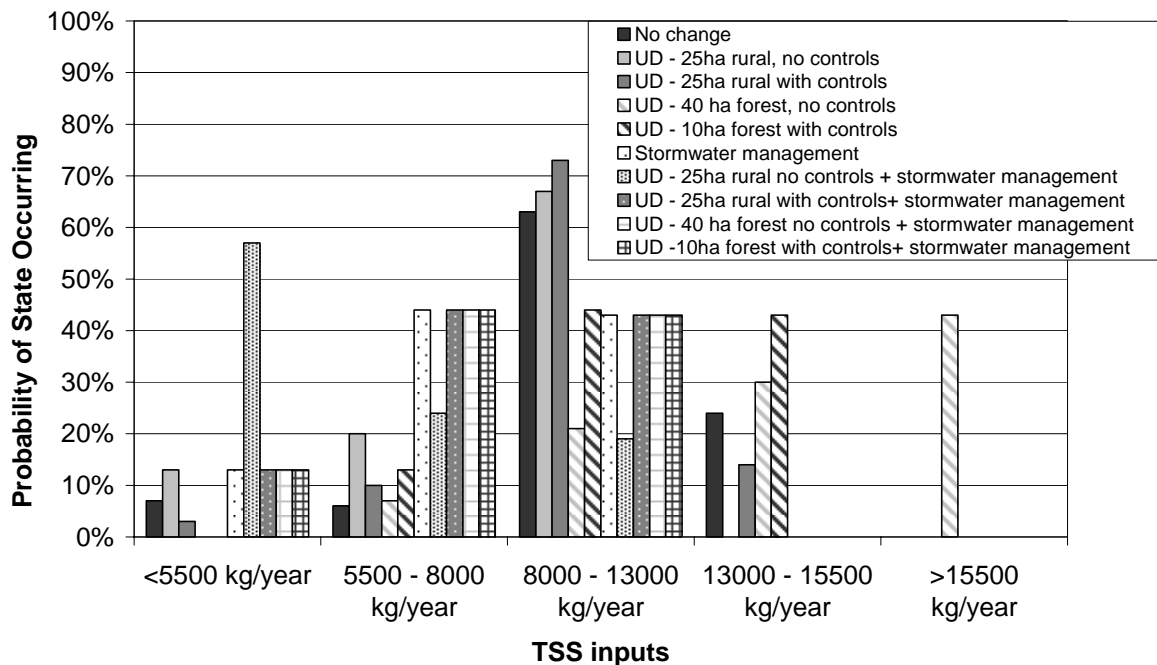


Figure 4. Probability of different levels of change in total suspended solid inputs under urban development scenarios with and without stormwater management scenarios

The impact of urban development and stormwater management on sedimentation of waterways (fig. 5) shows a more intuitive pattern, with the implementation of controls on runoff and stormwater management resulting in the largest decreases in sedimentation. An increase in sedimentation is likely if no controls are implemented or if 40 ha of forest is developed for urban land use with no stormwater management.

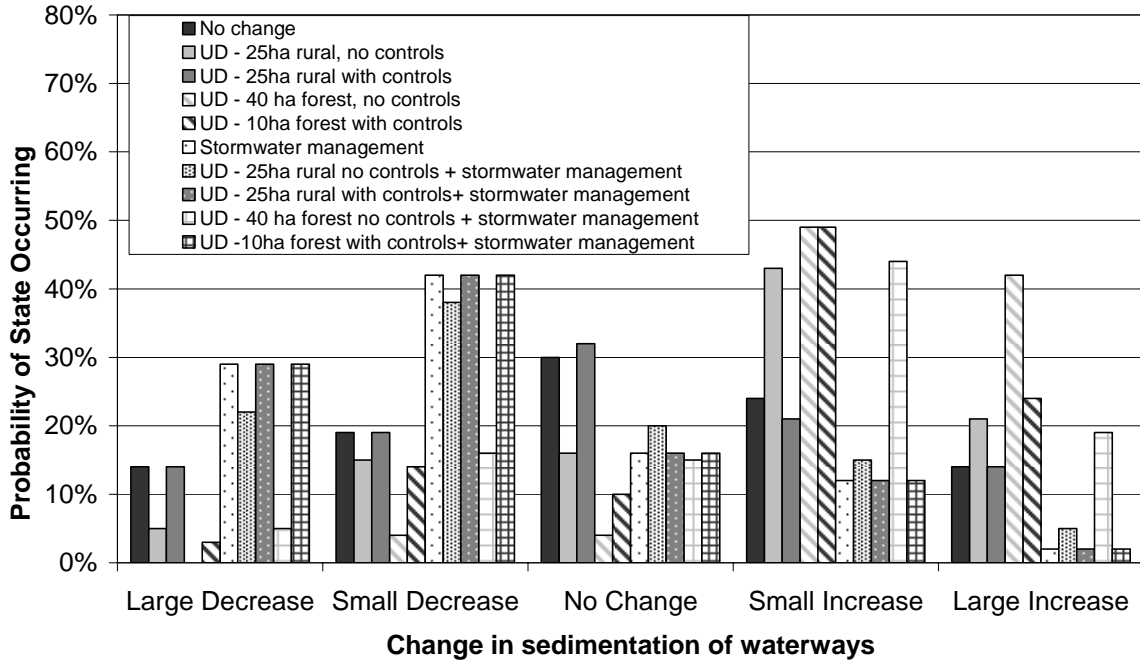


Figure 5. Probability of different levels of change in sedimentation of waterways under urban development scenarios with and without stormwater management scenarios

Figure 6 shows the impacts of urban development and stormwater management on aquatic habitat. All urban development scenarios with no change to stormwater management resulted in a decrease in aquatic habitat with the largest decrease for the development of forest areas. The implementation of stormwater management resulted in a large increase in aquatic habitat for all urban development scenarios with the exception of the development of 40 ha or forest, indicating that the environmental impact from development can be contained if appropriate controls are adhered to.

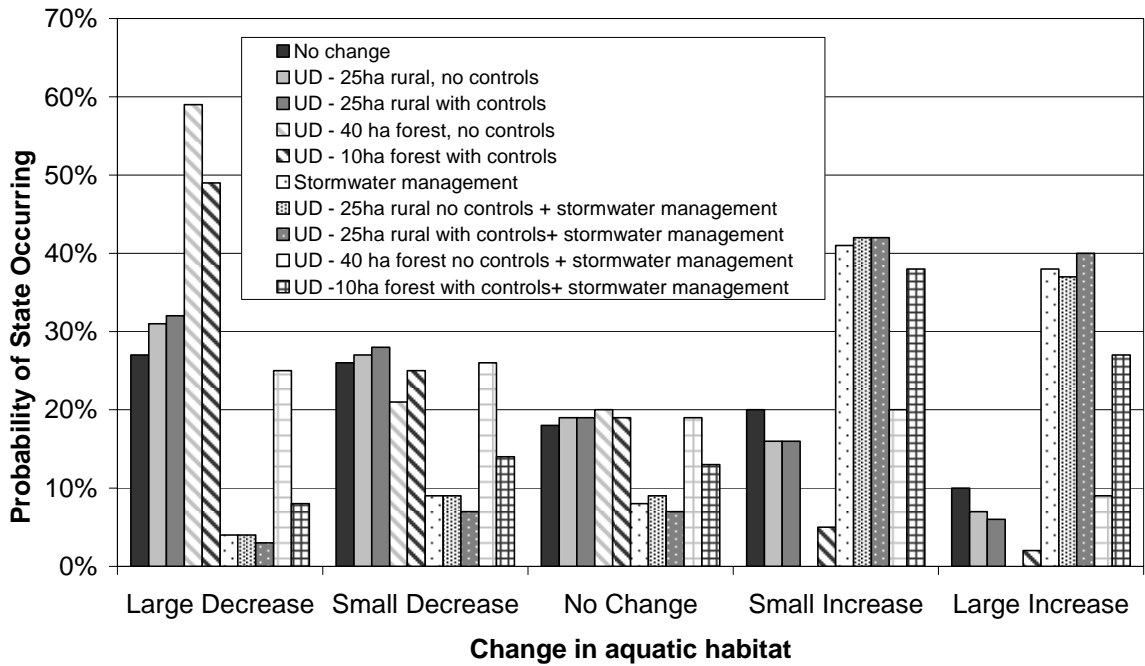


Figure 6. Probability of different levels of change in sedimentation of waterways under urban development scenarios with and without stormwater management scenarios

5.2 Riparian zone management

Riparian zone management options were run in isolation and their impacts considered for all nodes. Table 4 summarises the impacts of riparian zone management on all nodes for which there was an impact.

Table 4. Impacts of dredging on likely state values for impacted nodes

Values	Fence 20m buffers	Rehabilitate 20m buffers	Rehabilitate and fence 40m buffers	Control access to specified areas
Income of the Local Economy	v. small increase	v. small increase	v. small increase	negligible
Aboriginal Values	mod. increase	large increase	large increase	mod. increase
Erosion Off Catchment	mod. decrease	large decrease	large decrease	no change
Agricultural Productivity	mod. decrease	mod. decrease	mod. decrease	no change
Pathogens Inputs	negligible	negligible	negligible	negligible
Pesticide Inputs	mod. decrease	mod. decrease	mod. decrease	no change
Riparian Habitat Area	mod. increase	large increase	large increase	mod. increase
SEPP14 Wetland and Riparian Habitats	small increase	mod. increase	mod. increase	small increase
Fish and Aquatic Fauna Numbers or Health	mod. increase	large increase	large increase	small increase
Sedimentation of the Waterway	mod. decrease	large decrease	large decrease	no change
Extent of Flooding	v. small decrease	v. small decrease	v. small decrease	no change
Social Amenity and Scenic Quality	small increase	mod. increase	mod. increase	v. small increase

Unimpacted nodes were: upper creek salinity; creek water levels; flooding; TN inputs; TP inputs; TSS inputs; gross pollutants (litter); terrestrial habitat area; ASS runoff; algal blooms; threatened terrestrial flora and fauna; and aquatic habitat.

The table shows:

- overall there are large impacts (beneficial) as a result of rehabilitation of both 20 and 40 metre buffers with both showing similar change for all values impacted;
- Increases in riparian and wetland habitats are predicted under all options, as are increases in fish and aquatic fauna number or health, which indicates a strong positive relationship between riparian plantings and the associated ecological impacts;
- there was no impact on water quality inputs such as TN, TP or TSS and only negligible impact on pathogen inputs; and
- there was a moderate decrease to agricultural productivity for all riparian buffer management options and this was the only negative impact shown.

Figures 7 and 8 show detailed impacts of riparian zone management on erosion off the catchment and sedimentation of the waterway respectively. The moderate to large decrease in erosion as a result of buffer zone management also results in a moderate to large decrease in sedimentation of the waterway. Interestingly the model shows no change to TSS inputs or other water quality parameters such as TP or TN which can be associated with catchment erosion and transportation of suspended material. This may be due to different modelling approaches used for different nodes, or might be related to catchment processes and warrants further investigation before catchment changes are implemented or recommended.

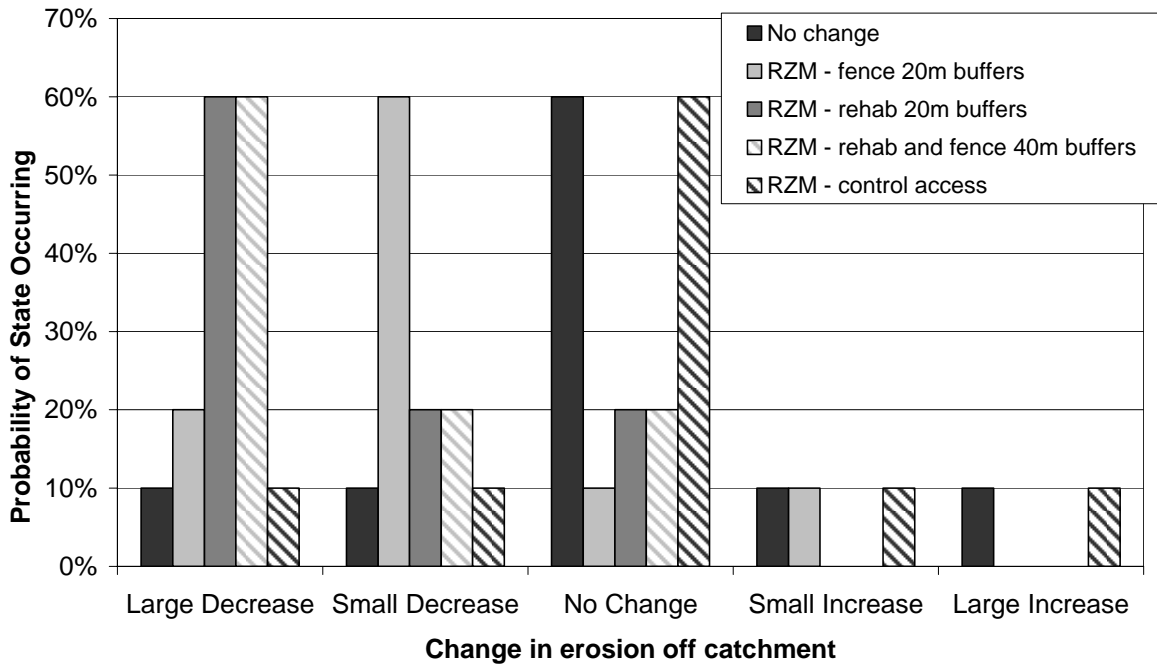


Figure 7. Probabilities of changes to the erosion off the catchment under riparian zone management scenarios.

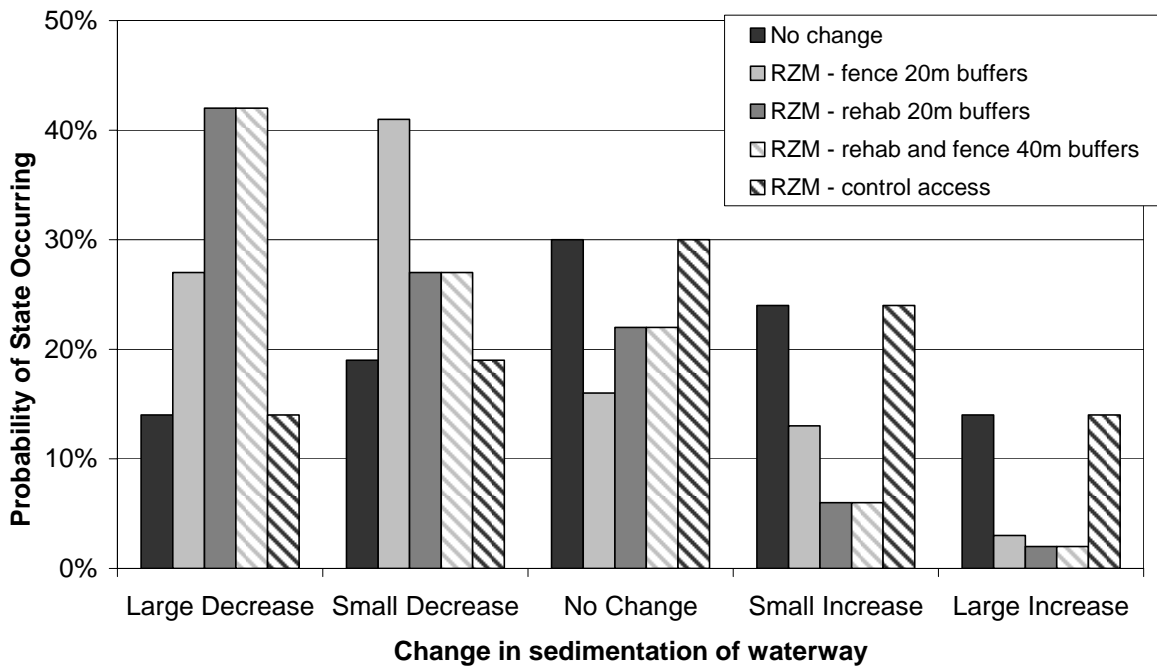


Figure 8. Probabilities of changes to the sedimentation of waterways under riparian zone management scenarios.

5.3 Agricultural management

Agricultural land management options were run in isolation and their impacts considered for all nodes. Table 5 summarises the impacts of agricultural management on all nodes for which there was an impact.

Table 5. Impacts of agricultural land management on likely state values for impacted nodes

Values	Implement BMP for fertilizers and pesticides	Regenerate 10ha of unproductive land	Implement BMP for erosion control
Income of the Local Economy	negligible	small increase	moderate increase
Erosion Off Catchment	no change	moderate decrease	large decrease
Agricultural Productivity	no change	moderate decrease	moderate increase
TN Inputs	small decrease	no change	small decrease
TP Inputs	small decrease	no change	small decrease
TSS Inputs	no change	very small decrease	moderate decrease
Pesticide Inputs	large decrease	moderate decrease	moderate decrease
Terrestrial Habitat Area	no change	moderate increase	no change
Algal Blooms	moderate decrease	no change	moderate decrease
SEPP14 Wetland and Riparian Habitats	no change	negligible	negligible
Fish and Aquatic Fauna Numbers or Health	moderate increase	small increase	moderate increase
Sedimentation of the Waterway	no change	moderate decrease	large decrease
Extent of Flooding	no change	very small decrease	small decrease
Social Amenity and Scenic Quality	no change	moderate increase	small increase
Threatened Terrestrial Flora and Fauna	no change	large increase	no change
Aquatic Habitat	small increase	very small increase	moderate increase

Unimpacted nodes were: upper creek salinity; creek water levels; aboriginal values; flooding; pathogens inputs; gross pollutants (litter); riparian habitat area; and ASS runoff.

The table shows:

- overall the impact of agricultural land management is moderate to small with large changes seen only in response to targeted options.
- Implementation of BMP's for fertilisers and pesticides resulted in a large decrease in pesticide inputs and small decreases in TN and TP inputs. This resulted in a moderate decrease in the probability of algal blooms and a moderate increase in fish and aquatic fauna.
- Implementation of BMP's for erosion control is likely to result in a large decrease in erosion off the catchment, subsequently reducing sedimentation of the waterways.
- Regeneration of 10ha of unproductive land resulted in a large increase in the threatened flora and fauna.
- Although the regeneration of unproductive land resulted in a moderate decrease in agricultural productivity, the implementation of BMP for erosion control resulted in a moderate increase in productivity. No option decreased income of the local economy.

Figure 9 shows the impact of agricultural land management options on the income of the local economy. Despite a reduction in agricultural productivity due to regeneration of agricultural land, the income is still likely to increase due to other benefits of this action. Local economy is impacted upon by agricultural production, flooding extents and scenic quality

and social amenity (Figure 3). So any decrease in the economic value directly from a loss of agricultural land is being offset by an increase in the economy from scenic quality and social amenity (in this example) through the improvement of water quality. Similarly the implementation of BMP is likely to increase the income of the local economy.

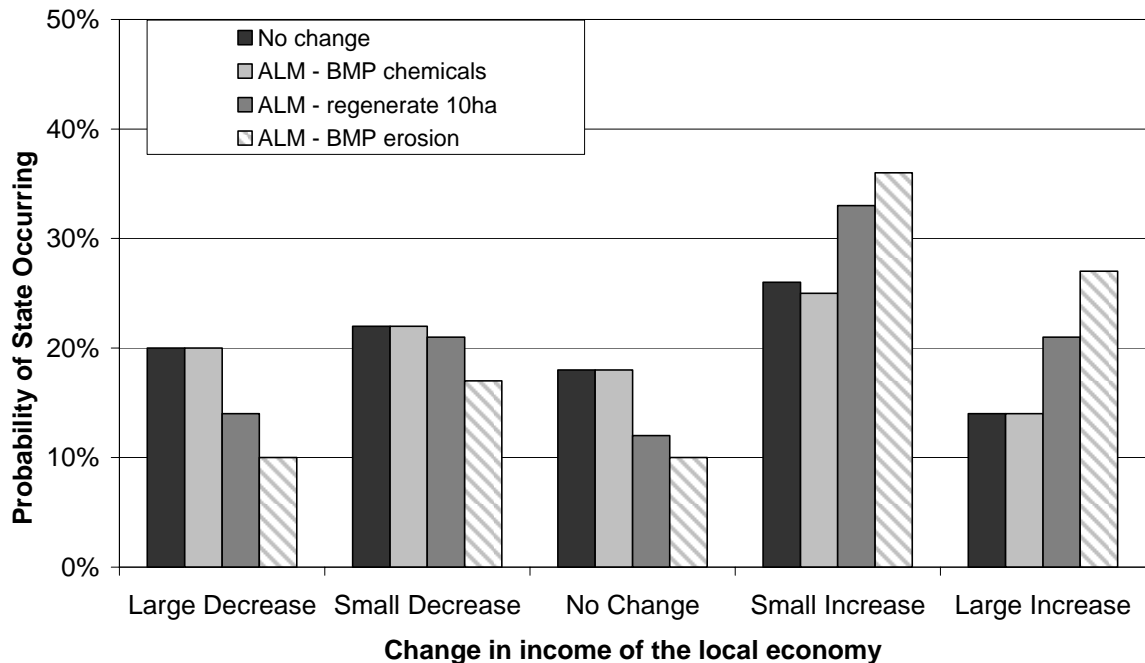


Figure 9. Probabilities of changes to the income of the local economy under agricultural land management (ALM) scenarios.

6 DISCUSSION OF THE RESULTS

This Sustainability Assessment report has provided a sample of results for urban development combined with stormwater management within Fiddamans Creek catchment as well as of the impacts of riparian zone management and agricultural land management. These options are a small subset of the total number of scenarios which can be considered by the Fiddamans Creek CLAM and as such do not provide conclusive evidence of the 'best' management options available.

These results show:

- urban development and stormwater management options impact on a large range of catchment values. The largest negative impacts are seen in the development of 40ha of forested land with no erosion or runoff controls and no stormwater management. Reduction of forest area developed to 10ha and implementation of controls reduces the impacts, as does the implementation of stormwater levy and follow on stormwater management.
- for urban development and stormwater management the largest differences between scenario options is for TSS inputs, sedimentation of waterways and aquatic habitat. Implementation of stormwater levy and management improved the aquatic habitat value for all urban development scenarios.
- for urban development and stormwater management there was no change for TP, TN and TSS input which can be considered inconsistent with the results for erosion off the catchment and sedimentation of waterways and warrants local review and further investigation.
- riparian zone management resulted in some large (beneficial) impacts as a result of rehabilitation of both 20 and 40 metre buffer zones.

- similar to urban development, riparian zone management impacts on erosion off the catchment and sedimentation of waterways which was not reflected in changes in related WQ parameters such as TP, TN and TSS.
- agricultural land management had a small to moderate impact on the catchment overall, although there were large to moderate impacts on those values that the management option targeted. For example, there was a large reduction in erosion of the catchment as a result of implementation of BMP for erosion control.
- Although regeneration of 10 ha of agricultural land reduced the agricultural productivity, no option decreased the income of the local economy, because agricultural decreases were offset by other impacts such as an increase in the scenic quality and social amenity, which lead to an overall increase in the economy.

The results shown here as well as the table of data quality provided in section 3.2 demonstrate some of the features of the data that has been used to underpin the Fiddamans Creek CLAM. Some variables contain poor quality data because there was not any detailed information available. These variables are focused around the ecological values such as aquatic habitat, flooding, fish and aquatic fauna and threatened terrestrial flora and fauna. Sedimentation of the waterways is also considered to be poor and may warrant further investigation due to inconsistencies between water quality related nodes. The CLAM is able to accept updates of such information over time as it becomes available. This should be considered in conjunction with other identified data collection requirements (see section 3.2).

7 ACKNOWLEDGEMENTS

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We would also like to acknowledge all stakeholders who provided the consultants, Verity Rollason and Phil Haines, with input and feedback on the CLAM scenarios, framework and data.

The CLAM model presented in this report has been developed by Verity Rollason and Phil Haines. They wrote scenario and output node descriptions used in this report.

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APPENDIX 1. SUMMARY OF NODES IN THE FIDDAMANS CREEK CLAM TOOL

Node	Description	Output States	Units
Aboriginal values	The impact of various scenario options upon the value of the creek and its catchment to the local Aboriginal community	Large decrease, small decrease, no change, small increase, large increase	
Agricultural productivity	The change in the productivity of agricultural land resulting from various management scenarios	Large decrease, small decrease, no change, small increase, large increase	
Algal blooms	The change in the frequency of nuisance algal blooms as a result of changes to the level of nutrients (nitrogen and phosphorous) in the creek system	Large decrease, small decrease, no change, small increase, large increase	
Aquatic habitat	The change in the health and extent of aquatic habitat resulting from changes to related components in the creek system	Large decrease, small decrease, no change, small increase, large increase	
ASS runoff	The change in acid sulfate soil (ASS) discharge	Large decrease, small decrease, no change, small increase, large increase	
Creek water levels	The change in creek water levels	Large decrease, small decrease, no change, small increase, large increase	
Erosion off catchment	The change in the amount of non-suspended sediment which erodes off the catchment surfaces	Large decrease, small decrease, no change, small increase, large increase	
Extent of flooding	The change in the extent of flooding (and flood levels)	Large decrease, small decrease, no change, small increase, large increase	
Fish and aquatic fauna	The change in the health, mortality and/or migration of fish and other aquatic fauna.	Large decrease, small decrease, no change, small increase, large increase	
Flooding	The change in the occurrence of flooding	Large decrease, small decrease, no change, small increase, large increase	

Gross pollutants	The change in the input of gross pollutants (particularly litter) into the creek and surrounds	Large decrease, small decrease, no change, small increase, large increase	
Income of the local economy (\$) (utility)	The dollar value of an increase or decrease in the income of the local economy resulting from changes to related natural, social and economic components of the creek and catchment	Dollar value	\$
Income of the local economy	The increase or decrease in income of the local economy resulting from changes to related natural, social and economic components of the creek and catchment	Large decrease, small decrease, no change, small increase, large increase	
Pathogen inputs	The input of faecal coliforms to the creek system. Current input (no change) is 130,000 to 150,000 cfu/100mL	<100,000, 100,000 to 130,000, 130,000 to 150,000, 150,000 to 180,000, >180,000	cfu/100mL
Pesticide inputs	The change in the input of pesticides to the creek.	Large decrease, small decrease, no change, small increase, large increase	
Riparian habitat area	The change in the area of riparian habitat	Large decrease, small decrease, no change, small increase, large increase	
Sedimentation of the waterway	The change in rate of sedimentation of the creek bed	Large decrease, small decrease, no change, small increase, large increase	
SEPP 14 wetland and riparian habitats	The change in the health and extent of SEPP14 Wetland No 318 and related riparian habitat resulting from changes to related components in the creek system	Large decrease, small decrease, no change, small increase, large increase	
Social amenity and scenic quality	The change in the quality of the scenic environment and the community value associated with the creek and its catchment	Large decrease, small decrease, no change, small increase, large increase	
Terrestrial habitat area	The change in the area of terrestrial habitat	Large decrease, small decrease, no change, small increase, large increase	

Threatened terrestrial flora and fauna	The change in the health and extent of threatened terrestrial flora and fauna	Decrease, no change, increase	
TN inputs	The total nitrogen (TN) load (in kg/year) input to the creek system. Current (no change) state estimated at 2,000 to 3,000 kg/year.	<1,500 1,500 to 2,000 2,000 to 3,000 3,000 to 3,500 >5,000	kg/year
TP inputs	The total phosphorus (TP) load (in kg/year) input to the creek system. Current (no change) state estimated at 150 to 300 kg/year.	<100, 100 to 150, 150 to 300, 300 to 350, > 350	kg/year
TSS input	The total suspended solids (TSS) load (in kg/year) input to the creek system. Current (no change) state estimated at 8,000 to 13,000 kg/year.	<5,500, 5,500 to 8,000 8,000 to 13,000 13,000 to 15,500 >15,500	kg/year
Upper creek salinity	The change in upper creek salinity levels	Large decrease, small decrease, no change, small increase, large increase	

APPENDIX 2. ADDITIONAL SCENARIO GROUPS AVAILABLE IN THE FIDDAMANS CREEK CLAM TOOL

1. Climate change
2. Sea level rise
3. Sewage overflow management

Climate change

This scenario assesses the impact of climate change predictions given by CSIRO for climate change in the Coffs Region of NSW.

1. No change.
2. Increased storm intensity and storm frequency (as per CSIRO (2004) predictions outlined below)
3. 40% decrease in annual rainfall (as per CSIRO (2004) predictions)
4. 40% increase in annual rainfall (as per CSIRO (2004) predictions)

Sea level rise

This scenario assesses the impact of predicted sea level rise. Predictions provided by IPCC (2007) for the increases in sea level by 2090-2099 are given below:

	Sea Level Rise (m at 2099 relative to 1980-1999)
B1 scenario	0.18 – 0.38
A1T scenario	0.20 – 0.45
B2 scenario	0.20 – 0.43
A1B scenario	0.21 – 0.48
A2 scenario	0.23 – 0.51
A1F1 scenario	0.26 – 0.59
Range assumed for CLAM	0.18 – 0.59

That is, for the purposes of the CLAM model, the IPCC predicted sea level rise of 0.18 – 0.59 m by 2090-2099 is taken to be the predicted range for 2100.

1. No change in sea levels
2. Increase in sea level to IPCC (2007) predictions for 2100

Sewage overflow management

This scenario addresses the impact of sewage overflow management. A reticulated sewerage network was installed for Fiddamans Catchment in 1999 and there are relatively few overflow incidents in Fiddamans Catchment. Human behaviour is a major contributor to overflow incidents. This scenario explores policing and educations as tools to reduce the occurrence of overflows.

1. Do nothing:
2. Increase education measures and policing of correct drain usage. This is aimed at reducing blockages caused by human actions, including tree planting, illegal dumping in drains and illegal connections (e.g., stormwater) to the network, prior to the occurrence of an overflow incident.