



Australia's National  
Science Agency

**GISERA** | Gas Industry Social and Environmental Research Alliance

# Progress report

Geochemical modelling and geophysical surveys to refine understanding of connectivity between coal seams and aquifers



**QGC**



**Santos**



Australian Government  
Department of Industry, Science,  
Energy and Resources



Supported by  
**Government of  
South Australia**



# 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           | Hydrochemical baseline sampling (water)                   | Jul 2022        | Dec 2022         | Completed |
| 2           | Geochemical baseline characterisation (rocks)             | Jul 2022        | Mar 2023         | Completed |
| 3           | Airborne electromagnetic (AEM) survey                     | Jul 2022        | Sept 2023        |           |
| 4           | Analysis of groundwater samples for environmental tracers | Sept 2022       | Sept 2023        |           |
| 5           | Geochemical modelling to test conceptual models           | Jul 2023        | Jan 2024         |           |
| 6           | Data integration and refinement of conceptual models      | Oct 2023        | Mar 2024         |           |
| 7           | Project reporting                                         | Jul 2022        | Jun 2024         |           |
| 8           | Communicate findings to stakeholders                      | Jul 2022        | Jun 2024         |           |

## Project schedule report

### TASK 1: Hydrochemical baseline sampling (water)

#### BACKGROUND

A previous GISERA project ('Assessment of faults as potential hydraulic seal bypasses in the Pilliga Forest area, NSW'; Raiber et al., 2022) identified multiple potential hydrogeological connectivity pathways between the Gunnedah Basin (containing the targeted CSG formations) and the Surat Basin (including the Pilliga Sandstone, the major Great Artesian Basin aquifer in this region) (Figure 1).

The study showed that there is a distinct change in hydrochemistry from east to west and north-west within the Pilliga Sandstone in the NGP area. The interpretation of the observed patterns was that there is no or only limited connectivity between the Gunnedah Basin (including coal seams) and Surat Basin in the south and east of the NGP area. However, in some of the areas where there may be some connectivity, there remains significant ambiguity in the interpretations due to the lack of hydrochemistry and environmental tracer data from Gunnedah Basin strata and the Purlawaugh Formation, the deepest formation of the Surat Basin which directly underlies the Pilliga Sandstone.

To close these knowledge gaps, additional water samples from the Purlawaugh Formation and from shallow Gunnedah Basin hydrostratigraphic units (e.g. Digby Formation and Napperby

Formation and Hoskissons coal seam) are required, thus providing critical pre-CSG development data and reduce the uncertainty of geochemical mixing models.

NSW DPIE have installed multi-level monitoring wells (screening different formations at the same site) throughout the region over the last few years (mostly drilled between 2019 to 2020) as part of its NSW Coal Basins water monitoring strategy (NSW DPIE, 2019), with many of the bores screened within the formations inferred to interact with the Pilliga Sandstone where there is a current lack of baseline data (Figure 2). However, so far, only basic water chemistry parameters have been analysed on groundwater samples collected from these bores. This new monitoring bore network provides an excellent opportunity to collect more baseline chemistry and tracer data prior to CSG development and close the knowledge gaps identified by Raiber et al. (2022).

## **TASK OBJECTIVES**

Groundwater samples will be collected from at least 15 groundwater monitoring bores for a comprehensive set of hydrochemical and isotopic tracers (e.g. stable noble gases such as He, Ne, Ar, Kr, Xe,  $^{222}\text{Rn}$ , dissolved methane (concentrations and isotopes), major and minor ion hydrochemistry, stable isotopes of water and strontium, tritium, carbon-14 and  $^{36}\text{Cl}$ ). Sampling sites will include primarily the new NSW DPIE groundwater monitoring bores in the Narrabri region (Figure 2), although samples from selected alluvial groundwater monitoring bores within the vicinity of the NGP area may also be collected.

## **TASK OUTPUTS AND SPECIFIC DELIVERABLES**

Collection of groundwater samples for a wide range of parameters from NSW DPIE groundwater monitoring bores and selected alluvial bores, and shipment of samples to laboratories (samples will be analysed at a wide range of laboratories in Australia and overseas (e.g. United States of America and New Zealand)).

## **PROGRESS REPORT**

This milestone is complete.

As of March 23/3/2023, as part of three sampling campaigns to the Narrabri region, we have completed collection of samples of 15 groundwater bores which are part of the NSW coal basins monitoring bore network (<https://www.industry.nsw.gov.au/water/science/groundwater-archive/managing-impacts-from-coal-mining-and-coal-seam-gas/water-monitoring-strategy-nsw-coal-basins>) and from Santos monitoring bores within the proposed Narrabri Gas Project area.

We have collected samples for a very wide range of hydrochemical and environmental tracer parameters from these bores. With the collection of these 15 samples, this milestone is complete (although we may collect some additional samples to further enhance the baseline dataset should the opportunity arise at a later stage).

## **TASK 2: Geochemical baseline characterisation (rocks)**

### **BACKGROUND**

A previous GISERA project ('Assessment of faults as potential hydraulic seal bypasses in the Pilliga Forest area, NSW'; Raiber et al., 2022) demonstrated that there is likely some groundwater mixing between the major GAB aquifer (Pilliga Sandstone) in the Narrabri region and underlying formations (and possibly also with the overlying Orallo Formation) in the north and north-western part of the NGP area. However, the assessment also showed that other hydrochemical processes

(e.g., mineral dissolution and ion exchange) may also proceed in parallel and confirmed that with the currently available data, it is not possible to remove the ambiguity.

To further understand and quantify the relative significance of inter-aquifer mixing between coal seams (and more broadly, Gunnedah Basin formations) and aquifers (e.g. Pilliga Sandstone and alluvial aquifers) and hydrogeochemical evolution from rock-water interactions, analyses of existing core samples (readily available from the NSW core library) from selected bores screened within key formations (e.g. Pilliga Sandstone, Purlawaugh Formation, Digby Formation and Early and Late Permian coal seams) for  $^{87}\text{Sr}/^{86}\text{Sr}$  and mineral assemblage (i.e. the presence and relative quantities of rock-forming minerals) are critical. The assessment of the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of both rocks and groundwater has proven to be very useful to determine connection of aquifers in the Surat Basin in Qld (Raiber et al., 2019)

Furthermore, the study by Raiber et al. (2022) (and other previous studies) highlighted the significance of igneous intrusion in this area. This suggested that in addition to faults, igneous intrusions such as dykes (dykes are igneous intrusive bodies that are often near-vertical and cross-cut (intrude into) horizontal sedimentary formations along pre-existing faults or fractures) and sills can also form potential hydrogeological connectivity pathways in the wider Narrabri Gas Project area.

It is very important to understand the timing when these igneous intrusions have occurred, as this will allow to refine the understanding on the structural history of the wider NGP area and help to determine whether the intrusions are present only within deeper formations or whether they are likely to intersect Gunnedah and Surat basins strata (thus, forming a potential connectivity pathway from the Gunnedah Basin to the Surat Basin).

## **TASK OBJECTIVES**

This task is complete.

The objective of this task is to provide baseline geochemistry data on the Pilliga Sandstone and under- and overlying formations (e.g., Purlawaugh Formation, Orallo Formation and Gunnedah Basin strata). When assessing connectivity between aquifers using geochemical modelling, it is important to characterise the different end members (e.g., the geochemistry of the rock and the hydrochemistry of different aquifers). To date, no such assessment has been conducted within the Narrabri region (or data are not publicly available). This assessment will include:

- analysis of 15 to 20 samples from different formations for their rock mineralogical assemblage using X-ray diffraction (XRD) and X-ray fluorescence (XRF).
- analysis of the  $^{87}\text{Sr}/^{86}\text{Sr}$  ratio of selected rock samples (15 to 20 samples) from different stratigraphic formations.
- analysis of the age of selected samples (approximately five samples) from intrusive rocks to determine the timing of emplacement of the intrusions.

An initial screening confirmed that suitable samples are held by the NSW core library, and communication with the core library confirmed that these samples are readily available for collection and analysis.

## **TASK OUTPUTS AND SPECIFIC DELIVERABLES**

This task will provide a comprehensive understanding of the geochemical composition and isotopic signature of the Pilliga Sandstone as well as under- and overlying formations within the

wider NGP area. The outputs will form a critical component of Task 5, representing the rock end member within the geochemical modelling.

**PROGRESS REPORT**

This milestone is complete. We have collected and analysed several samples (sixteen).

We have had 3 visits to the NSW core library and have collected samples from 31 depth intervals of Surat and Gunnedah Basin strata and from 17 igneous intrusions, providing a detailed overview on the spatial variability of the geochemical composition and the age and timing of intrusive activity in this region.

We have received analytical results for <sup>87</sup>Sr/<sup>86</sup>Sr of whole-rock analysis and for partly digested samples, and results of analyses for geochemical characterisation of the rocks (XRD, XRF and trace elements). We have received results for analysis of the rock age.

**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                                                                         |
|----------|---------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------|
| 15/03/23 | Following consultation with the various stakeholders the project team have requested to extend and add lines to the AEM survey. | An additional \$80,000 (\$61,696 GISERA funding and \$18,304 CSIRO funding) is allocated to complete this project taking the overall budget from \$1,044,719 to \$1,124,719. |  |

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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.