Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Progress report

Background Seismicity of Beetaloo Sub-basin and Seismic Hazard

Progress against project milestones

Progress against milestones/tasks are approved by the GISERA Director, acting with authority in accordance with the 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 is withheld.
  - 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 by GISERA Director.

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

TASK NUMBER	TASK DESCRIPTION	SCHEDULED START	SCHEDULED FINISH	COMMENT
1	Identification of Potential Seismic Sources	01 July 2022	31 August 2022	Completed
2	Detection and Location of Background Seismicity	01 September 2022	30 June 2024	Completed
3	1st Interim Report	01 September 2022	31 July 2023	Completed
4	Seismic Velocity Model Building	01 July 2022	30 June 2023	Completed
5	2nd Interim Report	01 May 2023	30 December 2023	Completed
6	3D Seismic Wave Simulations	01 August 2023	30 May 2024	Completed
7	Final Report	01 March 2024	30 December 2024	Completed
8	Communicate findings to stakeholders	01 July 2022	30 December 2024	Completed

Project schedule report

TASK 1: Identification of Potential Seismic Sources

BACKGROUND

The identification of existing seismic sources including man-made ones prior to the installation of the network is critical in discrimination in later stages.

TASK OBJECTIVES

Conduct desktop study to identify and map existing seismic sources from legacy data.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Time dependent 2D maps of seismic sources showing the variation historical seismicity. These maps will also indicate the information gap.

PROGRESS REPORT

This milestone is complete now.

-The shapefiles of the locations of the infrastructure road network, petroleum titles, mines (both historical and operating ones) have been obtained from the Northern Territory Geological Survey.
-Historical seismic event information and the current seismic monitoring station locations have been sourced from relevant earthquake catalogues.
-Reproducible python-based 2D mapping scripts have been developed to map this information.
-The mapped spatial information of road network, petroleum licenses and mine locations are assessed as potential source generators with respect to the station locations.

TASK 2: Detection and Location of Background Seismicity

BACKGROUND

Since mid-2021, a six-element passive seismic array is being operated by Geoscience Australia. The collected data from this array is freely open to anyone and contains important information about small magnitude local earthquake activity. However, the modern data processing techniques needs to be applied to extract more from the data. In addition to data from GA array, other datasets from temporary seismic deployments exist as well as operator recorded seismic data as part of hydraulic fracturing operations.

TASK OBJECTIVES

To develop workflows that receive and process seismic data and produce a location and magnitude for each event using the state-of-the-art detection and location algorithms**.**

TASK OUTPUTS AND SPECIFIC DELIVERABLES

a) Retrieve freely available continuous passive seismic data from GA's current seismic array, and other seismic deployments stored at Incorporated Research Institutions for Seismology (IRIS). Obtain continuous passive seismic data from industry as part of hydraulic fracturing operations.

b) Set up and refine triggering algorithms specific to the stations in this study with the aim of capturing magnitude 1.5 events and larger.

c) Automate location and magnitude calculations of seismic activity from the triggered events.

d) Incorporate outputs from Task 4 to refine the depth and magnitude estimates. Consider relocation of historic events using the refined velocity model

e) Produce a listing of the seismic activity details suitable for publication.

f) Estimate the magnitude-frequency distribution of natural earthquake activity.

PROGRESS REPORT

This task is complete. We utilised over three years of continuous passive seismic data, including an additional dataset provided by Geoscience Australia. We have not detected any measurable seismic activity in the region.

TASK 3: 1st Interim Report

BACKGROUND

The desktop study regarding the potential seismic sources aims to determine the location of existing sources and classify them. The workflow for detection and location of earthquakes will process the incoming data from Geoscience Australia's passive seismic network.

TASK OBJECTIVES

Provide a general outline of the potential and historical seismic sources. Provide a preliminary assessment of the workflow's performance about the existing data.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

A detailed report showing the results of the desktop study of seismic sources through maps and digital datasets. Assessment workflow with respect to the already collected data.

PROGRESS REPORT

The report has been finalised and is now publicly available on the website.

TASK 4: Seismic Velocity Model Building

BACKGROUND

Physics based ground motion modelling predicts time series for an expected earthquake (induced & natural) at any point, which is then used in the seismic hazard characterisation. The modelling requires high resolution 3D seismic velocity models as a primary input.

TASK OBJECTIVES

Build a database of open-source seismic reflection/refraction interpretations and borehole data for extracting the general geometry of the geological layers. Conduct passive seismic imaging (P and S-wave velocities) with the current and legacy passive seismic datasets. Construct a hierarchical 3D seismic velocity model as in Guo et. al. (2022) by combining interpretations of reflection datasets, results from passive seismic imaging (new and Chen et al., 2022).

TASK OUTPUTS AND SPECIFIC DELIVERABLES

A 3D seismic velocity model from surface to mid crust with P & S-wave velocities, attenuation, and realistic density values ready to be utilised in Physics Based Ground Motion Simulations (Task 6).

PROGRESS REPORT

This task has been completed by incorporating the model of Chen et al. (2023) and 3D wave simulations have started.

TASK 5: 2nd Interim Report

BACKGROUND

The workflow for detection and location of earthquakes will process the incoming data from Geoscience Australia's passive seismic network. Meanwhile, the Seismic velocity model building activity will create a detailed 3D subsurface model that will be used in refining the earthquake locations, and physics based ground motion modelling.

TASK OBJECTIVES

Provide an update of the detected baseline natural seismic activity in the Beetaloo Basin and completed 3D seismic velocity model.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Examples of detected local seismic activity: location maps, magnitude information. 2D & 3D Visualisation of the seismic velocity model characterising the subsurface.

PROGRESS REPORT

This task has been completed and the report has been sent to GISERA leadership team.

TASK 6: Physics Based Ground Motion Modelling for Seismic Hazard Characterisation

BACKGROUND

Physics based ground motion characterisation is used for predicting the effect of an earthquake due to hydraulic fracturing. These predictions will provide an overview of what kind of ground motions will be felt by the nearby communities and typical peak horizontal ground motions for the infrastructure and provide inputs to the future traffic light management systems.

TASK OBJECTIVES

Estimate the seismic hazard by aggregating the predicted ground motion time series for various earthquake scenarios including different rupture lengths, mechanisms, magnitudes and depths.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Expected peak ground horizontal motions for any realistic earthquake scenarios.

PROGRESS REPORT

This task is now completed.

Note: With the agreement of GISERA Management, this task has been converted into an activity to design future studies to quantify the risk in the Beetaloo Basin.

TASK 7: Project Reporting

BACKGROUND

Information from this project is to be made publicly available after completion of standard CSIRO publication and review processes.

TASK OBJECTIVES

To ensure that the information generated by this project is documented and published after thorough CSIRO Internal review.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

1) Preparation of a final report outlining the scope, methodology, scenarios, assumptions, findings and any suggestions/options for future research including a detailed analysis of the future seismic monitoring needs should production scenarios occur.

2) Following CSIRO ePublish review, the report will be submitted to the GISERA Director for final approval; and

3) Provide 6 monthly progress updates to GISERA office.

PROGRESS REPORT

This final report has been reviewed and has been submitted to GISERA Director. Public release is expected late May 2025.

TASK 8: Communicate project objectives, progress and findings to stakeholders

BACKGROUND

Communications of GISERA research are an important component of outreach and dissemination of findings to diverse audiences.

TASK OBJECTIVES

Communicate project objectives, progress and findings to stakeholders through meetings, knowledge transfer session, factsheet and journal article, in collaboration with GISERA Communications officers.

TASK OUTPUTS AND SPECIFIC DELIVERABLES

Communicate project objectives, progress and results to GISERA stakeholders according to standard GISERA project procedures which may include, but not limited to:

1) Knowledge Transfer session with Government/Gas Industry

2) Presentation of findings to Community members/groups

3) Preparation of article for GISERA newsletter and other media outlets e.g. The Conversation

4) Revision of project factsheet to include final results (a factsheet is developed at project commencement, and another will be done at completion)

5) Peer reviewed scientific manuscript ready for submission to relevant journal

6) Short animation about why there is a need for monitoring of baseline activity.

PROGRESS REPORT

This task is complete.

- A knowledge transfer session was conducted in December 2024 where results were presented to government and industry stakeholders.
- A project fact sheet was developed at commencement of the project and a second fact sheet (based on peer reviewed results) has been prepared with expected release in late-June 2025.
- An article has been prepared for the upcoming GISERA newsletter.

Variations to Project Order

Changes to research Project Orders are approved by the GISERA Director, acting with authority, in accordance with the GISERA Alliance Agreement. Any variations above the GISERA Director's delegation require the approval of the relevant GISERA Research Advisory Committee.

The table below details variations to research Project Order.

Register of changes to Research Project Order

DATE	ISSUE	ACTION	AUTHORISATION
27/10/22	After completion of task 1, the current outputs are not large enough to form an interim report. The first-stage outputs of tasks 1, 2 and 4 will be documented and will then form a better picture of the projects progress.	Milestone 3 extended from October 2022 to February 2023.	
26/06/22	Due to the project leaders personal reasons, milestone 3 and 5 are delayed	Milestone 3 extended from Feb 2023 to July 2023 and Milestone 5 extended from June 2023 to 16th August 2023.	
20/10/23	The project team will need to process a new dataset from Geoscience Australia	Milestone 5 extended from 15 August 2023 to 30 December 2023.	
26/04/24	Delays associated with processing of data	Milestone 2 extended from 31 March to 30 June 2024. Milestone 7 and 8 extended from 30 June to 30 December 2024.	

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GISERA is a collaboration between CSIRO, Commonwealth and state governments and industry established to undertake publicly-reported independent research. The purpose of GISERA is to provide quality assured scientific research and information to communities living in gas development regions focusing on social and environmental topics including: groundwater and surface water, greenhouse gas emissions, biodiversity, land management, the marine environment, and socio-economic impacts. The governance structure for GISERA is designed to provide for and protect research independence and transparency of research.