Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Progress report

Baseline Groundwater and Seismicity of northern Perth Basin

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	Water Level Monitoring – Preprocessing	March 2024	Apr 2024	Complete
2	Water Level Monitoring – Data Analysis	May 2025	Dec 2024	Complete
3	Water Level Monitoring – 4D Mapping of WL Changes	Jan 2025	Dec 2025	
4	Interim Report 1	Jul 2024	Sept 2024	Complete
5	Seismicity-Preprocessing	April 2024	Apr 2024	Complete
6	Seismicity – Event Detection	May 2024	Sept 2024	Complete
7	Seismicity-Initial Event Location	Oct 2024	1 May 2025	Complete
8	Local Velocity Model Integration	April 2025	Jan 2026	
9	Final Estimation of the Locations of Seismic Events and Catalogue Building	Jul 2025	Jan 2026	
10	Interim Report 2	Feb 2025	1 May 2025	Complete.
11	Final Report	Dec 2025	Jan 2026	
12	Communicate project objectives, progress and findings to stakeholders	Mar 24	Jan 2026	

Project schedule report

TASK 1: Water Level Monitoring – Preprocessing

BACKGROUND

A number of steps need to be followed to make the data ready for the next stage of the data analysis.

TASK OBJECTIVES

Removing instrument gain, homogenising the records, removing problematic recordings, and quality control the data.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

A homogenised seismic data collection, ready to be used in the next steps of the 4D seismic imaging.

PROGRESS REPORT

This milestone is complete.

Raw data imported into CSIRO's internal network, data homogenisation, spectral analysis and filtering complete. The data is in general ready for the next step of 4D monitoring.

TASK 2: Water Level Monitoring – Data Analysis

BACKGROUND

For the proposed groundwater depth monitoring with seismic waves, a correlational data processing step is needed to be applied to the homogenised dataset. This step includes auto and cross-correlation of seismic data for short term time windows e.g., hourly for the whole recording duration.

TASK OBJECTIVES

Estimation of hourly seismic velocity changes via auto and cross-correlation of the passive seismic data

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

Temporal velocity change curves for several station pairs and stations. These outputs will be later used for modelling and estimation of water levels.

PROGRESS REPORT

This task is complete.

We finished estimating temporal velocity changes for station pairs and stations in the Perth Basin. These velocity changes, calculated at two-week intervals, were compared with borehole in-situ measurements of groundwater levels. Our analysis revealed an inverse correlation between velocity changes and groundwater level fluctuations.

TASK 3: Water Level Monitoring – 4D Mapping of WL Changes

BACKGROUND

Changes in the seismic velocities measured via auto and cross-correlation of passive seismic data ultimately corresponds to the subsurface physical changes. So far, several studies showed that the largest contribution comes from ground water level fluctuations.

TASK OBJECTIVES

In this step, the team invert the previously computed velocity change curves to map the changes in the subsurface and also perform the physics-based modelling to constrain the depth of the changes from these results. Comparison of results between two regions (black and white rectangles).

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

- 4D seismic velocity images across both networks.
- Water level depths estimated for several months.

PROGRESS REPORT

This task will be completed in December 2025

TASK 4: Interim Report 1

BACKGROUND

This part uses the continuous seismic data from GSWA's WA Array and analyses the ground water level depths and seismic activity in northern Perth Basin.

TASK OBJECTIVES

Provide a general outline of the velocity changes and detected seismic events from the GSWA WA Array.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

A detailed report showing the results of the velocity analyses and detected seismic events using the GSWA WA Array seismic data.

PROGRESS REPORT

This milestone is complete.

A detailed report has been prepared and will be placed on the GISERA website. Using passive seismic data, we found that the seismic velocity is inversely correlated with the groundwater level from November 2022 to December 2023, which highlights the promise of using existing seismometers in Western Australia for monitoring groundwater levels. We also conducted machine-learning based analysis for earthquake detection and phase picking, and found several clusters of earthquakes.

TASK 5: Seismicity - Preprocessing

BACKGROUND

Seismic raw datasets often contain the signature of the measurement setup and also potential data glitches. Before proceeding to actual data processing, these effects need to be removed from the data and a QC analysis needs to be performed.

TASK OBJECTIVES

Application of instrument removal, filtering, and format conversion of the raw records.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

A homogenised seismic data library to be used in the coming steps.

PROGRESS REPORT

This milestone is complete.

As is the case in milestone 1, raw data has been imported into CSIRO's internal network, data homogenisation, spectral analysis and filtering complete. The data is in general ready for the next step of 4D monitoring.

TASK 6: Seismicity – Event Detection

BACKGROUND

It is a well-known fact that, with the deployment of dense seismic arrays, the seismic activity of a region can be mapped with an unprecedented resolution. Several locations that were considered seismically quiet can be found to be active after the operation of dense arrays.

TASK OBJECTIVES

Application of state-of-the-art seismic detection methods to map the seismic activity of the region.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

Time of the detected events, histogram plots (e.g., Activity vs time).

PROGRESS REPORT

This milestone is complete.

Seismicity-event detection has finished. We analysed the recorded seismic data using machine learning and found several clusters of earthquakes, for example, in the Southwest Seismic Zone (SWSZ), located about 150 km to the east of Perth in southwestern Australia and Region in the east and southeast of Wagin.

TASK 7: Seismicity – Initial Event Location

BACKGROUND

After detection of earthquakes or any other activity, it is critical to precisely locate the origin of the activity. However, this requires a precise subsurface model to produce maps of activity with low uncertainty.

TASK OBJECTIVES

Initial estimation of the locations of the earthquakes that were detected previously using the existing velocity models in the region and evaluate the quality of results.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

2D Maps showing the location of earthquakes, a catalogue of events with timing information, spatial coordinates depth estimate and uncertainty.

PROGRESS REPORT

This milestone is complete.

We analysed the detected seismic activity using a regional velocity model to locate seismic events. The location of each event (longitude, latitude, and depth) was estimated through an iterative process, applying multiple methods to progressively refine the hypocentres. Numerous earthquakes were identified, including several distinct clusters of seismic activity. The magnitude of each earthquake was also estimated.

TASK 8: Local Velocity Model Integration

BACKGROUND

In seismic event location and seismic imaging problems, accurate initial subsurface seismic models are crucial for achieving modelling convergence. In this task, the team will not conduct additional studies to create a subsurface model. Instead, the team will utilise the outputs of another GSWA project that will commence simultaneously with this project (subject to final approval).

TASK OBJECTIVES

Improving and utilisation of a model in 4D imaging and seismic locations.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

An improved seismic velocity model to be used in the next steps.

PROGRESS REPORT

This task will be completed January 2026.

TASK 9: Final Estimation of the locations of Seismic Events and Catalogue Building

BACKGROUND

Seismic velocity models play a key role in reducing the spatial uncertainty in the detected and located seismic activity.

TASK OBJECTIVES

Re-run the location algorithm with the new velocity model to improve the accuracy of the seismic event locations.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

A final catalogue of seismic activity will be constructed with uncertainty information.

PROGRESS REPORT

This task will be completed January 2026.

TASK 10: Interim Report 2

BACKGROUND

The passive seismic data from WA Array is analysed systematically to detect ground water changes in an unprecedented temporal and spatial resolution. The same dataset is also used to detect and located any seismic activity in the region.

TASK OBJECTIVES

Provide a summary of the progress seismic event detection-location and preliminary subsurface velocity changes in a clear format.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

A written report, with the spatial information presented with two spatial maps showing velocity changes.

PROGRESS REPORT

The report has been completed, internally reviewed and approved.

We observed seismic velocity changes associated with groundwater level changes in the Northern Perth Basin, which become more pronounced for shallower depths, while data from the outback do not show such pattern. We investigated the feasibility of providing high-resolution spatial maps for velocity changes, but sparse seismometer coverage limited the spatial resolution. We applied a machine learning–based approach for both earthquake detection and phase picking, and discovered several distinct clusters of earthquakes.

TASK 11: Final Report

BACKGROUND

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

TASK OBJECTIVES

A final report with the findings of the discrete analyses, written in a format that will be comprehensible by public as well as the scientific community. Methods, assumptions, limitations, and new insights will be discussed in the report.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

A written report outlining the final results. Also, two GIS layers will be produced (water level changes and seismicity), that will be provided to the team for the other GISERA project – 'Assessment of potential conflicts of subsurface resources development in the North Perth Basin'.

PROGRESS REPORT

This task will be completed January 2026.

TASK 12: Communicate project objectives, progress and findings to stakeholders

BACKGROUND

Communication of GISERA's research is an important component of all research projects. The dissemination of project objectives, key findings and deliverables to relevant and diverse audiences allows discourse and decision making within and across multiple stakeholder groups.

TASK OBJECTIVES

Communicate project objectives, progress and findings to stakeholders through meetings, a Knowledge Transfer Session, fact sheets, project reports and journal article/s, in collaboration with the GISERA Communication Team.

TASK OUTPUTS AND SPECIFIC DELIVERABLES:

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

1. Engagement with an established technical reference group
2. Knowledge Transfer Session with relevant government/gas industry representatives.
3. Presentation of findings to community stakeholders such as identified business and/or community groups in a workshop (virtual or face-to-face).
4. Preparation of an article for the GISERA newsletter and other media outlets as advised by GISERA's communication team.
5. Two project fact sheets: one developed at the commencement of the project, and another that will include peer-reviewed results and implications at completion of the project. Both will be hosted on the GISERA website.
6. Peer-reviewed scientific manuscript ready for submission to relevant journal.

PROGRESS REPORT

This task will be completed January 2026.

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
10/08/2024	Delay due to access to full data set only provided on 22 June 2024, sufficient time is required to review and interpret data.	Milestone 4 extended from July 2024 to September 2024.	

DATE	ISSUE	ACTION	AUTHORISATION
25/02/25	Delay due to final update on phase 1 and phase 2 being received, additional time is required to complete quality control of updated data and subsequent processing.	Milestone 7 extended from 31 March 2025 to 1 May, Milestone 10 extended from 1 March 2025 to 1 May 2025	

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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.