School of Civil and Environmental Engineering

Water Research Laboratory

Cost Benefit Analysis of Big Swamp Restoration Project

WRL TR 2019/19 | August 2019

By A J Harrison, W C Glamore and R Costanza

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Executive summary

The Big Swamp 2,000 ha floodplain is located on the Manning River estuary on the mid-north coast of New South Wales (NSW) (MidCoast Council 2019a), shown in Figure ES-1. Big Swamp has been prioritised for floodplain remediation works due to its classification as high priority Acid Sulfate Soils (ASS) hotspot, with planned works aimed at significantly reducing the impact of acid from this site affecting the health of the Manning River estuary. MidCoast Council has acquired a substantial proportion of the low-lying floodplain since 2012 and completed significant on-ground works to remediate the area. The designs and outcomes of that work are reported by Ruprecht et al. (2017).

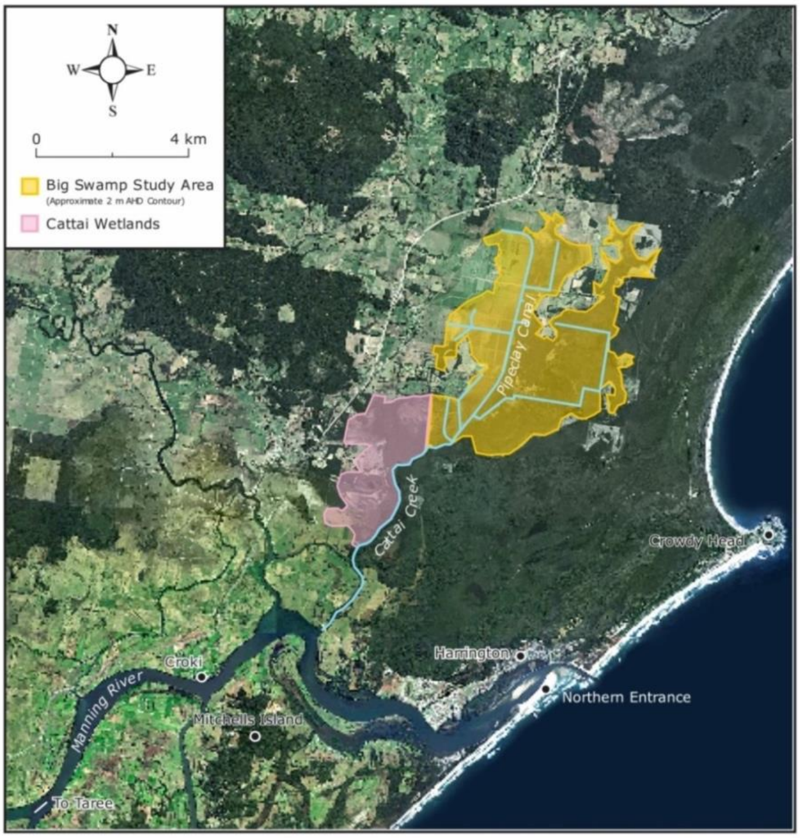

Figure ES-1: Study location

While on-ground works have been completed in the lowest sections of the Big Swamp floodplain, additional property acquisitions are required before further remedial works can be considered. This report investigates the economic feasibility of MidCoast Council purchasing a large property adjacent to the completed on-ground works and remediating it to reduce the ASS impacts. The key property of interest is a substantial portion of the degraded floodplain, which is owned by a single private landholder (approximately 650 ha below 2 m Australian Height Datum (AHD, equivalent to Mean Sea Level)), shown in Figure ES-2.

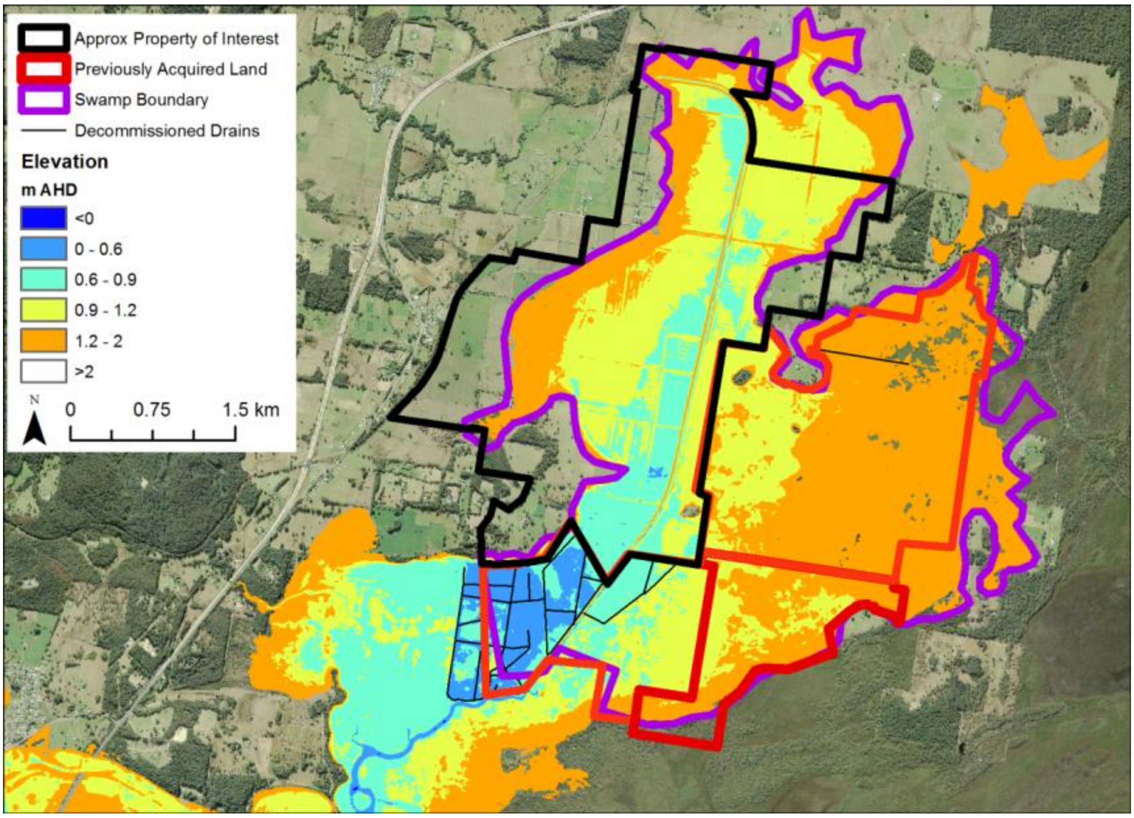

Figure ES-2: Acquired property and property of interest

An economic assessment was undertaken using a Cost-Benefit Analysis (CBA) that compares the net impact on economic welfare of the existing land uses (agricultural, primarily dairy, referred to as the 'business as usual') with the expected environmental benefits gained via remediating the floodplain. While detailed remediation plans do not currently exist for the site, it is assumed that plans would be prepared to maximise the reduction in ASS impacts while ensuring no change in the flood risk to the surrounding properties.

Table ES-1 summarises the adopted costs and benefits identified in this study. The results of the CBA show that the net benefits of remediating the private property outweigh the net benefits of the current land use by 7 to 1 (over $7 of benefits are realised for every $1 of costs). Despite initial costs and conservative estimates of ecosystem service values, the results indicate that the Net Present Value (NPV) of the remediation (Option 2) would exceed that of continued agricultural land use (Option 1) in 12 years (shown in Figure ES-3). While there are various assumptions within the analysis, sensitivity testing of the key variables has shown that values within the available literature range result in a NPV and Benefit Cost Ratio (BCR) for the remediation case (Option 2) that exceeds that of continuing agricultural use of the land (Option 1).

Table ES-1: Summary of adopted costs and benefits

Option	Variable	Adopted Value
Option 1 – Business as usual	Agricultural Production Value	+$350/ha/yr
	Agricultural Costs	-$273/ha/yr
	Ecosystem Services value	+$182/ha/yr
	Cost of ASS to estuary health	Not costed
Option 2 – Remediate floodplain	Acquisition Cost	-$200,000
	Construction Cost	-$3,100,000
	Project Management	-$50,000/year
	Monitoring and Maintenance	-$50,000/year
	Ecosystem services – tidal marsh	+$12,392/ha/yr
	Ecosystem services – freshwater wetland	+$5,551/ha/yr
	Ecosystem services – flood buffer	+$182/ha/yr

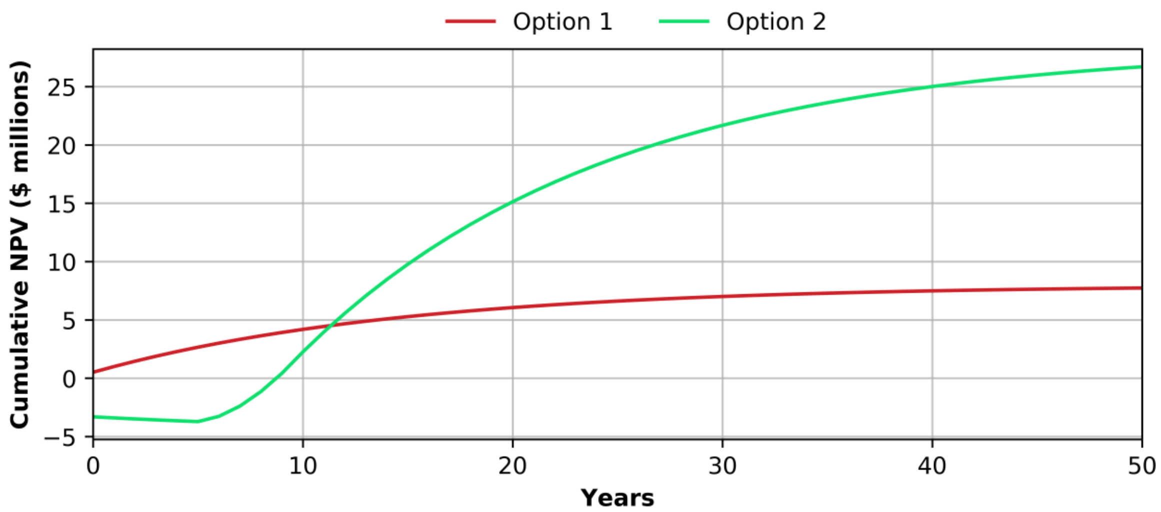

Figure ES-3: Cumulative NPV through time for both options

A distributional analysis is also presented in this report. The project would be funded through local and state government grants and levies, noting that the levies are existing and would not result in higher rates for the local community. The benefits of the project largely result from improving water quality, fisheries and general estuarine health within the floodplain and in the lower Manning River estuary. These improvements provide the greatest benefit to the local community and commercial fisheries (including oyster farmers).

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1 Introduction

The Big Swamp floodplain is located in the lower Manning River estuary, approximately 15 km upstream of the northern entrance of the Manning River at Harrington. The area has been identified as an Acid Sulfate Soil (ASS) hotspot in NSW (Tulau, 1999) and regularly discharges poor quality water, which impacts the health of the greater Manning River estuary (Ruprecht et al 2017).

This study is concerned with 650 ha of low lying land (< 2 m AHD) that comprises approximately one third of the area that is referred to as Big Swamp, shown in Figure 1-1. This land is part of a 1,000 ha property, held by a single land owner (herein referred to as the "private property"). Previous remediation programs have been implemented on adjacent landholdings, however the private property has been identified as high priority remediation land by Glamore et al. (2016) due to the presence of ASS which requires remedial actions to improve estuarine water quality.

The primary purpose of this study is to assess the costs and benefits of purchasing the private property and remediating the low-lying portion of the land to mitigate the impacts of ASS and improve environmental and economic outcomes. The Water Research Laboratory (WRL) of the School of Civil and Environmental Engineering at UNSW Sydney was engaged by MidCoast Council to undertake the cost-benefit analysis (CBA) for the proposed acquisition and on-ground works. This report details the CBA approach, methods and findings.

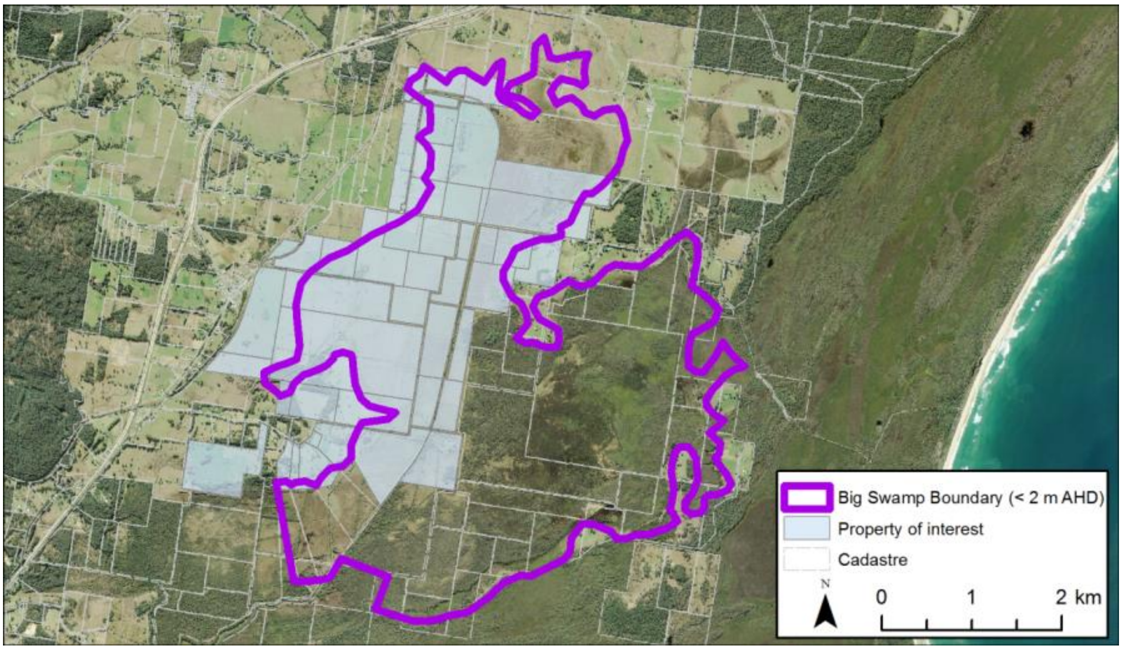

Figure 1-1: Area of interest for this project

1.1 About this report

This report comprises the following sections:

- **Section 2** provides a background to the project, including a summary of the work already undertaken at Big Swamp and the environmental issues that persist on the floodplain;
- **Section 3** provides an overview of the important economic concepts and methods that are used for this project;
- **Section 4** describes the alternatives considered in the economic analysis and how the various costs and benefits have been valued;
- **Section 5** presents the results of the CBA and includes an assessment of the sensitivity to key assumptions;
- **Section 6** provides more detail on the distribution of the costs and benefits to investigate the impact on stakeholders; and
- **Section 7** provides a summary of the key findings.

In addition, appendices have been included to provide further background on the assumptions and methods used in this study. The appendices are summarised below.

- **Appendix A** provides a detailed socio-economic profile of the region surrounding the Big Swamp floodplain;
- **Appendix B** summarises the environmental profiles associated with the two (2) alternative scenarios; and
- **Appendix C** provides more details on the valuation methods and estimates developed for this project, including a literature review on the value of natural capital.

2 Background

The Big Swamp floodplain is located on the left-bank of the Manning River, approximately 15 km upstream of the Manning River entrance, as shown in Figure 2-1. Big Swamp has been the site of major drainage and flood mitigation works since the mid-1800's. In 1905, Pipeclay Canal, a 6.5 km long artificial drain, was completed with the intention of improving drainage and allowing grazing and cultivation of the floodplain (PWD, 1904). This first attempt by the NSW Department of Works to drain the swamp was reported as a failure because of the drain's 'gradient, sedimentation and the large volume of water it was trying to remove' (GTCC, 2010). Numerous smaller drains have subsequently been constructed up until as late as 1997 to further encourage floodplain drainage (Glamore et al., 2014). However, these efforts to drain the swamp were fettered by what was later to become known as ASS, that is, stock would not drink from the drained water because of its smell, despite its 'crystal clear' appearance (The Sydney Morning Herald, 1912).

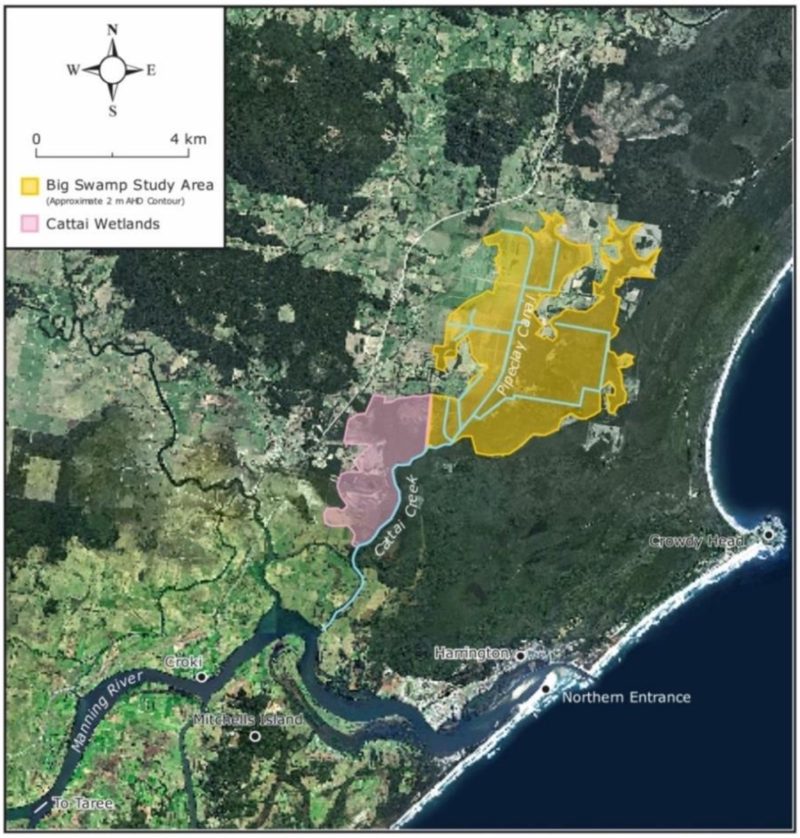

Figure 2-1: Study domain

There are extensive deposits of naturally occurring ASS in coastal floodplains across NSW (DERM, 2009). In an undisturbed state, ASS are benign. However, artificially draining areas affected by ASS can result in large scale acidification of floodplains, which has a detrimental impact on water quality, ecology and overall estuarine health (DECCW, 2008).

Big Swamp has been identified as one of the worst ASS hotspots in NSW (Tulau, 1999). Greater Taree City Council (now MidCoast Council) completed a feasibility study to assess a range of remediation strategies for the Big Swamp floodplain (GTCC, 2010), identifying large scale remediation of the floodplain areas below 2 m AHD as the preferred option. Since then, MidCoast Council has acquired almost 900 ha of low-lying land on the Big Swamp floodplain, as shown in Figure 2-2. After detailed field investigations and planning (Glamore et al., 2014), MidCoast Council completed substantial on-ground works in a portion of the floodplain to allow tidal flushing across ASS affected areas of the floodplain. Tidal flushing mitigates the impacts of acidification through the natural buffering capacity of bi-carbonates in marine water and increases the standing groundwater levels to reduce further acid production and transport. Additional non-tidal solutions, including drain and structure modifications to alter hydrological processes (e.g. increasing groundwater levels) were also implemented. These initial on-ground works included decommissioning approximately 13 km of drainage network and have resulted in a significant improvement in water quality, large scale changes in vegetation, and the recovery of some fish habitat within the area (Ruprecht et al., 2017).

Despite the management efforts to date, a significant area of the floodplain continues to discharge acid into the Manning River estuary. Not only does this result in poor water quality on the Big Swamp floodplain, but the acidic discharges also affects the wider estuary's health. A 2016 Remediation Action Plan for the Manning River highlighted Big Swamp as one of the highest priority sites for remediation in the region (Glamore et al., 2016). There are a number of studies that show that discharges from ASS reduce oyster productivity in the Manning region (e.g. DPI, 2007, Dove, 2003) and fish kills are a well-documented impact of ASS (e.g., DECCW, 2008). Because aquaculture and fishing provides almost $20 million (MidCoast Council, 2019b) in gross revenue per year, the detrimental impacts of the ASS affect the local economy.

This study relates to an additional area of approximately 650 ha of ASS affected area to address these ongoing acidic water quality issues. A significant portion of the private property was classified as 'high priority' for remediation by Glamore et al. (2016) based on the presence of ASS and the hydrology of the broader catchment draining the property.

This study assesses the costs and benefits of remediating a section of the floodplain versus the costs and benefits of the present agricultural land use. The CBA presented in this report has been completed to satisfy State Government requirements to justify government expenditure (NSW Treasury, 2017; OEH, 2018) and is designed to be one of a number of information sources supporting Council decision making when deciding whether or not to proceed with further remediation works.

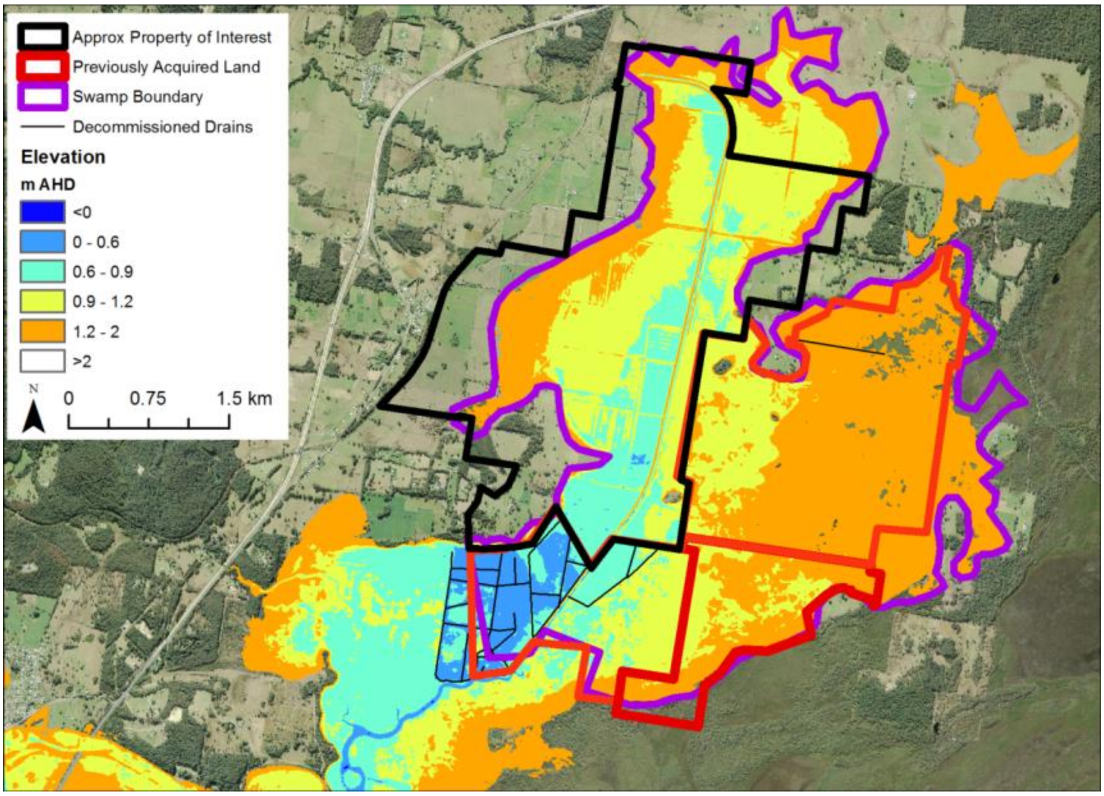

Figure 2-2: Land areas previously acquired (red) and proposed (black) with land elevation at Big Swamp

2.1 Socio-economic profile summary

This section provides a brief summary of the socio-economic profile of the area surrounding the Big Swamp floodplain based on the 2016 census data available from the Australian Bureau of Statistics (ABS). The profile was prepared to provide context of the local community, identify stakeholder groups, improve the decision support value of the CBA (OEH, 2018) and to inform the distributional analysis, which is provided in Section 6. While key points are summarised here, a detailed profile is provided in Appendix A.

The area around Big Swamp, and the MidCoast LGA generally, has a median age of over 50 years compared to a median of 38 years across NSW. The unemployment rate is higher than the state averages, around nine per cent and less than 50 per cent of the working age population is in the labour force (compared to 6 per cent and 63 per cent respectively for NSW), but comparable to unemployment in the MidCoast LGA. Median personal income in the rural area surrounding Big Swamp is approximately $455 per week, which is similar to the greater MidCoast LGA, but significantly lower than median income across the state ($664 per week). A large proportion (12 – 15 per cent) of people work in primary production (agriculture, fishing and forestry) in the immediate area around Big Swamp, which is significantly more than in the wider LGA (just over five per cent) and the state (around 2 per cent).

Based on the ABS Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD), both the MidCoast LGA and the agricultural region around Big Swamp are in the bottom 20^{th} percentile, indicating that they are relatively disadvantaged compared to the rest of the country. Relative disadvantage relates to the access that people have to materials and services and their ability to participate in society. A low IRSAD score, like those for the areas around Big Swamp, is typically a reflection of a high percentage of low income earners and unemployment, low levels of education, a high percentage of people in 'low skill jobs' and high disability rates (ABS, 2018a).

3 Cost Benefit Analysis (CBA) background

3.1 Preamble

This section provides an overview of a Cost Benefit Analysis (CBA) and key economic principles that underpin the analysis in this report.

3.2 What is a CBA?

A CBA is an economic instrument used to understand the change in economic welfare that might occur due to a change in management (OEH, 2018). NSW Treasury (2017) states that a "CBA measures the change attributable to a government action, relative to a situation without the proposed action". The general aim of the analysis is to compare a number of potential management scenarios and establish which option provides the greatest net-benefit, relative to the costs.

The first part of a CBA is the development of a base case, often the scenario in which there is no planned change in management. Once this is defined, one or more proposed alternatives can be developed for comparison against the base case. Because the CBA is a measure of relative change, only those costs and benefits that result in a net change in welfare are considered, which may not include all transactions. Many transactions are a transfer of wealth. For example, a government purchase of property does not result in a net change in wealth, as it is simply a transfer of money from the government to a private citizen and an equivalent transfer of property value. These transfers in costs and benefits are considered in a CBA through an analysis of the distributional consequences of each option considered in the CBA (described in Section 6).

For the scope of analysis for the CBA is the local government area (LGA) as per the guidance of OEH (2018). This means that only costs or benefits that change the economic wealth within the MidCoast LGA are considered.

A CBA can be undertaken using any common unit, although costs and benefits are typically described in dollar terms. While this is easily determined for goods and services that are commonly traded, such as labour or materials, a CBA must also capture social, environmental and ecological costs and benefits that are sometimes more difficult to quantify. Though monetary value estimations of non-market goods can be difficult to assess, it is important they are considered in the analysis because the results should reflect all costs and benefits to society.

For transparency, all assumptions used to arrive at the estimates for this study are clearly stated in the analysis below. Of particular relevance to this project are the benefits provided by various ecosystems, generally referred to as ‘ecosystem services’. These details are discussed further in Section 3.3.

3.2.1 Discount rates

Discounting converts costs and benefits that occur in the future into today’s dollars using a discount rate. Discount rates account for the time value of money, which gives more weight to impacts in the present or near present (NSW Treasury, 2017). A higher discount rate places a greater weight on present or near present impacts, while a lower interest rate results in more value being placed on costs and benefits that occur in the future. It is worth noting that the discount rate can have a substantial impact on the results of a CBA.

NSW Treasury (2017) explicitly states that a discount rate of 7 per cent should be used for all NSW government projects, with sensitivity testing at 3 per cent and 10 per cent. Note that all costs, benefits and discount rates are expressed in ‘real’ terms (i.e. without the inclusion of inflation).

3.2.2 Benefit Cost Ratio and Net Present Value

Benefit Cost Ratio (BCR) and Net Present Value (NPV) are two (2) common measures used to compare scenarios in a CBA. The BCR is defined as the time weighted benefits divided by the time weighted costs (shown in Equation 1) and is a measure of the value for money. A BCR value greater than one indicates that the benefits of a project exceed the costs. If all else is equal and there is a choice between two mutually exclusive projects, the project with the highest BCR would yield higher net benefits to the community.

NPV is the time weighted benefits minus the time weighted costs (shown in Equation 2). A project with a NPV greater than zero indicates that the benefits exceed the costs. If all else is equal and there is a choice between two mutually exclusive projects, the one with the highest NPV will be preferred.

For this project, both the NPV and BCR will be compared to assist decision making. A BCR of greater than one is equivalent to a positive NPV.

$$BCR = \frac{\sum_{i=0}^{n} \frac{B_i}{(1+r)^i}}{\sum_{i=0}^{n} \frac{C_i}{(1+r)^i}} \qquad \text{Equation (1)}$$

$$NPV = \sum_{i=0}^{n} \frac{B_i}{(1+r)^i} - \sum_{i=0}^{n} \frac{C_i}{(1+r)^i} \qquad \text{Equation (2)}$$

Where:

n= number of years

B_i = benefits in year i

C_i = costs in year i

r = discount rate

3.2.3 Time period

CBAs are typically undertaken over a defined time period, so that the stream of benefits or costs are finite. Based on advice from Department of Planning, Industry and Environment (DPIE, formerly OEH), NSW projects typically adopt time periods of 20 and 50 years for the purpose of CBAs. The adopted timeframe for this project is 50 years to account for the long-term benefits that could be derived from the remediation project. However, sensitivity testing is undertaken for a project timeframe of 20 years. Environmental projects, such as the remediation of the Big Swamp floodplain, typically result in long-term benefits that are potentially indefinite and are likely to continue beyond the timeframe of the economic analysis, which should be considered when comparing the results.

3.3 Ecosystem services

Environmental resources and natural capital have historically not been consistently included in economic decision making, as they are not generally bought or sold in traditional markets and are therefore may be difficult to monetise. However, there is an increasing awareness that natural capital interacts with human environments and provides a positive contribution to human welfare.

Ecosystems services is the term used to refer to the “benefits people obtain from ecosystems” (Millennium Ecosystem Assessment MEA, 2005), including both the direct and indirect contributions of ecosystems to human welfare (Costanza et al., 1997). These services are typically categorised into one (1) of four (4) types of services, as summarised in Table 3-1.

Table 3-1:Types of ecosystems services (adapted from Haines-Young and Potschin, 2018)

Service Type	Definition	Example services
Provisioning	Products derived from ecosystems	Food, freshwater, fuel
Regulation and Maintenance	Benefits derived from the regulating capacity of ecosystems processes	Flood mitigation, climate regulation, disease control, erosion control, carbon sequestration
Cultural	Non-material benefits from ecosystems	Recreational use, spiritual or cultural value

There is an increasing body of research that looks to provide a monetary value for a variety of ecosystems across the world. Typically this research is targeted at valuing a particular service(s) (such as fisheries production or flood protection) from a specific type of ecosystem (such as coastal wetlands or oceans) at a single location. There are a number of different methods that are used to provide an estimate for the value of ecosystem services, some of which are summarised in Table 3-2.

Table 3-2: Valuation techniques

Valuation Technique	Description
Market Based	Some environmental goods/services may be sold in a commercial market, and the value can be directly inferred
Avoided Cost/Replacement Cost	Estimates the value by assessing the cost of damages resulting from lost ecosystems (e.g. increase flood damage), or by pricing an alternative replacement to serve the same function (e.g. a waste treatment plant to replace the waste treatment function of a wetland)
Travel Cost	Infers the value of an ecosystem by assessing how much people are willing to pay to travel to visit
Hedonic Pricing	Infers value through changes in prices of market goods due to benefits from an ecosystem (e.g. proximity of a house to the beach)
Contingent Valuation	Estimates value based on surveys of people asking how much they are willing to pay for an ecosystem service
Choice Modelling	Similar to contingent valuation, choice modelling involves stated preferences in regard to ranking a series of pre-defined options
Benefit Transfer	Estimates economic value based on existing valuation studies for other sites or issues which are similar to those in question

For the purpose of this study, it is appropriate to adopt the ‘benefit transfer’ technique, as there have not been any studies to date that specifically value the ecosystem services anticipated on the

Big Swamp floodplain. A detailed literature review of the ecosystem services value for this project is provided in Appendix C and discussed in Section 4.

3.3.1 Discount rates and ecosystem services

The choice of discount rates has an important impact on the present value of an annual stream of benefits. In standard discounting, a constant discount rate is applied over the study period, and (for discount rates greater than zero) will diminish the value of benefits that occur into the future. There is some ongoing debate over the choice of discount rates to be used for ecosystem services and particularly whether the discount rate should be the same as those used for built capital (Costanza et al., 2011).

Sumalia and Walters (2005) argue that a conventional discount rate can lead to inter-generational inequity in regard to environmental costs and benefits, as it does not consider long-term sustainability and preferences the benefits to the current generation over those in the future. They suggest an alternative approach that allows for intergenerational discounting, which still acknowledges the time preferences of individuals, while placing a greater weight on the benefits that accrue into the future.

Costanza et al. (2011) suggests an approach that recognises the self-replicating nature of natural capital. They propose that natural capital should not be viewed in the same manner as human-built capital (that requires future investment and maintenance) and the benefits from which should be discounted at a separate, lower discount rate. This allows the benefits from built capital to be discounted in a conventional manner, while allowing for a greater weight for the benefits generated by natural capital in the more distant future. There is some debate on the value of the discount rate that should be adopted, although it is suggested that it should be as low as zero percent (e.g. no time preferences, Costanza et al., 2011).

The discount rates discussed in Section 3.2.1 will be applied for all aspects of the CBA, as per the guidelines of NSW Treasury (2017). However, current literature would suggest that this may underestimate the total present value of ecosystem services, which should be considered in decision making for the project.

4 Options and valuation

4.1 Preamble

Two (2) options are assessed in this CBA, as outlined in the scope of works provided by MidCoast Council. While other land uses may be possible and have economic benefits, only two (2) options, are evaluated in this study and this section provides an overview of these options which are:

1. Option 1 – Business as usual– in which the private property is not purchased, the current land practices continue and acid drainage continues from the areas of interest.
2. Option 2 - Remediate floodplain – in which the private property is purchased, and the acquired land is remediated into a wetland (similar to the existing restoration work in the lower Big Swamp area).

While some information is provided on the assumptions made in the valuations, the methodology behind the monetary valuation are described in Appendix C. For the purposes of this project, an optimistic estimate has been used to refer to assumptions that have been made that favour the business as usual. All values in this report have been converted to present day values using the ABS inflation calculator. The extent of the private property is shown in Figure 4-1. While the total property area is approximately 1,000 ha, this study is concerned with the 650 ha that lies below 2 m AHD (within the Big Swamp boundary). Based on conversations with MidCoast Council, it is assumed that current land uses will continue on the remaining higher land so there is no net change in production value from the upper 350 ha of property.

For the purpose of undertaking the CBA, all costs and benefits have been calculated compared to an arbitrary base case in which the land remains in private ownership, but is not used for agricultural production. This was chosen as the base case so that the benefits of the 'business as usual' case can be clearly identified in the study results.

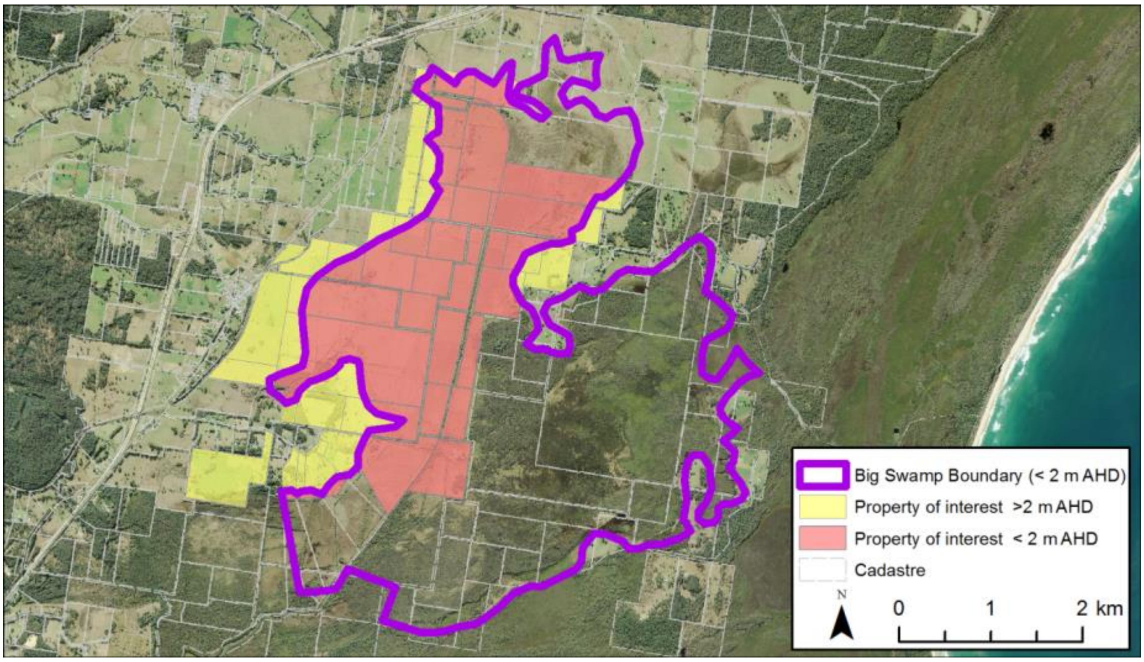

Figure 4-1: Property of interest on the Big Swamp floodplain

4.2 Option 1 – Business as usual

The Big Swamp floodplain has been identified as an acid sulfate soil hotspot in NSW and the Manning River (Tulau, 1999; Glamore et al., 2016), with detrimental environmental impacts both on the floodplain and in the wider Manning River estuary. An environmental profile of the existing landscape is provided in Appendix B, Section **Error! Reference source not found.**.

The private property is presently used for agriculture, primarily the grazing of dairy cattle. The main benefit associated with the base case is the value of production originating from the property. Based on local values, the value of production in this region (over all types of agriculture) was estimated to be $350/ha/yr. To assess the sensitivity of the CBA to this value, the value of agricultural production in the Mid North Coast Region was also considered and estimated to be $887/ha/yr. More details on the data and methods for developing these estimates can be found in Section C.3.1.

Agricultural production is associated with a variety of costs, including labour and material. Estimates of agricultural costs across NSW and Australia are provided annually by the Australian Bureau of Agricultural and Resources Economics and Sciences (ABARES). The costs associated with dairy farming in NSW are estimated to be approximately 78% of the value of production (ABARES, 2019), and this assumption is used for farm costs in this analysis. Alternatively, based on information across Australia between 2013 – 2017, farm costs are typically equal to 69% of the gross value of production (ABARES, 2018). This value is to test the sensitivity the results to farm costs. More details on the data and methods for developing this estimate can be found in Section C.3.2.

In addition to the agricultural benefits, grazing land provides ecosystem services to the local area. However, due to the presence of domesticated animals, cleared land and ASS, the value of this service is relatively small compared to values for other ecosystems in international literature (e.g. de Groot et al., 2012). Based on values from international databases, an ecosystem service value of $182/ha/yr has been adopted for the base case. This includes a valuation for services such as climate and gas regulation, pollination and biological control. More details on the data and methods for developing this estimate can be found in Section C.3.3.

While there are ecosystem services originating from agricultural land, the Big Swamp floodplain differs from most other grazing land due to the presence of ASS. Acid drainage of these soils has numerous impacts both on the floodplain and downstream regions (see Section B.3 for more details), including reduced oyster and fish production in the estuary. This reduced productivity results in a cost to the local community in the form of reduced commercial and recreational fishing, reduced recreational value and costs associated with poor water quality. However, there is limited available information to quantify the cost of acid sulfate soils on estuaries in NSW. Because Big Swamp is not the sole ASS hotspot on the Manning River, it is difficult to isolate the impacts of acid drainage from Big Swamp and, as such, no direct cost of ASS has been included in the base case. Thus the costs in the base case are underestimated which creates a bias towards the base case. A further discussion on this topic is provided in Section C.3.4.

A summary of the costs and benefits associated with the base case is provided in Table 4-1. A key assumption in the base case is that the land-use and production on the private property continues into the future, without any changes.

Table 4-1: Summary of cost and benefits of the base case

Variable	Details	Adopted Value	Sensitivity Test Value
Agricultural Production Value	Section C.3.1	+$350/ha/yr	+$887/ha/yr
Agricultural Costs	Section C.3.2	-$273/ha/yr	-$612/ha/yr
Ecosystem Services value	Section C.3.3	+$182/ha/yr	-
Cost of ASS to estuary health	Section C.3.4	Not costed	Not costed

4.3 Option 2 - Remediate floodplain

Under the Remediated Scenario, the private property would be acquired by MidCoast Council. While the entire 1,000 ha property would be purchased, it is assumed that the 350 ha of higher land (>2 m AHD) will continue to be used as farm land. Because there is no change in land use for this area there are no costs or benefits relative to the base case. The remaining 650 ha would be remediated and transformed into a wetland through infilling or shallowing of the drainage system and removal of flood control structures (as per the previous works downstream). A summary of the expected vegetation types, based on elevations, is shown in Figure 4-2 and largely consists of saltmarsh, freshwater wetlands, and an environmental buffer zone where minimal additional inundation would be encouraged (and assumed to remain grassland). In this analysis, it has been assumed that the vegetation will begin to have positive environmental benefits after five (5) years.

A detailed environmental profile of the remediated land is provided in Appendix B, Section B.3. It is assumed that all Council infrastructure on the property, including roads or paths, will be maintained throughout the remediation, and no-redirection or additional costs would be required. While the site could be made accessible for tourist visitation, it is assumed at this stage that no additional infrastructure would be built to accommodate additional visitation. This may be re-considered in the future.

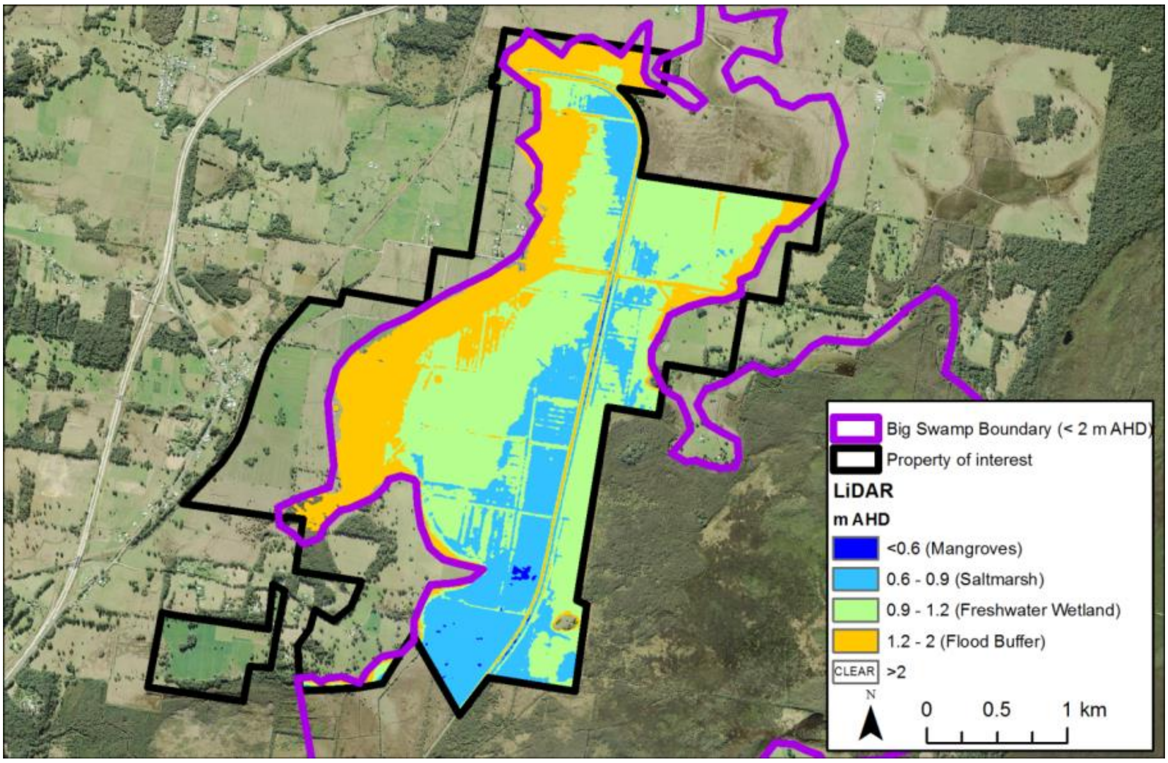

Figure 4-2: Forecast vegetation based on elevations on the private property

There are up-front net costs associated with remediating this property. Land must be acquired and a significant amount of on-ground works will be required. There is currently no detailed plan for the remediation of this site, although Glamore et al. (2016) provides guidance on the type of works that might be required. Based on previous on-ground works, the up-front net costs have been estimated to be $3,300,000. This includes an allowance of $60,000/km of drain for the entire drainage network within the property. This cost includes the infilling and shallowing of every drain, which may overstate the costs of Option 2 because it is unlikely that every drain would need to be infilled to achieve optimal environmental results. More information on the up-front costs can be found in Sections C.4.2 and C.4.3. An additional cost of $400,000 has been included for technical studies (including modelling and design) required to ensure the on-ground works would have no impact on surrounding properties.

Note that while land will be purchased, because the value of the land simply changes hands (the land holder is compensated with money which is equal to the value of his land), this purchase is a transfer and is not included as a cost of Option 2. A $200,000 allowance has been made for the existing land improvements (primarily the drainage network and flood mitigation structures) on the 650 ha of low-lying land, which is assumed to be the net loss in value as a result of the acquisition of the property (as these improvements will be largely abandoned).

There will also be some on-going costs associated with the project, both for project management, monitoring and maintenance. Based on MidCoast Council's current expenditure other rehabilitation projects at Big Swamp, it is expected that project management will cost approximately $50,000/year for the first five (5) years after the on-ground works are completed. After five (5) years, once the site has developed and stabilised, it is assumed that project management costs will be minimal. An additional cost of $50,000/year for indefinite monitoring and maintenance has been included. This cost includes water quality monitoring, vegetation and fish surveys (in excess of what already occurs), as well as any additional maintenance required (such as invasive species maintenance). More information on the on-going costs can be found in Section C.4.4.

The primary benefits of undertaking the remediation of the Big Swamp floodplain occur as a result of the ecosystem services that the remediated wetlands would provide. Based on the work of Glamore et al. (2016), the primary aim of the remediation would be to mitigate the impacts of ASS through facilitating inundation and flushing. A comprehensive description of the services that are likely to be provided by the 158 ha of saltmarsh (see Figure 4-2) and a literature review of the monetary values of these services is provided in Section C.4.5. Based on this review, a total value (including all ecosystem services) of $12,392/ha/year has been adopted (as per Creighton, 2013). Because this value is considered to be low when compared to international literature (such as de Groot et al., 2012), a value of $24,528/ha/year (Blackwell, 2007) is used to test the sensitivity of the results to this assumption.

The remainder of the property (approximately 300 ha) will be remediated to freshwater wetlands. However, most of the modelling and remediation work at Big Swamp to date has been focussed on the lower (<0.9 m AHD) areas of the floodplain, which can be converted into tidal wetlands. As such, there is a larger degree of uncertainty over the type of vegetation that may colonise the elevated area than those that are expected in the tidal zone. Therefore, it is prudent to assign a low and conservative value for the ecosystem services generated by this area. The minimum value for the total economic value of freshwater wetlands from a review of international literature undertaken by de Groot et al., (2012) has been adopted and equates to $5,551/ha/year. More information on the ecosystem services can be found in Section C.4.5.

The remainder of the 650 ha of remediated land (see Figure 4-2) has been designated as a flood buffer zone, with the intention that this area assists in preventing negative impacts further upstream (such as reduced drainage). For the purpose of this project, it is assumed that there is no remediation work on this part of the property and the ecosystem services will remain as per the base case ($182/ha/year).

A summary of the costs and benefits of Option 2 is provided in Table 4-2.

Table 4-2: Summary of cost and benefits for Option 2

Variable	Details	Adopted Value	Sensitivity Test Value	Timing
Acquisition Cost	Section C.4.2	-$200,000	-	Year 0
Construction Cost	Section C.4.3	-$3,100,000	-	Year 0
Project Management	Section C.4.4	-$50,000/year	-	Years 1 - 5
Monitoring and Maintenance	Section C.4.4	-$50,000/year	-	Indefinite after Year 1
Ecosystem services – tidal marsh	Section C.4.5	+$12,392/ha/yr	+$24,528/ha/yr	Linearly increasing from year 5 to 10, then indefinitely
Ecosystem services – freshwater wetland	Section C.4.5	+$5,551/ha/yr	- (adopted value conservative)	Linearly increasing from year 5 to 10, then indefinitely
Ecosystem services – flood buffer	Section C.4.5	+$182/ha/yr	- (adopted value conservative)	Linearly increasing from year 5 to 10, then indefinitely

5 Results and sensitivity

5.1 Preamble

This section provides an overview of the results of the CBA for the Big Swamp floodplain for the property of interest, including the sensitivity analysis of different discount rates and key variables.

5.2 Results

Based on the adopted values presented in Table 4-1 and Table 4-2, the NPV and BCR have been calculated for a discount rate of 7% and a project timeframe of 50 years. These results are summarised in Table 5-1. Option 2 provides a significantly higher NPV and BCR compared to the base case. While the NPV of Option 2 is substantially larger than the base case, it includes significant costs. However, the BCR indicates that for every dollar invested in the remediation of the private property, there is a $7.40 benefit to economic welfare within the local government area.

Table 5-1: Options Net Present Values (NPV) and Benefit Cost Ratios (7%, 50 Years)

Metric	Option 1	Option 2
NPV	$ 2,491,706	**$26,706,290**
BCR	1.9	**7.4**

5.3 Sensitivity analysis

This section assesses the sensitivity of the CBA to a number of different variables. The sensitivity analysis considers changes to:

- Discount rate;
- Time period;
- Gross production value from agricultural land, and the associated costs;
- Ecosystem services derived from the tidal wetland area (158 ha).

Sensitivity testing has considered the change of a single parameter at a time. Unless otherwise stated, a discount rate of 7% and a project timeframe of 50 years has been used.

5.3.1 Impact of discount rate

As discussed in Section 3.2.1, NSW Treasury (2017) requires the CBA analysis be undertaken with sensitivity tests at three per cent and 10 per cent. The impact of the discount rate (with all other values remaining equal to the adopted values) on the BCR and NPV results are shown in Figure 5-1 and Figure 5-2. The discount rate has a larger impact on the BCR and NPV of Option 1, which has large upfront costs and a 10 year delay in the onset of benefits following the completion of on-ground. These long term benefits are diminished by the higher discount rate and are reflected in a smaller NPV and BCR for Option 2 as discount rates increase. Because the costs and benefits are constant each year for the base case, the BCR is insensitive to the discount rate, while there is a small decrease in NPV for the base case at higher discount rates.

While the discount rate impacts the NPV and BCR, Figure 5-1 and Figure 5-2 show that regardless of the rate, Option 2 has a greater NPV and BCR than Option 1, the base case.

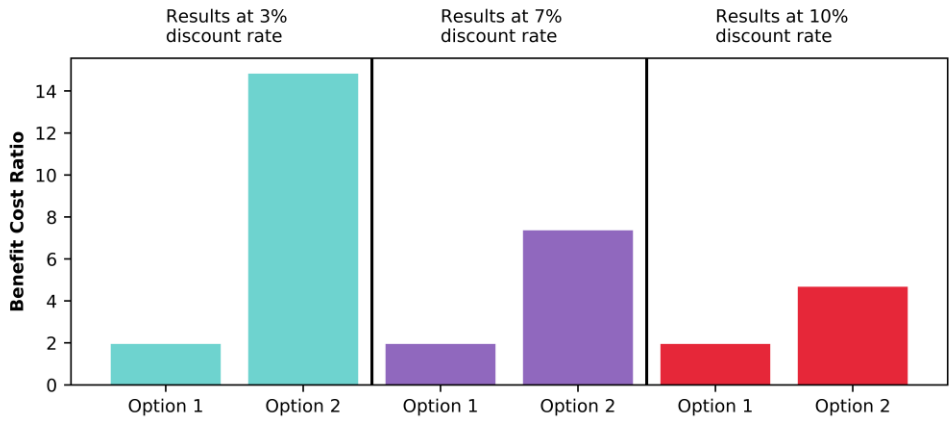

Figure 5-1: Sensitivity to discount rate on BCR

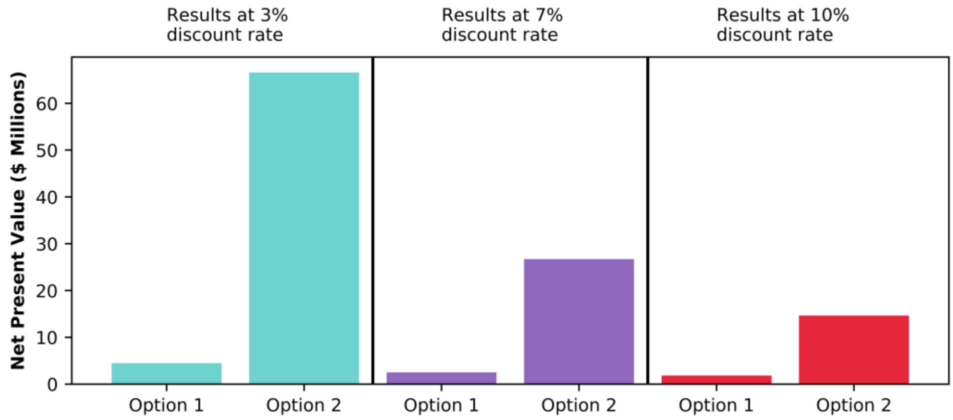

Figure 5-2: Sensitivity to discount rate on NPV

5.3.2 Time period

An analysis timeframe of 50 years was adopted for this project to capture the long-term nature of the benefit streams generated from an environmental remediation project. However, based on advice from DPIE, results for a 20 year period are also assessed. The impact of the time period on the NPV and BCR is shown in Figure 5-3. Similar to the higher discount rates, reducing the time period has a disproportionally larger impact on the NPV and BCR of the remediated scenario, which has large initial costs and benefits that only start accruing five years after the start of the project. However, despite the reduction in NPV and BCR, the CBA still indicates that the remediation scenario has significantly greater economic net benefit than the base case. Further, Figure 5-4 indicates that the NPV of Option 2 exceeds that of Option 1 after 12 years.

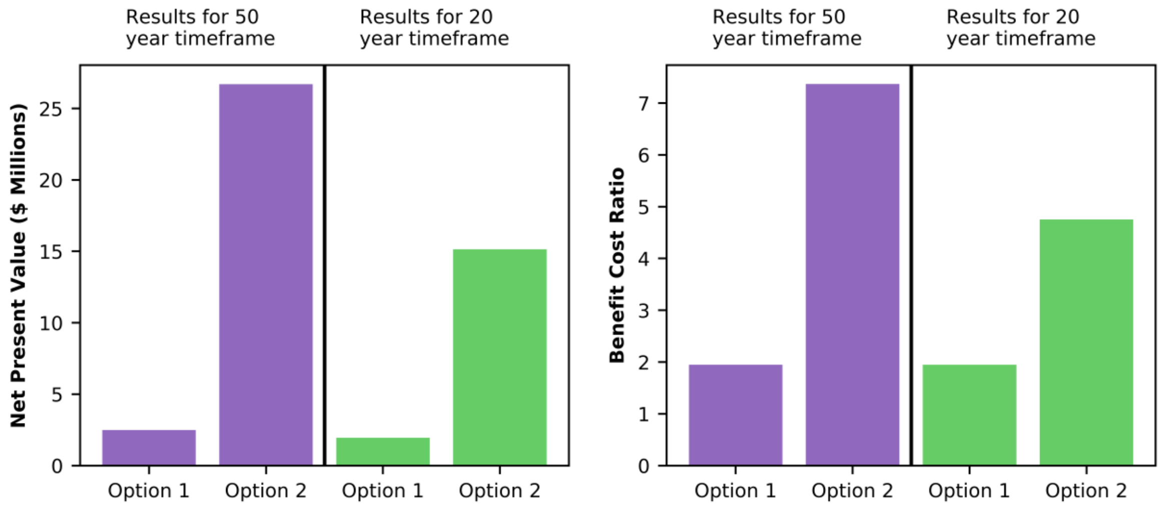

Figure 5-3: Sensitivity of results to time period

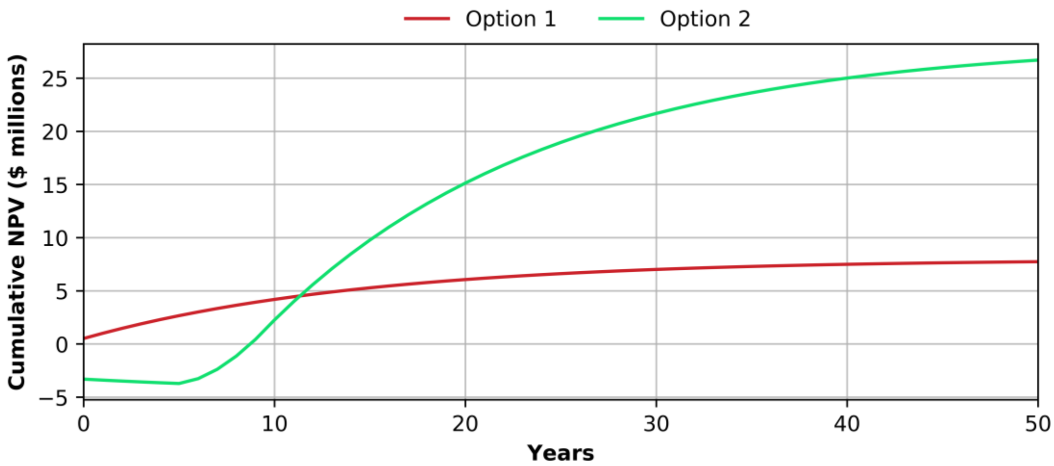

Figure 5-4: Development of cumulative NPV through time for both scenarios

5.3.3 Agricultural values

The agricultural gross production values adopted in this study have been based on local data in the Taree Region ($350/ha/year). However, as a sensitivity test, the gross production value in the Mid North coast region ($490/ha/yr) is also used. In the first case, an agricultural cost of 78% of production has been used, while the sensitivity test uses a value of 69% (as per the discussion in Section C.3.2). This only affects the NPV and BCR of the base case, the remediation scenario remains unchanged.

The increased production value from agriculture marginally increases the NPV of the base case, as shown in Figure 5-5. However, the increase is relatively small and still substantially smaller than the net benefits from Option 2.

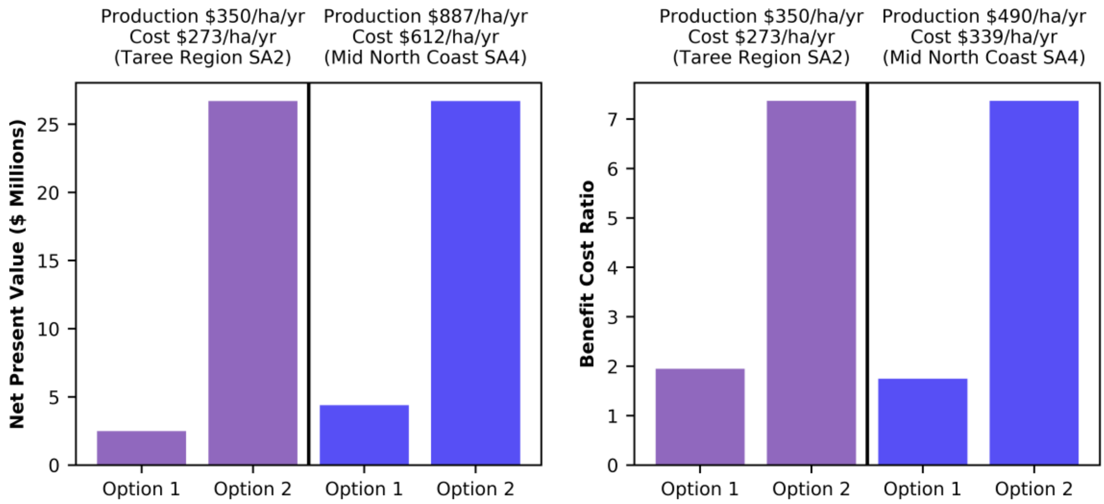

Figure 5-5: Sensitivity of results to agricultural value

5.3.4 Ecosystem services – saltmarsh

The floodplain area in which there is most information on the type of ecosystems that might be fostered through remediation is the saltmarsh area below 0.9 m AHD. There is a significant body of literature that provides a value for the ecosystem services of saltmarsh, and the total value adopted for this study ($12,392/ha/yr) is smaller than the median value in international literature (based on de Groot et al., 2012). Based on the estimates of Blackwell (2007), the impact of using a higher value of $24,528/ha/yr is tested to demonstrate the upper bounder potential for ecosystem service benefits.. This only impacts the value of Option 2 and will not affect the base case NPV and BCR.

Figure 5-6 shows the impact ecosystem services values have on results. Unsurprisingly, it substantially increases the NPV and BCR associated with the remediation and increases the NPV and BCR by approximately 60% and 50%, respectively. This shows the potential magnitude of gains.

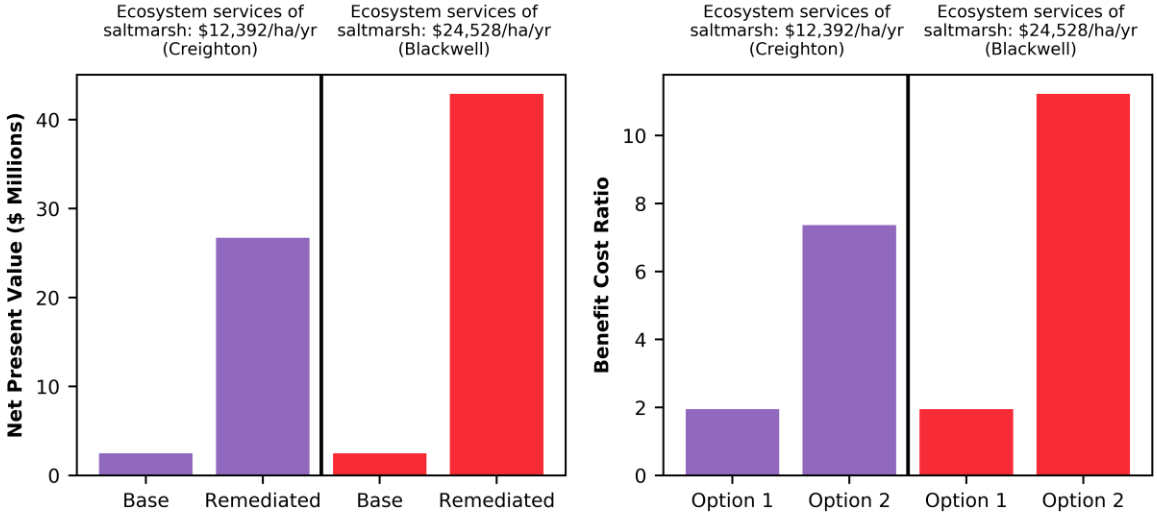

Figure 5-6: Impact of the saltmarsh ecosystem services value on results

5.3.5 Summary of sensitivity tests

There are numerous factors that influence the magnitude of the NPV and BCR for both options. However a key finding of the sensitivity tests is that the comparative result (e.g. which option has a higher NPV/BCR) did not change for any of the variable changes tested. In each case, the remediation of the private property resulted in higher net benefits than the base case.

5.4 Impact of key assumptions

A number of assumptions have been made in this analysis, which are not explicitly valued in the CBA. Table 5-2 details the potential option bias of each assumption. Each of the assumptions tends to make the net benefits of Option 1 relatively larger than the net benefits of Option 2. The values adopted for Option 2 are conservative because there is a greater level of uncertainty associated with this option because there is currently no detailed design for the on-ground works and the target ecosystems. As a result, the net benefits of undertaking the Option 2 may be understated by the results of this project.

More information on the assumptions associated with sea level rise, which has not been discussed previously, is provided in Sections 5.4.1.

Table 5-2: Qualitative assessment of the impact of key assumptions on the NPV of the base and remediated cases (note that the size of the arrow is indicative of the relative impact)

Assumption	Impact on Option 1	Impact on Option 2
Sea Level Rise not accounted for	↑	↓
Same discount rate for built and natural capital	↓ (small)	↓
Exclusion of the cost of ASS on present estuary health	↑	-
No additional ecosystem services generated from the flood buffer zone	-	↓
Conservative value from ecosystem services from freshwater wetlands	-	↓

5.4.1 Sea level rise

There is no consideration for sea level rise in the economic analysis presented in this report. The Big Swamp floodplain is in the lower Manning River estuary and the water levels in this area are driven by tidal ocean levels. As mean sea levels increase, the drainage systems that allow for viable agriculture in the low-lying floodplains in estuaries are likely to become less effective (Glamore et al., 2016b) and water will remain on the floodplain for longer periods. This is likely to reduce the agricultural production from low-lying estuarine floodplains like Big Swamp in the future or require significant costs to remove the water from the floodplain through other means.

Under the remediated option, sea level rise will change the elevation to which tidal waters could inundate the floodplain. This would change the mix of freshwater and tidal wetland environments that could be expected, increasing the tidal flushing. As tidal flushing and tidal inundation are effective ways to treat and mitigate the impacts of ASS (Glamore, 2003), and the adopted value for tidal wetlands exceeds the value for freshwater wetlands in this study, increasing sea levels is likely to increase the benefits that could be derived from natural capital on the floodplain.

6 Distributional Analysis

6.1 Preamble

A distributional analysis identifies the stakeholders within the LGA and investigates impact on the stakeholder groups. (OEH, 2018). A qualitative distributional analysis is provided below.

6.2 Results

A distributional analysis examines the change in welfare in Option 2 compared to Option 1 on individual sub-groups of the community. There are five (5) major stakeholder groups identified for this project, including the:

- MidCoast Council;
- Individual landholder of the private property;
- Surrounding landholders on the Big Swamp floodplain;
- Local community; and
- Local commercial fisheries and oyster producers.

The qualitative distributional analysis of Option 2 is summarised in Table 6-1. For this project, the majority of the benefits of the remediation accrue to the commercial fisheries and oyster industry and to the general public, while the costs would largely be incurred by the Local Council, who would be funding the project through grants and the existing environmental levy.

Table 6-1: Qualitative distributional analysis

Stakeholder	Potential impacts of remediation
MidCoast Council (with State Government grants)	MidCoast Council, with grants from the NSW State Government, will bear the majority of costs associated with the acquisition of land, technical studies, design, and on-going management and maintenance. Land acquisition and on-ground works are expected to be funded through state government grants and Council's existing environmental levy funds. It is expected that the on-going maintenance and monitoring is likely to be funded through the Council's existing environmental levy funds or supporting grants. Note that the environmental levy already exists and is unlikely to require additional funding through increased rates. As the socio-economic profile identified MidCoast as a relatively disadvantaged

Stakeholder	Potential impacts of remediation
	LGA, it is significant to identify that additional costs will not be put on rate payers.
Individual land holder of private property	The property is to be voluntarily purchased from a single landholder at an agreed market value based price for this project to proceed. Therefore, this landholder will be compensated for his property and is not expected to have a net change in welfare.
Surrounding land holders on the Big Swamp floodplain	The detailed design and modelling for this project must be sufficient to ensure that there will be no negative impacts on the drainage of the surrounding properties. There is not expected to be a significant change in welfare as a result of the remediation of the lower floodplain to the surrounding property owners, other than those that accrue to the greater local community.
Local community	The local community will benefit from the improved estuarine health as a result of the remediation works. It will improve opportunities for recreational fishing, boating, swimming and other recreational uses of the lower estuary (including tourism within the LGA). The local community (along with commercial fishery operations) are expected to be the main beneficiaries of the ecosystem service benefits generated from the remediation.
Local commercial fishing and oyster operations within the LGA	Commercial fisheries operations (including oysters) are expected to see positive impacts from the remediation. The socio-economic profile identified that the area has a disproportionally high percentage of people working in agriculture and fisheries. While there is a loss of agricultural land, there would be an increase in fisheries production as a result of the remediation. A reduction in acid discharge and an increase of fish habitat from the tidal areas of the remediated floodplain is estimated to increase commercial fishing production, which is included in the ecosystem services values for saltmarsh in the economic analysis. Commercial fisheries and oyster operations with in the LGA are assumed to be the only major benefactors within the industry, as the entrance of the Manning River is more than 20 km from the northern boundary of the LGA. Some minor benefits may accrue to fisheries outside the Mid Coast LGA.

7 Conclusion

MidCoast Council has been acquiring land on the Big Swamp floodplain for the purpose of large scale wetland remediation since 2012. To date, Council has purchased approximately 900 ha of the 2,000 ha floodplain (below 2 m AHD) and has undertaken substantial on-ground works on the lowest sections of the site. Since these works were completed, Ruprecht et al. (2017) have observed improvements in water quality, vegetation and fish habitat. This study has assessed the relative costs and benefits of extending this remediation work over an additional 650 ha of the Big Swamp floodplain, which continues to discharge acid into the lower Manning River estuary. The land is currently used for agricultural production (mostly dairy) by a single landholder. The freshwater swampland was historically drained by the NSW Public Works Department to expand agriculture, and in particular, dairy and cattle production in the region, given its high rainfall.

While there is presently no detailed design for the remediation works, it has been assumed every drain on the property will require some works to remediate the site. Based on the areas of the floodplain that have already been remediated and literature on the expected vegetation, estimates of the type of ecosystems that would exist if the site was remediated have been determined. While historically economic analyses have not included the contribution of ecosystems to human welfare, there is a growing body of research that suggests that coastal wetlands, such as those proposed at Big Swamp, have a large economic benefit to society through various services they provide (including primary production e.g. fisheries, improved water quality regulation, recreation and climate regulation).

The CBA results show that the current land uses of the property do have a net benefit to the MidCoast LGA, as indicated in the positive NPV and BCR greater than 1. However, these results do not include the negative impact of ASS discharges on the estuary and are outweighed by potential benefits that could be accrued if the site were remediated. The results highlight that while remediation will involve upfront capital costs, for every dollar that is invested in the remediation of the floodplain area, $7.40 of benefits (in present value) are returned over a 50 year period. The sensitivity analysis showed that variations in key variables affect the NPV and BCR of both options, however in each test the remediated option had both a greater NPV and BCR.

A qualitative distributional analysis undertaken for this study highlights that while MidCoast Council will incur significant costs associated with the remediation project, the benefits are mostly received by the local community and local fisheries industries.

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Appendix A Socio-economic profile

A.1 Preamble

This section presents a socio-economic profile of the community living in the vicinity of the Big Swamp floodplain. It considers several different sizes of community groups – from small scale local communities, to whole local government areas and the state of NSW. In developing a Cost Benefit Analysis for a publicly funded project, understanding the socio-economic profile of the impacted communities assists in assessing the equity of decisions made.

A.2 Locations

Big Swamp is located within the suburbs of Coralville and Moorland, approximately 30 km north west of Taree. The study location is within the MidCoast Council Local Government Area (LGA). To understand the socio-economic profile of the areas surrounding Big Swamp, data from the 2016 Australian Census was accessed through the Australian Bureau of Statistics (ABS). The ABS provides census data separated into 'Statistical Areas' (SA). The boundaries of the SAs are defined by the ABS and are specifically designed to be used for outputting statistics from the data. For the purpose of this project, two levels of statistical areas have been considered:

- Statistical Area Level 1 (SA1): SA1 areas typically encompass 200 – 800 people and is the smallest geographical area that the ABS publishes extensive statistics on. The Big Swamp floodplain lies between two (2) SA1s (with codes 1117012 – referred to as Moorland SA1 in this report and 1117036 – referred to as Coralville SA1 in this report). For this study, these two (2) SA1 areas have been combined and are referred to as Combined SA1. For some analysis, this area is too small to be statistically representative, and it has not been included; and
- Statistical Area Level 2 (SA2): SA2 areas are an aggregation of SA1 areas which generally cover 3,000 – 10,000 people. ABS states that SA2 represents "functional areas that represent a community that interacts socially and economically". The Big Swamp floodplain lies within the Taree Region SA2 region (code 11170). This aggregates the regional area around the Taree township, but excludes the townships of Wingham, Old Bar and Taree itself.

The socio-economic profiles of the MidCoast LGA and NSW have also been considered to provide a comparison against the smaller statistical areas around the Big Swamp floodplain. The areas considered in the socio-economic profile are shown in Figure A-1.

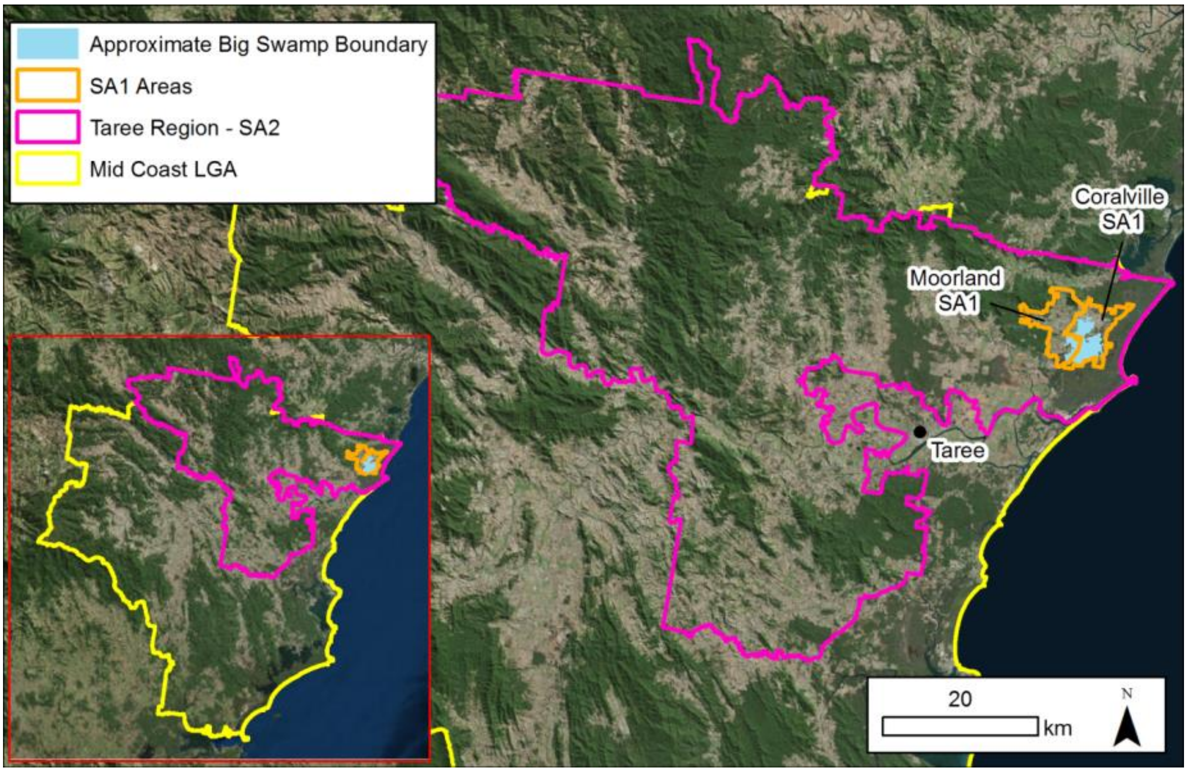

Figure A-1: Areas considered in the socio-economic profile of the Big Swamp floodplain

A.3 Population

Table A-1 shows the median age of the Taree Region SA2 and Combined SA1 area was fairly consistent with the MidCoast LGA. However, it also showed that the MidCoast region was aging compared the rest of NSW. Figure A-2 provides a breakdown of the population of the different areas by age and gender. Figure A-2 shows that the distribution of ages was similar between the Taree Region SA2, the SA1 areas and the MidCoast LGA, although these areas had disproportionally less people between the ages of 20 and 45, when compared to the rest of NSW. Figure A-2 also shows that there are more males than females in the Combined SA1 area for most age groups.

Table A-1: Populations

Area	Median Age	Population (2016)
NSW	38	7,480,228
MidCoast LGA	52	90,303
Taree Region SA2	53	12,438
Combined SA1	50	660
Coralville SA1	*50*	*152*
Moorland SA1	*50*	*508*

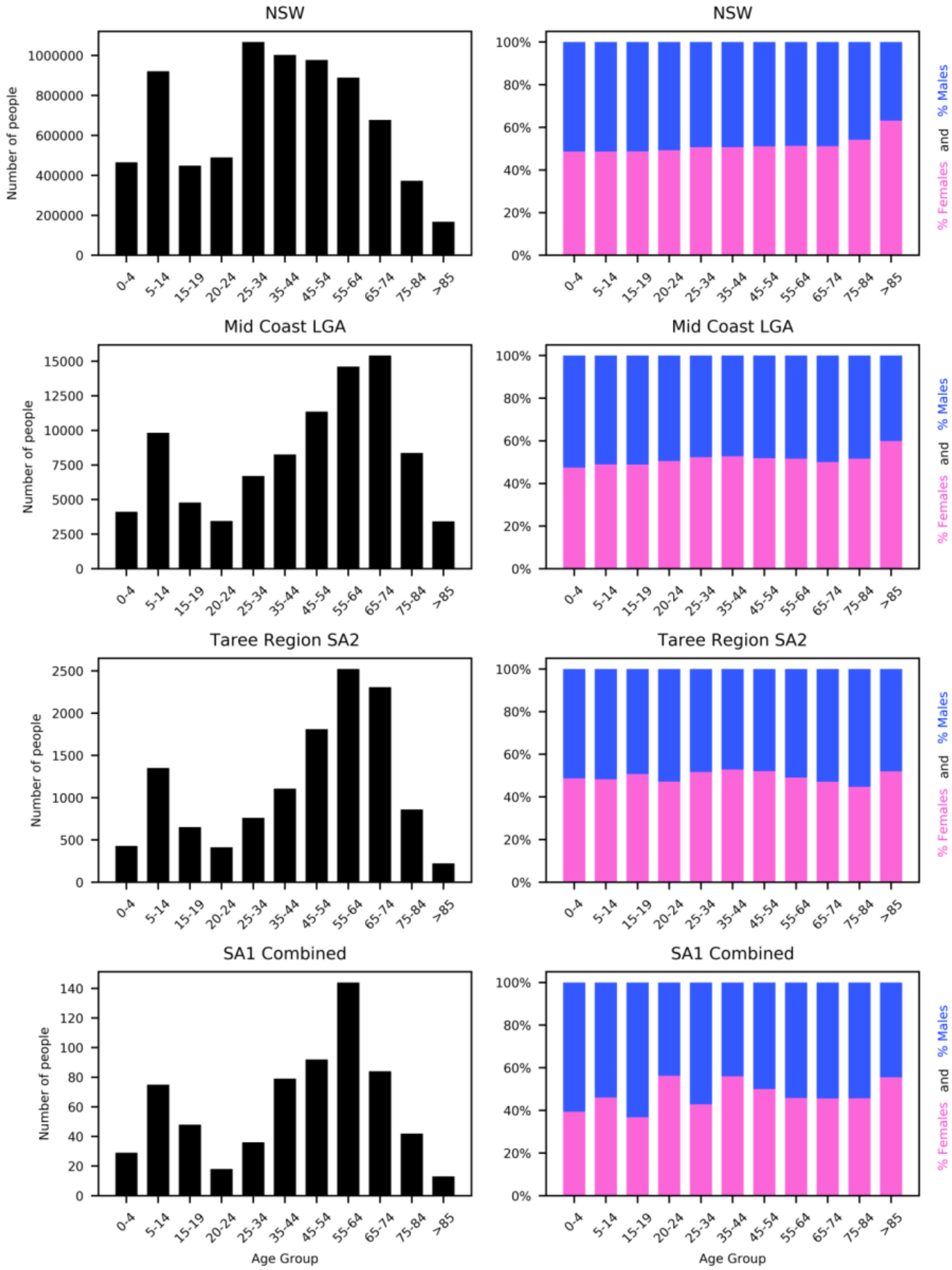

Figure A-2: Population by age and gender

A.4 Housing and household structure

Table A-2 summarises the average household size, median monthly mortgage repayments and median weekly rent each of the areas reported by the ABS. Households in the MidCoast LGA and the Taree SA2 region were smaller than those in NSW and likely to be a result of an older population. Rental and mortgage prices were generally lower around Big Swamp than the NSW median, although median mortgage repayments in Coralville SA1 were comparable to NSW. While rental rates were similar in the MidCoast LGA and the Taree Region SA2, it was 20% lower in the smaller SA1 regions.

Table A-2: Average household size, mortgage repayments and rent

Area	Average number of people per household	Median monthly mortgage repayments	Median weekly rent
NSW	2.6	$1,986	$380
MidCoast LGA	2.2	$1,324	$250
Taree Region SA2	2.3	$1,300	$248
Moorland SA1	2.3	$1,157	$200
Coralville SA1*	2.8	$1,967	$200

*Coralville SA1 only includes 42 occupied private dwellings and may not be representative.

Note that median monthly mortgage is based on properties being purchased and median rent is based on properties being rented on the day of the census.

A.4.1 Household relationship structure

Figure A-3 shows the relationships within households in each area. The statistics show that there are proportionally less children and dependent students in the areas around Big Swamp compared to wider NSW, which is consistent with an aging population. Similarly, group household members were less common in the MidCoast region.

Individuals were also more likely to live on their own in the MidCoast region than across NSW. This was also likely to be a result of the aging population within the MidCoast region, as lone person dwellings generally increases with age.

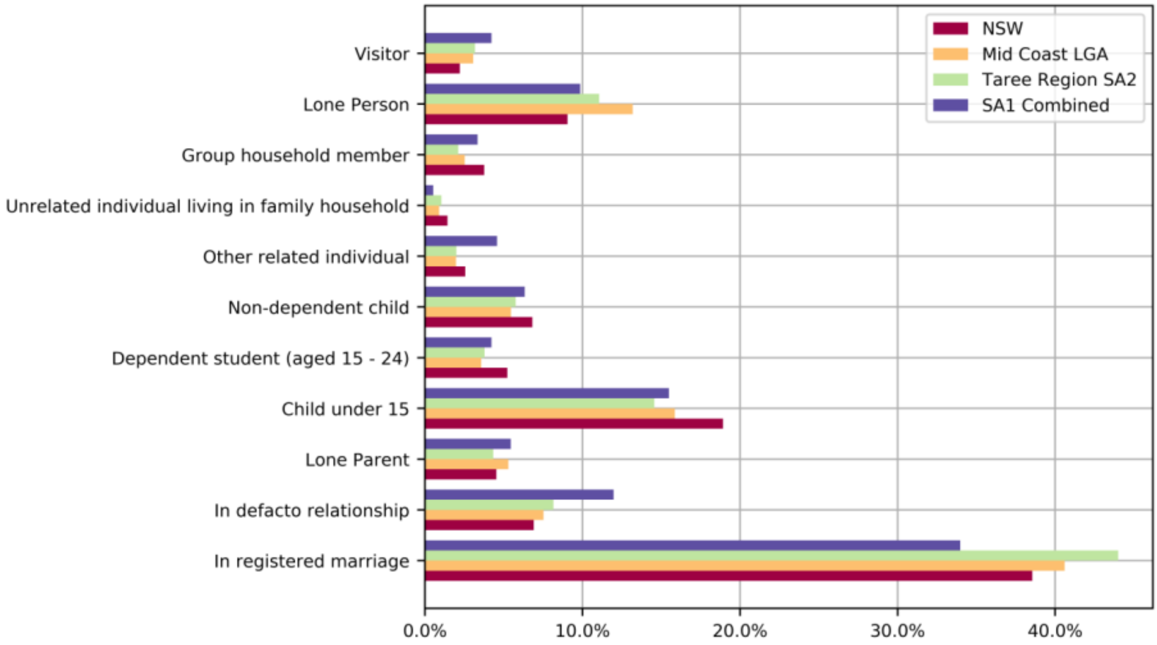

Figure A-3: Relationships within households

A.5 Education

A.5.1 Schooling

Figure A-4 shows the highest level of schooling completed in each of the relevant areas. The census results showed that less than 30% of the population finished school in the MidCoast LGA, the Taree Region (SA2) and the combined SA1 areas. Further, 26% of the population in the combined SA1 area completed year 12 and 49% completed year 10 or higher. In comparison, over 50% of people in NSW completed year 12 (or equivalent) and 72% of the total population of NSW completed up to year 10 or above.

Figure A-5 shows the differences in male and female levels of schooling for NSW and for the Taree SA2 region. In NSW, females were slightly more likely to finish year 12 (54.6%) than males (53.2%), however the differences were small. In the Taree Region SA2, however, the difference was more pronounced, where 26.6% of males finished year 12, compared to 31.7% of females.

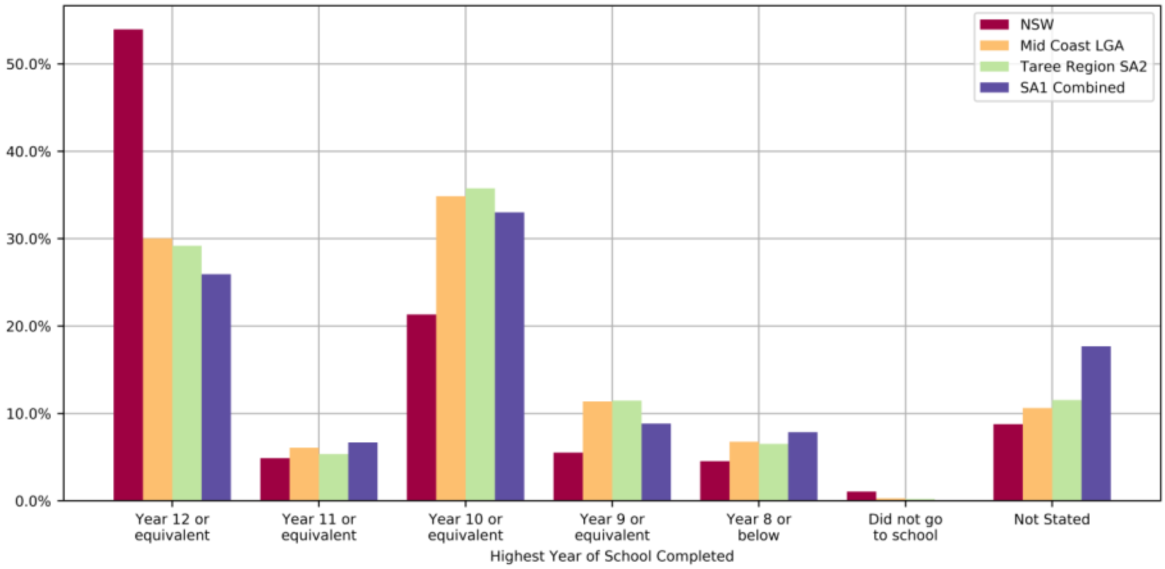

Figure A-4: Highest level of schooling in each area

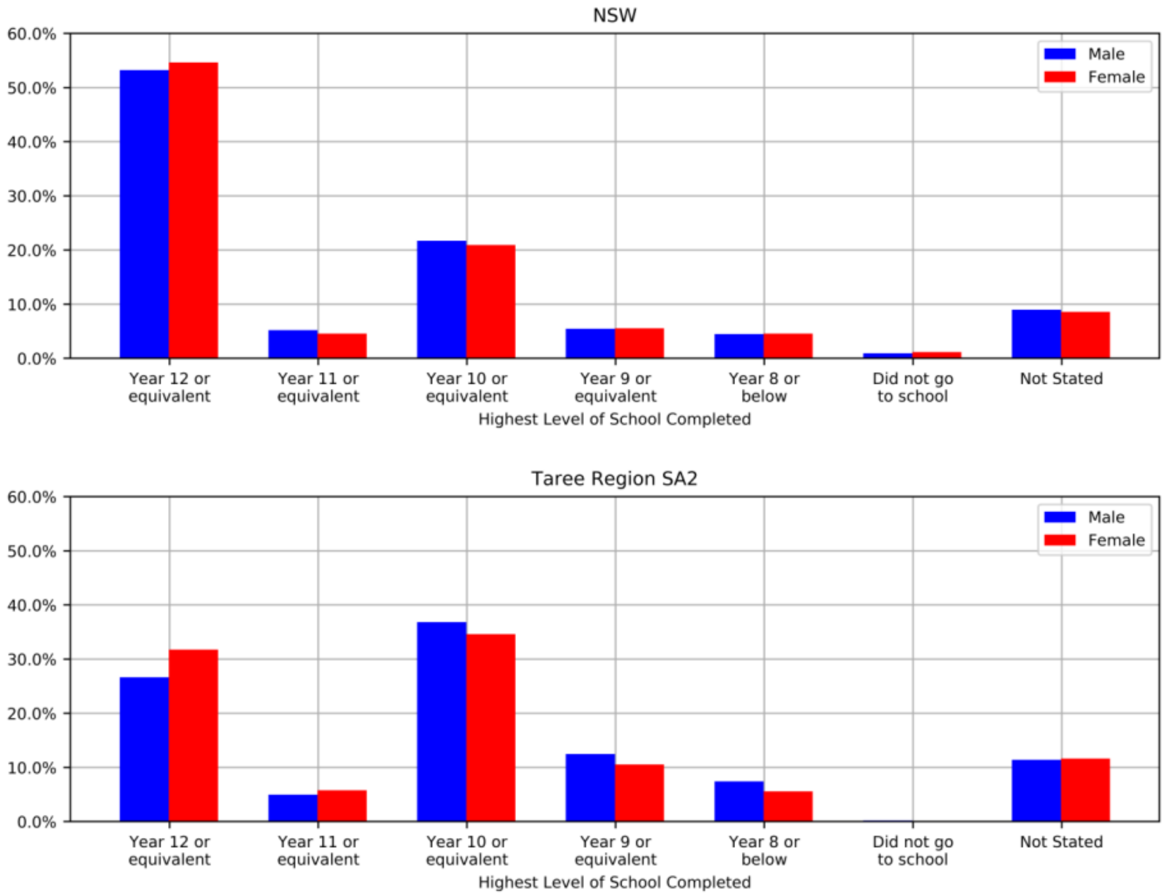

Figure A-5: Highest level of school completed per gender in (Top) NSW and (Bottom) Taree Region SA2

A.5.2 Non-school qualifications

The highest level of non-school qualifications, including undergraduate and post-graduate university degrees, diplomas and certificates obtained by residents in each area is provided in Figure A-6. The non-school qualifications in the MidCoast LGA, the Taree Region SA2 and the combined SA1 areas were generally comparable, while the greater population of NSW typically had a higher level of non-school education. Approximately 19% of the NSW population held a Bachelors degree or higher, compared to 8% in the MidCoast LGA and the Taree Region SA2, and 7% in the combined SA1 areas.

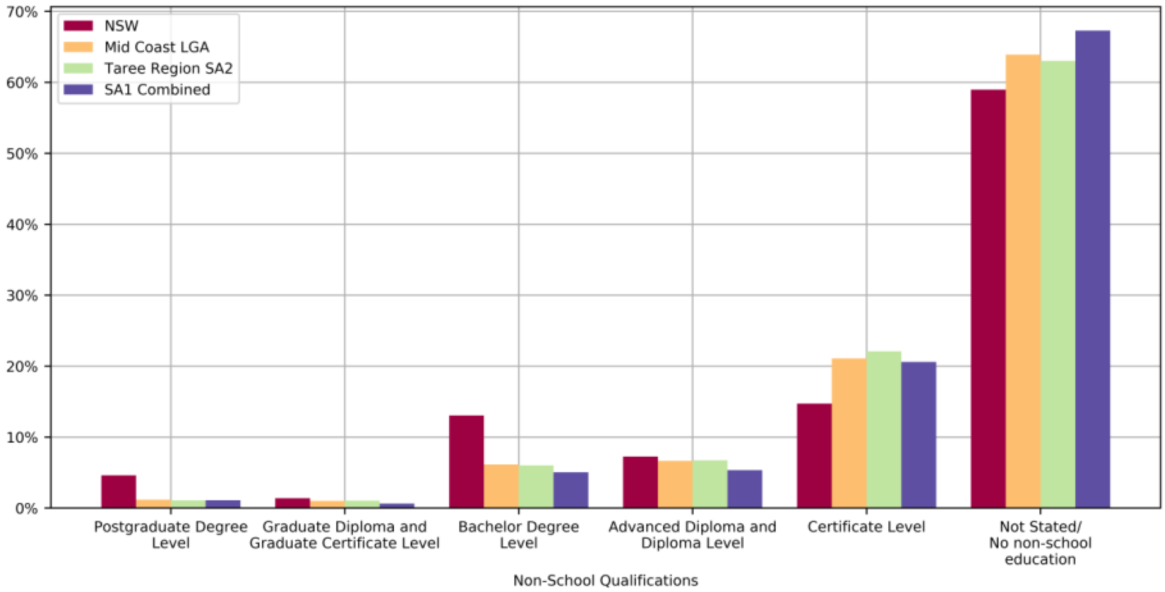

Figure A-6: Non-school qualifications

A.6 Employment

A.6.1 Unemployment and Labour Force Participation Rates

Table A-3 shows the employment statistics for the various regions. Note that Table A-3 does not include statistics on people who did not provide information on employment. Unemployment in the MidCoast LGA was significantly greater than in NSW, and the labour force participation rate was substantially smaller. This is an indication of economic stagnation in the region. While the Taree Region SA2 had a similar unemployment and labour force participation rate as the MidCoast LGA, the combined SA1 area had a higher unemployment rate. Figure A-7 provides the unemployment and labour force participation rates for different age groups. Due to the small number of people in the combined SA1 in each age group, this was not included in the analysis.

Table A-3: Employment statistics

	NSW	MidCoast LGA	Taree Region SA2	Combined SA1
Employed (Full time and Part Time)	3,380,332	30032	4294	212
Unemployed	225,546	2975	447	30
Total Labour Force	3,605,881	33007	4745	244
Not in the Labour Force	2,088,240	37807	5043	240
Unemployment Rate (Unemployed % of Labour Force)	6%	9%	9%	12%
Participation in Labour Force (Labour Force as % of Total)	63%	47%	48%	50%

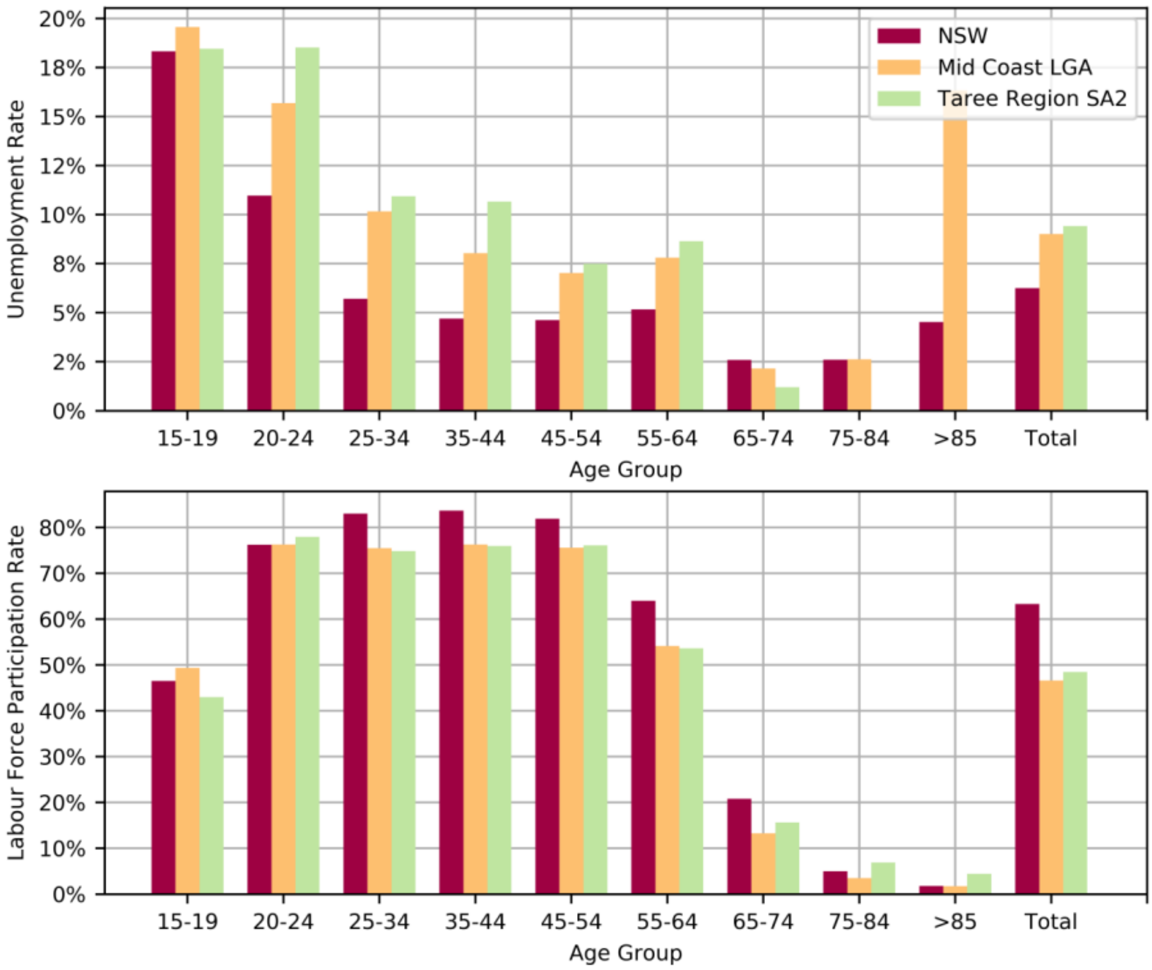

Figure A-7: (Top) Unemployment rate by age (Bottom) Labour force participation rate by age

Unemployment in the Big Swamp area was substantially higher than NSW for ages between 20 and 65, who represented more than 60% of the labour force in the region. Further, unemployment in the

MidCoast LGA was higher than the NSW unemployment rate for all ages groups younger than 65. Unemployment rates also varied by gender for NSW and the Taree Region SA2, as provided in Figure A-8. There was a bigger disparity between unemployment of males and females in the Taree Region, particularly for males aged under 25 whose unemployment rate was approximately 22%.

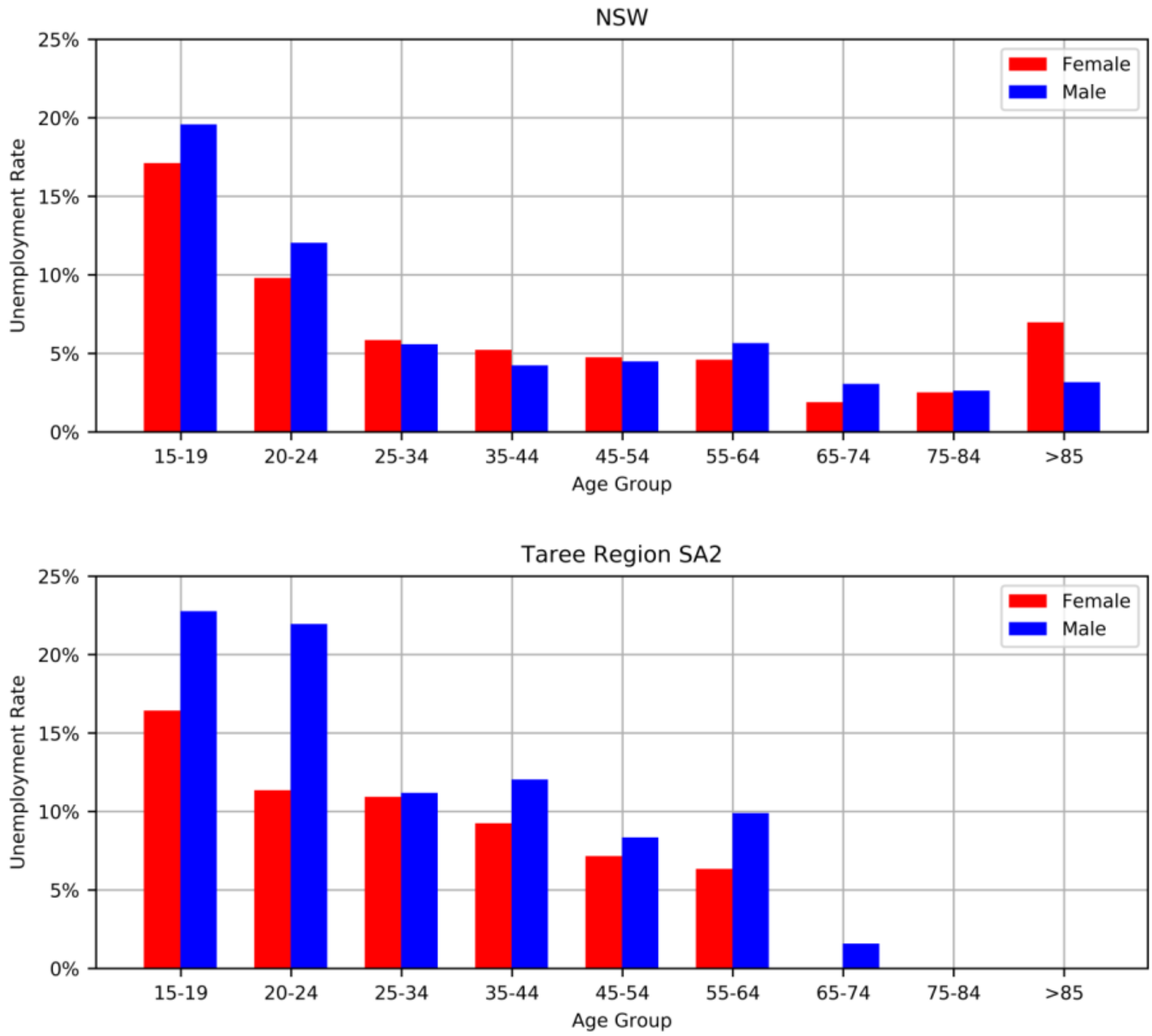

Figure A-8: Unemployment rates by gender in (Top) NSW) and (Bottom) Taree Region SA2

A.6.2 Industry

Figure A-9 shows the industry of employment by area, classified using the Australian and New Zealand Standard Industrial Classification (ANZSIC). It is clear that the Taree Region SA2 and the combined SA1 area, neither of which included any large townships, had a disproportionally high number of people employed in the agricultural, forestry and fishing industry (>12%), when compared to NSW (2%) and the MidCoast LGA (5%). The Health care and social assistance industry accounted for over 16% of employment in the three (3) regions immediately surrounding Big Swamp, while approximately 12.5% of people were employed by this sector across the state. As shown in Table A-4, both of these two (2) industries have lower than average weekly median earnings. Conversely, far fewer people in the MidCoast LGA and Taree Region were employed in the Professional, Scientific and Technical Services industry (≤4%), while 8% of employment in NSW was in this industry. Similarly, while 5% of NSW workforce was in the Financial and Insurance Services industry, less than 1.5% of the population in MidCoast LGA and Taree Region worked in this area. Both of these two (2) industries that are under-represented in the areas around Big Swamp are typically associated with higher than average incomes (see Table A-4).

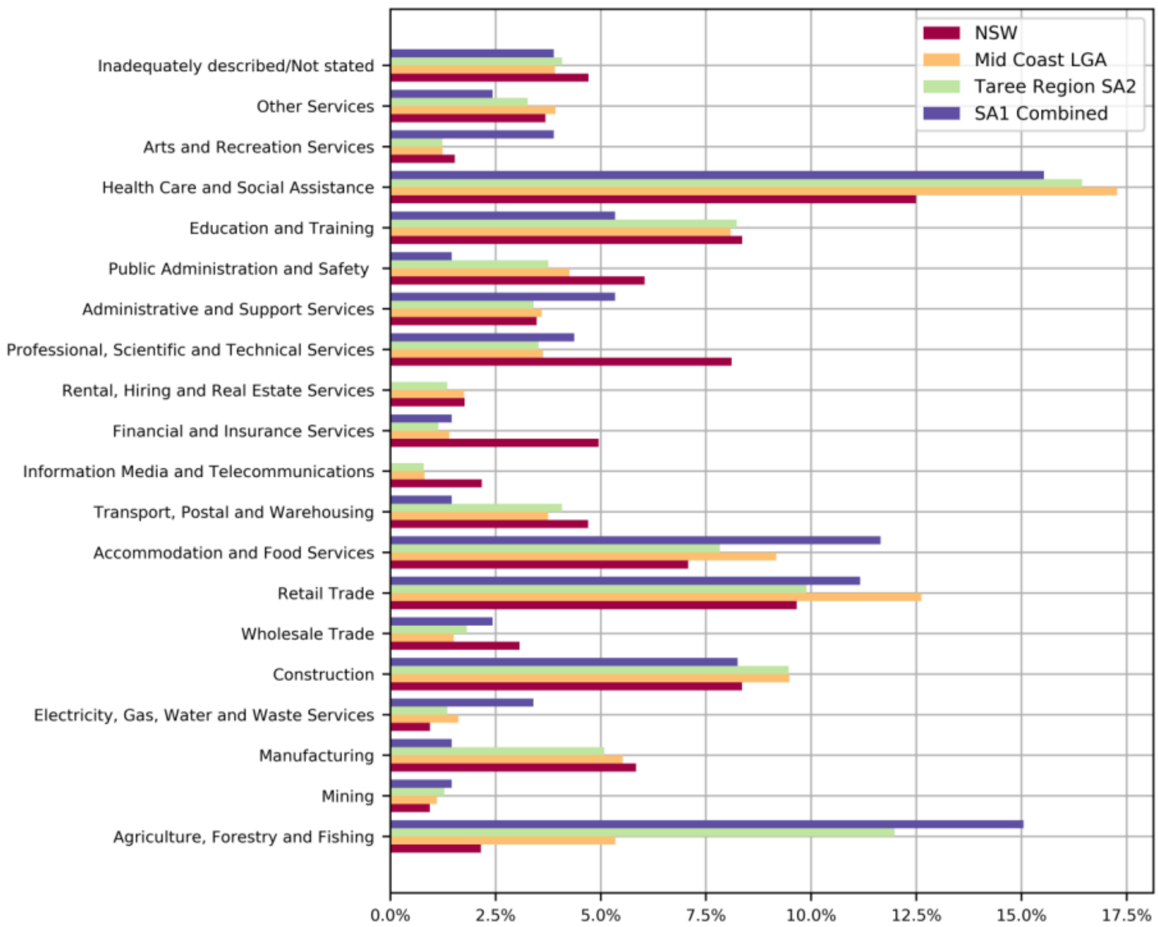

Figure A-9: Industry of employment by area

Table A-4: Median weekly earnings by industry (ABS, 2018)

Industry	Median weekly earnings
Agriculture, forestry and fishing	$ 944.51
Mining	$ 1,950.00
Manufacturing	$ 1,150.00
Electricity, gas, water and waste services	$ 1,500.00
Construction	$ 1,280.00
Wholesale trade	$ 1,141.24
Retail trade	$ 700.00
Accommodation and food services	$ 500.00
Transport, postal and warehousing	$ 1,182.67
Information media and telecommunications	$ 1,304.00
Financial and insurance services	$ 1,434.25
Rental, hiring and real estate services	$ 1,100.00
Professional, scientific and technical services	$ 1,380.00
Administrative and support services	$ 929.91
Public administration and safety	$ 1,411.44
Education and training	$ 1,150.00
Health care and social assistance	$ 1,000.00
Arts and recreation services	$ 699.00
Other services	$ 950.00

A.6.3 Occupation

Occupation is classified by the ABS using the Australian and New Zealand Standard Classification of Occupation (ANZSCO). The portion of the population in each area identified as each occupation, not including those who did not state their occupation, is provided in Figure A-10. The higher portion of people working as professionals across NSW compared to the areas around Big Swamp was consistent with the findings of the industry of employment above. The portion of the population who worked as labourers or community and personal service workers was higher in the areas around Big Swamp, when compared to the NSW population. These occupations are associated with lower weekly earnings than most other occupations, with the exception being sales workers, as provided in Table A-5.

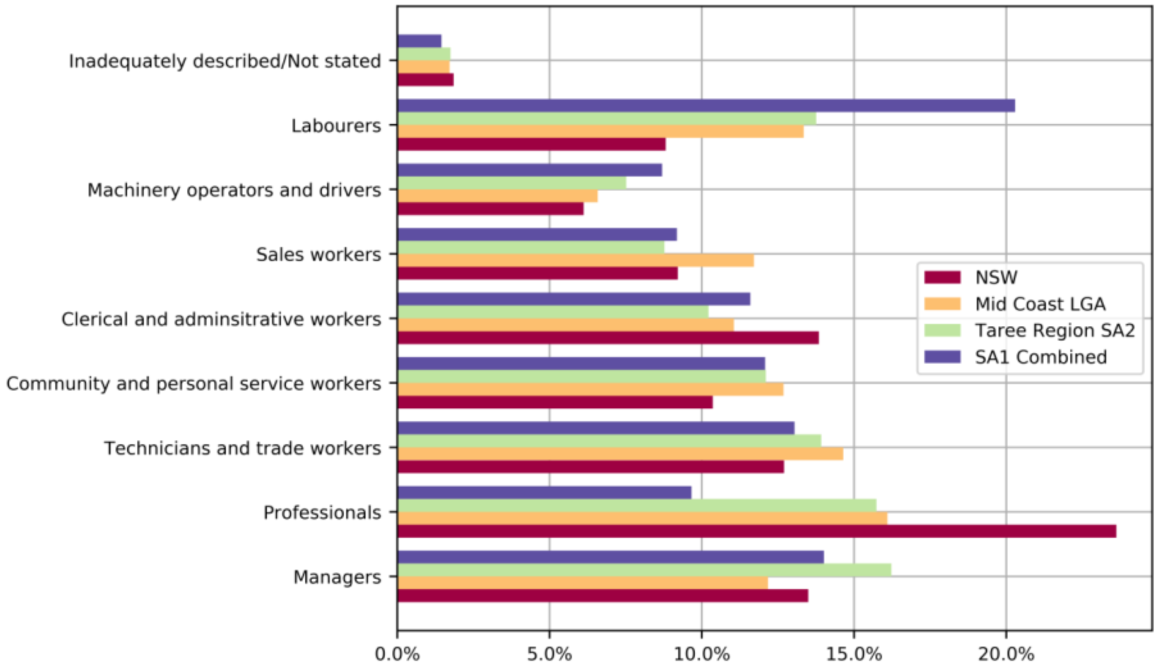

Figure A-10: Occupation by area

Table A-5: Median weekly cash earnings by occupation (Source: ABS, 2016 Census)

Occupation	Median Weekly Cash Earnings
Managers	$ 2,424.50
Professionals	$ 1,751.40
Technicians and trades workers	$ 1,421.70
Community and personal service workers	$ 815.90
Clerical and administrative workers	$ 1,087.80
Sales workers	$ 735.90
Machinery operators and drivers	$ 1,355.10
Labourers	$ 876.20
All occupations	**$ 1,288.70**

A.6.4 Income

Table A-6 shows that the median personal, household and family income in NSW significantly exceeded the incomes from the three (3) areas surrounding Big Swamp. Median personal incomes in the MidCoast LGA were slightly higher than the smaller SA2 and SA1 areas surrounding Big Swamp. The Coralville SA1, which was the smallest area considered, had the lowest weekly personal income at $381/week. Based on the findings above, the lower income was a result of:

- Higher unemployment;
- Lower labour force participation rates;
- Lower levels of school education and non-school qualifications; and
- A higher portion of the population working in occupations and industries associated with smaller weekly earnings.

Table A-6: Median personal, household and family weekly income

	NSW	MidCoast LGA	Taree Region SA2	Moorland SA1	Coralville SA1
Median Personal Income	$664	$476	$455	$450	$381
Median Household Income	$1,486	$887	$887	$922	$875
Median Family Income	$1,780	$1,108	$1,078	$1,090	$924

Figure A-11 shows the portion of the population within certain earnings bands, but does not include those who did not state their earnings. The data showed that a higher portion of people in NSW (almost 11%) reported having nil or negative income, when compared to the MidCoast LGA. However, approximately 34% of the population of NSW earnt $1,000 or more per week, while only 17 – 18% of people in the MidCoast LGA, Taree Region SA2 and combined SA1 fell in this earnings bracket.

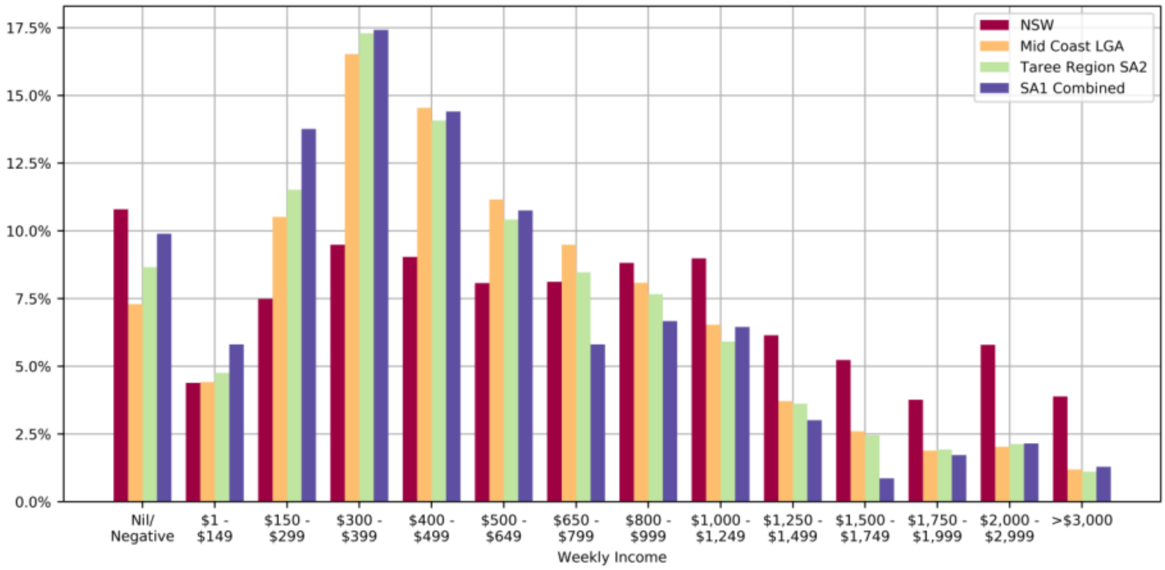

Figure A-11: Portion of the population within earnings bands in each area

A.7 SEIFA analysis

The ABS undertake a SEIFA (Socio-Economic Indexes for Areas) analysis to provide information on the relative socio-economic advantage and disadvantage across the country. The ABS define relative advantage and disadvantage as peoples access to material and social resources, and their ability to participate in society. For the purpose of this project, the Index of Relative Socio-Economic Advantage and Disadvantage (IRSAD) has been interrogated. Table A-7 summarises the attributes associated with relative advantage and disadvantage within the index. A low IRSAD score indicates greater relative disadvantage, while a high score indicates higher relative advantage. In this project, instead of showing the raw IRSAD score, which has little physical meaning, the percentile of the score nationally has been considered. A 10th percentile score indicates the IRSAD is in the bottom 10% of the country (relatively disadvantaged), while a 90th percentile score indicates the areas ranks higher than 90% of the nation (relatively advantaged).

Figure A-12 and Table A-8 summarise the IRSAD scores and percentile rankings for the ABS SA2 areas surrounding Big Swamp. The Taree region SA2 area was ranked in the bottom 20th percentile nationally, meaning it was relatively disadvantaged, and received a IRSAD score similar to the greater MidCoast LGA. However, the nearby more urbanised areas of Taree and Wingham are ranked in the 5th and 6th percentile respectively, and were considered more disadvantaged than the Taree Region SA2 area. The coastal areas of Old Bar – Manning Point – Red Head, south of Big Swamp were relatively more advantaged than the surrounding areas, although still ranked in the bottom 40th percentile of the country for relative advantage and disadvantage.

In terms of the smaller SA1 areas, the Coralville area received an IRSAD that was comparable to the MidCoast LGA and Taree Region SA2 area. However, the adjacent Moorland SA1 area was ranked as considerably more disadvantaged (bottom 9th percentile nationally) compared to the surrounding areas.

Table A-7: Attributes associated with relative advantage and disadvantage for IRSAD (ABS, 2018a)

Relative Advantage	Relative Disadvantage
Associated with: • Percentage earnings above $78,000 pa • Percentage of occupied dwellings with mortgage repayments exceeding $2,800 per month • Percentage of occupied dwellings with rent exceeding $470 per week • Percentage of occupied dwellings with 4 or more bedrooms • Percentage employed as 'Professionals' • Percentage of population over 15 years in tertiary education	Associated with: • Percentage earnings below $26,000 pa • Percentage whose highest level of education is year 11 or lower • Percentage employed as 'Labourers' or 'Machinery operators or drivers' or 'Low skill community and personal service workers' or 'Low skill sales' • Percentage of occupied dwellings with no internet connection • Percentage of families with children under 15 who live with jobless parents • Percentage of population under 70 with long-term health condition or disability that need assistance • Unemployment • Percentage of single parent families • Percentage of occupied dwellings with rent less than $215 per week • Percentage of population (over 15) who are separated or divorced • Percentage of population whose highest level of education is a Certificate III or IV • Percentage of people aged over 15 with no educational obtainment • Percentage of occupied dwellings with no cars • Percentage of occupied dwellings requiring one or more extra bedrooms

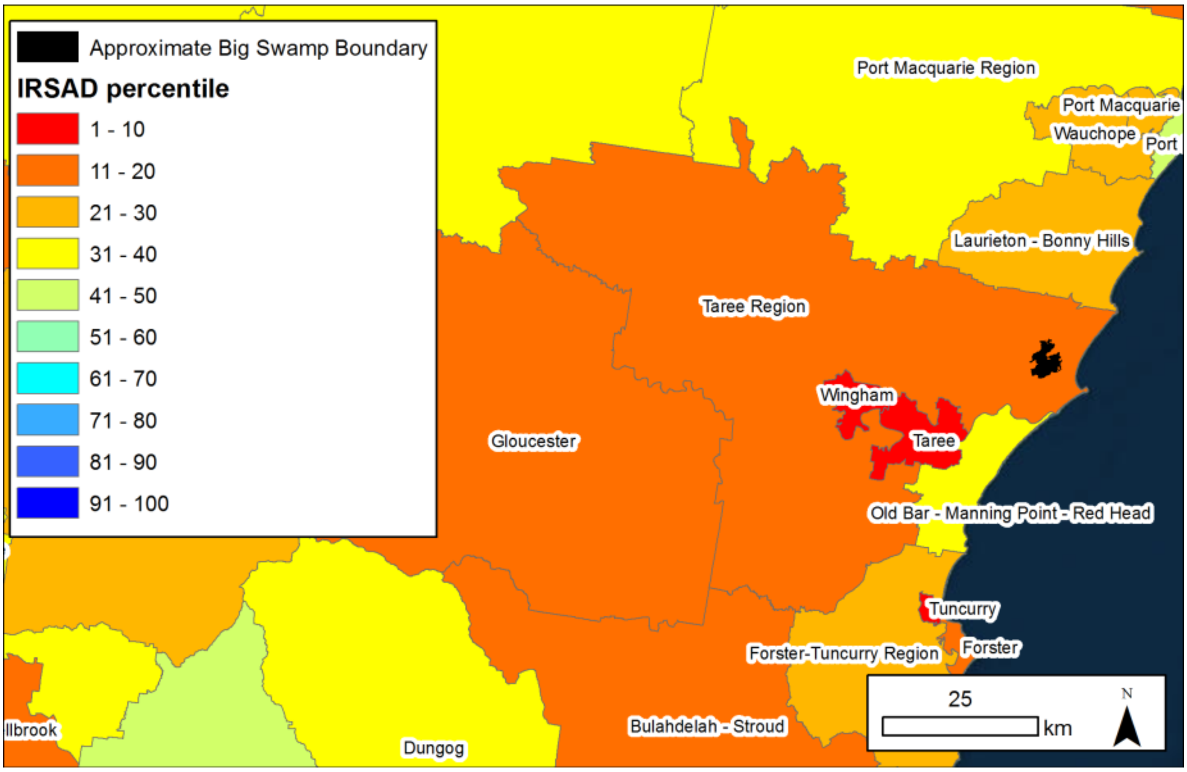

Figure A-12: IRSAD for SA2 areas around Big Swamp

Table A-8: IRSAD percentiles for the relevant areas

Area	IRSAD Score	IRSAD Percentile*
MidCoast LGA	911	19
Taree Region SA2	926	20
Taree SA2	867	5
Wingham SA2	875	6
Moorland SA1	859	9
Coralville SA1	923	22

* Note that percentile relates to national rankings of the appropriate areas
(i.e. LGA are compared separately to SA2 areas etc)

Appendix B Environmental profile

B.1 Preamble

This section provides an overview of the environmental profile for the Big Swamp floodplain, both in its existing state and under an assumed 'remediated' scenario.

B.2 Option 1 – Business as usual

The Big Swamp floodplain was once a shallow freshwater wetland. However, in the late 1800s, the Big Swamp Drainage Scheme commenced and included the construction of Pipeclay canal, a 6.5 km long and 1.2 m deep artificial drain that runs the length of the Big Swamp floodplain. The intention of this program was to promote rapid drainage and allow for agricultural production on the floodplain. Ultimately, this drain was insufficient to provide adequate drainage, and subsequently numerous smaller drains and floodgates were constructed across the floodplain to reduce inundation. Johnston (2007) reported that Big Swamp is one of the most intensively drained sites in NSW.

An un-foreseen impact of the intensive drainage was the exposure acid sulfate soils (ASS), which are naturally occurring in many estuaries in NSW. ASS are inactive when they are not exposed to oxygen, such as when they are permanently underwater. However, when these soils are exposed to the air and atmospheric oxygen, a chemical process occurs, called oxidation, which results in the production of sulfuric acid.

ASS exposed to oxygen readily acidify the groundwater and surrounding surface waters. The impacts of ASS on the environment are well documented and include (DECCW, 2008):

- Habitat degradation;
- Fish kills;
- Outbreaks of fish disease;
- Reduced resources for aquatic food;
- Reduced ability for fish to migrate;
- Reduced recruitment of fish;
- Changes to communities of water plants;
- Weed invasion by acid tolerant plants;
- Corrosion of engineering structures; and
- Indirect degradation of water quality.

A study by Dove (2003) showed that oyster production in the Manning River was regularly impacted by acidic discharges attributed to active ASS throughout the Manning Valley, including discharges originating from the Big Swamp floodplain. This study concluded that ASS affected water dramatically reduced oyster growth, when compared to unaffected areas. Glamore et al*.,* (2016) identified Big Swamp as one of the top three (3) contributors of acid flux to Manning River estuary and one of the highest priority areas to target remediation works.

Today, the majority of Big Swamp, including the private property which is the focus of this analysis, remains an extensively drained and cleared floodplain area that is primarily used for cattle grazing (largely dairy, with some beef cattle). The vegetation in the water ways is minimised for flood mitigation purposes and is cleared on the majority of the floodplain. Native flora and fauna other than grass land typically does not flourish due to the presence of cattle and acidic top soils.

A discussion of the value of the current environment is provided in Appendix C .

B.3 Option 2 – Remediate floodplain

In 2014, approximately 240 ha of the Big Swamp floodplain was remediated. While there is presently no detailed plan for the remediation of the remaining private property on the Big Swamp floodplain, it is assumed that the remediation works would be designed to best mitigate the impacts of ASS and would follow a strategy similar to existing remediated areas on the floodplain. Note that under a remediation scenario, the expected changes to vegetation on the surrounding private property would be based on elevations from publicly available LIDAR data.

The primary strategy to remediate the lowest lying areas of the private property would be to allow tidal flushing over the landscape. Bicarbonates that are naturally occurring in marine water are able to neutralise acidic water. In addition, by allowing tidal inundation the ASS remain in an anaerobic (low oxygen) environment which prevents the further activation and release of acid. This remediation technique was successfully applied on the first stage of remediation at Big Swamp.

Hitchings (2014) undertook a study to predict the type of coastal wetland vegetation that could be expected at Big Swamp based on tidal elevations and other similar coastal wetlands, including the Cattai Wetlands and Yarrahapinni Wetlands, as provided in Table B-1. The findings in Hitchings (2014) were also consistent with the findings of Ruprecht et al. (2017), who looked at mangrove and saltmarsh habitat in relation to tidal planes in the lower Hunter River. It is worth noting that recent vegetation surveys at Big Swamp (Ruprecht et al., 2017) showed that the vegetation changes onsite were consistent with the predictions made by Hitchings (2014).

Table B-1: Simplified results for expected vegetation at Big Swamp (after Hitchings, 2014)

Elevation (m AHD)	Expected Species
0.4 -0.5	mangroves, with some saltmarshes
0.5 – 0.6	mangroves transitioning to saltmarshes
0.6 – 0.8	saltmarshes, with some casuarinas, melaleucas and mangroves
0.8 – 0.9	saltmarshes transitioning to more fringing species

As tidal wetlands provide an effective remediation technique for mitigating the impacts of ASS, it was reasonable to assume that saltmarsh and mangroves would naturally return and inhabit suitable areas of the remediated areas of the floodplain. Based on this information, it was assumed that all areas below 0.6 m AHD would be colonised by mangroves, while the areas that lie from 0.6 to 0.9 m AHD would predominately become saltmarsh habitat. Note that there was limited available information on the exact type of vegetation that could exist above 0.9 m AHD. However, areas above 0.9 m AHD are likely to be above the tidal limit in the wetland, and were not expected to result in saltwater or brackish wetlands like those described by Hitchings (2014).

Further, it is expected that freshwater wetlands would be promoted in the upper sections (or high elevation areas) of the floodplain as permanent inundation by freshwater still provides some mitigation capacity to address ASS issues. Freshwater wetlands can address ASS issues through dilution of acidic water or the creation of sulfate-reducing environments during prolonged inundation. Freshwater wetlands can be created through the re-direction of catchment inflows throughout the floodplain, which could be targeted in the design of the remediation works.

For the purpose of the cost benefit analysis, floodplain areas from 0.9 to 1.2 m AHD would be assumed to be freshwater wetlands. Note that the flood mitigation capacity of the existing drainage system was assumed to remain un-changed for the areas above 2 m AHD (that is, outside the nominal Big Swamp boundaries), and a buffer zone from 1.2 to 2.0 m AHD is expected to be included in the design of the remediation. It was assumed that there would be minimal attempts to remediate these areas and wetland ecosystems would not be actively encouraged. While the vegetation in these areas are expected to change gradually due to the removal of cattle, it was assumed to remain similar to the existing grazing land.

Figure B-1 shows the areas of the private property that lie in each of the relevant elevation ranges. The assumed areas attributed to each vegetation type under a remediation scenario is summarised in Table B-2. For this project, it was assumed that this vegetation distribution could be achieved, while maintaining adequate drainage on the remaining privately owned land on the floodplain. This could be achieved through careful design and manipulation of the existing drainage network and, if necessary, construction of additional levees and flow control structures. It is expected that the remediation works would not only result in an increase in environmentally productive habitat, but would also reduce the impact of ASS drainage from the Big Swamp floodplain. Note that there has been no allowances for expected sea level rise in this environmental profile. Increases in sea level are likely to increase the maximum tidal level that is able to reach the Big Swamp floodplain.

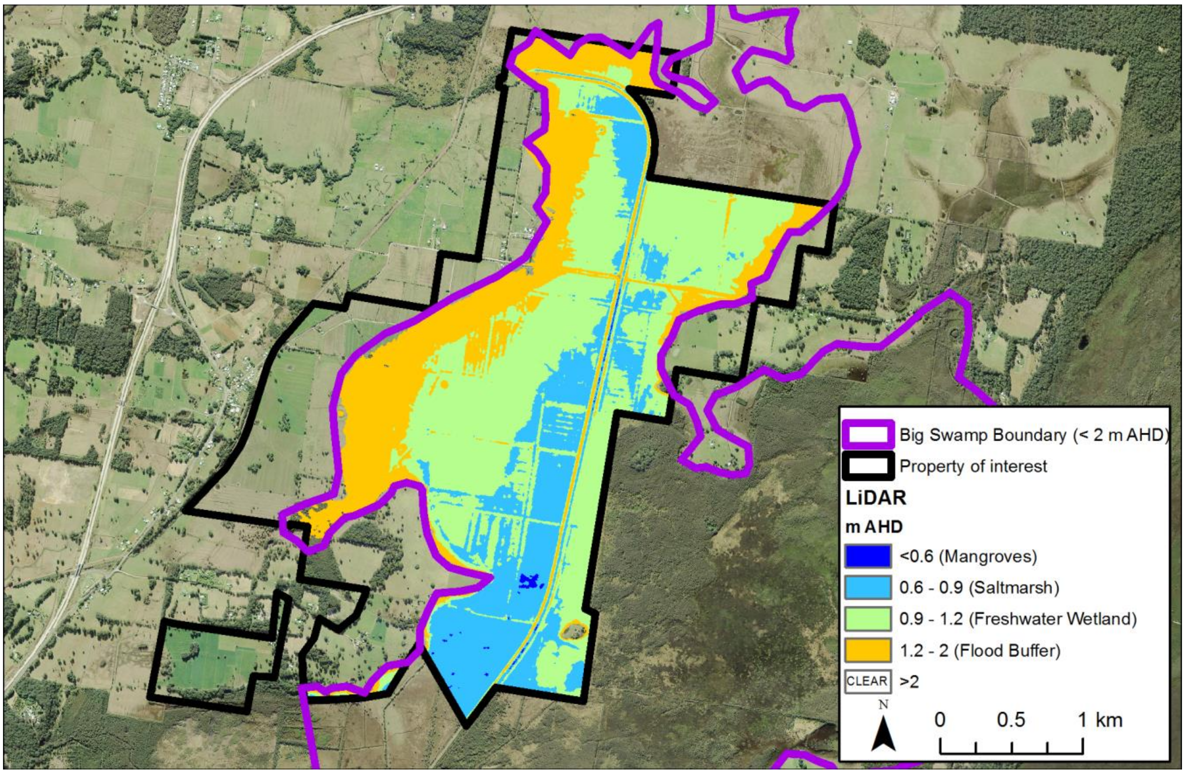

Figure B-1: Expected vegetation based on elevations on the Private property

Table B-2: Areas for different vegetation types

Elevation (m AHD) Vegetation Type	Area of Private Property (ha)
<0.6 m AHD Mangroves	2
0.6 – 0.9 m AHD Saltmarsh	158
0.9 – 1.2 m AHD Freshwater Wetland/Grassland	305
1.2 – 2 m AHD Flood buffer/Grassland	183
>2 m AHD Agricultural land use maintained	355

Appendix C Valuations and assumptions

C.1 Preamble

This section summarises the values adopted for the CBA, including a discussion of the required assumptions. A key concept in this project is the idea of ecosystem services, or the benefits of natural capital to human societies. As this is an emerging field that has only recently gained significance in decision making, a general overview of the concept is also provided in this section. All values in this section have been converted to present day Australian dollars, unless otherwise specified.

C.2 Ecosystem services

Environmental resources and natural capital has historically been largely left out of economic decision making, as they are not generally bought or sold in traditional markets, and are therefore difficult to monetise. However, there is an increasing awareness that natural capital interacts with human environments and provides a positive contribution to human welfare.

Ecosystem services is the term used by economists to refer to the "benefits people obtain from ecosystems" (MEA, 2005), including both the direct and indirect contributions of ecosystems to human welfare (Costanza et al., 1997). These services are typically categorised into one of three (3) types of services, summarised in Table C-1.

Table C-1: Types of ecosystems services (adapted from Haines-Young and Potschin, 2018)

Service Type	Definition	Example services
Provisioning	Products derived from ecosystems	Food, freshwater, fuel
Regulation and Maintenance	Benefits derived from the regulating capacity of ecosystems processes	Flood mitigation, climate regulation, disease control, erosion control, carbon sequestration
Cultural	Non-material benefits from ecosystems	Recreational use, spiritual or cultural value

There is an increasing body of research that will provide a monetary value for a variety of ecosystems across the world. Typically this research is targeted at valuing a particular service(s) (e.g. fisheries production or flood protection) from a specific type of ecosystem (e.g. coastal wetlands or oceans) at a single location. However, to utilise this information to assess the economic value of an alternative location (referred to as 'benefit transfer'), it is useful to aggregate the literature to get the total economic value of each system. This results in a single value per ecosystem type that represents the total human benefits. De Groot et al., (2012) provided a summary of over 1,350 value estimates from over 320 publications around the world, which they published in a database referred to as the "Ecosystem Service Value Database" (ESVD, Van der Ploeg et al., 2010). The ESVD includes information on 10 different types of ecosystems and values for 22 different types of ecosystem services, which were aggregated, and the mean and median values are provided in Table C-2.

Table C-2: Total mean and median values for different types of ecosystems (in 2019 AUD/ha/yr, adapted from de Groot et al. (2012))

Ecosystem	No. of estimates	Total of mean values ($AUD/ha/yr)	Total of median values ($AUD/ha/yr)
Open oceans	14	$903	$248
Coral reefs	94	$649,153	$364,018
Coastal systems	28	$53,190	$49,222
Coastal wetlands	139	$356,559	$22,373
Inland wetlands	168	$47,240	$30,413
Rivers and lakes	15	$7,849	$7,244
Tropical forest	96	$9,683	$4,332
Temperate forest	58	$5,542	$2,073
Woodlands	21	$2,921	$2,800
Grasslands	32	$5,281	$4,963

Based on the median and mean values in Table C-2, for some ecosystems there is a wide variety of valuations in the literature. For this analysis, Australian-based literature has been used wherever possible, with reference to international research to ensure the values chosen are within reasonable bounds.

C.3 Option 1 – Business as usual

C.3.1 Agricultural value

ABS (2017) provides a gross value of agricultural commodities over many different regions across Australia, including the Taree Region SA2 (see Appendix A for details on the region size). Based on this data, the gross values of agricultural commodities in the area are summarised in Table C-3. Livestock (including both livestock products and slaughtered) account for more than 90% of the agricultural value in the region. This indicates that the average agricultural return in the region is representative of the return from the property of interest, which is used for livestock (specifically cattle grazing and primarily for dairy production).

Table C-3: 2015 - 2016 gross value of agricultural commodities in the Taree region SA2

Commodity	Gross values ($AUD)	Percentage of regional agricultural production
All agricultural commodities	$67,249,020	-
Livestock products - total	$37,779,877	56%
Livestock products – milk only	$25,758,207	38%
Livestock slaughtered and other disposals - total	$23,576,230	35%
Livestock slaughtered and other disposals – cattle and calves	$17,791,536	26%

Figure C-1 shows the land use in the Taree Region SA2. Approximately 40% of the area, covering a total area of 191,756 ha, is used for agriculture, including cropping, grazing, horticulture and intensive agricultural production. Based on this area, and the total gross value of agricultural commodities in the region, the local agricultural production value is estimated to be $350/ha/yr. This value has been adopted throughout the cost benefit analysis in this project and is the primary benefit associated with the Option 1.

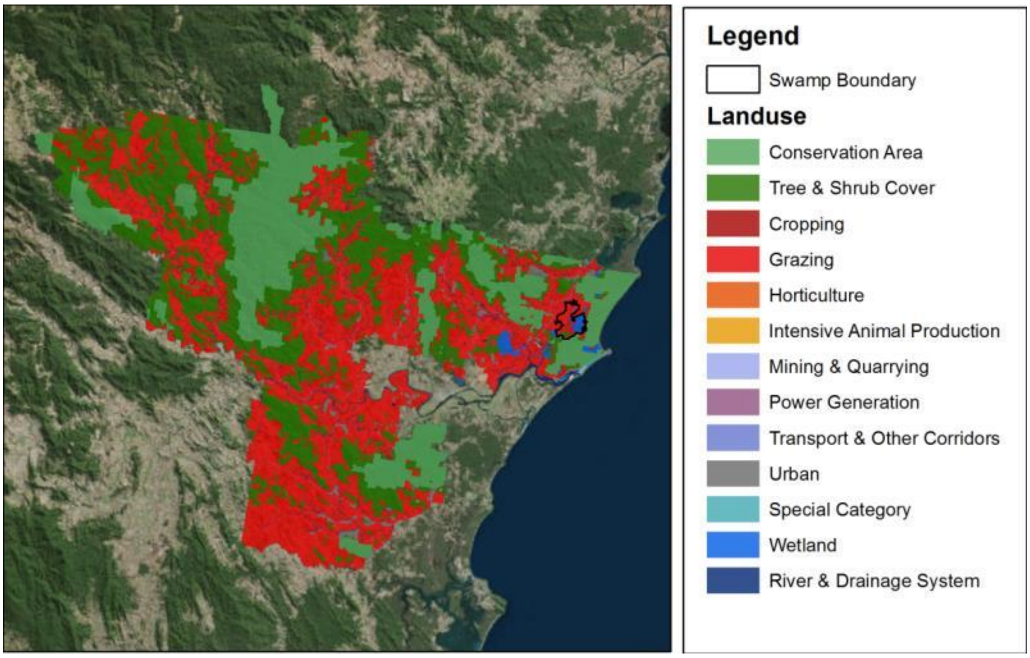

Figure C-1: Land use in the Taree Region SA2 Region

To provide a sensitivity to this value, the gross value of agricultural production and agricultural area was also interrogated for the Mid North Coast ABS SA4 region to obtain a regional value of up to $887/ha/yr . This will be used as an upper value in this analysis. It is assumed that the value of production generated from this property will remain the same throughout time.

C.3.2 Agricultural costs

Agricultural production incurs many costs, including the cost of feed, fertiliser, services and labour. ABARES (2018) provides data on the gross value of farm production and total farm costs aggregated across the country for the years 2013-14, 2014-15, 2015-16 and 2016-17, which is summarised in Table C-4. This shows that farm costs across Australia have been, on average, approximately 69% of the gross value of production.

Table C-4: Gross value of production and total farm costs across aggregated across Australia (ABARES, 2018)

Year	Gross Value of farm production ($ million)	Total farm costs ($ million)	Cost as a percentage of gross value
2013–14	51,464	37,957	74%
2014–15	54,387	38,441	71%
2015–16	56,554	38,516	68%
2016–17	61,629	39,828	65%

ABARES (2019) also developed an online tool (called ‘AgSurf’) which allows information on broadacre and dairy farm financial performance from 1990 to 2018 to be interrogated. Based on data from all NSW dairy farms, total farm cash costs have ranged between 66% and 93% of total cash receipts over the period 1990 – 2018, with both a mean and median of 78%. Cash costs typically do not account for the full labour costs associated with agriculture, as payment for family labour often does not reflect the amount of work done, so these costs do not reflect the total costs of operations. These values indicate that costs are typically higher (as a proportion of production value) than the average agricultural costs in Australia. AgSurf provides financial information for smaller sub-areas in the state for broadacre farms, but not for dairy farms, so it has not been considered.

Based on the AgSurf NSW dairy data, the agricultural costs would be assumed to be 78% of the agricultural benefits. Using the agricultural values for the Taree Region SA2 (discussed in section C.3.1) it was estimated that the costs of agricultural production in the region are approximately $273/ha/yr.

For the larger production value of the Mid North Coast SA4 region, the mean costs for Australian agricultural (as a percentage of the gross value of production) was adopted as approximately 69%, resulting in a cost of approximately $612/ha/yr.

C.3.3 Ecosystems services of existing land

Agricultural grazing land provides some environmental value which needs to be considered in this analysis. However, there is limited available literature that provides specific estimates for ecosystem services derived from grazing land similar to Australia, particularly those affected by ASS. Costanza et al*.* (2014) provided mean ecosystem services values for both croplands and grasslands based on the ESVD (see section C.2), categorised into 17 service sub-categories. As no single specific study provides an appropriate value for grazing land similar to that at Big Swamp, the mean values from a substantial body of literature provided the most reasonable approximation. By assessing each sub-category, and deciding whether or not it was applicable to the grazing land on the Big Swamp property, a value of $532/ha/yr, including the agricultural return for the value of food production (as calculated in section C.3.1) was adopted. The values and rationale are described in Table C-5.

C.3.4 Cost of acid sulfate soil on the Manning River Estuary health

The Big Swamp floodplain is a recognised 'hot-spot' for ASS and the environmental impacts of this legacy are well documented. The study area is prone to acidification and blackwater (low oxygen) events that not only impacts the floodplain environment, but also affects water quality in the lower Manning River estuary. Long-term surface water monitoring of the Big Swamp area shows that pH in Pipeclay Canal regularly falls below 4 after rainfall events.

Importantly, the impacts of ASS extend beyond the floodplain itself. Acid drainage from Big Swamp contributes to reduced water quality and reduced fish and oyster productivity in the lower Manning River, which imposes a cost to the local community. DPI (2007) showed that oysters in the Manning River that are exposed to the impacts of acid drainage have a significantly higher mortality rate (30 – 40%) after heavy rain, than oysters at a comparison site on the river.

However, Big Swamp is only one part of the active ASS floodplains on the Manning River. It is difficult to estimate the direct cost that acid drainage from Big Swamp has on the estuary compared to other adjacent areas, including Moto, or Ghinni Ghinni. Note that for the purpose of this study, no costs were included for the impacts of ASS on estuarine health. This means that the value of

Option 1 will be overestimated in the results of this project, resulting in a more conservative comparison with the remediation case.

Table C-5: Ecosystem services for grasslands and croplands, and application to Big Swamp (adapted from Costanza et al., 2014)

Ecosystem service sub-category	Grassland (average value $AUD/ha/yr)	Croplands (average value $AUD/ha/yr)	Assumed value at Big Swamp ($AUD/ha/yr)	Rationale
Gas Regulation	14	-	14	similar to grasslands
Climate Regulation	74	763	74	similar to grasslands
Disturbance Regulation	-	-	0	-
Water Regulation	5	25	0	presence of ASS, drained for grazing
Water Supply	93	619	0	highly drained, and presence of ASS
Erosion Control	68	166	0	cattle cause issues with erosion
Soil formation	824	3	0	presence of ASS
Nutrient Cycling	-	-	0	-
Waste treatment	116	615	0	presence of ASS, blackwater
Pollination	54	34	44	average of grasslands and croplands
Biological Control	48	51	50	average of grasslands and croplands
Habitat	1879	-	0	presence of domesticated animals
Food production	1845	3596	350	local estimate, see Section C.3.1
Raw Materials	84	339	0	largely cleared land for grazing
Genetic Resources	1879	1613	0	unlikely to be a unique source of genetic material due to poor soils and water quality
Recreation	40	127	0	privately owned
Cultural	259	-	0	privately owned

C.3.5 Summary of costs and benefits for Option 1

A summary of the costs and benefits of the option 1 is provided in Table C-6.

Table C-6: Summary of costs and benefits for the option 1

Variable	Cost/Benefit	Adopted value	Sensitivity test value
Agricultural Value	Benefit	$350/ha/yr	$887/ha/yr
Agricultural Costs	Cost	$240/ha/yr	$612/ha/yr
Ecosystem Services	Benefit	$182/ha/yr	-
Cost of ASS to estuary health	Cost	No costed	No costed

C.4 Option 2 – Remediate floodplain

C.4.1 Costs of works to date

As discussed previously, there is presently no detailed design for the remediation of the private property. However, based on previous on-ground works and an understanding of the site, some assumptions can be made regarding the on-ground works required.

MidCoast Council provided information on the cost of the remediation of the lower sections of Big Swamp, summarised in Table C-7. The remediation works completed, included the decommissioning of approximately 13 km of drainage system by removing floodgates, infilling or reshaping/swaling drains, and removing levees, as shown in Figure C-2. Further, Council estimated that they are currently spending approximately $40,000/year on monitoring and maintenance of the site.

Table C-7: Approximate on-ground costs to date (per comms, T Cross, MidCoast Council)

Item	Approximate cost to date
Project management	$250,000
On-ground works	$820,000
Technical studies and community engagement	$400,00

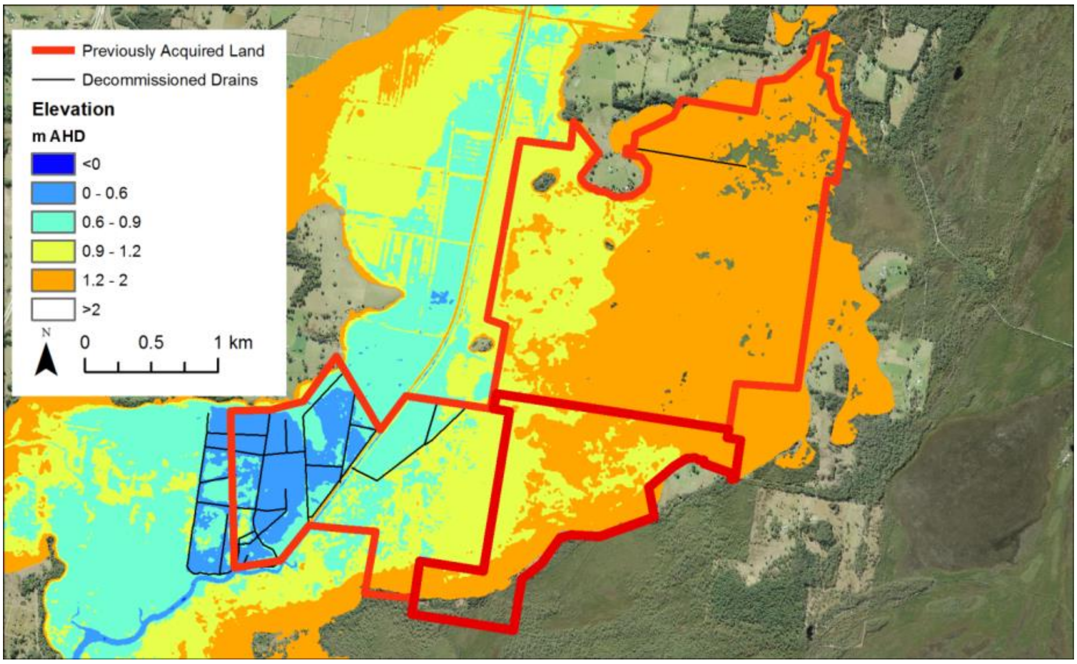

Figure C-2: Previous on-ground remediation works at Big Swamp

C.4.2 Acquisition costs

The private property under consideration in this project is approximately 1,000 ha in total, and is highlighted in Figure C-3. Council's current LEP identified the low-lying land on the Big Swamp floodplain as 'environmentally sensitive'. This allows for sub-division of the properties on the floodplain, as long as suitable plans for conservation and management are established for the low-lying areas. It was assumed that upon acquiring the proposed private property, Council would sub-divide the properties such that the areas above 2 m AHD can be re-sold, and the current agricultural land use continued. As such, the net change in ownership (from privately owned to publicly owned) would only include the 650 ha below 2 m AHD.

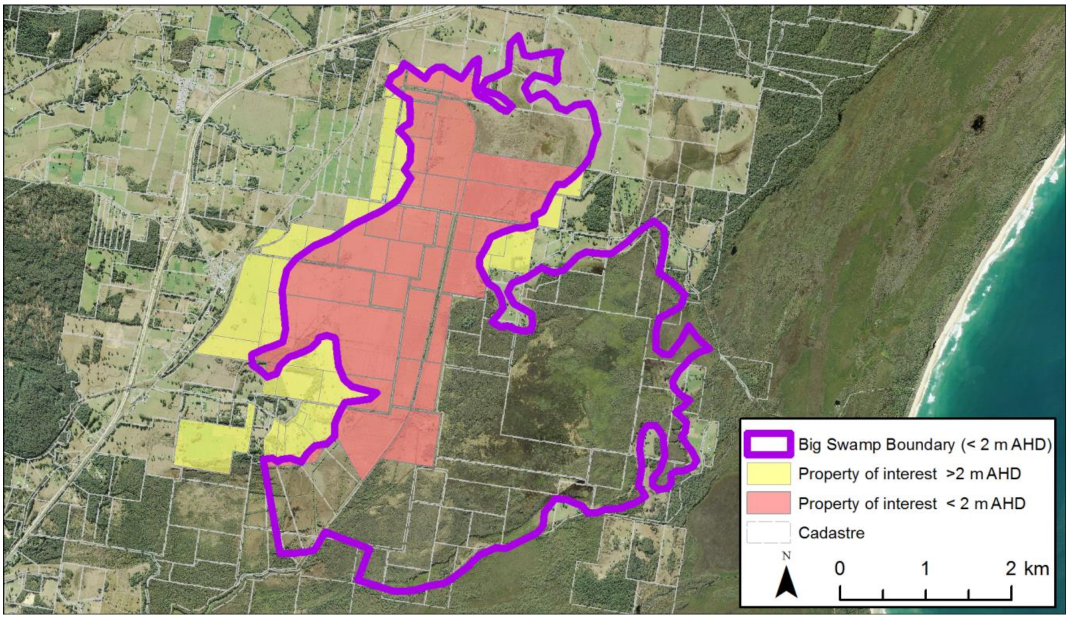

Figure C-3: Areas for land acquisition on the Big Swamp floodplain

The NSW Valuer General estimated the land value (without any improvements, including buildings and drainage) of the 1,000 ha at approximately $5,500,000, although Council representatives suggest that this may be an overestimate based on higher and more productive land throughout the region. While infrastructure on the site would increase the sale value above the land value, based on aerial imagery of the site, all buildings on these properties are situated on the high land above 2 m AHD, and current land practices would persist after the land was sub-divided. Infrastructure on the low-lying land is minimal and largely includes drains and small dam structures. An allowance for $200,000 for land improvements for the low-lying land was included in this study.

The cost benefit analysis focuses on net changes to wealth within the LGA. When the property is sold, there is typically no net change in total wealth, as the sale price is assumed to be equal to the worth of the property, particularly if the land use remains unchanged. In the case of Big Swamp, the cost of the land value is considered a ‘transfer’ in the cost benefit analysis and is not included in the analysis. Similarly, the total purchase price of the higher land (>2 m AHD), which will be re-sold to private owners, is also a transfer. The only net change in value results from the land improvements for the 650 ha of land that would be remediated. As a result, the net cost of land acquisition is assumed to be $200,000. The distributional impacts of these transactions is considered further in Section 6.

It is acknowledged that the blocks of land above 2 m AHD may be able to be further sub-divided and possibly sold for more than the valuation. However, further sub-division is likely to result in the requirement for the construction of additional roads, or road improvements, or other similar costs which would offset any increase in property value. Therefore, no net change in property prices was considered and decisions on further property sub-division may require additional analysis separate to this study.

C.4.3 Upfront costs – private property (excluding land acquisition)

The upfront costs of remediating the private property involve two (2) main components – the technical studies required, including hydrodynamic modelling and detailed design, and the on-ground works. To date, there have been several technical studies undertaken at Big Swamp that have led to the onsite remediation. While this work will contribute to the remediation of the rest of the floodplain, it was conservative to assume that technical studies of a similar magnitude would be required for the next stage of the remediation. Therefore, a total cost of $400,000 was assumed for additional technical studies and would occur in Year 0 of the remediation scenario. It was assumed that as part of the design, all Council assets (such as roads) would not require any changes as a result of the remediation works.

While the exact on-ground works are yet to be determined, it was assumed that infilling or major reshaping, including changes to levees would be required for each drain within the private property, as shown in Figure C-4. This is likely to be a conservative estimation, as some of these drains are small and shallow and may not require any modifications to achieve the remediation goals. Based on the remediation works previously completed, the cost of drainage modification was approximately $60,000/km of drain. Based on the drainage network provided in Figure C-4, there are a total of approximately 45 km of drains within the property of interest resulting in a total estimated costs of on-ground works of approximately $2,700,000.

In summary, the total upfront costs are estimated to be $3,100,000 for remediation, including both the technical studies and the on-ground works.

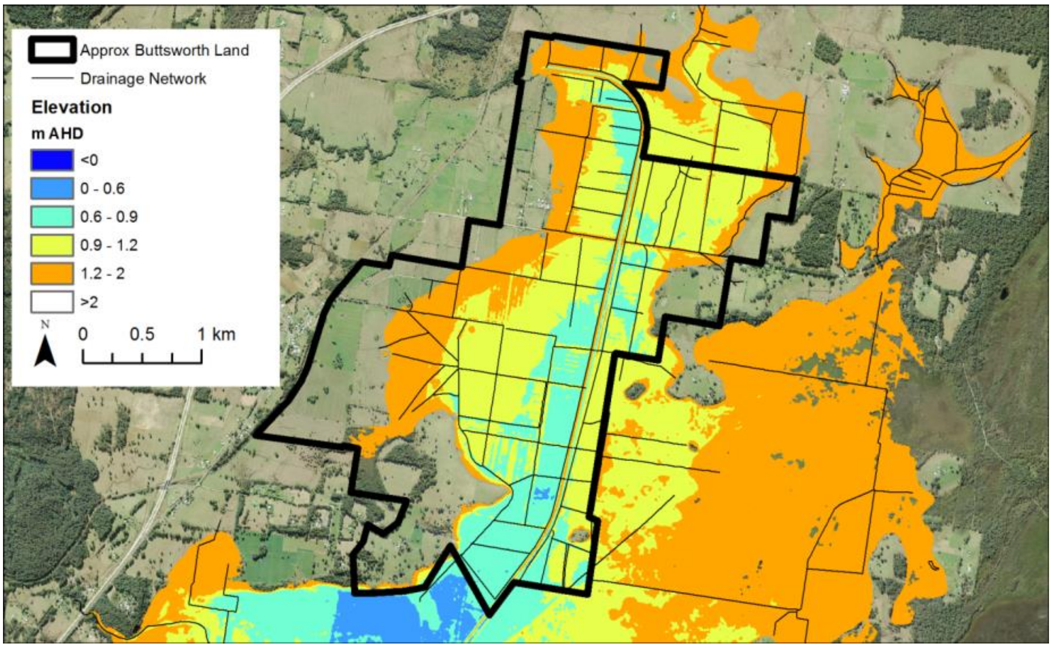

Figure C-4: Existing drainage system within the private property

C.4.4 On-going costs

There are two (2) types of on-going costs associated with the remediation scenario. The first is the project management cost throughout the duration of the remediation. MidCoast Council indicated that they have spent approximately $50,000 per year since the remediation works were completed at Big Swamp in 2014. It was assumed that this project management cost would be required for the remediation of the property of interest for the first five (5) years after on-ground works are completed, by which time significant changes should have been observed onsite, and the remediation work would require little or no additional work.

The other on-going costs are for maintenance and monitoring, and are expected to continue for the life span of the project. Council presently spends approximately $40,000 per year on the monitoring of water quality, vegetation surveys and fish surveys. It is anticipated that the current monitoring program would be expanded to cover a wider area of Big Swamp, for an additional annual cost of $20,000 per year. It was assumed that Council would continue monitoring to assess the effectiveness of remediation into the future. Maintenance would include maintaining the drainage network to ensure flood mitigation capacity and assessing and maintaining fire risks, which are estimated to cost approximately $30,000 per year indefinitely. In summary, on-going costs at Big Swamp under a remediation scenario were estimated to be $100,000 per year for the first five (5) years and $50,000 per year every year thereafter.

C.4.5 Ecosystem services of remediated land

An environmental profile of the remediated land was provided in Appendix B for the 648 ha of the low-lying private property. As a brief summary, approximately 158 ha of the land is assumed to be tidal saltmarsh, 300 ha is expected to be freshwater wetlands and the remaining land was assumed to remain in a similar state to the existing land (e.g. grassland) to maintain a flood buffer from any waterbodies. The values for ecosystem services adopted for each of these three areas are discussed throughout this section.

Tidal Marshes

Due to the presence of ASS in the lowest lying land at Big Swamp (the majority of which exists below 0.9 m AHD), the area predicted to be tidal wetland is likely to provide the greatest environmental benefits to the floodplain and wider Manning River estuary. A summary of the ecosystem services potentially provided by tidal marsh at Big Swamp is shown in Table C-8.

There is a significant body of literature that provides values for coastal wetlands and tidal marshes, some of which provide a value for a specific service (e.g. just the provisioning service), while others provide a total value, including all potential services. The ESVD includes 139 estimates of the value of ecosystem services from coastal wetlands, with estimates of the total value ranging from $552/ha/yr to over $1.6 million/ha/year depending on the location and estimates used (de Groot et al., 2012). The median value for coastal wetlands from the global literature compiled in the ESVD was found to be $22,373/ha/yr, while the average was significantly higher at $193,845/ha/yr.

A small number of Australian studies also provided the total value of tidal marshes. Blackwell (2007) estimated the total value of tidal marsh/mangrove ecosystems to be $24,528/ha/yr based on the work of Costanza et al. (1997), which is comparable to the median value in de Groot et al. (2012). The majority of this value (~67%) is due to the capacity for wastewater treatment which is relevant to Big Swamp (see Table C-8), while only $1,145/ha/yr is included for food production.

Table C-8: Ecosystems services provided by tidal marsh in remediation scenario

Service	Relative value	Type	Description and reference
ASS mitigation	High	Regulating	By encouraging tidal wetlands over the Big Swamp area, ASS impacts would be mitigated; both increased inundation times and the buffering capacity of bi-carbonates in marine water.
Fisheries production	High	Provisioning	Tidal wetlands are significant areas for fisheries, with almost 70% of commercially caught fisheries in eastern Australia spending some part of their life cycle in estuaries (Creighton, 2013).

			Saltmarsh in particular has been shown to be important to fisheries productivity in NSW estuaries (Taylor et al., 2018).
Waste treatment	High	Regulating	Wetlands have the capacity to remove significant amounts of nutrients (total phosphorus and total nitrogen) from catchment inflows. The Manning River estuary was assessed as being at 'moderate' pressure from nutrient input from the catchment, so additional natural treatment would be significant. This treatment capacity prevents nutrients from accumulating in the lower estuary, generally improving water quality and estuarine health.
Erosion control	High	Regulating/ Supporting	Tidal wetlands are associated with sediment retention and stabilisation that would reduce the total suspended solids delivered to the lower Manning River estuary. Removing cattle from the property would also reduce erosion. The Manning River estuary was assessed as being at 'high' pressure from sediment input, so additional natural reduction would be significant.
Biodiversity protection	High	Supporting	Wetland ecosystems are important to bio-diversity. Saltmarsh extent has been disappearing in NSW due to mangrove or urban encroachment, for example and is now recognised as an important ecosystem that could be supported at Big Swamp.
Fisheries nursery habitat	High	Supporting	Saltmarsh contributes directly to fisheries production, but also plays a supporting role in long-term fisheries nursery habitat.
Water	Moderate	Provisioning	Increase in groundwater and surface water levels, particularly during droughts, and the impact on increased water security on surrounding properties.
Carbon Sequestration	Low	Regulating	Salt marsh is recognised as an important ecosystem for carbon sequestration (Kelleway et al., 2005), which is important for regulating the climate.
Flood storage	Low	Regulating	Increased flood storage and mitigation of flood impacts associated with it.
Tourism/ Recreational fishing	Low/ Moderate	Cultural	There is potential for tourism within the Big Swamp area to be generated by the remediation, particularly if the area becomes habitat for migratory birds or provides significant recreational fishing opportunities. Recreational fishing in the lower Manning River estuary is also expected to improve.

Creighton (2013) undertook a study to assess the value of maintaining and improving estuarine ecosystems. The study provided a lower estimate for the total value of tidal marsh/mangrove ecosystems in eastern Australia than Blackwell (2007) of $12,392/ha/year, although there was no breakdown of the individual services in this study. A recent study by Bowe (2019) estimated the total value of saltmarsh to be equal to $39,792/ha/yr, of which over 50% is attributed to supporting services.

As an alternative to studies that assessed the total economic value of a wetland, the vast majority of literature values a single (or small number of) individual services provided by an environment, for example fisheries production, or erosion control. However, there are a limited number of studies that have undertaken these analysis for Australian coastal wetlands relevant to Big Swamp. Three (3) of the ecosystem services summarised in Table C-9 for the Big Swamp tidal marsh were readily quantifiable through Australian literature – fisheries production, waste treatment (but not ASS mitigation) and carbon sequestration. The values from Australian literature are summarised in Table C-9. Assessing the value of these three (3) services provides a way to assess the order of magnitude of the total value assessments from Blackwell (2007), Creighton (2013) and Bowe (2019).

Table C-9: Australian literature for individual ecosystem services of tidal wetlands

Service	Value ($)	Source
Fisheries production	4,904	Taylor et al. (2018)
Waste treatment	2,180	Schmidt (2008)
Carbon sequestration	25	Macreadie et al. (2017)

Saltmarsh is an important contributor to carbon sequestration in Australia (Kelleway et al., 2005). Macreadie et al. (2017) studied tidal marshes in Australia and estimated that these ecosystems sequester carbon at a rate of 75,477 tonnes of carbon per year over a total area of 13,825 km^2. By using unit rates for carbon from the Australian Clean Energy Regulator, the estimated value of carbon sequestration of saltmarsh in NSW is approximately $25/ha/yr, which is a similar to most values in the ESVD from international literature. The value for carbon sequestration is small compared to the benefits from fisheries production and is unlikely to greatly influence the total value of tidal marshes.

Morton (1990) provided an early estimate of the value of fisheries nurseries created by mangroves and coastal wetlands in Moreton Bay Queensland, valuing the fisheries production at $16,526/ha/yr. Taylor et al. (2018) estimated the gross value of fisheries production attributed to saltmarsh, including common fish species, crabs and school prawns for the Clarence and Hunter River estuary systems to be $4,904/ha/yr and $460/ha/yr respectively, with total economic output, including flow-on effects, estimated to be five (5) to six (6) times larger. Large differences between the two (2) estuaries were attributed to the warmer temperatures, greater waterway area, less regulated catchment flows and less urban and agricultural development (with associated pollutant runoff) in the Clarence region. The Manning River estuary has a similar level of development to the Clarence River, flow regulation is minimal and has a warmer climate than the Hunter River estuary, so the value for the Clarence River is considered more representative for this study. A fisheries production value of $4,904/ha/yr is significantly higher than the food provisioning benefit included in the total value stated by Blackwell (2007), and accounts for almost 40% of the total value specified by Creighton (2013). Note that these values only include commercial fisheries production, however it is likely that the saltmarsh also contributes to improvement in recreational fisheries as well.

Schmidt (2008) undertook an assessment of the economic value of the water filtration capacity of natural and constructed wetlands, based on dairy swamps in the Lower Murray in South Australia, however stated that the results are applicable to other wetlands across Australia. Values were determined based on the avoided cost of implementing water filtration plants instead of maintaining wetlands. This study stated that the filtration by natural wetlands that are permanently connected to the river system (assuming a 50% filtration efficiency) is worth $8,717/ha/year. Schmidt (2008) priced the filtration based on provision of domestic water supply, but suggested a factor of 0.25 to 0.5 could be applied to assess the value of clean water in excess of that used for domestic supply (e.g. for the improved swimming, boating or other recreational value in the wetland or downstream). While the increased inundation may improve water supply upstream by increasing groundwater levels in a drought, for the purpose of this project a factor of 0.25 was applied in the analysis to provide a conservative estimate for the filtration capacity of the Big Swamp tidal wetland area. The value adopted for wastewater treatment is therefore $2,180/ha/year. Note that this value does not include the improvements in water quality from the treatment of ASS and is substantially smaller than some estimates for wastewater treatment in international literature, and was considered conservative.

A recent study by Callaghan et al. (2019) showed that there was significant economic value from eco-tourism in the Manning Region as a result of migratory birds. This study showed that over 350 people visited the nearby area of Old Bar in 2017 after the sightings of *Aleutian Terns* (a species of migratory bird) were reported. These bird watchers were estimated to have spent over $200,000 in the local area over a short period. At this stage, it is difficult to forecast the potential habitat for migratory birds that might be created through the remediation of Big Swamp, but other similar sites (e.g. Tomago Wetlands in Newcastle) have seen a large increase in wader bird visitation as a result of on-ground works (WRL, 2016). While no specific value for tourism can be transferred to Big Swamp based on this study, it shows the potential for eco-tourism to have a significant value to the economy of the local government area as a result of improved habitats.

The ecosystem services of saltmarsh on the Big Swamp floodplain provided by carbon sequestration, fisheries production and wastewater treatment alone is conservatively estimated at $7,109/ha/yr, or almost 60% of the total value presented by Creighton (2013). Average values from the ESVD suggest that the additional services of erosion control and disturbance moderation (such as flood protection) provided by coastal wetlands alone provides another additional $17,000/ha/yr in benefits. Similarly, Bowe (2019) estimated that the supporting services from saltmarsh contributed over $20,000/ha/year. Given this information, and the median value in the coastal wetlands in the ESVD ($22,373/ha/yr), the total value estimate of Creighton (2013) is considered to be conservative and well suited for application at Big Swamp.

Based on Creighton (2013), a value of $12,392/ha/year was adopted for the ecosystem services provided by saltmarsh on the Big Swamp floodplain. However, because this value is likely to be conservative based on the value of individual services and international literature, a value of $24,528/ha/yr (based on Blackwell, 2007) was also considered in a sensitivity analysis. Both values were in the range of typical international literature in the ESVD and were appropriate considering Australian literature for the values of individual ecosystem services such as, fisheries production and wastewater treatment.

Freshwater wetland

The types of ecosystem services that would be generated from the remediated freshwater wetlands are similar to those described in Table C-9 for the tidal areas of the swamp. However, the types and extents of the ecosystems that may exist in the 300 ha of land that is expected to be freshwater wetland is more uncertain, as this area is higher than the parts of Big Swamp that have already been remediated. The value of this land would depend on how well the system can be designed to distribute catchment inflows to maintain the freshwater wetlands, and consequently made it more difficult to provide an accurate value for these ecosystems services.

To provide a conservative value of the ecosystem services generated by this area, the minimum total value for freshwater wetlands presented in the ESVD, $5,551/ha/yr, (Van der Ploeg et al., 2010) was adopted for this area. Note that this is more than five (5) times smaller than the median value of freshwater wetlands in the database and was considered suitably conservative given that it would still contribute to the mitigation of ASS and improvement of water quality, which is the primary aim of the remediation.

Flood buffer

It is not anticipated that any significant amount of works would be undertaken in the upper (>1.2 m AHD) area of the private property to maintain flood capacity to upstream properties. While vegetation on this land would naturally change over time when grazing is removed, this could take a substantial amount of time. To provide a conservative estimate value for the ecosystem services generated on this section of the land, the ecosystem services value used for Option 1 ($182/ha/yr, excluding gross agricultural production) was assumed to continue. This is likely to underestimate the environmental benefits of this area considerably as the removal of cattle would reduce nutrient and sediment export, encourage native vegetation to flourish and allow for native animals to inhabit the area.

C.4.6 Timing of ecosystem service benefits

Once on-ground works have been completed, the new ecosystems would take some time to develop from grasslands to tidal and freshwater wetlands. In other tidal wetland rehabilitation projects, changes to the hydrology through the removal or modification of flood mitigation structures has led to rapid changes in water quality, fish passage and bird visitation (WRL, 2016), although vegetation recruitment continues over a number of years (Russell et al., 2012). Monitoring of the lower section of the Big Swamp floodplain remediated in 2014 showed large changes in vegetation, improved water quality and increased fish passage after a period of three (3) years (Ruprecht et al., 2017). However, it also showed that the system is still changing and evolving. Saltmarsh and mangrove recruitment was occurring two (2) years after on-ground works were completed (Griffith, 2016). A fish survey at lower Big Swamp in 2017 showed numerous species of small fish within the drainage system, however acid drainage from the rest of the floodplain still caused large variations in water quality which often prevented a viable fish habitat throughout Pipeclay Canal.

For the purpose of this project, it was assumed that there was nil ecosystem services generated from the site for the first five (5) years, and following that the services would increase linearly for the next five (5) years. In this manner, the full ecosystem services would not be achieved until 10 years after on-ground works are completed. Allowing a five (5) year period without any realised ecosystem services is likely to be conservative based on changes observed at Big Swamp (Ruprecht et al., 2017) and changes at Tomago wetlands in the Hunter River estuary (Russell et al., 2012), both of which indicated that there was some immediate improvement in the environmental outcomes for remediated tidal wetlands.

C.4.7 Summary of costs and benefits for remediation

A summary of costs and benefits for the remediation scenario is provided in Table C-10.

Table C-10: Summary of cost and benefits for the remediation scenario (Option 2)

Variable	Cost/Benefit	Adopted Value	Sensitivity Test Value	Timing
Acquisition Cost	Cost	$200,000	-	Year 0
Construction Cost	Cost	$3,100,000	- (adopted value conservative)	Year 0
Project Management	Cost	$50,000/year	-	Years 1 - 5
Monitoring and Maintenance	Cost	$50,000/year	-	Indefinite after Year 1
Ecosystem services – tidal marsh	Benefit	$12,392/ha/yr	$24,528/ha/yr	Linearly increasing from year 5 to 10, then indefinitely
Ecosystem services – freshwater wetland	Benefit	$5,551/ha/yr	- (adopted value conservative)	Linearly increasing from year 5 to 10, then indefinitely
Ecosystem services – flood buffer	Benefit	$182/ha/yr	- (adopted value conservative)	Linearly increasing from year 5 to 10, then indefinitely