Project Order, Variations and Research Progress

Project Title: Putting Land Management Knowledge into Practice

This document contains three sections. Click on the relevant section for more information.

Section 1: Research Project Order as approved by the GISERA NT Regional Research Advisory Committee before project commencement

Section 2: Variations to Project Order

Section 3: Progress against project milestones

1 Original Project Order

GISERA
Gas Industry Social and Environmental Research Alliance

Project Order

Proforma 2020

1. Short Project Title

Putting Land Management Knowledge into Practice

Long Project Title	Putting knowledge from land management research into best practice for gas development in the Northern Territory
GISERA Project Number	L.10
Proposed Start Date	1/7/2020
Proposed End Date	31/03/2022
Project Leader	Dr Neil Huth

2. GISERA Region

- ☐ Queensland
- ☐ New South Wales
- ☒ **Northern Territory**
- ☐ South Australia
- ☐ Western Australia
- ☐ Victoria

3. GISERA Research Program

- ☐ Water Research
- ☐ GHG Research
- ☐ Social & Economic Research
- ☐ Biodiversity Research
- ☒ **Agricultural Land Management Research**
- ☐ Health Research

4. Project Summary

Objective

To assist communities of the Northern Territory to meet recommendations of the *Scientific Inquiry into Hydraulic Fracturing in the Northern Territory* through the provision of high-quality spatial data to farmers, regulators, and the gas industry to:

a) assist their evaluation of design and placement of gas infrastructure options
b) protect surface water and vegetation and reduce erosion, soil damage and dust as required by the recommendations from the NT Hydraulic Fracturing Inquiry
c) create novel communication tools to improve the exchange of data between different individuals and groups.

This project directly addresses the **Recommendations 7.1, 8.13 and 8.14** of the NT Hydraulic Fracturing Inquiry and will also assist with preliminary information for **Recommendations 8.7, 8.8, 8.11 and 8.15.**

Description

This research will demonstrate the use of modern data visualization to improve the management of potential environmental risk. Previous work has shown that a better understanding of landscape processes has helped land managers in agriculture and the gas industry to design gas infrastructure whilst also helping regulators in policy consideration. However, many of these processes, such as hydrology, soil loss and pasture dynamics are difficult to see with the naked eye because they occur over large scales in space or time. The use of virtual or augmented reality, as developed in previous research projects, will allow the communication of these processes and potential risks, and lessons on best management practices to mitigate these. By presenting these data within a virtual landscape in which gas development will occur, we make the invisible, visible.

CSIRO has used these techniques to great effect in communicating issues of environmental risk for farmers and the gas industry in other areas where there have been impacts to soils, pastures and livestock on farms, but also to access tracks, pipelines and well pads, with significant impacts on rehabilitation costs. Furthermore, the techniques have been sought by regulators to assist in formulation of policy. The same information requirements and risk management activities have been captured in the recommendations of the Northern Territory Hydraulic Fracturing Inquiry and so this research capacity will be useful for the Northern Territory gas development going forward.

In particular, the results of this project will help land managers and gas developers to

1) understand wet season surface water flows so that erosion risks can be managed

2) identify existing farm infrastructure (e.g. farm tracks for re-use) and their existing environmental issues (e.g. existing erosion threats or grazing pressures) to ensure that the design of gas development accounts for these. Research in other gas developments has demonstrated ways for gas development to add value to existing farm operations.
3) determine the locations of surface water features (e.g. dams, watering points) whose quality must be maintained (e.g. sediment, spills) and the related catchment areas that need to be considered in infrastructure design.
4) determine pasture/land condition across a development area to highlight zones that may be vulnerable to disturbance or highly productive and requiring protection.
5) know where cattle graze, camp and move to ensure protection of productive areas, and to manage overlapping pressures from both cattle and gas development.
6) prioritise revegetation efforts to protect soil rehabilitation from erosion and livestock to save time and money for both graziers and the gas industry.
7) understand variation in soil types and their management requirements across a development (in conjunction with hydrological processes described above).
8) understand simple methods to reduce impacts from dust emissions.

The project has been designed to provide a stage gate mid-way through the project to approve progress to community engagement and knowledge transfer once the effectiveness of the project capability has been determined.

Need & Scope

The Final Report of the Scientific Inquiry into Hydraulic Fracturing in the Northern Territory recommended that construction of infrastructure should be guided by best practice designed specifically for the NT to minimise possible unacceptable impacts on wet season surface water flows and erosion. Furthermore, the Inquiry also stated that there should be careful large-scale design of all roads and pipelines to avoid issues arising from *ad hoc* or incremental development. These are referenced within the section immediately below. These recommendations will be directly addressed within this research project.

A significant body of research is completed for gas development in Australia (Queensland and South Australia) and overseas with many of these lessons relevant to agricultural lands in the Northern Territory. The scope of this project will include methods for the management of soils, water flows, pastures and livestock within gas development as in previous GISERA work within grazing systems (https://gisera.csiro.au/project/inside-the-herd/). However, the project will also study methods for effectively communicating knowledge of complex processes to develop and facilitate the implementation of required best practices by land managers.

Surveys of key stakeholders in gas development areas within Queensland, as part of the *"Telling the Story"* project (https://gisera.csiro.au/project/telling-the-story-2/) found that spatial data, and visualisation techniques were highly effective and valued by farmers, regulators and industry because they:

- Provided for a range of communication needs for people who were directly impacted, from the local area, the wider public, or those involved in policy development.
- Helped people to engage with information on their terms - Information presented in a neutral way builds confidence in the information provider.
- Allow the person to engage in the discussion and come to their own judgement, thus empowering the individual.

The research team has extensive experience in community engagement via kitchen table sessions, stalls at regional shows, or presentations to key stakeholder groups. Communications activities using these approaches were also found to provide a valuable touchpoint for the community with many expressing gratitude in being able to speak to researchers directly. The project team will work with the Project's Technical Reference Group to identify appropriate stakeholders (e.g. agriculture, industry, indigenous, community, government) and methods for engagement.

NT Hydraulic Fracturing Inquiry Recommendations

This research project directly addresses the following Recommendations of the NT Hydraulic Fracturing Inquiry. Some of the issues raised by the Inquiry have been studied in other gas development areas by the project team and these lessons will be studied and communicated to stakeholders within this project using the tools described in the methodology section below.

Recommendation 7.18

That to minimise the adverse impacts of any onshore shale gas infrastructure (roads and pipelines) on the flow and quality of surface waters, the Government must ensure that:

- *landscape or regional impacts are considered in the design and planning phase of development to avoid unforeseen consequences arising from the incremental (piecemeal) rollout of linear infrastructure; and*
- *roads and pipeline corridors must be constructed to:*
    - *minimise the interference with wet season surface water flow paths;*
    - *minimise erosion of exposed (road) surfaces and drains;*

- *ensure fauna passage at all stream crossings; and*
- *comply with relevant guidelines such as the International Erosion Control Association Best Practice for Erosion and Sediment Control and the Australian Pipeline Industry Association Code of Environmental Practice 2009.*

Recommendation 8.13

- *That roads and pipeline surface water flow paths minimise erosion of all exposed surfaces and drains.*

Recommendation 8.14

- *That all corridors be constructed to minimise the interference with wet season stream crossings and comply with relevant guidelines, such as the International Erosion Control Association Best Practice for Erosion and Sediment Control and the Australian Pipeline Industry Association Code of Environmental Practice 2009.*

These Recommendations are also captured within the Code of Practice for Onshore Petroleum Activities in the Northern Territory which states:

- Infrastructure site/route selection must minimise interference with wet season water flow paths and exposure of infrastructure to flooding (Requirement A.3.1d)
- Road and pipeline corridor designs must (Requirement A.3.4d):
  i. minimise erosion of exposed road surfaces and drains;
  ii. ensure that roads and pipeline surface water flow paths minimise erosion of all exposed surfaces and drains;
  iii. comply with relevant guidelines

Techniques developed for broad scale surface water flow mapping to inform the placement and design of access tracks and pipeline corridors (GISERA Project A4 1215 – Making Tracks, Treading Carefully, https://gisera.csiro.au/project/making-tracks-treading-carefully/) will prove invaluable in facilitating large-scale regional design at the planning phases of development to minimise risks from smaller-scale or localised environmental processes to wet season surface water flow paths and subsequent erosion or road surfaces and drains (**Recommendations 7.18, 8.13 and 8.14**).

Recommendation 8.7

- *That the area of vegetation cleared for infrastructure development (well pads, roads and pipeline corridors) be minimised through the efficient design of flowlines and access roads, and where possible, the co-location of shared infrastructure by gas companies.*

Recommendation 8.7 is also captured in requirement A.3.1b.iii of the Code of Practice for Onshore Petroleum Activities in the Northern Territory which states “the area of vegetation to be cleared for infrastructure development (including well pads, roads and pipeline corridors) has been minimised through efficient design and where possible, use of existing infrastructure and the co-location of shared infrastructure”

Research on agricultural properties with gas infrastructure has shown the importance of careful design and placement of gas infrastructure to minimise impact on farm operations, livestock, crops and pastures. This knowledge can be used to limit the surface footprint through the efficient design of access roads and pipeline corridors, the co-location of shared infrastructure and tracks on pastoral properties (**Recommendation 8.7**); In some cases, co-location of gas infrastructure with farm infrastructure can not only reduce the footprint, but provide improved infrastructure for farm operations (e.g. improved trafficability during the wet season). These issues have been studied through GISERA Project “Gas-Farm Design” (https://gisera.csiro.au/project/gas-farm-design/). Such considerations for grazing properties also need to take into account designs to minimise the disturbance on areas of productive pastures as demonstrated in the GISERA Project “Inside the Herd” (https://gisera.csiro.au/project/inside-the-herd/).

Recommendation 8.8

- *That well pads and pipeline corridors be progressively rehabilitated, with native vegetation re-established such that the corridors become ecologically integrated into the surrounding landscape.*

Recommendation 8.11

- *That clearing for corridors, well pads and other operational areas be kept to a minimum, that pipelines and other linear infrastructure be buried (except for necessary inspection points), and that all disturbed ground be revegetated.*

Where disturbance does take place, rehabilitation and revegetation should be undertaken as soon as possible (**Recommendations 8.8 and 8.11**). These recommendations are also captured in the requirements outlined in A.3.9 within the Code of Practice for Onshore Petroleum Activities in the Northern Territory. However, revegetation within operational grazing lands will require consideration and planning to account for impacts of weather, soil type and livestock interactions for it to be successful. The importance and difficulty of these efforts has been highlighted by both graziers and gas companies during engagement activities by this project team, with the tools described here used by land managers to inform contractors undertaking these activities. These issues have been explored and clearly demonstrated previously by the project team in the GISERA Project “Inside the Herd” (https://gisera.csiro.au/project/inside-the-herd/).

Recommendation 8.15

- *That to minimise the impact of any onshore shale gas industry on landscape amenity, gas companies must demonstrate that they have minimised the surface footprint of development to ALARP, including that:*
    - *well pads are spaced a minimum of 2 km apart; and*
    - *the long-term infrastructure within any development area (exploration or production) has little to no visibility from any major public roads.*

These recommendations follow requirements within A.3.1c of the Code of Practice for Onshore Petroleum Activities in the Northern Territory.

The placement and design of gas infrastructure can be used to minimize impacts on amenity, farm operations and dust emission. The visualisation techniques employed within this project will be well placed to demonstrate amenity issues. The importance of landscape aesthetics has been studied by the project team previously in the GISERA Project "A Shared Space" (https://gisera.csiro.au/project/shared-space/) and methods employed by landholders and gas developers have been studied by the project team in the Project "Gas-Farm Design" (https://gisera.csiro.au/project/gas-farm-design/). The project will communicate these needs, but also lessons on addressing them using the visualization techniques described in the following section.

Methodology

The methodology used within this project will build upon efforts already developed, tested and evaluated with landholders in previous work in Coal Seam Gas developments in Queensland. The following methodology has been developed, tested and employed in Queensland grazing lands to study impacts of gas development. A case study location will be identified during the early stages of the project in collaboration with the Technical Reference Group and this will be used to address the goals of the project. The case study will be chosen to include a range of environmental conditions (soils, vegetation, hydrology) in an area of gas development. If required, a number of smaller case study locations may be used within logistical constraints. The project will follow the following methodology:

1. Photogrammetry will be used to derive high resolution vegetation and soil surface elevation maps for the case study area. Previous GISERA projects have developed ground elevation maps at 20cm resolution over areas > 100,000 km^2. These have previously been determined to be accurate via direct comparison to surveyors' measurements.

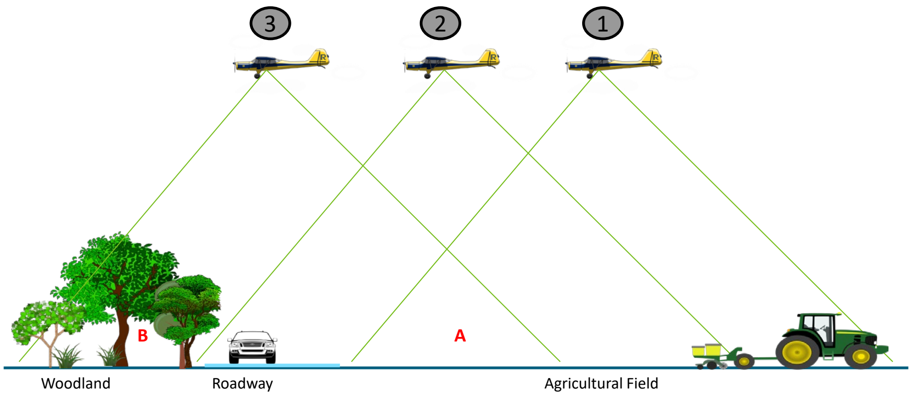


Figure 1*. A point "A" in an agricultural field is identified in three overlapping images. If the position of the aircraft is known for locations 1,2 and 3, the position of A can be calculated. Ground surface points within wooded areas (e.g. Point B) may need to be inferred from other nearby visible points if the view is obscured by foliage*

2. High resolution terrain analysis to map large (hundreds of square kilometres) catchment processes and fine scale (<1m resolution) water flow paths to highlight natural water flow processes and the exact location of likely erosion risks.

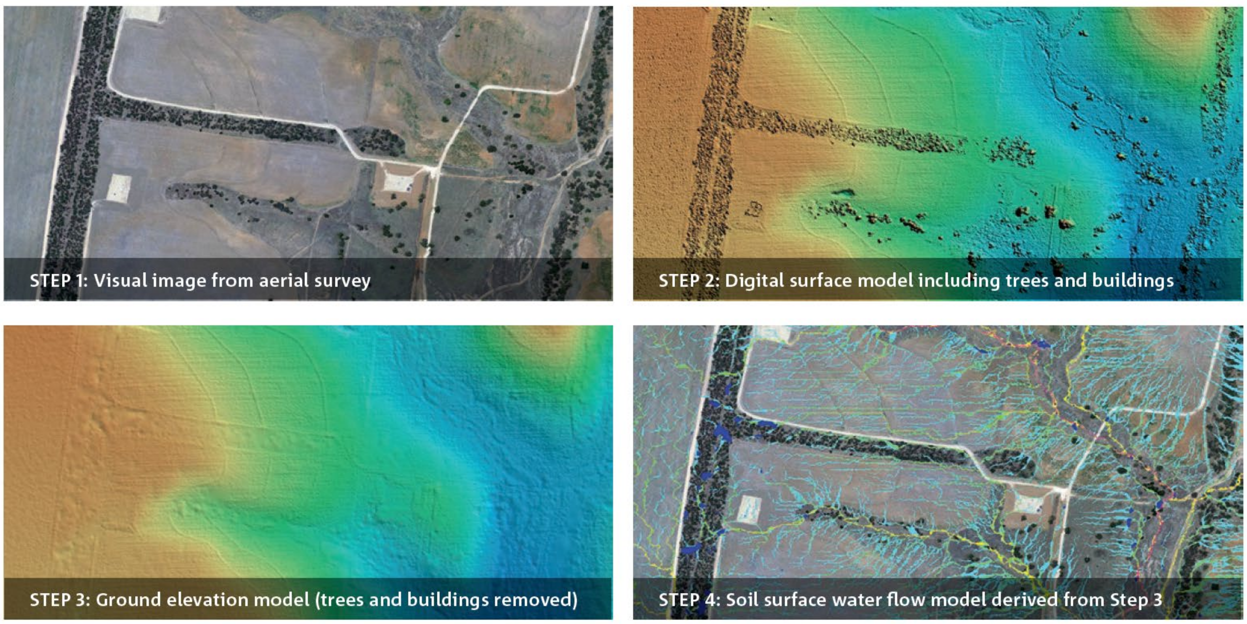


Figure 2. *The four main steps in deriving the water flow model. 1) Aerial survey conducted using digital photogrammetry. 2) A digital surface model (DSM) is constructed by triangulating the elevation of each pixel in the image. Note that contour banks and well pads are prominent in the image. The surface also includes surface features such as vegetation and buildings. 3) Surface features are removed and the ground surface beneath them is interpolated. Note that the surface depressions (e.g. "Gilgai") are now revealed from beneath the trees. 4) The ground surface elevation is used to calculate water flows according to small-scale topographical variation and features such as gullies, contour banks, drains and roadways.*

3. Long term satellite data (c.30 years) to show spatial variability in land condition (e.g. pasture cover/persistence, tree cover) as indicators of likely areas of fragile or vulnerable soil/vegetation conditions. These are analysed to derive maps of land condition score (a standard within the northern grazing industry).

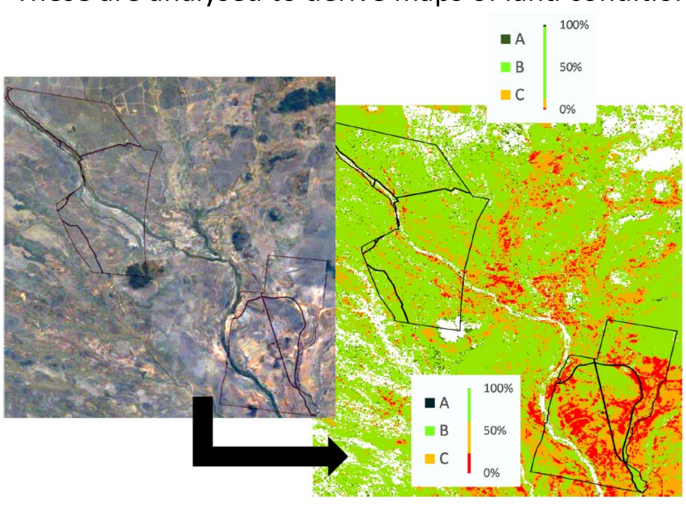


Figure 3. *Aerial photograph of two grazing properties showing different levels of A (high), B (medium), and C (low) condition grazing land.*

4. Deployment of spatial data through an online service integrating data layers developed with the project and also data sources already owned/operated by the farm enterprise. This platform will allow 3D visualisation of the agricultural area, existing infrastructure and the processes to be protected. We anticipate that the project should deliver a capacity to demonstrate environmental issues for both agriculture and gas industries using modern techniques, such as augmented reality. We will deploy these via targeted stakeholder communications.

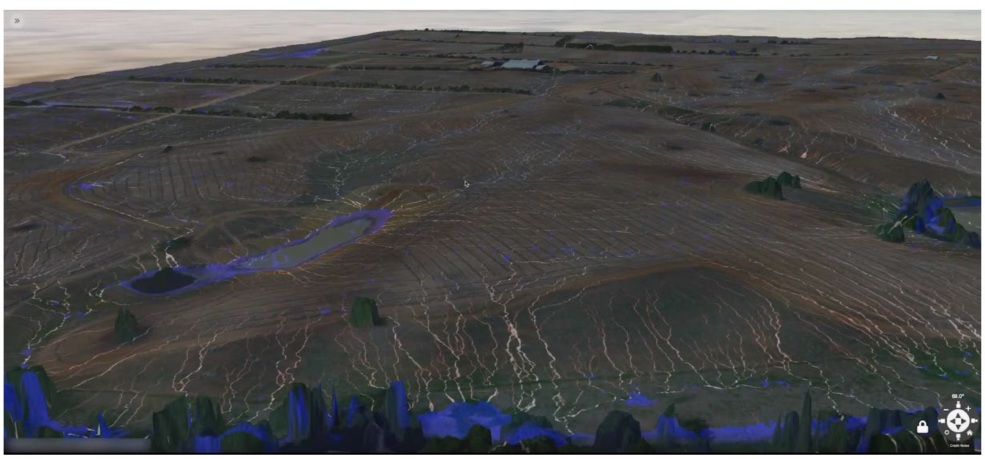


Figure 4. *Digital models of two farms in Southern Australia, the second with surface water flows superimposed onto the ground surface*

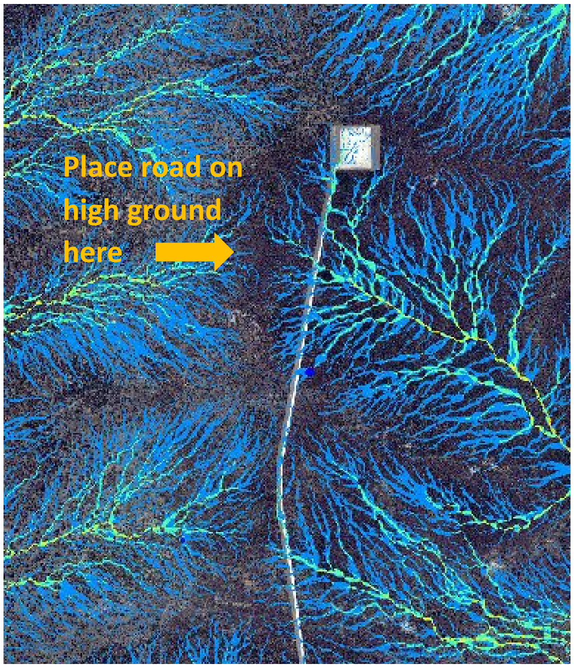


Figure 5 *Map of a woodland area after gas development and surface water flows demonstrating the areas of highest erosion risk. This example shows how careful placement of infrastructure can allow for water to flow away from roads or pipelines, rather than across and along them. This image also suggests that a minor change in the placement of the access track could have further minimized potential risks.*

5. Engagement processes developed with local gas and agriculture industry stakeholders. Previous projects have used a mix of one-on-one and small group sessions, or public demonstrations at rural shows. These have proven successful in demonstrating the science and facilitating engagement with some project outreach efforts achieving over 100 direct, one-on-one interactions with farmers, government (local, state, federal), industry, academia, and the general public. The process will deliberately aim to develop understanding and transfer knowledge to key stakeholders to improve best practice. The project team will work closely with the project's Technical Reference Group to identify opportunities for communication and impact.

Figure 6*. GISERA researchers talking with graziers at a regional agricultural show within a gas development area. Gas companies and regulators have requested similar engagement with their staff and landholders.*

5. Project Inputs

Research

Best practice needs to be employed in the design and development of gas infrastructure in rural areas. Previous research from around the world has shown that rural roads are a major source of sediment flows into waterways. Commonly, over 40% of the sediment can be shown to have its origin in unpaved rural roads even though these roads only make up about 1% of the total area of a catchment (Table 1). With gas development, the area of roadways and pipelines in rural areas will increase and there is a risk that erosion losses will increase likewise. Standard engineering methods for mitigating erosion threats are available if the location of problem areas can be identified. Recent research in gas development areas in Queensland has shown the value of detailed water flow path mapping to highlight areas of potential risk and methods for mitigation. These methods will prove useful for the protection of wet season water flows as required by the recommendations of the NT Hydraulic Fracturing Inquiry.

Table 1. Data on roads as % of catchment and % of sediment source (https://gisera.csiro.au/project/making-tracks-treading-carefully/).

Country	% of Area	% of Sediment
China	1	42.3
Indonesia	5	40
Brazil	1.5 to 2	28-69
USA	Less than 5	23-30
Australia (forest)	2.4	18-39
Australia (farm)	1	41-52

The impact of gas infrastructure and vehicle movements on soils, pastures and cattle in grazing systems has also been studied in previous GISERA research (https://gisera.csiro.au/project/inside-the-herd/). These studies have shown that soils in grazing lands can often be fragile and prone to erosion processes. GPS monitoring of cattle in this research found that cattle did not avoid gas traffic infrastructure but instead spent 18% more time on average along gas right-of-ways leading to extra pressure on areas of disturbance undergoing rehabilitation. GISERA researchers have used long term mapping of pasture dynamics and land condition derived from satellite data to again highlight areas of elevated risk. These data are valuable for land managers to understand the inherent resilience of land being managed. Land in high condition is resilient and can withstand impacts from periods of drought, grazing, or site disturbance whereas land in lower states of condition needs to be managed closely. Mapping prior to gas development aids land managers in better placing infrastructure to minimise environmental risk and maximise longer term sustainability and profitability.

Many of the techniques used within this project have been developed and tested in previous research efforts as described above. This project will complement these previous efforts by exploring new ways to make this science available and usable directly by decision makers in planning for future gas development. This will involve the use of modern visualisation techniques being developed for landholders on a case study site in the

NT gas development region. Through the use of modern digital technics, a “digital twin” will be developed for the case study location where environmental processes for soils, water flows and pastures can be explored using visualisation and augmented reality. The project will also develop new knowledge by deriving new understanding of pasture and livestock processes through analysis of these high-resolution datasets.

The project team for this research will include the leadership and many of the staff involved in the development and testing of the techniques to be deployed here. These previous efforts included the demonstration and discussion of problems and solutions with landholders at stakeholder workshops, rural field days, agricultural shows and kitchen table sessions with farmers. Stakeholder surveys at rural shows included input from government (local, state, federal), industry (gas, agriculture, related contractors), universities, natural resource managers and technology companies. This broad consultation has enabled the project team to develop techniques, but also to test approaches with key stakeholders.

This project will similarly include close engagement with stakeholders from the agriculture and gas industries using the tools described above and knowledge of environmental risks and their management gathered in previous research.

Resources and collaborations

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Dr Neil Huth	37 days	Farming Systems Research	>25	CSIRO Agriculture and Food
Mr Brett Cocks	45 days	Soil Science and Farmer Engagement	>20	CSIRO Agriculture and Food
Mr Brett Abbott	25 days	Landscape Ecologist (Grazing systems)	>25	CSIRO Land and Water
Dr Xiaoliang Wu	10 days	Image Processing and Spatial Analysis	>25	CSIRO Data61

Subcontractors (clause 9.5(a)(i))	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Stu Adam	10 days	Aerial Survey and Farm Visualisation	<5	Agronomeye

Budget Summary

Source of Cash Contributions	2020/21	2021/22	2022/23	% of Contribution	Total
GISERA	$126,369	$61,003	$0	75%	$187,372
- Federal Government	$115,181	$55,602	$0	68.36%	$170,783
- NT Government	$6,116	$2,953	$0	3.63%	$9,069
- Origin Energy	$2,157	$1,041	$0	1.28%	$3,198
- Santos	$2,157	$1,041	$0	1.28%	$3,198
- Pangaea Resources	$758	$366	$0	0.45%	$1,124
Total Cash Contributions	**$126,369**	**$61,003**	**$0**	**75%**	**$187,372**
Source of In-Kind Contribution	**2020/21**	**2021/22**	**2022/23**	**% of Contribution**	**Total**
CSIRO	$42,123	$20,334	$0	25%	$62,457
Total In-Kind Contribution	**$42,123**	**$20,334**	**$0**	**25%**	**$62,457**

Cultural Monitoring Program

The cultural monitor program is considered mutually beneficial, increases engagement and participation of the local traditional owners and provides additional safeguards against the research proponent or other fieldworkers inadvertently entering into a sacred site or other culturally sensitive area. Cultural monitors are engaged via the NLC whenever a company or operator goes out in the field.
In GISERA projects where CSIRO researchers are being escorted onto leases by company representatives who have organised permit access, those company procedures will apply.

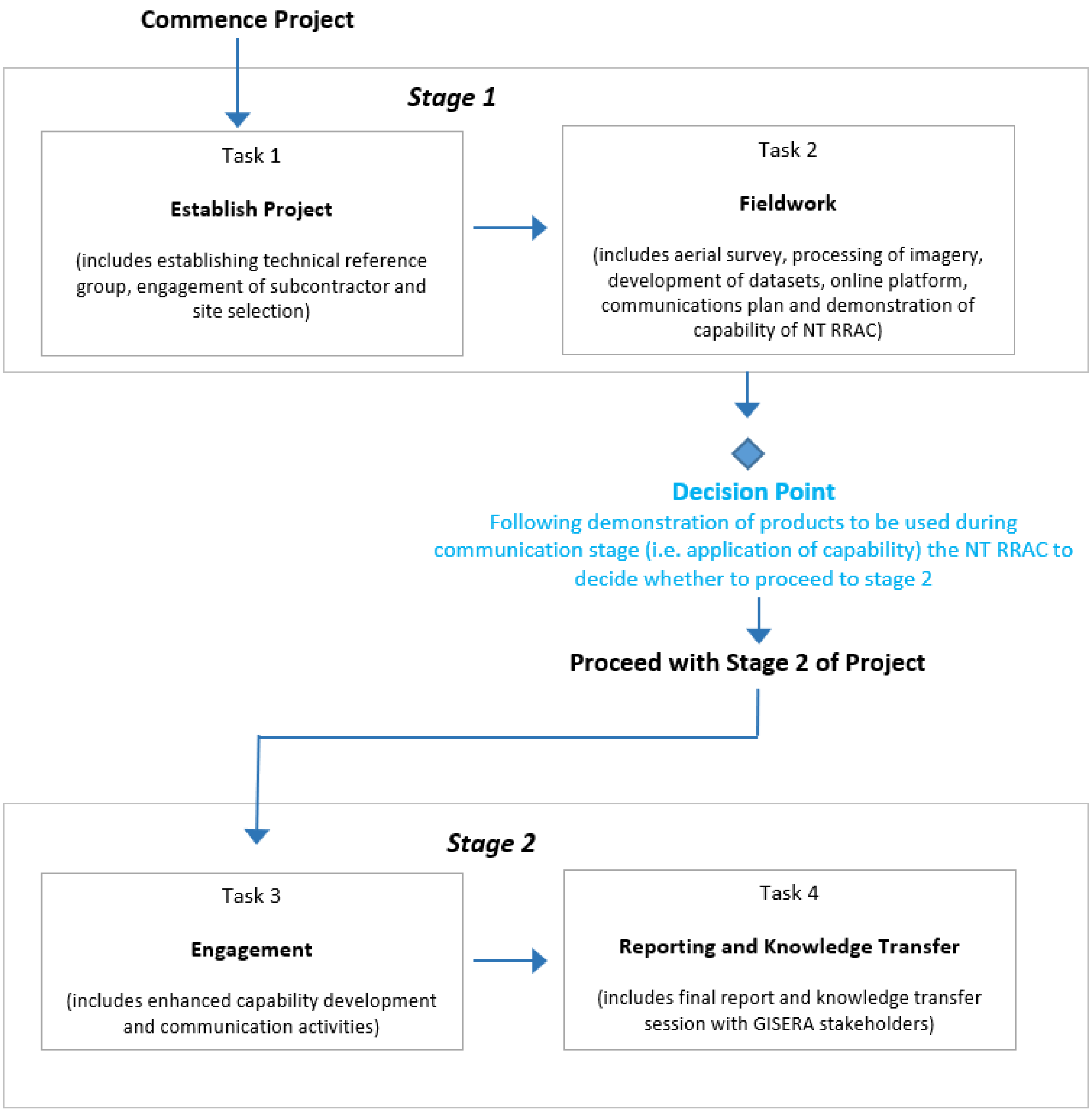
For all other GISERA projects (particularly environmental and social projects) where CSIRO researchers are not being escorted by industry, CSIRO will work with the NLC to apply this practice.

6. Project Impact Pathway

Activities	Outputs	Short term Outcomes	Long term outcomes	Impact
Task 1 1) Initial team meeting 2) Sub-contract 3) Build links with local gas and agricultural industry. 4) Planning	Short progress report outlining outcomes of project meeting and initial engagements with external collaborators	Good working relationship with TRG ensures stakeholder needs are communicated Identification of appropriate case study site provides good foundation for Task 2 and 3.	New knowledge empowers communities to manage current and future issues. Reduced public discontent and improved social licence. Improved industry practice and decision making to maximise benefits and minimise costs. Recommendations of the NT Hydraulic Fracturing Inquiry are enacted with benefits to the community and the environment	Improved land management under coexistence between gas and agriculture Revegetation efforts are successful Wet season water flows are maintained Erosion losses are minimised Improved outcomes for agricultural land holders.
Task 2 1) Aerial survey 2) Processing of imagery 3) Development of spatial datasets 4) Development of on-line platform 5) Development of communication plan	Short progress report outlining outcomes of aerial survey and spatial analyses and plans for communication.	Quality dataset obtained for use in analysis and communications Online platform developed and tested to be fit for purpose. Input from TRG ensures that communication plan will be appropriate for key stakeholder groups		
Task 3 Conduct communications exercises	Communications efforts that allow key stakeholders to gain better understanding of key environmental processes and improve industry best practice. A short report outlining the communications exercises undertaken and some key feedback provided by participants.	Improved understanding of risks and land management options by key stakeholders Improved understanding and support for the work of GISERA in the Northern Territory		

Task 4 To document project and undertake knowledge transfer.	1) A final report 2) Knowledge Transfer to GISERA stakeholders	Lessons from project are documented Stakeholders informed of outcomes GISERA maintains trust from stakeholders through open and transparent communication of its research		

7. Project Plan



Project Schedule

ID	Activities / Task Title (should match activities in impact pathway section)	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Establish Project	Neil Huth	July 2020	Sep 2020	
Task 2	Field Work	Neil Huth	Oct 2020	Mar 2021	Task 1
Task 3	Engagement	Neil Huth	Apr 2021	Sep 2021	Task 2
Task 4	Reporting and Knowledge Transfer	Neil Huth	Oct 2021	Mar 2022	Task 3

Task description

Task 1

TASK NAME: Establish Project

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 3 months (1 July- 30 September 2020)

BACKGROUND: This project team includes staff from multiple business units, scientific disciplines and sites, and an external contractor. Furthermore, this project team will need to establish links with local industry, select case study sites and develop project plans and protocols for project work at remote locations. That being the case, a significant level of communication and organisation is required in establishing the project. A subcontract is required to engage the contractor for digital technologies. Finally, it is critical that the case study location is well chosen to ensure that it is undertaken in an area capturing existing infrastructure development and where future development designated to occur. Furthermore, site selection will need to include input from key stakeholders from the community, gas industry and agriculture and approval by landholders. The technical reference group will play an important role in this process. This will improve impact of work, in particular around communications. Further engagement with NT Department of Environment and Natural Resources will be undertaken to ensure links with ongoing work on soils and pastures within the area of interest. All these efforts are required early in the project in order to allow any aerial surveys prior to the wet season.

TASK OBJECTIVES: 1) Initial team meeting, 2) Sub-contract established with sub-contractor, 3) Build links with local gas and agricultural industry and 4) Planning for aerial survey.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Short progress report outlining outcomes of project meeting and initial engagements with external collaborators.

Task 2

TASK NAME: Field Work

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 5 months (1 October 2020 to 31 March 2021)

BACKGROUND: An aerial survey is required to build the "digital twin" of the chosen case study site. On ground land condition assessments are required for testing of long term spatial layers to be developed from satellite imagery. Information on important soil types is required for communication to stakeholders. A communication plan will be required for efforts to turning "knowledge into practice". The outcomes of this phase will be used to determine continuation to further stages of community engagement and knowledge transfer.

TASK OBJECTIVES: 1) Aerial survey of chosen case study location, 2) Processing of imagery into "digital twin" of the chosen case study location, 3) Development of spatial datasets for erosion risk and grazing land condition, 4) Development of on-line platform to allow stakeholders to immerse themselves in the data, 5) Development of a plan to use the developed capability in communication processes with stakeholders, 6) Demonstration of project capability and approval to continue to final stages of the project.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Short progress report outlining outcomes of aerial survey and spatial analyses and plans for communication. A demonstration of the initially developed capability will be provided through online interaction with the digital twin as an example of methods for communicating environmental issues to stakeholders.

Task 3

TASK NAME: Engagement

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 6 months (1 April to 30 September 2021)

BACKGROUND: This project aims to convert knowledge derived from previous research into improved practice for the design and maintenance of gas development. This phase of the project will take the tools developed using a case study in the region in planned communications exercises with stakeholders. An initial capability will be developed during Task 2 and this will be enhanced further prior to community communications. Engagement with NT Department of Environment and Natural Resources will assist with relevant and consistent messaging with stakeholders.

TASK OBJECTIVES: To conduct communications exercises according to the plan developed in Task 2.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: A short report outlining the communications exercises undertaken and some key feedback provided by participants.

Task 4

TASK NAME: Reporting and Knowledge Transfer

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 6 months (1 October 2021 to 30 March 2022)

BACKGROUND: Information from this project is to be made publicly available after completion of standard CSIRO publication and review processes. Furthermore, all GISERA projects must complete a knowledge transfer process with key external stakeholders to assist in generating impact from research efforts.

TASK OBJECTIVES: To ensure that the information generated by this project is documented and published after thorough CSIRO Internal review, and to assist knowledge transfer via direct communication and discussion of project outcomes.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: 1) A final report documenting project findings, and 2) Knowledge Transfer session communicating results to GISERA stakeholders according to standard GISERA project procedures.

Project Gantt Chart

		2020-21												2021-22								
Task	**Task Description**	**Jul 20**	**Aug 20**	**Sept-20**	**Oct-20**	**Nov-20**	**Dec-20**	**Jan-21**	**Feb-21**	**Mar-21**	**Apr-21**	**May-21**	**Jun-21**	**Jul-21**	**Aug-21**	**Sep-21**	**Oct-21**	**Nov-21**	**Dec-21**	**Jan-22**	**Feb-22**	**Mar-22**
1	Establish Project																					
2	Field Work																					
3	Engagement																					
4	Reporting & Knowledge Transfer																					

8. Technical Reference Group

The Technical Reference Group will need to include stakeholders from the Northern Territory cattle industry, gas industry and government departments. Subject matter experts will be needed for environmental issues (soil, water, vegetation) but also for input on processes for engagement with industry and community.

9. Communications Plan

Stakeholder	**Objective**	**Channel** (e.g. meetings/media/factsheets)	**Timeframe** (Before, during at completion)
Traditional Owner communities	To pursue relations with Traditional Owner communities (via cultural monitors)	Engagement with TO communities – as a wider context as part of CSIRO communications (considered mutually beneficial)	Ongoing
Primary industries, Dependant Sectors, local community and wider public	GISERA seen as trusted source of information by community	Fact Sheets, Demonstrations, Media and selected meetings/presentations Engagement during communications phase (Task 3)	During
Gas Industry	Industry adopts methods for improving land management	Presentation of findings at Knowledge Transfer Session (Task 4) Engagement during communications phase (Task 3)	During At Completion
Government	Advice provided to senior bureaucrats / ministers / policy makers	Presentation of findings at Knowledge Transfer Session (Task 4) Engagement during communications phase (Task 3)	During At Completion

10. Budget Summary

Expenditure	2020/21	2021/22	2022/23	Total
Labour	$120,992	$74,337	$0	$195,329
Operating	$12,500	$7,000	$0	$19,500
Subcontractors	$35,000	$0	$0	$35,000
Total Expenditure	**$168,492**	**$81,337**	**$0**	**$249,829**

Expenditure per Task	2020/21	2021/22	2022/23	Total
Task 1	$37,609	$0	$0	$37,609
Task 2	$81,190	$0	$0	$96,774
Task 3	$49,693	$38,731	$0	$72,840
Task 4	$0	$42,606	$0	$42,606
Total Expenditure	**$168,492**	**$81,337**	**$0**	**$249,829**

Source of Cash Contributions	2020/21	2021/22	2022/23	Total
Federal Government (68.36%)	$115,181	$55,602	$0	$170,783
NT Government (3.63%)	$6,116	$2,953	$0	$9,069
Origin Energy (1.28%)	$2,157	$1,041	$0	$3,198
Santos (1.28%)	$2,157	$1,041	$0	$3,198
Pangaea (0.45%)	$758	$366	$0	$1,124
Total Cash Contributions	**$126,369**	**$61,003**	**$0**	**$187,372**

In-Kind Contributions	2020/21	2021/22	2022/23	Total
CSIRO (25%)	$42,123	$20,334	$0	$62,457
Total In-Kind Contributions	**$42,123**	**$20,334**	**$0**	**$62,457**

	Total funding over all years	Percentage of Total Budget
Federal Government Investment	$170,783	68.36%
NT Government Investment	$9,069	3.63%
Origin Energy	$3,198	1.28%
Santos	$3,198	1.28%
Pangaea Resources	$1,124	0.45%
CSIRO Investment	$62,457	25%
TOTAL	**$249,829**	**100%**

Task	Milestone Number	Milestone Description	Funded by	Start Date (mm-yy)	Delivery Date (mm-yy)	Fiscal Year Completed	Payment $ (excluding CSIRO contribution)
Task 1	1.1	Establish Project	GISERA	Jul-20	Sep-20	20/21	$28,207
Task 2	2.1	Field Work	GISERA	Oct-20	Mar-21	20/21	$60,893
Task 3	3.1	Engagement	GISERA	Apr-21	Sep-21	21/22	$66,318
Task 4	4.1	Reporting and Knowledge Transfer	GISERA	Oct-21	Mar-22	21/22	$31,955

12. References

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2 Variations to Project Order

Changes to research Project Orders are approved by the GISERA Director, acting with authority provided by the GISERA National Research Management Committee, in accordance with the National GISERA Alliance Agreement.

The table below details variations to research Project Order.

Register of changes to Research Project Order

Date	Issue	Action	Authorisation

3 Progress against project milestones

Progress against milestones are approved by the GISERA Director, acting with authority provided by the GISERA National Research Management Committee, in accordance with the National GISERA Alliance Agreement.

Progress against project milestones/tasks is indicated by two methods: Traffic Light Reports and descriptive Project Schedule Reports.

1. Traffic light reports in the Project Schedule Table below show progress using a simple colour code:
    - Green:
        - Milestone fully met according to schedule.
        - Project is expected to continue to deliver according to plan.
        - Milestone payment is approved.
    - Amber:
        - Milestone largely met according to schedule.
        - Project has experienced delays or difficulties that will be overcome by next milestone, enabling project to return to delivery according to plan by next milestone.
        - Milestone payment approved for one amber light.
        - Milestone payment withheld for second of two successive amber lights; project review initiated and undertaken by GISERA Director.
    - Red:
        - Milestone not met according to schedule.
        - Problems in meeting milestone are likely to impact subsequent project delivery, such that revisions to project timing, scope or budget must be considered.
        - Milestone payment is withheld.
        - Project review initiated and undertaken by GISERA Regional Research Advisory Committee.
2. Progress Schedule Reports outline task objectives and outputs and describe, in the 'progress report' section, the means and extent to which progress towards tasks has been made.

Project Schedule Table

ID	Activities / Task Title (should match activities in impact pathway section)	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Establish Project	Neil Huth	July 2020	Sep 2020	
Task 2	Field Work	Neil Huth	Oct 2020	Mar 2021	Task 1
Task 3	Engagement	Neil Huth	Apr 2021	Sep 2021	Task 2
Task 4	Reporting and Knowledge Transfer	Neil Huth	Oct 2021	Mar 2022	Task 3

Project Schedule Report

TASK 1

TASK NAME: Establish Project

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 3 months (1 July- 30 September 2020)

BACKGROUND: This project team includes staff from multiple business units, scientific disciplines and sites, and an external contractor. Furthermore, this project team will need to establish links with local industry, select case study sites and develop project plans and protocols for project work at remote locations. That being the case, a significant level of communication and organisation is required in establishing the project. A subcontract is required to engage the contractor for digital technologies. Finally, it is critical that the case study location is well chosen to ensure that it is undertaken in an area capturing existing infrastructure development and where future development designated to occur. Furthermore, site selection will need to include input from key stakeholders from the community, gas industry and agriculture and approval by landholders. The technical reference group will play an important role in this process. This will improve impact of work, in particular around communications. Further engagement with NT Department of Environment and Natural Resources will be undertaken to ensure links with ongoing work on soils and pastures within the area of interest. All these efforts are required early in the project in order to allow any aerial surveys prior to the wet season.

TASK OBJECTIVES: 1) Initial team meeting, 2) Sub-contract established with sub-contractor, 3) Build links with local gas and agricultural industry and 4) Planning for aerial survey.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Short progress report outlining outcomes of project meeting and initial engagements with external collaborators.

PROGRESS REPORT: This milestone (establish project) is 100% complete.

The Technical Reference Group (TRG) has convened with two members from the gas industry and one member from the NT Department of Environment and Natural Resources. The meeting of the TRG also included two CSIRO staff involved in project management and logistics, and a representative of the sub-contractor involved in the conduct of the aerial survey. The case study location has been chosen and will ensure that the case study is completed in an area with a high probability of development which is suitable for project logistics (e.g. access roads). The exact dimensions of the case study will be finalised just prior to the aerial survey pending final decisions on flight logistics. Longterm data derived from Landsat satellite imagery has been used to evaluate vegetation dynamics for a much larger areas surrounding the proposed case study location to ensure the case study represents much of the variability in vegetation found within the area. The aerial and ground surveys are anticipated to be complete within October 2020.

The sub-contractor agreement with Agronomeye has been executed.

TASK 2

TASK NAME: Field Work

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 5 months (1 October 2020 to 31 March 2021)

BACKGROUND: An aerial survey is required to build the "digital twin" of the chosen case study site. On ground land condition assessments are required for testing of long term spatial layers to be developed from satellite imagery. Information on important soil types is required for communication to stakeholders. A communication plan will be required for efforts to turning "knowledge into practice". The outcomes of this phase will be used to determine continuation to further stages of community engagement and knowledge transfer.

TASK OBJECTIVES: 1) Aerial survey of chosen case study location, 2) Processing of imagery into "digital twin" of the chosen case study location, 3) Development of spatial datasets for erosion risk and grazing land condition, 4) Development of on-line platform to allow stakeholders to immerse themselves in the data, 5) Development of a plan to use the developed capability in communication processes with stakeholders, 6) Demonstration of project capability and approval to continue to final stages of the project.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Short progress report outlining outcomes of aerial survey and spatial analyses and plans for communication. A demonstration of the initially developed capability will be provided through online interaction with the digital twin as an example of methods for communicating environmental issues to stakeholders.

PROGRESS REPORT: This milestone is 100% complete.

Digital Twin

The study area location (near Dunmarra, approximately 60km South West of Daly Waters) was determined following consultation with the project's Technical Reference Group. An aerial survey was then undertaken to derive high resolution vegetation and soil surface elevation maps. The images from the aerial survey were combined with other data to develop a 'digital twin' of the location, where environmental processes for soils, water flows and pastures can be explored.

The digital twin developed for the 16km x 16km case study area within the Beetaloo Basin was acquired at 15cm resolution and processed to provide an ability to explore the region interactively. The digital twin is accessed via a normal internet browser via the third party engaged for the study. The system can be easily navigated via virtual flyover, with various data layers displayed directly over the 3D landscape.

Water Flow Path Predictions

Data from the aerial survey was used to create a 3D model of the soil surface with which a comprehensive analysis was undertaken to provide water flow path predictions. These data have been uploaded into the platform for online visualisation. Data quality issues have impacted on the predictions in some parts of the case study. However, some areas were found to provide suitable data for effective visualisation of water flow paths and catchment processes.

Land Condition Maps

Long term satellite data have been processed for a much larger area of potential gas development within the Beetaloo. On-ground surveys were undertaken at the time of the aerial survey to provide training data for algorithms to predict land condition. A range of land types were chosen within the survey area and, within each, several transects were walked by members of the team documenting the spatial patterns of soil (surface quality and evidence of hydrological behaviour), litter (cover), pasture (cover, biomass and pasture type) and trees (cover and type). Observations were adjusted via calibration data obtained on the day to quantify and adjust predictions for observer biases. These data were then incorporated into the land condition modelling to provide broad-scale land condition maps which also included the case study location. These maps have also been incorporated into the digit twin, allowing users to explore the property, but also to identify areas of high erosion risk where water flows and unprotected soils coincide.

Demonstration Video

A short video has been created to demonstrate the capability of the tools developed for the case study site. The video has been targeted at a general audience, with some basic description of the types of approaches used to generate the datasets. It is hoped that such a video will also be valuable in any future communications activities with various community groups.

The video can be viewed at

https://gisera.csiro.au/project/putting-land-management-knowledge-into-practice/

Communications Plan

The remainder of the project includes two main communications efforts. The first includes community engagement to communicate knowledge and lessons from other gas developments. The second contains the final knowledge transfer process during which the project team will communicate back to the GISERA Stakeholders the lessons from the technology development and community engagement, and provide a final report to document these clearly.

Before proceeding, we note here that this project assumes that lessons from research in other regions will have relevance to the Northern Territory. Whist the climate, environmental conditions, farming and gas developments are indeed different, the lessons chosen to be communicated by the team are likely to remain relevant. Some environmental issues, such as soil protection and erosion processes have already been highlighted as important by the *Scientific Inquiry into Hydraulic Fracturing in the Northern Territory.* Other messages, such as lessons on the importance of good communications, and ways to improve communications between persons from agricultural and non-agricultural backgrounds are likely to be relevant in nearly all developments. Finally, the project team is well practiced in listening to the audience to explore differences when they are raised. Where differences do exist, they can serve as a good discussion-starter for open exploration by all parties within the engagement.

Planning Process

The team will engage with key members of the Technical Reference Group and Research Advisory Committee prior to any community communications efforts to determine the best means to achieve project outcomes. Communications may be impacted by travel limitations due to the COVID-19 pandemic, availability of key stakeholders during different times of the year, availability of high-speed internet at some locations, project resources, large distances for travel for both stakeholders and project staff from Queensland and New South Wales, and the need to work alongside other communications within this area to avoid confusion or maximise effectiveness in messaging. Because of this, a six-month period has been incorporated into the project plan to ensure adequate time for coordinated planning.

Stage Gate Demonstration to NT RRAC

On 10 June 2021, the NT Regional Research Advisory Committee were presented with a demonstration of the application of the technology which resulted in approval for the project proceeding to stage two of project as detailed in the original Project Order.