Australia's National
Science Agency

GISERA | Gas Industry Social and Environmental Research Alliance

Project Order

Short Project Title

Analysis of Dust Near CSG Sites to Assess Potential for Respirable Crystalline Silica

Long Project Title	Analysis of Dust Samples in the Vicinity of Coal Seam Gas (CSG) Operations in the Surat Basin, Queensland, To Assess Potential Presence and Distribution of Respirable Crystalline Silica
GISERA Project Number	H.4
Start Date	06/02/2023
End Date	06/02/2025
Project Leader	Chad Hargrave

GISERA State/Territory

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

Basin(s)

- ☐ Adavale
- ☐ Amadeus
- ☐ Beetaloo
- ☐ Canning
- ☐ Western Australia
- ☐ Carnarvon
- ☐ Clarence-Morton
- ☐ Cooper
- ☐ Eromanga
- ☐ Galilee
- ☐ Gippsland
- ☐ Gloucester
- ☐ Gunnedah
- ☐ Maryborough
- ☐ McArthur
- ☐ North Bowen
- ☐ Otway
- ☐ Perth
- ☐ South Nicholson
- ☒ **Surat**
- ☐ Other (please specify)

GISERA Research Program

- ☐ Water Research
- ☒ **Health Research**
- ☐ Biodiversity Research
- ☐ Social & Economic Research
- ☐ Greenhouse Gas Research
- ☐ Agricultural Land Management Research
- ☐ Land and Infrastructure Management Research
- ☐ Other (please specify)

1. Project Summary

Airborne dust can be generated at all stages of coal seam gas (CSG) operations, including site construction, drilling, well development, production and (where used) the injection of hydraulic fracturing fluid. In many cases sand and other products are added to drilling and hydraulic fracturing fluid[1] and it is possible that these additives may also contribute a proportion of material to process-generated dust. In addition to direct processes, there is also the potential for dust to be generated from dried deposits of sediment generated by CSG operations.

CSIRO's GISERA H.2 Project –*Identification and screening for potential human health effects of coal seam gas (CSG) activity in the southern Surat Basin, Queensland* identified respirable crystalline silica (RCS) as a substance that warranted further assessment for its potential risk to human health in the study area. Crystalline silica (c-silica) in the form of quartz is one of the most abundant minerals in the Earth's crust and is a natural, albeit minor, component of background dust. It is also present in clays, shale and sandstone and thus is encountered during CSG operations. Respirable dust particles are those capable of entering the human respiratory system and penetrating deep into the lungs: they are defined as particles less than 10 µm in diameter, or PM10 particles[2]. Thus, to assess the potential risk associated with respirable crystalline silica, it is important to not only quantify the total amount of c-silica in dust samples but also the proportion which is present in size distributions that correspond to the respirable range, resulting in respirable c-silica or RCS. There is the potential for coal seam gas operations to alter the amount of RCS present in dust through its generation by drilling or the use of silica-containing materials. It is further possible that RCS from these sources could accumulate in sediments in water treatment infrastructure, which could be released as dust as the sediment ponds dry out.

This project will assess the potential risk posed by respirable crystalline silica (RCS) by investigating the current composition of dust and the size distributions of the different constituents in the study area to determine the abundance of respirable crystalline silica (RCS). These results will be compared against samples collected at the same time from reference sites which are not impacted by the CSG operation. The various potential sources for c-silica in dust related to coal seam gas operations (construction, drilling, hydraulic fluid additives, etc.) will be evaluated for their potential to change the composition of RCS in dust over time. The risks to human health will be assessed using the composition data gathered and predictions for any changes in composition over time.

[1] https://geology.com/articles/frac-sand/

[2] https://www.qld.gov.au/environment/management/monitoring/air/air-pollution/pollutants/particles

2. Project description

Introduction

In response to community concerns about potential human health risks from CSG activities, CSIRO's GISERA conducted the GISERA H.1 project—*Human Health effects of Coal Seam Gas—Designing a Study Framework* (Keywood et al., 2018) to develop a robust approach to conducting research into possible health effects associated with CSG activities. The scoping, identification and screening stages of the framework developed in that project were applied in the GISERA H.2 Project *Identification and screening for potential human health effects of coal seam gas (CSG) activity in the southern Surat Basin, Queensland*. The H.2 project investigated a range of factors associated with CSG activities including chemical factors found in additives used in drilling or hydraulic fracturing, produced water and air emissions and physical factors including noise, light and dust. The aim of the project was to identify any factors that warranted further assessment.

The H.2 project identified and appraised 97 unique chemical factors from 140 drilling or hydraulic fracturing additives. At the end of this process, 25 chemicals were found to warrant further assessment as they were either appraised to be Chemicals of Potential Concern (COPC) or there were knowledge gaps that meant a complete appraisal was not possible. This project will progress the assessment on respirable crystalline silica (RCS), a group of three unique chemicals, which are the chemicals associated with dust/atmospheric pathways. A companion CSIRO GISERA project (*Human health risks associated with chemicals used in the coal seam gas industry*) will assess the other seven chemicals associated with soil and water.

Crystalline silica (c-silica, CAS RN 14808-60-7)[3], primarily as quartz, is one of the main components of the earth's crust. It is present in the quartz sand added to hydraulic fracturing fluids used in a minority of wells in the study area and is also found in very small amounts as an impurity in mineral-based drilling additives that are widely used in the study area. Respirable crystalline silica (RCS) refers to particles of c-silica less than 10 micrometres (µm) in diameter, a size distribution which constitutes a very small component of sand. To summarise, the following definitions will be used throughout:

- Elemental Silicon (Si) designates identified silicon in any form
- Crystalline Silica (c-silica) designates SiO_2 of any size distribution
- Respirable Crystalline Silica (RCS) designates c-silica particles smaller than 10 µm

[3] The H.2 project also identified two other polymorphs of c-silica, christabolite (CAS RN 14464-46-1) and tridymite (CAS RN 15468-32-3) may be present in trace amounts in some drilling additives. They are included as unique chemicals, however they are all forms of c-silica that have distinct crystal structures.

Respirable c-silica was progressed to the status of a COPC as it is known to be toxic to humans; while there is no evidence that exposure levels to the public in the study area are of any concern, the lack of available data warrants further investigation. Further assessment is warranted to determine current and future RCS levels in dust within the study area. Occupational exposure to RCS in dust is known to cause lung diseases (silicosis or silico-tuberculosis) and increases the risk of tuberculosis, non-malignant renal disease and autoimmune diseases[4] [5]. The general population can also be exposed to respirable c-silica through dust. Adverse effects of inhaled silica have not been linked to exposure of low levels in the environment or particles above respirable size and there are no known cases of respiratory disease due to c-silica reported in the region to date.

Airborne dust is an aerosol (a suspension of particles in a gaseous medium) consisting of fine, solid particulate matter[6]. It consists of a wide range of constituent materials which can include organic material, salts, plastics, rubber, coal, fly ash, silica and various other minerals[7]. The relative abundance of different materials in airborne dust is affected by a wide range of factors including weather patterns, vehicular traffic, agriculture and local industrial operations.

Dust samples can be collected using scientific devices such as Dustfall Deposition gauges, High Volume Air Samplers (HVAS) or low volume air samplers (Figure 1). The dust deposition gauges collect the particulates which fall into the funnel at the top of the bottle and then passes into the glass bottle. The data is generally collected over a specified time period, and the results are reported as grams of dust per cubic metre (g/m^3) per time period. This sampling method provides comparative information of the relative dustiness of different sampling sites. HVAS collect the particulates which are deposited on a pre-weighed filter paper whilst a known volumed of air is drawn through the sampler, generally for 24 hours. These samplers can be configured with different inlet heads so that all particles (Total Suspended Particulates (TSP)), particles less than 10 microns (PM10) or particles less than 2.5 microns (PM2.5) are collected on the filter paper. At the completion of the sampling period the filter paper is then reweighed and the particulates are reported as mg of dust/m^3 of air.

Samples can also be collected using low volume air samples which draw ambient air through the sample and deposit the particulates onto a filter paper for subsequent removal. These samplers provide real time size distribution of the entire sample and the sample collected on the filter paper can be prepared for microscopy analysis to obtain size distribution information for the different constituents, including RCS.

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[4] https://www.healthdirect.gov.au/silicosis

[5] "Silica and the Lung" (March, 2020) Workplace Health and Safety, Queensland Government, sourced at https://www.worksafe.qld.gov.au/__data/assets/pdf_file/0021/17238/silica-lung-factsheet.pdf

[6] ISO 4225, 1994.

[7] O'Brien, Graham et al. "Obtaining Quantitative Information of the Coal and Non-coal Dust Particulates near Coal Mines and Ports," ENCO 2019, New Delhi (2019).

Samples may also be collected using a paint brush and dustpan to remove the dust which has been deposited in places such as on verandas, roofs, or cars. Many of the samples supplied by local community members have been collected in this manner. The analysis of these samples can provide information of the type of particles which are present but do not provide quantitative information about dust deposition rates or the proportion of dust present in a nominated volume of air.

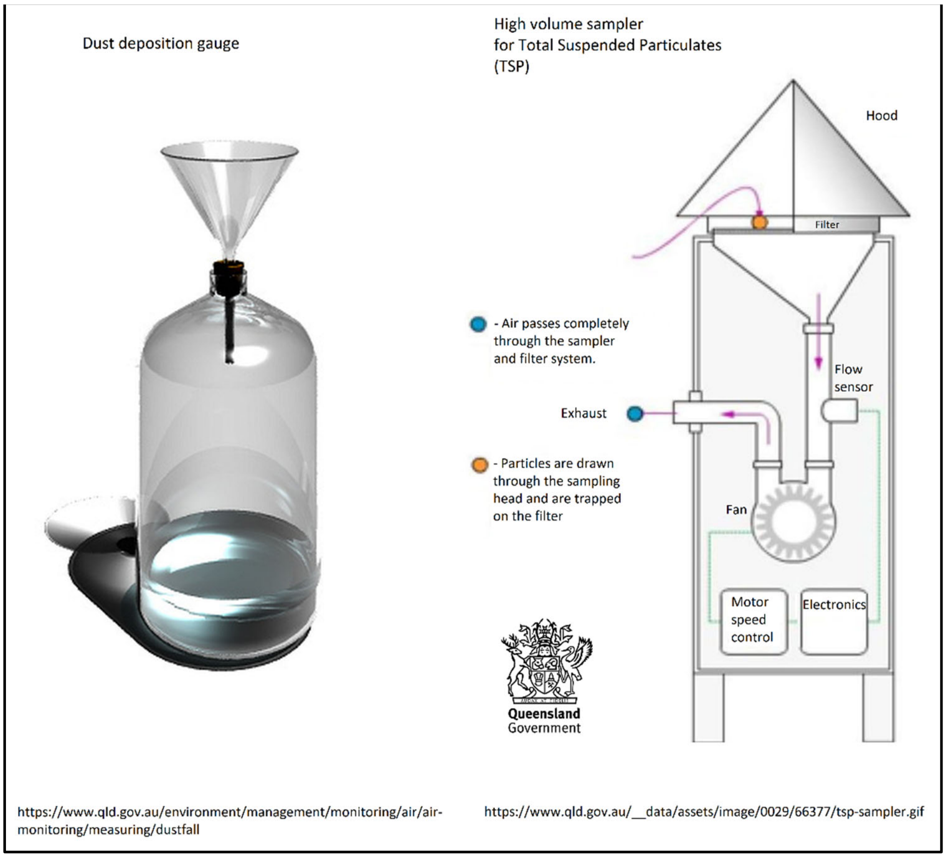

Figure 1 Different types of equipment used to collect dust samples

Once collected there are a number of chemical and microscopic methods which can be used to obtain qualitative and quantitative information on the makeup of dust. Optical reflected light microscopy is one method which provides quantitative information for the different types of material present in these samples. With this method the collected dust sample is mixed with a polyester resin and the set block is then cut and polished to a mirror finish. When prepared in this manner cross sections of the different types of particles can be viewed and analysed using proprietary software (Figure 2)[8].

[8] O'Brien, Graham et al. "Obtaining Quantitative Information of the Coal and Non-coal Dust Particulates near Coal Mines and Ports," ENCO 2019, New Delhi (2019).

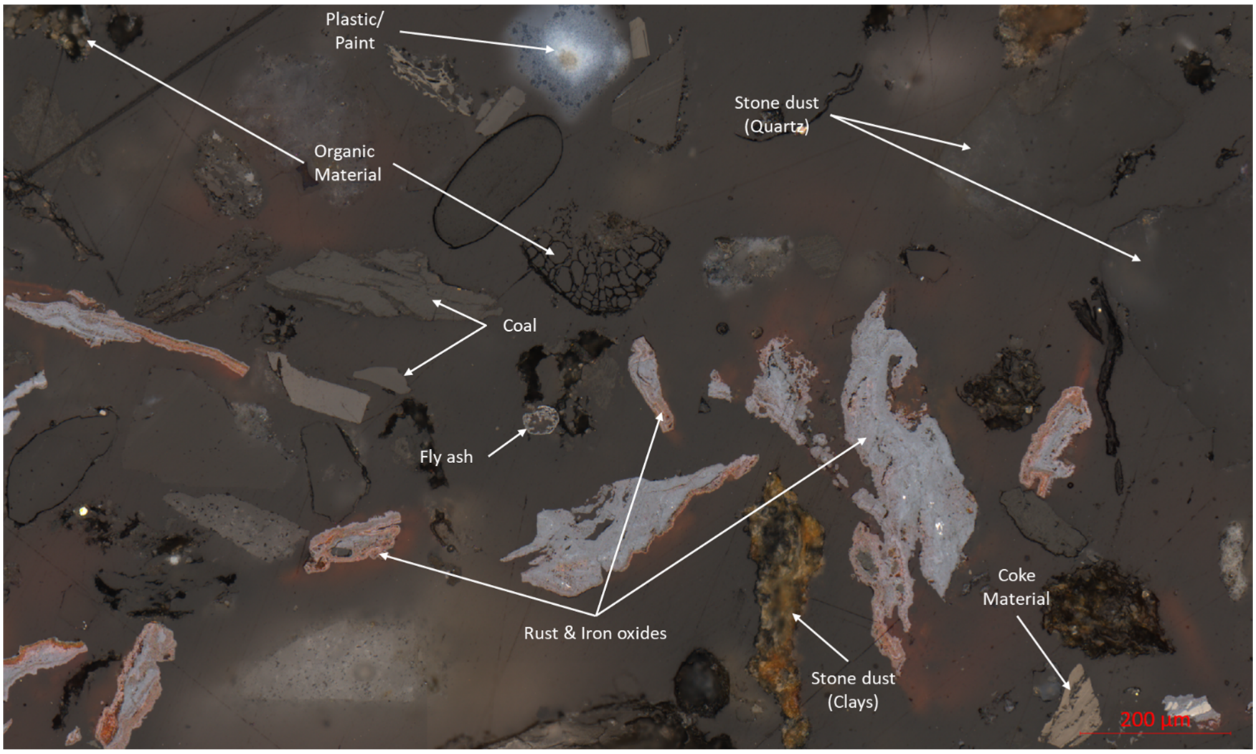

Figure 2 Example particles identified and quantified in an urban dust sample

The health risks associated with the inhalation of RCS are well documented. To establish whether or not there is a substantial risk to CSG workers and the local communities, the degree of exposure to aerosolised RCS must be established. There are no general environmental exposure limits for RCS, however the occupational exposure limit in Queensland is 0.05 mg/m^3 8-hour time weighted average. For all airborne particulate matter, the general environmental PM_{10} (sub-10 µm particles) exposure guideline in Queensland is 0.10 mg/m^3 (1hr avg) and 0.05 mg/m^3 (24hr avg).

Prior Research

Previous GISERA projects have provided key information related to the ambient concentrations, composition and sources of airborne particulate matter (PM):

- Ambient Air Quality Monitoring in the Surat Basin 2014 – 2018 (Lawson et al 2018) Available: https://gisera.csiro.au/project/ambient-air-quality-in-the-surat-basin/
- Measurements of Air Quality at Hydraulic Fracturing Sites in the Surat Basin (Dunne et al 2020) Available: https://gisera.csiro.au/wp-content/uploads/2020/04/Water-12-Milestone-3-report_final.pdf

While the air quality monitoring network was initially established by CSIRO's GISERA as part of the Surat Basin Ambient Air Quality Monitoring study, since August 2016 the data has been streamed to the Queensland Department of Environment and Science (DES) website under South West Queensland region available: https://apps.des.qld.gov.au/air-quality/.

Summary of Key Findings from GISERA projects

The National Environment Protection (Ambient Air Quality) Measure (NEPC 2021) prescribes objectives for monitoring and reporting of ambient concentrations of 7 criteria air pollutants including particulate matter (PM) with diameters less than 10 µm (PM10) and 2.5 µm (PM2.5).

The 24 h NEPM objective for PM10 is 50 ug/m3. Typical PM10 mass concentrations of 5 – 45 ug/m3 were reported from ambient monitoring at 5 sites over the period 2015 - 2019 with maximum levels as high as 550 ug /m3. The most common cause of exceedances of the NEPM objectives were associated with PM10 events many of which were attributable to CSG activities such as vehicle movements and construction along with other activities and sources typical of rural areas (farming, road-dust, windblown soil).

The sources and composition of PM10 during well development activities which utilise silica additives were examined in more detail in the hydraulic fracturing study (Dunne et al 2020). The chemical composition of ~3 months of PM10 sampling were statistically analysed to identify the factors contributing to PM10 mass collected on the samples. Nine factors that contributed to PM10 concentrations were identified the largest of which was soil dust.

At the elemental level Silicon (Si) was identified as a major contributor to PM10 composition in the samples collected at the site, however not all elemental Silicon will be due to c-silica. An average 24 h concentration of 3 ug/m3 with a maximum of 22 ug/ m3 was reported from the ~3 months of sampling during drilling and hydraulic fracturing activities at the site. The concentrations of Si were highly correlated (R2 > 0.96) with known soil markers aluminium and titanium oxides, and their ratios to Si were typical of soil dust (Lide 1997). These data suggest that a significant proportion of the Si present in samples may be due to background sources, however establishing the contribution of CSG-generated c-silica will require a characterisation technology that can identify the various components of dust samples and provide accurate size distribution information for each component. The proposed research campaign will provide this direct evidence of the prevalence and size distribution of liberated (i.e., non-chemically bound) c-silica by comparing the results of dust samples acquired in the vicinity of CSG operations to samples acquired away from the CSG sites. The study will not, however, address any potential vectors whereby RCS particles identified in the environment may be introduced into human lungs.

Urban dust studies

An ongoing challenge for researchers and commercial laboratories undertaking dust analysis testing is that the analysis results can be closely scrutinised and the findings questioned by scientists, residents and community groups. An effective engagement method for presenting results is to provide, in addition to statistical results, the raw optical images (such as shown in Figure 2) in which the individual particles can be identified.

The image shown in Figure 2 was collected with CSIRO's Component Characterisation Imaging System (CCIS) which uses Component Grain Analysis (CGA) techniques. This system captures a large number of contiguous, very high-resolution images of a particulate block and stiches them together without reducing image quality. The resolution obtained in these images allows for clear identification of the dust particles > 1µm in size. This system has been used successfully to undertake studies around coal ports in NSW and QLD, and for an opencut coal mine in NSW (O'Brien et al., 2021, Improved Precision of Determining Coal in Urban Dust, ACPS, 18^{th} Australian Coal Preparation Conference, pp 144-159).

Image Viewing Software has been developed which allows results for dust analyses to be uploaded to dedicated servers and viewed by interested parties via the internet. This software provides the size and composition information for each individual particle, and the amount and composition of the material in the nuisance (+10 µm) and respirable (-10 µm) size fractions. Hyperlinks to the dust results uploaded into the image viewer dynamically demonstrate how the image viewer is able to be used to obtain detail for every particle in the sample together with summary information for the different particulates in each of the different size fractions (Table 1).

Table 1. Results of dust analyses shown in the web-based Image Viewer

Sample	Link to the Image Viewer	QR-code
1	https://cloudimaging.csiro.au/Sample/Viewer/bd54f52c-3949-4552-b5d8-6a69e07c5145	
2	https://cloudimaging.csiro.au/Sample/Viewer/5c626df8-d893-432f-bb29-d029b73f4f37	
3	https://cloudimaging.csiro.au/Sample/Viewer/e2e0ee06-77f2-4e09-b201-38d181aac17c	

An advantage of using this software to report results is that it is possible for any part of the image to be transformed from the unprocessed stage to the processed stage, and back again. This feature enables the analysis, which was undertaken by CSIRO, to be separately interrogated, and to verify, for example, that all coal particles in the sample have been accurately classified. The data is also summarised in a family of charts which provides compositional information for each size fraction.

This has proven to be a very effective method for the reporting of results to clients and where appropriate to the general community.

Need & Scope

The GISERA H2 project identified that RCS in dust warrants further assessment. This project progresses that assessment on the potential human health risk presented by respirable crystalline silica within the GISERA H.2 project study area.

Objective

This project's objectives are to:

- Characterise the composition of dust in the study area, with a particular emphasis on RCS, across a full year to capture seasonal variations. This characterisation will include:
    - Composition of dust by size fraction,
    - Seasonal variations and impacts of prevailing weather conditions,
    - Comparison with a control site without CSG activities.
- Model future contributions to RCS in dust from CSG operations
    - Sediment ponds as accumulators of fine material,
    - RCS in additives.
- Compare with national and international standards (where they exist) for environmental exposure to RCS in dust.

Methodology

- Preliminary sample study. One month sampling process at two sites (one background, one in proximity to CSG site). Sample preparation. Sample image acquisition. Image analysis. Brief report. Results also provided by CSIRO online image viewing software.
- Over a 15-month period collect and analyse dust samples routinely (i.e., one sample a month) from a minimum of five locations in the Surat Basin using Dust Deposition gauges. Additional samples collected by local landholders may also be analysed.

- Over a 15-month period acquire sediment samples at three-monthly intervals from CSG settling ponds and nearby areas (note sample size limitation of 100 g).
- Each dust sample will be analysed using optical and SEM microscopy methods to provide abundance and size distribution on the water insoluble particulates and information and the water-soluble constituents (salts). In addition (where sufficient sample volume has been obtained) traditional chemistry methods (XRF and XRD), and Laser induced Breakdown Spectroscopy (LIBS) will be employed to provide additional chemical and elemental data for analysis.

- Each sediment sample will be analysed using traditional chemistry methods (XRF and XRD), optical and SEM microscopy methods and Laser induced Breakdown Spectroscopy (LIBS) to investigate whether the sediment samples contain elevated amounts of free c-silica grains.

Samples will be collected by an external contractor from the selected sites on a monthly basis and supplied to CSIRO Pullenvale Laboratory. Additional samples, if any (up to 10 samples in total), collected by local stakeholders can also be sent to CSIRO Pullenvale laboratory. Communicating the capacity for these independently collected samples to the public will be coordinated with the CSIRO's GISERA Communications Team to ensure suitable messaging of this option. Figure 3 provides detail of CSG sites in the Surat Basin. In consultation with project monitors sample sites upwind and downwind of CSG operations will be selected in order to provide a spatially diverse analysis.

Sediment samples from up to two settling ponds will be acquired on a quarterly basis throughout the project.

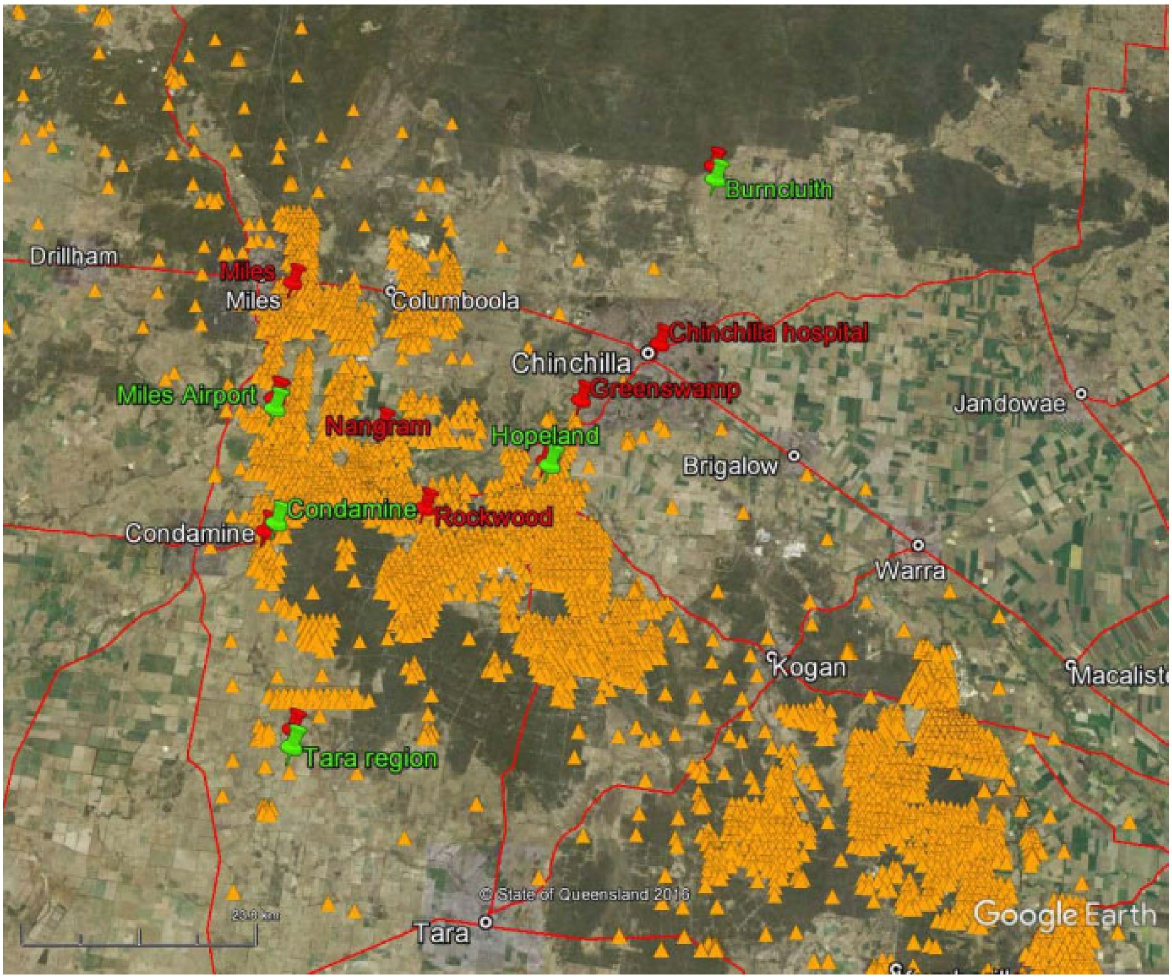

Figure 3: CSG sites in the Surat Basin

The samples will be collected using dust deposition gauges as this method will provide sufficient material for the detailed chemistry and optical microscopy analyses.

Sampling

Dust deposition gauges will be deployed and collected each month at the nominated sites by an external service provider. This is expected to generate between 75-90 samples (18 monthly samples from each of the 5 sites). An additional 10 samples may be provided by local stakeholders. Air quality data, wind speed, direction, and rainfall will be collected during the projects. Detail of external events such as wind storms or fires, which may also impact on air quality, will also be collected.

At two sediment settling ponds, a manual sampling method will be used to collecte particulate material from the surface layer. At a location proximate to each of these sites, samples of surface dirt (to provide a background comparison sample) will also be collected.

Sample Analysis

Dust Deposition samples. Each sample will be filtered and the mass of particulate matter recorded. This material will then be screened at approximately 100 microns and the mass % of material in each fraction recorded. This step is undertaken to remove insects and other extraneous material which may have been collected in the samples. Detailed microscopy and chemical analysis will then be undertaken on this fraction.

Community supplied samples. In the first instance optical microscopy will be undertaken. If the samples warrant further study then additional analyses will also be done.

Sediment and dirt samples. The samples will be filtered and detailed microscopy and chemical analysis will then be undertaken on the water insoluble fraction. A gravimetric method will be used to determine the proportion of salt and, if required, further analysis will be undertaken on this fraction to determine salt composition. Laser Induced Breakdown Spectroscopy (LIBS) will also be used to characterise sediment samples from CSG settling ponds and nearby areas to investigate whether the sediment samples contain elevated amounts of free silica grains.

Reporting

An interim report will be provided after the one-month preliminary study at two sites. This interim report detailing components found in the samples will focus on c-silica (but also other silicas and materials of interest). The optical microscopy results will also be provided via the image viewer platform. A final report will be provided after the successful analysis of all samples has been completed.

Follow-up Sampling and Analysis Beyond Project Term

While the project has been designed with an 18-month sampling period to capture seasonal variations and mitigate the impact of any unusual or extreme weather events on the representative veracity of the samples, it is nevertheless recognised that ongoing sample collection and analysis would be desirable to derive the most value from the project investment. For this reason, the project team will actively seek to engage with local land care or Natural Resource Management (NRM) groups to facilitate continuity of sampling after the project close. If a local group or groups are prepared to assume this role, the passive dust deposition stations can be left in their care at the end of the project. Information regarding the leasing and use of the high volume air sampling stations (including the local supplier/lessor and the environmental sample collection company) will also be provided so that any local groups may consider whether to seek to fund ongoing sampling of this nature. The CSIRO team will also provide information and costings for the analysis of any future samples so that any local groups who are interested in maintaining a sampling program will have a clear idea of costs, which may be of assistance in seeking future funding sources for such activities.

3. Project Inputs

Resources and collaborations

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Chad Hargrave	24 days	Project management, data analysis	25+	CSIRO
Priyanthi Hapugoda	90 days	Mineralogical characterisation, petrography, data analysis	25+	CSIRO
Joe Perkins	90 days	Chemical characterisation, Optical/SEM imaging, LIBS, data analysis	5+	CSIRO
Jessica Gray	90 days	Petrography, sample preparation, Optical/SEM imaging, data analysis	15+	CSIRO
Luke Powell	50 days	Software engineering, ML/AI algorithm development	5+	CSIRO
Jason Ward	20 days	Aerosol sampling, aerosol characterisation and modelling	5+	CSIRO
Erin Dunne	20 days	Aerosol modelling, air pollution and health impacts, atmospheric chemistry	5+	CSIRO
Melita Keywood	8 days	Aerosol modelling and characterisation, chemical and microphysical compositions	25+	CSIRO

Subcontractors (clause 9.5(a)(i))	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Contracted Sample Acquisition	18 months x 5 samples acquired according to Australian Standard. Budget: $54,000	Environmental sample acqusition		ALS Environmental or other company

Technical Reference Group

The project will establish a Technical Reference Group (TRG) aimed at seeking peer-to-peer technical advice on contextual matters and to discuss research needs as well as outputs as the project progresses. The TRG will include the project leader and a group of different stakeholders as appropriate which may include:

- Regulators (Qld Department of Resources, QLD Department of Environment and Sciences and Qld Health)
- Company representatives (Shell/QGC, Origin/APLNG)
- Dust and environmental health technical expertise

Budget Summary

Source of Cash Contributions	2022/23	2023/24	2024/25	2025/26	% of Contribution	Total
GISERA	$103,592	$206,349	$151,821	$0	80%	$461,762
- Federal Government	$77,694	$154,762	$113,866	$0	60%	$346,321
- APLNG	$19,424	$38,690	$28,466	$0	15%	$86,580
- QGC	$6,475	$12,897	$9,489	$0	5%	$28,860
Total Cash Contributions	**$103,592**	**$206,349**	**$151,821**	**$0**	**80%**	**$461,762**

Source of In-Kind Contribution	2022/23	2023/24	2024/25	2025/26	% of Contribution	Total
CSIRO	$25,898	$51,587	$37,955	$0	20%	$115,440
Total In-Kind Contribution	**$25,898**	**$51,587**	**$37,955**	**$0**	**20%**	**$115,440**

TOTAL PROJECT BUDGET	2022/23	2023/24	2024/25	2025/26	-	TOTAL
All contributions	**$129,490**	**$257,936**	**$189,776**	**$0**	**-**	**$577,202**
TOTAL PROJECT BUDGET	**$129,490**	**$257,936**	**$189,776**	**$0**	**-**	**$577,202**

4. Communications Plan

Stakeholder	Objective	Channel	Timeframe
Regional community stakeholders/wider public including land holders and traditional owners.	To communicate project objectives and key messages and findings from the research	A fact sheet at commencement of the project which explains in plain English the objectives of the health projects, how they relate to each other and the H.2 project. Project progress reported and outcomes (e.g., final papers, final factsheets) on GISERA website to ensure transparency for all stakeholders including regional communities. Interim report showing preliminary results of dust analyses at two sites published on the GISERA website. Publication of optical microscopy analyses of dust samples results through the Image Viewing platform has been developed which allows results for dust analyses to be uploaded to dedicated servers and viewed by interested parties via the internet. Public release of final report Plain English factsheet summarising the outcomes of the research Local government and/or community groups invited to community forum (virtual or face-to-face) to learn of and share their reflections on the findings of the overall suite of health studies. This may be conducted as a component of broader GISERA communication activities.	At commencement of project Ongoing Task 1 Quarterly (as a component of Task 3) Project completion Project completion
Gas Industry, Government	To communicate the final results of the project.	Presentation of findings at joint Gas Industry/Government Knowledge Transfer Session	At project completion
Scientific Community	To provide scientific insight into the relative distribution of silicates and other particulate matter in environmental samples around CSG installations	Peer-reviewed scientific publication. Dataset(s) available through CSIRO’s data repository, images viewable using the web-based portal.	After completion of project

In addition to project specific communications activities, CSIRO’s GISERA has a broader communications strategy. This strategy incorporates activities such as webinars, roadshows, newsletters and development of other communications products.

5. Project Impact Pathway

<table>
<tr><th>Activities</th><th>Outputs</th><th>Short term Outcomes</th><th>Long term outcomes</th><th>Impact</th></tr>
<tr><td>Sample acquisition</td><td>Longitudinal sample collection from Queensland</td><td>Unique record of dust/sediment samples from regional CSG study</td><td rowspan="2">The findings regarding the amount and distribution of fine particle silicates will provide guidance regarding what action, if any, should be taken to minimise health and environmental impacts of the use of sand for CSG injection.</td><td rowspan="3">New understanding of environmental distribution of particular matter (specifically silicates) caused by CSG – particularly the use of sand additives.
New understanding of long-term presence of silicates in run-off/sediments associated with CSG.
Enhanced understanding of the potential health impacts (for both CSG workers and local communities) of CSG activities, in particular sand injection.
Use of web-based imaging portal to allow public review of data will provide an opportunity to improve and extend community engagement for the CSG industry.</td></tr>
<tr><td>Sample Analysis</td><td>Multimodal (optical and SEM) imaging of all samples, including fused and characterised images with composition and size distribution information.</td><td>Database of easily accessible images that will remain available for future research purposes. Summary particle composition and size-distribution reports for each image and across image dataset.</td></tr>
<tr><td>Reporting</td><td>Detailed review and analysis of sample data and summaries, featuring assessment of impacts associated with silicate quantities and distribution.</td><td>Actionable information regarding the prevalence and distribution of fine-particle silicates, in particular respirable silicates, due to CSG activities.</td><td>The project will enhance the understanding of the environmental and health impacts of CSG activities, in particular the use of sand additives. Both of these impacts will have indirect economic consequences, e.g., potential health impacts may demand new handling techniques be employed to minimise dust from sand injection.</td></tr>
</table>

6. Project Plan

Project Schedule

ID	Activities / Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Preliminary study	Chad Hargrave	6 Feb 2023	30 March 2023	
Task 2	Field Sampling	Priyanthi Hapugoda	6 March 2023	31 August 2024	
Task 3	Sample Analysis	Chad Hargrave	1 April 2023	30 September 2024	
Task 4	Project reporting	Chad Hargrave	1 August 2024	06 January 2025	
Task 5	Communicate findings to stakeholders	Chad Hargrave	Full duration of project		

Task description

Task 1: Preliminary Sampling Study

OVERALL TIMEFRAME: 2 months (6 February – 30 March 2023)

BACKGROUND: Preliminary sample study to establish methodology.

TASK OBJECTIVES: One month sampling process at two sites (one background, one in proximity to CSG site). Sample preparation. Sample image acquisition. Image analysis. Brief report. Results also provided by CSIRO online image viewing software.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Interim report providing review of the sampling and analysis methodology including recommendations for any process modifications for the main study.

Task 2: Field Sampling

OVERALL TIMEFRAME: 18 months (6 March 2023 – 31 August 2024)

BACKGROUND: Primary sampling activity for the project.

TASK OBJECTIVES: Acquire dust and sediment samples in a controlled manner in order to provide suitable high quality data for analysis.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Monthly samples from each dust deposition site. Quarterly samples from each sediment site. Ad hoc community samples as available.

Task 3: Sample Analysis

OVERALL TIMEFRAME: 18 months (1 April 2023 – 30 September 2024)

BACKGROUND: Each dust sample will be analysed using optical and SEM microscopy methods to provide abundance and size distribution on the water insoluble particulates and information and the water-soluble constituents (salts). In addition (where sufficient sample volume has been obtained) traditional che mistry methods (XRF and XRD), and Laser induced Breakdown Spectroscopy (LIBS) will be employed to provide additional chemical and elemental data for analysis.

TASK OBJECTIVES: Each sediment sample will be analysed using traditional chemistry methods (XRF and XRD), optical and SEM microscopy methods and Laser induced Breakdown Spectroscopy (LIBS) to investigate whether the sediment samples contain elevated amounts of free silica grains.

TASK OUTPUTS AND SPECIFIC DELIVERABLES: Quarterly summary reporting of progressive analysis of the monthly samples, including interim findings and identified trends regarding the percentage mass and size distribution of respirable crystalline silica across the range of sampling sites.

Task 4: Project Reporting

OVERALL TIMEFRAME: 5 months (1 August 2024 – 06 January 2025)

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 for future research;

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.

Task 5: Communicate project objectives, progress and findings to stakeholders

OVERALL TIMEFRAME: Full duration of project

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 as advised by GISERA's communication team
4) Two project factsheets: A factsheet, hosted on the GISERA website, will be developed at commencement of project, and another that will include peer-reviewed results and implications will be developed at completion of project.
5) Peer reviewed scientific manuscript ready for submission to relevant journal

Project Gantt Chart

		2023/24																	24/25							
Task	**Task Description**	**Feb 23**	**Mar 23**	**Apr 23**	**May 23**	**Jun 23**	**Jul 23**	**Aug 23**	**Sep 23**	**Oct 23**	**Nov 23**	**Dec 23**	**Jan 24**	**Feb 24**	**Mar 24**	**Apr 24**	**May 24**	**Jun 24**	**Jul 24**	**Aug 24**	**Sep 24**	**Oct 24**	**Nov 24**	**Jan 25**	**Feb25**
1	Preliminary study	■	■																						
2	Field Sampling		■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■					
3	Sample Analysis			■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■				
4	Project reporting																			■	■	■	■	■	
5	Communicate findings to stakeholders	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■	■

7. Budget Summary

Expenditure	2022/23	2023/24	2024/25	2025/26	Total
Labour	$99,490	$206,436	$182,776	$0	$488,702
Operating	$12,000	$21,500	$1,000	$0	$34,500
Subcontractors	$18,000	$30,000	$6,000	$0	$54,000
Total Expenditure	**$129,490**	**$257,936**	**$189,776**	**$0**	**$577,202**

Expenditure per task	2022/23	2023/24	2024/25	2025/26	Total
Task 1	$22,895	$0	$0	$0	$22,895
Task 2	$53,478	$106,737	$16,727	$0	$176,942
Task 3	$51,308	$147,479	$86,463	$0	$285,250
Task 4	$0	$0	$82,760	$0	$82,760
Task 5	$1,809	$3,720	$3,826	$0	$9,355
Total Expenditure	**$129,490**	**$257,936**	**$189,776**	**$0**	**$577,202**

Source of Cash Contributions	2022/23	2023/24	2024/25	2025/26	Total
Federal Govt (60%)	$77,694	$154,762	$113,866	$0	$346,321
APLNG (15%)	$19,424	$38,690	$28,466	$0	$86,580
QGC (5%)	$6,475	$12,897	$9,489	$0	$28,860
Total Cash Contributions	**$103,592**	**$206,349**	**$151,821**	**$0**	**$461,762**

In-Kind Contributions	2022/23	2023/24	2024/25	2025/26	Total
CSIRO (20%)	$25,898	$51,587	$37,955	$0	$115,440
Total In-Kind Contributions	**$25,898**	**$51,587**	**$37,955**	**$0**	**$115,440**

	Total funding over all years	Percentage of Total Budget
Federal Government investment	$346,321	60%
APLNG investment	$86,580	15%
QGC investment	$28,860	5%
CSIRO investment	$115,440	20%
Total Expenditure	**$577,202**	**100%**

Task	Milestone Number	Milestone Description	Funded by	Start Date	Delivery Date	Fiscal Year Completed	Payment $ (excluding CSIRO contribution)
Task 1	1.1	Preliminary study	GISERA	Feb-23	Mar-23	2022/23	$18,316
Task 2	2.1	Field Sampling	GISERA	Mar-23	Aug-24	2023/24	$141,554
Task 3	3.1	Sample Analysis	GISERA	Apr-23	Sept-24	2023/24	$228,200
Task 4	4.1	Project reporting	GISERA	Aug-24	Jan-25	2024/25	$66,208
Task 5	5.1	Communicate findings to stakeholders	GISERA	Feb-23	Feb-25	2024/25	$7,484

8. Intellectual Property and Confidentiality

<table>
<tr><td rowspan="3">Background IP
(clause 11.1, 11.2)</td><td>Party</td><td>Description of Background IP</td><td>Restrictions on use (if any)</td><td>Value</td></tr>
<tr><td></td><td></td><td></td><td>$</td></tr>
<tr><td></td><td></td><td></td><td>$</td></tr>
<tr><td>Ownership of Non-Derivative IP
(clause 12.3)</td><td colspan="4">CSIRO</td></tr>
<tr><td>Confidentiality of Project Results
(clause 15.6)</td><td colspan="4">Project Results are not confidential.</td></tr>
<tr><td>Additional Commercialisation requirements
(clause 13.1)</td><td colspan="4">Not Applicable</td></tr>
<tr><td>Distribution of Commercialisation Income
(clause 13.4)</td><td colspan="4">Not applicable</td></tr>
<tr><td rowspan="4">Commercialisation Interest
(clause 13.1)</td><td colspan="2">Party</td><td colspan="2">Commercialisation Interest</td></tr>
<tr><td colspan="2">CSIRO</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">APLNG</td><td colspan="2">N/A</td></tr>
<tr><td colspan="2">QGC</td><td colspan="2">N/A</td></tr>
</table>

9. References

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