Sunwater: Rookwood Weir Project
EPBC 2009/5173
Water Quality (Nitrogen)
Offset Management Plan




earthtrade

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Prepared for: Sunwater

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Review and Approval

Role	Position	Name	Signature	Date
Reviewer	Environmental Manager	Michael Dixon	M R Dixon M R Dixon (Mar 27, 2024 09:52 GMT+10)	27/03/2024
Approver	Project Director Senior Project Manager	Inaki Goni Mark Cope	Mark Cope (Mar 27, 2024 09:54 GMT+10)	27/03/2024

ACKNOWLEDGEMENTS AND DISCLAIMER

This report should be cited as: *Sunwater: Rookwood Weir Project EPBC 2009/5173 Water Quality (Nitrogen) Offset Management Plan*

ACKNOWLEDGEMENTS:
This document has been prepared by Environmental Offset Solutions Pty Ltd t/a Earthtrade with support from Sunwater.

Table of contents

List of abbreviations

Abbreviation	Description
AEIS	Additional information to the EIS
AHD	Australian Height Datum
CHRC	Central Highlands Regional Council
CQU	Central Queensland University
DBC	detailed business case
DCCEEW	Department of Climate Change, Energy, the Environment and Water (Commonwealth)
DEM	Digital Elevation Model
DES	Department of Environment and Science (Qld)
EIS	Environmental Impact Statement
EOP	Environmental Offsets Policy (October 2012) (EPBC Act)
EPBC Act	*Environment Protection & Biodiversity Conservation Act 1999* (Cth)
FBA	Fitzroy Basin Association
FSL	Full Supply Level
FullCAM	Full Carbon Accounting Model
GAWB	Gladstone Area Water Board
GBR	Great Barrier Reef
GBRMP	Great Barrier Reef Marine Park
GBRWHA	Great Barrier Reef World Heritage Area
ha	Hectares
Horizon	Horizon Soil Science and Engineering
km	Kilometres
LFRIP	Lower Fitzroy Infrastructure Project
m	Metres
MNES	Matters of National Environmental Significance
NBP	Net Benefit Policy
OMP	Offset Management Plan
Project	Rookwood Weir Project
Reef 2050 Plan	*Reef 2050 Long-term Sustainability Plan* 2021-2025 (July 2021)
RL	Relative Level
RRC	Rockhampton Regional Council
RUSLE	Revised Universal Soil Loss Equation
SS	Suspended Solids

Abbreviation	Description
SRTM	Shuttle Radar Topography Mission
WQIP	*Reef 2050 Water Quality Improvement Plan 2017-2022*
WQMP	Water Quality Monitoring Program

Glossary

Term	Definition
business day	A day that is not a Saturday, a Sunday or a public holiday in the state or territory of the action.
compliance report/s	Written reports: a) providing accurate and complete details of compliance, incidents, and non-compliance with the conditions and plans; b) consistent with the Department's Annual Compliance Report Guidelines (2014) (or subsequent published revision); c) include a shapefile of any impact of any protected matters, or their habitat, undertaken within the relevant 12 month period; and d) identifying the version/s of the plans prepared and in existence in relation to the conditions of this approval during the relevant 12 month period.
Department	The Australian Government Department responsible for the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) from time to time.
Minister	The Minister administering the *Environment Protection and Biodiversity Conservation Act 1999*.
nutrients	Water quality parameters including Nitrogen and phosphorus.
Plan/s	Any of the documents required to be submitted to the Department, implemented by the approval holder and/or published on its website in accordance with the approval conditions.
riparian zone	The area within a minimum of 100 metres of the defining bank of any watercourse (as defined under the Queensland *Water Act 2000*).
site specific assessment/s	A baseline investigation which explains the scientific basis on which the description and location of impact/s and associated users, performance indicators, trigger values and limits have been derived, or not derived.
suitably qualified person	A person who has professional qualifications, training, skills and/or experience related to the nominated subject matter and can give authoritative independent assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods and/or literature.
suspended solids	Small solid particles which remain in suspension in water as a colloid or due to motion of the water. Suspended solids can be removed by sedimentation if their size or density is comparatively large, or by filtration. It is used as one indicator of water quality and of the strength of sewage, or wastewater in general.
water quality	Levels of pesticides and farm chemicals, nutrients such as phosphorus and Nitrogen, sediments and other suspended solids. A detrimental impact to water quality would be an increase in any of these parameters above established baselines.
website	A set of related web pages located under a single domain name attributed to the approval holder and available to the public.

Declaration

I declare that to the best of my knowledge, all the information contained in, or accompanying this document is complete, current and correct. I am duly authorised to sign this declaration on behalf of the proponent/approval holder. I am aware that:

a. *section 490 of the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) makes it an offence for an approval holder to provide information in response to an approval condition where the person is reckless as to whether the information is false or misleading.*
b. *section 491 of the EPBC Act makes it an offence for a person to provide information or documents to specified persons who are known by the person to be performing a duty or carrying out a function under the EPBC Act or the Environment Protection and Biodiversity Conservation Regulations 2000 (Cth) where the person knows the information or document is false or misleading.*
c. *the above offences are punishable on conviction by imprisonment, a fine or both.*

Signed: Chris Delamont (Mar 27, 2024 11:05 GMT+10)

Full name: Chris Delamont

Organisation: Sunwater Limited

EPBC Referral Number: EPBC 2009/5173

EPBC Offset Management Plan

Date: 27/03/2024

Executive summary

The Rookwood Weir Project (the **Project**) involves the construction of the new Rookwood Weir component of the Lower Fitzroy River Infrastructure Project (**LFRIP**). The LFRIP was approved by the Queensland Government's Coordinator General in December 2016 and the Australian Minister for the Environment in February 2017 (EPBC 2009/5173), subject to conditions.

Sunwater Limited (**Sunwater**) (ACN: 131 034 985; ABN: 17 020 276 523) is the sole proponent of the Project. Sunwater is a statutory government-owned corporation under the Queensland *Government Owned Corporations Act 1993*. Sunwater owns and operates the Queensland Government's bulk water supply and distribution infrastructure located throughout regional Queensland.

This Offset Management Plan (**OMP**) that has been prepared to meet the offset obligations and conditions for matters of national environmental significance (**MNES**) related to water quality (Nitrogen) under the approval given under the *Environment Protection and Biodiversity Conservation Act 1999* (**EPBC Act**). The Project was conditioned to offset nitrogen as the Fitzroy River, on which the Project is located, flows into the Great Barrier Reef World Heritage Area (**GBRWHA**). This OMP describes how the offsets for the potential increase of Nitrogen resulting from decaying vegetation in the inundation area will be delivered as per item vii in Condition 4 b) Table 1 of the approval. An overview of the nitrogen impact and the resultant offset requirement is provided in *Table 1*.

Other MNES impacted by the project include:

- Water quality impacting the GBRWHA, including;
    - nutrients, sediments, farm chemicals and/or other water quality parameters
- Terrestrial MNES, including.
    - threatened ecological community (TEC), being Brigalow (*Acacia harpophylla* dominant and co-dominant) (brigalow TEC);
    - flora species (black ironbox (*Eucalyptus raveretiana*)), and
    - one terrestrial fauna species (red goshawk (*Erythrotriorchis radiates)).*
- Aquatic fauna species (Fitzroy River Turtle).

Separate OMPs have been developed for each of these matters to address Condition 4 b) Table 1.

Detailed ecological surveys were undertaken in the inundation area of the Project and the quantum of Nitrogen resulting from decaying vegetation had been calculated using the full Carbon Accounting Model (**FullCAM**). The calculations and summarised methodology of this Nitrogen modelling is consistent with the approach accepted in the EIS that informed the EPBC Act and CG Conditions of Approval with a resultant target 358 tonnes included in the Rookwood Wier offset Strategy approved by DCCEEW in November 2022.

Subsequent to this a review of the initial FullCAM modelling was undertaken by Alluvium Consulting in May 2023 on behalf of Sunwater. This review resulted in a reduction of the estimated nitrogen amount (Refer to *Attachment 1)*. The modelling estimated a range for the amount nitrogen to be released in the first year of inundation from 30 – 267 tonnes depending on nitrogen content of the vegetation and the estimated decay rates. Based on the Alluvium Consulting review and endorsement of this modelling by the Office of Water Services within DCCEEW on 13 September 2023, Sunwater has adopted an offset target of 194 tonnes with

approximately 80% of this (158t) delivered within the first six years of the weir being commissioned and inundation occurring, and the remainder over an additional 4 years.

Sunwater's method to providing offsets for water quality (Nitrogen) is based on a two stage approach.

Stage 1 includes a streambank erosion protection and sediment interception project co-located with the Terrestrial Offsets for the project. A study has been undertaken at properties known as Foleyvale and Stoney Creek that are located on the Mackenzie River to confirm the suitability of the sites for streambank erosion protection and sediment interception projects. Stage 1 will be implemented on the approval of this OMP and the terrestrial offset OMP. Additionally Stage 1 will see the initiation of the water quality research work with Central Queensland University (CQU).

The delivery of offset components will be initiated as soon as reasonably practicable following the commencement of operations. Any components identified for delivery in Stage 2 that are able to commence in Stage 1 will be brought forward where possible to ensure the greatest amount of offset delivery is provided at the start of the project to match the potential impact from the inundation period.

Following the development of a Water Quality Offset Review Report to be compiled at end of the first year of operation, the remaining chosen offset programs assessed in the report shall be delivered in Stage 2. Following 2 years of operation of the weir and corresponding water quality data collection, an assessment of the nitrogen offset shall be conducted. A subsequent Water Quality Offset Review Report shall also be produced following the first five years of operation to assess the delivery of any residual offset amount required. This approach has been taken to ensure the most cost effective programs are chosen to deliver the greatest benefit to the Great Barrier Reef water quality. The assessed impacts to Nitrogen and planned offsets are summarised in *Table 1*.

Table 1: Summarised project impacts versus proposed offset outcomes

Matter	Impact	Offset component	Estimated reductions in Nitrogen (tonnes)
Nitrogen (Potential impact on the Great Barrier Reef due to Rookwood Weir inundation area)	194 tonnes	Foleyvale / Stoney Creek Sediment interception/reduction and streambank erosion protection	6.8 t/annum
		Central Queensland University Water Quality Research Projects	18t
		Streambank Rehabilitation	9.1t/annum
		Weed Harvesting	10t/annum
		Landcare Program	1t/annum
		In Stream Structure Dredging	TBA
		Financial Contribution eg Reef Credit Schemes	As required

This OMP demonstrates that the proposed Nitrogen offset projects meet the principles of the EPBC Act Environmental Offsets Policy (**EOP**) and is a suitable offset for approved increases in

water Nitrogen levels resulting from the Rookwood Weir Project. The plan utilises the findings of the studies from both the impact site and the offset projects to outline how the offset obligations under the EOP are addressed. The plan demonstrates that the proposed offsets are suitable to meet all the EOP requirements and the approval conditions.

Sunwater commits to the implementation of this OMP.

Part A: Project Details and Impact

1 Introduction

1.1 Project description

The Rookwood Weir Project (the **Project**) involves the construction of the new Rookwood Weir component of the Lower Fitzroy River Infrastructure Project (**LFRIP**). The LFRIP was approved by the Queensland Government's Coordinator-General in December 2016 and the Australian Minister for the Environment in February 2017 (EPBC 2009/5173), subject to conditions.

The LFRIP included the construction and operation of a new weir at Rookwood and the existing Eden Bann Weir on the Fitzroy River in Central Queensland. A staged development process was proposed for both weirs comprising two stages:

- Rookwood Stage 1: mass concrete weir to a full supply level (**FSL**) of 45.5m
- Rookwood Stage 2: addition of 3.5m high flap gates to FSL 49.0m
- Eden Bann Stage 2: raising of the existing structure to FSL 18.2m
- Eden Bann Stage 3: addition of 2m high flap gates to FSL 20.2m.

Following approval of the environmental impact statement (**EIS**), in late 2017, Sunwater and the Gladstone Area Water Board (**GAWB**), in partnership with Building Queensland, completed the detailed business case (**DBC**) for construction of Rookwood Weir Stage 2 (**RW2**). Both State and Federal governments agreed in principle to jointly fund RW2 on a 50:50 basis. In mid-2018, the State Government advised that Sunwater would continue as the sole preferred proponent for the Project and to continue with preparatory activities that had previously commenced under the joint venture agreement between Sunwater and GAWB.

In parallel with the preparatory works, a budget review was undertaken using the detailed design. This review indicated that project costs had increased beyond those outlined in the DBC and exceeded the funding commitments by the State and Australian Governments. Sunwater was directed by the Queensland Department of Natural Resources, Mines and Energy (now the Department of Regional Development, Manufacturing and Water) to work within the approved budget. This necessitated investigating an un-gated solution analogous to Stage 1 as outlined in the EIS. The outcomes of this investigation identified that RW2 would exceed the budget outlined in the DBC and Sunwater was directed to proceed with Rookwood Stage 1 to be delivered under an alliance arrangement, and jointly funded by the Australian and Queensland Governments. During this time, an optimisation assessment was undertaken in consultation with both the Queensland and Australian Governments to assess the most economically viable weir height. The assessment identified a raising of the weir by 700mm to relative level (**RL**) 46.2m Australian Height Datum (**AHD**). All impacts outlined in this OMP are those resulting from a weir height of RL 46.2m AHD. This is less than the maximum assessed in the EIS that was approved by the Queensland and Australian Governments.

Sunwater have not progressed updating the Eden Bann Raising Business Case and it is not currently on the list of projects to be further developed in the current horizon, and is instead on the list of possible projects to be considered in 2-5 years from now.

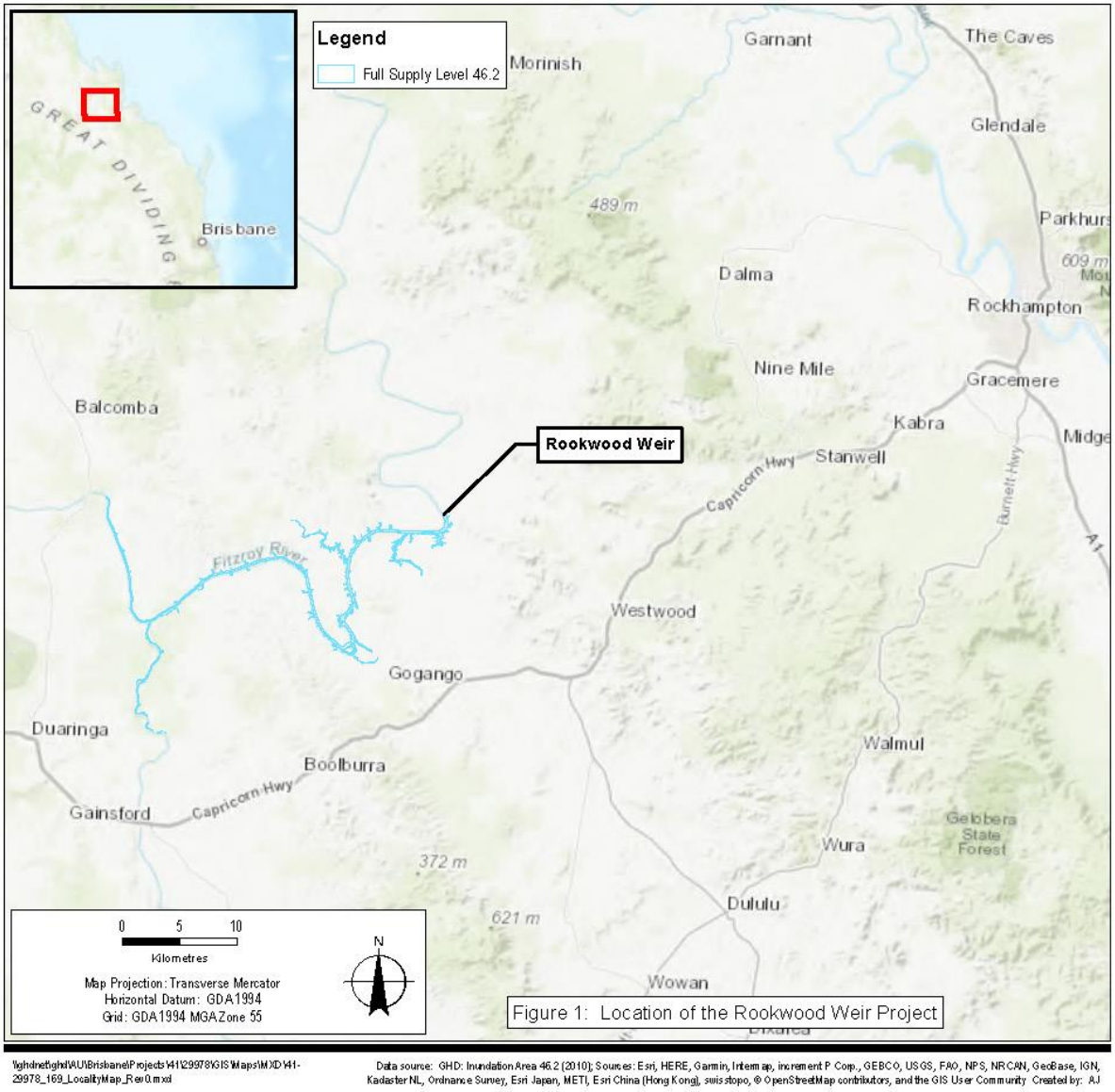
1.1.1 Project location

The Rookwood Weir is located on the lower Fitzroy River, within the Fitzroy sub-catchment, central Queensland (refer to *Figure 1*). The Fitzroy River forms at the confluence of the Mackenzie River (flowing from the north) and Dawson River (flowing from the south) and flows

out into the Coral Sea. This is where the Great Barrier Reef World Heritage Area (**GBRWHA**) and the Great Barrier Reef Marine Park (**GBRMP**) are located.

The Fitzroy River passes through the city of Rockhampton, which lies approximately 59 kilometres (**km**) from the mouth of the Fitzroy River. The Rookwood Weir Project is located within the Brigalow Belt bioregion, Mount Morgan Ranges subregion.

Figure 1: Project location



1.1.2 Rookwood Weir

The Rookwood Weir is a ‘greenfield’ development near Rookwood Crossing on the Fitzroy River.

Key project components include:

1. Constructing a new weir at Rookwood to capture and store water resources to an approximate height of RL 46.2 metres (**m**) AHD
2. Constructing turtle- and fish-passage infrastructure to facilitate movement of turtles and fish around Rookwood Weir

3. Replacing the low-level crossing at Riverslea with a new bridge and associated road approaches up-stream of the weir
4. Upgrading the low level and existing culvert crossing at Hanrahans Crossing downstream of the weir
5. Upgrading public roads (state and local) to facilitate construction traffic along Thirsty Creek Road (a local road) from the Capricorn Highway (including the intersection with the state-controlled road) at Gogango.
6. Upgrading the low level and existing culvert crossing at Foleyvale Crossing upstream of the weir

The development of weir infrastructure (and associated works) and the resultant storage of water (inundation of the riverbed and banks), as shown at Item 1 in the list above are the only project components that will have an impact to water quality Nitrogen levels, which comprises the scope of this OMP. The Rookwood Weir Project does not include water delivery infrastructure (e.g. pipelines) to supply water to users.

1.2 Purpose and objectives of this management plan

The purpose of this OMP is to address Condition 5 of EPBC 2009/5173 approval dated 27 July 2021, specifically relating to water quality (Nitrogen) offsets.. The requirements are provided in *Table 2*, and the OMP reference section is also provided.

The outcomes of this OMP are measurable improvements in water quality through the interception of Nitrogen. These improvements are defined in detail in *Section 10* of this document (Offset completion criteria and performance targets).

Table 2: EPBC Approval conditions for offsets addressed in this document

<table>
<tr><th>Condition</th><th></th><th>OMP section or comment</th></tr>
<tr><td colspan="3">Offset Strategy</td></tr>
<tr><td colspan="2">4. b) Table 1</td><td rowspan="3">Approved Offset Strategy</td></tr>
<tr><td>vii. any increase in nitrogen due to decaying vegetation in the inundation area</td><td>At least 645 tonnes</td></tr>
<tr><td></td><td>Unless the monitoring required at condition 1 b) i. conclusively determines that the impact is less than predicted.</td></tr>
<tr><td colspan="3">Offset Management Plans</td></tr>
<tr><td colspan="2">5.
a) The approval holder must submit for the Minister's written approval a separate offset management plan for each weir to be constructed or raised, addressing each offset requirement in Condition 4 for any weir for which an offset strategy has been approved by the Minister.</td><td rowspan="2">This document</td></tr>
<tr><td colspan="2">b) The offset management plan for each weir must be consistent with the approved offset strategy for the relevant weir.</td></tr>
<tr><td colspan="2">c) The offset management plan for each weir must include, but not be limited to:</td><td></td></tr>
</table>

Condition		OMP section or comment
(i)	the offset area/s to be secured for the listed threatened species and ecological communities listed in Table 1	*Section 5*
(ii)	a description and map to clearly define the location and boundaries of the offset area/s, accompanied by the offset attributes;	*Section 5*
(iii)	information about how the offset area/s provide connectivity with other relevant habitats and biodiversity corridors	*Connectivity with Terrestrial OMP - Section 5*
(iv)	a description of the management measures (including timing, frequency and duration) that will be implemented in each offset area;	*Section 5*
(v)	details of how the management measures proposed are consistent with relevant approved conservation advice, recovery plans and threat abatement plans	*Consistent with Reef 2050 Plan – Section 2.2*
(vi)	performance and completion criteria for implementing the offset management plan/s for evaluating its effectiveness, and criteria for triggering corrective action/s;	*Section 10*
(vii)	a program for monitoring and reporting on the effectiveness of the management measures, and progress against the performance and completion criteria;	*Section 11*
(viii)	a description of potential risks to the successful implementation of the offset/s, and contingency measures that can be implemented to mitigate against these risks; and	*Section 6*
(ix)	evidence that the offsets are in accordance with the EPBC Act Environmental Offsets Policy and relevant Reef 2050 Plan requirements including the net benefit principle.	*Section 2*
e)	The approval holder must not begin inundation of the impoundment of a weir unless the Minister has approved in writing an offset management plan for the relevant weir for all offset requirements in the approved offset strategy for that weir. The approved offset management plan for each weir must be implemented.	*This document*
Standard conditions		
9.	The approval holder must maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plan, program, strategy or code of practice required by this approval, and make them available upon request to the Department. Such records may be subject to audit by the Department or an independent auditor in accordance with section 458 of the EPBC Act, or used to verify compliance with the conditions of approval. Summaries of audits will be posted on the Department's website. The results of audits may also be publicised through the general media.	*Section 11*
10.	Within three months of every 12-month anniversary of the commencement of the action, the approval holder must publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication must be provided to the Department at the same time as the compliance report is published.	*Section 11*
18.	Unless otherwise agreed to in writing by the Minister, the approval holder must publish all management plans, reports, strategies, or codes of practice referred	*Section 11*

Condition	OMP section or comment
to in these conditions of approval on their website. Each management plan, report, strategy or code of practice must be published on the website within 15 business days of being approved by the Minister or being submitted under Condition 12a).	
Reporting non-compliance	
19. The approval holder must notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in approved plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance. The notification must specify:	*Section 9*
a) any condition which is or may be in breach;	
b) a short description of the incident and/or non-compliance; and	
c) the location (including co-ordinates), date, and time of the incident and/or non-compliance. In the event the exact information cannot be provided, provide the best information available.	
20. The approval holder must provide to the Department the details of any incident or non-compliance with the conditions or commitments made in an approved plan as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance, specifying:	*Section 9*
a) any corrective action or investigation which the approval holder has already taken or intends to take in the immediate future;	
b) the potential impacts of the incident or non-compliance; and	
c) the method and timing of any remedial action that will be undertaken by the approval holder.	

1.3 Commitments made in the OMP

The Rookwood Weir Offset Strategy was approved by DCCEEW in November 2022. In this strategy the agreed amount of nitrogen to offset was 358t. Following a review and assessment of this modelling in May 2023 this figure was revised. A submission was made to DCCEEW in July 2023 on a revised methodology for calculating the nitrogen amount which was endorsed by DCCEEW. A target of 194 tonnes has since been determined as the agreed offset between Sunwater and DCCEEW.

This section summarises the commitments made throughout this OMP to intercept 194 tonnes (**t**) of Nitrogen that is currently within the Fitzroy River System. 80% of this is to occur within 6 years of the Rookwood Weir being commissioned and inundation occurring with the remaining 20% in an additional 4 years. It is noted that this requirement may be reduced if the Water Quality Monitoring Program at Condition 1. b) i. of the EPBC Approval conclusively determines that the impact is less than predicted, as stated in Condition 4. b) Table 1.

Additional commitments are also made in alignment with the standard and administrative conditions of the approval. *Table 3* below lists each of these commitments and provides references to the sections in this OMP where these commitments are detailed.

Table 3: Commitments made in this OMP

Commitment	Relevant approval Condition	OMP section or comment
The approval holder will submit for the Minister's written approval a separate offset management plan for each weir to be constructed or raised, addressing each offset requirement in Condition 4 for any weir for which an offset strategy has been approved by the Minister.	5.a)	*This document*
The approval holder will not begin inundation of the impoundment of a weir unless the Minister has approved in writing an offset management plan for the relevant weir for all offset requirements in the approved offset strategy for that weir. The approved offset management plan for each weir will be implemented.	5.e)	*Section 13*
The approval holder will maintain accurate records substantiating all activities associated with or relevant to the conditions of approval, including measures taken to implement the management plan, program, strategy or code of practice required by this approval, and make them available upon request to the Department.	9.	*Section 11*
Within three months of every 12-month anniversary of the commencement of the action, the approval holder will publish a report on their website addressing compliance with each of the conditions of this approval, including implementation of any management plans as specified in the conditions. Documentary evidence providing proof of the date of publication will be provided to the Department at the same time as the compliance report is published.	10.	*Section 11*
Unless otherwise agreed to in writing by the Minister, the approval holder will publish all management plans and reports on their website within 15 business days of being approved by the Minister or being submitted under Condition 12a).	18.	*Section 11*
The approval holder will notify the Department in writing of any: incident; non-compliance with the conditions; or non-compliance with the commitments made in approved plans. The notification must be given as soon as practicable, and no later than two business days after becoming aware of the incident or non-compliance.	19.	*Section 9*
The approval holder will provide to the Department the details of any incident or non-compliance with the conditions or commitments made in an approved plan as soon as practicable and no later than 10 business days after becoming aware of the incident or non-compliance.	20.	*Section 9*

1.4 Plan structure

The OMP is divided into 2 parts – **Part A** (Project Details and Impact Areas) and **Part B** (Offset Land Management Details).

Part A contains:

- Introduction to the Project and the purpose of the plan;
- How the offsets address the EOP, EPBC plans and GBR plans; and
- Impact area description.

Part B contains the Water Quality Nitrogen Offset Management Plan, containing:

- Offset options and modelling;
- Offset project descriptions;
- Risk analysis;
- Offset management measures;
- Completion criteria and performance targets;
- Non-conformance and incident reporting;
- Monitoring and reporting; and
- Adaptive management and plan review.

2 EPBC Act Environmental Offsets Policy and framework

This section describes how the proposed offset meets the relevant requirements of the EPBC Act Environmental Offsets Policy (October 2012) (**EOP**), plans and guidelines.

2.1 Policy principles

The EPBC Act EOP sets out eight key overarching principles to determine the suitability of offsets. *Table 4* outlines each of the policy principles and how it has been considered in the OMP, with a reference to the relevant OMP section.

Table 4: EPBC Act Environmental Offset Policy principles

Policy principle	Project offsets
Suitable offsets must deliver an overall conservation outcome that improves or maintains the viability of the protected matters.	All offset options will deliver a conservation outcome by reducing the levels of Nitrogen bound to sediment entering the waterways that drain into the GBR lagoon. Where streambank rehabilitation and land management options are implemented, the offset sites will be managed to intercept and reduce sediment loads through streambank erosion protection and adjacent land management.
Suitable offsets must be built around direct offsets but may include other compensatory measures.	A substantial proportion of the Project's water quality (Nitrogen) offset obligations will be acquitted by the proposed direct offsets.
Up to 10% of offset may be delivered through indirect offsets	The project shall deliver a proportion of the offset amount through indirect offsets in the form of water quality research programs.
Suitable offsets must be in proportion to the level of statutory protection that applies to the protected matter.	The quantum of Nitrogen offset required was calculated during the EIS process using FullCAM modelling. The Project was subsequently conditioned as per that modelling. The same modelling was used to update the impacts after the final weir height had been agreed between the proponent and the Australian and Queensland Governments after the pre-clearance surveys had determined the extent of vegetation within the inundation area. Similarly, the final offset amount was developed utilising a scientifically robust methodology as approved by DCCEEW.
Suitable offsets must be of a size and scale proportionate to the residual impacts on the protected matter.	The extent of the offset has been calculated based on a preliminary model that identified land use changes, including the exclusion of cattle from the riverbanks and larger gullies as well as streambank protection. This will deliver a reduction in sediment and attached

Policy principle	Project offsets
	particulate nitrogen. This is addressed through the suite of offset programs described in Section 5.
Suitable offsets must effectively account for and manage the risks of the offset not succeeding.	The risks associated with the offset have been assessed (refer to *Table 22 & 23*).
Suitable offsets must be additional to what is already required, determined by law or planning regulations, or agreed to under other schemes or programs.	The proposed offsets are all being undertaken over and above project environmental approval requirements including Commonwealth, State and local council. The proposed offset projects are not part of any Sunwater funded programs outside of the Rookwood Weir project or as part of current agreements Sunwater holds with delivery partners.
Suitable offsets must be efficient, timely, transparent, scientifically robust and reasonable	The proposed offsets will be efficient and timely as the Stage 1 offset will be established and implementation commenced within 12 months of the Minister approving this OMP.
Suitable offsets must have transparent governance arrangements including being able to be readily measured, monitored, audited and enforced.	Section 10 Completion Criteria and Section 11 Monitoring and Reporting

2.2 Addressing relevant EPBC plans and advice

The EOP states that an offset should address key priority actions for the impacted MNES in any approved recovery plans, threat abatement plans, conservation advice, or approved Australian Government management plans. The *Reef 2050 Long-term Sustainability Plan* 2021-2025 (July 2021) (**Reef 2050 Plan**) addresses many of the threats to the GBR including water quality.[1] The *Reef 2050 Water Quality Improvement Plan 2017-2022* (**WQIP**) is a joint commitment of the Australian and Queensland governments that seeks to improve the quality of water flowing from the catchments adjacent to the Great Barrier Reef. The WQIP is a nested plan under the Reef 2050 Plan and contains actions that relate to land-based sources of water quality pollution (diffuse source pollutants). *Table 5* summarises how this OMP addresses the relevant actions in the WQIP.

The Reef 2050 Water Quality Improvement Plan is supported by a robust monitoring and evaluation program in the form of the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program.

[1] https://www.dcceew.gov.au/sites/default/files/documents/reef-2050-long-term-sustainability-plan-2021.pdf

Table 5: Reef 2050 Plan and WQIP actions addressed in this OMP

Document	Key threats	Section addressed in document
Reef 2050 Long-term Sustainability Plan 2021 – 2025 (July 2021)	• Nutrient run-off • Sediment run-off • Vegetation clearing	This OMP includes actions to reduce nutrient and sediment run-off through the Fitzroy River catchment. This is demonstrated through the list of programs to improve or repair riparian vegetation, streambanks, gullies, and waterways as described in *Section 5*. The prevention of erosion and transport of sediment to the Great Barrier Reef though programs outlined in this OMP will additionally lead to a reduction in nutrient levels in the form of particulate nitrogen. Other programs outlined within Section 5 of this document such as weed harvesting would see the direct removal of nitrogen through extraction of plant biomass from the Fitzroy River. Programs including streambank rehabilitation and improved land care practices will have a direct impact on reducing sediment run-off to the Great Barrier Reef. Rehabilitation programs such as the colocation of water quality offsets with terrestrial offsets at the Foleyvale / Stoney Creek site will have a positive impact on preventing the loss of vegetation within the catchment.

2.3 Net Benefit Policy

The GBRMPA's Reef 2050 Plan includes a Net Benefit Policy (NBP) that has been developed to provide guidance on designing or implementing programs, plans and actions to improve the condition and trend of values and achieve an overall net benefit to the Great Barrier Reef. A Net Benefit is defined as:

'an overall improvement in the condition and/or trend of a Great Barrier Reef value, or those actions which result in the net improvement.'

Through the delivery of the water quality offset outlined below in this plan, Sunwater intends to deliver an overall improvement to the key GBR value of water quality, specifically with respect to nitrogen.

Functional Group of Values (NBP Table A1.1): Physical, chemical and ecological processes

Key ecological processes (NBP Table A2.2): Nutrient cycling

Nutrients from catchment runoff is identified as a key pressure impacting the GBR and is rated as a 'very high' risk in the NBP (Table A3.1). Sunwater has developed a range of appropriate programs, plans and actions to maximise improvement to water quality values for the GBR. The nitrogen modelling for the inundation of the weir that has been undertaken has an inherent conservatism with respect the total impact on the Great Barrier Reef. This includes an assumption of a 100% delivery ratio and no losses through nutrient cycling that may occur in the Fitzroy River between the weir and the reef (refer to section 3.1 below).

For all of the offset options outlined in this plan Sunwater has taken a collaborative approach with local delivery partners including:

- Traditional owners – location of the Foleyvale / Stoney Creek streambank rehabilitation project at on Woorabinda Aboriginal Shire Council and Woorabinda Pastoral Company land;
- Regional Natural Resource Management Groups – utilising existing local groups such as Fitzroy Basin Association (FBA) and Burnett/Mary River Group (BMRG) to deliver stream rehabilitation and land management programs;
- Local Council – working with Rockhampton Regional Council's (RRC) Advance Rocky program for weed harvesting;
- Education and Research – partnering with Central Queensland University (CQU) to undertake water quality research programs.

By engaging with these partners Sunwater is able to deliver the offsets in a timely manner and on an effective scale that improves the condition and trend of the water quality value for the GBR.

3 Impact site description

The Rookwood Weir Project is the construction of a new weir at Rookwood on the Fitzroy River, Central Queensland. The Fitzroy River forms at the confluence of the Mackenzie River (flowing from the north) and the Dawson River (flowing from the south), before flowing out into the Coral Sea (including the GBRWHA and GBRMP, some 300 km downstream. The Fitzroy River passes through the city of Rockhampton at the Fitzroy Barrage, which lies approximately 59 km from the river mouth.

For the purposes of this OMP, the 'Project area' refers to the area impacted by the inundation of the Rookwood Weir with a weir height of RL 46.2 m AHD, which results in the inundation of 1,314.2 hectares (**ha**). This inundation footprint is shown in *Figure 2*. Rookwood Weir is located at 162km AMTD which correlates to the distance to the mouth of the Fitzroy River and boundary of the Great Barrier Reef Marine Park. Between Rookwood Weir and the GBRMP are two in stream structures, Eden Bann Weir and the Fitzroy Barrage.

3.1 Potential nutrient loads from decaying vegetation

The potential rate at which the nitrates and phosphates will break down within the impoundment areas during the Project's operation was determined in the EIS by calculating the above-ground vegetation biomass, and the amount of N and P contained within that biomass, using the Full Carbon Accounting Model (**FullCAM**) (Richards and Evans 2000).[2]

The program identifies a number of parameters, including: soil data; regional soils list; maximum above-ground forest biomass; forest productivity index (annual rate); average air temperature; rainfall; open-pan evaporation; forest topsoil moisture deficit; and tree species groups for Queensland.

Running the FullCAM program provided an output, which shows the total dry mass of above-ground biomass per hectare. Below ground biomass was calculated using the National Carbon Accounting System (Australian Greenhouse Office, 2002). The proportion of above-ground biomass for coarse and fine root masses, as well as stems, bark, branches and leaves, was identified. A range of literature was used to derive an approximate proportion of nutrient to dry mass for acacia woodland and eucalypt woodland (1.02% Nitrogen component of dry mass per hectare). A decay coefficient of 0.62 yr -1 was adopted. The calculations for the phosphorus component also adopt literature figures for the approximate proportions of nutrient to dry mass for acacia woodland and eucalypt woodland (0.18% phosphorus component of dry mass per hectare) and a decay coefficient of 0.51 yr -1 was adopted.

The results show that that approximately half the available nitrogen is liberated in the first year of impoundment and will reduce significantly in each subsequent year for a period of approximately 6 years.[3]

This methodology was repeated in June 2022 after the pre-clearance vegetation surveys of the impoundment area were undertaken. The results of this recalculation using field-validated data and the revised weir height of 46.2m resulted in a reduction to 358t which is reflected in the Rookwood Weir Offset Strategy Plan

In May 2023 a revision of the modelling was undertaken by Alluvium Consulting that considered a number of factors including updated decay rates and the nitrogen content of the biomass to be inundated. A nitrogen amount of 110 tonnes was estimated as the median value of the modelling range that extended from 30 to 267 tonnes. The value modelled is assumed to be entirely in the form of dissolved nitrogen with a 100% delivery rate to the GBRMP. Hence it is likely that this is a conservative estimate due to losses through particulate nitrogen and nitrogen cycling within the impoundment, thus reducing the delivery ratio to the GBRMP below 100%. Consultation with the department indicated that a nitrogen load value towards the higher end of the range should be utilised as a target to provide a conservative approach to the quantity of nitrogen to be released.

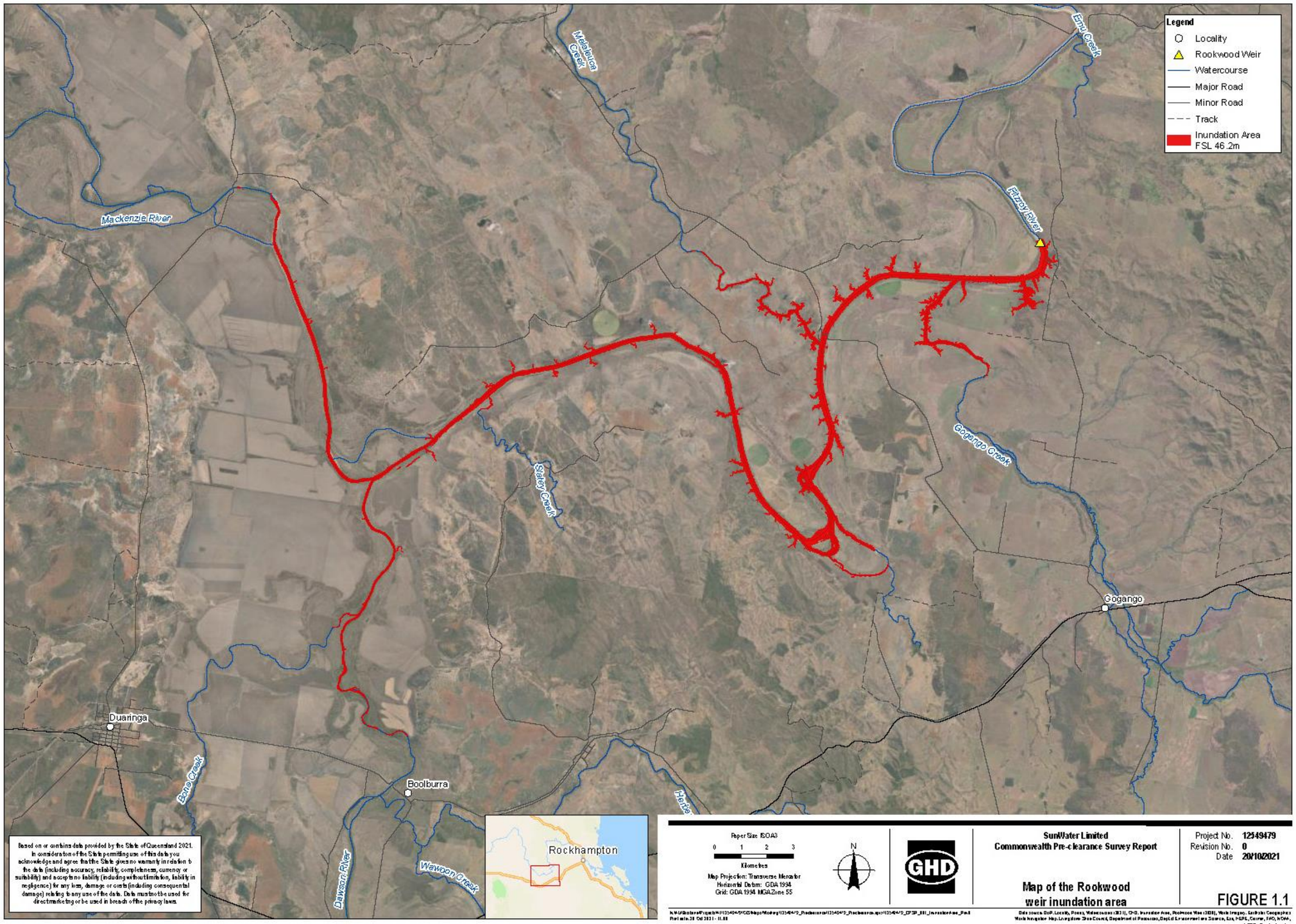
[2] Cited in the EIS Chapter 11, Section 11.1.4.3
[3] EIS Chapter 11, Section 11.3.2.1

Table 6 – Revised Nitrogen Modelling Values

Scenarios	N load released 1st year		
	N upper	N expected	N lower
Decay rate upper	267.27	149.29	68.33
Decay rate expected	195.10	109.66	48.31
Decay rate lower	130.57	72.20	29.82

Refer to Attachment 1 for the Alluvium revised modelling report.

Figure 2: Project inundation area



Part B: Nitrogen Offset Management Plan

4 Offset delivery and modelling

4.1 Overview

From the revised modelling it has been estimated that between 30 and 267 tonnes of Nitrogen may be released during the first year of inundation once the Rookwood Weir is commissioned. However, the actual impact will be assessed by the water quality monitoring program (**WQMP**) that is required to address Condition 1 of the EPBC approval. The water quality monitoring will confirm and give validation to the actual Nitrogen impacts as per Condition 4 Table 1 Part vii that states: “unless the monitoring required at Condition 1b) i. conclusively determines that the impact is less than predicted”. Currently the project has a target of 194 tonnes of nitrogen to be offset.

4.1.1 Delivery of Conservation Outcome

The Rookwood project is intending on offsetting the potential impact of the release of nitrogen from the inundation of vegetation in the weir impoundment area on the Great Barrier Reef. As described previously a conservative approach has been undertaken both in the revised modelling methodology and adoption of a target nitrogen value of 194 tonnes in the upper portion of the predicted range 30 – 267 tonnes. Through the suite of offset projects described in Section 5 below, the project shall deliver an offset that is compensable to the impact from inundation to maintain the viability of the protected matter. Refer to Table 8 for a breakdown on how the 194 tonnes of nitrogen will be delivered through the offset.

4.1.2 Offset Delivery Timeframe

The time to achieve the ecological benefit for the GBRWHA and GBRMP is an important consideration for completing offsets related to potential impacts from the release of Nitrogen due to the inundated vegetation. DCCEEW Officers recommended a maximum of 6 years ‘time to ecological benefit’ or completion of offset outcomes for Nitrogen, as the optimum to reduce impacts on the reef. This 6-year period is equivalent to the total estimated duration of the impact of Nitrogen as originally modelled in the EIS,[4] and would start when water quality impacts begin from inundation.

Further discussions on the delivery of offsets and practical implementation timeframes for projects has resulted in Sunwater requiring additional time to deliver the offset over 10 years with the delivery front loaded (80%) to first 6 years. Refer to the Offset Delivery Schedule in Table 7 below. This allows for some flexibility for supplementary programs to be added at the back end of the delivery schedule to achieve the greatest benefit for the reef. Where possible offset programs will be undertaken as soon as practicable to maximise the offset at the start of the delivery timeframe to minimise the residual amount required to be deliver in the last 4 years.

[4] GHD (2015). EIS, Volume 1, Chapter 11, Section 11.1.4.3

4.1.3 Staging of Offset Delivery

The offsets shall be staged to deliver some projects immediately in the first year and to allow further studies, establishment, and procurement to be undertaken for other projects. The Stage 1 projects to commence during year 1 include:

- streambank erosion protection and adjacent land management at the terrestrial ecology offset site at Foleyvale and Stoney Creek.
- water quality research projects with Central Queensland University

To allow water quality monitoring to determine the actual Nitrogen water quality impacts from the action while balancing the time to ecological benefit of the offsets, a staged and adaptive management approach is proposed to meet the Nitrogen water quality offset targets, as shown in *Table 7* below, based on the Rookwood Weir Biodiversity Offset Strategy.[5]

Consultation with key regional stakeholders (eg Rockhampton Regional Council (**RRC**), Fitzroy Basin Association), on a range of additional options will continue to be investigated during the Stage 1 actions. These options are included in Section 5 of this document and will be further updated in the Water Quality Offset Review Report (as shown in *Table 7*).

A Water Quality Offsets Review Report (Year 1) shall be prepared post year one and prior to the end of year 2 of the weir operation, to guide the required offset program options for the following years.. This is one year earlier than proposed in the Offset Strategy to ensure that offset options are undertaken as soon as reasonably practical to align with the potential water quality impacts at the start of the inundation period at the weir. This report will include the following:

- Further assessment of nitrogen load reduction for the list of programs eg weed harvesting, streambank rehabilitation;
- Provide details on the feasibility and development of the proposed offset projects chosen to be implemented from Year 2 to 6 to meet the offset target; and
- Any consultation undertaken with stakeholders including State regulatory authorities and local community groups with respect to the delivery of nitrogen offsets.

A Nitrogen Assessment Report of water quality data from the first two years of weir operation will be prepared in relation to determining the actual amount of nitrogen that was released during inundation. This has been identified through modelling as the time with the greatest potential to impact the GBR. This will include an assessment against Approval Table 1 Part vii where monitoring conclusively determines that the impact is less than predicted. The report will be prepared by a water quality SQP on behalf of Sunwater utilising data collected by the project's Water Quality Monitoring and Reporting Program. Depending on the findings this may or may not result in a reduction in the nitrogen offset target as currently proposed.

A second Water Quality Offsets Review Report (Year 5) shall be prepared in Year 5 to review and assess the delivery of the program to date and finalise the proposed options to finalise the delivery of the offsets. This report will not involve a re-assessment of the nitrogen offset amount as undertaken in the Nitrogen Assessment Report at the end of Year 2.

[5] Earthtrade (2022c). *Rookwood Weir Offset Strategy (Version 7)*.

Table 7 below summarises the proposed staging of actions that will be implemented towards achieving the required offset outcome.

Table 7: Staged approach to delivery of water quality (Nitrogen) offset programs

Stage 1 Actions	Water Quality Offset Review Report (Year 1)	Stage 2 Actions	Water Quality Offset Review Report (Year 5)	Residual Stage 2 Actions
First year from commencement of weir inundation	Submit to DCCEEW following one year of commencement of weir inundation	Following Water Quality Offset Review and Report (Year 1) approval by DCCEEW	Submitted to DCCEEW following five years from commencement of weir inundation	Following Water Quality Offset Review and Report (Year 5) approval by DCCEEW
Undertake Foleyvale and Stoney Creek streambank and research offset projects as per Section 5.	Must assess project success towards 6-year water quality offsets and measures required to meet offset outcomes in 6-year timeframe	Actions must be implemented as per approved Water Quality Offset Review Report (Year 1).	Must assess and project success to date towards 10-year water quality offsets and measures required to meet offset outcomes in 10-year timeframe	Actions must be implemented as per approved Water Quality Offset Review Report (Year 5).
Investigation / scope other options for water quality offsets (refer to sections below)	Must propose appropriate actions for Stage 2 to complete water quality offsets against residual impacts	Submit to DCCEEW Nitrogen Assessment Report at the end of Year 2	Must propose appropriate actions for Stage 2 to complete water quality offsets against residual impacts	

4.1.4 Offset Delivery Schedule

The following table represents an indicative timeframe for the delivery of the offset programs in the first six years of operation. A minimum of 80% of the target is to be met within the first 6 years with an allowance for a further 4 years to meet 100% of the target. The number and scale of the programs is to be determined based on the Water Quality Offset Review Reports.

Table 8: Offset Program Delivery Schedule (tonnes of nitrogen)

Stage	Item	Year 1	Year 2	Year 3	Year 4	Year 5	Year 6	Year 7-10
1	Foleyvale / Stoney Creek[1]	6.8t	6.8t	6.8t	6.8t	6.8t	6.8t	35.8t
	Research		6t		12t			
	WQ Offset Review Report							
2	Streambank (Bingara)		9.1t	9.1t	9.1t	9.1t	9.1t	
	Weed	5t	10t	10t	10t	10t	5t	
	Landcare		1t	1t	1t	1t	1t	
	Dredging[2]		*9t*					
	Financial[3]		*TBC*					
	Other[4]		TBC					
Annual Total		11.8t	31.9t	29.4t	31.4t	26.9t	26.9t	35.8t
Cumulative Total		11.8t	43.7t	73.1t	104.5t	131.4t	158.3t	194t

Notes:

1 – Foleyvale / Stoney Creek rehabilitation co-located with terrestrial offsets and managed by Sunwater until 2046 hence has been included the nitrogen contribution each year. Refer to section 5.1 below.

2 – Dredging of existing Sunwater waterway infrastructure option subject to analysis and hence has not included in contributing to the nitrogen offset amount. Refer to section 5.6 below.

3 – Financial offsets through the purchase of reef credits may be undertaken if there is a shortfall in nitrogen in the other programs. Timing will be dependent on market availability. Refer to section 5.7 below.

4 – Other – In the event new technologies and other offset opportunities develop in the coming years Sunwater may choose to take advantage of these situations. Examples may include:

- a severe weather event that occurs in the Fitzroy region causing streambank erosion that requires repair at a location not currently included in this plan.
- Technologies currently being trialled such as harvesting algae at wastewater treatment plants or new wetland technology is proven and can be utilised on a scale to contribute to the offset of nitrogen for the GBR.

The Years 7 -10 have been allowed for as contingency for the delivery of the programs. Sunwater will endeavour to meet the offset target as soon as practicable within this period and may not require the full 4 four years to reach completion. This will be detailed in the Year 5 Water Quality Offset Review Report. Details of the tasks to be undertaken for each of the programs during Stage 1 and Stage 2 are included in Section 5 of this document.

4.2 Modelling methodology for the sediment interception projects

In order to estimate the potential nitrogen offset from bank stabilisation works the estimated fine sediment abatement shall be calculated using the methodology outlined in the *Reef Trust Gully and Stream Bank Toolbox 3rd Edition* (Wilkinson et. al, 2022) and supporting guidelines provided in the *Stream bank Erosion Control Assessment Tool (SECAT) Survey User Guide, Paddock to Reef Integrated Monitoring, Modelling and Reporting Program* (Humphreys and Wilkinson, 2021).

This methodology involves:

1. **Determining historic erosion rate –** The historic erosion rate determined using the 'Recent period method' as outlined in the SECAT user guide
2. **Determining baseline erosion rate** - The baseline erosion rate is defined as the rate of erosion that would likely occur in future years in the absence of any management intervention (Humphreys and Wilkinson, 2021). The baseline erosion rate is derived from the historic erosion rate and a suitable adjustment for climate variability using a climate correction factor.
3. **Calculate sediment yield** – Based on the efficacy of proposed stabilization works - *The effectiveness of the works at reducing fine sediment volumes is estimated at 60% based on Erosion control treatment 10. "Engineered stream bank protection and revegetation" from Table 1 (Pg 23) in the Gully toolbox 3rd edition (Wilkinson et. al, 2022). Value – 60 %*
4. **Calculate total fine sediment reduction at the coast** - The fine sediment reduction at the coast is calculated by multiplying the Total fine sediment yield at site (t/y) by the Fine sediment delivery efficiency to coast (Delivery ratio). *The delivery ratio to GBR Lagoon –is determined from values adopted within the Source - Paddock to Reef catchment modelling*

Specifically for the Foleyvale / Stoney Creek site, Sunwater has sought extensive advice from DES including Dr Paul Lawrence, Executive Director, Science Delivery, the Fitzroy Basin Association (**FBA**) and Dr Roger Shaw, co-chair of the FBA Scientific Panel and chair of the Wet Tropics Scientific Panel, regarding the GBR water quality modelling and water quality offsets. On the advice of Dr Lawrence and Dr Shaw, Sunwater engaged subconsultants from Horizon Soil Science and Engineering (**Horizon**) (a regular consultant to DES (Science Section)) to develop a concept model for the sediment interception project to be located at the properties where the terrestrial offsets are located (Foleyvale and Stoney Creek).[6] The model developed was used to calculate the amount of sediment, and attached Nitrogen, that will be intercepted by returning areas that are currently heavily grazed pasture areas, to a vegetation community as well as implementing a range of management measures aimed at reducing sediment, and therefore nutrient loss. Horizon issued a technical memorandum (Horizon, 2022) describing the model and the calculations which is provided at *Attachment 2*.

The model used methodology agreed to by Dr Lawrence and Dr Shaw (refer to *Attachment 2*) and was populated with data from soils reports for the area (to justify parameter selection for possible soils onsite). A summary of the findings of the Brigalow Research Station water quality data was also utilised to benchmark the model outcomes. Slope and drainage data for the site was reviewed for model parameterisation with the modelling integrated with the peer reviewed models developed for the Reef 2050 Plan. The Revised Universal Soil Loss Equation, as used in the Paddock to Reef Source Catchments model (**Source model**), was used to estimate soil

[6] Note that Dan Rattray (Horizon Soil Science and Engineering) who undertook the modelling also authored the HowLeaky modelling in the Great Barrier Reef catchments, Technical Report, Great Barrier Reef Report Card 2019.

erosion in areas such as the remnant vegetation and grazing area (Waters et al., 2014, cited in Horizon, 2022). Source model data for the 2017 and 2018 Report Cards (Reef 2050 WQIP, 2019) was provided by the Paddock to Reef modelling team (Darr, pers. comm. 2019, cited in Horizon, 2022). The modelling was undertaken using the models that underpin the Reef WQIP. Further, the models implemented follow a similar process to that outlined in the Reef Trust Gully and Stream Bank Toolbox (Reef Trust, 2022),[7] along with the methods used by the FBA Natural Resource Management Group to develop their gully and streambank erosion protection priority list.

To refine the modelling further and to confirm the quantum of Nitrogen that can be intercepted over the timeframe required, targeted site-specific soil sampling on the offset site will be undertaken. This will verify the soil types, slope, current estimated erosion types and rates as well as utilise historical aerial imagery to assess long term groundcover. This data will be entered into the model to calculate more site-specific outputs. The baseline data will be a critical input to the water quality monitoring and proposed water quality research project discussed below (Stage 1 as shown in *Table*).

5 Offset Projects

5.1 Foleyvale / Stoney Creek Streambank Rehabilitation

5.1.1 Project location

The selected properties for this offset project are portions of Foleyvale (Lot 1 LR146 being 10,665ha in area) and Stoney Creek (Lot 2 LR37 being 4,876ha in area). The properties adjoin the impoundment or Project impact area (see *Figure 3*). Foleyvale and Stoney Creek are located approximately 170 km south-west of Rockhampton, and 21 km north of the township of Duaringa. They are approximately 30km west of the Rookwood Weir project. On Foleyvale approximately 5,000 ha has been cultivated for cropping, consisting of a variety of crops including wheat, corn, chickpea, sorghum and mung bean. The balance of the country is utilised for cattle grazing.

Stoney Creek is used for cattle grazing with smaller areas of cultivation having recently been developed. The Mackenzie River is the main watercourse adjoining the boundary of the entire survey area and flows in a north to south-east direction.

The properties were selected for their suitability, including:

- Delivery of the offset adjacent to the impact site (*Figure 3*).
- The property management and Traditional Owners' objectives aligning with the offset management objectives.
- The location of other offsets on the same property for other projects thus creating larger areas of biodiversity offsets and achieving a better environmental outcome.

The terrestrial offsets on Foleyvale and Stoney Creek will be secured be being declared as an area of high conservation value under section 19F of the VM Act. Once this has been registered on the title, the offset area will be mapped as a category A area on the property map of

[7] Available at https://www.agriculture.gov.au/sites/default/files/documents/reef-trust-toolbox-3rd-edition.pdf

assessable vegetation (**PMAV**). An area mapped as category A on a PMAV is described as an 'area subject to compliance notices, offsets and voluntary declarations'.

As the location of the sediment interception project occurs within the terrestrial offset areas, this process of establishing the offset will be completed as a part of the terrestrial offsets. The declared area will remain in place as the legally securing mechanism for the offset area. The declared area and approved terrestrial OMP will ensure the offset completion criteria are attained, and then maintained for the period of the EPBC Act approval (i.e. until 2046). Statutory protection of the offset area is maintained under the *Vegetation Management Act 1999*, *Nature Conservation Act 1992* (Qld) and EPBC Act (or subsequent legislation). This process for the terrestrial offsets complements the delivery of the water quality offsets as is guarantees best practice management is undertaken on the land and any improvements are maintained for the life of the project, hence reducing the potential for erosion and loss of sediment from the site.

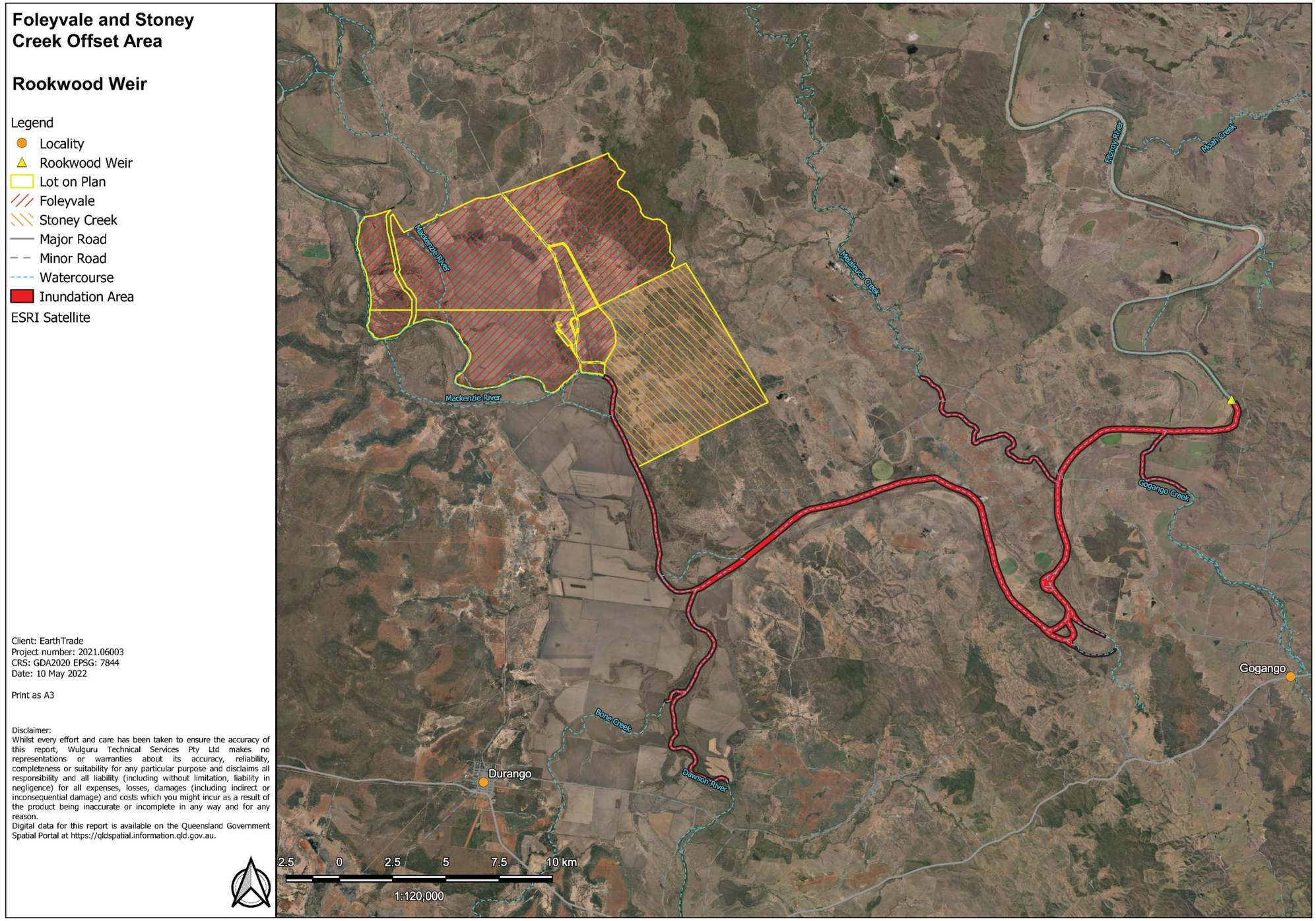
Management and monitoring of the offset area will be undertaken in accordance with commitments in the approved Terrestrial OMP. Whilst the majority of items are complementary this plan will also see additional management and monitoring to the Terrestrial OMP focussed on streambank remediation specifically focussed on erosion and sediment control and water quality impacts.

Onsite management will be conducted by the current land managers the Woorabinda Pastoral Company (WPC) on behalf of Sunwater. This will see the WPC undertake land management practices in the offset area such as:

- Installation and management of site infrastructure such as fencing and off river water supply;
- Movement of stock around the property including away from streambank rehabilitation areas;
- Weed and feral pest animal control;
- Bushfire management practices.

Additionally Sunwater have engaged an water quality and streambank rehabilitation SQP (Alluvium Consulting) to develop, plan and assess the rehabilitation works. The site shall be assessed for key areas requiring additional erosion control treatment and stabilisation works in addition the exclusion of stock from the streambanks and management detailed above.

Figure 3: Location of the offset site in relation to the Project



5.1.2 Project assessment and modelling

As discussed above, Earthtrade engaged Horizon to assess the reduction in total Nitrogen loss that could be achieved through improved management of the Foleyvale property and the downstream neighbouring property Stoney Creek on the Mackenzie River.

The assessment areas are defined below:

- Foley Vale (L1 LR146)
    - 2,800 hectares of regrowth and remnant vegetation bounded by the Mackenzie River that is currently grazed (Assessment area 1)
    - 3,270 hectares of cultivation (Assessment area 2)
    - 2,800 ha of gully stabilisation (within Assessment area 1)
    - 22 km of streambank (the Mackenzie River bordering Assessment area 1).
- Stoney Creek (Lot 2 LR27)
    - 290 hectares of regrowth and remnant vegetation bounded by the Mackenzie River that is currently grazed (Assessment area 3)
    - 5,000 hectares of grazing (Assessment Area 4)
    - 5,290 ha of gully stabilisation (within Assessment Areas 3 and 4)
    - 6 km of streambank (the Mackenzie River bordering Assessment area 3).

The preliminary model identified that land use changes including the exclusion of cattle from the riverbanks and larger gullies, plus streambank protection, resulted in a reduction in sediment and attached Nitrogen to offset the potential impacts of Nitrogen (refer to *Attachment 2*, Tables 2 and Tables 3 (Horizon Soil Science and Engineering Report)). However, this is based on a high-level desktop assessment using a range of generic inputs and it is expected the site-specific field survey would result in an increased amount of Nitrogen that could be reduced from entering the river.

Foley Vale

Assessment Area 1 is comprised of highly degraded regrowth and remnant vegetation described as two classes:

- Areas that have been cleared and have some regrowth. These areas would be protected from re-clearing.
- Remnant vegetation that is heavily grazed.

Both areas were described to be in “D” class conditions and would be managed to either “A” or “B” class condition.

Stoney Creek

Assessment Area 3 is comprised of highly degraded regrowth and remnant vegetation described as two classes:

- Areas that have been cleared and have some regrowth. These areas would be protected from re-clearing.
- Remnant vegetation that is heavily grazed.

Both areas were described to be in “D” class conditions and would be managed to either “A” or “B” class condition.

5.1.3 Summary of assessment results from the modelling

Table 9 below summarises the sediment generation rates. Refer to attachment 2 for all modelling assumptions and details. The largest source of SS and particulate Nitrogen was streambank erosion, accounting for 95% and 72% of the total for Foleyvale and Stoney Creek respectively.

Table 9: Baseline generation rates of suspended sediment and particulate Nitrogen under existing management

Site	Area or distance	Suspended sediment rate	Total suspended sediment delivered	Total particulate Nitrogen delivered
Foleyvale				
Assessment Area 1 Remnant and regrowth	2,800 ha	0.01 t/ha/yr	31 t/yr	0.07 t/yr
Gully erosion	2,800 ha	0.10 t/ha/yr	280 t/yr	0.64 t/yr
Streambank	22 km	900.00 t/km/yr	19,800 t/yr	45.50 t/yr
			Subtotal for Foleyvale:	46.21 t/yr
Stoney Creek				
Assessment Area 3 Remnant and regrowth	290 ha	0.03 t/ha/yr	8.10 t/yr	0.02 t/yr
Gully erosion	5,290 ha	0.10 t/ha/yr	530.00 t/yr	1.24 t/yr
Streambank	6 km	680.00 t/km/yr	4.080.00 t/hr	9.38 t/yr
			Subtotal for Stoney Creek:	10.64 t/yr
			TOTAL:	**56.85 t/yr**

(Source: Darr pers. comm., 2019)

Table 10 summarises the estimated reductions in suspended sediment and particulate Nitrogen using assumptions outlined above. The 14.79 t/yr reduction in total particulate Nitrogen is an average annual value.

The greatest reductions in suspended sediments and particulate Nitrogen come from streambank erosion, accounting for 89% and 76% of the total for Foleyvale and Stoney Creek respectively. This suggests that the greatest benefits in reducing total Nitrogen loss would be achieved by focusing on streambank stabilisation in this length of the Mackenzie River.

Table 10: Estimated reduction of suspended sediment and particulate Nitrogen under "A" class management

Site	Area or distance	Suspended sediment reduction rate	Total suspended sediment	Total particulate Nitrogen
Foleyvale				
Assessment Area 1 Remnant and regrowth	2,800 ha	0.01 t/ha/yr	25.00 t/yr	0.06 t/yr
Gully erosion	2,800 ha	0.05 t/ha/yr	140.00 t/yr	0.35 t/yr
Streambank	22 km	225.00 t/km/yr	4,950.00 t/yr	11.4 t/yr
			Subtotal for Foleyvale:	11.81 t/yr
Stoney Creek				
Assessment Area 3 Remnant and regrowth	290 ha	0.03 t/ha/yr	7.40 t/yr	0.02 t/yr
Gully erosion	5,290 ha	0.05 t/ha/yr	265.00 t/yr	0.61 t/yr
Streambank	6 km	170.00 t/km/yr	1,020.00 t/yr	2.35 t/yr
			Subtotal for Stoney Creek:	2.98 t/yr
			TOTAL:	**14.79 t/yr**

As per the above sediment modelling undertaken by Horizon Soil Science, it is anticipated that the exclusion of cattle from the stream banks and riparian areas and the improved groundcover to be maintained due to improved management regimes would intercept 13.75 t of particulate Nitrogen/year. Applying the Source-Paddock to Reef catchment modelling to determine the fine sediment reduction at the coast, the delivery ratio would result in a reduction of 6.8t/annum to the Great Barrier Reef.

5.1.4 Further Investigation and Planning

In Year 1 Sunwater shall undertake further review of the existing information and site investigations including: Critical review of the overall strategy for the Foleyvale/Stoney Creek site;

- Review of proposed offset works and supplementary activities such as additional rehabilitation activities;
- Field investigations including soil sampling (nitrogen content and particle size distribution), LiDAR capture of ground topography and slopes; and
- Establishment of a Monitoring and Reporting framework

This will ensure that the most efficient use of this location for nitrogen offsets occurs and robust nitrogen offset values are determined.

To confirm any assumptions provided in the calculations leading to anticipated nitrogen reduction Sunwater will undertake a targeted field investigation campaign. Investigations will involve a targeted soil sampling regime, which will quantify soil nitrogen content, particle size distribution and soil type. Samples are to be taken at several locations which will capture the variability

exhibited at the site. During the field investigations and subsequent LiDAR capture any potential areas of concern will be identified, with locations of areas detailed spatially (e.g. KML/KMZ file).

Sunwater proposes to undertake Lidar capture and imagery over the whole site. There is limited detailed surface topography at the site, with 1m resolution data limited to approximately 30% of the site, captured in 2012. Shuttle Radar Topography Mission (SRTM) data is available (at approximately 30m resolution), however the lack of resolution this would provide would lead to additional ambiguity around efficacy of management solutions. A fine scale Digital Elevation Model (DEM) will be generated as it is imperative in ensuring that the slope characteristics are appropriately represented in the RUSLE equation, to determine erosivity of the landscape. Further, it provides a sound baseline for future monitoring and reporting works, if/where elevation needs to be recaptured.

If additional specificity is required around streambanks and/or gully areas, this can be undertaken concurrently with the lidar survey. Following the completion of the field investigations and LiDAR capture, a Project Offset Plan will be prepared by Sunwater's water quality SQP and submitted within 6 mths of the commencement of the operation of the weir to DCCEEW for approval. The report will include but not be limited to:

- Results of the field investigation and LiDAR survey;
- Provide updated nitrogen offset calculations without additional works completed (i.e follow the current plan for the site);
- Identify and prioritise potential additional works and treatments;
- Estimation of potential improvement in sediment and nitrogen loss for the additional works completed;
- Monitoring and reporting framework.

5.1.5 Monitoring and Reporting Framework

Monitoring and maintenance of the stream stabilisation works is required to evaluate and ensure the success of the works. Monitoring of these stream stabilisation works requires an assessment of riparian condition, including structural works and vegetation works, and sediment loss. The monitoring and evaluation of works is required not only to enable sediment abatement, and associated nitrogen offset calculations, but also to evaluate and ensure the success of the works.

A detailed monitoring and maintenance program specifically for this project including key performance indicators and remedial actions, and frequency/timing will need to be developed and included in the project offset plan as detailed above. This will include vegetation monitoring and maintenance, and topographic monitoring. Inspections of the site will be undertaken on a quarterly basis in line with the Terrestrial OMP developed for the site.

A milestone reporting program will be developed for the site as a part of the plan and is required to ensure the plan achieves the erosion control and revegetation outcomes identified. Performance Reports will be submitted by the contractor to Sunwater for the duration of the monitoring program following each monitoring event and summarised in a yearly progress update report. These monitoring reports will be included in Sunwater's annual Water Quality (Nitrogen) Offsets Report to DCCEEW as per Section 11.2 below.

It is anticipated that this monitoring and reporting framework will be supported by the understanding of monitoring and reporting though previous works undertaken by Sunwater's SQP and will include tasks such as vegetative assessments as an indicator of stability and understanding elevation difference through lidar, along with guidance from references such as the *Gully and Stream Bank Toolbox* (Wilkinson et al, 2022).

During the monitoring and maintenance phase the following performance triggers and corrective actions will be applied to the Foleyvale / Stoney Creek offset site. These will be further expanded following the investigative works to be tailored to site specific conditions:

Table 11: Monitoring Performance Criteria

Item	Monitoring Performance Criteria	Management Trigger	Corrective Action
Force Majeure			
Drought	Loss of ground cover	<50% groundcover	Remedial revegetation (eg seeding)
Cyclones/ Severe Tropical Lows / Flooding	Sediment loss	Bank failure or rill erosion	Remedial batter works
Catastrophic Bushfire	Fire damage	Vegetation or infrastructure destroyed or badly damaged	Work with land manager to correct loss of vegetation / infrastructure. Review preventative management controls.
General			
Excessive sediment loss	Annual erosion rate	Erosion rate greater than predicted in Project Offset Plan	Review site management strategies. Additional offset to be delivered through another offset project if substantial failure occurs.
Vegetation failure	Remaining diversity of riparian vegetation	< 85% survival of vegetation	Remedial revegetation to achieve tree survival rate
Erosion	Sediment loss	Bank failure or rill erosion	Remedial batter works

5.1.6 Project Delivery Schedule

The following table outlines the proposed activities and indicative timing for the establishment and delivery for the first two years of the Foleyvale / Stoney Creek offset project:

Table 12 – Foleyvale / Stoney Creek Startup Delivery Schedule

Task	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Finalise Agreement with WPC and WASC								
Voluntary declaration with State								
Establishment of farm infrastructure (fencing, water pipes and troughs)								
Project review and site investigations								
Project Offset Plan								
Site Maintenance and management by WPC								
Site Monitoring by Sunwater								

5.2 Research Projects

Under the department's Environmental Offsets Policy a portion of the offset may be delivered by indirect offsets such as research and education. Sunwater are partnering with Central Queensland University (CQU) to undertake water quality research in the Lower Fitzroy River catchment. Under this arrangement Sunwater will fully fund a PHD student for four years and a Masters student for two years. This is planned to commence during the first year of operation of the weir.

5.2.1 Scope of research

Project 1: Monitoring options for freshwater algal communities in a new tropical impoundment (Masters – 1.5 to 2 years)

Impoundment of rivers affects hydrology and water chemistry, with flow on effects to biological assemblages. Decreasing flow and turbidity following impoundment support higher light infiltration and water temperatures, which in combination with enhanced nutrients from decaying vegetation can increase the intensity and frequency of algal blooms. A new weir development in central Queensland presents an opportunity to monitor the transition of tropical freshwater algal communities following impoundment, and to develop cost-effective monitoring methods to detect early changes that might signal the onset of a bloom. By identifying lower-cost monitoring methods, sampling can be conducted more frequently. This increases the chance of success for early nutrient and algal management interventions to reduce the downstream effects of the impoundment.

Project 2: Efficient monitoring frameworks for tropical impoundments (PhD – 3 to 4 years)

The construction of the new Rookwood Weir in the Lower Fitzroy River necessitated the development of a water quality monitoring and reporting program, to predict potential and detect actual impacts on the Great Barrier Reef (GBR) World Heritage Area. Water quality monitoring in tropical rivers is complicated by highly variable weather and flows, large and complex water basins, and the cumulative impacts of other land uses, often including historical land clearing practices. Comprehensive monitoring programs that account for all of these complexities have high monitoring costs, especially in regional Australia where there are long travel times to sites and few sample analysis options are available. Options to streamline monitoring programs for tropical impoundments are the subject of a new research project at CQUniversity, providing for more targeted and cost-effective programs. A key objective of optimising such monitoring programs is to maintain the high environmental standards required to protect sensitive tropical habitats like the GBR. During the development of water quality monitoring and offset programs for Rookwood Weir, the dynamics of nutrient release from decaying vegetation during the inundation phase was identified as a knowledge gap. Nutrients are priority pollutants for the GBR, so this knowledge gap is highly relevant in terms of optimising monitoring programs for tropical weirs. This PhD project will work alongside the wider CQUniversity project, aiming to streamline monitoring of nutrient concentrations while investigating and modelling the changes in nutrient dynamics that occur as inundated vegetation decomposes in a tropical impoundment.

5.2.2 Project Delivery Schedule

The following table outlines the proposed activities and indicative timing for the establishment and delivery for the first two years of the water quality research offset project:

	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Establish agreement with CQU to undertake research projects and scope of work								
Engage research students to do work and refine topics								
Start Masters topic								
Start PHD topic								

The Masters research topic is planned to be completed within two years of commencement and the PHD topic within four years subject to alignment with university semesters. Although the work will start in the first year Sunwater are not planning on apportioning the offset amount until the completion of the research projects.

5.3 Streambank Rehabilitation Projects

5.3.1 Reducing Sediment Loss

As part of the suite of offset options to be further investigated during stage 1 in the first year of the project's operation there are a number of stream bank rehabilitation projects that have been identified. These projects involve the reinstatement of currently eroding streambanks to a natural form that will protect from erosion and prevent the transport of sediment to the Great Barrier Reef. The reduction in the sediment load in the waterway correlates to a reduction in particulate nitrogen and hence offset of nitrogen loads to the GBR.

Whilst the Fitzroy catchment was targeted as a priority for projects during this assessment, neighbouring Great Barrier Reef catchments were also included to ensure the highest reduction in impact on the GBR was attained by the offsets. The following projects have been shortlisted following initial assessment by Alluvium Consulting:

Table 14: Short List of Streambank Rehabilitation Sites

Project Site	Catchment	Description	Estimated N Removal (t/annum)
Macfield	Fitzroy River	Remediate 1550m of streambank including bank reprofiling, overland flow and rock batter chutes, rock toe/pile fields and revegetation	3.3
Bingera	Burnett River	Remediate 850m of streambank including bank reprofiling, pile fields, large wood installation and revegetation	9.1
Calliope	Calliope River	Remediate 300m of streambank including bank reprofiling, pile fields, large wood installation and revegetation	2.0
Ogmore	Styx River	Remediate 250m of streambank including bank reprofiling, pile fields, large wood installation and revegetation	1.8

Sunwater, in partnership with the local waterway management organisations (Burnett-Mary River Group / Fitzroy basin Association) shall undertake further assessment of these projects to determine the most cost effective method of delivering the projects and maximising the reduction of sediment loss. Depending on the site the project may involve:

- Reprofiling of the river bank and removal of material
- Installation of structural bank stabilisation features such as timber pile fields
- Drainage controls such as rock batter chutes
- Revegetation of the banks with native species

The calculation of loads from these projects shall be undertaken as described in Section 4 above as per the Paddock to Reef modelling.

Additionally once the work has been undertaken Sunwater shall commit to a monitoring and maintenance regime from the completion of the works until Year 6. This will monitoring regime will be consistent with the approach for the Foleyvale / Stoney Creek offset site. This shall be included in the project plan to be developed in Stage 1 and will ensure that the area is established and stabilised and further erosion is prevented.

Refer to Attachment 3 for details on the initial assessment of each of the four projects.

5.3.2 Project Delivery Schedule

The following table outlines the proposed activities and timing for the establishment and delivery for the first two years of the streambank rehabilitation offset project:

Table 15 – Streambank Rehabilitation Startup Delivery Schedule

Task	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Site feasibility assessments								
Site investigations and engagement with stakeholders								
Agreements with delivery partners (BMRG/FBA)								
Sunwater Commitment								
Finalisation of budgets								
Project permits and approvals								
Onboarding of construction partners								
Construction works								
Site maintenance and monitoring								

The early assessment of each site will be undertaken in the first half of Year 1 with a decision on which projects are to be carried forward to the construction phase made in at the end of Q2. Those that are continued are due to be constructed by Q2 of Year 2 prior to the wet season of late Year 2. Hence contribution towards the offset value will commence in Year 2. Depending on the scale of the works, permits required, and favourable weather conditions there is a possibility that construction may commence earlier allowing a contribution towards the offset amount to be made earlier.

5.3.3 Sediment Removal

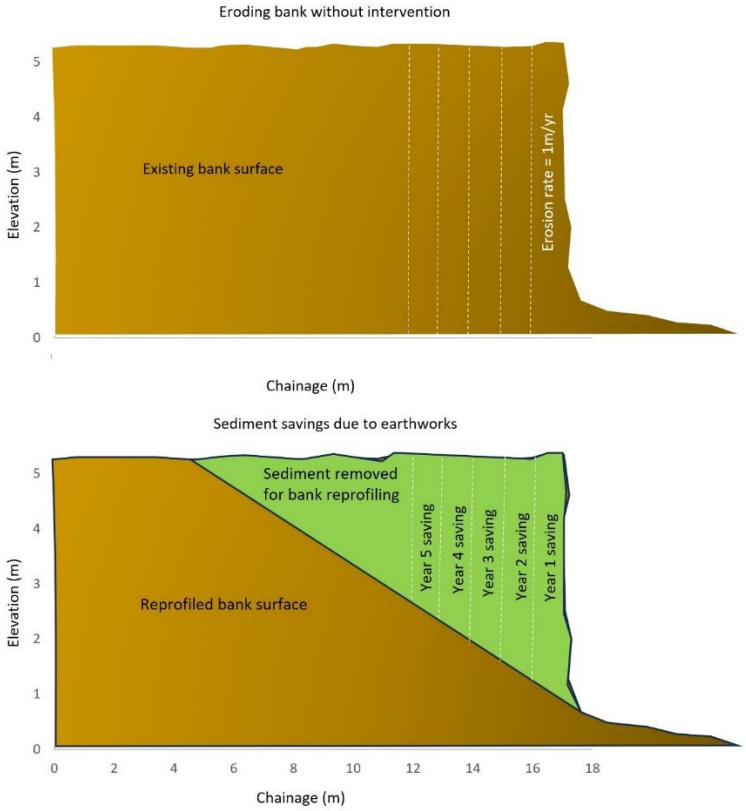
As part of undertaking the rehabilitation of these sites a volume of material is also required to be removed from site. The removal of this soil would result in an amount of material that would not be available to be eroded and transported to the GBR during the flood event. Hence the removal and the associated nitrogen contained in the organic matter in the soil would reduce the water quality impact on the GBR. By taking this material to a location whereby it is no longer able to be transported to the reef there is a direct reduction that can be calculated as an offset.

For all of the potential offset sites, bank reprofiling to a gradient of minimum 1V:3H is generally required to provide geotechnical stability and a slope suitable for establishment of native vegetation. The spoil removed due to reprofiling is typically placed in floodplain depressions or utilised for other purposes by the land manager. Depending on the location the sediment removed can therefore not be eroded and mobilised into the stream. By considering the erosion rate at the site, the program period and the spoil removed from the system due to bank reprofiling, it is proposed that this could be used to calculate the sediment/nitrogen offset.

The proposed methodology for calculating the offset using this methodology is as per the Paddock to Reef modelling described in Section 4.2 above although further work is to be undertaken to develop the contribution to nitrogen reduction on the GBR.

Sunwater is not currently including this additional nitrogen calculation to contribute to achieving its offset target, however this may change during Stage 1 where further development of this item shall be undertaken. Refer to Attachment 3 for further information.

Figure 4: Typical schematic of streambank sediment loss



5.4 Weed Harvesting Project

5.4.1 Background

The Fitzroy Basin Association (FBA) are currently managing a pilot program to harvest water hyacinth weed from a section of the Fitzroy River. This is a known location of extensive growth near Yamba which is downstream of Rookwood Weir and of upstream of the Fitzroy Barrage. The project is currently funded by the Cooperative Research Centre for Northern Australia (CRCNA) and the Rockhampton Regional Council (RRC) Making Water Work program. The study will seek to test the viability of harvesting the weed for production of product with a nutrient and commercial value.

The project has multiple environmental benefits including:

- the reduction of weed that is transported downstream to the GBR in high flow events following the growth period during the winter low flow;
- Removal of weed for improved aquatic fauna movement in the river;
- Removal of weed for recreational water users and irrigators; and
- Significant reduction in the amount of herbicide that is currently sprayed by the Rockhampton Regional Council to control the water hyacinth each year.

Currently it is estimated that up to 24-36t of nitrogen may be removed through the harvesting of 10ha of weed which equates to approximately 800-1200t of dry mass. The study will also include further analysis of the water hyacinth to detail the nitrogen removed per tonne of dry material. The project will see the development of scientific paper by James Cook University (JCU) to be published by the end of 2024. However the results of the laboratory analysis will be completed in the first half of 2024 allowing an assessment of the program and determination of next steps to occur by the end of 2024.

5.4.2 Sunwater Program

Following completion of the pilot program being undertaken by FBA , Sunwater intends to work with CRCNA / RRC / FBA to utilise the learnings form the program to develop a future program to harvest water hyacinth from the lower reaches of the Fitzroy River upstream of the Fitzroy Barrage. This would see the reduction in nitrogen load to the Great Barrier Reef on a yearly basis. The material removed would be composted / processed to ensure the product is utilised in a way that the nitrogen is not available for return to a waterway. There is an opportunity to partner with Rockhampton Regional Council to assist facilitate processing.

Current opportunities for the product to be utilised include:

- Composting at current nearby farming operations (eg macadamia nut and lychee) for uptake of nitrogen by plants
- Development as a feedstock for cattle
- Use as an input into energy project at a local power station

Existing estimates are the plant has a dry weight Nitrogen content of 3%. Therefore through the extraction of approximately 3000t of wet material in any one year, which reduces to 300t of dry material, approximately 10t of nitrogen would be extracted. Depending on the weather conditions and hence weed growth this could be scaled accordingly to increase up to double this amount should the weed be present in the river.

Depending on the final use of the product, a methodology shall be developed to determine the nitrogen removed and support the claim of nitrogen prevented from reaching the Great Barrier Reef. This will be supported through the scientific paper produced by James Cook University from the pilot program.

5.4.3 Project Delivery Schedule

The following table outlines the proposed activities and timing for the establishment and delivery for the first two years of the weed harvesting offset project:

Table 16 – Weed Harvesting Startup Delivery Schedule

Task	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Pilot Program completed								
JCU Analysis								
Engagement with stakeholders								
Feasibility Assessment								
Development of end use process								
Finalisation of budgets								
Procurement of delivery partners								
Establishment of facilities								
Harvesting Operations (weed and weather conditions dependent)								
Site maintenance and monitoring								

5.5 Landcare Projects

5.5.1 Non-Rookwood Scheme Agriculture

Sunwater will look to partner with existing landcare delivery groups such as Advance Rocky and Fitzroy Basin Association to fund improvement programs on agricultural land in the Lower Fitzroy basin. An opportunity exists to improve practices at agricultural operations who are not customers of Sunwater through the Rookwood project. Currently the funding for the existing Advance Rocky program is until June 2024.

Additionally there are a number of irrigators in the Fitzroy Region that utilise water from non-Rookwood schemes. Therefore an opportunity exists to work with these landholders to develop Farm Plans to replicate the Rookwood Land Management Code of Practice requirements and reduce pollutant loads on the Great Barrier Reef. The farm plans would not form part of the requirements for Rookwood Weir's DCCEEW approval but would be used as a template for other farmers.

5.5.2 Gully Restoration

Gully restoration projects have been undertaken in recent years through various landcare / catchment organisations in the Fitzroy catchment which have been funded through government programs such as the Reef Trust. These programs have proved to be successful in reducing the sediment loads reaching the Great Barrier Reef. In turn this provides an opportunity to reduce the particulate nitrogen load associated with this sediment.

Sunwater are proposing to work with local organisations and landholders to develop programs to address gully erosion sites on properties. These properties will not necessarily be Sunwater customers but instead be agricultural operations outside of the Land Management Code of Practice scheme such as cattle grazing operations within the Fitzroy River catchment.

The typical works undertaken for gully restoration and rehabilitation include but not limited to:

- Construction of fencing along gully and riparian zones to prevent cattle accessing waterways and providing alternative watering points such as troughs.
- Reshaping of eroded banks
- Installation of drainage controls such as check dams and chutes
- Revegetation of gully streambank areas
- Improved grass cover for pastures to prevent erosion

Sunwater propose to develop this during Year 1 of the operation of the weir with details of specific programs to be included in the Water Quality Offsets Review Report.

5.5.3 Legume Planting

One specific opportunity involves the planting of legumes for nitrogen fixing within the soil to improve pasture for grazing. Certain species of legumes are known to fix high rates of nitrogen in the soil. They also grow fast, are highly palatable and seed spread by cattle and other animals ensure that it will continue regrow in the paddock. When sown in a pasture it is estimated that around 25- 30kg of Nitrogen fixing per hectare per year can be achieved. Provided the legumes are present, the nitrogen fixing will occur. This can be monitored over a 2 year period to provide assurance of the project effectiveness. If deemed viable and cost effective, Sunwater would establish a program over several properties.

An indicative sequence of steps for project implementation would be as follows:

1. Undertake further project development of business case with Fitzroy Basin Association (FBA) to understand project costs, risks and expected reduction in nitrogen. From this Sunwater will determine the scope of the project.
2. Contracting - Contract development between FBA and Sunwater
3. Implementation
    1. Expression of interest round
    2. Landholder engagement to verify suitability
    3. Property visit 1 - to confirm property and business dynamics and capture baseline data
    4. Landholder agreements to ensure work risk, roles and responsibilities are agreed
    5. Sow inoculated legume seeds
    6. Property visit 2 - to confirm plant germination (2-4months) and capture data to show improvement
    7. Maintenance – if required, do a follow sow to improve legume establishment.
4. Monitoring - Property visits to ensure effectiveness and measure success
5. Reporting - Project completion report

This methodology is very common and well-known in the industry and supported by scientific data of which legume will ensure what level of Nitrogen fixing occurs in a pasture. Additionally landholders are generally in favour of this planting as it increases the yield on their land.

Refer to Attachment 4 for literature supporting this method.

5.5.4 Project Delivery Schedule

The following table outlines the proposed activities and indicative timing for the establishment and delivery for the first two years of the landcare offset project:

Table 17 – Landcare Programs Startup Delivery Schedule

Task	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Establish partnerships with local landcare delivery providers (eg Advance Rocky, FBA)								
Identify opportunities for delivery and landholder engagement								
Develop programs for landholders in the Fitzroy								
Finalise contracts, budgets and delivery arrangements								
Commence programs								
Monitoring of programs								

5.6 In Stream Structure Dredging

Sunwater has investigated the option of undertaking maintenance dredging of material currently trapped by in stream structures in the Fitzroy, MacKenzie and Dawson Rivers. The removal of sediment would result in the associated removal of particulate nitrogen from the watercourse and reduce the amount of nitrogen to the Great Barrier Reef. Currently this material is trapped by the instream structure but then released when flood events occur and the velocity of the river resuspends particulates which are transported over the structure and downstream. The following is a list of priority Sunwater structures identified:

- Fitzroy Barrage;
- Eden Bann Weir;
- Tartrus Weir; and
- Neville Hewitt Weir.

The structures closest to the Great Barrier Reef would be prioritised to maximise the amount of nitrogen reduction. Once dredged the material shall be utilised in a way that prevents the material and hence nitrogen from entering the waterway such as use as construction / building materials.

Sunwater have conducted some preliminary calculations for dredging at Edan Bann Weir with the following yields expected from the dredging program:

Table 18 – Estimated Maintenance Dredging Yield

Item	Amount
Volume extracted	10,000m3
Tonnage sediment	12,000 tonnes
Tonnage Nitrogen	18 tonnes

Sunwater have made a conservative assumption that 50% of this material may be available for the purposes of contribution towards delivery of the offset ie 9 tonnes. Currently Sunwater have not included this option as contributing to the nitrogen offset total.

During Year 1 the following process shall be undertaken to investigate the viability of maintenance dredging for existing in stream structures:

- Undertake bathymetry survey
- Conduct sediment sampling and laboratory analysis for particle size analysis and nitrogen
- Engage with regulatory departments for environmental approvals
- Engage with dredging contractors to undertake the work and end of use processing contractors

The outcomes of these shall be detailed in the Water Quality Offset Review Report.

5.6.1 Project Delivery Schedule

The following table outlines the proposed activities and indicative timing for the establishment and delivery for the first two years of the maintenance dredging offset project:

Table 19 – Dredging Startup Delivery Schedule

Task	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Conduct site investigations (bathymetry, environmental)								
Develop methodology								
Procurement and disposal / resource use agreements								
Environmental approvals assessment								
Commence programs (dry season weather dependent)								
Monitoring of programs								

5.7 Financial Offsets

Where previously described offset program options are not found to be successful during any stage of the delivery period Sunwater may opt to fund the balance of any outstanding offset amounts through organisations undertaking Great Barrier Reef water quality improvement programs or Reef Credits.

The Reef Credit scheme is administered by Eco-markets Australia and is in its early stages at present. Organisations such as Green Collar are currently generating and trading credits on a one-on-one basis to potential buyers. Whilst there are methodologies for the delivery of dissolved inorganic nitrogen and fine sediment there are no approved methodologies for particulate nitrogen qualification. Further methodologies are planned to be developed in the coming years which would facilitate this being available as an option.

Additionally, for the Rookwood Weir project the generation of substantially more credits would be required to be available in the scheme which are currently limited. The number of credits currently available are not enough to offset the entire nitrogen amount however it is anticipated that the Reef Credit market will mature and grow in the coming years. Depending on the successful implementation of the above offset program options, Sunwater may utilise this option and acquire Reef Credits to supplement any shortfall in nitrogen offsets.

5.7.1 Project Delivery Schedule

The following table outlines the proposed activities and timing for the establishment and delivery for the first two years of the financial offset project:

Table 20 – Financial Offsets Startup Delivery Schedule

Task	Year 1				Year 2			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
Establish partnerships with reef credit delivery providers (eg Green Collar)								
Identify opportunities for delivery								
Develop programs for Reef Credits (as required)								
Purchase of credits based on market availability (as required)								

6 Analysis of risks to achieving management objectives and offset completion criteria

Potential risks to achieving the management objectives and outcomes have been considered in this OMP (*Table 22 & 23)*. They have been assessed against the risk matrix (*Table 21*) that was supplied by DCCEEW. The risk matrix has been used to assess the risk that the Plan's objectives will not be met and identify the sources of those risks and strategies for managing them.

The risk assessment:

a) identified events that will, may, or are likely to impact the attainment of the completion criteria
b) assessed the likelihood and consequences of those events, and characterises residual risk levels, taking into consideration the mitigation of the risk by implementing the management actions
c) identified the level of uncertainty in mitigating the risk with the management actions and trigger criteria and corrective actions until the risk is reduced to an acceptable level.

Table 21: Risk matrix

RISK MATRIX	
Qualitative measure of likelihood (how likely is it that this event/circumstances will occur after management activities are implemented)	
Highly likely	Is expected to occur in most circumstances
Likely	Will probably occur during the life of the project
Possible	Might occur during the life of the project
Unlikely	Could occur but considered unlikely or doubtful
Rare	May occur in exceptional circumstances
Qualitative measure of consequences (what will be the consequence/result if the issue does occur)	
Minor	Minor incident of environmental damage that can be reversed (*e.g. short-term delays to achieving plan objectives, implementing low-cost, well-characterised corrective actions*)
Moderate	Isolated but substantial instances of environmental damage that could be reversed with intensive efforts (*e.g. short-term delays to achieving plan objectives, implementing well-characterised, high-cost/effort corrective actions*)
High	Substantial instances of environmental damage that could be reversed with intensive efforts (*e.g. medium-long term delays to achieving objectives, implementing uncertain, high-cost/effort corrective actions*)
Major	Major loss of environmental amenity and real danger of continuing (*e.g. plan objectives are unlikely to be achieved, with significant legislative, technical, ecological and/or administrative barriers to attainment that have no evidenced mitigation strategies*)
Critical	Severe widespread loss of environmental amenity and irrecoverable environmental damage (*e.g. plan objectives are unable to be achieved, with no evidenced mitigation strategies*)

		Consequence				
Likelihood		**Minor**	**Moderate**	**High**	**Major**	**Critical**
	Highly Likely	Medium	High	High	Severe	Severe
	Likely	Low	Medium	High	High	Severe
	Possible	Low	Medium	Medium	High	Severe
	Unlikely	Low	Low	Medium	High	High
	Rare	Low	Low	Low	Medium	High

Table 22: Risk assessment for the Foleyvale / Stoney Creek sites

Note: The risk ranking codes relate to the risk matrix as follows: L = Likelihood C = Consequence R = Risk

Risk	Threats	Initial risk ranking			Management measures	Management measures/actions	Residual risk ranking		
		L	C	R			L	C	R
Force majeure events									
Drought	The threat posed by drought is a decrease in dry matter yield (**DMY**) and groundcover, an increase in the likelihood of unplanned fire due to the dry conditions. There would also be lower levels of growth expected and hence less groundcover to prevent erosion.	Likely	Moderate	Medium	Offset area management Grazing management	Cattle will be excluded from the streambank offset area at all times.	Likely	Minor	Low
Cyclones/ severe tropical lows/ flooding	The most significant impact from tropical cyclones or tropical lows is typically flooding. Systems generally form between November and April. Potential for damage from floodwaters to streambank areas.	Likely	Moderate	Medium	Offset area management	The offset areas on Foleyvale and Stoney Creek are in parts of the landscape that regularly experience flooding. However the likelihood of extended flooding of the areas is extremely low due to flood waters usually receding within 1 week. However, cyclones and/or severe tropical lows are relatively infrequent (though likely to occur at some point during the life of the approval). However, flooding is not expected to be of sufficient duration, and winds are not expected to be sufficiently severe, to cause substantial long-term harm to the site. Additionally, the increased availability of soil moisture following extreme weather events is expected to increase growth rates, likely assisting natural repair of any potential damage. Flooding may also contribute to erosion (see below).	Likely	Minor	Low
Degradation of habitat or erosion through land management									
Degradation of habitat	The degradation of habitat due to the lack of environmental management of the offsets area including appropriate grazing regimes, invasive plant control, fire management, and/or infrastructure maintenance.	Possible	High	Medium	Offset area management Grazing management	Cattle will be excluded from the offset area at all times. Land has a high level of management as the area is co-located with the project's terrestrial offsets.	Unlikely	Minor	Low
Erosion	Raindrops hit bare soil with enough force to break the soil aggregates. These fragments wash into soil pores and prevent water from infiltrating the soil. Water then accumulates on the surface and increases runoff which takes soil with it.	Highly likely	Minor	Medium	Offset area management Grazing management	The expected severity of erosion at this site may occur due to the topography of the site. However, that risk can be further reduced by excluding stock from riparian areas in the terrestrial offset area and maintaining a groundcover.	Possible	Minor	Low
Fire: the impact from uncontrolled fire would be a reduction in groundcover resulting in a higher risk of erosion									
Unplanned or non-controlled fire in offset area.	The impact from uncontrolled fire would be a reduction in DMY and overall groundcover, thinning of the canopy, destruction of regrowth and emerging saplings and an overall increased erosion risk.	Likely	Moderate	Medium	Fire management	The Foleyvale and Stoney Creek offset site is largely comprised of remnant eucalypt species circa 12-22m in height. These communities are adapted to fire and the risk of a 100% loss is low.	Possible	Minor	Low
Increased fire risk due to high fuel loads	During periods when a low-level grazing regime has occurred and an average or above average wet season, there is an opportunity for fuel loads in the form of dry matter to accumulate to unacceptable levels. When this occurs and the high levels of fuel are present prior to summer, then the risk of wild and/or high-intensity fires is exacerbated.	Possible	High	Medium	Fire management	In the offset area, a cold fire is only to be used at 3 to 5-year intervals during the months of June, July, August and September, when wind speeds are less than 5km/h on the offset site. At the request and under the coordination of the Traditional Owners, cultural burns will be undertaken as required.	Unlikely	Minor	Low

Risk	Threats	Initial risk ranking L	C	R	Management measures	Management measures/actions	Residual risk ranking L	C	R
Invasive plants: introduction, establishment and spread of non-native weeds including restricted invasive plants listed under the* Biosecurity Act 2014 *(Qld)									
New infestations or expansion of existing of invasive weed species in the offset area.	Infestation of previously unidentified invasive weeds within the offset area. The extent of existing infestations of restricted invasive plants species expand or the species become more abundant within the area. If a weed infestation is unchecked, it may cause a significant deterioration in the offset site by reducing groundcover and increasing erosion risk.	Possible	High	Medium	Invasive plants management listed under the *Biosecurity Act 2014* (Qld)	The offset sites on Foleyvale and Stoney Creek are remote and access to the offset area will be limited, to reduce/prevent pathogen/propagule transmission vectors. All vehicles accessing the offset area are required to have undergone a weed inspection and vehicle hygiene check, confirming that they are weed free, before accessing the site. Chemical and/or mechanical control of all restricted invasive plants in accordance with the control measures outlined in the Biosecurity Queensland Fact Sheets or other sources of information.	Unlikely	Minor	Low
Pest/feral animals in the offset area									
Increased population of feral animals in the offset area.	Wild cat, pig and dog populations are extensive and highly transient, and therefore the scale of impact is potentially large. Major damage to the environment/habitat occurs when large numbers of animals congregate in the area. Potential for disturbance of streambank areas.	Highly likely	High	High	Pest animal management	Current control of pigs and wild dogs is undertaken via a feral pest management program on the property. Additionally, during regular inspections of the offset area may remove any wild cats, pigs or wild dogs that are seen. If an increase in pig or dog activity is noted, an additional control program is to be instigated until the increased activity has ceased.	Possible	Minor	Low

Table 23: Risk Assessment for Offset Projects

Risk	Threats	Initial risk ranking			Management measures	Management measures/actions	Residual risk ranking		
		L	C	R			L	C	R
Research Project									
Student Commitment	Due to unforeseen circumstances the student involved does not complete study.	Rare	Critical	High	Engagement	Regular communication and meetings with CQU and research students to ensure needs of the program are being supported and met. Sunwater to appoint an Industry Supervisor to each of the research programs to provide guidance. Revision and continuation of the program with an alternative student as appropriate.	Rare	Critical	High
Streambank Rehabilitation Project									
Cyclones/ severe tropical lows/ flooding	Extreme weather events causing damage to rehabilitation sites	Possible	High	Medium	Offset area management	Plan to undertake offset works during the dry season to avoid damage from extreme weather events and to ensure areas are established prior to the wet season in the particular year of work. Sunwater to partner with local catchment groups experienced in delivering these projects within their local area. Utilise local knowledge on river behaviour and weather conditions to plan the delivery of the projects. Sunwater to undertake regular monitoring and maintenance on of the streambank projects.	Unlikely	Minor	Low
Cost effectiveness	Further analysis demonstrates that the project is not a cost effective way of delivering a nitrogen reduction	Highly likely	Minor	Medium	Survey and Investigation	Undertake extensive preliminary survey and investigations on the prospective site to ensure the maximum return of the site and cost effective rehabilitation methods are employed. Undertake analysis on a number of sites to ensure the project is not reliant on one option should it not be deemed viable.	Possible	Minor	Low
Weed Harvesting Project									
Final Product Use	A marketable product is not able to be developed from the weed material	Likely	Moderate	Medium	Reuse and disposal options analysis	Following the pilot study undertake an extensive stakeholder consultation program in the region to establish options for product use. This would involve a number of parties including: - Rockhampton Regional Council - DES and DAF - Resource and waste processing companies - Agricultural industry - Community groups	Possible	Minor	Low
Harvesting and weed management	The process of harvesting and managing the weed limits the volume able to be removed.	Possible	High	Medium	Equipment	Investigate the opportunity for Sunwater to procure equipment used in the harvesting, handling and transfer process to improve efficiency and / or extend the harvesting period.	Unlikely	Minor	Low
Landcare Project									
Landholder Engagement	Limited number of landholders are interested in being involved in the project.	Possible	High	Medium	Engagement	Utilise existing organisations with established relationships with landholders within the Fitzroy catchment to deliver the program.	Unlikely	Minor	Low
Time of delivery	The delivery of landcare programs take longer than six years and are unable to contribute to the offset.	Highly likely	High	High	Delivery Timeframe	Partner with existing third party providers to extend and/or increase the scale of programs as soon as practicable during Stage 1 following commissioning of the weir.	Unlikely	Minor	Low

Risk	Threats	Initial risk ranking			Management measures	Management measures/actions	Residual risk ranking		
		L	C	R			L	C	R
Financial									
Credits not available	Offset credit market is not mature enough to have generated the number of credits needed to be purchased by Sunwater	Possible	Moderate	Medium	Engagement	Regular communication with the Eco-market and Green Collar representatives to understand when credits are coming to market and opportunities arise to purchase. Position Sunwater as a potential buyer of credits within the market. Investigate opportunities for Sunwater to be a generator of credits through other programs within the business.	Possible	Moderate	Medium
Offset projects fail to intercept the Nitrogen required to be offset, as determined by the WQMP, as per Condition 1 of the EPBC approval									
Offset fails to achieve the interim performance targets and/or completion criteria	Failure to achieve and maintain offset completion criteria	Possible	High	Medium	Offset area management	Review the implementation and the management actions of this OMP on a regular basis. Investigate other projects that could intercept Nitrogen and new technology is developed. Monitor and report on attainment of interim Nitrogen interception.	Unlikely	Moderate	Low

7 Offset management measures

7.1 Project Management

Sunwater have resourced a dedicated environmental team for the operational phase of the Rookwood Weir project. This team shall be responsible for the project management and delivery of the nitrogen offset projects along with the other DCCEEW offset projects related to the EPBC approval. This team, with the support of specialist in the water quality modelling and monitoring fields shall undertake ensure Sunwater delivers on the water quality offsets and environmental outcomes for the Great Barrier Reef.

Project management for Stage 1 offset projects is detailed below. For Stage 2 projects, further information shall be provided in the Water Quality Offsets Review Report (Year 1).

7.1.1 Foleyvale / Stoney Creek Project

As the Foleyvale / Stoney Creek streambank project is co-located within the terrestrial offset area, management measures include, but are not limited to, management actions required on the offset site to abate those threats identified in the Terrestrial Offset Management Plan. The offset area management measures provide for the management, reporting, and the monitoring program that will be undertaken for the period of the EPBC Act approval (EPBC 2009/5173). Protection of the offset area will be maintained under the Queensland Vegetation Management Act through a Voluntary Declaration (V-Dec).

A number of management actions for the terrestrial management plan also correlate to the management of the area for water quality offsets. Management measures that maintain groundcover and vegetation onsite and hence minimise of erosion and sediment loss include, but not limited to:

- Limiting vegetation clearing to only those areas required for maintaining fencing and fire control lines;
- Restricting unauthorised access;
- Installation of fencing and providing alternate water sources to excluding domestic livestock from the river banks;
- Undertaking minor site works for protection and rehabilitation of the riverbanks, and other high risk erosion areas onsite where identified;
- Controlling feral animals;
- Managing fire; and
- Controlling weeds.

Sunwater shall be responsible for the overall management of this site to ensure compliance and delivery of the water quality offset. The project shall utilise the property owners and specialised subcontractors to manage, monitor and report on the site. As previously mentioned in section 5.1 above, a monitoring and reporting program shall be developed and implemented throughout the duration of the offset.

7.1.2 CQU Research Projects

Sunwater shall collaborate with Central Queensland University to undertake water quality research programs with a PHD and Masters students. The students shall be working under the guidance of Dr Nicole Flint (Principal Research Fellow | Postgraduate Research Coordinator) and other staff at the university. During the course of the program Sunwater shall conduct regular meetings with the university staff and students to ensure the research projects are delivered in a timely manner and the requirements are being met. A Sunwater representative shall be appointed as an Industry Supervisor for each of the research programs to provide guidance.

8 Responsible parties

As approval holder, Sunwater is accountable for implementing the plan and programs to achieve the required offset target for nitrogen and meeting the conditions of the EPBC approval. Sunwater will be responsible for coordinating reporting, reviewing, inspections, auditing and any adaptive management changes to the plan. A Sunwater representative (e.g. Environment Manager) will be assigned the responsibility of managing offset requirements for the Rookwood Weir project.

For each of the offset projects, Sunwater will engage suitably qualified persons to undertake the appropriate studies and surveys, prepare reports and undertake inspections, as required. Additionally for each of the offset projects Sunwater shall enter into signed agreements with delivery partners which detail the responsibilities of each party to deliver the offset. Where these are yet to be specified they will be included in the Water Quality Offset Review Plan as the programs are developed in Year 1.

For Foleyvale and Stoney Creek streambank rehabilitation project site which has co-located offsets, Sunwater has entered into an agreement with the landowners (Woorabinda Pastoral Company) to undertake the offset management actions and day to day management of the site, including fencing, managing fire breaks, weed management, and feral animal management.

9 Non-Conformance & Incident Reporting

As per approval Condition 19, Sunwater will notify the Department within 2 business days of becoming aware of any incident, non-compliance with conditions, or non-compliance with any of the commitments made in this OMP. Similarly with Condition 20, Sunwater will also provide the details of any incident or non-compliance to the Department as soon as practicable and no later than 10 business days of becoming aware of the incident or non-compliance. (See also *Section* 12 - Adaptive management and plan review).

This report shall specify:

a) any corrective action or investigation, which the approval holder has already taken or intends to take in the immediate future;
b) the potential impacts of the incident or non-compliance;
c) the method and timing of any remedial action that will be undertaken by the approval holder.

Incidents relating to impacts to MNES identified at any of the offset sites will be reported by the landowner or site occupants to Sunwater. The level of severity will dictate the necessary actions through the company's formal incident management system. Responses to incidents related to any offset project will be coordinated by Sunwater, to ensure any necessary notifications and corrective actions are undertaken as soon as reasonably possible.

10 Offset completion criteria and performance targets

Offset completion criteria and performance targets have been determined for each of the offset projects based on the principles outlined in the guidelines published by ANZMEC (2000), stating completion criteria should be:

1. Specific enough to reflect the unique set of environmental, social and economic circumstances.
2. Flexible enough to adapt to changing circumstances without compromising objectives.
3. Include environmental indicators suitable for demonstrating that rehabilitation trends are heading in the right direction.
4. Undergo periodic review resulting in modification if required due to changed circumstances or improved knowledge.
5. Based on targeted research which results in more informed decisions.

The staged approach to the water quality (Nitrogen) offsets (as discussed in *Section 4* and shown in *Table 7*) will enable Sunwater to monitor the results of each project to determine the total extent of Nitrogen interception achieved, and these results will inform the later stages of the overall offset project.

Over the course of the management period a number of completion criteria have been proposed for each project, as shown in *Table 24.*

The completion of management actions will enable the offset projects to achieve the outcomes required in *Table 24*, thus meeting the completion criteria required of the offset. The annual reports will provide transparency regarding how the site management actions are being implemented, and where relevant, identify any force majeure events impacting the offset site, and any non-compliance with the management plan.

Table 24: Offset completion criteria

Project	Timeframe	Estimated Total Nitrogen Intercepted	Method of Calculation
Foleyvale and Stoney Creek – interception and reduction of sediment and streambank restoration	Established in year 1 and maintained for the life of the action	40.8t (6.8 tonnes/year)	To be quantified through Paddock to Reef modelling
Water Quality Research (CQU)	Years 1 to 4	18t (up to 10% of total as indirect offset)	Published PHD and Masters
Streambank Rehabilitation - Bingara	Established in year 2 and maintained to year 6	9.1 tonnes/yr	To be quantified through Paddock to Reef modelling
Weed Harvesting	Years 1 to 6	10 tonnes/yr	Quantified through scientific assessment conducted in pilot program and associated scientific paper
Landcare Projects	Years 2 to 6	1 tonnes/yr	To be quantified through Paddock to Reef modelling
In stream Structure Dredging	Years 3 to 6 (TBC)	TBA	Nitrogen content sampling and volume of material removed
Financial	As required	TBA	As per accepted regulatory methodology depending on scheme

11 Monitoring and reporting

11.1 Monitoring

Monitoring of all projects will be undertaken on a regular basis by Sunwater to ensure compliance and delivery of nitrogen load reduction to the Great Barrier Reef. This will be completed in conjunction with the water quality monitoring reporting. Sunwater shall employ a dedicated team of environmental professionals to oversee the delivery of each of the offset programs. As part of their role they shall undertake a monitoring regime tailored to the timeframes and requirements of each of the programs to offset nitrogen by Sunwater. Monitoring methods shall include but not be limited to:

Table 25: Offset Monitoring Frequency

Project	Monitoring Frequency
Foleyvale and Stoney Creek – streambank restoration	Inspection of the water quality offset site on a quarterly basis
Research	Quarterly meeting with Central Queensland University researchers and staff
Streambank Rehabilitation - Bingara	Inspection of the offset site on a quarterly basis
Weed Harvesting	Monthly inspection of the river site during weed harvesting operations. Quarterly monitoring of ancillary areas such as stockpiles.
Landcare Projects	Inspection of the offset site(s) on a quarterly basis
In stream Structure Dredging	Monthly inspection of the river site during dredging operations. Quarterly monitoring of ancillary areas such as stockpiles.
Financial	Six monthly communication with Reef Credit market organisations

11.2 Reporting

Sunwater, its successors or assigns, will, as per Condition 10 of the approval, provide an Annual Compliance Report each year following the date of the commencement of the action for the period of the approval. This is provided to DCCEEW and published on the Rookwood Weir Project website.[8] Offset reports describing the progress of the Water Quality (Nitrogen) offset

[8] https://www.sunwater.com.au/projects/rookwood-weir-project/environment/

over the relevant 12-month period will be part of those reports until the completion criteria are achieved. The reporting schedule is provided in Table 20 below.

The annual Water Quality (Nitrogen) Offset Reports will contain records substantiating all activities relevant to the implementation and management of the offsets, in keeping with the requirements of Condition 10 of the Approval.

Where offsets have been co-located such as the Foleyvale / Stoney Creek site, the progress of the different requirements (ie terrestrial and water quality) shall be assessed and reported separately.

Sunwater, its successors or assigns, will publish the annual compliance reports, of which the Water Quality (Nitrogen) Offset Reports form a part, on the website within three months of the relevant 12-month period. Sunwater, its successors or assigns, will supply documentary evidence showing proof of the date of publication of the compliance report will be supplied to the Department at the same time that the compliance report is published. These commitments ensure that Condition 10 of the approval is being met.

Table 26: Reporting schedule

Report Details to DCCEEW	Reporting period	Submission due date
Compliance Report Detailing compliance with approval conditions under the EPBC Act, including compliance with the offset conditions, as detailed in this OMP. This will be provided at https://www.sunwater.com.au/projects/rookwood-weir-project/environment/	Every 12 months following commencement of the action 17 July, as per approval Condition 10.	Within 3 months following 17 July
Foleyvale / Stoney Creek Project Offset Plan	NA	Within 6mths of weir operation
Water Quality Offset Review Report (Year 1) Detailing delivery of Stage 1 offset projects and planned offset projects to be implemented years 2 to 5	Year 1 following the date the weir becomes operational	Within 3mths of the start of Year 2 of operation
Nitrogen Assessment Report Reviewing the first two years of water quality data	Year 1 and 2 of operation	Within 3mths of the start of Year 3 of operation
Water Quality Offset Review Report (Year 5) Detailing delivery of offset projects and planned offset projects to be implemented years 6 to 10	Year 1 to 5 of operation	Within 3mths of the start of Year 6 of operation
Water Quality (Nitrogen) Offsets Report Detailing offset project delivery over the past year	Annual Report Year 1 to Year 10	Within 3 months following 17 July

12 Adaptive management and plan review

This plan has been prepared to be implemented until the offset completion criteria have been achieved or when the approval for the action ceases. Management measures will be reported in the annual offset reports and adapted as required, should triggers be reached and corrective actions be implemented. If management measures need substantial adjustment, Sunwater will review this plan in consultation with the landholder, delivery partners and/or other stakeholders.

13 Conclusion

This Offset Management Plan has been prepared to address all the requirements of the *Environment Protection and Biodiversity Conservation Act 1999*.

The staged approach to providing the Nitrogen interception projects described in this plan will successfully deliver offsets for the Rookwood Weir Project's impacts to water quality (Nitrogen).

These offsets for the Project will be implemented consistent with the EPBC Act *Environmental Offset Policy* and the approval conditions for the project. The approval holder commits to the implementation of this plan.

As per EPBC approval Condition 5.e), the approval holder will not begin inundation of the impoundment of Rookwood Weir unless the Minister has approved this OMP in writing.

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Great Barrier Reef Marine Park Authority 2018, *Net Benefit Policy*, GBRMPA, Townsville

Attachment 1: Revised Nitrogen Modelling – Alluvium Consulting

Memo

Subject	Revised Method Outline
Project	Rookwood Weir Nitrogen Offset Support
Distribution	Dale McNab, Sunwater
Date	27 June 2023

Rookwood Weir is planned to be constructed along the Fitzroy River to the southwest of Rockhampton. The weir is expected to lead to approximately 890 ha of land becoming permanently inundated. As a result of this inundation, terrestrial vegetation in the area will become submerged and decay over time, releasing nitrogen (amongst other elements) to the waterbody. As part of the approval conditions, Sunwater are required to offset nitrogen released due to decaying vegetation on Matters of National Environmental Significance (MNES). This memo describes the original approach taken to estimate the amount of nitrogen requiring offsets and some of the associated limitations with the approach. A revised method to estimate the nitrogen load requiring offsets that addresses some of these limitations is presented.

1 Original approach

The Full Carbon Accounting Model (FullCAM) was applied to estimate the quantum of nitrogen released from the decaying vegetation and, by extension, the estimated sum that would be exported to the Great Barrier Reef Lagoon. FullCAM is a widely used tool for modelling Australia's greenhouse gas emissions from terrestrial sources. It provides integrated estimates of carbon and biomass in forest and agricultural systems based on inputs, such as the dominant underlying vegetation, soil type, and climate.

In the original approach for the EIS, GHD (2010) applied the FullCAM model to estimate the total quantity of biomass that would be inundated by weir impoundment and, the amount of nitrogen that would likely be released due to biomass decay. The FullCAM modelling in the original approach applied mapped regional ecosystems (REs) developed in 2007 (Nangura, 2007) in the assessment. The total amount of biomass was estimated from the RE mapping, and the total nitrogen released was calculated from the amount of biomass and an estimate of vegetation nitrogen content. The nitrogen content used in the original approach was equal to 1.02% of the total mass (based on acacia woodland), which was one of the dominant vegetation types in the original RE mapping. The EIS conditions provided in 2017 for Rookwood Weir 49.0 mAHD, specified that the required offset equalled 695 t, which was the expected amount of nitrogen expected to be released during the first year. The offset was revised in 2020 to 645 t due to a revised inundation area for Rookwood Weir 46.2 mAHD.

Revised ground-truthed RE mapping undertaken in 2020 and 2021, for the inundation extent has shown there to be negligible acacia woodlands within the inundation extent. The ground-truthed RE mapping was also combined with an updated inundation area in revised modelling (2021) to update the nitrogen expected to be released from decaying vegetation and was estimated to be equal to 358 tonnes. This value was included in the Offset Strategy for Rookwood Weir currently approved by DCCEEW.

All of the previous modelling used the exponential decay function in the equation below. The decay rate *k* adopted was consistently applied and equal to 0.62 yr^{-1}, though it was not clear from the documentation of the

original approach on what basis the decay rate was derived. A description of the parameters applied in this equation is provided in Table 1.

$$N\ release = N_0 \times exp(-k \times t)$$

The quantum of biomass, nitrogen mass, and nitrogen mass released from the first year for each of the vegetation types considered within the original FullCAM model is presented in Table 2.

Table 1. Parameters adopted in the exponential decay equation used in the original approach to determine nitrogen released after one year

Parameter	Name	Comments
N_0	Initial Nitrogen Mass (t)	The initial nitrogen mass available for release in the original work was calculated from the acacia woodland x nitrogen content (645 tonnes TN)
k	Decay Rate	Original decay rate (0.62 yr^{-1})
t	Time (year)	Number of years of decay (1 year)

1.1 Limitations of the original approach

There are a number of limitations associated with the original approach, which may have led to unreliable estimates of the quantum of nitrogen requiring offsets. The RE mapping used for this initial method had been noted in subsequent ground-truthed mapping to have been inaccurate (GHD, 2021). This has led to a slight overestimation in the biomass present within the inundation extent of the weir and a change in the predominant vegetation types within the inundation extent.

The original nitrogen content value adopted in this original analysis (1.02%) was based on acacia woodlands, which were determined to not be present within the inundation extent through the subsequent ground-truthed mapping activities (GHD, 2021). Therefore, this nitrogen content value may no longer represent the actual vegetation affected by weir impoundment. It was further noted that the decay rate used in the original analysis did not seem to be based on any discernible line of evidence (i.e. no reference sources). It would be preferable if values adopted in the analysis were based on the available literature and well cited. It was also noted that a single value for the nitrogen content and decay rate each was used in the original analysis for all vegetation types (stem, branch, bark, and leaf dry biomass). In reality, the various vegetation types would be expected to contain different levels of nitrogen (leaf matter the most and stems the least) and decay at different rates (leaf matter the quickest and stems the slowest).

Furthermore, the equation adopted for calculating the decay of the vegetation within the first year appears to have been applied incorrectly. The outputs from the equation above determine the quantum of nitrogen that remains within the vegetation matter after a certain period of time and not the quantum of nitrogen released, which should have been calculated.

Table 2. Above-ground biomass and nitrogen release from the original FullCAM modelling (GHD, 2021)

Vegetation type	Above ground biomass (tonnes)	Nitrogen content (%)	Nitrogen released 1-year (tonnes)
Stem	37,248	1.02	204.4
Branch	15,520	1.02	85.2
Bark	10,346	1.02	56.8
Leaf	2,069	1.02	11.4
Total	65,183	1.02	357.7

2 Revised approach

Based on the limitations of the original method, Sunwater has requested that the nitrogen release be remodelled to better represent the actual conditions. This revised approach is outlined below.

2.1 Exponential decay equation

As previously noted, the form of the exponential decay equation applied in the original approach appears to have been mistakenly applied to calculate the nitrogen release when it instead calculated the nitrogen remaining within the vegetation. To calculate the amount of nitrogen released, the equation below should be adopted, which is inversely proportional to the equation above (Figure 1). This has led to an overestimation of the quantum of nitrogen released in the first year. This revised nitrogen decay equation is used henceforth for the calculations of the nitrogen released from the first year.

$$N\ release = N_0 - N_0 \times exp(-k \times t)$$

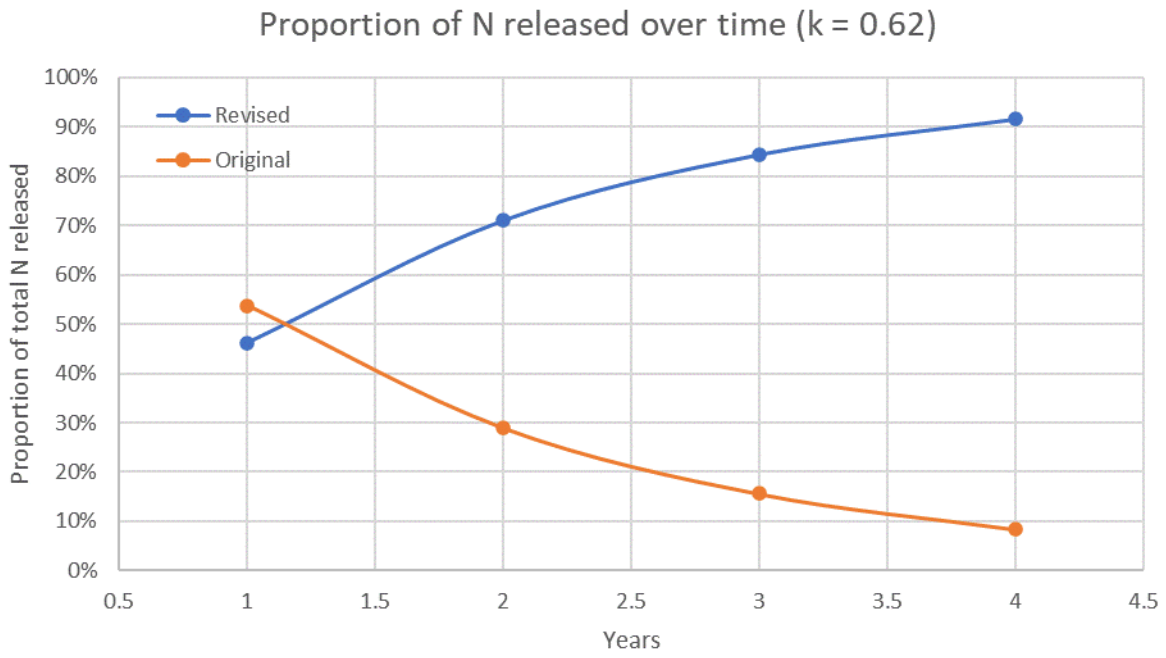

Figure 1. *Comparison of estimated nitrogen released from decaying vegetation over time using the decay equation from the original approach and the revised decay equations*

2.2 Revised RE mapping

Revised RE mapping was conducted by GHD (2021) with a focus on ground-truthing the original RE mapping conducted in 2007. This represents an improvement compared to previous work, which relied on relatively outdated and inaccurate RE mapping. This revised RE mapping showed that weir impoundment was expected to impact mostly on eucalypt and melaleuca species of vegetation (GHD, 2021). The ground-truthed RE mapping results were then applied to the FullCAM model by GHD (2023) to estimate revised dry biomass totals. These biomass totals were then used with the revised decay equation but the original nitrogen content value (1.02%) and original decay rate (0.62 yr^{-1}) to estimate (Table 3) and compare the quantum of nitrogen and the amount of nitrogen released from the first year to the original approach (Table 4). In this instance, the revised equation for estimating nitrogen decay resulted in a lower estimate of the nitrogen released compared to the previous modelling (Table 4).

Table 3. Above ground biomass and nitrogen release from the revised FullCAM modelling (GHD, 2021) applied in the original approach

Vegetation type	Above ground biomass (tonnes)	Nitrogen content (%)	Nitrogen released 1-year (tonnes)
Stem	27,200	1.02	128.2
Branch	20,806	1.02	98.0
Bark	7,669	1.02	36.1
Leaf	6,630	1.02	31.2
Total	62,305	1.02	293.6

Table 4. Comparison of the estimated nitrogen load requiring offsets using the original FullCAM modelling and original decay equation with the revised FullCAM modelling and revised decay equation

Method	Nitrogen released 1-year (tonnes)
Original	358
Revised	294

2.3 Revised vegetation assumptions

A review of the originally adopted nitrogen content values for the vegetation biomass and the adopted decay rate was conducted as it was not clear from the original reporting how these values were derived. The revised method adopted here has applied updated nitrogen content and decay rate values for each of the vegetation types. The selection of these values has been based on the available literature and the vegetation types that were mapped within the inundation extent. Values identified from literature were incorporated into a spreadsheet model to provide a clear line of evidence to relevant sources. The sections below discuss these revisions in more detail.

Revised Nitrogen Content

For the revised approach, nitrogen content from each of the vegetation types was based primarily on measured data from numerous studies of Australian native forests compiled by Snowdon et al. (2005), but also from values suggested by Gilfford (1999). The tables of data used for this can be found in the 'Nitrogen Content' tab of the spreadsheet model. Lower, middle (expected), and upper bounds of nitrogen content in the different vegetation types have been applied to represent the range of values suggested in the literature (Table 5). The middle (expected) estimate was determined from all the available literature and selected as a value that was in line with the majority of the data. It would be important to note that this selection was somewhat subjective, but within the bounds of reported literature values. A detailed overview of nitrogen content in different vegetation types and species is available in the 'Nitrogen Content' tab of the spreadsheet model. The revised nitrogen content numbers were then used with the modelled biomass (Table 3) to estimate the quantum of nitrogen from all vegetation types ('Vegetation Types' tab of the spreadsheet model).

Table 5. Estimated nitrogen content (%) for the different vegetation types (upper, middle (expected), and lower values are provided). Values can be found in the 'Nitrogen Content' tab of the spreadsheet model.

Vegetation type	N content upper	N content expected	N content lower
Stem	0.4	0.16	0.08
Branch	0.46	0.365	0.27
Bark	1.32	0.42	0.2
Leaf	2.1	1.5	0.5

Revised Decay Rate

To revise the nutrient decay rate, estimated rates from the different vegetation types in northern Australia (north of latitude 30°) were retrieved from Mackensen and Bauhus (1999). These values differed from the previously adopted values, with higher values suggested for leaves and bark and lower values used for stems and branches (Table 6). Again upper, middle (expected), and lower values for the decay rate have been applied, which can be found in the 'Decay Rate' tab of the spreadsheet model. The middle estimate was again somewhat subjectively selected as a value that was in line with the majority of the literature. Decay rates are used with the nitrogen mass to estimate the quantum of nitrogen released in the first year.

Table 6. Estimated nitrogen decay rate (k (yr^{-1})) for the different vegetation types (original, upper, middle (expected), and lower values are provided). Values can be found in the 'Decay Rate' tab of the spreadsheet model.

Vegetation type	Decay rate original	Decay rate upper	Decay rate expected	Decay rate lower
Stem	0.62	0.50	0.20	0.10
Branch	0.62	0.50	0.28	0.10
Bark	0.62	1.50	1.00	0.62
Leaf	0.62	1.50	1.00	0.62

Revised Nitrogen Release Calculation

The updated lower, middle (expected), and upper values for nitrogen content and decay rates found within the literature were applied to calculate a matrix of possible nitrogen first-year releases for the range of different nitrogen content and decay rate combinations (Table 7). The revised estimated nitrogen load requiring offsets using the original decay rate and original nitrogen content is also shown for comparison. The revised numbers are seen to be significantly lower than that of the original number. The expected nitrogen load requiring offsets from this revised analysis is approximately 110 tonnes (Table 7). The results of this analysis can be found in the 'Results' tab of the spreadsheet model.

Table 7. Estimated nitrogen released in the first year from the combination of different nitrogen content values and various decay rates. Results can be found in the 'Results Cleaned' tab of the spreadsheet model. The nitrogen requiring offsetting using the original nitrogen content and decay rate but with the updated decay equation and RE mapping was 293.6 tonnes (Table 3).

	N load released 1st year		
Scenarios	N upper	N expected	N lower
Decay rate upper	267.27	149.29	68.33
Decay rate expected	195.10	109.66	48.31
Decay rate lower	130.57	72.20	29.82

Nitrogen Speciation

Some consideration was made to the speciation of nitrogen from the decaying vegetation. We did not consider this in the calculations as there was little evidence to quantify the speciation of decaying vegetation between dissolved and particulate forms. It has therefore been assumed that all the released nitrogen would be in dissolved organic forms and would therefore all be delivered to the reef (delivery ratio of 1). This would be considered the conservative approach. If a portion of the release nitrogen were to be in particulate forms, it is likely that the sum delivered to the reef would be reduced.

Previous Paddock to Reef modelling for the region (Dougall et al., 2014) shows there is significant trapping of sediments and particulate nutrients within the weirs along the Fitzroy River, as indicated by the modelled

delivery ratios. It stands to reason that if a portion of the released nitrogen from decaying vegetation was in particulate forms, that some additional reduction factors could be applied due to the impacts from downstream weirs (Edan Bann and Fitzroy Barrage) but also from Rookwood Weir itself.

Rookwood Weir was estimated to have a sediment trapping capacity of 11% using the LEWIS formula (Lewis, 2013) (refer to the 'LEWIS Trapping' tab of the spreadsheet model for calculations), which was similar to the trapping capacities for the two downstream weirs, Eden Bann and Fitzroy Barrage (~15% from P2R modelling). The existing P2R delivery ratio for the site was approximately 56% for particulates, indicating 44% of particulate matter is not exported from the system. Adding Rookwood Weir brings the total delivery ratio down to 49%, indicating approximately half of all particulate matter would not make it to the reef. Hence, if any of the nitrogen released from decaying vegetation were in particulate forms, it could be argued that the total nitrogen delivered to the reef would be lower than that released from the vegetation. This, however, does not consider any form of nutrient cycling within the weir itself, which may convert particulate matter to dissolved forms. It should also be noted that the weir will work to trap additional sediments and nutrients from the upper catchments and that this has not been considered in this analysis. Hence, not considering these factors would be considered the conservative approach.

Outcome

A range of revised nitrogen content and decay rate values have been considered in this revised approach to develop more refined estimates of the quantum of nitrogen released requiring offsetting. These ranges were implemented to conduct sensitivity testing on the nitrogen to be offset, with upper, middle, and lower bounds presented (Table 8). Using this revised approach, if the expected value for the nitrogen released was adopted, this was estimated to be made up of approximately 110 tonnes (TN).

Table 8. Estimated nitrogen released in the first year from the combination of different nitrogen content values and various decay rates. The nitrogen requiring offsetting using the original nitrogen content and decay rate but with the updated decay equation and RE mapping was 293.6 tonnes (Table 3).

	N load released 1st year		
Scenarios	N upper	N expected	N lower
Decay rate upper	267.27	149.29	68.33
Decay rate expected	195.10	109.66	48.31
Decay rate lower	130.57	72.20	29.82

3 Recommendation

Due to some of the limitations associated with the original nitrogen offset calculations, a revised approach has been developed. Based on this revised approach, the total quantum of nitrogen that would be expected to be released to the Great Barrier Reef from the first year of decaying vegetation is equal to approximately 110 tonnes. As such, a revised offset program should be designed to achieve this number.

4 References

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Attachment 2: Sediment modelling Foleyvale and Stoney Creek

Horizon
Soil Science and Engineering

Technical Memorandum

To: Earthtrade

From: Horizon Soil Science and Engineering

Date: 6 December 2019

Subject: Rookwood Weir Nitrogen Offset Assessment

1. Our Understanding

We understand that the Rookwood Weir Environmental Impact Assessment process requires an offset for the nitrogen projected to be released due to vegetation decay in the inundated area. The offset requirement is 645 t of total nitrogen (Key pers comm, 2019).

Earthtrade engaged Horizon Soil Science and Engineering (Horizon) to assess the reduction in total nitrogen loss that could be achieved through improved management of the Foley Vale property (L1 LR146) and the downstream neighbouring property Stoney Creek (L2 LR27) on the Mackenzie River (property boundaries for both properties shown in Appendix B Map 1).

The assessment areas are defined below (refer to Appendix B Map 2):

- Foley Vale (L1 LR146)
    - 2800 hectares of regrowth and remnant vegetation bounded by the Mackenzie River that is currently grazed (Assessment area 1);
    - 3270 hectares of cultivation (Assessment area 2);
    - 2800 ha of gully stabilisation (within Assessment area 1); and
    - 22 km of streambank (the Mackenzie River bordering Assessment area 1).
- Stoney Creek (L2 LR27)
    - 290 hectares of regrowth and remnant vegetation bounded by the Mackenzie River that is currently grazed (Assessment area 3);
    - 5000 hectares of grazing (Assessment Area 4); and
    - 5290 ha of gully stabilisation (within Assessment Areas 3 and 4); and
    - 6 km of streambank (the Mackenzie River bordering Assessment area 3).

The project was proposed as a hillslope erosion modelling assessment, however, as more information became available, the scope was changed to include the contribution of gully and streambank erosion in the assessment.

This memorandum details the investigative process and summarises preliminary findings of our assessment.

2. Background

2.1. Primary References

The scope of work requested a review of the Brigalow Research Station (BRS) water quality data to benchmark the erosion and nutrient loss estimates. We have provided a summary of BRS site data sourced from the HowLeaky field studies database (Freebairn, 2019) as Appendix A.

With the change in scope necessitating the inclusion of streambank and gully erosion, we identified a key source of data for the assessment was the Source Catchments modelling by the Paddock to Reef (P2R) for the Fitzroy basin. The streambank and gully erosion estimates rely on SedNet modelling functionality incorporated in the Source Catchments modelling. The streambank erosion component relies on streamflow data as a model input.

Source model data for Report Card 2017 and 2018 (Reef 2050 Water Quality Improvement Plan, 2019) was provided by the P2R modelling team (Darr pers. comm., 2019). As the 2017 and 2018 round of modelling is unpublished, references to model assumptions made here refer to Water et al. (2014).

2.2. Assumptions provided

Horizon has relied on discussion with Key pers. comm. (2019) as background to current and proposed site conditions. The following summarises our understanding of improvements that could be made in management practices. Note that the following section refers to ABCD management levels for grazing and cropping that are described in Waters et al. (2014), where classes are:

A – Cutting edge practices, achievable with more precise technology and farming techniques.

B – Best management practice, generally recommended by industry.

C – Code of practice or common practices.

D – Unacceptable practices that normally have both production and environmental inefficiencies.

Foley Vale (Lot 1 LR146)

Assessment Area 1. The area is highly degraded regrowth and remnant vegetation described as two classes:

- Areas that have been cleared and have some regrowth. These areas would be protected from re-clearing.
- Remnant vegetation that is heavily grazed.

Both areas were described to be in "D" class conditions and would be managed to either "A" or "B" class condition.

Assessment Area 2. The area is highly degraded cultivation. The area was described to be in "D" class conditions and would be managed to either "A" or "B" class condition.

No information was provided as to gully or streambank condition.

Stoney Creek (L2 LR27)

Assessment Area 3. The area is highly degraded regrowth and remnant vegetation described as two classes:

- Areas that have been cleared and have some regrowth. These areas would be protected from re-clearing.
- Remnant vegetation that is heavily grazed.

Both areas were described to be in "D" class conditions and would be managed to either "A" or "B" class condition.

Assessment Area 4. The area is highly degraded grazing. The area was described to be in "D" class conditions and would be managed to either "A" or "B" class condition.

No information was provided as to gully or streambank condition.

2.3. Assumptions

Erosion rates in cultivation

Site specific datasets (soils, slope and climate) were available to Horizon for Assessment area 2. HowLeaky was run for the site for both "D" and "A" class cropping management (specific model runs not presented here). These runs showed a reduction in sheet erosion from 2.0 t/ha/yr to 0.7 t/ha/yr, a reduction of 1.3 t/ha/yr. A delivery ratio for suspended sediment of 10% was applied (Water et al., 2014) giving a current generation rate of 0.2 t/ha/yr and an estimated reduction of 0.13 t/ha/yr of suspended sediment when moving from class "D" to class "A" management (data included in Table 2 and Table *3*).

Gully and streambank erosion rates

Darr pers. comm. (2019) did not provide the current condition data for streambank and gully erosion estimates, however it was suggested we should assume a low confidence in generation data at the scale of assessment. We have assumed that the current practice is "D" class and used the following table to estimate improvements that could be achieved due to management. Moving from "D" class to "A" class provides a 50% reduction for both gully and streambank erosion rates. However, we have assumed that improvement management would only apply to 1 of the 2 banks for the streambank erosion reduction, effectively providing a 25% reduction rate.

Spatial data from the Source model was clipped to the assessment areas and is shown in Appendix B Map 4 and Map 5 for Streambank and Gully Sediment respectively. These rates shown are for sediment delivery to the end of sub-catchment accounting for sediment delivery ration of total eroded sediment (Darr pers. comm, 2019).

Table 1: Gully and streambank erosion rates relative to C class practice (Source: Waters et al., 2014)

Grazing practice change	A	B	C	D
	(%)			
Relative gully erosion rate	0.75	0.90	1	1.25
Relative streambank erosion rate	0.6	0.75	1	1.1

Erosion rates in remnant vegetation and grazing

The Revised Universal Soil Loss Equation (USLE) is used in the Source Catchments model to estimate soil erosion in areas such as the remnant vegetation and grazing area (Waters et al., 2014). Horizon was provided baseline input data (except for the seasonal C factor data used in Source – an average C factor was provided) to apply this technique. Darr pers. comm., (2019) was able to provide the Source Catchments model data for the assessment areas 1, 3 and 4 (remnant vegetation and grazing). The data is presented in Appendix B Map 6, 7 and 8 for the USLE rainfall erosivity (R-factor), a combined USLE soil erodibility (K-Factor), Length (L), Slope (S) and rock (r) factor, and for the USLE soil cover (C-factor) respectively.

The USLE method calculates soil erosion as shown below (Source: Water *et. al.*, 2014.). Note that this assessment used an average annual C and R factor and hence A is an estimate of annual average erosion.

$$A = R * K * S * L * C * P \qquad (1)$$

Where

A = soil erosion per unit area (t/ha) (generated as a daily value)

R = Rainfall erosivity EI30 (MJ.mm/ha.h.day) (generated as a daily value)

K = Soil erodibility (t.ha.h/ha.MJ.mm) (static value)

L = Slope length (static value)

S = Slope steepness (static value)

C = Cover management factor (one value generated per year for each 25 m x 25 m grid cell)

P = Practice management factor (static value)

The RUSLE was applied using GIS by Horizon and the data for total hillslope erosion is presented in Appendix B Map 10. For assessment areas 1, 3 and 4 (remnant vegetation and grazing) the spatially averaged annual erosion rates were 0.16, 0.54 and 3.9 t/ha/yr respectively. These were converted to suspended sediment (SS) generation rates by apply clay/silt fractions (refer Appendix B, Map 9) and a 10% delivery ratio, giving SS generation rate of 0.01, 0.3 and 0.21 t/ha/yr for assessment areas 1, 3 and 4 respectively. The results for assessment area 4 (grazing) were comparable to the BRS data (Refer Table Appendix A Table A1) where rates were measured at 0.2 to 0.3 t/ha/yr.

Estimates of reduced generation were made by assuming a constant C-factors equivalent to maintaining "A" management cover. This reduced suspended sediment and particulate nitrogen reductions due to improved management by 80% (refer Table 3).

Floodplain erosion/deposition not considered

It should be noted that the Assessment Area 1, 2 and 3 are within flood zones of the Mackenzie River (refer Appendix B Map 3). Our understanding of the assessment techniques used by Waters et al. (2014) and Reef 2050 Water Quality Improvement Plan (2019) only report sheet erosion associated with rainfall impact, and do not consider sheet erosion due to overland flow. The modelling does consider deposition and it is conceivable that under improved management that these assessment areas would be deposition sites. We are not aware of any modelling techniques being applied, or available, that estimate rate of erosion due to overland flow erosion.

Nitrogen concentrations in sediment

There is limited data on the particulate nitrogen concentrations in soils and suspended sediment (Darr pers. comm., 2019). For this assessment data was available for the generalised soils type within the cultivation (Chamberlain, in-prep) where soil nitrogen concentration was estimated at 0.13%, and on a whole of Fitzroy basis we were able to compare suspended sediment to total particulate nitrogen ratio (Darr pers. comm., 2019) where the ratio was 0.23%. For the purpose of this report we have assumed the nitrogen concentration to be 0.23%. We believe this is a reasonable first estimate as nutrient concentrations in suspended sediment are often greater than the original soils surface, that is the sediments are enriched in nutrients, the enrichment ratio is typically greater or equal to one (Walling, 1983).

Edge of paddock versus end of system

Our assessment assumes delivery to the end of sub-catchment and does not account for delivery to the end of whole of basin. Roughly, we could expect about 40-50% of the sediment and nitrogen to be delivered to end of basin (Darr pers. comm., 2019).

Management improvement period

The assessment assumes that management improvements would have an immediate and sustained improvement. In reality the improved management of grazing, gullies and streambanks could take a number of years to realise their full potential.

3. Result Summary

Table 2 summarises suspended sediment generation rates. The largest source of suspended sediments and particulate nitrogen was streambank erosion, accounting for 95% and 72% of the total for Foley Vale and Stoney Creek respectively.

Table 2: **Baseline generation rates of suspended sediment (SS) and particulate nitrogen (PN) under existing management (Source: Darr pers. comm., 2019)**

Site	Area	SS Rate	Total SS Delivered	Total PN Delivered
Foley Vale				
Assessment Area 1 Remnant and regrowth	2800 ha	0.01 t/ha/yr	31 t/yr	0.07 t/yr
Assessment Area 2 Cultivation	3270 ha	0.2 t/ha/yr	687 t/yr	1.59 t/yr
Gully erosion	2800 ha	0.1 t/ha/yr	280 t/yr	0.64 t/yr
Streambank	22 km	900 t/km/yr	19800 t/yr	45.5 t/yr
		Sub-total for Foley Vale		47.8 t/yr
Stoney Creek				
Assessment Area 3 Remnant and regrowth	290 ha	0.03 t/ha/yr	8.1 t/yr	0.02 t/yr
Assessment Area 4 Grazing	5000 ha	0.21 t/ha/yr	1072 t/yr	2.47 t/yr
Gully erosion	5290 ha	0.1 t/ha/yr	530 t/yr	1.24 t/yr
Streambank	6 km	680 t/km/yr	4080 t/hr	9.38 t/yr
		Sub-total for Stoney Creek		13.1 t/yr
			TOTAL	**60.9 t/yr**

Table *3* summarises the estimated reductions in suspended sediment and particulate nitrogen using assumptions outlined in section 2.3. The 15.9 t/yr reduction in total particulate nitrogen is an average annual value.

The greatest reductions in suspended sediments and particulate nitrogen come from streambank erosion, accounting for 89% and 76% of the total for Foley Vale and Stoney Creek respectively. This suggests that the greatest benefits in reducing total nitrogen loss would be achieved by focussing on streambank stabilisation in this length of the Mackenzie River.

Based on the reduction rates estimated in Table *3*, if all management improvement were adopted and effective at the estimated rates, the period required to offset the 645 t of total nitrogen, would be ~ 40 years.

Table 3: Estimated reduction of suspended sediment (SS) and particulate nitrogen (PN) under "A" class management

Site	Area	SS Reduction Rate	Total SS	Total PN
Foley Vale				
Assessment Area 1 Remnant and regrowth	2800 ha	0.01 t/ha/yr	25 t/yr	0.06 t/yr
Assessment Area 2 Cultivation	3270 ha	0.13 t/ha/ha/yr	438 t/yr	1.01 t/yr
Gully erosion	2800 ha	0.05 t/ha/yr	140 t/yr	0.35 t/yr
Streambank	22 km	225 t/km/yr	4950 t/yr	11.4 t/yr
		Sub-total for Foley Vale		12.8 t/yr
Stoney Creek				
Assessment Area 3 Remnant and regrowth	290 ha	0.03 t/ha/yr	7.4 t/yr	0.02 t/yr
Assessment Area 4 Grazing	5000 ha	0.17 t/ha/yr	874 t/yr	2.01 t/yr
Gully erosion	5290 ha	0.05 t/ha/yr	265 t/yr	0.61 t/yr
Streambank	6 km	170 t/km/yr	1020 t/hr	2.35 t/yr
		Sub-total for Stoney Creek		3.1 t/yr
			TOTAL	**15.9 t/yr**

4. References

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Waters, DK, Carroll, C, Ellis, R, Hateley, L, McCloskey, GL, Packett, R, Dougall, C, Fentie (2014) Modelling reductions of pollutant loads due to improved management practices in the Great Barrier Reef catchments – Whole of GBR, Technical Report, Volume 1, Queensland Department of Natural Resources and Mines, Toowoomba, Queensland (ISBN: 978-1-7423-0999).

APPENDIX A: Brigalow Research Station Data Review Summary (Source: Freebairn, 2019)

Purpose:

The purpose of the Brigalow Catchment Study was to determine the impact of land use change (Brigalow vegetation to cropping and grazing) on hydrology.

Methods

Rainfall and runoff data were obtained over 17 years to define the hydrology of 3 adjoining catchments. Following the initial monitoring period, 2 of the 3 catchments were cleared with 1 of them being used for cropping and the other used for grazing. The catchments were then monitored for water balance, resource condition, productivity, rainfall and runoff.

Thornton *et al.* (2007) used several analytical techniques to confirm that land use has an influence on runoff.

Radford *et al.* (2007) monitored the decline in productivity levels of developed brigalow land over 23 years post clearing.

Titmarsh *et al.* (2009) collected nitrogen and phosphorous levels in rainfall and runoff samples over three years for thirty-one plots (<10 ha in size), each with a particular land use and soil type combination and from three sets of larger nested catchments (3 - 200000 ha) with mixed land use/soils in the Queensland Murray Darling Basin (QMDB).

Key findings

- Thornton *et al.* (2007) found total annual runoff increased to 11% and 9% of annual rainfall in the cropping catchment and pasture catchment respectively (average annual runoff in the virgin state is 5% of annual rainfall).
- Radford *et al.* (2007) observed a decline in crop production per year by 20% between 2 successive 10-year periods.
- Grain yield from 14 winter crops without added nutrients declined significantly in 20 years from 2.9 to 1.1 t/ha/year on the upper-slope clay soil (92 kg/ha/year) and from 2.4 to 0.6 t/ha/year on the Sodosol (88 kg/ha/year).
- The grazed site had an initial pasture dry matter on offer of 8 t/ha which halved 3 years after clearing, and a decline in cattle live weight gain of 4 kg/ha/year was observed over an 8-year period with constant stocking of 0.59 head/ha.

- Thornton *et al.* (2012) found that subsequent reductions in soil chloride under cropping were only significant in the upper clay soil, while under pasture, no further significant change occurred.
- Chloride mass balance analysis indicates deep drainage of 0.17 mm/year for clay soils and 0.26 mm/year for Sodosols under virgin brigalow scrub. These drainage rates increased during the land development phase to 59 mm/year for C2 and 32 mm/year for C3.
- Titmarsh *et al.* (2009) found that the export of N and P from all the single land use/soil type catchments was positively correlated with soil fertility and increased as land use intensity increased. Nutrient export rates for the nested catchments did not correlate well to land use. Average rainfall TN and TP concentrations were 0.38 and 0.04 mg/L respectively.

Table A1: Summary of Observed Average Annual Runoff and Sediment Loss for Brigalow catchment study. HowLeaky simulation results presented for trial period (Freebairn and Cutajar 2012)

Description of Management system	Observed (1984-2004)		Predicted (1984-2004)	
	Runoff (mm)	Sediment loss (t/ha)	Runoff (mm)	Sediment loss (t/ha)
Brigalow scrub (C1)	30.6	0.3 –0.33	31.5	0.26
Opportunity cropping (C2)	71.1	0.8 - 3.2	69.7	1.30
Buffel grass pasture (C3)	58.9	0.17 - 0.28	63.6	0.32

Table A2. Suspended sediment and nutrient export rates for Theodore (Titmarsh *et al*. 2009).

Catchment	Suspended sediment export rate kg/ha/mm	Average suspended sediment concentration, g/L	Total Nitrogen export rate, g/ha/mm	Average Total Nitrogen concentration, mg/L	Total Phosphorous export rate, g/ha/mm	Average Total Phosphorous concentration, mg/L
Theodore – Brigalow C1	14.2	1.4	134.1	7.8	6.2	0.4
Theodore – Brigalow C2	30.6	2.0	71.2	7.2	13.5	1.1
Theodore – Brigalow C3	19.9	0.8	28.6	2.3	3.8	0.4

1. Cowie BA, Thornton CM, Radford BJ. (2007). The Brigalow Catchment Study: I. Overview of a 40-year study of the effects of land clearing in the brigalow bioregion of Australia. *Australian Journal of Soil Research* 45: 479–495.

2. Cowie BA. Surface water quality project: Brigalow Catchment Study Hydstra brief.

3. Radford BJ, Thornton CM, Cowie BA, Stephens ML. (2007a). The Brigalow Catchment Study: III. Productivity changes on brigalow land cleared for long-term cropping and for grazing. *Australian Journal of Soil Research* 45: 512–523.

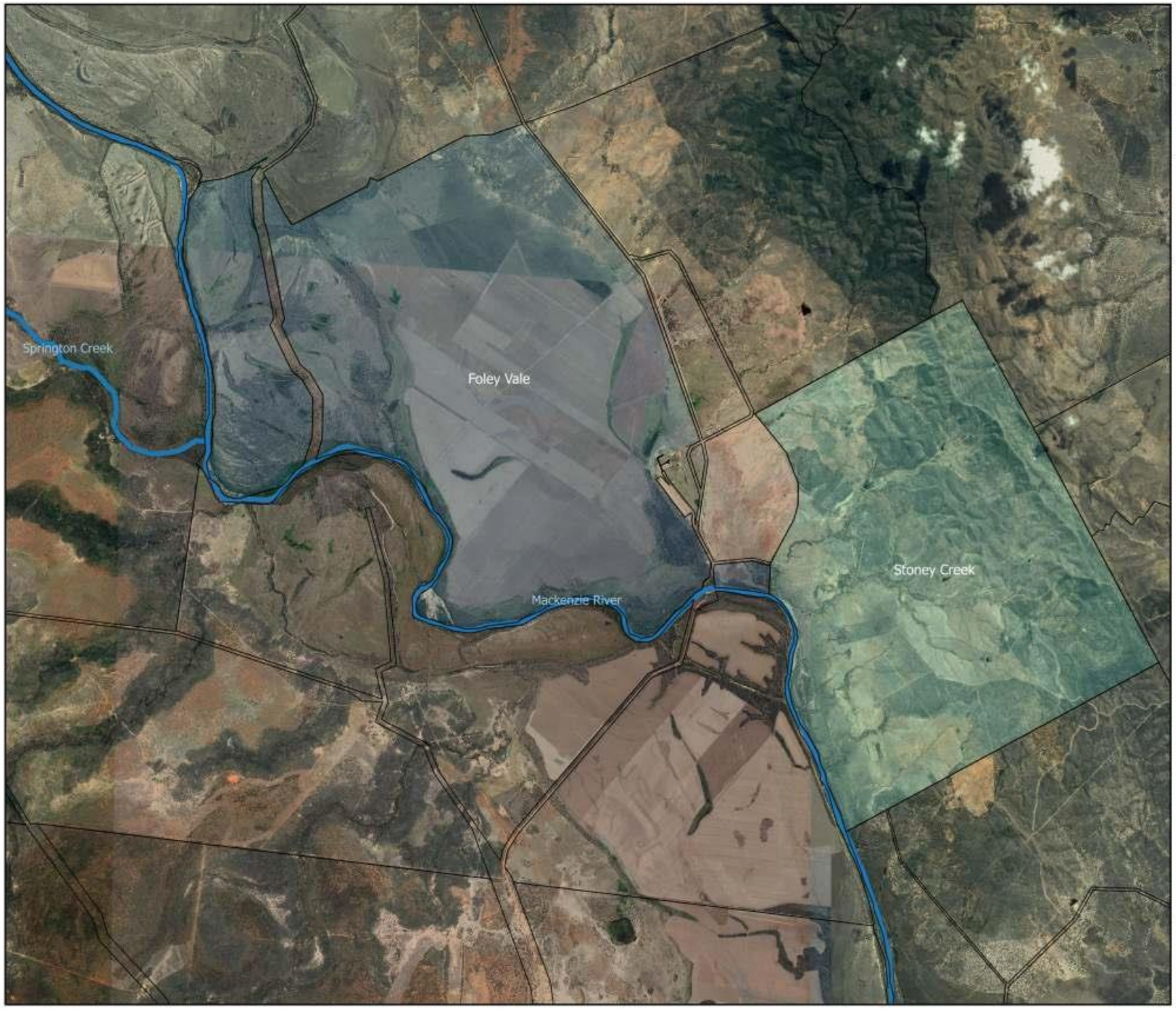
4. Thornton CM, Cowie BA, Freebairn DM, Playford CL. (2007). The Brigalow Catchment Study. II. Clearing brigalow (*Acacia harpophylla*) for cropping or pasture increases runoff. *Australian Journal of Soil Research* 45: 496–511.

5. Thornton C, Cowie B and Silburn M. (2012). The Brigalow Catchment Study: forty-five years of paired catchment monitoring in the Brigalow Belt of Australia. XXV IUGG General Assembly, IAHS Publ. 353.

6. Titmarsh G, Cameron A, and Lock C. (2009). Nitrogen and phosphorous in runoff from small catchments in the Queensland Murray Darling Basin increases with intensity of catchment land use

APPENDIX B: Site Maps

12



Map 1
Property Boundaries

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 13/11/2019

0 2 4 km

Legend

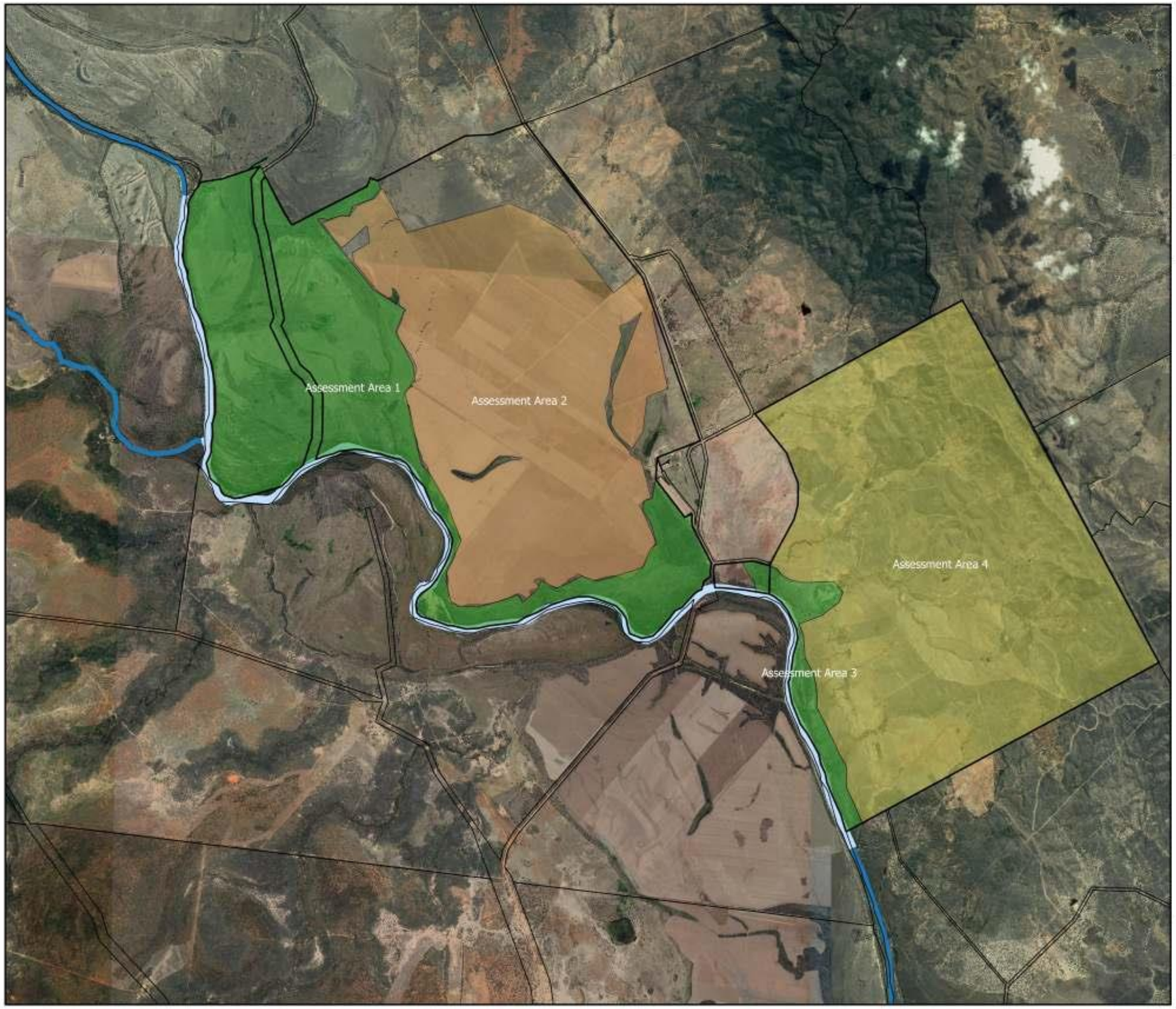
- Cadastre

Foleyvale and StoneyCk

- Foley Vale
- Stoney Creek

Google Satellite

Horizon
Soil Science and Engineering



Map 2
Assessment Areas

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 13/11/2019

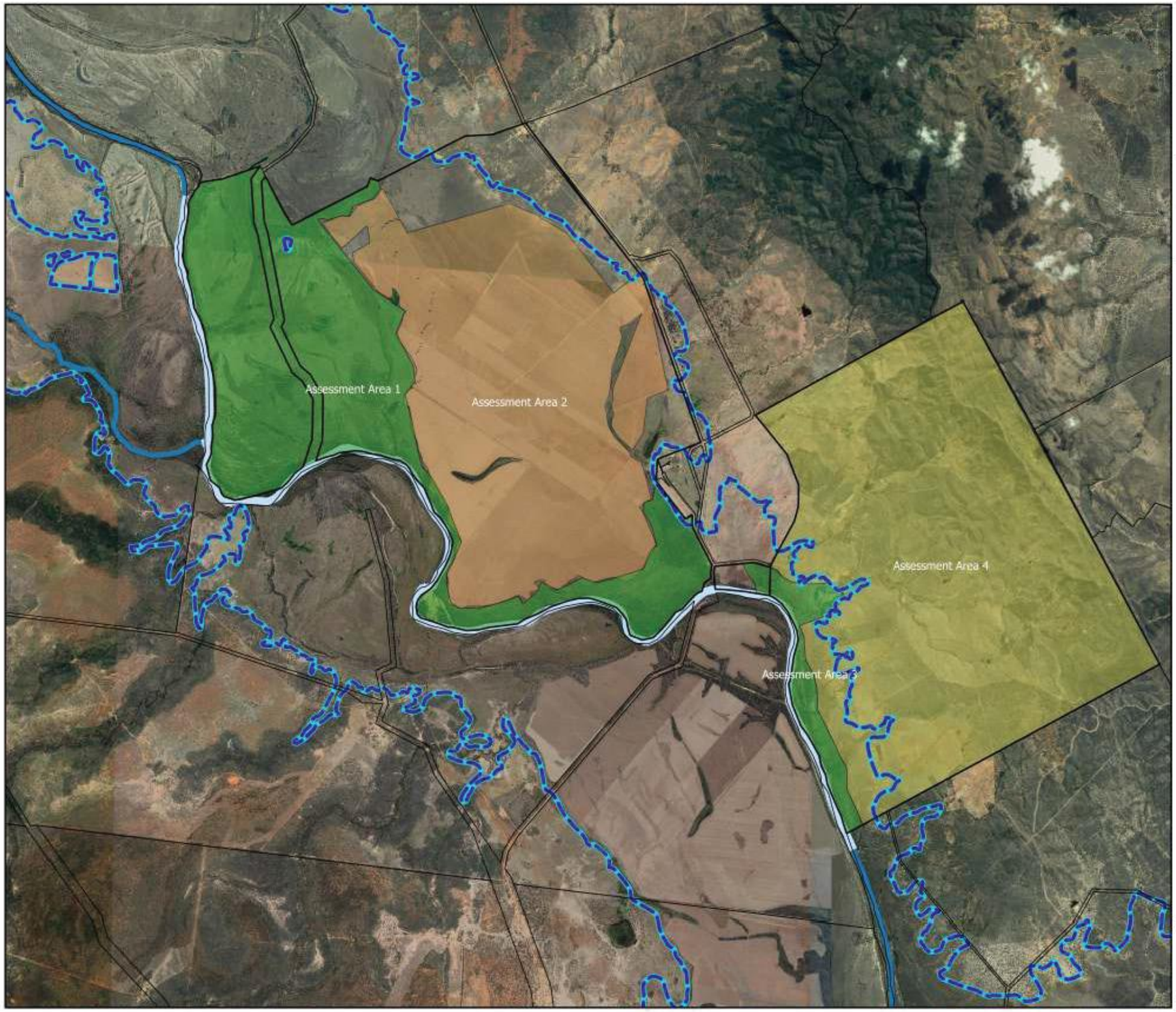
0 2 4 km

Legend

Assessment Areas
- Grazing
- Cleared and Remnant Vegetatio
- Cultivation
- Streambank Assessment Length

Google Satellite

Horizon
Soil Science and Engineering



Map 3
Flood Extent

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 13/11/2019

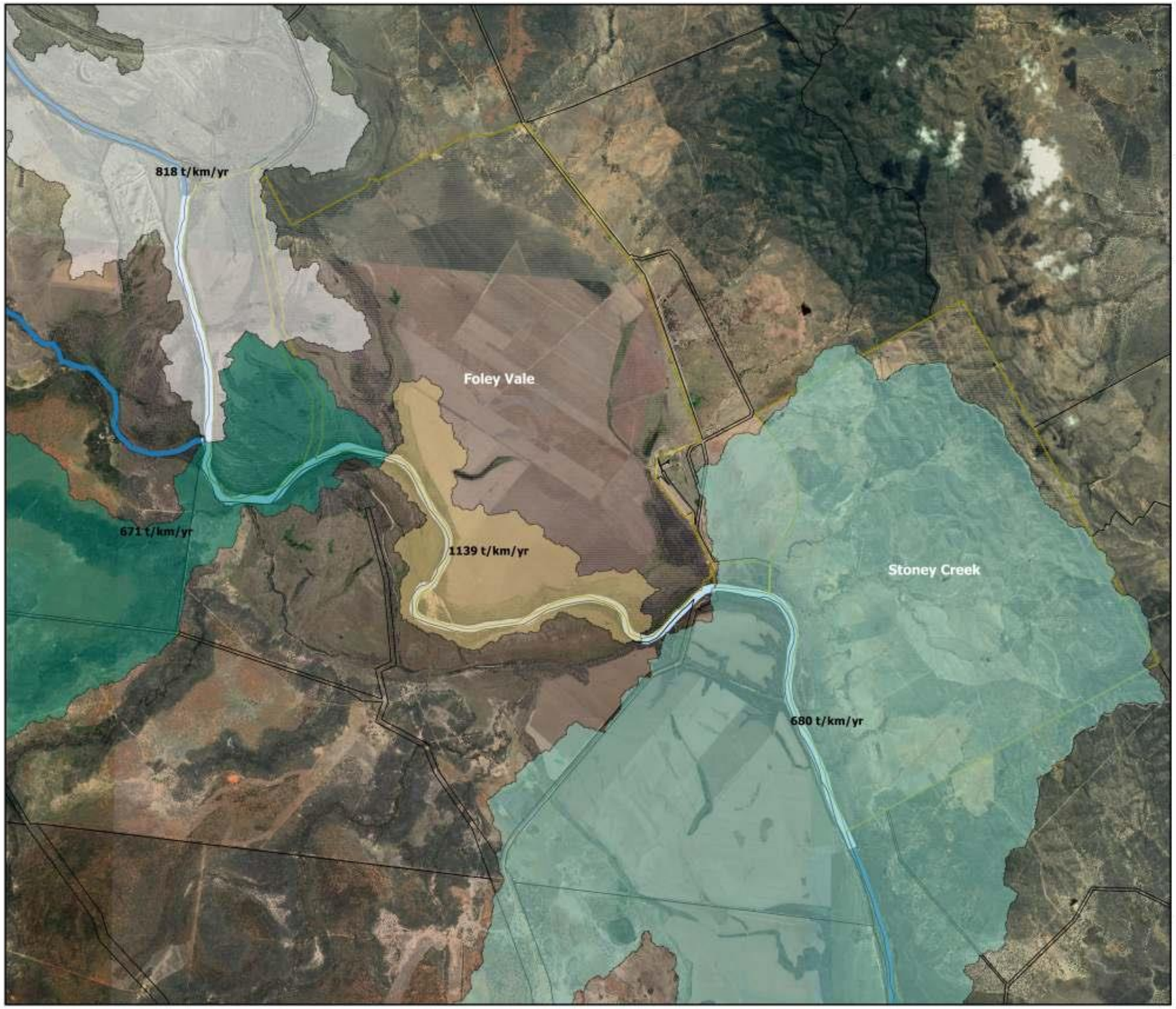
0 2 4 km

Legend

Assessment Areas
- Grazing
- Cleared and Remnant Vegetatio
- Cultivation
- Streambank Assessment Length
- Flood extent Mackenzie R Apri 2

Google Satellite

Horizon
Soil Science and Engineering



Map 4
Streambank Sediment

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

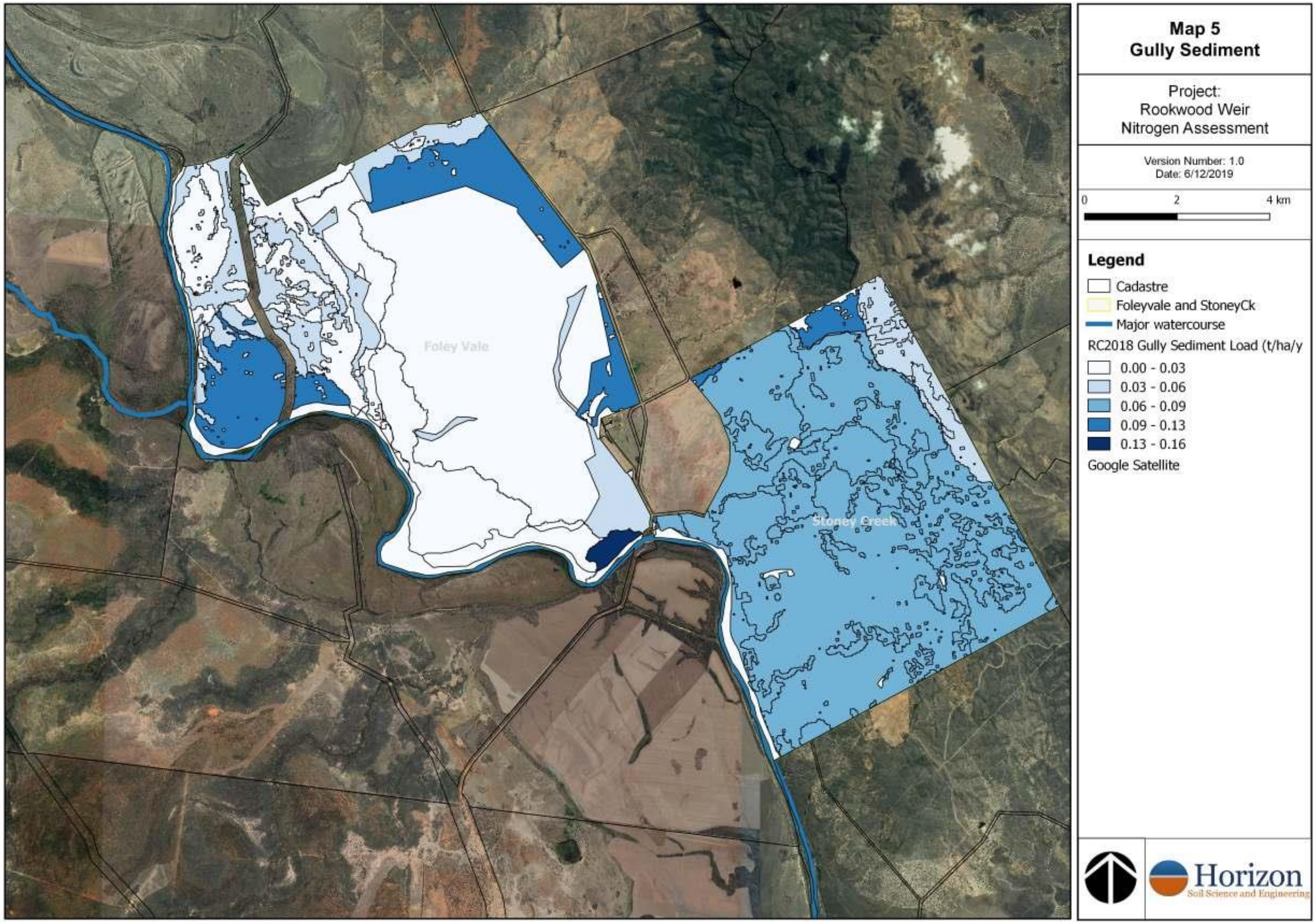
- Cadastre
- Foleyvale and StoneyCk

RC2018 Streambank Sediment Load

- 671
- 680
- 818
- 1139
- Assessment streambank
- Major watercourse

Google Satellite

Horizon
Soil Science and Engineering



Map 5
Gully Sediment

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

- Cadastre
- Foleyvale and StoneyCk
- Major watercourse

RC2018 Gully Sediment Load (t/ha/y

- 0.00 - 0.03
- 0.03 - 0.06
- 0.06 - 0.09
- 0.09 - 0.13
- 0.13 - 0.16

Google Satellite

Horizon
Soil Science and Engineering

Map 6
USLE R

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

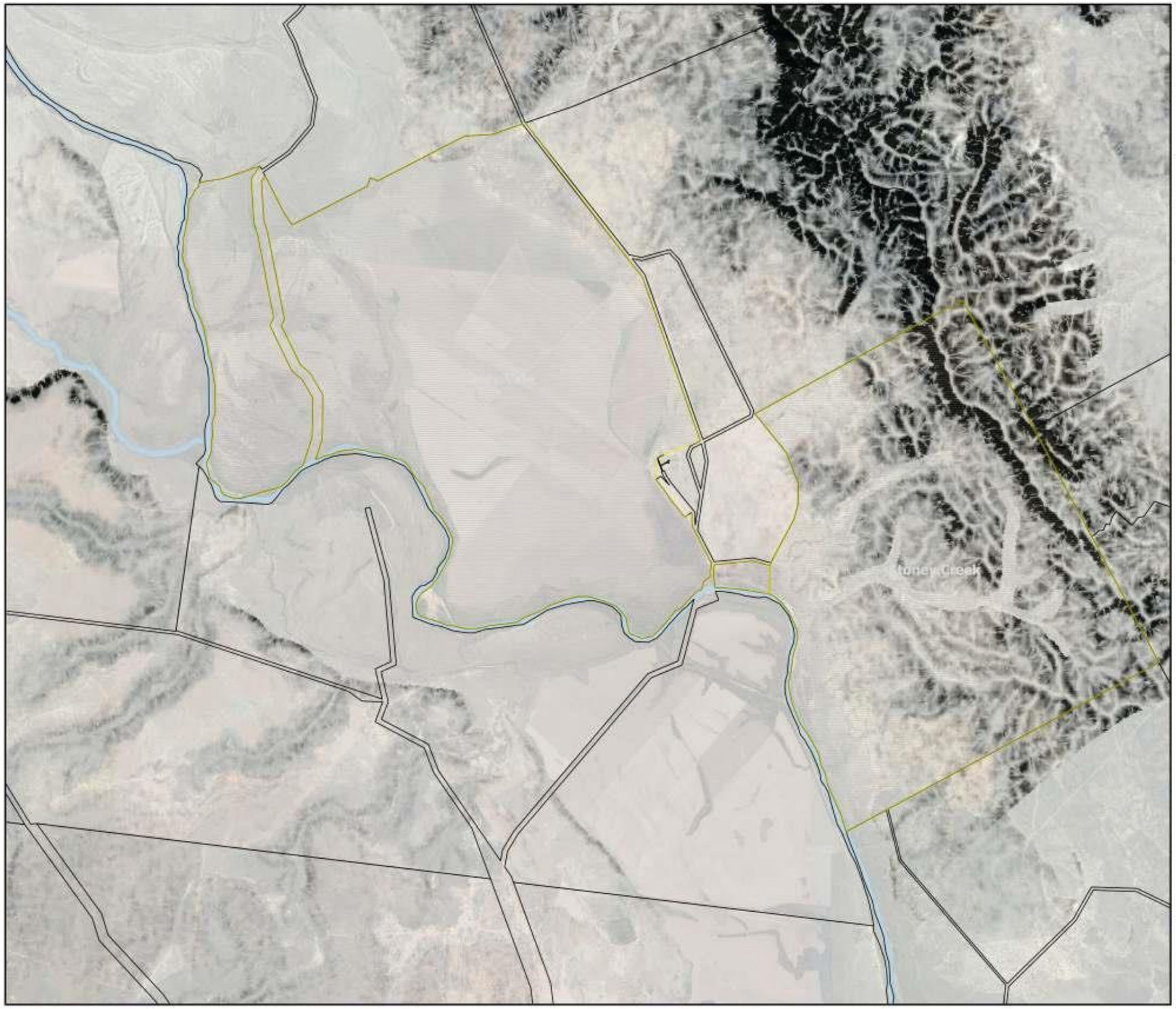
- Cadastre
- Foleyvale and StoneyCk
- Major watercourse

QLD USLE R

- 1970
- 2325

Google Satellite

Horizon
Soil Science and Engineering



Map 7
USLE KLSR

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

- Cadastre
- Foleyvale and StoneyCk
- Major watercourse

RC2018 USLE KLSR

- 0.01
- 0.32

Google Satellite

Horizon
Soil Science and Engineering

Map 8
USLE C

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

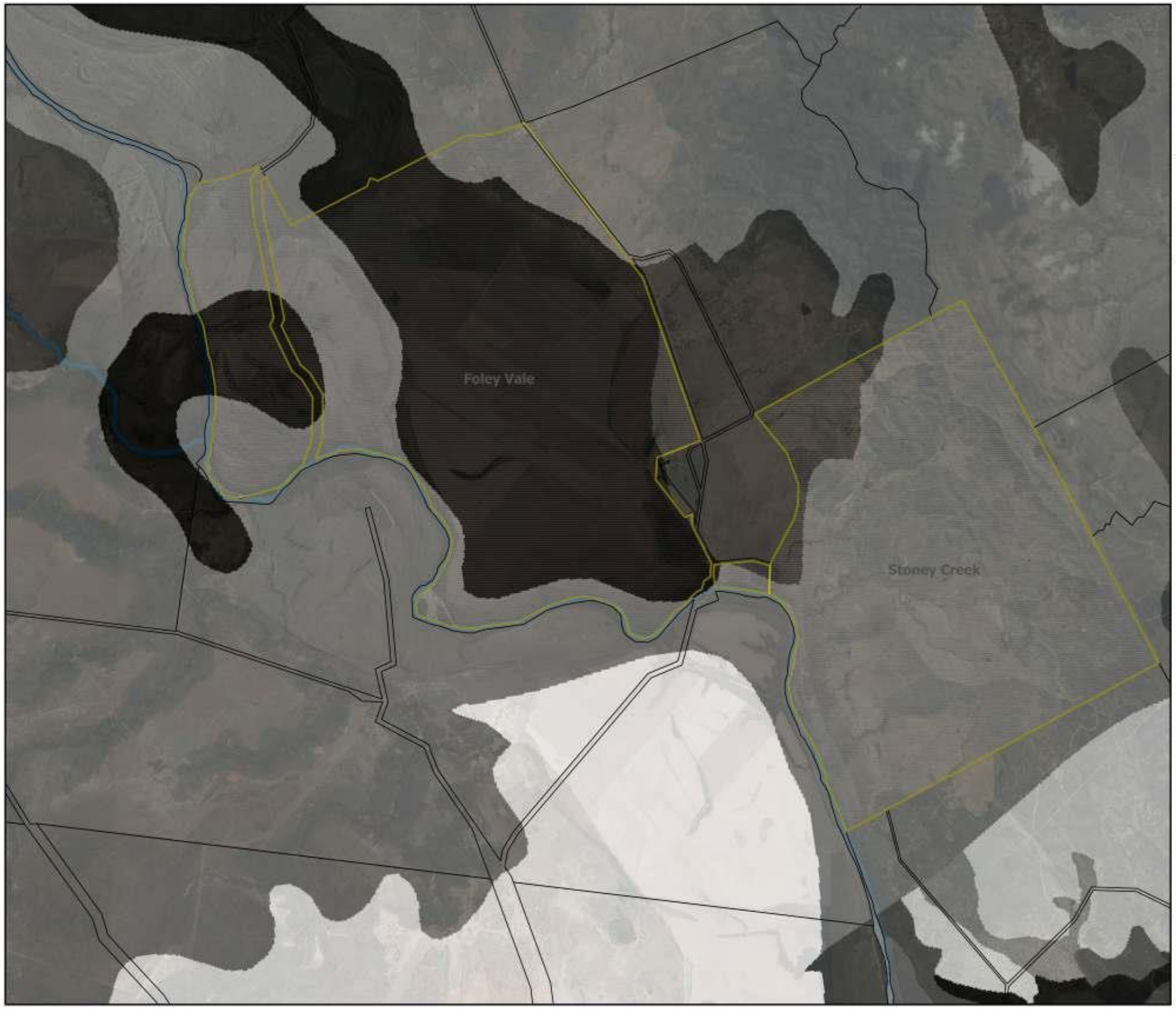
- Cadastre
- Foleyvale and StoneyCk
- Major watercourse

RC5 Average C Factor

- 0.003
- 0.095

Google Satellite

Horizon
Soil Science and Engineering



Map 9
Clay/Silt %

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

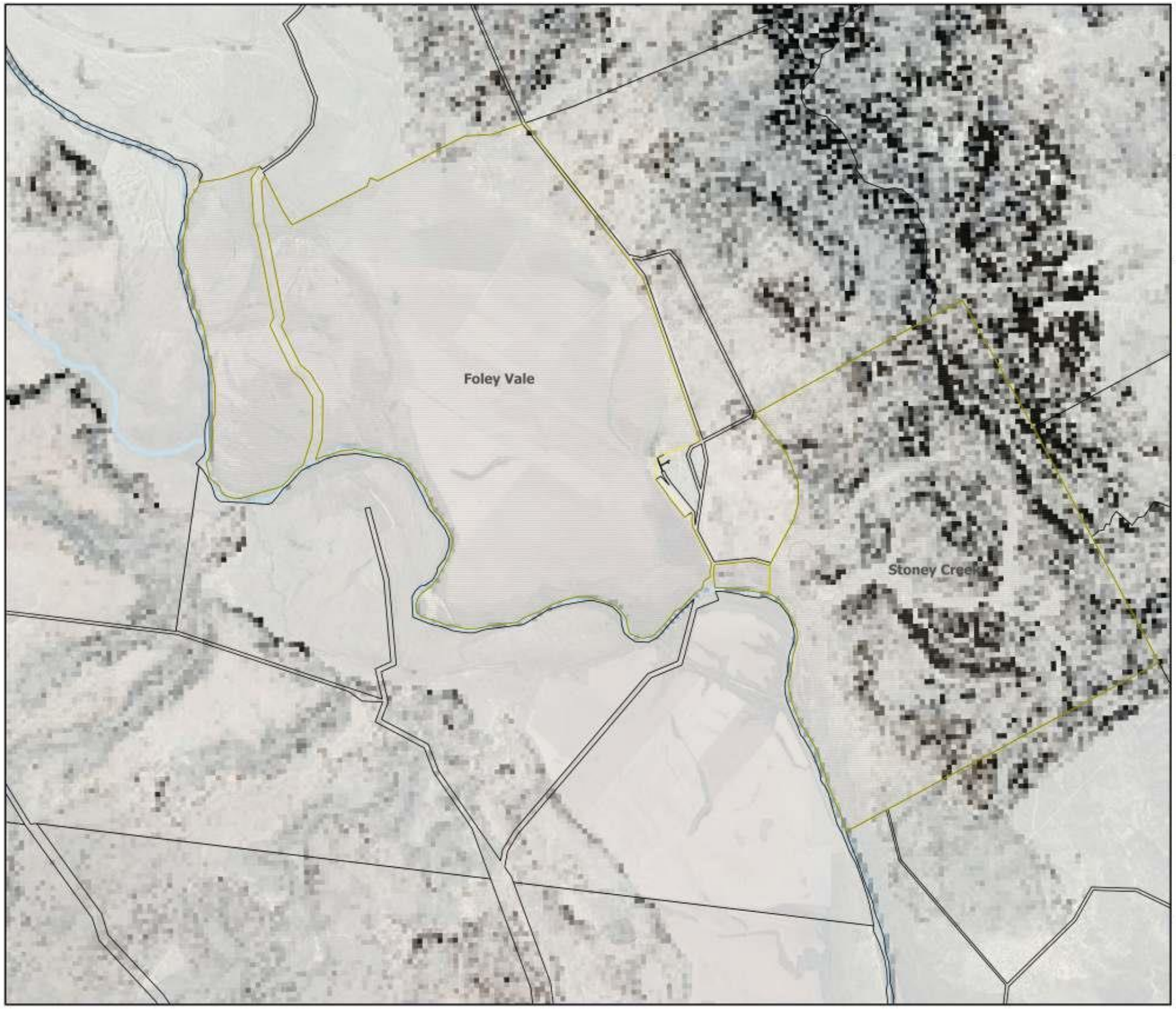
- Cadastre
- Foleyvale and StoneyCk
- Major watercourse

Clay and Silt Percentage (%)

- 15
- 85

Google Satellite

Horizon
Soil Science and Engineering



Map 10
USLE Erosion

Project:
Rookwood Weir
Nitrogen Assessment

Version Number: 1.0
Date: 6/12/2019

0 2 4 km

Legend

- Cadastre
- Foleyvale and StoneyCk
- Major watercourse

USLE Erosion (t/ha/yr)

- 0.007
- 12.8

Google Satellite

Horizon
Soil Science and Engineering

Attachment 3: Streambank Projects' Assessment

Memo

Subject	Multi Criteria Assessment
Project	Rookwood Weir Nitrogen Offset Support
Distribution	Dale McNab, Sunwater
Date	19 September 2023

Rookwood Weir is planned to be constructed along the Fitzroy River to the southwest of Rockhampton. The weir is expected to lead to approximately 890 ha of land becoming permanently inundated. As a result of this inundation, terrestrial vegetation in the area will be submerged and decay over time, releasing nitrogen (amongst other elements) to the waterbody. As part of the approval conditions, Sunwater are required to offset nitrogen released due to decaying vegetation on Matters of National Environmental Significance (MNES). This memorandum presents, at a high level, detail around a number of potential offset opportunities in the Fitzroy and wider region. Each of the offset opportunities have been quantitatively assessed as part of a Multi Criteria Assessment (MCA) to understand what performs best under a predetermined set of criteria.

1 Offset opportunities

Using our understanding of the region and opportunities which exist, Alluvium have developed a suite of offset opportunities, all based around streambank remediation, located both within the Fitzroy region and further afield. The localities of these 17 opportunities are presented in Figure 1.

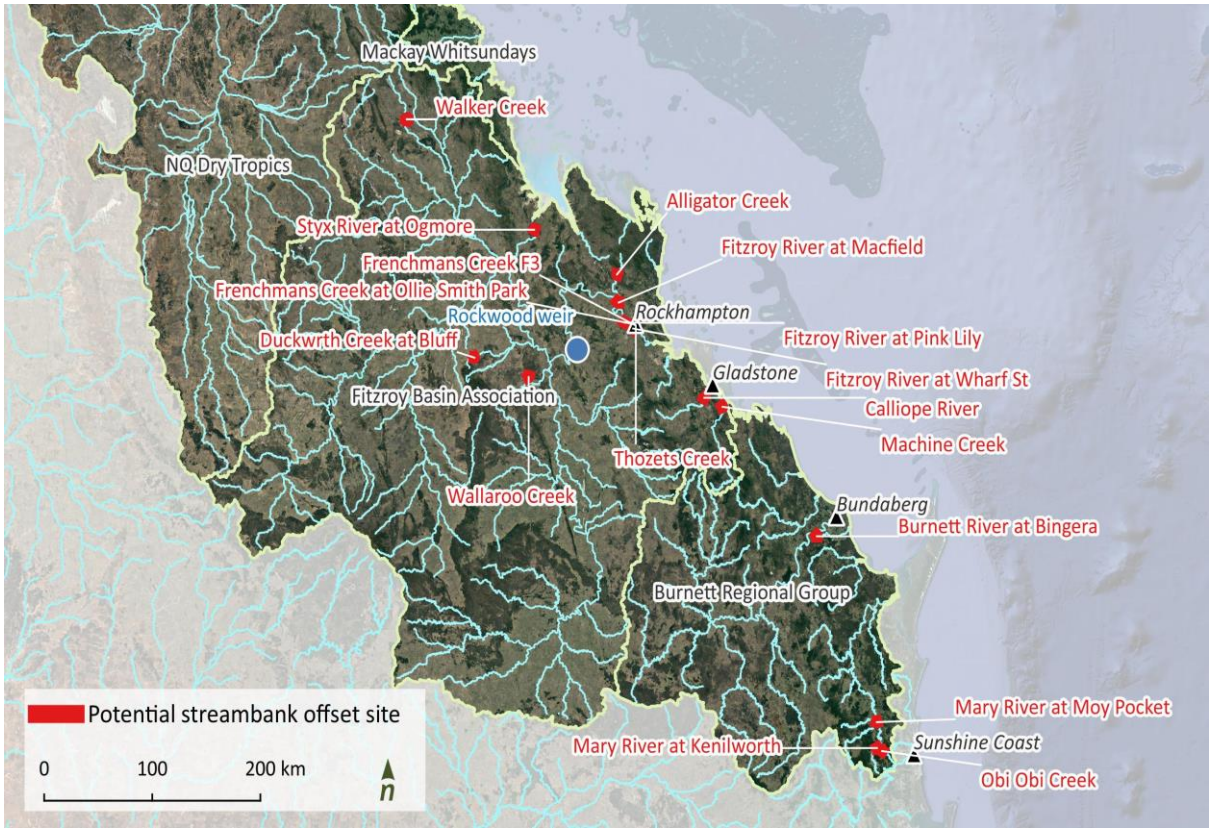


Figure 1. *Localities of potential offset opportunities*

A matrix of the characteristics of each of these offset opportunities are provided as Attachment 2 of this memorandum.

2 Multi Criteria Analysis

Multi-criteria analyses are a useful decision support tool which enables decision makers to advance in solving complex problems where several conflicting points of view must be taken into consideration. Typically, they are useful where there is no obvious or optimal solution, thereby allowing decision makers to identify the most preferred solution/s. When an independent and impartial assessment of different options that considers the technical issues, cost-effectiveness and stakeholder desires is required, a multi-criteria analysis is a useful approach to the problem.

In an MCA, there are typically several relevant criteria against which each option is assessed, with scoring using a combination of quantitative and qualitative approaches depending on the criteria. Option scores for each criterion can then be normalised (i.e. put on a scale from 0 to 1 where 0 is the worst score and 1 is the best score). These criteria are also typically weighted to reflect their relative importance. Results of the MCA overall option scores can then be ranked and prioritised.

2.1 Criteria and weightings

There are ten (10) criteria used in this MCA to evaluate each potential offset site. Table 1 presents the MCA criteria, their individual scoring approaches, and weightings.

Table 1. MCA criteria, scoring approaches, and weightings

Criteria	Scoring approach	Weighting
Cost efficacy	Quantitative assessment of cost and efficacy for each offset location.	25%
Offset amount	Scored based on an understanding of the total annual amount of nitrogen reduced through mitigative action	20%
Landholder willingness	Qualitative assessment, scored on a 3-point scale from low to high based on our understanding of these sites.	15%
Length of mitigation	Quantitative based on length of works for each site, acting as a proxy for length to complete works (shorter = quicker)	10%
Suitability of data obtained	Qualitative assessment, scored on a 3-point scale from low to high based on data collated to undertake this assessment	10%
Priority area	Qualitative assessment, scored on a 5-point scale based on priority detailed in the WQIP 2050.	10%
Complexity of approvals	Qualitative assessment, scored on a 3-point scale from low to high based on how complex approvals are likely to be.	5%
Land tenure	Qualitative assessment, scored on a 3-point scale from low to high based on land tenure.	5%
Multiple benefits	*Scored the same for all offset opportunities.*	
Treatment efficacy	*Scored the same for all offset opportunities.*	

2.2 Normalisation methodology

The characteristics of each criteria have varying scales and units, as one would expect. As such, an equalization approach is required to compare and summate on the same scale. Consequently, normalisation of each criteria's data was carried out to resolve the dataset to a common scale for more simple and accurate comparison. The two grouping of data type are continuous and discrete.

For continuous data (i.e. cost efficacy, offset amount and length of mitigation), the minimum and maximum values were adopted as the upper and lower bounds (1 and 0 respectively), with each unique value placed along the spread of the sample set. For discrete data (i.e. landholder willingness, suitability of data, priority area, approval complexity and land tenure), data was normalised over the amount of categories which exist in that criteria. The final step was to multiply each value from the respective categories with the pre-established weighting percentages (as presented in Table 1).

2.3 Civil works nitrogen removal

In order to estimate the potential nitrogen offset from bank stabilisation works the estimated fine sediment abatement has been calculated using the methodology outlined in the *Reef Trust Gully and Stream Bank Toolbox 3rd Edition* (Wilkinson et. al, 2022) and supporting guidelines provided in the *Stream bank Erosion Control Assessment Tool (SECAT) Survey User Guide, Paddock to Reef Integrated Monitoring, Modelling and Reporting Program* (Humphreys and Wilkinson, 2021).

This methodology involves:

1. **Determining historic erosion rate –** The historic erosion rate determined using the 'Recent period method' as outlined in the SECAT user guide
2. **Determining baseline erosion rate** - The baseline erosion rate is defined as the rate of erosion that would likely occur in future years in the absence of any management intervention (Humphreys and Wilkinson, 2021). The baseline erosion rate is derived from the historic erosion rate and a suitable adjustment for climate variability using a climate correction factor.
3. **Calculate sediment yield** – Based on the efficacy of proposed stabilization works - *The effectiveness of the works at reducing fine sediment volumes is estimated at 60% based on Erosion control treatment 10. "Engineered stream bank protection and revegetation" from Table 1 (Pg 23) in the Gully toolbox 3rd edition (Wilkinson et. al, 2022). Value – 60 %*
4. **Calculate total fine sediment reduction at the coast** - The fine sediment reduction at the coast is calculated by multiplying the Total fine sediment yield at site (t/y) by the Fine sediment delivery efficiency to coast (Delivery ratio). *The delivery ratio to GBR Lagoon –is determined from values adopted within the Source - Paddock to Reef catchment modelling*

An alternative approach for estimating the potential sediment/nitrogen offset by considering the sediment removed in the bank stabilisation process through civil works is discussed below.

For all of the potential offset sites, bank reprofiling to a gradient of minimum 1V:3H is generally required to provide geotechnical stability and a slope suitable for establishment of native vegetation. The spoil removed due to reprofiling is typically placed in floodplain depressions or utilised for other purposes by the land manager. The sediment removed can therefore not be eroded and mobilised into the stream. By considering the erosion rate at the site, the program period and the spoil removed from the system due to bank reprofiling, it is proposed that this could be used to calculate the sediment/nitrogen offset.

The proposed methodology for calculating the offset using this methodology is presented schematically in Figure 2 and summarised below.

1. **Determine historic erosion rate –** Determine the historic erosion rate using the 'Recent period method' as outlined in the SECAT user guide and use this to develop a bank retreat rate in m/yr.
2. **Determining baseline retreat rate** - The baseline erosion rate is defined as the rate of erosion that would likely occur in future years in the absence of any management intervention (Humphreys and Wilkinson, 2021). The baseline erosion rate is derived from the historic erosion rate and a suitable adjustment for climate variability using a climate correction factor.
3. **Calculate sediment/nitrogen avoided losses due to earthworks** – Use the baseline retreat rate, existing bank surface and proposed design surface, and the period of offset project to determine the sediment loss volume avoided due to earthworks (see Figure 2).
4. **Calculate total fine sediment/nitrogen reduction at the coast** - The fine sediment reduction at the coast is calculated by multiplying the total fine sediment avoided losses due to earthworks at site (tonnes) by the Fine sediment delivery efficiency to coast (Delivery ratio). *The delivery ratio to GBR Lagoon –is determined from values adopted within the Source - Paddock to Reef catchment modelling.*

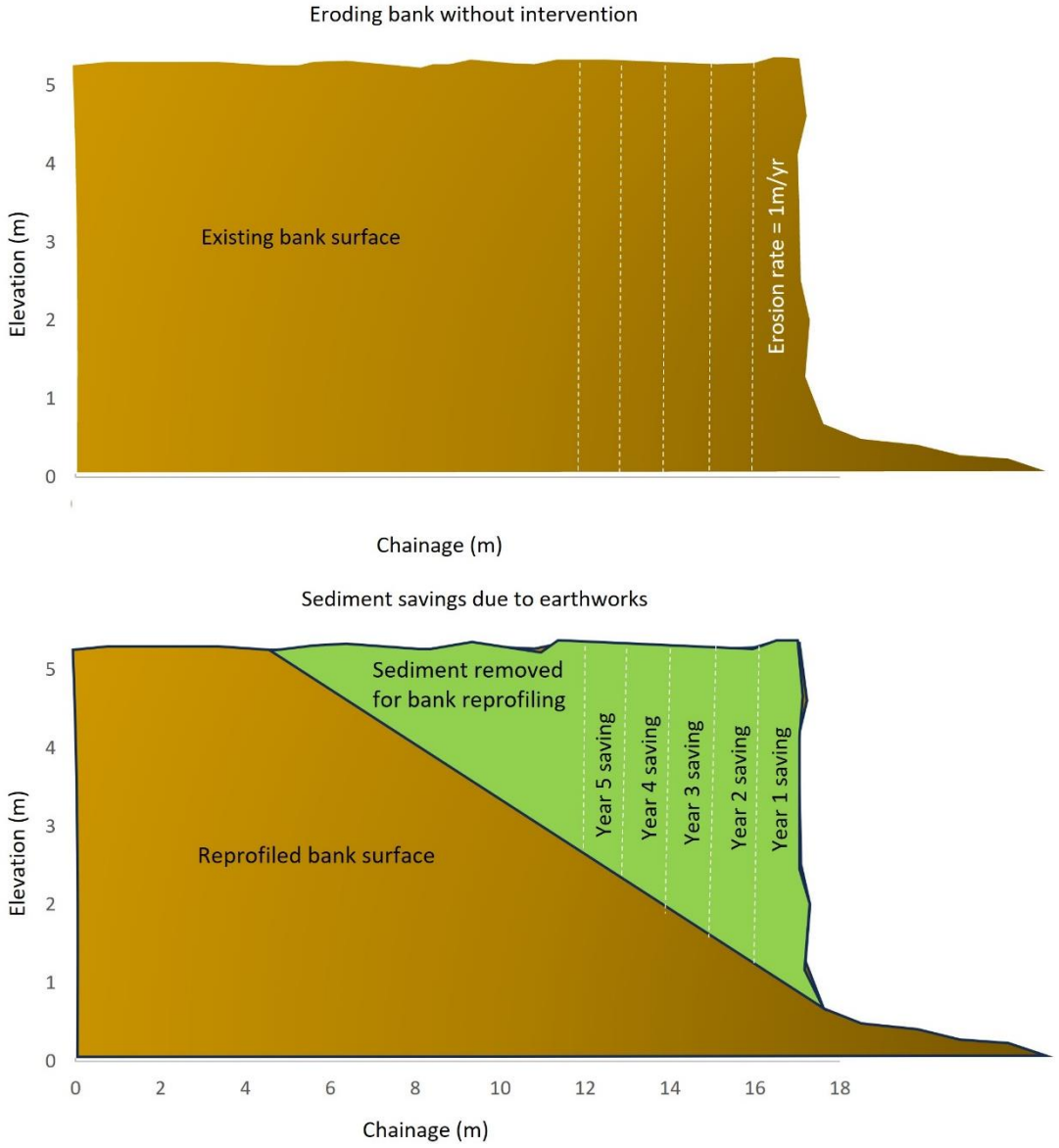


Figure 2. *Schematic representation of sediment/nitrogen removal due to civil earthworks*

3 Results

Developing and running the multi criteria analysis presents a list of results, which consider the unique offset option characteristics, and the weighted values of each criterion (Table 1). The results of this analysis are presented in Figure 3.

Normalised_with Weighting

	Rating										
	25%	20%	15%	10%	10%	10%	5%	5%	0%	0%	
Site ID	**Cost efficacy ($/t)**	**Offset amount**	**Landholder willingness**	**Duration of project (dependant lengt**	**Suitability of data obtained**	**Priority area**	**Complexity of approvals**	**Land type**	**Multiple benefits**	**Treatment efficacy**	**Overall Score**
Burnett River at Bingera	0.25	0.20	0.15	0.05	0.05	0.03	0.04	0.01	0.00	0.00	0.78
Obi Obi Creek	0.21	0.03	0.15	0.05	0.05	0.05	0.04	0.01	0.00	0.00	0.59
Calliope River	0.23	0.04	0.15	0.09	0.05	0.00	0.02	0.01	0.00	0.00	0.59
Alligator Creek at Canal Creek	0.23	0.02	0.08	0.09	0.05	0.03	0.05	0.01	0.00	0.00	0.56
Mary River at Moy pocket	0.20	0.02	0.08	0.09	0.05	0.05	0.05	0.01	0.00	0.00	0.55
Frenchmans Creek_01	0.17	0.00	0.15	0.09	0.03	0.03	0.05	0.04	0.00	0.00	0.55
Mary River at Kenilworth	0.24	0.04	0.00	0.08	0.08	0.05	0.05	0.01	0.00	0.00	0.55
Fitzroy River at Macfield (overall)	0.19	0.07	0.15	0.00	0.05	0.03	0.04	0.01	0.00	0.00	0.54
Styx River at Ogmore	0.23	0.04	0.08	0.09	0.05	0.00	0.03	0.01	0.00	0.00	0.52
Walker Creek	0.19	0.02	0.08	0.08	0.03	0.03	0.05	0.01	0.00	0.00	0.48
Thozets Creek	0.02	0.00	0.15	0.10	0.05	0.03	0.05	0.04	0.00	0.00	0.44
Machine Creek at Gladstone	0.16	0.00	0.08	0.10	0.05	0.00	0.03	0.01	0.00	0.00	0.43
Fitzroy River at Pink Lily (upstream extent)	0.11	0.01	0.08	0.07	0.05	0.03	0.05	0.01	0.00	0.00	0.40
Duckworth Creek at Bluff	0.06	0.00	0.08	0.09	0.05	0.03	0.05	0.04	0.00	0.00	0.40
Wallaroo Creek	0.00	0.00	0.08	0.02	0.03	0.03	0.04	0.01	0.00	0.00	0.20

Figure 3. *Multi criteria assessment matrix of results.*

3.1 Final project scoring

Following discussion with Sunwater (September 2023), treatment efficacy (i.e. nitrogen reduction at the coast) was the primary criteria of concern. To further shortlist the projects, any which exhibits a treatment efficacy (i.e. nitrogen reduction at the coast) of less than 1.8 t/yr was excluded from further assessment. This results in four sites identified for further investigation, including:

1. Burnett River at Bingera
2. Fitzroy River at Macfield (overall)
3. Callope River
4. Styx River at Ogmore.

A more detailed project on a page (POAP) is presented for each of these sites in Attachment 1. It is recommended that the above four projects be carried into the next stage. This is to include development of a project schedule, scope of works, and understanding of implementation risks for each project.

Attachment 1 – Project(s) on a Page (POAPs)

Site Attributes	Details		
Region	Fitzroy	Catchment	Fitzroy River
Site ID	Fitzroy River at Macfield (overall)		
Site Tenure	Freehold		
Likely remediation works	Bank reprofiling, overland flow and rock batter chutes, rock toe/pile fields (dependent on bathymetry /geotechnical investigation) and revegetation		

Concept Details			
Remediation Type:		Streambank	
Remediated Length:		1550	m
Pollutant Abatement at coast:	TSS =	2223	t/yr
	TN =	3.3	t/yr
Costs:	Min. Cost =	$ 5,000,000	
	Max. Cost =	$ 7,000,000	
Pollutant Abatement Cost:	TSS =	$ 2.70	/ kg.yr
	TN =	$ 1,799	/ kg.yr

Considerations

• Willing landholder who may co-contribute. Currently a Macadamia farm 'Macfields' owner concerned about ongoing erosion threatening their macadamia crop.

• Site is within the Fitzroy River weir pool - previous works in the weir pool have not been 100% successful and recommending similar works as other sites upstream has risk to it. Consideration will also need to be given to potential for raising of tidal barrage which has potential to impact sites with the weir pool.

alluvium

Proposed Site:

Fitzroy River at Macfield (overall)

Civil Work Considerations		
Fine sediment reduction at coast from civil works:	124,600	tonnes
Nitrogen reduction at coast from civil works:	113.5	tonnes

Notes:
• Additional information required for feasibility (e.g. bathymetry & geotechnical survey) .

Prepared by:
de Groot, A., Teague, J.

Sep-23

Site Attributes	Details		
Region	Fitzroy	Catchment	Calliope River
Site ID	Calliope River		
Site Tenure	Freehold		
Likely remediation works	Bank reprofiling, pile fields, large wood installation and revegetation		

Concept Details			
Remediation Type:			Streambank
Remediated Length:			300 m
Pollutant Abatement at coast:	TSS =		1312 t/yr
	TN =		2 t/yr
Costs:	Min. Cost =	$	1,300,000
	Max. Cost =	$	1,600,000
Pollutant Abatement Cost:	TSS =	$	1.11 / kg.yr
	TN =	$	737 / kg.yr

Considerations

- Willing landholder when visited in 2021.
- Potential for acid sulfate soils existis. More complex approvals are likely due to tidal zone, and dugong protection and fish habiatat areas.

alluvium

Proposed Site:

Calliope River

Civil Work Considerations		
Fine sediment reduction at coast from civil works:	25,352	tonnes
Nitrogen reduction at coast from civil works:	38	tonnes

DRAFT

Notes:
- Additional information required for feasability (e.g. bathymetry & geotechnical survey) .

Prepared by:
de Groot, A., Teague, J.

Sep-23

Site Attributes	Details		
Region	Burnett Mary	Catchment	Burnett River
Site ID	Burnett River at Bingera		
Site Tenure	Freehold		
Likely remediation works	Bank reprofiling, pile fields, large wood installation and revegetation.		

Concept Details			
Remediation Type:		Streambank	
Remediated Length:		850	m
Pollutant Abatement at coast:	TSS =	6045	t/yr
	TN =	9.1	t/yr
Costs:	Min. Cost =	$ 1,500,000	
	Max. Cost =	$ 2,000,000	
Pollutant Abatement Cost:	TSS =	$ 0.29	/ kg.yr
	TN =	$ 193	/ kg.yr

Considerations

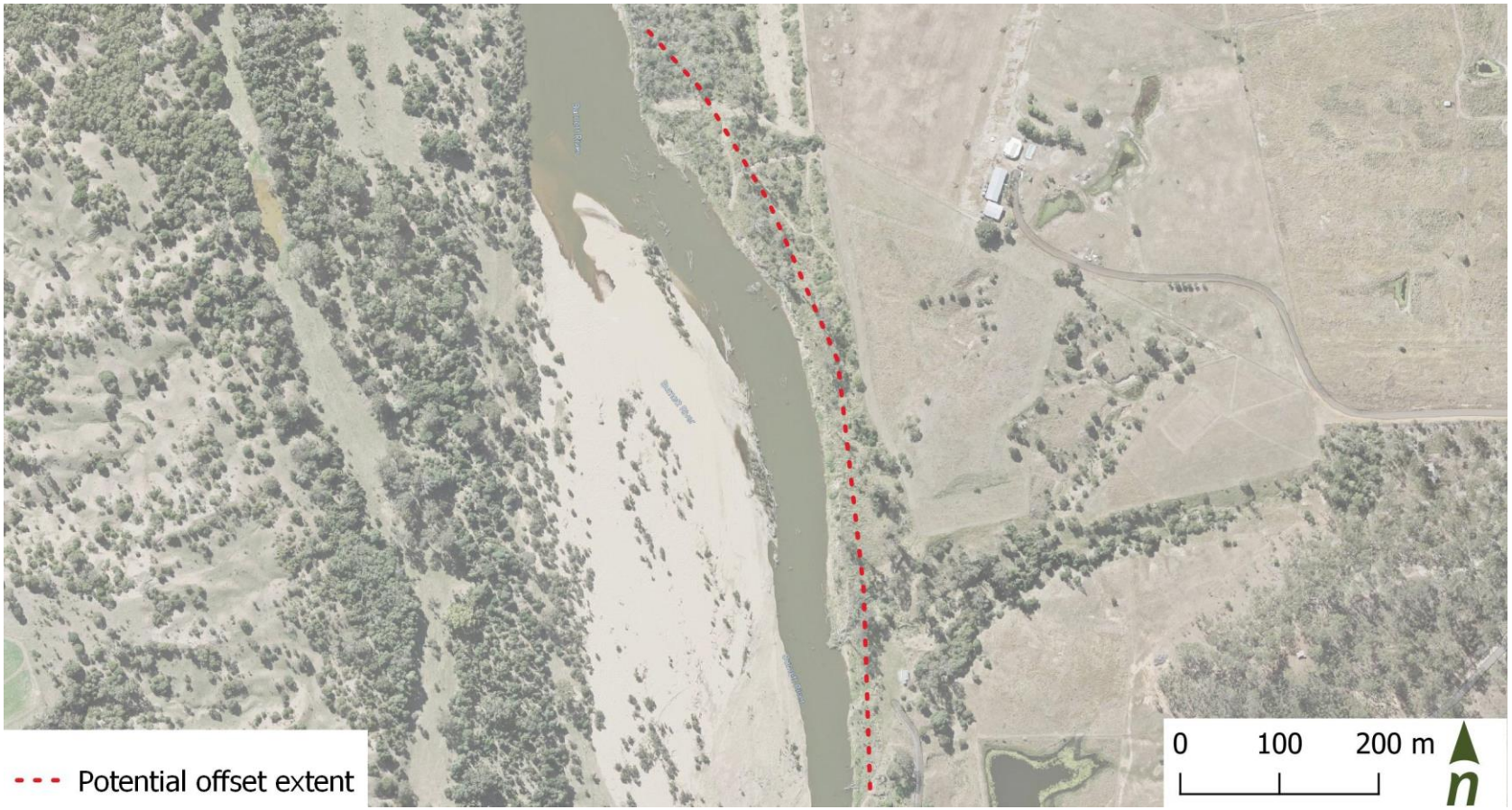
- Willing landholder.
- Other benefits can include significant habitat values for threatened species such as white throated snapping turtle.
- Requires approval from BMRG before we can put them forward as projects.

alluvium

Proposed Site:

Burnett River at Bingera

Civil Work Considerations		
Fine sediment reduction at coast from civil works:	25,352	tonnes
Nitrogen reduction at coast from civil works:	38	tonnes



DRAFT

Notes:
- Additional information required for feasability (e.g. bathymetry & geotechnical survey) .

Prepared by:
de Groot, A., Teague, J.

Sep-23

Site Attributes	Details		
Region	Fitzroy	Catchment	Styx River
Site ID	Styx River at Ogmore		
Site Tenure	Laregly freehold, some 'revserve' upstream		
Likely remediation works	Bank reprofiling, pile fields, large wood installation and revegetation		

Concept Details			
Remediation Type:		Streambank	
Remediated Length:		250	m
Pollutant Abatement at coast:	TSS =	1200	t/yr
	TN =	1.8	t/yr
Costs:	Min. Cost =	$ 1,300,000	
	Max. Cost =	$ 1,600,000	
Pollutant Abatement Cost:	TSS =	$ 1.21	/ kg.yr
	TN =	$ 805	/ kg.yr

Considerations

- Landholder not yet contacted.
- Potential for acid sulfate soils.
- In tidal zone but outside of designated fish habitat zone.

alluvium

Proposed Site:

Styx River at Ogmore

Civil Work Considerations		
Fine sediment reduction at coast from civil works:	25,814	tonnes
Nitrogen reduction at coast from civil works:	38.7	tonnes

DRAFT

Notes:

- Additional information required for feasability (e.g. bathymetry & geotechnical survey) .

Prepared by:

de Groot, A., Teague, J.

Sep-23

Attachment 2 – Offset Opportunity Characteristics

Site ID	Region	Catchment	Priority Ranking (Reef WQIP 2017-2022)	SedNet link	Assessment type	Analysis period	Total sediment loss (m3)	Annual average sediment loss - Historic erosion rate (m^3/yr)	Climate correction factor	Baseline erosion rate (m^3/yr)	Bulk density (sednet)	Percentage fine fraction (SedNet)	Efficacy of works (Gully toolbox Table 1 pg 23)	Fine sediment yield at site (tonnes/yr)	Fine sediment reduction at the coast (tonnes/yr)
Fitzroy River at Macfield (overall)	Fitzroy	Fitzroy River	Low	106	2019 - 2008 DoD	11	105110	9,555	0.6	6,102	1.5	0.46	0.6	2,526	0.88
Wallaroo Creek	Fitzroy	Dawson River	Low	728	2019 - 1999 imagery using 2019 LiDAR for bank height	20	20371	1,019	1.0	1,019	1.5	0.5	0.6	458	0.21
Burnett River at Bingera	Burnett Mary	Burnett River	Low	576	Imagery/LiDAR	19	391567	20,609	0.7	14,426	1.5	0.48	0.6	6,232	0.97
Obi Obi Creek	Burnett Mary	Mary River	Moderate	509	2022 - 2008 DoD	14	41986	2,999	0.8	2,279	1.5	0.57	0.6	1,169	0.71
Fitzroy River at Pink Lily (upstream extent)	Fitzroy	Fitzroy River	Low	97	2019 - 2008 DoD	11	15058	1,369	0.6	874	1.5	0.44	0.6	346	0.89
Mary River at Kenilworth	Burnett Mary	Mary River	Moderate	210	2022 - 2008 DoD	14	45741	3,267	0.9	2,986	1.5	0.57	0.6	1,532	0.71
Walker Creek	Fitzroy	Isaac River	Low	826	2022 - 2000 Imagery using 2017 field visit for bank height estimate	22	131929	5,997	0.8	4,797	1.5	0.53	0.6	2,288	0.25
Mary River at Moy pocket	Burnett Mary	Mary River	Moderate	585	2022 - 2009 DoD	13	34081	2,622	0.8	1,992	1.5	0.54	0.6	968	0.73
Calliope River	Fitzroy	Calliope River	Not Applicable	1777	2022 - 2009 imagery and average bank height from 2014 LiDAR	24	55440	2,310	1.0	2,360	1.5	0.65	0.6	1,381	0.95
Frenchmans Creek_01	Fitzroy	Fitzroy River	Low	1858	2015-2008 DoD	7	2773	396	0.50	199	1.5	0.75	0.6	134	0.99
Styx River at Ogmore	Fitzroy	Styx River	Not Applicable	36	2020 - 2009 DoD	11	35144	3,195	0.7	2,364	1.5	0.6	0.6	1,277	0.94
Alligator Creek at Canal Creek	Fitzroy	Fitzroy River	Low	1740	2019 LiDAR, 200o georeferenced imagery	19	21066	1,109	1.0	1,053	1.5	0.85	0.6	806	0.88
Duckworth Creek at Bluff	Fitzroy	Mackenzie River	Low	1702	2019-2011 DoD	8	3407	426	1.0	405	1.5	0.81	0.6	295	0.32
Machine Creek at Gladstone	Fitzroy	Boyne River	Not Applicable	1802	2023 - 2003 imagery and 2014 LiDAR for bank height	20	9198	460	0.9	398	1.5	0.47	0.6	168	0.94
Thozets Creek	Fitzroy	Fitzroy River	Low	1858	2015-2008 DoD	7	292	42	0.5	21	1.5	0.75	0.6	14	0.99

Offset Opportunity Characteristics (cont'd)

Site ID	% nitrogen	Nitrogen reduction at coast (tonnes/yr)	Volume sediment removed through civil works(m3)	Fine sed reduction at coast through civil works (tonnes)	Nitrogen reduction at coast from civil works (tonnes)	Length of works (m)	Minimum cost	Average cost	Maximum Cost	Cost efficacy ($/kg)
Fitzroy River at Macfield (overall)	0.0015	3.3	124,600	75,657	113.5	1,550	$5,000,000	$6,000,000	$7,000,000	$1,799
Wallaroo Creek	0.0015	0.1	5,754	906	1.4	1,200	$700,000	$950,000	$1,200,000	$6,580
Burnett River at Bingera	0.0015	9.1	36,301	25,352	38.0	850	$1,500,000	$1,750,000	$2,000,000	$0.29
Obi Obi Creek	0.0015	1.2	18,088	10,980	16.5	850	$1,300,000	$1,450,000	$1,600,000	$1,164
Fitzroy River at Pink Lily (upstream extent)	0.0015	0.5	43431.5	25,512	38.3	500	$1,500,000	$1,750,000	$2,000,000	$3,787
Mary River at Kenilworth	0.0015	1.6	6350	3,855	5.8	350	$600,000	$750,000	$900,000	$460
Walker Creek	0.0015	0.9	26,353	5,238	7.9	350	$1,300,000	$1,450,000	$1,600,000	$1,690
Mary River at Moy pocket	0.0015	1.1	28,932	17,107	25.7	300	$1,300,000	$1,450,000	$1,600,000	$1,368
Calliope River	0.0015	2.0	31,470	29,149	43.7	300	$1,300,000	$1,450,000	$1,600,000	$737
Frenchmans Creek_01	0.0015	0.2	651	725	1.1	280	$300,000	$450,000	$600,000	$2,258
Styx River at Ogmore	0.0015	1.8	30,513	25,814	38.7	250	$1,300,000	$1,450,000	$1,600,000	$1.21
Alligator Creek at Canal Creek	0.0015	1.1	7027	7,884	11.8	200	$600,000	$750,000	$900,000	$705
Duckworth Creek at Bluff	0.0015	0.1	9127.2	3,549	5.3	200	$600,000	$700,000	$800,000	$4,945
Machine Creek at Gladstone	0.0015	0.2	6,185	4,099	6.1	150	$500,000	$600,000	$700,000	$2,528
Thozets Creek	0.0015	0.02	381	424	0.6	100	$100,000	$125,000	$150,000	$5,979

Offset Opportunity Characteristics (cont'd)

Site ID	Likely works	Landholder willingness	Implementation factors (land tenure, access, likely feasibility etc.)	Approval factors (number of approvals, time to achieve approvals)	Other considerations
Fitzroy River at Macfield (overall)	Bank reprofiling, overland flow and rock batter chutes, rock toe/pile fields (dependent on bathymetry/geotechnical, revegetation	Willing landholder who may co-contribute. Currently a Macadamia farm 'Macfields' owner concerned about ongoing erosion threatening their macadamia crop.	Site is within the Fitzroy River weir pool - previous works in the weir pool have not been 100% successful and recommending similar works as other sites upstream has risk to it. Consideration will also need to be given to potential for raising of tidal barrage which has potential to impact sites with the weir pool.		Additional information required for feasibility (e.g. bathymetry & geotechnical survey).
Wallaroo Creek	Bank reprofiling, large wood installation, revegetation	Not yet contacted			Only had a high-level look at site - requires further investigation - however relatively low sed sevaings for the extent of works likely required
Burnett River at Bingera	Bank reprofiling, pile fields, large wood installation and revegetation	Willing landholder	Freehold land		Other benefits include significant habitat values for threatened species such as white throated snapping turtle. Requires approval from BMRG before we can put them forward as projects.
Obi Obi Creek	Bank reprofiling, pile fields, large wood installation and revegetation	Willing landholder	Freehold land		Requires approval from BMRG before we can put them forward as projects.
Fitzroy River at Pink Lily (upstream extent)	Bank reprofiling, overland flow and rock batter chutes, rock toe/pile fields (dependent on bathymetry/geotechnical, revegetation	Possible	There is a pump station and easement within works area which could complicate works. There is active sand dredging occurring in the reach which could have unknown impacts on works - increases risk of failure		
Mary River at Kenilworth	Bank reprofiling, pile fields, large wood installation and revegetation	Current landholder not willing but property is on the market for sale			Detailed designs have been completed for this site - Landholder was interested and then decided to put property on the market for sale so pulled out. Negotiations would need to occur with new owner once sold. Would be a great site as it's in the middle of the Kenilworth reach where we have undertaken significant works and this would link the reach really well. Requires approval from BMRG before we can put them forward as projects.
Walker Creek	Bank reprofiling, pile fields and revegetation	Not yet contacted	Freehold land		No topographic data here so all estimates are less accurate, requires some survey/site visit to confirm
Mary River at Moy pocket	Bank reprofiling, pile fields, large wood installation and revegetation	Not yet contacted	Freehold land		Requires approval from BMRG before we can put them forward as projects.
Calliope River	Bank reprofiling, pile fields, large wood installation and revegetation	Landholder visited in 2021 and seemed willing	Potential for acid sulfate soils, more complex approvals likely due to tidal, dugong and fish habitat area	In tidal zone, fish habitat area, and dugong protection area complicating approvals	
Frenchmans Creek_01	Bank reprofiling, rock protection and large wood installation, revegetation	Rockhampton Council site	Council also want works carried out at this site		Sed number could change - can update once we have access to Nearmaps and use current aerial imagery to reassess.
Styx River at Ogmore	Bank reprofiling, pile fields, large wood installation and revegetation	Not yet contacted	Largely on freehold land with a section of 'reserve' at upstream extent. Potential for acid sulfate soils	In tidal zone but outside of designated fish habitat zone	
Alligator Creek at Canal Creek	Bank reprofiling, pile fields, large wood installation and revegetation	Not yet contacted	Freehold		
Duckworth Creek at Bluff	Bank reprofiling, pile fields, large wood installation and revegetation	Not yet contacted, believe its on Council land and they could be interested			
Machine Creek at Gladstone	Bank reprofiling, pile fields, large wood installation and revegetation	Not yet contacted	Freehold	In tidal zone but not fish habitat area	Potential Acid sulfate soils
Thozets Creek	Bank reprofiling, rock protection and revegetation	Rockhampton Council site			limited sed saving opportunity

Attachment 4: Legume Planting Literature Review

Ideal Legume Percentage in Tropical Pasture:

There is no specific reference for the ideal legume amount in a tropical pasture, but based on data from the HOF project, the Sown Pasture Rundown project, and prior DAF research (e.g., Galloway plains trial, referenced in the attachment 4), aiming for around 40-50% legume content seems suitable. Leucaena made up about 50% of cattle diet on average throughout the year, varying from <10 to over 80% in the HOF project. Achieving a balance between legume and grass is crucial, rather than excessive amounts of either.

Seeding Rate and Establishment:

For herbaceous tropical legumes like stylos and desmanthus, a recommended sowing rate is about 2kg/ha of uncoated seed. This should yield a minimum of 4 plants/meter, which is the desired establishment population. Managing grazing and nutrients is essential to maintain a good legume and grass population, aiming for at least 25% legume content in the pasture and potentially up to 50% for optimal animal performance. A well-balanced pasture is key, with more legume content improving diet and nitrogen fixation.

Literature Review

- *There are an estimated 46.6 million hectares of the managed, legume-based pastures (ABS 2019), producing an average 4.6 tonnes of shoot biomass per hectare annually, 41 per cent of which is legume, and fixing a total (including root N) of 3.2 million tonnes of N. That works out to be, on average, 69kg N per hectare. Source:* Farquharson EA, Ballard RA, Herridge DF, Ryder MH, Denton, MD, Webster A, Yates RJ, Seymour NP, Deaker RJ, Hartley, E, Gemmel LG, Hackney B, O'Hara GW. 2022. *Inoculating Legumes: Practice and Science*, Grains Research and Development Corporation, Australia.
- Pasture legumes eg stylos are more effective at fixing N compared to Leucaena and other crop legumes due to longer life cycle. As Leucaena persists much longer then stylos, it consumes its own N that it produces vs stylos that die and regrow and don't have the opportunity to consume the N.
- Productivity decline in well-established sown grass pastures can be directly attributed to a reduction in the supply of available N in the soil. There is no measurable net loss of total soil N associated with rundown in extensive pastures, rather there is uptake of the available N by the pasture grasses and a reduced rate at which N is released from organic forms in the soil (Graham et al. 1981; Robertson et al. 1997). In these systems, the net loss of nutrients, including nitrogen, is very small. The amount of nitrogen exported through removal of animal products is small in extensive grazing situations (Radford et al. 2007).
- Farming system studies have confirmed that nitrogen exported through product removal under grazing is low relative to other agricultural land uses. Over 22 years "The Brigalow Catchment Study" in central Queensland reported N removal rates of 1.6 kg N/ha/yr for cattle grazing buffel grass pasture compared to 36.1 kg N/ha/yr in grain (Radford et al. 2007).
- N availability has a much greater impact on pasture production than nutrient removal (Graham et al. 1981; Jones et al. 1995; Myers and Robbins 1991; Robertson et al. 1997). Graziers will ultimately need to replace the nutrients removed through beef production. However, the amounts are small and can be replaced through currently available practices. For example, P supplementation of stock is sufficient to replace the amount of P removed in animal products and legumes are capable of fixing many times the amount

of N removed in animal products (Burrows 1991; Cameron 1996; Clarkson et al. 1987; Jones et al. 1996; Radford et al. 2007).

- In unfertilised pastures inputs of N can accrue from biological N fixation (symbiotic and asymbiotic) or in rainfall (Figure 4). Sources of N and indicative quantities of input for sown pastures are as follows;
    - Pastures legumes can fix significant amounts of N in the right circumstances (Section 4.4.3) in a range from zero (with no legume present) to >100kg N/ha/yr with good legume growth (Peoples et al. 2001).
- Grass/legume pastures have the potential to fix atmospheric nitrogen and therefore sustain higher levels of production than grass-only pastures. Nitrogen fixed by legumes in the pasture will improve feed quality and ultimately contribute more available nitrogen to grasses for dry matter production.
- The amount of N fixed by legumes is directly related to their biomass production (Peoples et al. 1995). Improved nutrition, strategic grazing and other practices can increase legume growth and the amount of N fixed in grass/legume pastures, and such practices must become more widely used to sustain their positive impacts on productivity.
- The amount of N fixed by legumes is influenced by a number of factors (Lloyd et al. 2007; Peoples et al. 1995) the most important being:
    - Effective nodulation which is enhanced by inoculation
    - available N in the soil. N fixation is energetically expensive therefore legumes tend not to fix much N if it is freely available in the soil. In rundown pastures N is in short supply and legumes are therefore stimulated to fix N. However, disturbance (e.g. cultivation) associated with legume establishment releases N from soil organic matter which promotes grass growth increasing competition which can reduce legume growth and therefore establishment and N fixation.
    - Legume biomass production. N fixation is related to how much biomass legumes produce. Legume N fixation is approximately 2.5% of above-ground biomass production. N losses occur during decomposition with N contribution to companion grasses being approximately 1.2 – 1.5% of above ground biomass (Lloyd et al. 2007). Therefore factors that impact upon legume growth impact directly on N fixation. Important considerations for maximising legume production are:
    - Legume content in the pasture. To fix large amounts of N, legumes need to be a significant percentage of pasture composition. Initial establishment, grazing management (timing and intensity) and nutrition are important for maintaining high legume content in pastures.
- Stylos average 30 – 80kg N/ha/yr to following crops (Cameron 1996; Jones et al. 1996).
- Leucaena Fix 75 – 150 kg N/ha/yr (Dalzell et al. 2006).
- CQ average yields are estimated to be approximately 2500 kg DM/ha/yr (Clem et al. 1993; Radrizzani et al. 2010), therefore about 63 kg N fixed, and 38 kg N/ha/yr to the companion grass (Lloyd et al. 2007).
- Research shows for every 1kg N supplied (fixation or applied fertilizer) results in 25Kg grass growth therefore if 38kg N/ha/yr supplied by stylo N fixation will result in 950kg extra pasture growth.