Greening Australia and Department of Environment and Science

*Innovative Gully Remediation Project*

# Monitoring and Evaluation Plan

## December 2018

This initiative has been funded by the Queensland Government and Greening Australia to identify more innovative and cost-effective gully remediation techniques.

Greening Australia

Queensland Government

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# Executive Summary

The Innovative Gully Remediation Project is a large scale remediation trial located on Strathalbyn Station in the Burdekin-below-dam sub-catchment (NQ Dry Tropics, 2016), approximately 45km north-west of Collinsville and 60km due south of Ayr.

The Innovative Gully Remediation project includes among its objectives (Greening Australia, 2018) the following three:

1. To trial different techniques for gully remediation on at least 5 treatment sites (across 150ha) to deliver more cost-effective solutions that can be applied across regions.
2. To trial innovative monitoring techniques to determine reduction of sediment and particulate nutrient loads to the Great Barrier Reef and the costs of achieving those reductions based on different interventions.
3. To engage with scientists and remediation experts to ensure the project builds upon the latest scientific understanding.

In essence these objectives focus on four main evaluation criteria: measured sediment reduction, measured treatment effectiveness, calculated treatment cost effectiveness over the Project's trial sites, and level of project collaboration.

This Monitoring and Evaluation Plan sets out how the project seeks to answer these four criteria which have been framed into Key Evaluation Questions:

- What are the measurable reductions in fine sediment export (measured in tonnes of sub-20µm delivered to the GBR lagoon) from treatment gullies compared to baseline measured sediment export rates and/or the control gully sites.
- Which treatment options or combinations are the most effective in reducing the export of sub-20µm particles from treatment sites.
- Which treatment options are the most cost-effective in terms of $ cost per tonne of sub-20µm delivered to the GBR lagoon.
- How have the methodologies used, including new and emerging monitoring and evaluation techniques and equipment, improved our understanding of how to treat alluvial gully systems and monitor those treatment's effectiveness and cost efficiency in reducing sediment export.

The Plan identifies the monitoring metrics which will be collected throughout the project, using adaptive strategies to progressively implement the program as the implementation phases of the remediation trails are completed. The metrics include datasets covering landscape scale, catchment scale, individual gully scale, and specific attributes scale data relevant to answering the evaluation questions such as water quality sample sediment concentrations and particle size distributions for example. Risk and mitigation strategies to ensure the listed datasets are collected in safe and reliable way are included at the end of the Plan document.

The Plan also identifies the methods of collection, responsibilities, and timeframes for collection of monitoring data. The custodians of each dataset are identified along with proposed access to data rules. It is envisaged that most data will be accessible to third parties under Creative Commons licencing to facilitate further research and analyses of the data beyond the life of the Innovative Gully Remediation Project. To this end, currently collaborating or linked projects that may benefit from data sharing arrangements are listed.

Communication of the monitoring and evaluation plan results will be guided by the Innovative Gully Remediation Project Communication Plan (Greening Australia 2017). Communications activities include specific project updates and communiques, scientific papers and conference presentations, participation in the Queensland Government's Sediment Working Group, and through mainstream media releases and web and social media content.

The data and information collected under this program will be reported in line with the requirements of the project collaborative agreement. This includes reporting on the outcome of the monitoring program against the key evaluation questions, producing recommendations for monitoring of future large scale gully remediation programs, and synthesising the monitoring and evaluation outcomes into the project Final Report in 2020. Importantly, the data will also be used to feed into other related Queensland Government evaluation frameworks such as the Paddock to Reef Program and the Reef Water Quality MERI evaluation template (DES, 2018).

**The full list of Monitoring and evaluation activities that are discussed in the body of the report are conveniently summarised in *Table 5* on page 24**.

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# Introduction

## The Innovative Gully Remediation Project

The Innovative Gully Remediation Project is a collaborative project supported by the Queensland Government's Reef Innovation Fund and Greening Australia's Reef Aid Program.

The purpose of the collaboration is to develop cost-effective and scalable options for the reduction of sediment and particulate nutrient export to the Great Barrier Reef lagoon ecosystem from alluvial gullies in grazing landscapes. The program is specifically focussed on trialling methodologies that can be replicated in or transferred to other areas of the Burdekin and within other Great Barrier Reef catchments.

The project site is at Strathalbyn Station, 45km north-west of Collinsville and 60km due south of Ayr, located in the Burdekin-below-dam catchment on the eastern bank of the Burdekin River (*Figure 1*).

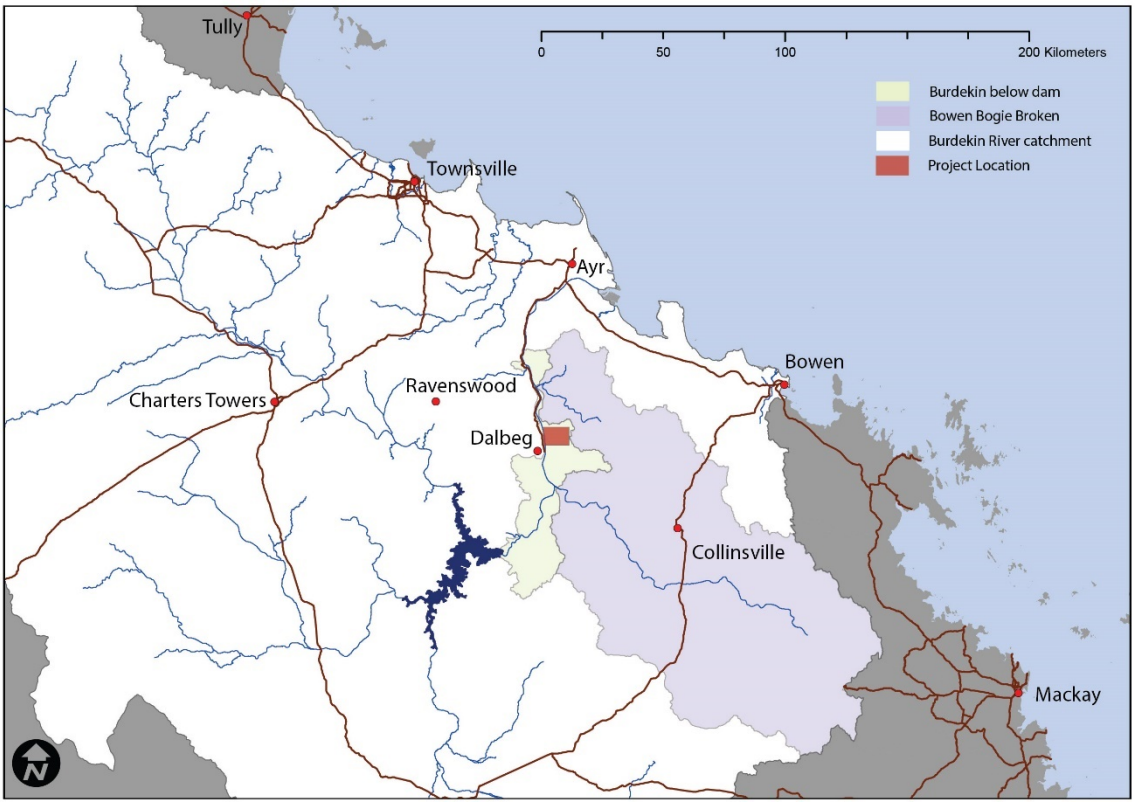


*Figure 1* *Strathalbyn Station, the site of gully stabilisation trials being implemented under the Innovative Gully Remediation Project.*

## Monitoring and Evaluation Objectives

The Innovative Gully Remediation Project has a number of objectives including to:

1. **Trial different techniques for gully remediation on at least 5 treatment sites (across 150ha) to deliver more cost-effective solutions that can be applied across regions.**
2. **Trial innovative monitoring techniques to determine reduction of sediment and particulate nutrient loads to the Great Barrier Reef and the costs of achieving those reductions based on different interventions.**
3. Harness innovative ideas and facilitate cross boundary interaction and fresh thinking to tackle the challenge of gully erosion.
4. Engage innovative individuals and organisations with a history of success but not necessarily in the Reef catchments and industries to borrow learnings and successes from other fields.
5. **Engage with scientists and remediation experts to ensure the project builds upon the latest scientific understanding.**
6. Build upon and integrate with existing and new gully remediation projects being delivered by Queensland and Australian governments and other partner organisations.
7. Communicate the outcomes of the trials broadly, particularly in Reef catchments, to ensure broad uptake of best practice gully remediation techniques.

The primary objectives for this monitoring and evaluation plan stem from the Innovative Gully Remediation Project objectives 1,2 and 5.

In essence these objectives focus on four main evaluation criteria: measured sediment reduction, measured treatment effectiveness, calculated treatment cost effectiveness over the Project's trial sites, and level of project collaboration.

## Key Evaluation Questions

The key evaluation questions around which this monitoring and evaluation plan have been framed are:

1. What are the measurable reductions in fine sediment export (measured in tonnes of sub-20µm delivered to the GBR lagoon) from treatment gullies compared to baseline measured sediment export rates and/or the control gully sites.
2. Which treatment options or combinations are the most effective in reducing the export of sub-20µm particles from treatment sites.
3. Which treatment options are the most cost-effective in terms of $ cost per tonne of sub-20µm delivered to the GBR lagoon.
4. How have the methodologies used, including new and emerging monitoring and evaluation techniques and equipment, improved our understanding of how to treat alluvial gully systems and monitor those treatment's effectiveness and cost efficiency in reducing sediment export.

## Supporting documents used in the preparation of this Plan

The monitoring and evaluation approach for this project has utilised a number of sources in its development including:

- The Innovative Gully Remediation Project Plan which details the essential delivery steps required to meet the project objectives as agreed by the funding parties in the collaborative agreement
- The Innovative Gully Remediation Project's Forum Outcomes Report which documented the discussions around monitoring and evaluation methodologies and techniques from the project's Gully Remediation Forum held in Townsville in May 2017
- The requirements for communicating project progress and findings detailed in the IGRP Communications Plan
- The guidelines contained within the Department of Environment and Science Appendix B MERI Plans v1 (dated 29 June 2018)
- The requirements of the Paddock to Reef program as detailed in the Grazing WQ Risk Framework 2018 at https://www.dropbox.com/sh/zw4gwqjbq3j808m/AABTkcprmwGxt8Ybm00dzj8oa?dl=0&preview=Grazing+WQ+Risk+Framework+2018.pdf

# Conceptual outline of the Monitoring and Evaluation Approach for this Project

The development of this Monitoring and Evaluation Plan has been influenced by the outcomes of the Project's Gully Remediation Forum held in Townsville in May 2017.

It was apparent at that Forum that a nested hierarchy approach may best answer the key evaluation questions posed. This reflects the fact that there are both broad-based drivers of erosion and sediment export (land use management, catchment and landscape setting, climate) and narrower drivers including specific gully attributes, soil attributes, vegetation attributes, hydrology, etc. Additionally, the focus on determining actual reductions in sediment export on a individual gully scale requires monitoring techniques which hone in on individual treatment techniques and water quality and flow dynamics.

The following sub-sections outline the relevant findings of the Forum and then describe the nested approach adopted by this plan. Many of the conclusions of the Forum Outcomes Report have been adopted and incorporated into the Project's M&E Plan.

## Monitoring and evaluation of sediment reduction effectiveness: the Forum outcomes

The Forum Outcomes Report (Greening Australia, 2018 ) includes a number of conclusions from the forum discussions:

- There are a wide variety of accessible monitoring tools and technologies available. The level of detail required to answer the questions being asked will dictate the monitoring equipment and methodologies required and also the cost.
- Technological advancements (eg. Drone-based LiDAR) have the potential to make high resolution land elevation measurements more affordable.
- Sediment reduction programs should focus on the sub 20 micron fraction of the suspended sediment loads in run-off waters, as this is the material that when suspended can be transported into the GBR lagoon.
- Intensive baseline investigations are required to accurately determine any sediment reductions resulting from treatment interventions.
- Aerial LiDAR data is valuable as a gully classification tool, as a design aid, and as a monitoring methodology if repeated and compared post-treatment.
- Terrestrial LiDAR has the capacity to record very detailed land surface measurements and therefore may be particularly useful for measuring changes from surface erosion.
- BACI (Before After Control Impact) design is important but can be difficult 'in the field", assumptions should be documented.

- A system of gully categorization and classification will allow the results of treatment trials to be more usefully transferred to future treatment sites.
- Detailed soil mapping can greatly assist gully classification and provide important information relevant to remediation/rehabilitation design, soil amelioration, and vegetation establishment.
- Vegetation surveys and biomass calculations can assist in determining the end-goal of remediation/rehabilitation as well as demonstrating a treatment's longer-term effectiveness.

## A nested approach

The nested approach to monitoring and evaluation is simply a conceptual model for how and why specific data is being collected to answer the Key Evaluation Questions. For this Plan it is suggested that the hierarchy consists of assessments and tools that fit into the following hierarchy: Landscape scale, Catchment scale, Gully scale, and Attribute scale (*Figure 2*).

### *Landscape scale metrics*

For this Plan, landscape scale data are collected to determine landscape scale change over time. The purpose of this data for this project is to determine trends in landscape change that have implications for sediment export rates. Tools used in these assessments include:

- historic aerial photograph interpretation (or tools such as VegMachine® and FORAGE) to detect landscape scale vegetation change, land use or land management change.
- soil mapping to determine factors driving susceptibility to erosion processes.
- climatic data to determine rainfall and seasonal weather fluctuations.

### *Catchment scale metrics*

Catchment scale data are used in this Plan to identify factors relevant to catchment scale processes that influence sediment export rates or which assist management of sediment export processes at the catchment level. Tools used to monitor catchment scale factors in this Plan include:

- mapping of gully catchment areas and gully extent
- historical aerial photograph interpretation and LiDAR analyses including DEM of Difference to determine rate of expansion of gully complexes within catchments, and to estimate historical sediment export from gully systems.
- historic aerial photograph interpretation (or tools such as VegMachine® or FORAGE) to detect catchment vegetation change, land use or land management change.
- Topographic (grade, long profile and depth) and field analyses to determine gully morphology and processes.
- Catchment vegetation survey focussing on vegetation cover at key periods (end-of-dry, end-of-wet) and vegetation functional groups (eg. Exotic perennial grasses, native perennial increaser and decreaser species, annual species, etc).

- Catchment hydrology (modelled) and changes in gully catchment rainfall – runoff relationships
- Historic and contemporary land use (including stocking rate and grazing management systems) and land condition assessments (LCAs)

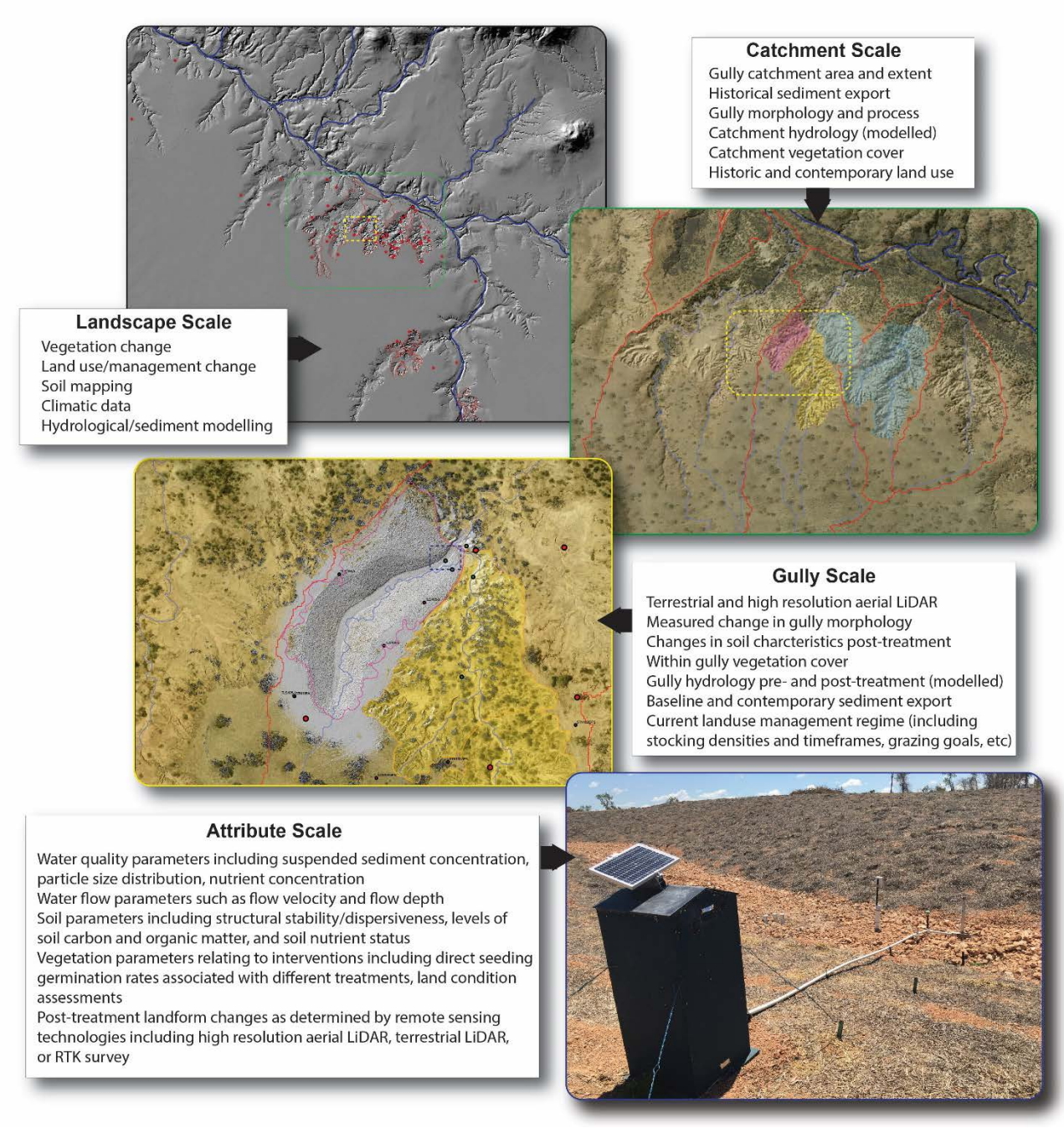


*Figure 2 Nested approach to monitoring and evaluation data collection (Landscape, Catchment, Gully, and Attribute scale metrics)*

## *Gully scale metrics*

Gully scale data are collected in this Plan to determine the morphological and process changes that occur within treated, untreated and control gully systems with a particular focus on changes occurring as a result of rainfall events during the Innovative Gully Remediation project timeframe. Tool used to monitor gully scale factors in this Plan include:

- Terrestrial LiDAR of treated and control gully systems.
- High Resolution Aerial LiDAR of treated, untreated, and control gully systems
- Measured changes in gully morphology post treatment (through survey or LiDAR).
- Soil type distribution and soil characteristics (including particle size, bulk density, sodicity, salinity, CEC, nutrients, and soil organic matter).
- within gully vegetation cover, diversity and functional groups.
- individual gully hydrology (modelled) before and after treatment.
- historical sediment export and where possible baseline contemporary sediment export.
- Current land use management regimes (including property wide grazing management approaches) and LCAs

## *Attribute scale metrics*

Attribute scale data are used in this Plan to facilitate comparisons between the pre-treatment or control status of a specific attribute of interest with post-treatment outcomes, or for analysing specific attributes related to remediation interventions such as costs of individual treatment options. Broadly, the attribute data are focused on determining treatment effectiveness in terms of fine sediment export reduction against costs of intervention.


Examples of attribute scale data include comparisons between pre- and post-treatment sediment concentration in event water quality samples (*Plate 1*), the particle size distribution within water samples, flow parameters including event discharge, hydrological parameters such as rainfall runoff coefficients, changes in vegetation cover resulting from changed management (for example changed practices relating to grazing management including fencing and water infrastructure or stock rates) or treatment interventions (including soil amelioration and direct seeding), and cost per unit area for specific treatment options.

*Plate 1*

*Sediment concentration in event water samples, when combined with event discharge, is an important attribute in determining treatment effectiveness.*

Current methodologies used in monitoring treatment effectiveness include the following:

- Digital camera time lapse photography
- Site rainfall data using tipping gauges
- Traditional survey techniques using RTK survey for determining scarp boundaries or cross-sectional changes
- Soil sampling and analyses
- Vegetation response including vegetation surveys and land condition assessments
- Water quality sampling systems included automated sampling units linked to either velocity sensors or sediment concentration sensors, water level loggers, rising stage samplers, and opportunistic grab samples
- Aerial LiDAR capture and DEMs of difference
- Terrestrial laser scanning to get high resolution landscape changes (sub 5cm)

Emerging technologies with potential applications in monitoring treatment effectiveness at the attribute scale include:

- High resolution aerial LiDAR capture
- Drone photogrammetry and drone based aerial LiDAR
- Lower cost water quality sampling systems

*Plate 2*

*High resolution aerial LiDAR capture is an emerging technology for use in monitoring treatment effectiveness (Source: Griffith University, 2018).*

# Overview of the Strathalbyn Innovative Gully Remediation Program Monitoring and Evaluation Strategy

The following overview of the Monitoring and Evaluation Strategy includes the actions undertaken to date under the Innovative Gully Remediation Program which have formed the basis for the Plan going forward, and the specific details of the actions to be undertaken during the 2018-2019 wet season.

This Plan will be reviewed as necessary to encompass future activities in the 2019-2020 monitoring period as required. The overview includes details of the linked projects and activities that are being undertaken collaboratively with other organisations and which assist in answering the Key Evaluation Questions.

Importantly, the information collected under this Monitoring and Evaluation Strategy will assist in evaluating the project against the criteria outlined in the Queensland Government's Reef Water Quality Program MERI process (DES, 2018). The assessment of the Innovative Gully Remediation Program under the MERI process will be undertaken by August 2020.

## Purpose

The Strathalbyn Innovative Gully Remediation Program Monitoring and Evaluation Plan outlines how data will be collected, analysed and communicated to answer the four Key Evaluation Questions identified:

1. What are the measurable reductions in fine sediment export (measured in tonnes of sub-20µm delivered to the GBR lagoon) from treatment gullies compared to baseline measured sediment export rates and/or the control gully sites.
2. Which treatment options or combinations are the most effective in reducing the export of sub-20µm particles from treatment sites.
3. Which treatment options are the most cost-effective in terms of $ cost per tonne of sub-20µm delivered to the GBR lagoon.
4. How have the methodologies used, including new and emerging monitoring and evaluation techniques and equipment, improved our understanding of how to treat alluvial gully systems and monitor those treatment's effectiveness and cost efficiency in reducing sediment export.

## Key Monitoring Metrics

The key monitoring metrics which will be collected under this Plan are outlined in *Table 1*. A summary of the timing of collection of these metrics and brief description of the methodologies used are contained in *Table 5* on page 24.

*Table 1 Key monitoring metrics used in the Innovative Gully Remediation Program Monitoring and Evaluation Plan*

| Key Monitoring Metric | Sub-category | Key Evaluation Question Relevance | Scale of Assessment | | | |
|---|---|---|---|---|---|---|
| | | | Landscape | Catchment | Gully | Attribute |
| Gully erosion rate | Estimated historical rates | **2** | ✔ | ✔ | | |
| | Contemporary rates versus post-remediation treatment | **1,2,4** | | | ✔ | ✔ |
| Sediment export load[1] | Estimated historical rates | **2** | ✔ | ✔ | | |
| | Contemporary rates versus post-remediation treatment | **1,2,4** | | | ✔ | ✔ |
| Change in vegetation[2] | Within gully: pre-treatment versus post-treatment | **2,4** | | | ✔ | ✔ |
| | Land condition assessments: pre and post land management/land use change | **2,4** | | | ✔ | ✔ |
| Change in soil conditions | Measured change in soil attributes or characteristics[3] | **2,4** | | ✔ | ✔ | ✔ |
| Treatment effectiveness | Effectiveness in reducing fine sediment export over time | **1,2,4** | | | ✔ | ✔ |
| Treatment cost | Cost of treatment per tonne of fine sediment saved[4] | **3** | | | ✔ | |
| | Transaction costs of treatments | **3** | | ✔ | ✔ | |
| | Efficiency savings involved in large-scale remediation programs | **3** | ✔ | ✔ | | |

1 proportion under 63µm and under 20µm
2 cover, biomass, and functional group (end-of-dry and end-of-wet survey)
3 soil sodicity, salinity, EEC, nutrient, organic matter and soil carbon
4 as measured against the specific gully baseline or control gully trend

## Pre-works baseline data collection

Pre-works baseline data collection includes both the preliminary assessment of the landscape and catchment scale metrics, and the on-going collection of baseline sediment export and hydrological data in gully systems targeted for remediation but not yet treated.

The purpose of the pre-works baseline data collection is to establish the conditions and processes occurring within the project area's catchment and gullies prior to intervention and to establish historic trends in sediment export to allow comparisons of pre- and post-treatment export rates to establish effectiveness.

### *Landscape and Catchment Scale Metrics*

The preliminary assessment of the landscape and gully catchments in the project area was undertaken between November 2016 and May 2017 (Griffith University, 2017). The data collected was aimed at defining landscape scale factors and processes influencing gully erosion within the project area including:

- derived datasets from an aerial LiDAR dataset captured by RPS in November 2016 (catchment hydrology, gully catchment areas, vegetation)
- field survey,
- soil sample analyses, and
- rainfall data from the Dalbeg gauge records.

Estimated historical sediment yield from gully complexes within the project area were calculated based upon a modelled DEM of difference by estimating the volume of sediment exported at selected time points guided by the availability of historical aerial photography series, and extrapolating remnant and relic surfaces identified in the field and in the LiDAR dataset. The difference between time series in $m^3$ was then converted to tonnes (using bulk density) and the yearly rate of export determined.

### *On-going baseline assessment of individual gullies pre-treatment*

Pre-treatment baseline data collection for target remediation sites provides information on contemporary sediment export from individual gullies, allowing a comparison between the post-treatment remediated gully and its pre-treated export rates and between the treated gully and the control gully. In addition, surveys of the pre-treatment vegetation, land management, and topography of the gullies and catchment are important data which are useful in assessing the causal factors of any post-intervention response in terms of sediment reduction.

The collection of this data has not been uniform across the project area for a number of reasons:

- not all gullies within the project area can be monitored due to budgetary constraints
- the number and location of treatment gullies has evolved as the project has developed
- there has been limited rainfall events since the project's inception

- the whole of site land management has necessarily changed just to allow interventions of the scale of this project's treatments to occur
- the project treatments have necessarily progressed rapidly to meet the project's implementation schedule
- collection of water quality data in dynamic gully environments with very high sediment concentrations is difficult

For these reasons, the datasets collected have evolved over the project's life (see *Appendix 1* for 2016-17 setup, *Appendix 2* for 2017-18, and *Figure 3*) but have variously involved the following methods and datasets (for a more detailed summary of the methodologies used please see *Table 5* on page 24):

- Gully and catchment vegetation cover, functional group, and biomass
- Land condition assessment within and outside the project area
- LiDAR survey including aerial LiDAR, high resolution aerial LiDAR, and limited terrestrial LiDAR scanning
- Soil testing and mapping (including extensive soil sampling under the NESP 3.1.7 project)
- Water quality sampling including:
    - depth of flow at the gully outlet (using barometrically compensated pressure transducer dataloggers)
    - Rising stage samplers to collect water quality samples at various flow stages within the gully at the outlet (giving suspended sediment concentration and particle size distribution)
    - ISCO automated water quality sampling units to collect event samples at varying stages of the hydrograph
    - Velocity sensors to determine velocity of event flows
    - RTK survey of channel dimensions to allow calculation of discharge when combined with flow depth and velocity
- Rainfall gauge to determine rainfall totals and intensities for events
- Time-lapse cameras to record gully processes

## Wet season and post-wet season monitoring of treatment response

To date the Plan has used an adaptive approach to the collection of monitoring data. This reflects the nature of the project's development which has involved successive stages of project site identification, site investigations and assessments, project design in terms of trial sites and control sites, and phased treatment implementation and works monitoring.

The program adopts a modified BACI (Before-After-Control-Impact) approach with a single control gully located centrally between the treatment gullies. The approach has been termed "modified" as the before or baseline dataset is limited by budgetary and time constraints in that not all treatment gullies have complete baseline datasets or the datasets are for only a single wet season. Additionally, where gully treatments are only of a single batter or where there is

no defined gully outlet sampling of event flows is compromised and so other methodologies to measure sediment export are required.

## *Event water quality monitoring of treatment and control sites*

Rainfall event water quality data collection is an important aspect of the evaluation of treatment effectiveness in reducing sediment export.

Water quality monitoring for this project focusses on sampling event runoff in the control gully and in treated gullies with defined gully outlets. *Appendix 1* and *2* show the progressive development of the water quality monitoring strategy over the period November 2016 through to May 2018, while *Figure 3* shows the Innovative Gully project's current 2018-2019 water quality sampling set out.

The equipment used under the water quality sampling program and its purpose is shown in *Table 2*. *Plates 3-5* show the general installations of the main components of the equipment.

*Table 2 Innovative Gully Remediation Program water quality sampling program equipment and purposes*

| Equipment/method | Purpose | When used |
|---|---|---|
| Tipping rain gauge | Records rainfall quantity and intensity | All year |
| Pressure transducer datalogger | Records water depth at deployment location when compensated with a barometric dataset | All year |
| Barometric pressure transducer | Collects barometric pressure to allow compensation of the water level loggers deployed on site | All year |
| Rising stage sampler | Collects a 1L sample on the rising stage of a flow event at the height of the bottle intake | All year |
| ISCO automated water sampler | Collects up to 24x1L samples on a set time interval | Wet season only |
| Liquid level actuator | Triggers the ISCO sampler to collect samples upon water contact and discontinues sampling when flow recedes | Wet season only |
| Velocity sensor | Collects flow velocity at the deployment location, logged at a predetermined interval | Wet season only |
| Time-lapse camera | Takes digital photographs on a set interval to document flow processes | Wet season only |
| DH48 manual grab sampler | Allows an isokinetic water quality sample to be collected in the field | Opportunistic |
| Handheld current meter | Allows stream flow to be manually recorded during flow events for calibration or gauging purposes | Opportunistic |
| High resolution LiDAR dataset | Allows modelling of stream discharge using a derived DEM, rainfall and calibration readings where available | Post wet analyses |

*Plate 3*

Integrated water quality sample station on Treatment 3 located at the outlet of the treated gully

*Plate 4*

Sensor assembly and pump intact on image right with triple rising stage sampler and PASS sampler on image left, Treatment 4 setup

*Plate 5*

Unidata velocity sensor and ISCO pump intake mounted below with hobo water level logger (beneath the green cap)

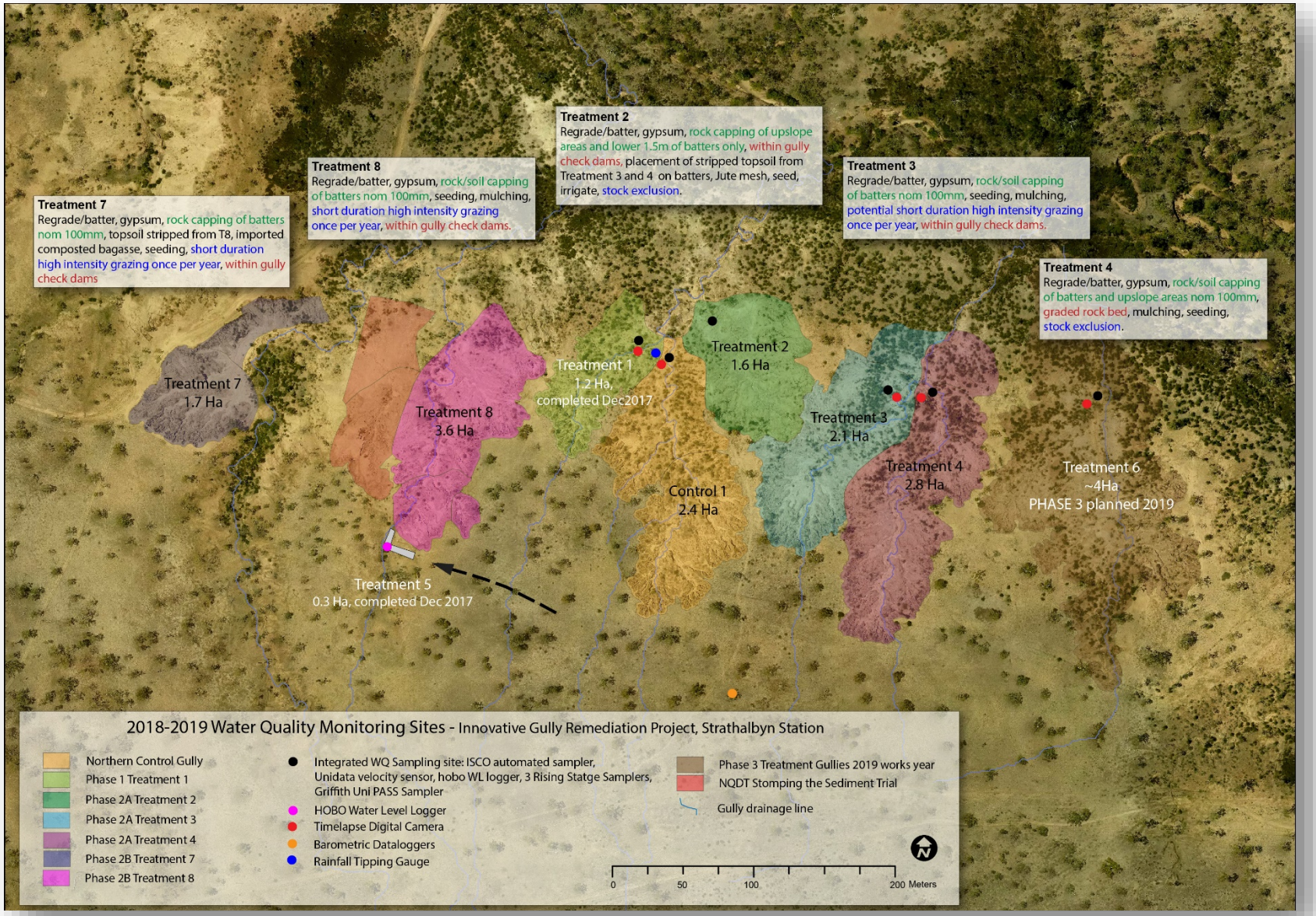


*Figure 3*

*2018-2019 wet season monitoring equipment set-out on the northern gullies complex of the Strathalbyn Innovative Gully Remediation Project.*

### *Vegetation, Land use and topographic data collection*

The types of vegetation, land use and topographic/landform datasets collected under this program and the purpose of their collection are shown in *Table 3.*

*Table 3 Innovative Gully Remediation Program vegetation, land use and topographic data collection*

| Equipment/method | Purpose | When used |
|---|---|---|
| Vegetation survey | Determining change in vegetation cover, biomass, and function | End-of-dry and end-of-wet surveys |
| Land Condition Assessment | Determining change in land condition after land use management change | End-of-dry and end-of-wet surveys |
| RTK Survey of gully scarps | Accurate determination of gully scarp location between LiDAR capture. | |
| Terrestrial LiDAR survey | Accurate determination of landform and topography (with some limitations depending upon treatment type). | Opportunistic, dependent upon DES availability |
| Aerial LiDAR survey | Creation of a DEM useful for gully identification, characterisation, and morphology. Also useful baseline dataset for determination of landscape characteristics and change over time. | Commencement of project in 2016 |
| High resolution aerial LiDAR datasets | As above for standard LiDAR dataset but much improved resolution and representation of the land-surface. | Post-construction and pre-wet season and post-wet season |
| Before and after treatment photo points | Qualitative documentation of change and also useful for determining sediment export processes. | Pre- and post-construction, pre- and post-wet season |
| Before and after drone imagery and video footage | Qualitative documentation of change and also useful for determining sediment export processes and also treatment methodologies. | Pre- and post-construction, pre- and post-wet season |

## Data management and access

The collaborative agreement between the Queensland State Government and Greening Australia stipulates that all data is jointly owned by the parties. However, for practical purposes it is proposed that depending upon the dataset there may be different organisations acting as custodians for the various datasets produced under the project. Custodians of datasets under this program are responsible for creating and maintaining appropriate metadata for each dataset held and facilitating access that data as appropriate.

*Table 4* identifies the main datasets which will be produced through the monitoring and evaluation program, the relevant organisation acting as custodian, and any caveats on the use of that data. It is expected that most datasets produced under the project will be accessible for appropriate use under Creative Commons Attribution 3.0 Australia (CC BY) licence[5].

[5] Creative Commons Attributions as per *http://creativecommons.org/licences/by/3.0/au/deed.en*

*Table 4 Management of data collected under the Innovative Gully Remediation Program*

| Dataset | Coverage | Date of capture | Custodian | Licence |
|---|---|---|---|---|
| Aerial LiDAR and orthophoto raw data | ~350km$^2$ covering most of Strathalbyn Station and the Bonnie Doon Creek catchment | November 2016 | QSpatial data hub | By request to QSpatial |
| Interpreted products based on the 2016 LiDAR capture | ~350km$^2$ covering most of Strathalbyn Station and the Bonnie Doon Creek catchment | May 2017 | DES Information Science | CC3 |
| high resolution aerial LiDAR capture and orthophotography | The northern, central, and southern gully complexes on Strathalbyn Station | 2017 | Griffith University | Under licence to Griffith University |
| | The northern, central, and southern gully complexes on Strathalbyn Station plus an additional area east of the northern gully sites covering the NQDT black soil gully remediation programs | May 2018 | QSpatial data hub | By request to QSpatial |
| | The northern, central, and southern gully complexes on Strathalbyn Station | October 2018 | QSpatial data hub | By request to QSpatial |
| Terrestrial LiDAR survey of Treatment 1 | Terrestrial LiDAR survey | December 2017 | DES Information Science | By Request |
| RTK survey datasets | Gully head scarp location above the control gully and above treatments 3 and 4 prior to remediation | March 2018 | Greening Australia | CC3 |
| | Temporary benchmarks around the northern and central gully locations in AHD(m) | 2018 | Greening Australia | CC3 |
| Project Water quality data | Event hydrographs covering the northern, central and south-eastern gully complexes | Incomplete, commencing November 2016 | Greening Australia | CC3 |
| | Sample Sediment concentration and TSS from wet season rising stage samples | Commencing November 2017 | Greening Australia | CC3 |
| | Sample particle size distribution from wet season rising stage samples | Commencing November 2017 | Greening Australia | CC3 |
| | Limited event flow velocity data, capture ongoing | February 2018 | Greening Australia | CC3 |

| Dataset | Coverage | Date of capture | Custodian | Licence |
|---|---|---|---|---|
| | Site Rainfall data | Incomplete dataset from November 2016 continuing | Greening Australia | CC3 |
| Bonnie Doon Creek WQ data | Event water quality data and stream discharge information | Commencing September 2018 | DES Water Quality Investigation | By request to DES |
| Digital time-lapse photographs | Treatment and control gullies | Various, commencing December 2018 | Greening Australia | CC3 |
| Drone aerial imagery of treatment and control sites | Treatment and control gullies | November 2017 continuing | Greening Australia | Copyright, use under licence |
| General photography and videos | Various | November 2016 and continuing | Copyright owner | By request |
| GIS datasets of implemented treatments | Various datasets created relating to treatment and control areas | November 2016 continuing | Greening Australia | CC3 |
| Vegetation survey datasets | Multiple locations within the project area covering both treatment and control sites | November 2017 continuing | Greening Australia | CC3 once completed |
| Treatment costs | Costs of treatment options implemented on the trial sites | November 2017 continuing | Greening Australia | Access to information once reported |

## Collaboration and linkages with other programs

### *Economic Evaluation*

The economic evaluation of large scale gully remediation programs is critically important to understanding the potential of such programs to make an impact on the Australian and Queensland Government's Reef 2050 water quality targets.

The economic evaluation of the trials undertaken under the Innovative Gully Remediation Program is an important objective. To meet this objective the project is collating data on the costs of various forms of intervention to allow the cost-benefit of various treatment options to be assessed. In many ways the trials at Strathalbyn Station are unique as they have not to date been undertaken at this scale anywhere within the Great Barrier Reef space. These data will be made available to the Queensland Government to assist in evaluating the economic and cost implications of undertaking similar works.

At the time of compiling this monitoring and evaluation plan it had been proposed that this analysis be undertaken through the Queensland Government's Sediment Working Group to ensure that the analysis of costs of remediation are undertaken against a standard framework that differentiates direct costs of treatments from transaction type costs associated with site specific characteristics include site constraints such as access, remoteness, availability of

resources, etc. In any event, the project specific evaluation of treatment costs remains a key objective of this project and will be reported on in the Project's Final Report in 2020.

## *Paddock to Reef Program*

The effectiveness of projects directed towards improved farm management practices under the Reef 2050 Water Quality Improvement Plan are monitored and reported on by the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program (known as Paddock to Reef).

The management practice adoption component of the Paddock to Reef program measures progress towards the Reef Plan targets, focussing on the industry-specific management practice frameworks relevant to water quality risk. Practices are ranked from lowest risk (innovative practices that have the lowest water quality risk) to high risk (superseded practices that have the highest water quality risk).

The reporting of information on practice change to the Paddock to Reef Program is undertaken by groups delivering the projects. The Innovative Gully Remediation Project is reported on a yearly basis by Greening Australia. The information is collated with other program results and used to model the impact of the improvements on reef water quality by the Paddock to Reef Program.

## *National Environmental Science Program Project 3.1.7*

The NESP funded and Griffith University led project "Reducing sediment loads to the Great Barrier Reef: developing optimal approaches for treating alluvial gully erosion" aims to work collaboratively with delivery partners implementing gully rehabilitation works to test the effectiveness of different treatments for large active alluvial gully rehabilitation in different soil types in different catchments.

As part of the NESP project, Griffith University has undertaken a comprehensive soil sampling and mapping program over the Strathalbyn project site, supported by DES Science Division and DES Office of the Great Barrier Reef. This dataset will be useful in a monitoring and evaluation context in evaluating both treatment effectiveness in different soil types and also for post-treatment evaluations of soil structure and chemistry.

The project is also trialling alternative low cost sampling methodologies that may assist in determining remediation treatment effectiveness in future programs. The 2018-2019 monitoring equipment set-out of the NESP program is detailed in *Appendix 3*.

## *Burdekin MIP: Landholders Driving Change*

The Queensland Government funded Burdekin MIP program, known as the "Landholder's Driving Change" project, is being implemented by NQ Dry Tropics through a project panel and consortia.

The LDC project is collaborating with the Innovative Gully Remediation Project through contributing to the installation of the DES Water Quality monitoring station on Bonnie Doon Creek. The collaboration between DES, NQ Dry Tropics and Greening Australia recognises the importance of long-term monitoring of sediment reduction programs through monitoring the catchment outflow for changes in sediment export over decadal timeframes.

### *Reef Trust IV*

The Australian government has funded two programs under its Reef Trust IV initiative which currently have project sites adjacent to the QLD Government/Greening Australia Innovative Gully Remediation Program on Strathalbyn Station. The two projects are:

- the Greening Australia (QLD) Pty Ltd "Priority Gully Restoration" program; and
- the NQ Dry Tropics Pty LTD "Stomping the Sediment" program.

The Reef Trust IV program has specific monitoring requirements detailed within the program's "Gully Toolbox", including several metrics which could be utilised to compare results more broadly between the programs. These include a requirement to undertake end-of-dry and end-of-wet vegetation and LCA assessments and to make qualitative observations of the effectiveness of treatment approaches. For the Greening Australia program this includes utilising high resolution aerial LiDAR and limited RTK survey transects through large "breakout" alluvial gully treatment and control sites to determine changes to the extent and depth of gully erosion on these sites.

### *DES Water Quality Station*

The Department of Environment and Science have installed an automated water quality station on Bonnie Doon Creek to collect water quality and water discharge data over a 10 year period. The Station is linked to the State Water Quality Monitoring Information Portal.

Data from the DES water quality station will supplement the datasets being collected by the Innovative Gully Remediation Program in addition to being useful to other linked programs including the NESP 3.1.7 project, the NQ Dry Tropics Landholder Driving change project program, and the Greening Australia and NQ Dry Tropics Reef Trust IV projects.

### *Testing methods of landform change analysis*

Griffith University, Department of Environment and Science, and Department of Natural Resources and Mines have initiated research to determine the effectiveness and cost efficiencies of different methods of landform change analyses using various LiDAR, photogrammetric and point-cloud capture technologies. This research will assist in determining the usefulness of these technologies in monitoring landform change as a method of estimating sediment export from both remediated and un-remediated gully landscapes.

## Communication activities related to the M&E Program

The communication of the findings of the monitoring and evaluation against the Key Evaluation Questions will be undertaken in line with the Innovative Gully Remediation Project Communication Plan adopted in June 2017 (Greening Australia, 2017),

Specific activities related to the monitoring and evaluation program detailed in the Communication Plan include:

- The development and distribution via electronic and printed means of Communique #3 "Post-works monitoring outcomes"

- The development and distribution via electronic and printed means of Communique #4 “Strathalbyn Gully Remediation Update 2018”
- The development and distribution via electronic and printed means of Communique #5 “Strathalbyn Gully Remediation Update 2019”
- The communication of project achievements to mainstream audiences through media releases, web site content, and social media updates

Additional mechanisms for communicating the results of the trials and learnings from the monitoring program include:

- The presentation of peer review papers in journals
- The presentations at relevant conferences and forums (eg. the annual Australian Stream Management Conference or International Gully Remediation Forum in Townsville in 2019)
- Participation in the Queensland Government’s Sediment Working Group or other industry focussed activities.

## Reporting

The reporting requirements for the Innovative Gully Remediation Project are determined by the collaborative agreement between Greening Australia and the Queensland Government. In accordance with that agreement and the Project Plan approved by the Office of the Great Barrier Reef the following reporting framework will be adopted for the monitoring and evaluation components of the project:

1. Produce a concise report on the outcomes of the monitoring and evaluation program against the Key Evaluation Questions by 1 August 2020.
2. Synthesise the final outcomes of the Monitoring and Evaluation Report into the Innovative Gully Remediation Final Report by 1 September 2020.
3. Produce a set of recommendations for essential project monitoring steps for future large scale gully remediation by 31 December 2020.

In addition to the requirements under the collaborative agreement, this Monitoring and Evaluation Plan will also contribute to a number of additional evaluation programs which seek to determine the impact of activities and investments under a number of related Queensland Government Programs. These include:

- Providing the information and GIS data required to meet the needs of the Paddock to Reef Integrated Monitoring, Modelling and Reporting Program
- Providing data to assist the evaluation of the Innovative Gully Remediation Program using the Reef Water Quality MERI evaluation template (DES, 2018).

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## Summary of the Monitoring and Evaluation Plan

*Table 5* provides a summary of the Innovative Gully Remediation Program's Monitoring and Evaluation Plan and the activities, methodologies and measures adopted to answer the Key Evaluation Questions.

*Table 5 Summary of activities, methodologies and measures adopted for the Strathalbyn Innovative Gully Remediation Program Monitoring and Evaluation Plan.*

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| **Determine baseline conditions** | Define catchment and gully morphology and attributes | Catchment area (Ha), gully area (Ha) | Utilise 2016 LiDAR to determine catchment areas, gully extents | 1,4 | LiDAR capture in November 2016 | Greening Australia staff or qualified contractors | Completed May 2017 |
| | Define baseline gully sediment export rates | Change in gully area (Ha/year) | Utilise historical aerial photographs | 1,2,3 | 2016-2017 | Greening Australia staff or qualified contractors | Completed October 2018 |
| | | Change in gully morphology and depth over time period ($m^3$/year) | Model historical gully topography and create time series DEMs of difference | 1,2,3 | 2016-2017 | Greening Australia staff or qualified contractors | Completed October 2018 |
| | Update soil mapping over the project area | Soil type, characteristics, chemistry, and extent | Soil sample analyses and landscape assessments | 1,2 | 2016-2017 | Utilise mapping undertaken by Peter Zund (DES) and under the NESP 3.1.7 project | Completed May 2018 |
| | Identify gully erosion processes | DEMs of difference | Process type and implications | 2,4 | Preliminary assessment | Greening Australia staff and consultants as appropriate | Completed May 2018 |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| **Determine baseline conditions cont…** | Under take baseline gully vegetation assessments | Species, diversity, functional group, and cover | Field survey of vegetation functional groups in quadrats along established transects | 1,2,3 | End-of-dry and end-of wet assessments | Greening Australia staff | Baseline assessments completed December 2017 |
| | Undertake baseline Land Condition Assessments | Land type, vegetation functional group, pasture condition, soil condition, and cover | "Stocktake" analysis within and outside treatment areas. | 1,2,3 | End-of-dry and end-of wet assessments | Greening Australia staff | Baseline assessments December 2017 |
| **Document treatment approaches for comparison to baseline/control conditions** | Define Control areas | Gully area (Ha) | Utilise high resolution LiDAR, either terrestrial or aerial (as available) to determine extent of gully treatments. | 1,2,3 | Before remediation commences in any identified gully complex | Greening Australia in conjunction with OGBR Steering Panel | Completed October 2017 for Northern Gully Complex |
| | | Soil Characteristics | Utilise soil mapping undertaken by Peter Zund and the NESP 3.1.7 project. | 2,3 | Prior to remediation of adjoining treatment gullies | Peter Zund (DES) | Completed May 2018 |
| | Define treatment areas | Gully area (Ha) | Utilise high resolution LiDAR, either terrestrial or aerial (as available) to determine extent of gully treatments. | 2,4 | Before remediation commences in any identified gully complex | Greening Australia utilising the preliminary assessment report undertaken by Griffith University | Completed October 2017 for Northern Gully Complex |
| | | Soil Characteristics | Utilise soil mapping undertaken by Peter Zund and the NESP 3.1.7 project. | 2,3 | Prior to remediation to determine appropriate amelioration approaches | Peter Zund (DES) | Completed May 2018 |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| **Document treatment approaches for comparison to baseline/control conditions cont…** | Define treatment approaches | Gully scarp treatments qualitative (description of treatment) and quantitative (area in Ha, application rates in volume $m^3$ or thickness in mm, application rates in tonnes/Ha) | Document treatment approaches and qualities | 3 | Before undertaking detailed design of remediation approaches | Greening Australia in conjunction with OGBR Steering Panel | Completed October 2017 for Phase 1 treatments; completed April 2018 for Phase 2A and 2B |
| | | Gully channel treatments qualitative (description of treatment) and quantitative (area in Ha, application rates in volume $m^3$ or thickness in mm, application rates in tonnes/Ha) | Document treatment approaches and qualities | 3 | Before undertaking detailed design of remediation approaches | Greening Australia in conjunction with OGBR Steering Panel | Completed October 2017 for Phase 1 treatments; completed April 2018 for Phase 2A and 2B |
| **Collect channel dimension data** | Utilise RTK survey to determine post-treatment channel dimensions | Gully profiles at location of all water quality monitoring installations in metres AHD | Utilise RTK survey equipment and qualified surveyor | 1,3 | Prior to wet season in treated, proposed to be treated, and control gullies | Greening Australia and contracted surveyor | Completed December 2017 for the northern gully and central gully complex |
| **Establish RTK benchmarks within treatment and control gullies** | Utilise RTK survey to establish AHD benchmarks in all treatment and control gullies | Benchmark location in GDA94 and benchmark height in metres AHD | Utilise RTK survey equipment and qualified surveyor | 1,2,3 | Prior to commencement of remediation program | Greening Australia and contracted surveyor | Completed May 2018 for the northern gully and central gully complex |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| **Collect end-of-dry monitoring datasets** | Undertake end-of-dry season vegetation surveys | % cover total, estimated biomass, % cover of specified vegetation function groups | Field survey of vegetation functional groups in quadrats along established transects | 2,3 | End-of-dry surveys | Greening Australia staff | Completed up until end-of-dry 2018, to continue for duration of project |
| | Undertake end-of-dry season Land Condition Assessments | Land type, vegetation functional group, pasture condition, soil condition, and cover | "Stocktake" analysis within and outside treatment areas. | 2,3 | End-of-dry surveys | Greening Australia staff | Completed up until end-of-dry 2018, to continue for duration of project |
| **Collect and analyse event water quality and flow data** | Collect, process and analyse water quality samples from all equipment after triggering events | Suspended Sediment Concentration (mg/L) in Rising Stage Samplers or ISCO automated samples. | Samples collected throughout the hydrograph during run-off events | 1,2,3,4 | Event based throughout the wet season | Contractor for sample collection, Greening Australia for data processing, NATA accredited laboratory for analysis, and independent consultant for analyses. | Completed for 2016-17 and 2017-18 wet seasons; to continue for duration of project |
| | | Particle size distribution (µm) of all samples collected | Samples collected throughout the hydrograph during run-off events | 1,2,3,4 | Event based throughout the wet season | As above | As above |
| | | Concentration of sub-20µm sediment in mg/L | Extrapolated from laboratory analyses | 1,2,3,4 | Event based throughout the wet season | As above | As above |
| | Collect, process and store water level information | Height of flow during run-off events in metres above AHD | Barometric compensation of water level data to get water level height above gully bed (m AHD) | 1,2 | Throughout the wet season | Greening Australia staff | As above |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| **Collect and analyse event water quality and flow data cont…** | Calculation of discharge during run-off events | Velocity (m/s) of within gully flows during rainfall runoff events in m/s at or near the gully outlet | Download velocity sensor information from the dedicated datalogger and calculate with reference to gully cross-section and flow height data | 1,2,3,4 | End-of-wet assessment | Independent consultant contracted by Greening Australia | Completed for 2017-18 wet season; to continue for duration of project |
| | Download time-lapse cameras after events | Qualitative assessment of change | Comparison of time-lapse photography | 4 | Throughout the wet season | Greening Australia staff | Completed for 2017-18 wet season; to continue for duration of project |
| **Collect end-of-wet monitoring datasets** | Undertake end-of-dry season vegetation surveys | % cover total, estimated biomass, % cover of specified vegetation function groups | Field survey of vegetation functional groups in quadrats along established transects | 2,3 | End-of-wet surveys | Greening Australia staff | Completed up until end-of-wet 2018, to continue for duration of project |
| | Undertake end-of-dry season Land Condition Assessments | Land type, vegetation functional group, pasture condition, soil condition, and cover | "Stocktake" analysis within and outside treatment areas. | 2,3 | End-of-wet surveys | Greening Australia staff | Completed up until end-of-wet 2018, to continue for duration of project |
| **Undertake analyses of cost and treatment effectiveness** | Contribute to the development of a "Standard" for analysis of treatment costs | Differentiation of direct and indirect costs, transactional costs, etc | Utilise discounting methods, ecosystem services, etc | 3,4 | End-of-project | Contributions from Greening Australia staff to the SWG | By August 2020 |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| | Analyse cost of treatment data | Direct construction costs, costs of construction management, ancillary costs related to construction activities | Utilise the methodology recommended by the QLD Govt Sediment Working Group | 3,4 | End-of-project | Greening Australia to coordinate | By August 2020 |
| | Compare cost of treatment with treatment effectiveness | $/tonne of sub20µm sediment saved | Determine reduction in export of target sediment and divide by treatment costs | 3,4 | End-of-project | Greening Australia staff | By August 2020, but recommend continued monitoring of treatment effectiveness for a minimum of 10 years |
| **Manage data** | Ensure data is stored with the appropriate custodian | Data appropriately stored and available for access where appropriate | Storage on secure servers or public data hubs as appropriate | 1-4 | As data is created | Data custodians | As the data is created |
| | | Metadata statements produced for all stored data | Storage on secure servers or public data hubs as appropriate | 1-4 | As data is created | Data custodians | As the data is created or stored |
| | Share data with researchers and practitioners involved in sediment reduction programs | Number of programs using project produced data | Collaborate with linked and associated projects by providing access to project data as appropriate | 4 | As required | Project leaders for collaborating or linked projects (eg. DES, DNRM, Griffith University, NQ Dry Tropics, and Reef Trust) | On-going activity |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| **Manage M&E program risks** | Ensure monitoring data is collected | Data is reliably collected after events or at scheduled intervals | Maintain monitoring installations, schedule end-of-dry and end-of wet data collection, plan for access after events. | 1-4 | After rainfall events, end-of-dry and end-of-wet periods, pre- and post-implementation as appropriate | Greening Australia and contractors | Continue until completion of project |
| | Ensure WHS compliance | Risk identification and management, JSEA development, incident reporting. | Operate under a WHS Management Plan and regularly review risk assessments and any applicable JSEAs | n/a | Whenever monitoring or evaluation activities are being undertaken, particularly field-based activities | Greening Australia and contractors | Continue until completion of project |
| **Communicate monitoring and evaluation outcomes** | Complete communication activities as per the IGRP Communication Strategy | Communication products and activities completed as per the IGRP Communications Plan | Follow the IGRP Communications Plan activities list. | 4 | After analysis of wet-season data or as required for significant events such as conferences, forums or other opportunities | Greening Australia | Continue until completion of project |
| **Report to stakeholders** | Monitoring and Evaluation Final Report | Report compiled, reviewed and finalised | Analyse data and report outcomes. | 1-4 | Compiled on completion of the monitoring and evaluation program | Greening Australia | August 2020 |
| | Innovative Gully Remediation Program Final Report | Report compiled, reviewed and finalised | Report project outcomes. | 1-4 | Compiled at the completion of the Innovative Gully Remediation Project | Greening Australia | September 2020 |

| Objectives | Activities | Measures | Methodologies | Key Evaluation Question answered | Timeframes | Responsibilities | Completion Dates |
|---|---|---|---|---|---|---|---|
| | Recommendations for Monitoring Programs for large-scale remediation programs | Recommendations made, peer reviewed, and communicated. | Draft recommendations for peer review by stakeholders involved in monitoring sediment reduction programs in the GBR space, review, and report | 4 | Compiled at end of project evaluation period | Greening Australia | December 2020 |

# Risk and mitigation strategies

This Plan represents a multi-faceted and logistically challenging program of data collection. There are inherent risks in undertaking such programs in areas that are remote and where access is generally restricted during the times when data collection is most important. The risks include:

- Missing data collection windows due to restricted access during and for an extended period after intense weather events.
- Failure of automated sampling equipment or other equipment resulting in a loss of data.
- Worker safety considerations particularly relating to access and site conditions during rainfall events.

To counter these risks, the following mitigation measures have been implemented:

- Regular monitoring activities scheduled and staffing resources allocated (such as pre- and post-wet season vegetation survey).
- Adaptive management and systems to ensure data and information collection under most conditions.
- Planning for wet season data collection including pre-determining access arrangements
- Collaborating where possible with other data collection and monitoring programs to facilitate shared resourcing
- Regular inspection and maintenance of field equipment and installations
- Developing and adhering to site specific WHS management plans, risk assessments and JSEAs
- Quarterly meetings between the Office of the Great Barrier Reef and Greening Australia to review the monitoring and evaluation program and to revise and adapt the program as appropriate.

# References


Greening Australia (2017) Greening Australia and EHP Innovative Gully Remediation Project Communications and Engagement Strategy 2017-2020, June 2017, unpublished report to the Queensland State Government.

Greening Australia (2018) Greening Australia and EHP Innovative Gully Remediation Project Forum Outcomes Report, March 2018, unpublished report to the Queensland State Government.

DES (2018) Department of Environment and Science Appendix B MERI Plans v1 (dated 29 June 2018), unpublished guideline produced by the Queensland Government Office of Great Barrier Reef.

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NESP 3.1.7 Reducing sediment loads to the Great Barrier Reef: developing optimal approaches for treating alluvial gully erosion. Program summary at https://nesptropical.edu.au/index.php/round-3-projects/project-3-1-7/

NQ Dry Tropics (2016) Burdekin Region Water Quality Improvement Plan 2016, NQ Dry Tropics, Townsville.

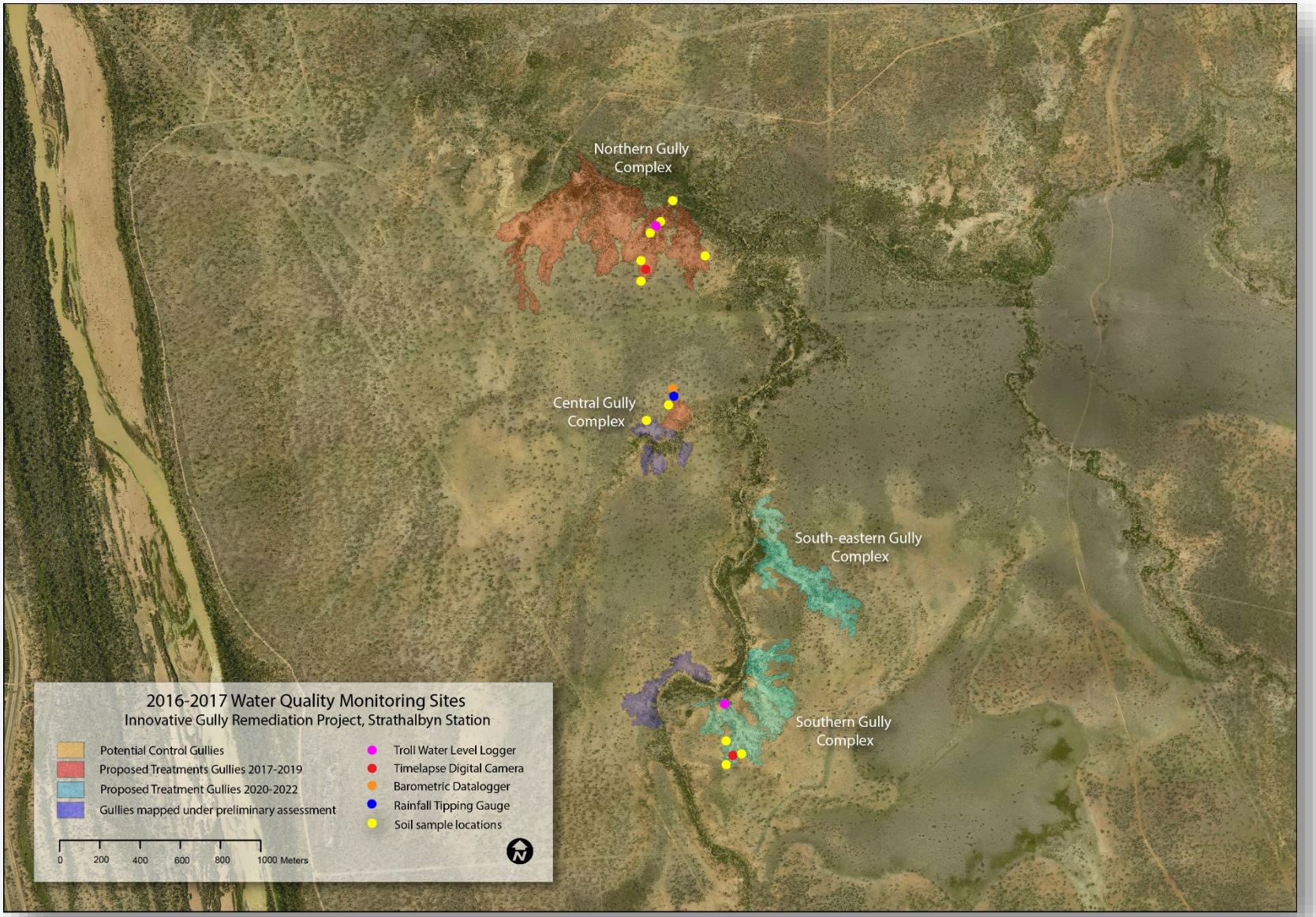


*Figure A1*

*2016-2017 monitoring locations and instrumentation for pre-works baseline water quality and rainfall event data collection.*

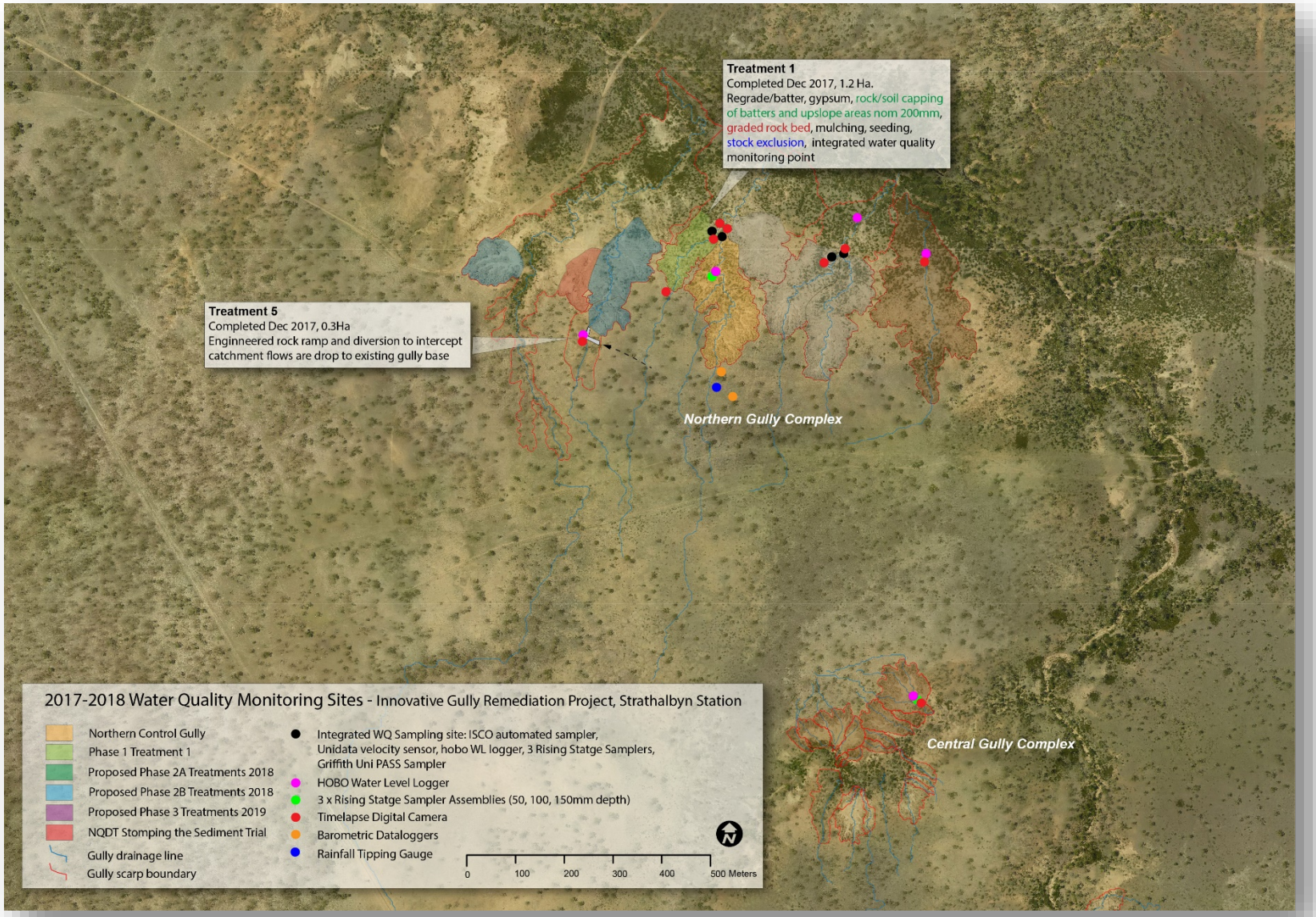


*Figure A2*

*2017-2018 monitoring locations and instrumentation for pre-works baseline water quality and rainfall event data collection.*

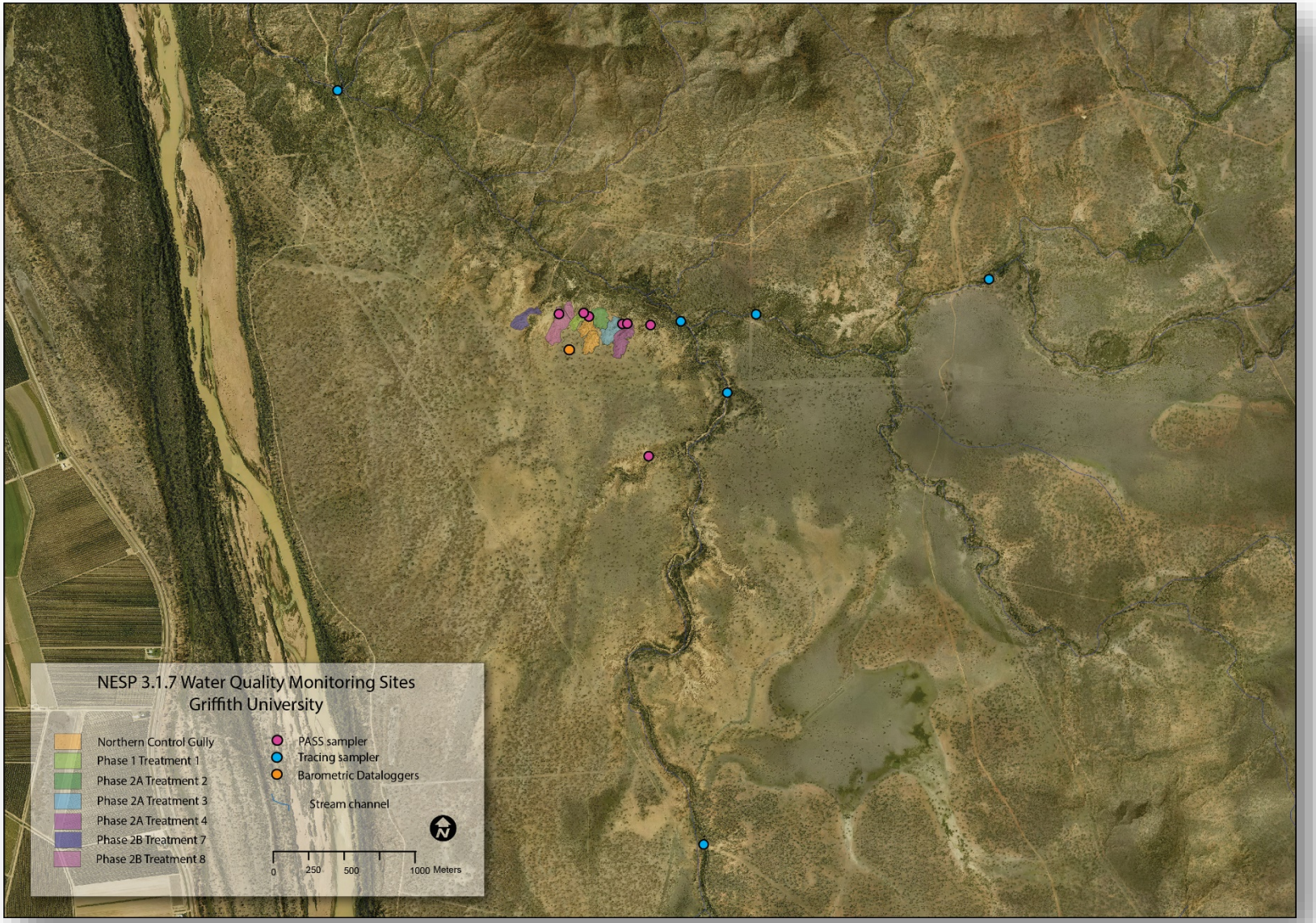


*Figure A3*

*2018-2019 monitoring locations and instrumentation for Griffith University's NESP 3.1.7 Project (Source: John Spencer, 2018)*

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