7. Prioritisation and Cost Benefit Results

7.1 Load contributions and gains from the catchment

The prioritisation and cost benefit results in this section are underpinned by the modelled contributions of major land uses to overall catchment loads to Corner Inlet and Nooramunga and the improvements to water quality that could be achieved through the implementation of actions. The process also explicitly considers feasibility and costs as fundamental components of the prioritisation process.

Agricultural land uses (beef/sheep which occupies over 40% catchment area and dairy which occupies approximately 10%) contribute most of the nutrient and sediment loads to the Corner Inlet Ramsar Site. Accordingly, it is with the improved management of these lands that the largest gains in nutrient and sediment reduction are likely to be made. The distribution of dairy and beef/sheep farms across the catchment is shown in figure 7.1.1.

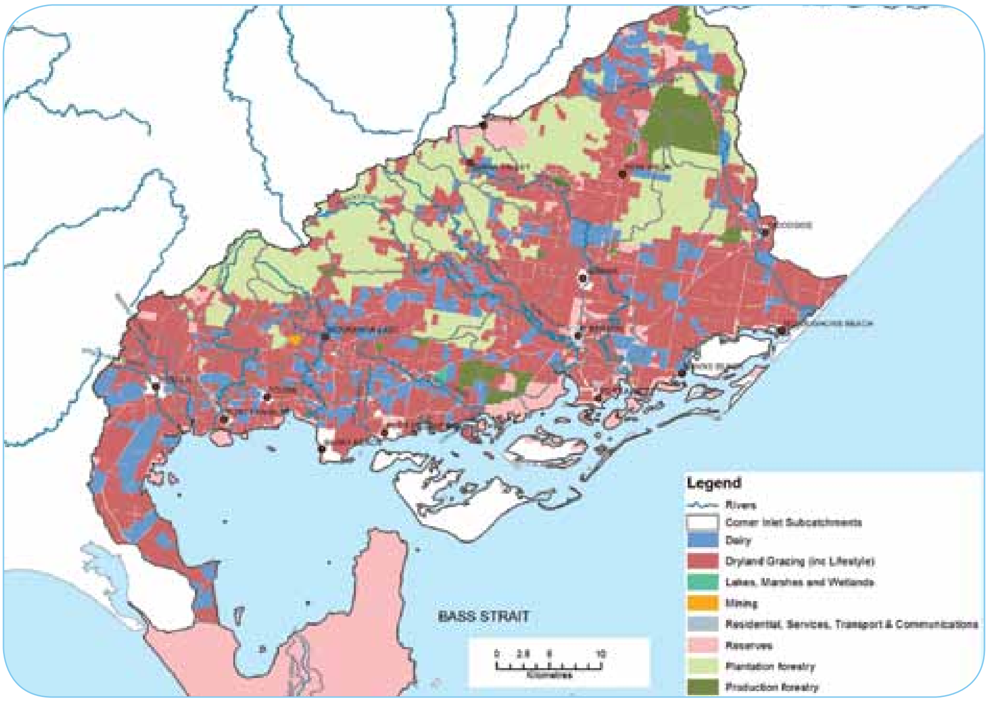

Figure 7.1.1 Land uses in the Corner Inlet and Nooramunga catchments

Plantation forestry is also an important land use across the area, mostly located in upper catchments as shown in figure 7.1.1. Initial catchment modelling indicated surprisingly high levels of sediment and nitrate-N loads generated from plantation forestry land. Both Hancock Victorian Plantations (HVP) and the Technical Panel are doubtful of these results. In view of this uncertainty, and the fact that this plan could not evaluate the effectiveness and costs and benefits of forestry management practices, the WQIP works program has been developed on the basis of load reduction targets being met solely from agricultural land management BMPs and fencing activities.

With respect to urban nutrient pollution, contributions from treatment plant outfalls are of concern. Whilst these need to be managed, their contribution to sediment and nutrient load in the Corner Inlet Ramsar Site is low overall.

Although there is uncertainty about the contribution of forestry to total loads and the contributions from urban areas is very small, local stakeholders and the Technical Panel have agreed it is important to identify actions relating to water quality from both these sectors and include them in the WQIP works program.

The loads of TN, TP and TSS from agricultural land uses are shown in the following graphs and figures.

Figures 7.1.2, 7.1.3 and 7.1.4 show the modelled agricultural loads of TN, TP and TSS from the major catchments in Corner Inlet and Nooramunga. The graphs show current (before WQIP) loads and the modelled improvements that will result (after WQIP) from implementation (assuming full implementation of all management actions). The approach for the development of the works program, namely the bioeconomic modelling and INFFER work, is outlined below in Sections 7.2 and 7.3.

Although load reductions are projected to come from all river basins, the largest reductions are predicted from the Western Tributaries (TN, TP, figures 7.1.2 and 7.1.3), the Jack and Albert River catchments (TN, TSS, figures 7.1.2 and 7.1.4), and the Franklin River and Bennison Creek catchments (TSS, figure 7.1.4).

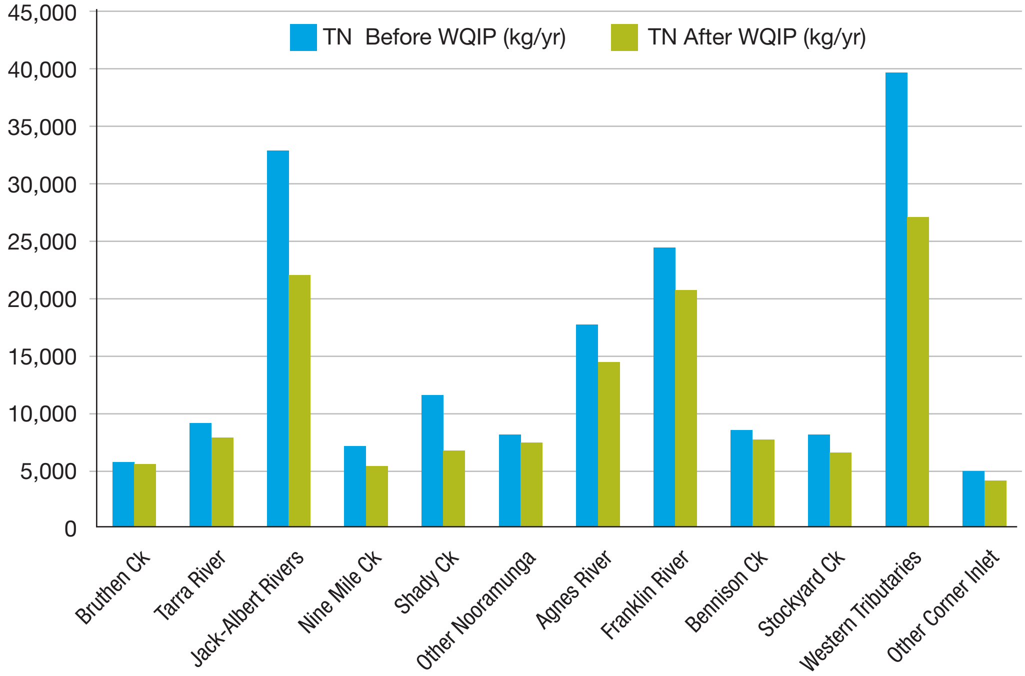

Figure 7.1.2 Total Nitrogen loads (TN kg/year) from agricultural land uses from major catchments before and after WQIP implementation

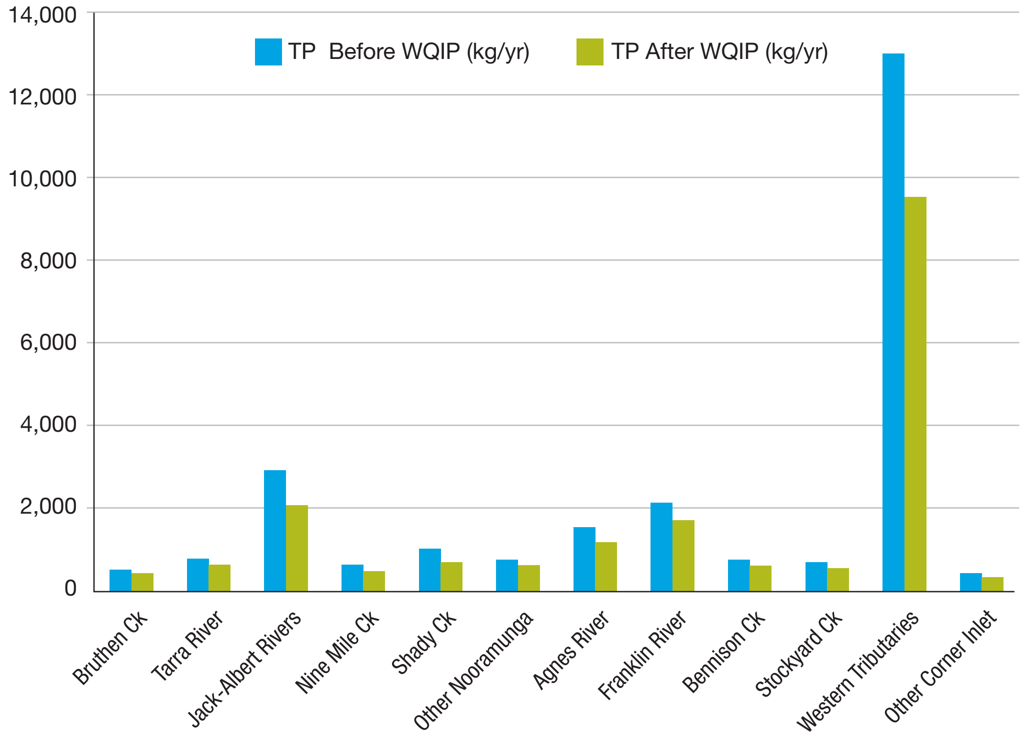

Figure 7.1.3 Total Phosphorus loads (TP kg/year) from agricultural land uses from major catchments before and after WQIP implementation

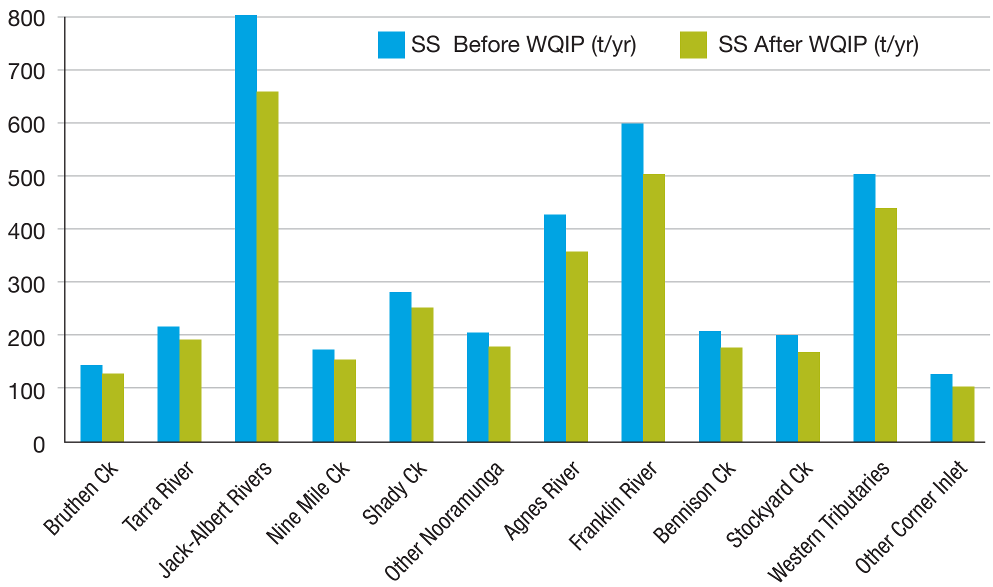

Figure 7.1.4 Total Suspended Sediment loads (TSS t/year) from agricultural land uses from major catchments before and after WQIP implementation

Figures 7.1.5 to 7.1.10 show a more detailed picture of nutrient and sediment loads associated with agricultural land management changes.

Figures 7.1.5, 7.1.7 and 7.1.9 depict the subcatchment loads for each of TN, TP and TSS prior to WQIP implementation.

Figures 7.1.6, 7.1.8 and 7.1.10 depict the change in load for each TN, TP and TSS after the WQIP is implemented.

Note that the southern end of the Western Tributaries catchment (E2 subcatchments 64 and 65) (figure 7.1.1) are not shown in figures 7.1.5 - 7.1.10. This is because the E2 modelling on which the loads are based did not cover these subcatchments. Given that both subcatchments contain agricultural land use, we would expect future implementation programs to extend to both of these subcatchments. The area omitted is 5% of the total catchment area.

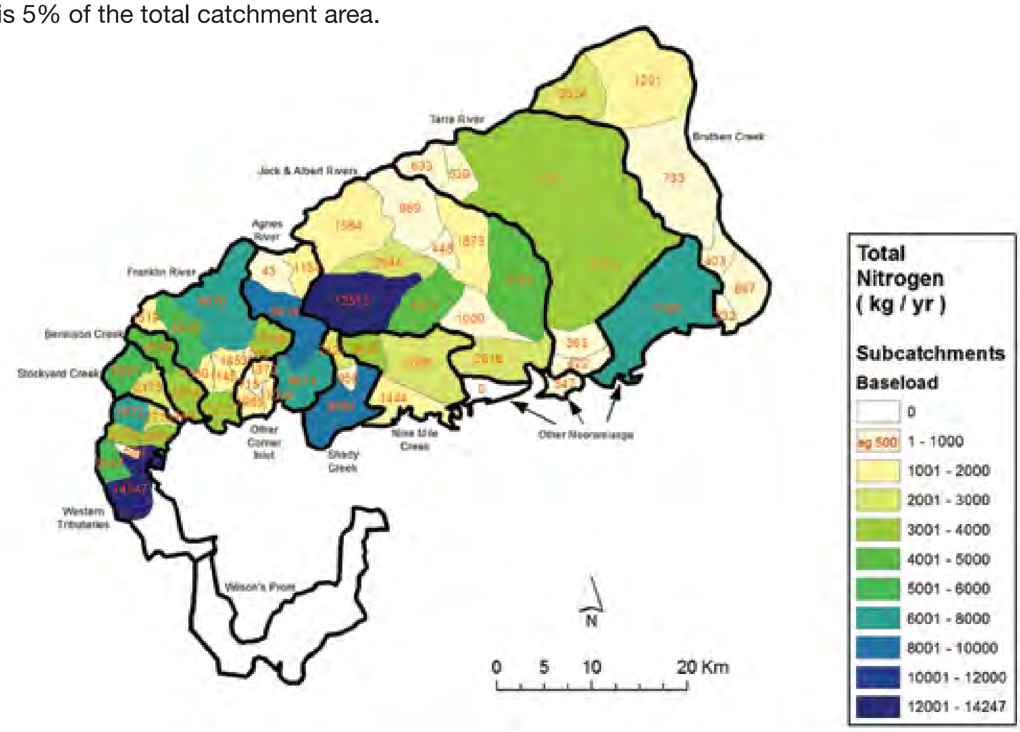

Figure 7.1.5 Total Nitrogen loads (TN kg/year) from agricultural land uses before WQIP implementation

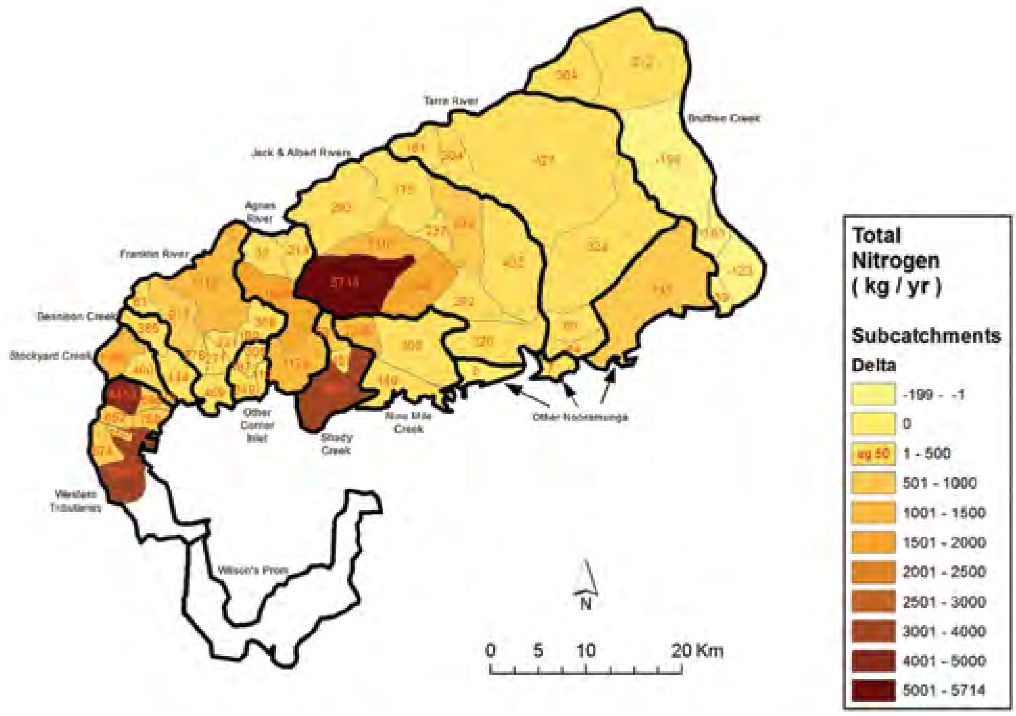

Figure 7.1.6 Change in Total Nitrogen loads (TN kg/year) from agricultural land uses assuming full implementation of the WQIP

Maps in figures 7.1.5 to 7.1.9 illustrate the spatial patterns of Nitrogen, Phosphorus and sediment loss.

Overall, there are high N losses from the Corner Inlet subcatchments and in parts of the Jack, Albert and Tarra catchments (figure 7.1.5). Whilst implementation of management actions needs to occur over most subcatchments, most TN load reduction is predicted to come from the Jack and Albert Rivers, Shady Creek, and the Western Tributaries (figure 7.1.6).

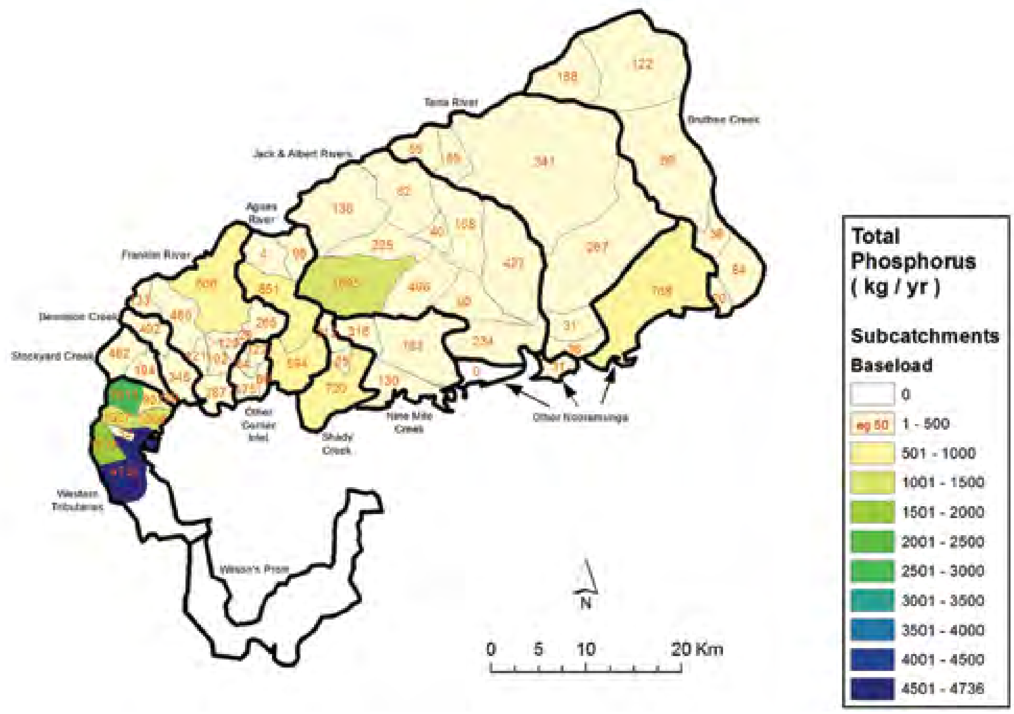

Figure 7.1.7 Total Phosphorus loads (TP kg/year) from agricultural land uses before WQIP implementation

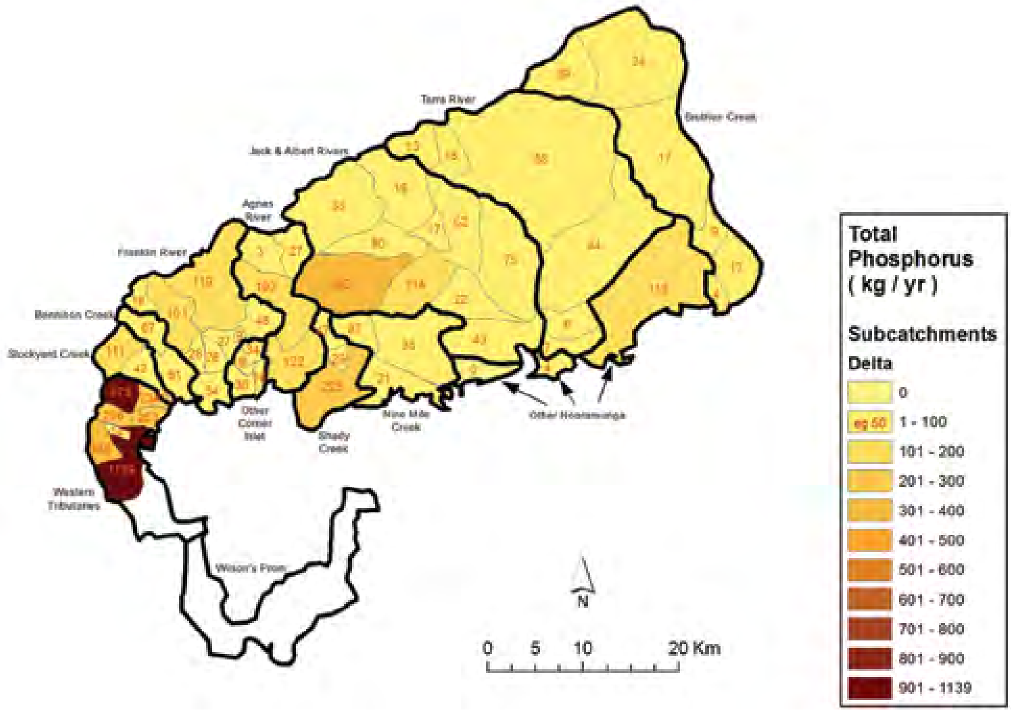

Figure 7.1.8 Change in Total Phosphorus loads (TP kg/year) from agricultural land uses assuming full implementation of the WQIP

The TP loads from agriculture are highest in the Western Tributaries of Corner Inlet (figure 7.1.7). The Jack and Albert catchment is also an important source of TP. The Western Tributaries, the Jack and Albert catchment, and Shady Creek are where the largest TP load reductions are predicted to occur as a result of the implementation of the Corner Inlet WQIP.

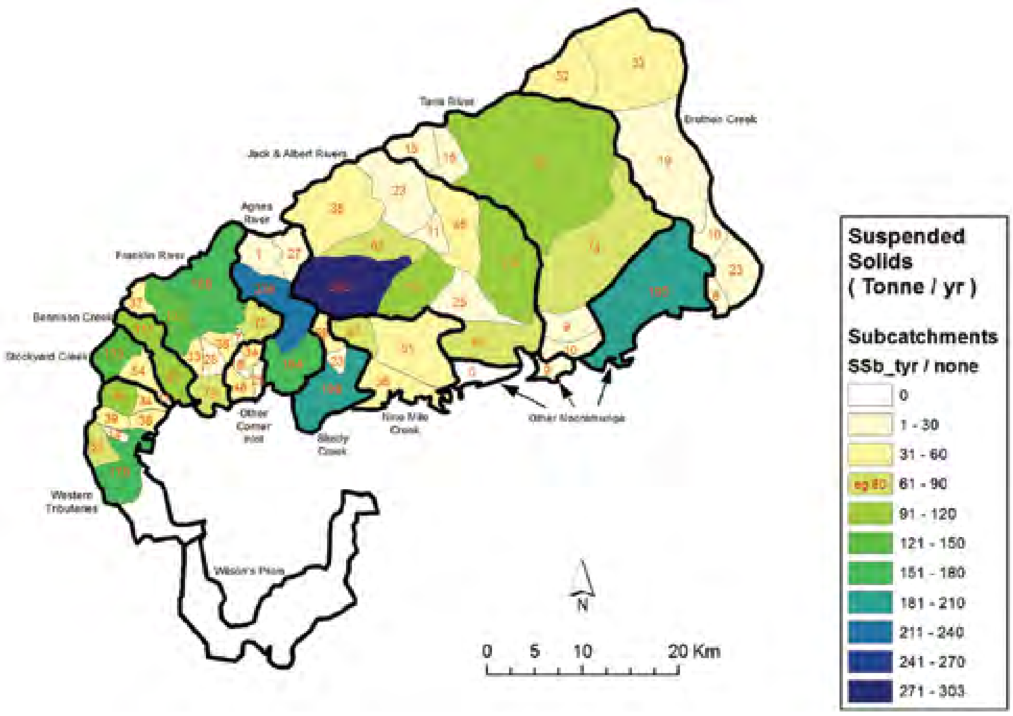

Figure 7.1.9 Total Suspended Sediment loads (TSS t/year) from agricultural land uses before WQIP implementation

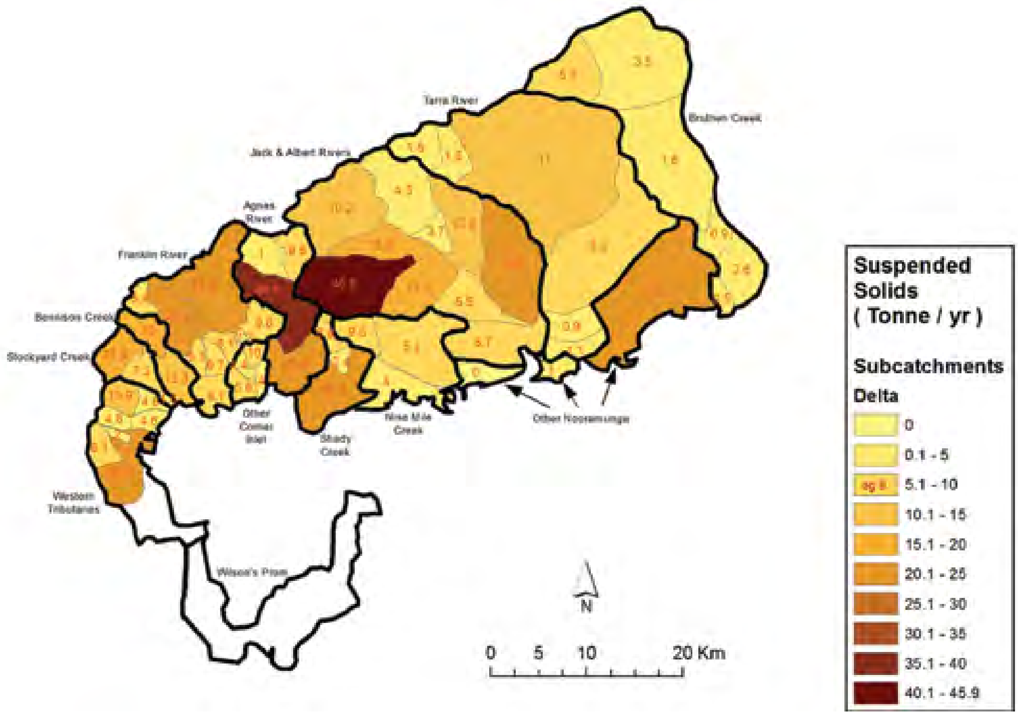

Figure 7.1.10 Change in total Suspended Sediment loads
(TSS t/year) from agricultural land uses assuming full implementation of the WQIP

Compared with TN and TP, sediment load reduction is somewhat less targeted, with load reduction of over 10t/year needing to occur in a number of subcatchments, but especially in the Jack and Albert catchment and the Agnes River catchment.

7.2 Costs and implications of achieving targets (bioeconomic modelling)

Bioeconomic modelling was used to assess the feasibility and costs of management actions to achieve the water quality targets outlined in Section 6.2. A summary of the approach is outlined in Appendix 2 along with assumptions about the effectiveness of farm management actions and costs.

Over 20 scenarios were analysed in response to WGCMA and Technical Panel discussions. Scenario testing enabled increased understanding of predicted land use/management change implications associated with achieving differing load reduction targets. Three scenarios are presented (see table 7.2.1) to illustrate the costs and implications of achieving different targets.

The three scenarios (A, B and C) include one for higher aspirational targets (A) and two (B and C) for the revised targets that were chosen to be examined for implementation. Out of the three scenarios, the third (C) was selected for use in the implementation of the Corner Inlet WQIP. This scenario was arrived at through an iterative process that included consultation with the Technical Panel on two occasions and additional discussion with the WQIP Project Managers.

The logic behind the final implementation scenario is as follows:

- The Technical Panel agreed to the revised implementation targets outlined in Section 6.2.
- Whilst the least-cost solution (B) is predicted to be $8.58M/year (table 7.2.1), the results predict large-scale land use changes and this is not an acceptable outcome for the socio-economic viability of the local community. Best Management Practices (BMPs) and traditional activities were judged to be much more acceptable to the local community. The cost from the selected scenario (C) is only slightly greater $8.95M/year for a much more politically acceptable outcome (no land retirement). The trade-off however is that the sediment reduction target met in Nooramunga is only 5% in scenario C rather than 10% in scenario B. Apart from this, scenario C meets the same targets as scenario B.
- Due to its greater catchment size and the importance of sediment, it is much more costly to achieve targets in Nooramunga than in Corner Inlet. The Jack and Albert Rivers (subcatchments 17-26) are major contributors of sediment from agricultural areas within the Nooramunga catchment and these subcatchments provide a logical focus for traditional activities (fencing of waterways and erosion control) to reduce sediment loads.

Table 7.2.1 Costs and management implications of achieving load reduction targets for the Corner Inlet and Nooramunga catchments

Scenario	% load reduction estimated as achievable TN:TP:TSS	Cost $million (M)/year	Summary of management actions required to achieve targets[e]
A. Aspirational targets at least cost	CI[a] 30:30:11[c] N[b] 20:22[c]:20	$30.15M (CI $6.55M, N $23.60M)	• 46% dairy retirement to beef/ sheep (16%CI, 66%N) • dairy BMPs in some of both catchments • 28% beef land retirement to native vegetation • BMPs in beef/sheep in remainder and traditional activities
B. Implementation targets at least financial cost	CI[a]15:19[c]:10 N[b]12[c]:17[c]:15[c]	$8.58M (CI $0.95M, N $7.63M)	• 59% dairy retired to beef/sheep (11% CI, 83%N) • small amount of dairy intensification in several subcatchments • 2% beef retirement to native vegetation. Dairy BMPs in some of both catchments • extensive beef BMPs • range of traditional activities
C. Implementation targets using BMPs across both catchments and focus on sediment reduction in the Jack and Albert River catchments	CI[a]15:20[c]:10 N[b]10:11[c]:5[d]	$8.95M (CI $3.78M, N $5.17M)	• extensive dairy and beef/sheep BMPs in both catchments, including small amount of dairy intensification in several subcatchments (2-6 in Bruthen Creek) and extensification in others in the Franklin River (44,47), Bennison Creek (52) and the Western Tributaries (57,63,64 and 65) subcatchements • traditional activity focus in Jack and Albert River catchments (17-26) and much of Corner Inlet

CI[a] Corner Inlet
N[b] Nooramunga
[c] *In seeking to achieve all three targets, some targets can be over-achieved at no additional cost*
[d] *Confining TSS activities to the Albert and Jack catchments does not achieve 10% TSS reduction*
[e] *More detailed results are available, it is only possible to list summary results here*

Modelling results indicate that the scale of adoption and funding would need to be significantly increased compared with current program allocations for the WQIP targets to be achieved. With the exception of one BMP (nutrient application), all BMPS and traditional fencing activities cost farmers money. This financial impost to farmers, combined with the predominantly public benefit from the activities, means that it is unrealistic to expect sustained practice-adoption without investment in long-term stewardship payments that achieve outcomes for the public good.

Voluntary one-off or short-term incentive type programs, as have been commonly used in Australia, will not be sufficient. Regional agencies have successfully led BMP adoption programs such as CORE4 in West and South Gippsland, however catchment-wide adoption is likely require to a broad spectrum of approaches, including long-term incentives in the form of stewardship that are backed up by compliance for regulated activities across agricultural, forestry and urban land uses.

Left: Binginwarri Landcare group members learning about the native vegetation of the Corner Inlet catchment. Photo – Yarram Yarram Landcare Network.

Right: Weed management work on Macks Creek helped reveal a stand of rare warm temperate rainforest vegetation. Photo – HVP.

Fencing programs have the most impact on sediment reduction whereas many BMPs offer greater potential for nutrient reduction. Maintaining riparian and gully fencing programs whilst increasing other BMP programs requires a shift in emphasis. There is also increased risk in moving to BMP programs due to less experience in implementation and less tested confidence in terms of their effectiveness. In contrast, there is both more experience in waterway and erosion control programs and it is also much easier to assess whether works are maintained than to determine whether BMP programs will be effective.

BMP programs, whilst potentially cost-effective in reducing nutrients, present social and financial challenges not faced previously. Public funding of long-term stewardship payments needs to be underpinned by contracts, appropriate farm-level metrics and auditing of performance. There will also be a need for increased emphasis on assessing compliance for regulated activities both for initial implementation and for ongoing management. To be credible in the long-term, auditing of BMPs should be conducted by an independent third party and regulated activities audited by either a third party or the EPA.

It is acknowledged that the current knowledge base is inadequate to provide a high level of confidence regarding the level of catchment load reduction needed to maintain seagrass condition and extent. Until model confidence is improved the implementation targets should be considered as interim.

Development of robust water quality targets should also be guided by:

- improved catchment modelling that simulates the contributions of all major land uses with a high degree of confidence
- finer scale farm heterogeneity and cost information
- updated BMP and traditional waterway and erosion control activity effectiveness estimates.

Regardless of the scale of targets required to maintain seagrass and other water quality dependent values relating to the Corner Inlet Ramsar Site, it will be critical to further investigate the feasibility of reducing loads from the catchment through BMPs (across all major land uses) and through on-ground actions.

If aspirational load reduction targets are required to maintain the ecological character of the Ramsar site, BMPs and waterway and erosion control actions alone will not be sufficient. If so, other options will need to be investigated in partnership with industry and the community. This could include targeting land use in the catchment to minimise impact from intensive activities and/or formally setting nutrient caps and implementing nutrient trading schemes, drawing on models from New Zealand, the United States of America and Europe. Beginning a conversation about the possible need for targeted land use change should be contemplated.

The acknowledgment that the values of the Corner Inlet Ramsar Site may be threatened by catchment water quality, and that aspirational level water quality targets may not be able to be met through BMPs is an important factor for the community and public funders to understand and discuss. This will better ensure that active decisions can be made about what to do and will provide the community with information and time to think about the trade-offs involved.

7.3 INFFER analysis and cost effectiveness

INFFER (Investment Framework for Environmental Resources (Pannell et. al., 2011)) was used to assess the relative cost-effectiveness for each scenario and was based on the logic of Benefit:Cost Analysis (Boardman et. al., 2010). The scenarios were assessed for relative cost-effectiveness using the INFFER Project Assessment Form. The assessments calculated a Benefit:Cost ratio (BCR) for each scenario (see table 7.3.1).

Undertaking the analysis required collection of the following information:

- Clear identification of the environmental asset, including spatial location and extent.
- Significance or value of the asset.
- Threats that are affecting or are likely to affect the environmental asset.
- Specific, measurable, time-bound goals.
- Works and actions that are proposed to be undertaken to achieve the goals.
- Time lag between undertaking the project and the generation of benefits.
- Future degree of environmental damage with and without the proposed works and actions.
- Risk of technical failure of the project.
- Positive and negative spin-offs from the project (e.g. impacts on other environmental assets).
- Likely extent of adoption by private landholders of the works and actions that would be required to achieve the stated goals.
- Risk that, despite new public investment, private landholders will adopt new works and actions that would further degrade the environmental asset.
- Legal approvals required to undertake the works and actions.
- Policy mechanisms/delivery mechanisms to be used to encourage and facilitate uptake of the required works and actions.
- Socio-political risks.
- Costs of the current project.
- Annual maintenance costs required to maintain benefits after the current project is complete.
- Risk of not obtaining those essential maintenance costs, such that project benefits are lost.

The variables that feed into calculation of the Benefit:Cost Ratio (Pannell, 2012) are mostly specified as proportions, and are included in the index multiplicatively.

$$BCR = \frac{V \times W \times A \times F \times B \times P \times G \times DF \times 20}{C + PV(M + E) \times G}$$

Within this approach, there is no need to provide weights for each variable (as one would do in a multi-criteria analysis).

The variables that feed into calculation of the BCR are:

- V = value of the asset
- W = multiplier for impact of works
- F = multiplier for technical feasibility risk
- A = multiplier for adoption
- B = multiplier for adverse adoption
- P = multiplier for socio-political risk
- G = multiplier for long-term funding risk
- DFB = discount factor function for benefits, which depends on L
- L = lag until benefits occur (years)
- C = short-term cost of project
- PV = present value function
- M = annual cost of maintaining outcomes from the project in the longer term
- E = compliance costs for private citizens, if the project involves enforcement of regulations.

Using this approach a BCR was estimated for several scenarios that are summarised in table 7.3.1.

As well as the three scenarios (A, B and C) presented earlier, table 7.3.1 presents a new 'future' scenario (labeled D). Under this scenario it is envisaged that the on-ground cost of reducing nutrient and sediment loads entering the Corner Inlet Ramsar Site could be reduced from $8.95M/year (scenario C) to $6M/year.

Reducing costs could be possible with both finer scale modelling (enabling stronger targeting of nutrient reduction activities) and a market-like mechanism such as a nutrient trading scheme, whereby farm heterogeneity can be much better utilised. Stewardship payments could then be targeted to individual farms based both on the capacity for nutrient reduction (from the finer scale modelling) and the amount farmers would need to be paid for sustained practice-adoption (through farmer bids and competition in the market).



Left: River restoration work has been well supported by landholders on Corner Inlet's Western Tributaries. Photo – WGCMA.

Top right: Off-stream watering points for cattle reduces bank erosion on waterways and improves water quality. Photo – WGCMA.

Lower right: Fencing to exclude stock and planting of riparian vegetation on the creeks and tributaries flowing through dairy and mixed grazing properties. Photo – WGCMA.

Table 7.3.1 Summarised INFFER analysis results

Scenario with % load reduction estimated as achieved TN:TP:TSS	Direct costs for works $M/year	In-direct costs $M (over 5 years)	Maintenance costs $M/year (after 5 years)	Benefit:Cost Ratio (BCR)	BCR parameter values		Comment
A. Aspirational targets at least cost CI[a] 30:30:11[c] N[b] 20:22[c]:20	$30.15M (CI $6.55M, N $23.60M)	$6.0M	$0.5M	0.003	V = 50 L =10 F = 0.92 B = 1 C = 151 E = 0	W = 0.45 DFb (L) = 0.61 A = 0.4 P = 0.05 M = 30.15 G = 0.1	Large-scale landscape change increases works effectiveness but with very high socio-political risk (P=0.05) and likelihood of future funding is very low (G=0.1).
B. Implementation targets at financial least cost CI[a]15:19[c]:10 N[b]12[c]:17[c]:15	$8.58M (CI $0.95M, N $7.63M)	$5.7M	$0.45M	0.047	V = 50 L = 10 F = 0.87 B = 1 C = 42.9 E = 0	W = 0.30 DFb (L) = 0.61 A = 0.4 P = 0.2 M = 8.58 G = 0.2	Requires some land use change to high socio-political risk (P=0.2), likelihood of funding still very low (G=0.2).
C. Chosen implementation targets. BMPs across both catchments, sediment reduction in Jack and Albert CI[a]15:20[c]:10 N[b]10:11[c]:5[d]	$8.95M (CI $3.78M, N $5.17M)	$6.0M	$0.45M	0.229	V = 50 L =10 F = 0.87 B = 1 C = 44.75 E = 0	W = 0.28 DFb (L) = 0.61 A = 0.5 P = 0.75 M = 8.95 G = 0.3	Much lower socio- political risk (P=0.75) associated with no land use change.
D. Possible future implementation scenario	$6.00M	$6.0M	$0.5M	0.366	V = 50 L =10 F = 0.87 B = 1 C =30 E = 0	W = 0.30 DFb (L) = 0.61 A = 0.5 P = 0.75 M = 6 G = 0.3	Lower costs and similar socio-political risks as WQIP Implementation Plan scenario C. Increased BCR as a result of the reduced on-ground costs.

CI[a] Corner Inlet
N[b] Nooramunga
[c] *In seeking to achieve all three targets, some targets can be over-achieved at no additional cost*
[d] *Confining TSS activities to the Albert and Jack catchments cannot achieve10% TSS load reduction*

The four scenarios outlined in table 7.3.1 are different in terms of the scale of the nutrient and sediment reduction target, overall cost, and ultimate cost-effectiveness. Achieving the aspirational target (scenario A) is very costly ($30.15M/year in direct works costs and additional indirect costs). The scenario requires large-scale landscape change, along with a range of traditional on-ground actions, such as waterway fencing and stewardship payments for dairy and beef farmers to adopt BMPs in some subcatchments. As well as the large costs, scenario A is likely to be viewed as unacceptable from a socio-political perspective (P value of 0.05 indicates very high socio-political risk). The BCR for this scenario at 0.003 indicates that it is 75 times less cost-effective than WQIP Implementation Plan scenario C (BMPs plus traditional activities).

Scenario B achieves only half the nutrient and sediment target of scenario A, however at $8.58M/year (in direct costs), it is less than a quarter of the cost of scenario A. Land use changes are still amongst the selected options, which means that the socio-political risks (P=0.2) remain high. As a result the BCR is still very low (0.047).

The chosen WQIP Implementation Plan scenario C, requires no agricultural land use change and thus is estimated to have much lower socio-political risks (P value 0.75). Water quality targets are achieved at only slightly higher costs ($8.95M/year direct costs) compared to scenario B. This scenario will still require unprecedented levels of investment, in both traditional on-ground fencing actions and stewardship BMP payments to landholders. With the exception of not achieving the sediment target in Nooramunga, similar levels of nutrient and sediment reduction are achieved to those of scenario B.

Lower socio-political risks are the main reason for scenario C having a higher BCR (0.229) than scenarios A and B. Under the future scenario D, the BCR is increased to 0.366 due to the lower on-ground costs which are projected to be achieved through the use of a market-based mechanism such as a well-designed nutrient trading scheme underpinned by finer scale modelling.

In calculating the BCR for each scenario the best available estimates and judgment for parameter values have been used, but there is uncertainty with parameters. To illustrate this, a basic sensitivity analysis was conducted by varying parameter values based on pessimistic, realistic and optimistic assessments for each value within the four scenarios for the chosen implementation scenario C (see table 7.3.2). Adjustment of values was restricted to factors including works effectiveness, technical feasibility, lag times, adoption and socio-political risks. Costs were unchanged for the sensitivity analysis as there is no basis for suggesting these would differ markedly from the base case costing already developed. The likelihood of future funding (G – long-term funding risk), rated as low for both pessimistic and realistic scenarios, has been assigned a value of 1 for the optimistic scenario.

Table 7.3.2 Benefit:Cost ratios for pessimistic, realistic, optimistic assessments for 4 water quality scenarios

Scenario	Pessimistic	Realistic	Optimistic
A. Aspirational targets	0.001	0.003	0.091
B. Implementation (least cost)	0.009	0.047	0.561
C. Chosen implementation (BMPs + traditional)	0.042	0.229	0.904
D. Future scenario with nutrient trading scheme	0.063	0.366	1.461

Table 7.3.2 shows a wide range of BCRs, from extremely cost-ineffective to potentially cost-effective (where a BCR score of 1 = cost-effective). The current political constraints (lack of guaranteed long-term funding and socio-political risks) are commonly the major reasons for poor BCR values. Even the most optimistic assessment of parameter values suggests that the aspirational and least financial costs WQIP targets (scenarios A and B) are not cost effective (BCR values less than 1).

The BCR for the chosen implementation target (0.229) could become close to cost-effective (0.904) with several BCR constraints lessened. Furthermore, the future scenario with lower costs due to a nutrient trading scheme could potentially be cost-effective (BCR 1.46) in reaching the WQIP nutrient reduction targets.

For a project of this scale and complexity, achieving a BCR of greater than 1 is a very good result. It highlights that reducing nutrient and sediment loads to the Corner Inlet Ramsar Site is much more cost-effective than for a previous analysis on the Gippsland Lakes, where only P was able to be considered and the assumptions used at the time about practice effectiveness were over optimistic.

8. Delivery Mechanisms

Implementation of the WQIP will require actions across a range of land uses including agriculture, forestry and urban areas.

In particular, actions on agricultural land to improve water quality are required across the majority of subcatchments. To select appropriate delivery mechanisms for implementation it is important to consider the relative levels of public (external) and private (internal) net benefits from the proposed actions. Depending on relative levels, it may be appropriate to use positive incentives, negative incentives, extension, technology development, or no action. To guide the choice of policy tools relating to private land the Public:Private Benefits Framework (Pannell, 2008) has been used. Under this approach policy mechanisms are grouped into one of five categories:

1. Positive incentives (financial or regulatory instruments to encourage change)
2. Negative incentives (financial or regulatory instruments to inhibit change)
3. Extension (technology transfer, education, communication, demonstrations, support for community network)
4. Technology change (development of improved land management options such as through strategic research and design (R&D), participatory R&D with landholders, provision of infrastructure to support a new management option)
5. No action.

The framework highlights the importance of targeting funds for environmental programs to selected areas, based on the levels of public and private net benefits. In particular, the framework indicates that mechanisms should be used as follows:

- Positive incentives – where public net benefits are highly positive and private net benefits are close to zero
- Negative incentives – where public net benefits are highly negative and private net benefits are slightly positive
- Extension – where public net benefits are highly positive and private net benefits are slightly positive
- Technology development – where private net benefits are negative (but not too negative) and public net benefits are positive
- No action – where private net benefits outweigh public net costs, where public and private net benefits are both negative, where private net benefits are sufficiently positive to prompt rapid adoption of environmentally beneficial activities, or where private net costs outweigh public net benefits (provided that technology development is not sufficiently attractive).

To date, a range of programs have been used successfully in the Corner Inlet catchment to encourage adoption of best management practices (BMPs) in order to reduce sediment and nutrient loads entering the Corner Inlet Ramsar Site. Below in table 8.1.1 the major delivery mechanisms used in recent programs are categorised.

Table 8.1.1 Programs used in Corner Inlet to improve water quality and associated main delivery mechanisms

Program	Primary Delivery Mechanism	Comment
Beef Cheque, BetterBeef and BestLamb	Extension	Beef Cheque – Delivered by regional TAFEs in collaboration with DEPI and Meat and Livestock Australia (MLA). BetterBeef and BestLamb – DEPI in partnership with MLA. These state-wide networks provide opportunities for producers to access the latest research messages and participate in courses that increase skills and knowledge.
Fert $mart	Extension	Dairy Australia initiative being developed to improve the efficiency and profitability of fertiliser use.
Core 4	Extension and positive incentives (differential incentives based on farmer expressions of interest)	Australian Government funded through the Caring for Our Country initiative. It was originally developed for the Gippsland Lakes catchments and has been trialled in the Agnes, Franklin and Stockyard Creek sub-catchments of Corner Inlet in 2012-13.
Direct grants/ devolved grants – waterway and erosion control incentives	Positive incentives	The WGCMA, South Gippsland Landcare Network and Yarram Yarram Landcare Network currently have grant programs in place for landholders within the Corner Inlet and Nooramunga catchments.
Market based instruments (MBI)	Positive incentives	The Corner Inlet Ramsar Site was included in a recent Saltmarsh Protection Project, which used a tender style market based instrument to achieve protection of habitat. However, such mechanisms have not used for catchment-scale water quality actions to date.
EPA compliance activities	Negative incentive/regulation	Auditing of dairy effluent systems and intensive animal licences in line with regulations.
Forestry Timber Code of Practice	Negative incentive/regulation	Forestry operators comply with a Code of Practice. Compliance is assessed through inspection by local councils and some independent auditors.
Wastewater treatment plant upgrades	Negative incentive/regulation	EPA inspections.
Domestic waste water treatment	Negative incentives/regulation	Council inspections.

Landholders, community groups, contractors and agency staff are an effective combination. Photos – Top left: WGCMA, Centre left: Yarram Yarram Landcare Network, Bottom left: Parks Victoria. Right by Sharyn Allott, courtesy South Gippsland Landcare Network.

Extension, positive incentives and regulation compliance activities have all been used in the Corner Inlet and Nooramunga catchments. For agricultural land activities, most programs have been focused on incentive and extension activities to influence the implementation of actions and the adoption of BMPs. Some of these programs operate in tandem; for example, extension activities often identify on-ground works, such as waterway fencing, which are then implemented through direct grant programs. Likewise incentive delivery is generally coupled with extension information for landholders outlining appropriate maintenance activities.

These programs have been successful in engaging landholders in the implementation of actions and the adoption of BMPs, and have been delivered in a collaborative way across agencies. Current programs and partnerships can be used as a foundation for a scaled-up delivery program, subject to available funding. However, bioeconomic modelling results indicate that the level of payments and scale of current programs are not sufficient to achieve the required reduction in nutrient and sediment entering the Corner Inlet Ramsar Site.

Achieving the implementation objectives (outlined in Section 7) will require a mix of incentive, extension and regulatory mechanisms, albeit at a much-increased scale compared to the current situation. This approach, with an appropriately designed and robust metric tied to water quality objectives and an adequate funding pool, has a high likelihood of success.

Overall delivery mechanisms are constrained by the level of funding available and the types of mechanisms funders are willing to support. There is community willingness to support programs at the current scale of investment. Continued willingness to participate in markedly scaled-up programs with actions at much greater levels than is currently the case would need to be assessed should funding become available. A further limitation of current programs is that there is no mechanism to ensure BMP implementation is maintained over the long-term.

9. Implementation Programs

Implementation programs include direct on-ground actions and enabling activities. The activities that need to be undertaken in the WQIP Works Program are described below.

9.1 Direct works

9.1.1 Agriculture – dairy, beef and sheep

Grazing industries (dairy, beef and sheep) contribute the majority of the nutrient and sediment load to the Corner Inlet Ramsar Site, and thus a major focus is on these land uses and their management in reducing these loads. The agricultural BMPs and waterway and erosion control management actions, along with their assumed levels of effectiveness in nutrient and sediment reduction, are outlined in Appendix 2 (table A2.2 for dairy, table A2.3 for beef).

The effectiveness estimates and assumptions that underpin the actions are based on a local understanding of current practice and recognise that there are differences in the level of adoption of BMPs across the two major agricultural land uses (dairy and dryland grazing – sheep/beef). For example, for dairy it is assumed that there is currently a high proportion of permanent waterways already fenced to exclude stock. This assumption is based on dairy industry data captured through the Dairying for Tomorrow Survey completed in 2012. Whilst for beef and sheep the proportion of waterways already fenced is assumed to be much lower. This assumption was developed from the knowledge of local experts. More comprehensive details are outlined in Stott and Roberts (2013).

The management actions identified in the WQIP Works Program (Section 10) have been modelled to achieve the plan's water quality objectives for Phosphorus, Nitrogen and sediment. The selection of actions through the modelling process draws on a combination of factors including modelled nutrient loads from subcatchments, type of land use, and the effectiveness and costs of management actions.

Note that with the exception of nutrient application, all other activities, whilst giving a benefit to the public, are at a cost to farmers. Implementation at the scale required to reduce nutrient loads entering the Corner Inlet Ramsar Site will require long-term incentive payments, referred to as stewardship payments.

Although the best available information has been used to underpin the WQIP Works Program (including BMP effectiveness and costs information), considerable uncertainties remain (see Section 12 Reasonable Assurance Statement). Further research and investigation in terms of updated integrated modelling is required to better assess the potential for management actions to reduce nutrient and sediment loads, in particular, from agriculture and forestry.

The implementation of BMP programs at a larger scale than has occurred previously will need careful consultation, partnership and design with agricultural and forestry industries prior to implementation.

9.1.2 Forestry

Production forestry is the second largest category of land use in the catchments of the Corner Inlet Ramsar Site, covering approximately 22 percent of the catchment area. Forestry activities are governed by the Code of Practice for Timber Production. The Code outlines a range of standards that must be used to protect water quality and environmental values from the impacts of forestry.

The Code provides a series of rules and guidance covering a number of activities. It concentrates on protecting soil, water quality, flora and fauna. The Code covers the following items: plantation planning and design; environmental values; the establishment and management of plantations; plantation roading; and timber harvesting. Advice from HVP Victoria is that the Code is being fully implemented across the land they manage.

HVP has voluntarily developed BMPs which are over and above that required by the Code. Forestry BMPs are grouped under the following headings:

- Protection of riparian vegetation around streams and drainage lines (buffers and filters)
- Slope limitations to harvesting
- Location, use and drainage of snig tracks and log landings
- Wet weather restrictions to forest operations
- Rehabilitation of harvested areas
- Careful planning, design, location, construction, drainage and maintenance of roads
- Design and construction of stream and drainage line crossings.

Due to the significance of the values in the Corner Inlet and Nooramunga catchments the WQIP Works Program aims to ensure that the Code of Practice is adhered to and routinely audited, that BMPs go beyond the requirements of the code and innovation in practice continues. An example of this would be to minimise the time between clearing and rehabilitation to reduce the likelihood of severe sediment loss from large rainfall events and bare ground exposure.

The available catchment modelling estimated that forestry sediment and nitrogen loads were predicted to be surprisingly high. In view of the uncertainties in the catchment modelling, and on the advice from HVP that the Code is being fully implemented, no additional on-ground management actions for forestry have been identified. Confirmation of the contribution of production forestry (through improved monitoring and modelling) to the overall loads of sediment and nutrient to the Corner Inlet Ramsar Site is an important research priority for the WQIP.

9.1.3 Urban

Approximately one percent of land in the catchments surrounding the Ramsar site is under urban use. The urban population has remained stable for the last 30 years and this is predicted to continue at this level over the next 30 years. The majority of towns with over 100 residents are sewered and include Foster, Toora, Welshpool, Port Welshpool and Port Albert. Smaller towns are serviced by septic tanks; however, Alberton is scheduled to be sewered in 2014.

Left: Corner Inlet's attractions and lifestyle make it popular with residents, visitors and holiday makers. Photo – InDetail Comms & PR.

Right: Production forestry is the second largest land use in the catchment. Photo – WGCMA.

South Gippsland Water's urban wastewater program focuses on:

- impacts from unsewered towns
- the upgrade of waste water treatment plants to land reuse schemes
- minimising impact of development through use of water sensitive urban design
- minimising impacts from any industrial developments.

9.1.4 Wetland protection

Wetland protection activities aim to provide a continuous buffer of protected frontage to the Corner Inlet Ramsar Site. These activities will involve the fencing and management of fringing wetland vegetation for conservation. Control of invasive weeds will be required to assist with protection and re-establishment of salt marsh and swamp scrub vegetation communities. Primarily, the program will aim to ensure that all fringing coastal land (Crown or freehold) is managed for conservation purposes and that fences are appropriately located.

Note that fringing wetland protection costs have not been included in the bioeconomic modelling or INFFER analysis as the costs and benefits of these activities cannot be assessed using current information.

9.2 Enabling Actions

In addition to direct works, a number of enabling actions are crucial in order to build on existing networks and the progress already made within the community, as outlined below.

9.2.1 Leadership and partnerships – Corner Inlet Steering Committee

The West Gippsland Catchment Management Authority (WGCMA) will lead and co-ordinate implementation of the Corner Inlet WQIP. The WGCMA will continue to deliver on-ground waterway management works at priority sites across the Corner Inlet and Nooramunga catchments as part of existing programs and activities, subject to available funding. These works include the construction of waterway stability structures, willow and weed management, and other waterway works such as fencing and revegetation. The WGCMA also leads key investigations regarding waterway management and the health of the Corner Inlet Ramsar Site and its surrounding catchments.

Partnerships are crucial to the success of the WQIP. The WGCMA has strong relationships with government, industry, non-government organisations and landholders in the Corner Inlet and Nooramunga catchments. The Corner Inlet Steering Committee (CISC) is the enabling partnership mechanism. The formation of the partnership in 2007 marked an important step in the region's history of stewardship and reinforced a commitment to a productive and healthy Corner Inlet. The partnership continues to facilitate or provide:

- a catchment wide approach to addressing water quality issues in the Corner Inlet Ramsar Site and in its surrounding catchments
- the sharing of expertise between organisations, groups and individuals
- a strong base for more competitive funding applications, showing support from a broad range of stakeholders
- increased efficiency and better return on investment
- the sharing of the costs, risks and rewards between partners
- the opportunity for more people to become actively involved and supportive of programs for Corner Inlet
- access to new ideas, information, equipment and resources
- an effective platform and mechanism for targeted and coordinated communication and engagement.

Input and discussion with local stakeholders during the development of the WQIP. Photo – WGCMA.

9.2.2 Governance

The CISC, made up of representatives from natural resource management agencies, local industry and community groups such as Landcare, will oversee the implementation of the Corner Inlet WQIP and will develop the associated engagement and reporting outputs required for the WQIP.

9.2.3 Communication and engagement

Clear communication and effective engagement with landholders, industry groups, government and the wider community is central to the successful implementation of the WQIP.

There is a strong foundation of existing networks within the Corner Inlet and Nooramunga catchments (e.g. South Gippsland Landcare Network, Yarram Yarram Landcare Network), industry representation (GippsDairy, SeaNet) and established programs (e.g. Gip Rip, Core4, Fert$mart, Beef Cheque). These provide a platform on which to build an understanding of the ongoing actions required for the implementation of the WQIP.

The development of the Corner Inlet WQIP has led to an improved understanding of the:

- technical effectiveness of BMPs and traditional activities, such as waterway and gully fencing, in reducing sediment and nutrient transport from agricultural land to the Corner Inlet Ramsar Site
- current level of adoption of BMPs and traditional activities by landholders
- barriers to increased adoption (largely constrained by financial factors).

Existing extension programs have developed clear messaging in relation to the appropriate management practices required to reduce sediment and nutrient run-off. These programs should be seen as the basis for a scaled-up communication and engagement effort, especially with beef, sheep and dairy farmers within the catchment. Some areas, for example the catchments of the Jack and Albert Rivers, have been identified as requiring targeted effort for land management actions and should therefore be supported by additional extension effort.

9.2.4 Lifestyle properties

Whilst urban settlements are predicted to remain relatively stable, an increase in the number of lifestyle properties can be expected. Due to both an ageing farm population and the proximity of Corner Inlet to Melbourne, there has been a significant reduction in the number of commercial farms in the catchments of Corner Inlet and Nooramunga. In 2006 there were 499 dairy farms in the catchment and 468 beef properties, whereas by 2010 it was estimated that only 240 dairy and 270 beef farms would remain. Some of the reduction in numbers will be due to the consolidation of smaller farms into larger enterprises particularly in the dairy industry, whilst some land has been retired from commercial production.

Lifestyle properties may be owned by absentee landholders or may be occupied. With the exception of appropriate septic tank management, the recommended actions to minimise sediment and nutrient runoff from these properties is the same as for other agricultural properties (maintaining groundcover as for beef and sheep farms is important).

There is a need to offer specifically targeted programs for these properties to ensure that best practice is followed. Education and engagement will be a key focus of in the WQIP Works Program. Social research into the barriers and drivers for the adoption of BMPs is also required to determine the likely level of landholder uptake, both with and without incentives

Overall, assuming appropriate septic tank management and groundcover is maintained, an increase in lifestyle properties has positive potential for the reduction of nutrient loads. Furthermore, if smaller or no incentive payments are required to encourage adoption of practices then the on ground costs associated with the WQIP could be considerably reduced.

9.2.5 Stewardship payments, agreements and auditing

Land stewardship payments (long-term incentive payments to off-set loss of production) for beef, sheep and dairy farms are required to ensure that the benefits of BMPs are achieved and maintained. Given the significance of long-term payments there is need for greater accountability of public spending than is required for current programs.

Long-term stewardship payments will need to be underpinned by:

- contracts
- appropriate farm-level metrics
- performance auditing
- assessment to ensure that the conditions of continued stewardship payments are adhered to.

To be credible in the long-term, auditing of BMPs should be conducted by an independent third party, as occurs in other parts of the world such as in the Chesapeake Bay region of the United States of America.

Left: Landcare engages with the community and provides advice and support for onground projects. Photo – South Gippsland Landcare Network.

Right: Land stewardship is a priority for local landholders and for the health of the catchment. Photo – South Gippsland Landcare Network.

9.2.6 Compliance of regulated activities

There will also be a need for increased emphasis on assessing compliance for regulated activities, including effluent collection and management and urban waste water and domestic waste water systems, both for initial implementation and for ongoing management. Compliance auditing could be conducted by the EPA or, potentially, by an independent third party auditor. Where necessary, enforcement may need to be undertaken by the EPA.

For plantation forestry, the Code of Practice needs to be adhered to and routinely audited by local government and independent auditors as appropriate. BMPs that go beyond the requirements of the code such as those implemented by HVP are also strongly encouraged as they contribute to improvements in water quality in the catchment.

9.2.7 Knowledge Gaps – research and investigations

As outlined in a number of parts of this WQIP, particularly in the Reasonable Assurance Statement (Section 12) and in the detailed INFFER analyses conducted, there remain a number of knowledge gaps. The most important knowledge gaps that need to be addressed to enable increased confidence in achieving water quality outcomes for the Corner Inlet Ramsar Site are:

- **Improved quantification**, based on empirical data, of the links between sediment and nutrient loads from all sources and their impacts on seagrass (including re-suspension of sediments) and other components of the marine ecosystem.
- **Finer scale and recalibrated catchment modelling** to address the knowledge gaps identified in the WQIP. The modelling approach should be based on a review of the current model and learnings from the development of the WQIP and those from other regions.
- **Improved catchment water quality monitoring**, particularly to systematically capture more of the high flow events in the region. Enhanced water quality monitoring programs should be designed in consultation with catchment modellers; this will ensure that the additional monitoring information collected can be used in an updated modelling approach.
- **Social research** to ascertain drivers and barriers to the uptake of BMPs, with segmentation incorporating the range of agricultural enterprises in the catchments (dairy, beef, sheep, lifestyle).

Additional research and investigations required to improve confidence regarding the link between land use, management practices and water quality impacts are listed below. These have not been costed within this WQIP.

- **Updated estimates of management practices** and their effectiveness for dairy and beef/sheep production. Field studies are prohibitively expensive, thus expert and modelling approaches (possibly Bayesian networks and/or linked catchment-farm ‘treatment train’ based approaches) would be worth exploring.
- **Improved accounting for farm heterogeneity in modelling** (dryland grazing and dairy farms), building on work completed for dairy in this WQIP (Stott and Roberts, 2013; Stott et. al., 2013).
- **Updated soil and land use information**. An updated land use layer was developed for the WQIP to provide greater resolution for agricultural land uses. In the longer term, an updateable approach based on the Victorian Land Use Information System would be useful (Morse-McNabb, 2013).
- **Improved gully length estimates** using a rapid assessment approach based on Whitford et. al. (2011).
- **Updated bioeconomic modelling and INFFER analyses** once improved catchment modelling, effectiveness estimates and heterogeneity information is developed.

9.2.8 Reinstating hydrology

Artificial drains and earthen seawalls are features of the farming infrastructure in the low-lying land areas within the Corner Inlet and Nooramunga catchments. The infrastructure allows farming in areas that would generally be inundated with water for much of the year. A pilot program will investigate the extent of landholder interest in reinstating some of the natural hydrology through the removal of artificial drainage and seawalls.

Activities could include:

- reducing the frequency of drain clearing
- ceasing drain-clearing activities.

An additional action for consideration is the removal of small sections of the sea wall from along the coastline, encouraging the re-establishment of swamp scrub and other floodplain and estuarine wetland vegetation, thus reinstating natural wetlands. This activity in particular requires a detailed feasibility investigation undertaken in consultation with relevant stakeholders including landholders and councils and would require exploration of issues associated with ownership, maintenance and benefits of the current structures and an alternate arrangement.

Note that fringing wetland protection costs have not been included in the bioeconomic modelling or INFFER analysis for reasons outlined earlier (9.1.4).

It should also be noted that sea level rise resulting from climate change is expected to increase the frequency and extent of coastal flooding; this needs to be considered in the planning and implementation activities around hydrological reinstatement.

9.2.9 Monitoring and evaluation

A detailed monitoring and evaluation (MERI) plan has been developed for the Corner Inlet WQIP. Its purpose is to demonstrate the process for monitoring and evaluating progress towards the agreed targets of the WQIP. The MERI plan:

- documents the program logic
- identifies assumptions and their associated risks
- identifies management measures to address those risks
- identifies and addresses evaluation questions
- identifies and addresses monitoring requirements
- enables reporting on progress toward, and achievement of, targets
- enables the adaptation of activities to ensure these targets are achieved and activities remain relevant over the implementation period of the WQIP.

Left: Australian Grayling a nationally threatened species is found in Corner Inlet's rivers and estuaries. Photo – Tarmo A Raadik.

Right: Corner Inlet is an important resting and feeding ground for migratory bird species such as the Red Knot which flies from the Northern Hemisphere. Photo – Parks Victoria.

10. Works Program

This section outlines the Implementation Programs and Management Actions required to achieve the water quality objectives set for the Corner Inlet WQIP over the period 2013-2021. The quantities required to be delivered have been derived from the bio-economic modelling results described in Section 7.

The WQIP Works Program has been set out as three tables, one for each of the Corner Inlet and Nooramunga catchments and one for the associated catchment-wide enabling activities. The tables identify actions at a range of scales including whole-of-river catchment and specific locations such as townships. The modelling sub-catchments have also been used to identify the location of specific actions. A map depicting river catchments and modelling subcatchment numbers is provided below for reference (figure 10.1.1 and table 10.1.1).

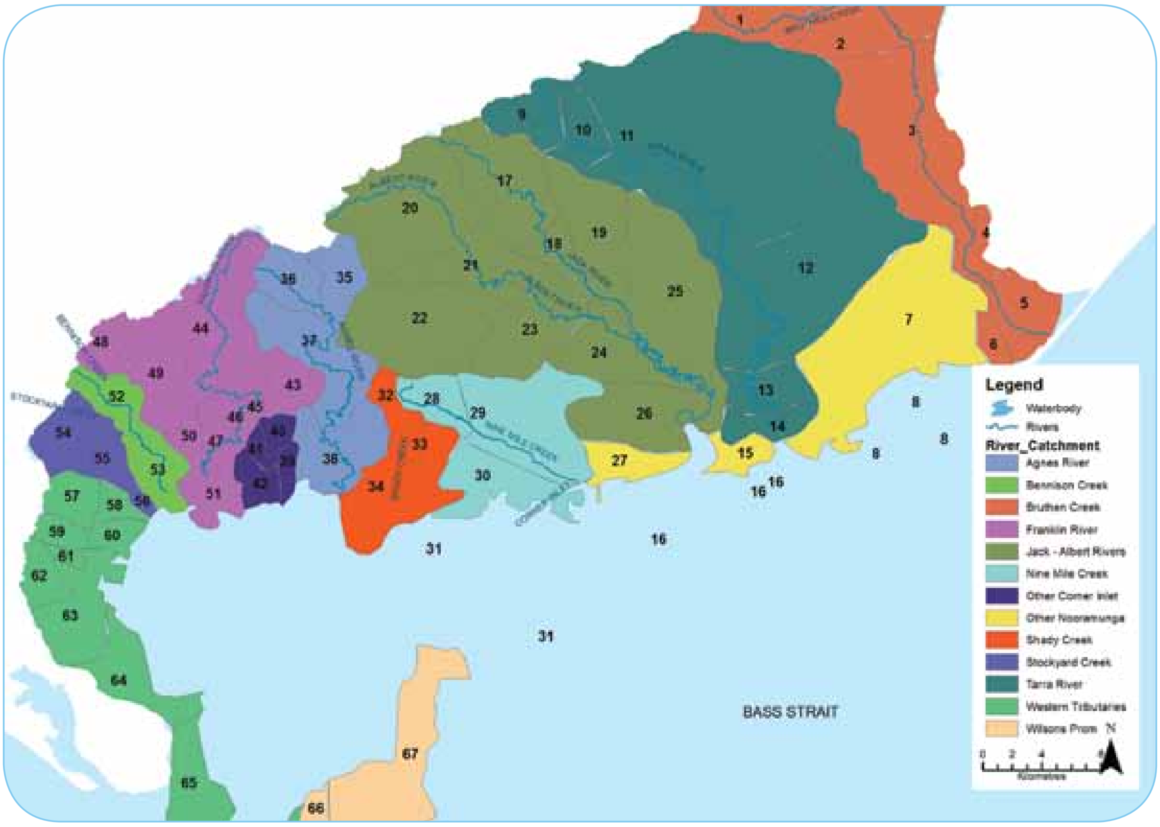

Figure 10.1.1. Corner Inlet and Nooramunga river catchments and modelling subcatchments

Table 10.1.1 Corner Inlet and Nooramunga river catchments and modelling subcatchments

Nooramunga	
River Catchment	Subcatchment
Bruthen Creek	1
	2
	3
	4
	5
	6
Other Nooramunga	7
Island	8
Tarra River	9
	10
	11
	12
	13
	14
Other Nooramunga	15
Island	16
Jack - Albert Rivers	17
	18
	19
	20
	21
	22
	23
	24
	25
	26
Other Nooramunga	27
Nine Mile Creek	28
	29
	30
Island	31
Shady Creek	32
	33
	34

Corner Inlet	
River Catchment	Subcatchment
Agnes River	35
	36
	37
	38
Other Corner Inlet	39
	40
	41
	42
Franklin River	43
	44
	45
	46
	47
	48
	49
	50
	51
Bennison Creek	52
	53
Stockyard Creek	54
	55
	56
Western Tributaries	57
	58
	59
	60
	61
	62
	63
	64
	65
Wilsons Promontory	66
	67

Table 10.1.2 Corner Inlet Catchment Works Program[1]

Works Program	Management Actions /BMPs	River Catchments, Towns or Location	Total Area (ha), Length (km) or Quantity	Cost ($/year[a] or total[b])	Lead Agency	Main Supporting Partners
Agriculture – Dairy	• Nutrient application rates • Effluent collection • Effluent management • Tracks and crossings • Wet area management	Agnes River, Buckland Drain, Muddy Creek, Franklin River, Bennison and Stockyard Creeks and Western Tributaries	BMPs required on 97% of dairy land (6447ha of total 6631ha in Corner Inlet) and in all subcatchments containing dairy	$559,000/year	DEPI Industry based organisations WGCMA	Dairy companies
Agriculture – Dryland Grazing	• Tracks and crossings • Pasture management (groundcover) • Restoring bare areas • Restoring landslips (fencing and revegetation)	Agnes River, Buckland Drain, Muddy Creek, Franklin River, Bennison and Stockyard Creeks and the Western Tributaries BMPs effectively needed in all subcatchments	BMPs required on 97% beef land (19351ha of 19887ha)	$1,388,000/year	DEPI Industry based organisations WGCMA	Landcare
Permanent Waterways	• Fencing to exclude/ manage stock grazing	Some works estimated in all subcatchments, except for 42 (Muddy Creek), 43,48, 51, 56 (Franklin River), 64, 65 (Western Tributaries)	107km	$525,000/year	WGCMA	DEPI Landcare
Streams	• Fencing to exclude/ manage stock grazing	Some works in most subcatchments, except for 39 (Buckland Drain), 64,65 (Western Tributaries)	173km	$550,000/year	WGCMA	DEPI Landcare
Gullies	• Fencing and remediation	Some gully work in all subcatchments	181km	$721,000/year	DEPI Industry based organisations WGCMA	Dairy companies
Drains	• Fence and encourage grass buffer establishment around constructed drains	Some drain work in all subcatchments	71km	$37,000/year	DEPI Industry based organisations WGCMA	Landcare

Continued from page 74... Table 10.1.2 Corner Inlet Catchment Works Program[1]

Works Program	Management Actions /BMPs	River Catchments, Towns or Location	Total Area (ha), Length (km) or Quantity	Cost ($/year[a] or total[b])	Lead Agency	Main Supporting Partners
Forestry	• Code of Practice and HVP BMPs implemented for timber production: 1) protection of riparian vegetation around stream and drainage lines 2) slope limitations for harvesting 3) location, use and drainage of snig tracks and log landings 4) wet weather restrictions to forest operations 5) rehabilitation of harvested area 6) planning, design, location, construction, drainage and maintenance of roads 7) design and construction of stream and drainage line crossings	All subcatchments containing plantation forestry as indicated in the land use map – subcatchments 35-37, 43, 44, 49, and 54.			Forestry operators	Wellington Shire Council South Gippsland Shire Council DEPI
Urban	• Waste water programs for unsewered towns	Yanakie – audit of wastewater management systems	Audits undertaken in line with revised Municipal Domestic Wastewater Management Plan		South Gippsland Shire Council	Department of Health
Urban	• Upgrade Wastewater Treatment Plant	Foster		$11million (total)	South Gippsland Water	EPA
Wetland protection	• Fencing of coastal fringe to protect remnant vegetation, salt marsh, swamp scrub, mangrove			$60,000	WGCMA DEPI	Landcare Parks Victoria

[a] *These are costs for stewardship payments. To maintain benefits, stewardship payments require on-going annual payments.*
[b] *One-off cost.*
[1] *Areas and lengths were based on the best available information available regarding land use, waterway, stream, gully and drain information. It is possible that there will be some inconsistencies between modelled predictions and local knowledge that can only be resolved in the future.*

Table 10.1.3 Nooramunga Catchment Works Program[1]

Works Program	Management Actions/BMPs	River Catchments, Towns or Location	Total Area (ha), Length (km) or Quantity	Cost ($/year[a] or total[b])	Lead Agency	Main Supporting Partners
Agriculture - Dairy	• Nutrient application rates • Effluent collection • Effluent management • Tracks and crossings • Wet area management	Bruthen, Manns, Gelliondale, Nine Mile and Shady Creeks, Tarra, Jack and Albert Rivers The only subcatchments without BMPs are those not containing dairy (8,15,27,31)	BMPs required on 99% of dairy land (9333 of 9462ha in Nooramunga) and in all subcatchments containing dairy	$1,004,000/year[a]	DEPI Industry based organisations WGCMA	Dairy companies
Agriculture – Dryland Grazing	• Tracks and crossings • Pasture management (groundcover) • Restoring bare areas • Restoring landslips (fencing and revegetation)	Bruthen, Manns, Gelliondale, Nine Mile and Shady Creeks, Tarra, Jack and Albert Rivers BMPs needed in all subcatchments containing beef	BMPs required on 99% beef/sheep land (39201 of 39719ha in Nooramunga)	$2,398,000/year[a]	DEPI Industry based organisations WGCMA	Landcare
Permanent Waterways	• Fencing to exclude/ manage stock grazing	Works required in all Jack and Albert River subcatchments (17-26)	123km	$617,000/year[a]	WGCMA	DEPI Landcare
Streams	• Fencing to exclude/ manage stock grazing	Works required in all Jack and Albert River subcatchments (17-26)	172km	$569,000/year[a]	WGCMA	DEPI Landcare
Gullies	• Fencing and remediation	Works required in all Jack and Albert River subcatchments (17-26)	141km	$567,000/year[a]	WGCMA Landcare	DEPI
Avulsion Works	• Works between the Jack and Albert Rivers (Pound Rd West to Jack River confluence) to minimise risks			Not costed	WGCMA	DEPI
Drains	• Fence and encourage grass buffer establishment around constructed drains	Works required in all Jack and Albert subcatchments (17-26)	29km	$18,000/year[a]	WGCMA Landcare	DEPI

Continued from page 76... Table 10.1.3 Nooramunga Catchment Works Program[1]

Works Program	Management Actions/BMPs	River Catchments, Towns or Location	Total Area (ha), Length (km) or Quantity	Cost ($/year[a] or total[b])	Lead Agency	Main Supporting Partners
Forestry	• Code of Practice for Timber Production (details in table 10.1)	As indicated in land use map – subcatchments 1-4, 9-12, 17-25, 29		Not costed	Forestry operations	Wellington Shire Council
Urban	• Alberton sewering	Alberton		$2.2M (project underway and set for completion in May 2014)	South Gippsland Water	Wellington Shire Council
Urban	• Waste water program for unsewered towns and settlements (e.g. continue to implement actions as per Domestic Waster Water Management Plans)			Not costed	Wellington and South Gippsland Shire Councils	Department of Health
Wetland Protection	• Fencing of frontage and exploration of covenants			$33,500[b]	WGCMA	Landcare
Waterway Management	• Willow management (Gelliondale Rd to Pound Rd West) • Undertake stabilisation works (Gelliondale Rd to Pound Rd West)			To be determined based on site survey and designs	WGCMA	Landholders

[a] *These are costs for stewardship payments. To maintain benefits, stewardship payments require on-going annual payments.*
[b] *One-off cost.*
[1] *Areas and lengths were based on the best available information available regarding land use, waterway, stream, gully and drain information. It is possible that there will be some inconsistencies between modelled predictions and local knowledge which can only be resolved in future.*

Table 10.1.4 Enabling actions

Enabling Actions	Description	Cost ($m/year[a] or total[b])	Lead Agency	Main Supporting Partners
Leadership	• Overall responsibility for oversight of WQIP implementation • Undertake mid-term review of the WQIP in 2017 • Undertaken final review of the WQIP in 2021	0.4 FTE $68,000/year	WGCMA	Corner Inlet Steering Committee (CISC)
Governance	• In partnership with the WGCMA, will ensure implementation of the WQIP Works Program and strategic engagement with the local community is well coordinated between partners	4 x 0.5 day meetings per annum Assume 10 organisations attend	CISC	WGCMA
Project Management	• 3 full-time positions to design and implement the program of stewardship payments program @ $170,000/FTE including expenses	$540,000/year[a]		
Communication	• Communication activities including catchment health report card every two years including summary of Waterwatch, EstuaryWatch and continuous monitoring water quality data, research results and works completed • Signage • Community awareness campaign for compliance with onsite waste water management focussing on Yanakie	$40,000/year[a]	WGCMA	CISC

Continued from page 78... Table 10.1.4 Enabling actions

Enabling Actions	Description	Cost ($m/year[a] or total[b])	Lead Agency	Main Supporting Partners
Engagement	• Develop a strategic engagement plan for the implementation of the Corner Inlet WQIP • Develop annual engagement activity work plan • Encourage community participation in activities e.g. Waterwatch, EstuaryWatch, seminars to educate the community • Hold seminars such as the Estuaries Unmasked series to discuss the values of Corner Inlet and Nooramunga and their catchments • Hold stakeholder tours to highlight work sites, project outcomes and best management practices • Undertake field days of demonstration sites aimed at encouraging BMP use on lifestyle properties	$50,000/year[a]	WGCMA	CISC
Compliance and Enforcement – effluent collection	• Inspections on dairy properties to assess effluent storage facilities and adequacy of distribution to ensure no effluent leaves the farm • Issuing of notices and enforcement if required	$100,000/year[a]	EPA	DEPI Dairy companies Dairy Foodsafe Victoria
Compliance and Auditing – stewardship payments	• Farm visits and assessment of performance against management agreements for BMP implementation and stewardship payments	$100,000/year[a]	WGCMA or DEPI *Dependant on delivery mechanism	Independent third party auditor dependent on delivery mechanism
Research to Fill Knowledge Gaps	• Finer scale and recalibrated catchment modelling, updated BMP information, design of market-mechanism (e.g. nutrient trading program)	$400,000/year for 5 years	WGCMA	DEPI or research contractor
Research to Fill Knowledge Gaps	• Monitoring of seagrass condition • Improved quantification of the links between nutrient and sediment loads from all sources and their impacts on seagrass condition and extent including resuspension aspects	$390,000[b] (total)	Parks Victoria WGCMA	Research contractor

Continued from page 79... Table 10.1.4 Enabling actions

Enabling Actions	Description	Cost ($m/year[a] or total[b])	Lead Agency	Main Supporting Partners
Research to Fill Knowledge Gaps	• Improved understanding of the impacts of predicted climate change on the environmental values of Corner Inlet, water quality impacts and proposed actions (e.g. hydrological reinstatement)	Not costed, look for other government funding sources	WGCMA	Research contractor
Research to Fill Knowledge Gaps	• Social research regarding lifestyle property adoption of BMPs	$75,000[b]	WGCMA	DEPI or research contractor
Research to Fill Knowledge Gaps	• Undertake geomorphological investigation (potential for avulsions) between the Jack River and Albert River (Pound Rd West to Jack River confluence) • Investigate options for re-engaging the lower Albert River with the floodplain	$100,000[b] $50,000[b]	WGCMA	Research contractor
Research to Fill Knowledge Gaps	• Undertake detailed sediment and nutrient monitoring associated with forestry operations - including runoff from tracks and roads	$40,000[b]		Forestry operator
Research to Fill Knowledge Gaps	• Investigate relationship between water quality and flow including the synergies and risks to inform future water and natural resource management planning decisions	$50,000[b]	WGCMA	DEPI
Biophysical Monitoring	• Enhanced water quality monitoring to capture high flow events • Install/maintain continuous water quality and flow monitoring stations at appropriate locations • Waterwatch monitoring of key waterways • Marine water quality monitoring	$205,000 for catchment monitoring based on one year of event based sampling $80,000 for marine water quality based on one year of event-based sampling $20,000/year[a] Waterwatch	WGCMA Parks Victoria	

Continued from page 80... Table 10.1.4 Enabling actions

Enabling Actions	Description	Cost ($m/year[a] or total[b])	Lead Agency	Main Supporting Partners
Performance Monitoring and Evaluation	• Monitoring and evaluation will focus on the level of uptake of BMPs and fencing activities	0.5 FTE $85,000/year[a]	WGCMA	DEPI
MERI Program	• Implement the requirements of the Corner Inlet WQIP – Monitoring, Evaluation, Reporting and Improvement Plan (MERI Plan)	0.5 FTE $85,000/year[a]	WGCMA	
Assessments	• Undertake assessment to determine if there are areas where the boundaries of Crown land are compromised through historical management or lack of fencing and survey	3 @ $5000 each	DEPI	WGCMA Parks Victoria DEPI
Planning	• Ensure future developments recognise the values of the Corner Inlet Ramsar Site and its catchments and that appropriate protection is put in place through the use of statutory planning mechanisms, i.e. environmental significance overlays, reference to regional strategies, etc. • Continue to ensure that clear policy and standards for waste water management on new subdivisions is applied at the planning permit stage, and appropriate auditing of compliance is undertaken following development	Not costed	Wellington and South Gippsland Shire Councils	WGCMA DEPI

[a] *These are costs for stewardship payments. To maintain benefits, stewardship payments require on-going annual payments.*
[b] *One-off cost.*

11. Future Challenges to Water Quality Improvement

11.1 Background

The Corner Inlet Ramsar Site is one of Victoria's most important environmental assets. Both the Australian and Victorian governments have obligations to protect its unique values and maintain its ecological character. The Corner Inlet WQIP focuses on the protection and maintenance of water quality in its role in supporting the aquatic ecosystem values and critical wetland habitats of Corner Inlet.

The Corner Inlet WQIP brings together the experience and knowledge gained from almost ten years of research, monitoring, investigations and on-ground action. The work completed during the development of the WQIP has shown that, notwithstanding future impacts of climate change, the site is in relatively good condition. It is hoped that the water quality targets that have been set in the WQIP are sufficient to maintain this good condition.

The WQIP Works Program (Section 10) sets out the core activities that are the immediate focus for protecting water quality. These are:

- agricultural BMPs
- waterway fencing
- remediating gully erosion
- actions for forestry and urban land uses.

As outlined previously (Section 7.2), a marked increase in the scale of adoption and funding from existing levels is required to achieve the Corner Inlet WQIP targets. Furthermore, if it is found that aspirational load reduction targets are required to maintain the health of Corner Inlet, then current levels of BMPs and fencing activities are unlikely to be sufficient.

Once implemented, the WQIP Works Program will deliver significant benefits in terms of nutrient and sediment reductions to the Ramsar site. While these benefits are expected to occur in the short to medium term, future pressures from climate change, land use intensification and/or change, as well as demographic changes, pose a challenge to protecting the values of Corner Inlet in the longer term.

11.2 Future challenges and policy directions

Based on current knowledge, the key future challenges within the catchment, from a water quality perspective, will include:

- *Managing changes in the scale and area of highly productive land uses that bring in significant amounts of nutrients from external sources such as horticulture, dairy and feedlots*

  By 2050 we might expect to see fewer but larger dairy farms in the catchment as well as an increase in horticulture production and intensive animal operations such as feedlots.

  Increased areas of horticulture production and increased feed lotting of beef cattle in the Corner Inlet and Nooramunga are possible as water security and urban expansion around Melbourne displaces these land uses from their current locations.

  For dairy, the past few decades have seen a decline in the number of dairy farms, offset by an increase in average farm size, an increase in cows per farm and an increase in milk production per cow (Stott et. al., 2013). The adoption of feedpad use to capture and control effluent and increased substitution of fertiliser nitrogen for bought-in feed, have potential to increase profitability without markedly increasing nutrient losses compared to continued trends in high fertiliser use.

- *Increasing adoption of BMPs across extensive grazing (beef and sheep)*

  Large scale BMP programs that aim to reduce nutrient and sediment losses from agriculture have historically largely focussed on working with the dairy industry. However, dryland grazing (beef/sheep) is the predominant land use in the Corner Inlet and Nooramunga catchments (40%) and, as such, the WQIP Works Program identifies that in addition to focus on dairy, significant focus on BMPs for the beef/sheep industry is required. Unlike dairy, beef and sheep producers are not as well linked to a major supplier network (such as a milk factory). This poses additional challenges for engaging with landholders, encouraging industry peer support and ensuring adoption of BMPs at the required levels.

- *Engaging with and influencing NRM practice across lifestyle properties*

  The ageing farmer population and Corner Inlet's proximity to Melbourne will continue to put pressure on land use change away from dairying and commercial beef production. Lifestyle properties can have positive and/or negative impacts on the environment. On the positive side, fertiliser applications are often low or nil and environmental revegetation can be less constrained by financial concerns. On the negative side, disposal of household septic waste poses a challenge as does potential for overgrazing (and hence potential for increased sediment loss), particularly by close-grazing animals such as horses and sheep. By 2050, an increase in lifestyle properties is expected – this trend is already evident.

These challenges, as well as the possibility that nutrient and sediment load reduction targets may need to increase in the future, have implications for the long-term protection of the Corner Inlet Ramsar Site. Funding also places significant constraints to the implementation of the WQIP and adoption of BMPs. For these reasons, it is suggested that a staged approach be implemented over the next decade to improve knowledge and develop appropriate policy tools where required.

Stage 1. Continuing to build knowledge

- **Assembling the evidence base**
  An improved evidence base is required to inform the monitoring and evaluation of the implementation of the WQIP. This will ensure that nutrient reduction resulting from the WQIP can be assessed and measured.

  An improved modelling approach underpinned by robust water quality monitoring (including event-based sampling) that simulates the contributions of all the major land uses with confidence is recommended. This should be hydrologically-based modelling which links rural and urban sources, uses finer spatial resolution (to enable greater targeting), can be updated as land uses change, and which can be used to inform future bioeconomic modelling. Whether groundwater contributions need to be included is also important to consider.

  The development of linked farm-catchment scale metrics (such as those developed in the USA and New Zealand) to assess nutrient load reductions from farms is required to inform future policy approaches.

  The future impacts of climate change on catchment dynamics will also need to be considered in future modelling research and investigation.

- **Addressing critical knowledge gaps**
  A critical knowledge gap for this WQIP has been the lack of site-specific thresholds for water quality and seagrass. Under the Ramsar Convention the Australian Government is required to monitor ecological character and understand if there is human induced change to the ecological character of a Ramsar site over time. Seagrass health has a number of drivers, including many that will be influenced by climate change or cannot be addressed through catchment-based actions.

  Understanding the acceptable water quality conditions in Corner Inlet is fundamental to setting revised water quality improvement targets to protect ecosystem values, including seagrass. Targets need to continue to be specific, measurable, attainable and time-bound. Constructive engagement with the whole community and targeted research to quantitatively establish the thresholds and links between nutrient and sediment loads on water quality dependant values are required.

- **Actively valuing Corner Inlet**
  The above steps may reveal that the condition of Corner Inlet cannot be maintained through the current suite of management actions outlined in this plan. If this is the case, the community and government need to examine alternate policy tools and institutional arrangements, explore the trade-offs of implementing/not implementing these, and potentially make difficult decisions related to the long term protection of Corner Inlet.

Stage 2. Identification of alternate policy tools and institutional arrangements

- **Active land use planning decisions**
  Finer scale modelling and land use changes provide opportunities for more targeted land use planning. For example, in nutrient 'hot-spot' areas, moving from nutrient intensive to lower intensity land uses would be desirable. Restrictions on phosphorus (P) application above threshold soil P concentrations, as occurs in the USA and Europe, would be useful. A shared commitment and active collaboration between the WGCMA, industry, local and state governments will be required.

- **Institutional arrangements**
  As has been reviewed recently (Roberts and Craig, 2013), current Victorian regulations on diffuse-source pollution need improving. There is a lack of clarity of institutional responsibilities particularly between state and regional levels as well as a lack of resources and clarity around regulatory enforcement. Adoption of a source-based approach (e.g. as outlined by Beverly, Roberts and Stott, 2013), creation of a legal mechanism for linking point and diffuse sources, and increased government accountability are all crucial for the WGCMA, and local and Victorian governments to protect environmental assets such as the Corner Inlet Ramsar Site.

Stage 3. Finalising a policy approach

- **Developing a targeted, cost-effective and efficient policy approach**
  The costs for achieving a given set of water quality objectives are driven by two key factors; the scale of the water quality objectives being aimed for and the range of management actions used in order to achieve the objectives. Efficient and effective policy programs seek to achieve outcomes at least cost and that are socially and politically acceptable to communities.

  Nutrient trading schemes, such as that developed by the Waikato Regional Council in New Zealand's North Island to protect Lake Taupo (Anon., 2011), offer significant promise for achieving outcomes at a lower cost than current incentive programs used in Australia. Although the hydrology of Lake Taupo is different to that of Gippsland, the principles underpinning the approach are relevant and innovative on a global scale. The institutional settings (importance of both grazing industries and tourism, deregulated agricultural markets, small tax payer base) are sufficiently similar to Australia to render the policy experiences more directly applicable to this country than those of Europe and the USA where agriculture is highly subsidised.

  Institutional reform takes time, as does assembling a sufficiently strong, transparent and evidence-based approach to underpin programs where some level of land use/management restrictions and regulations are required. There is likely to be a significant (20+ year) time lag between implementing actions and measuring improved environmental condition. Given this, if the issues outlined in under Stages 1 and 2 (above) are not addressed in the coming decade it is possible that implementation programs to protect the values of Corner Inlet will not provide successful outcomes by 2050.

  Future effects of climate change are predicted to be significant for Corner Inlet and have the potential to have a major influence on the effectiveness of the actions proposed in this WQIP. Improved understanding of these impacts will be required to support an adaptive management approach to the implementation of the Corner Inlet WQIP.

12. Reasonable Assurance Statement

The science that underpins this WQIP is the best available and has been undertaken in good faith. Listed below are the major components of work that underpin the plan.

Seagrass Studies

The Technical Panel acknowledged that the location-specific information to link catchment nutrient and sediment reduction to seagrass condition and extent was inadequate to allow definitive conclusions to be drawn. The interaction of a number of different factors is believed to be responsible for loss of seagrass in the Corner Inlet Ramsar Site rather than one single factor. Increased sediments and nutrients are believed to be legitimate contributing factors, amongst others, to seagrass decline in the Ramsar site. The range of factors believed to contribute to seagrass decline in Corner Inlet is described in Appendix 1.

Overall uncertainty – moderate to high

Available Catchment Modelling (a previously calibrated E2 model) (Law et. al., 2008)

The Corner Inlet E2 catchment model used a relatively limited amount of water quality data (spatial and temporal) for calibration. It needs to be noted that the model was calibrated in a relatively dry period (1997-2006) and there was acknowledgement that data relating to high flow (and hence high load) events could not be captured. As such the loads from the calibrated model are likely to be conservative.

The E2 modelling suggested that urban source loads of nutrient and sediment are low and likely to remain so. Whilst treatment plant outfall concentrations are of most concern, in relation to urban land use, and need to be managed, they provide low load overall and their operations are in the process of being upgraded.

Modelled forestry sediment and Nitrogen loads were predicted to be surprisingly high, and a review of literature and expert knowledge from other catchments within Australia suggest this is highly uncertain, an opinion also shared by HVP.

Whilst dryland agriculture was estimated to contributed the greatest load to the catchments of Corner Inlet and Nooramunga, the impact and management practices relating to different agricultural land uses (dairy, beef and sheep production), could not be estimated using the original modelling and information had to retro-fitted accordingly. Finer scale hydrologically-based modelling is recommended to improve confidence in the modelled estimates of nutrient and sediment loads and to assess management impacts.

Overall uncertainty – moderate

Decision Support System

A simple integration of modelling results based on the E2 modelling and Mike21 Hydrodynamic model (Water Technology, 2008) was used to inform the likely zone of influence of catchment nutrient loads on seagrass beds.

Overall uncertainty – moderate

Literature Review and Workshops

To define and estimate the effectiveness of agricultural best-management practices (BMPs) for the dairy and beef industries literature reviews and workshops were undertaken. This information is the best available and in line with limited literature but remains subject to considerable uncertainty.

Overall uncertainty – moderate

DPI's Accountable Dairy Project (Stott and Roberts, 2013; Stott et. al., 2013)

This project was used as the basis for defining representative dairy and beef farms and the costs associated with management practices. This used available local knowledge and expert opinion and, for the time, is the best available knowledge at hand. The true heterogeneity of farms and costs is likely to be under-estimated and thus costs associated with achieving water quality targets may be over-estimated.

Overall uncertainty – low

Land Use Mapping

The WGCMA developed a new land use map to delineate dairy and dryland grazing (beef/sheep) farms within the catchments of the Corner Inlet Ramsar Site. Loads from dairy farms were assumed to be three times larger than those from dryland grazing farms, which is reasonable given the difference in management intensity and results of modelling undertaken in DPI's Accountable Dairying project in a nearby catchment. Given the local input used, there is a high degree of confidence in the land use layer used. For the WQIP, nutrient and sediment losses from lifestyle properties were assumed to be similar to beef farms.

Overall uncertainty – low

Field Surveys

Gully erosion estimates were based on available field surveys (Dudley, unpublished), local knowledge and modelling work conducted in the neighbouring Latrobe catchment (Vigiak et. al., 2011).

Overall uncertainty – moderate

Waterway Data

Waterway and streambank lengths were estimated using available waterway mapping, aerial photographs, assessment of mapped existing fencing activities and local knowledge.

Overall uncertainty – low

Bioeconomic Modelling

Using GAMs (General Algebraic Modelling System), bioeconomic modelling was based on catchment nutrient loads from E2, the land use mapping layer, BMP estimates and costs information as outlined in Section 6. This is a 'state of the art' technique.

Overall uncertainty – moderate to high (given the uncertainties of almost inputs)

INFFER Analysis

The INFFER analysis was used to assess the cost-effectiveness of actions to achieve targets. INFFER is based on theoretically sound Benefit:Cost analysis principles (Pannell et. al., 2011; Roberts et. al., 2012). The Corner Inlet Ramsar analysis has been based on the above information and considerable local knowledge. Despite the uncertainties of the inputs, there is confidence that the overall conclusions and implications of the results are consistent with previous work.

Overall uncertainty – low

Despite the considerable uncertainties outlined in this section, the scientific information used in the development of this plan is the best available and similar to that used to underpin many other WQIPs. The Benefit:Cost analysis and bioeconomic modelling is 'state-of-the art' and information has been used in a highly integrated and logical way.

The WGCMA is reasonably certain that the scenarios outlined in this WQIP, if implemented at the scale at which they are required, will achieve a measurable impact on the sediment and nutrient reduction targets described in this document. The WGCMA has a high degree of confidence that these impacts will be sufficient to move catchment loads much closer to being able to maintain the Corner Inlet Ramsar Site in an acceptable ecological condition.

At this stage the WGCMA has not included climate change impacts in the WQIP. As climate change is likely to have significant effects on the environmental values, catchment hydrology and ecological responses of the inlet and its surrounding catchment, improved understanding of these issues is a priority to support an adaptive management approach to the implementation of the Corner Inlet WQIP.

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Appendix 1

Conceptual model for seagrass health underlying the program logic

Underlying the program logic for Corner Inlet is the conceptual understanding of factors affecting seagrass condition and extent. A review of existing literature relating to seagrass health and Corner Inlet proposed that the conceptual model presented in Ball et. al. (2009) adapted and presented in figure 1, reasonably represented the factors likely to adversely affect seagrass health in the Corner Inlet Ramsar Site. These factors, including evidence to support these, are presented below.

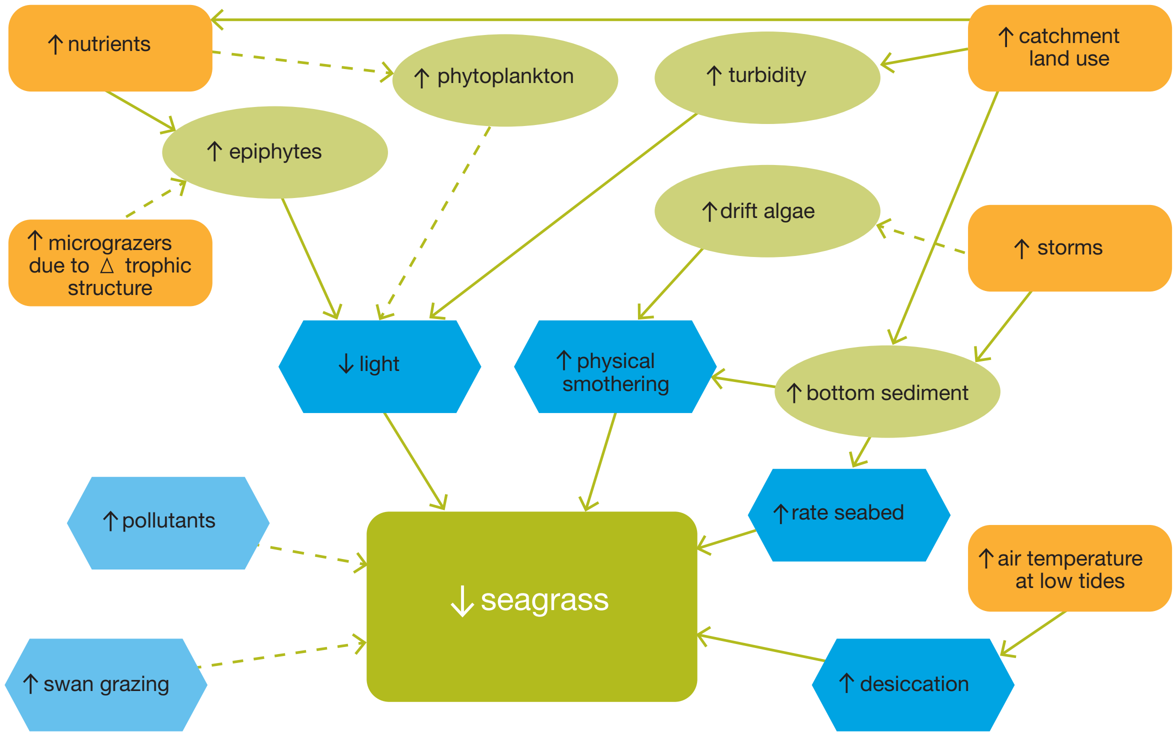

Figure 1. Conceptual model of factors affecting seagrass health in southern Australia (modified from review by Ball et. al., 2009). The four most commonly cited proximate causes of widespread seagrass decline are depicted in dark blue, two other localised proximate causes are in light blue. The primary environmental drivers of the often interconnected pathways are depicted in orange and the secondary drivers in yellow.

There has been substantial loss of seagrass cover in Corner Inlet and Nooramunga (Poore, 1978; Roob et. al., 1998; Hindell et. al., 2009; Ball et. al., 2010). Seagrass decline in Corner Inlet was first noticed by professional fisherman operating from Port Franklin who related it to a decline in the fishery of rock flathead, flounder, whiting and garfish (Poore,1978). The *Posidonia australis* decline was wide spread and particularly noticeable from 1972 into the late 1970s, at the same time a similar decline was reported from Flinders Island in Bass Strait (Poore,1978). However, comparison of aerial photography from 1965, 1972 and 1978 showed no change in cover (Poore,1978).

Comparison of seagrass cover in Corner Inlet only from aerial mapping done in 1998 and 2006 indicated highest losses at the Franklin River Channel and Stockyard Channel in the northwest of Corner Inlet (Ball et. al., 2010). An expansion in cover, thought to be an expansion of the *Zosteraceae* into areas previously vegetated with *Posidonia*, was observed in aerial mapping between 2006 and 2007, but without ground truthing this could not be confirmed (Ball et. al., 2010). It is difficult to quantify the area and species lost in this previous mapping due to no or minimal ground truthing and lack of error calculations (Monk et. al., 2011; Pope et. al., 2013). There is evidence that there was a high degree of misclassification of seagrass in the 1998 mapping (Monk et. al., 2011). The mapping of Pope et. al. (2013) is currently the best mapping available due to its small pixel size, extensive ground truthing and automated classification with error calculation. In a review of evidence of historical changes in seagrass extent and condition in Corner Inlet and Nooramunga, Kirkman (2013) concluded that historical extent and loss could not be quantified.

Seagrass cover in Corner Inlet Ramsar Site is variable (Hindell et.al., 2009; Ball et. al., 2010; Stevenson and Pocklington, 2011). Loss of *Posidonia* beds is of greatest concern because it can take many decades to re-establish vegetatively in eastern Australia, if at all (Fox et. al., 2007; Warry and Hindell, 2009; Kirkman, 2013). In a three year study in Corner Inlet in the mid-2000s no seeds of *P. australis* were observed (Ball et. al., 2010). *Zosteraceae* cover is known to be particularly variable and may have expanded during the drought (Pope, 2006; Monk et. al., 2011). Coring by Poore (1978) and CEC (2008) established that there were seagrass rhizomes in areas that were bare when sampled.

The cause of a putative anthropogenic decline of seagrass beds in Corner Inlet and Nooramunga has not been established. Ball et. al. (2010) summarised the known causes of seagrass bed decline in a conceptual model. This forms the bases of examining the assumptions and knowledge gaps of seagrass loss in Corner Inlet and Nooramunga. The Ball et. al. (2010) conceptual model of the processes that affect seagrass in southern Australia shows the often interconnected pathways by which the causes of seagrass decline are manifested. No single factor is thought to be responsible for seagrass decline, rather, a number of different factors interact (Fox et.al., 2007; Ball et. al., 2010).

The experience of past declines in seagrasses in Australia and other parts of the world suggest numerous potential causes for the suggested dieback in Corner Inlet and Nooramunga (Poore,1978). There can be long time lags between nutrient loading increases and seagrass losses (Fox et. al., 2007). Ball et. al. (2010) in the mid-2000s tested some parts of the conceptual model by measuring epiphyte and drift algal abundance and micro-grazer community composition; and indirectly inferred heat/desiccation stress by measuring changes in the percentage of brown seagrass leaves at intertidal sites over three years. Experimental results from a major study by the South Australian government investigating causes of seagrass loss, including *Posidonia* spp., off the coast of Adelaide were not able to conclusively establish that compromised light climate alone could have caused the loss of seagrass, although this remains a possibility (Fox et. al., 2007). They did unambiguously prove that chronic, yet minor, increases in water nutrients (as might be associated with waste water treatment plant and industrial inputs) could have caused the slow decline of *Amphibolis* and *Posidonia* in shallow, previously nutrient poor, coastal waters (Fox et. al., 2007). Further research is required to better understand the complex interactions between light availability, suspended sediment concentrations, nutrient enrichment, and seagrass/epiphyte response (Fox et. al., 2007).

At a recent workshop (December 2012) an expert panel established by the West Gippsland Catchment Management Authority considered the potential drivers for seagrass loss in Corner Inlet and Nooramunga and concluded that these could include:

- increased nutrients leading to increased epiphyte growth and or algal growth resulting in reduced light availability for seagrass
- increased sediments in the water column from flood flows combined with increased wind/wave action (re-suspension) from storms resulting in reduced light availability for seagrass
- exposure of seagrass at low tide leading to desiccation of exposed plants, of particular concern in intertidal seagrass beds and includes Nooramunga
- sediment instability causing suspension of sediments resulting in reduced light availability for seagrass
- increased turbidity.

It is often difficult to distinguish impacts associated with elevated turbidity in the water from those attributable to increased sedimentation on the seagrass bed (Ball et. al., 2010). Loss of seagrass beds can also lead to higher turbidity as bare mudflats are subject to wave, wind and tide resuspension (Warry and Hindell, 2009; Ball et. al., 2010). Wind generated suspension of seabed sediments occurs on the intertidal and shallower subtidal flats (< 1m) of Corner Inlet and Nooramunga and occurs under typical wind conditions particularly near the shore (CEC, 2008).

Tidal river channels and the area of their immediate discharge are important nutrient sources (CEC, 2008). The sediments of the upper beaches and in the immediate neighbourhood of river mouths contain small but significant amounts of finer sand and silt, with the content of these materials tapering off within a couple of kilometres of the shoreline (CEC, 2008). Terrestrial silts settle out in the quieter sections of the tidal river channels and backwater drainage channels (CEC, 2008). The lower and mid estuarine regions undergo considerable reworking of the sedimentary deposits resulting in the clay materials either being washed into the upper estuarine reaches or being flushed out of the system onto the marine shelf (CEC, 2008). Modelling of hydrodynamics (WT, 2008) showed that numerous seagrass beds near the mouth of rivers would be influenced by the river discharge even with the low flow and high tidal flushing in Corner Inlet and Nooramunga. The rates of deposition of sediment on seagrass beds located within a few hundred metres of a river mouth may also be impacted by sediments carried by large floods (>10yr) (CEC, 2008).

Reductions in light (sediment)

Seagrass can be affected by a reduction in light due to increased turbidity and suspended sediments (Ball et. al., 2010). Advice from ecologists for modelling the hydrodynamics indicated that high suspended solids over a period of two weeks is considered to have an impact on seagrass as it affects the available light, and hence the ability for the plant to photosynthesise (WT, 2008). Poore (1978) thought that the breaks in seagrass beds at the river mouths and ports could be due to the effects of turbidity and lowered light levels. However he did discuss that *Posidonia* in Corner Inlet grows in particularly shallow depth (occasionally exposed at low tide) so light limitations seemed unlikely. From the coring carried out and predicted sediment surface velocities it was concluded that there was limited fine sediment available and accessible and that typical wind stirring would not generate high sediment concentrations and transports in Corner Inlet and Nooramunga (CEC, 2008). However, the study did not take many cores in the near shore or in the north-west section of Corner Inlet. An onshore wind may trap flood water inshore or at the water surface, making the turbid water more visible for a longer period (CEC, 2008). Local residents at McLoughlins Beach observe turbid water persisting for about a week following flood events (CEC, 2008).

Increased rates of seabed erosion

Seagrasses are sensitive to seabed erosion driven by changes in bottom sediment transport (Ball et. al., 2010). Near-shore sediment transport may be influenced by long term climatic variation such as changes in wind speed and direction (Ball et. al., 2010). Storms can tear out seagrass plants, although *Posidonia* can directly resist wave action by producing deeply rooted rhizomes that form dense mats within the sediment (Ball et. al., 2010). Storm intensity and frequency is predicted to alter with climate change. Seagrass beds can become fragmented by mudflat ‘blow outs’ but it is unknown if this is a major factor in Corner Inlet and Nooramunga.

Increased seabed height

Increased sediment can increase seagrass bed height potentially making them more vulnerable to desiccation (Poore, 1978; Ball et. al., 2010). Poore (1978) found no recent records of increased turbidity from the catchment and observed that the sediment load from rivers is largely deposited in the mangrove and shallow seagrass (*Zosteraceae*) zones close to the mouths. The presence of *Posidonia* fibres deep in the sediments of Corner Inlet indicates the possibility of gradual elevation of the seagrass beds (Poore, 1978). This process may have been accelerated by clearing of forest for agriculture but no evidence of this was apparent (Poore, 1978).

Physical smothering and burial

Seagrasses are sensitive to burial driven by changes in bottom sediment transport (Fox et. al., 2007; Ball et. al., 2010). Sediment movement can prevent seagrass bed regrowth (Fox et. al., 2007). A crude estimate of total sediment inflow based on Malloy et. al. (2005) is in the order of 14,000 tonnes/yr (CEC, 2008). An average sediment inflow of 2500 tonnes/yr is equivalent to a deposition of a 3mm layer over an area of less than half a kilometre of sea bed (CEC, 2008). Thus catchment sediment is unlikely to form significant deposits except within the tidal river channels and their immediate point of discharge into the inlets, although there may be widespread turbidity and very minor deposition following a flood (CEC, 2008).

Despite the stability of the channels and mudflats, there has been coastal erosion due to waves at Foster and, by implication, Port Albert and other locations (CEC, 2008). Sea walls have been constructed to protect against erosion and levees to exclude seawater from land now used for agriculture (CEC, 2008). There is no evidence to suggest that the sedimentation rates on the major sand bodies and channels has been accelerated to any observable degree through impact by human activities in Corner Inlet and Nooramunga, and any increase in sediment supply from the catchments, resulting from recent human activities, is likely to be minor in comparison with the large sediment storage within Corner Inlet and Nooramunga (CEC, 2008).

Poore (1978) found little evidence to suggest massive sand movements in Corner Inlet, nor any measurable changes in levels of meadows. He also found no evidence of storm erosion or of more gradual erosion of seagrass beds and thought that the shallow depth and relatively short fetch of the inlet ruled out this possibility. Aerial photographs and local observation do not support the hypothesis that *Posidonia* banks have become higher in recent time or that the plants have died as a result of desiccation or heat stress (Poore, 1978). Physical damage by fishing equipment did not seem to be a probable cause either (Poore, 1978), although this is contested by O'Hara et. al. (2002).

Seagrass beds can also be smothered by drift algae or wrack (Ball et. al., 2010). They found that drift algae in both the intertidal and subtidal did not exceed 30% and was usually <10%.

Increased nutrients

Increased nutrients from the catchment are thought to be one of the factors influencing seagrass beds in Corner Inlet and Nooramunga (Hindell et. al., 2009). It seems likely that Nitrogen, rather than Phosphorus, plays a key role in the degradation of marine (and seagrass) systems (Fox et. al., 2007). Poore (1978) found no spatial trend in water nutrients across Corner Inlet, levels were low and basically similar to those in Western Port, with slightly higher organic Phosphorus (Poore, 1978). Hindell et. al. (2009) found nutrient concentrations in Corner Inlet often exceeded SEPP, and were significantly higher than those of Port Phillip Bay but less than those of the Gippsland Lakes. Auditing of farms in Corner Inlet and Nooramunga found that a large percentage of farms had nutrient runoff issues, particularly in the Yanakie region (WT, 2008). Targeted sampling found that Golden Creek had particularly high nutrient concentrations (WT, 2008).

South Gippsland Water intend to cease sewage discharge into Corner Inlet and Nooramunga as soon as budget and planning approvals allow upgrade projects to proceed, removing this source of nutrient input from the Corner Inlet Ramsar Site (Dickson, 2012). The rivers draining into Corner Inlet and Nooramunga are relatively small and direct rainfall on Corner Inlet and Nooramunga is about four times river inflow (CEC, 2008). Tidal flows dominate river flows and direct rainfall, on average, by a factor of about 1000 (CEC, 2008). The tides still exceed the freshwater inflows from flooding rains and associated river flows by a factor of 10 and 35 respectively (CEC, 2008). WT (2008) concluded that short residence times of freshwater in Corner Inlet indicate it has significant capacity to accept runoff from the catchment and exchange these waters with Bass Strait. Accordingly, poor water quality in the streams/rivers discharging into Corner Inlet may not be resulting in impacts as severe as might be observed in other less well-flushed Inlets. In contrast, Nooramunga receiving waters, with a lower flushing rate, were potentially at higher risk of suffering under nutrient and sediment discharges (WT, 2008).

Water quality data in the catchment and particularly in the inlets is sparse. Two studies that have tried to address this, WT (2008) in the catchment and Hindell et. al. (2009) in Corner Inlet, were both conducted during a major drought, so it is unclear how well their sampling represents wetter, more normal years. WT (2008) found that water quality data from Waterwatch and Hindell et. al. (2007) indicated that Corner Inlet had elevated Nitrogen concentrations, most likely from river discharge. Phosphorus loadings also appear to be elevated, but this is not reflected in elevated Phosphate in Corner Inlet, suggesting the system is phosphorus limited. Western streams, Foster WWTP, Franklin River, Agnes River and Albert River were producing loads significant enough to influence nearby seagrass beds (WT, 2008). Very high nutrients can create toxic conditions in sediments and inhibit seagrass growth (Fox et. al., 2007).

Reductions in light (biotic)

Seagrass can be affected by decreased light due to increased epiphyte growth stimulated by increased nutrients (Ball et. al., 2010). In a three-year study, epiphyte biomass on seagrass beds in Corner Inlet was found to be very variable across the embayment (Ball et. al., 2010). Episodes of large amounts of filamentous algae growth on seagrass or 'slub' over large areas of Corner Inlet have been reported in the last few decades (Michelle Dickson, pers. comm.)

Seagrass can be affected by decreased light due to increased phytoplankton growth stimulated by increased nutrients (Ball et. al., 2010). Hindell et. al. (2009) did not find significantly elevated water chlorophyll levels indicating large amounts phytoplankton or blooms.

Large numbers of the small bivalve *Electroma georgiana* (Wing Shell or Butterfly Shell) smothered *Posidonia* beds in Corner Inlet in May 2011. The reasons for their large increase in density are not known (Kirkman, 2013).

Desiccation

Temperature extremes coinciding with low tides can lead to the desiccation of seagrass beds. This has been documented as causing major seagrass dieback in the Spencer Gulf and Western Port Bay (as stated in Ball et. al., 2010). Examination of air temperatures for the Corner Inlet region did not suggest that this was associated with the 1970s seagrass loss (Poore, 1978).

Desiccation events may have a greater impact where the heights of intertidal flats have increased through the accrual of sediments (Ball et. al., 2010). Higher temperatures for longer durations as part of extreme events are predicted with climate change. Climatic changes as a causative factor on seagrass condition and extent cannot be ruled out even though no evidence of major temperature changes has been found (Poore, 1978). *Posidonia* in Corner Inlet is near its southern most limit of distribution, possibly close to its low temperature tolerance, and its intertidal position subjects it to considerable temperature stress in mid-summer or mid-winter (Poore, 1978).

Increased pollutants

Ball et. al. (2010) regarded pollutants as a more localised proximate cause of seagrass loss. Biocides, petroleum hydrocarbons and heavy metals from the catchment can cause seagrass loss (Poore, 1978; Fox et. al., 2007). Water quality sampling in Corner Inlet and Nooramunga has not found toxicants to be of concern (Poore 1978; Hindell et al 2009). Aerial spraying of the herbicide Fusilade Forte occurs in Corner Inlet and Nooramunga as part of *Spartina* control, but this is not thought to impact on seagrass beds. Pollutant loads associated with the ports within the inlets has not been assessed.

Increased swan grazing

Ball et. al. (2010) regarded swan grazing as a more localised proximate cause of seagrass loss. Corner Inlet and Nooramunga are listed as a Ramsar site, due to their large number of wader birds. The impact of direct bird grazing on the seagrass beds in Corner Inlet and Nooramunga has not been specifically assessed.

As discussed in Ball et. al. (2010) there are many factors cited as causes of major seagrass loss and a wide acceptance that there are complex interactions and feedback loops between the factors. From the investigations undertaken in Corner Inlet and Nooramunga there is no one or two particular factors that stand out. The major land use change (from native vegetation to cleared, agricultural, urban and production forestry land uses), since European settlement, in the catchments does imply that catchment sediment and nutrient supply to Corner Inlet and Nooramunga has increased although direct causative links to seagrass loss have not been established.

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Appendix 2

Outline of the bioeconomic modelling approach used to underpin the INFFER analysis

An essential component of INFFER is to assess the technical feasibility of achieving set targets. This requires the estimation of the effectiveness of available land management options in reducing catchment nutrient loads. A bioeconomic modelling approach was used to assess the technical feasibility and associated costs of management interventions to achieve defined environmental targets. The approach used is outlined in Beverly et al. (2013) and summarized below.

1. Adaptation of a previously calibrated catchment model (E2 model, Argent et al. 2006) which included updated mapped land use data on dairy and beef systems and gully risk mapping based on aerial photos and survey data which was correlated to streambank and gully erosion estimates derived in nearby catchments (Vigiak et al., 2011). The revised E2 modelling provided subcatchment load estimates of TN, TP and TSS from each of 67 subcatchments (33 in Corner Inlet and 34 in Nooramunga).
2. Estimation of the % effectiveness of alternative management practices. In the absence of locally relevant field and published information, two workshops of technical experts were held to identify meaningful so-called 'best management practices' (BMPs) for reducing nutrient and sediment losses. Details are outlined in Stott and Roberts (2013). BMPs were identified, some relevant to either beef or dairy, with some relevant to both. Effectiveness estimates in terms of percentage reduction for TN, TP and TSS were assigned to each BMP compared to the current practice. The effectiveness of some practices on dairy farms was assessed as lower than for beef farms (for example sediment reduction effectiveness for gully erosion, all constituents for drains) due to current practice on dairy farms being higher (more gullies and drains already fenced) than on beef farms.
3. Construction of representative farming systems. Three land-use enterprises were considered, namely dairy, beef and revegetation. Within the dairy systems, 4 levels of intensity (extensive, moderately extensive, moderately intensive, intensive – see Table below) were constructed which covered the range of intensity of dairy farming currently. The four representative farming systems were constructed using a combination of available data (Gilmour et al., 2012), field surveys in the neighbouring Moe River catchment and discussion with local extension staff. Details of the current systems are outlined in Stott et al. (2013).
4. Estimation of the costs of implementing management practices on farm types. The annual net private benefit (+) or cost (-) of implementing each BMP on each dairy or beef representative farm was calculated relative to a baseline, this being the annual 'Operating Profit' for each system. The operating profit was calculated as gross income minus costs (including variable costs and fixed costs or overheads). Full calculation details are outlined in Stott and Roberts (2013) and the costs assumed for dairy and beef farms are outlined in Table A2.1 below.
5. Development of a bio-economic optimisation model using the General Algebraic Modelling System (GAMS, Brooke et al. 2008). The optimisation model maximises total net benefits expressed as the difference between producer profit and regulatory costs for a given nutrient target. This cost-effectiveness approach, where emissions goals are sought at least cost (e.g. Doole, 2012; Doole and Pannell, 2012) avoids the difficulty and cost of assessing the benefits associated with improved water quality.
6. Development of scenarios to assess changes in profit and land management implications associated with achieving sediment and nutrient reduction targets. Following the initial aspirational and revised target setting with the Technical Panel, CMA *staff and modellers worked through a range of scenarios to assess implications on profit, land use and management changes required to achieve targets*. CMA staff also worked with the Steering Committee who provided feedback as to the economic and political acceptability of some of the management implications, which then led to additional scenarios being tested. Because there was no information regarding current distribution of dairy farm intensity in the catchment, under the 'base case' (before optimisation) all land under dairy farming was assumed to be in the 'moderately intensive' system under current practice conditions. This farm type was believed to best represent an average dairy farm in the catchments. Under optimisation, any of the 4 dairy farm systems and single beef system and associated best management practices could be selected as could traditional activities. Land retirement could also be selected if this was less costly than management practice change.

Table A2.1 Assumptions about farming system intensity underpinning the Corner Inlet analysis

	Total area (ha)	Milking area (ha)	Operating profit ($/ha)	Fert. N (kg/ha)	Fert. P (kg/ha)	Concentrates fed (tDM/cow)	Cows (no. per farm)	Stocking rate (cows/ha)	Milk (kg MS/ha)
Beef	175	-	397	0	7	0	204	1.3	-
Dairy – extensive	150	95	565	35	16	1.0	180	1.3	418
Dairy – mod extensive	150	95	810	70	16	1.2	210	1.5	600
Dairy – mod intensive	175	110	1,057	140	16	1.5	275	1.8	783
Dairy – intensive	175	110	1,332	210	16	1.7	330	2.1	987

Table A2.2 Assumed effectiveness estimates and costs/ha for dairy BMPs and traditional activities

	Assumed effectiveness at reducing load			Cost[a] (profit) $/ha	Notes/assumptions about farm area to which the BMP is applied
	%TN	%TP	%TSS		
Best management practices ($ are on a per ha basis)					
Nutrient application rates	5	2	0	(26.23)	100% farm area
Effluent collection	90	90	0	23.93	10% farm area
Effluent management	20	20	0	2.11	50% farm area
Tracks and crossings[b]	50	50	50	199.11	2% farm area
Wet area management	90	90	90	58.14	10% farm area
Traditional fencing activities ($ are on a per km basis)					
Gullies	5	5	20	4513	Differing lengths assumed per farm based on spatial information (hydro layer, % dairy farms in each subcatchment
Permanent waterways	15	20	40	6367	
Streams	10	13	25	3976	
Constructed drainage lines	2	2	5	312	1500 m drainage lines assumed per farm, already fenced

a *Note that costs have been calculated on a per hectare basis assuming a moderately intensive dairy farm (see Table A.2.1 in Appendix) of 150 ha in size.*

b *Length of tracks and crossings was not possible to gain from available spatial information, therefore a simple proportion of farm area was assumed*

Table A2.3 Assumed effectiveness estimates and costs/ha for beef and sheep BMPs and traditional activities

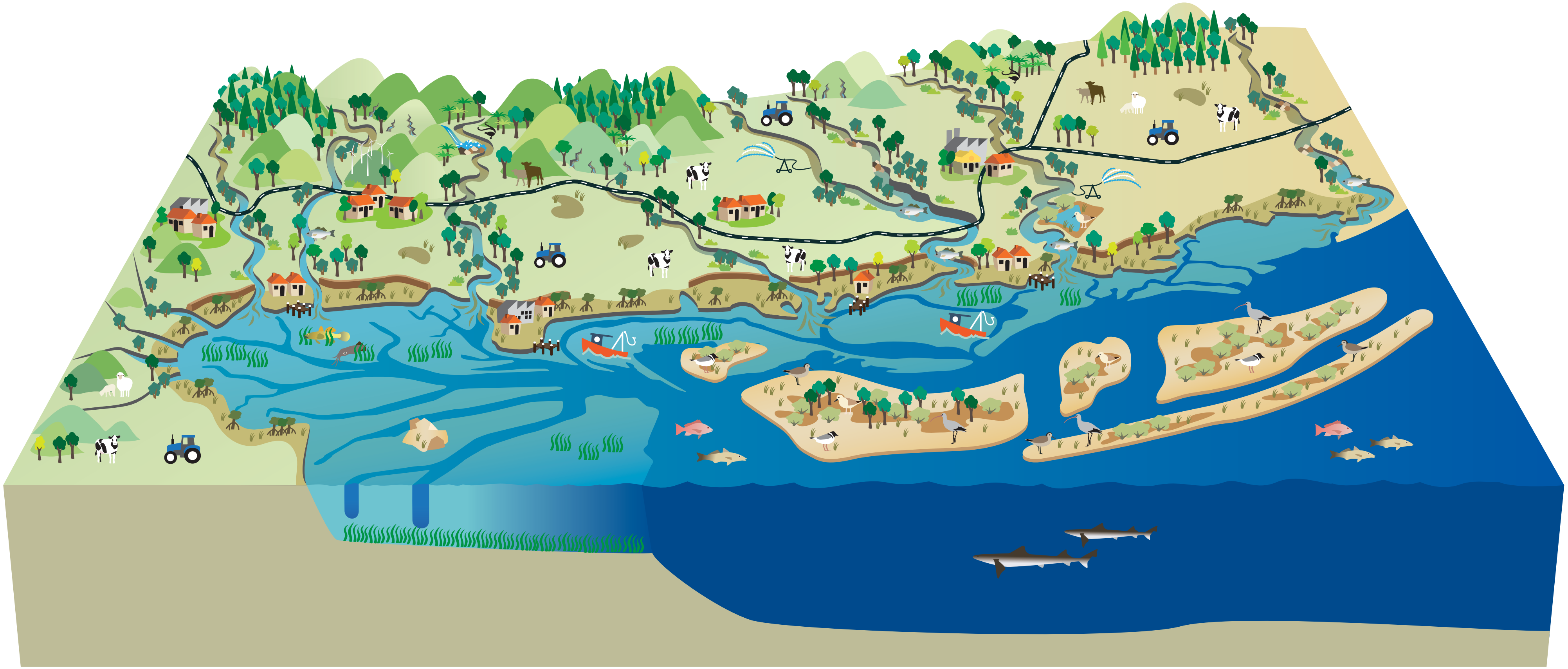
	Assumed effectiveness at reducing load			Cost (profit) $[a]	Notes/assumptions about farm area to which the BMP is applied
	%TN	%TP	%TSS		
Best management practices ($ are on a per ha basis)					
Tracks and crossings	50	50	50	21.7	0.5% farm area
Pasture management (groundcover)	0	5	5	66.53	100% farm area
Restoring bare areas	20	80	20	7.68	10% farm area
Restoring landslips	50	70	90	10.48	1% farm area
Traditional fencing activities ($ are on a per km basis)					
Gullies[a]	5	5	50	4513	Differing lengths assumed per farm based on spatial information (hydro layer, % dairy farms in each subcatchment
Permanent waterways	15	20	40	5438	
Streams	10	13	25	3697	
Constructed drainage lines	2	2	5	2065	125m drainage lines assumed on beef farms, all unfenced

a *The effectiveness in sediment reduction by gully fencing was assessed as higher (50%) on beef farms than on dairy farms (20%). More gullies have already been fenced on dairy farms compared with beef and sheep farms and thus the ability to further reduce sediment loads was estimated to be lower on dairy farms.*

Acronyms

ANZECC	Australian and New Zealand Environment Conservation Council
BCR	Benefit : Cost Ratio
BMPs	Best Management Practice
CISC	Corner Inlet Steering Committee
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DEPI	Department of Environment and Primary Industries
DEWHA	Department of the Environment, Water, Heritage and the Arts
DWC	Dry Weather Concentration
ECD	Ecological Character Description
EMC	Event Mean Concentration
EPBC Act	*Environment Protection and Biodiversity Conservation Act 1999*
GAMs	General Algebraic Modelling System
GLaWAC	Gunaikurnai Land and Waters Aboriginal Corporation
Giffard GMA	Giffard Groundwater Management Area
GRSWS	Gippsland Region Sustainable Water Strategy
HVP	Hancock Victorian Plantations
INFFER	Investment Framework for Environmental Resources
LGA	Latrobe Group Aquifer
MBI	Market Based Instruments
MERI	Monitoring, Evaluation Reporting and Improvement
MLA	Meat and Livestock Australia
R&D	Research and Development
SEPP	State Environment and Protection Policy
SGW	South Gippsland Water
SMART	Specific, Measurable, Attainable, Realistic and Time-bound
SRW	Southern Rural Water
TN	Total Nitrogen consisting of Total Kjeldahl Nitrogen plus Nitrate and Nitrite
TP	Total Phosphorus
TSS	Total Suspended Solids
WGCMA	West Gippsland Catchment Management Authority or West Gippsland CMA
WQIP	Water Quality Improvement Plan
WSPA	Water Supply Protection Area
WWTP	Waste Water Treatment Plant

Corner Inlet Catchment – conceptual map



Illustrated by Italicherry Design Studio for the WGCMA.

Cover: *View of Corner Inlet from Silcocks Hill. Photo – InDetail Comms & PR.*

Above: Seagulls at Corner Inlet. Photo – WGCMA.

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