



GISERA
Gas Industry Social and
Environmental Research Alliance

Project Order, Variations and Research Progress

Project Title: An intensive monitoring campaign to measure the air, water and soil impacts of hydraulic fracturing of production wells in the Surat Basin

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

- Section 1: [Research Project Order as approved by the GISERA Research Advisory Committee and GISERA Management Committee before project commencement](#)
- Section 2: [Variations to Project Order](#)
- Section 3: [Progress against project milestones](#)



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GISERA
Gas Industry Social and
Environmental Research Alliance

1 Original Project Order



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Project Order

Proforma 2016

1. Short Project Title

Air, water and soil impacts of hydraulic fracturing

Long Project Title

An intensive monitoring campaign to measure the air, surface water, groundwater and soil impacts of hydraulic fracturing of production wells in the Surat Basin

GISERA Project Number

W.11

Proposed Start Date

1 February 2017

Proposed End Date

30 June 2017

Project Leader

Melita Keywood

2. GISERA Region

Queensland New South Wales Northern Territory

3. GISERA Research Program

Water Research GHG Research Social & Economic Research
 Biodiversity Research Agricultural Land Management Research Health

4. Research Leader, Title and Organisation

Melita Keywood, Principal Research Scientist, CSIRO Oceans and Atmosphere

5. Background

The potential impact on air, surface water, groundwater and soil of hydraulic fracturing (HF) operations in coal seam gas production are of general concern to communities living in gas development regions. The Surat Basin is no different, and members of the Western Downs community want evidence that they will not be subjected to any adverse impacts as HF becomes increasingly used in that region. Community concerns center around disclosure of the nature and type of chemicals used in the HF operations; potential enhanced mobilization of geogenic contaminants (Rn, Hg, VOCs) from the coal seam; the possible environmental fate of HF chemicals and geogenic contaminants; and the potential for impacts on human health and the environment.

As a response to these concerns, GISERA is undertaking new projects in 2017 on health impacts of CSG development (initially in NSW but extending into Queensland subject to government funding outcomes). In order to accurately assess potential health impacts, it is necessary to know the environmental fate and concentration HF-related contaminants.

The objective of this study is to conduct a comprehensive study on the effects of HF on air, water and soil. This will involve measurements of contaminant concentrations before, during and after HF at selected sites in the Surat Basin. The project will also investigate contaminant sources, pathways and environmental fate.

The project comprises a Phase 1 Review and Monitoring/Sampling Design (5 months) and a Phase 2, Monitoring and Sampling Program (13 months). This Project Order concerns the approval of Phase 1 with a stage-gate 'Go/No-Go' decision step to be approved by the Queensland Regional Research Advisory Committee (RRAC) prior to commencement of Phase 2.

This project presents an important opportunity to generate a definitive account of the potential for environmental impacts from CSG production including hydraulic fracturing. The project presents a unique opportunity to access production wells during an extended HF program over 17 months in 2016 and 2017. Origin Energy will allow unrestricted access, where safe, to air, surface water, groundwater and soil in the vicinity of wells being hydraulically fractured for establishing instruments, sample collection and ongoing monitoring. Origin Energy will also liaise with researchers to maximize data collection during Phase 2.

There may be a perceived risk around conflict-of-interest which could present a risk to CSIRO independence associated with this project as Origin Energy will have involvement in enabling access to the well field. However, these risks will be mitigated through institution of the following oversight mechanisms:

- Establishment of an external Review Panel consisting of four independent external scientists of international reputation

- Peer review of the air, surface water, groundwater and soil sampling and measurement program by the Review Panel
- Opportunity for the external Review Panel to observe the implementation of measurements and to examine the field site during measurements if they so wish.
- Peer review of the final research report(s) by the Review Panel (and any other external and independent expert the Review Panel sees fit to invite to review documents)
- The convening of a Stakeholder Panel of local representatives engaged through a GISERA 'Knowledge Transfer' session to examine the design and implementation of the measurement program.

Significant work is already underway that will be incorporated into the project. In October 2016 Origin Energy secured the permission of landholders, and engaged SGS Leeder to undertake passive monitoring of VOCs and H₂S at the proposed study site. In addition, Origin Energy is currently in final negotiations with Ecotech for the provision of a fixed air quality monitoring station (AQMS) also to be located at the study site. Surface and groundwater sampling by Origin and SGS Leeder is also underway in the vicinity of the proposed study site. CSIRO O&A visited the proposed study sites in October 2016 and provided advice and oversight on the selection of sites for the VOC monitoring and AQMS. In addition to providing important baseline air quality data for the proposed project, the AQMS and VOC monitoring will also provide significant additional data to the current GISERA Surat Basin Ambient Air Quality Study and vice versa.

Origin Energy will provide CSIRO with information on chemicals used during HF (including a sample of the HF fluid to be collected and analysed to confirm its composition) and provide information about the HF process; will provide access to the wells during the HF activities; and, ensure a safe work environment and necessary HSE training and PPE.

CSIRO will oversee program design and GISERA governance; audit procedures of third party air sampling and analysis providers; compile and analyse data; report data; and, make data/reports publically available on GISERA website with open public access to data.

6. Project Description

The project consists of two phases:

1. Phase 1 - Review, study design for a measurement program and establishment of baseline monitoring/sampling
2. Phase 2 - Implementation of measurement program designed in Phase 1. Approval of Phase 2 is NOT SOUGHT by the Queensland Regional Research Advisory Committee (RRAC) at this time.

Phase 1: Impact of HF on air, surface water, groundwater and soil: Review of state of the knowledge, study design and review of baseline monitoring/sampling (6 months, complete by July 2017, stage-gate 'Go/No-Go' decision by March/April 2017)

1. Review of state of the knowledge about the potential sources of air, surface water, groundwater and soil pollutants associated with CSG extraction using HF incorporating findings from the National Chemical Assessment. This will include the review of publically available industry reports and peer reviewed publications. In addition this study will request information from Origin/the hydraulic fracturing services company on chemical compounds that will be used in the proposed HF operations.
2. Establishment of external Review Panel.
3. Design of monitoring and sampling protocols for air, surface water, groundwater and soil observations).
4. Peer review of proposed air, surface water, groundwater and soil sampling and measurement programs by the Review Panel
5. Establishment of baseline observations for air, surface water, groundwater and soil measurements;.
 - a. CSIRO will oversee commissioning of AQMS including QA/QC audit checks (underway) and commissioning of passive VOC network including QA/QC audit checks (underway).
 - b. Baseline surface and groundwater measurements: data provided by Origin will be reviewed and gaps (if any) identified.
 - c. Baseline soil measurements: data provided by Origin will be reviewed and gaps (if any) identified.
6. Preliminary measurements:
 - a. Air- VOC passive monitoring and AQ station during HF at the Field Site
 - b. Supplementary baseline data (if required): water - surface and ground water quality samples from Site 1 and surrounds
 - c. Supplementary baseline data (if required): Soil quality samples from Site 1 and surrounds
7. Analyse preliminary data
8. Review Panel to peer review design and implementation of measurement program and to examine field site during first measurements. Review Panel to sign off on research quality.
9. Construct research reports on Phase 1 and undertake external project representation consistent with GISERA Communications and Engagement Strategy.
10. Stage-gate 'Go/No-Go' decision based on the developed measurement program plan to be made by March/April 2017

The outcomes of Phase 1 will include:

- A review of the state of knowledge from peer reviewed literature and reports to identify CSG and HF-specific sources of air, surface water, groundwater and soil pollutants.
- A study design for a measurement program to provide enhanced information of the impacts of HF on air, surface water, groundwater and soil quality to be carried out in Phase 2.
- Analysis of available baseline measurements of air (AQMS and VOC network installed in October 2016), surface water, groundwater and soil.

Air measurement program study design

Phase 1 total cost \$194.4K

CSIRO contribution: \$60.1K

GISERA contribution \$0k

Origin Energy cash contribution \$134.3K

Origin Energy will also provide in kind contribution \$400k

Surface water, groundwater and Soil measurement program study design

Phase 1 total cost \$136.4k

CSIRO contribution: \$25k

GISERA contribution \$0k

Origin Energy contribution \$111.4k

Phase 2: Measurement Programs (13 months, complete by June 2018)

Approval of Phase 2 is NOT SOUGHT by the Queensland RRAC at this time. Implementation of the approved measurement program following approval by the Review Panel and Go/No-Go decision by the Queensland RRAC will occur in February/March 2017.

Phase 2: Air Measurement Program

Intensive measurements of air pollutants at up to 6 wells during HF activities in mid-2017. CSIRO through GISERA will undertake community consultation, interpretation, reporting and Knowledge Transfer sessions to community, government and industry.

Precise details of the measurement program will be developed in Phase 1 and could include

1. A single fixed AQMS located within the field of wells to be hydraulically fractured. The AQMS will be equipped with standardised, high quality measurement systems for

measurements of criteria air pollutants and additional target species identified as part of the study design

2. Additional sensitive, high time resolution VOC and particle measurements in AQMS.
3. Portable fixed monitoring systems be deployed for fence-line monitoring at well sites with capability to measure a subset of target compounds including:
 - a. Methane
 - b. VOCs
 - c. Particulate matter including black carbon
 - d. CO
 - e. NOx
 - f. Ozone
 - g. Radon
 - h. Mercury
4. Mobile (vehicle mounted) monitoring equipment to measure well site and fugitive emissions of CSG and selected CSG trace species.
5. Well head gas sampling with subsequent composition analysis for methane, VOCs, Radon, Mercury, and other target compounds identified in Phase 1 measurement program.

Ambient air measurements of target compounds at the well sites and surrounding area will occur immediately prior to HF to determine pre-HF conditions. Source characterisation including well head gas and emissions from CSG extraction infrastructure and equipment will be undertaken by external contractors organised by Origin.

Milestone reporting over the duration of the Phase2-GISERA project will include a report of the data summary report of HF measurements (air), a data summary report of post-fracking measurements (air), a draft final report and a final report. In addition, CSIRO will make data/reports publically available on GISERA website with open public access to data. The final report and the final monitoring study design reports will undergo peer review as per oversight mechanism defined above.

Phase 2 Surface water, groundwater and Soil Measurement Program

Precise details of the surface water, groundwater and soil measurement program will be developed in Phase 1 and sampling could comprise the following methodology:

1. Surface water sampling sites

Samples will be collected at Dogwood Creek (3 sites) and 1 farm dam. There will be three sampling events: before, during and after HF.

2. Groundwater bore samples

Three bores will be sampled within the 5 km radius. Samples will be collected pre-, during and post HF.

3. Fracturing fluid

A recipe for the frack program will be provided by Origin Energy. A sample of the HF fluid will also be collected and analysed to confirm its composition.

4. Flow-back water

Three wells will be sampled at three time points over the duration of flow-back water collection. Based on previous experiences in this region this phase of the study last for less than one week at each well.

5. Produced water

The three wells that were sampled for flow-back waters will be sampled during the production phase for produced waters. Samples to be taken from the gas-liquid separator well head. It is proposed there are three sampling events per well. The exact timing of the sampling events is to be determined.

6. Water treatment facility water

The produced water treatment facility waters will be sampled pre-treatment and post-treatment on one occasions over the study period giving a total of two samples.

7. Soil samples

Five soil samples will be collected adjacent to one fracked well before and after HF activities. This will lead to a total of 10 soil samples, which will be subjected to the same chemical characterisation as the water samples following suitable sample preparation/extraction of the soil.

CSIRO staff will make one site visit during the course of Phase 1 to provide training on water and soil sample collection to contractors, oversight sampling operations and gain familiarity with the study sites.

Phase 2 Air measurement program total cost \$1166k (estimate)

CSIRO contribution: \$296k

GISERA contribution \$0k

Origin Energy contribution \$870k

Costs for external providers of air sampling and analytical services (including ANSTO and Macquarie University), \$150K included in price

Phase 2 Surface water, groundwater and soil measurement program total cost \$598K (estimate)

CSIRO contribution: \$119.6k

GISERA contribution \$0k

Origin Energy contribution \$478.4k

Costs for external providers \$150K (estimate) included in price

Importance and necessity

- While the use of HF is currently not widespread in the Surat Basin HF is likely to be increasingly employed as CSG production from high permeability coal seams peaks and future reserves are dominated by lower permeability coal seams which necessitates HF for CSG extraction.
- With an increase in HF operations in the Surat Basin, the level of community concern about the impact of the CSG industry on human health and the environment is likely to persist or increase
- The independent study will provide detailed knowledge about the likely impact of HF for CSG extraction on air, surface water, groundwater and soil quality which will inform future management, regulatory and community actions
- Measurements of air, surface water, groundwater and soil quality at HF sites will be reported and made available to the public.

Community benefits -access to independent information on the potential impacts of HF

Industry benefits- social licence through acknowledgement of community concerns, engagement of independent scientific institutions, transparency in relation to chemicals and processes employed in HF and provision of access to industry sites.

7. Budget Summary

Expenditure	2016/17	2017/18	2018/19	Total
Labour	193,732	-	-	193,732
Operating	56,207	-	-	56,207
Subcontractors	80,857	-	-	80,857
Total Expenditure	330,796	-	-	330,796

Expenditure per Task	2016/17	2017/18	2018/19	Total
Task 1	50,614	-	-	50,614
Task 2	26,775	-	-	26,775
Task 3	9,798	-	-	9,798
Task 4	79,060	-	-	79,060
Task 5	14,697	-	-	14,697
Task 6	37,936	-	-	37,936
Task 7	111,916	-	-	111,916
Total Expenditure	330,796	-	-	330,796

Source of Cash Contributions	2016/17	2017/18	2018/19	Total
GISERA (0%)	-	-	-	-
Origin Energy (74%)	245,670	-	-	245,670
Total Cash Contributions	245,670	-	-	245,670

In-Kind Contribution from Partners	2016/17	2017/18	2018/19	Total
CSIRO (26%)	85,125	-	-	85,125
Total In-Kind Contribution from Partners	85,125	-	-	85,125

	Total funding over all years	Percentage of Total Budget
GISERA Investment	\$0	0%
Origin Energy Investment	\$245,670	74%
CSIRO Investment	\$85,125	26%
TOTAL	\$330,795	

Task	Milest one Number	Milest one Description	Funded by	Start Date (mm-yy)	Delivery Date (mm-yy)	Fiscal Year Completed	Payment \$ (excluding CSIRO contribution)
Task 1	1.1	Establishment of Review Panel	CSIRO / Origin	Feb 2017	Apr 2017	2016/17	\$37,589
Task 2	2.1	Report including: state of the knowledge about the potential sources of air pollutants associated with CSG extraction using hydraulic fracturing;	CSIRO / Origin	Feb 2017	Apr 2017	2016/17	\$19,885
Task 3	3.1	Report including: state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using hydraulic fracturing;	CSIRO / Origin	Feb 2017	Apr 2017	2016/17	\$7,277
Task 4	4.1	Peer reviewed report describing a suitable measurement program to provide enhanced information of the impacts of HF on air quality.	CSIRO / Origin	Feb 2017	Apr 2017	2016/17	\$58,715
Task 5	5.1	Peer reviewed report describing a suitable measurement program to provide enhanced information of the impacts of HF on surface water, groundwater and soil quality.	CSIRO / Origin	Feb 2017	Apr 2017	2016/17	\$10,915
Task 6	6.1	Report on measurements of air made before HF commenced (i.e. October 2016 to April 2017)	CSIRO / Origin	May 2017	June 2017	2016/17	\$28,174
Task 7	7.1	Report on measurements on surface water, groundwater and soil made before HF commenced (i.e. October 2016 to April 2017)	CSIRO / Origin	May 2017	June 2017	2016/17	\$83,116

8. Other Researchers (include organisations)

Researcher	Time Commitment (Phase 1)	Principle area of expertise	Years of experience	Organisation
Melita Keywood	30 days	Air quality science leader	20	CSIRO O&A
Erin Dunne	40 days	Air quality scientist and measurement techniques	7	CSIRO O&A
Jason Ward	10 days	Air quality measurement techniques	15	CSIRO O&A
James Harnwell	10 days	Air quality measurement techniques	25	CSIRO O&A
Simon Apte	10 days	Water quality	30	CSIRO L&W
Rai Kookana	12 days	Water & soil quality	30	CSIRO L&W
Mike Williams	22 days	Water & soil quality	6	CSIRO L&W

9. Subcontractors

Subcontractors (clause 9.5(a)(i))	Subcontractor	Role
	TBD	Peer reviewer 1 study design (Milestone 4.1 & 5.1)
	TBD	Peer reviewer 2 study design (Milestone 4.1 & 5.1)
	TBD	Peer reviewer 3 study design (Milestone 4.1 & 5.1)

10. Project Objectives and Outputs

Objectives for phase 1

1. To summarise the current state of knowledge regarding sources of air, surface water, groundwater and soil pollutants associated with CSG extraction using HF.
2. To develop a suitable measurement program to provide state of the art information on the impacts of HF on air, surface water, groundwater and soil quality

Outputs

1. Report summarising the current state of knowledge regarding sources of air, water and soil pollutants associated with CSG extraction using HF.
2. Peer Reviewed Report detailing the study design for a measurement program to provide enhanced information of the impacts on HF on air, surface water and groundwater and soil quality.

3. Report summarising data on air, surface water, groundwater and soil quality collected during the pre-fracturing period (i.e. baseline data).

11. GISERA Objectives Addressed

Carrying out of research and improving and extending knowledge of social and environmental impacts and opportunities of unconventional gas projects for the benefit of the Gas Industry, the relevant community and the broader public.

Informing government, regulators and policy-makers on key issues regarding policy and legislative framework for the Gas Industry.

12. Project Development

This project was developed through consultation between Origin Energy and CSIRO O&A. Given the significant community concern associated with hydraulic fracturing, CSIRO O&A then approached GISERA to consider including the project in the GISERA umbrella.

A number of states have instigated moratoriums on HF. However gas is widely regarded as a transition energy source from coal to renewables. While the use of HF is currently not widespread in the Surat Basin, HF is likely to be increasingly employed as CSG production from high permeability coal seams peaks and future reserves are dominated by lower permeability coal seams which necessitates HF for CSG extraction. This study will provide much needed data on the impacts of HF on air, surface water, groundwater and soil to generate some evidential basis for future decisions around HF activity. These data will also be required to accurately assess potential health impacts in future health studies.

This project provides a world-first opportunity to investigate the air, surface water, groundwater and soil impacts before, during and after HF activities. The study will establish air, surface water, groundwater and soil baseline concentrations of various identified chemical species before HF; identify air, surface water, groundwater and soil pollutants present above background levels during and after hydraulic fracturing; and, investigate pollutant sources, pathways and environmental fate. This project presents a unique opportunity to access production wells during an extended HF program. Origin Energy will allow unrestricted access, where safe, to air, surface water, groundwater and soil in the vicinity of wells being hydraulically fractured and Origin Energy will also liaise with researchers to maximise data collection during Phase 2.

13. Project Plan

13.1 Project Schedule

ID	Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Establishment of Review Panel	Melita Keywood	1 February 2017	30 April 2017	
Task 2	Review of state of the knowledge about the potential sources of air pollutants associated with CSG extraction using hydraulic fracturing	Melita Keywood	1 February 2017	30 April 2017	
Task 3	Review of state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using hydraulic fracturing	Simon Apte	1 February 2017	30 April 2017	
Task 4	Study design for a measurement program to provide enhanced information of the impacts of HF on air quality.	Erin Dunne	1 February 2017	30 April 2017	
Task 5	Study design for a measurement program to provide enhanced information of the impacts of HF on soil, surface water and groundwater quality.	Simon Apte	1 February 2017	30 April 2017	
Task 6	Analysis of measurements of air made before HF commenced (i.e. October 2016 to April 2017)	Erin Dunne	1 May 2017	30 June 2017	
Task 7	Analysis of measurements of surface water, groundwater and soil made before HF commenced (i.e. October 2016 to April 2017)	Simon Apte	1 May 2017	30 June 2017	

13.2 Australia Pacific LNG Payment Schedule

Invoice Number	Task Milestones	Date invoice to be issued to APLNG	Amount
1	Tasks 1 - 5	February 2017	\$134,380
2	Tasks 6 and 7	April 2017	\$111,290

It is important to note that:

- payment is to be received from APLNG prior to completion of milestones. Payment will reside in GISERA's Bank WBS until the GISERA Director is satisfied that each milestone has been completed.
- APLNG's financial contribution to this project is separate from their contribution for membership to GISERA.

Task 1

TASK NAME: Establishment of peer review panel and community engagement

TASK LEADER: Melita Keywood

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND: There may be a perceived risk around conflict-of-interest associated with this project as Origin Energy will have involvement in enabling access to the well field. However, these risks will be managed through the establishment of an external Review Panel consisting of up to four independent external scientists of international reputation. The external Review Panel will

- Peer review the design of the of the air, surface water and groundwater and soil sampling and measurement program during Phase 1
- Peer review the final research report(s) and invite any other external and independent expert the Review Panel sees fit to invite to review documents during Phase 2
- In addition, a Stakeholder Panel of local representatives will be engaged through a GISERA 'Knowledge Transfer' session to examine the design and implementation of the measurement program during Phase 2 and provide feedback

TASK OBJECTIVE: to demonstrate independence in the design of the of the air, surface water, groundwater and soil sampling and measurement program

TASK OUTPUTS: Review panel members and terms of reference documented: summary of Knowledge Transfer Session

SPECIFIC DELIVERABLES: Short report documenting Review panel members and terms of reference and summary of Knowledge Transfer Session.

Task 2

TASK NAME: Review of state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

TASK LEADER: Melita Keywood

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND:

The review will investigate the different processes involved in HF and for each process identify activities (e.g. use of chemicals, combustion etc) with the potential to release contaminants to the air.

The review will draw heavily on the previous work of the team including literature reviews (on Geogenic and Hydraulic fracturing Chemicals), Risk Assessment work (NICNAS) and existing air, water and gas composition data collected as part of GISERA Surat Basin ambient air quality study (CSIRO), where the project team has been involved over last three years. In addition, previous studies of community concerns around HF will be consulted in order to account for these aspects when designing a comprehensive air quality study.

Note that review of industry data pre-fracking air quality will be carried out as part of Task 6.

TASK OBJECTIVE: To review of state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

TASK OUTPUTS: Report on state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

SPECIFIC DELIVERABLES: Report on state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

This review will be used to inform the design of the monitoring program (Task 4).

Task 3

TASK NAME: Review of state of the knowledge about the potential sources of surface water, groundwater and soil pollutants associated with CSG extraction using HF

TASK LEADER: Simon Apte

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND:

The review will investigate the different processes involved in HF and for each process identify activities (e.g. use of chemicals, combustion etc) with the potential to release contaminants to the water or soil.

The review will draw heavily on the previous work of the team including literature reviews (on Geogenic and Hydraulic fracturing Chemicals), Risk Assessment work (NICNAS), Deep Groundwater (CSIRO) projects and existing air, water and gas composition data collected as part of GISERA Surat Basin ambient air quality study (CSIRO), where the project team has been involved over last three years. In addition, previous studies of community concerns around hydraulic fracturing will be consulted in order to account for these aspects when designing a comprehensive surface water, groundwater and soil quality study.

Note that review of industry data pre-fracking surface water, groundwater and soil quality will be carried out as part of Task 7.

This review will be used to inform the design of the monitoring program (Task 5).

TASK OBJECTIVE: To review of state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using HF

TASK OUTPUTS: Report on state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using HF

SPECIFIC DELIVERABLES: Report on state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using HF

Task 4

TASK NAME: Study design for a measurement program to provide enhanced information of the impacts of HF on air quality.

TASK LEADER: Erin Dunne

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND:

Based on the occurrence, environmental fate, toxicity profiles of the chemicals described in the Review produced in Task 2, a suite of target compounds will be identified for the monitoring study. In doing so, the guiding principle will be to represent different classes of chemicals rather than covering every possible compound that may naturally be present in the air given the practicalities of being able to measure the compound.

The HF process and therefore the recipe of HF fluid is continuously changing. The suite of target compounds selected for the monitoring study will be guided by the current practices of the industry and will be finalised in consultation with the industry.

The study design will be peer reviewed.

TASK OBJECTIVE: To design a measurement program that will produced information of the impacts of HF on air quality.

TASK OUTPUTS: Report detailing the design of a measurement program that will produced information of the impacts of HF on air quality.

SPECIFIC DELIVERABLES: Report detailing the design of a measurement program that will produced information of the impacts of HF on air quality.

Task 5

TASK NAME: Study design for a measurement program to provide enhanced information of the impacts of HF on water and soil quality.

TASK LEADER: Simon Apte

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND:

Based on the occurrence, environmental fate, toxicity profiles of the chemicals described in the Review produced in Task 2, a suite of target compounds will be identified for the monitoring study. In doing so, the guiding principle will be to represent different classes of chemicals rather than covering every possible compound that may naturally be present in the water and soil given the practicalities of being able to measure the compound.

The HF process and therefore the recipe of HF fluid is continuously changing. The suite of target compounds selected for the monitoring study will be guided by the current practices of the industry and will be finalised in consultation with the industry.

The study design will be peer reviewed.

TASK OBJECTIVE: To design a measurement program that will produced information of the impacts of HF on water and soil quality.

TASK OUTPUTS: Report detailing the design of a measurement program that will produced information of the impacts of HF on water and soil quality.

SPECIFIC DELIVERABLES: Report detailing the design of a measurement program that will produced information of the impacts of HF on water and soil quality.

Task 6

TASK NAME: Analysis of measurements of air before HF commenced (October 2016 to April 2017)

TASK LEADER: Erin Dunne

OVERALL TIMEFRAME: 1 May 2017 to 30 June 2017

BACKGROUND:

In October 2016 Origin Energy secured the permission of landholders, and engaged SGS Leeder to undertake passive monitoring of VOCs and H₂S at the proposed study site. In addition, Origin Energy is currently in final negotiations with Ecotech for the provision of a fixed air quality monitoring station (AQMS) also to be located at the study site. CSIRO O & A visited the proposed study sites in October 2016 and provided advice and oversight on the selection of sites for the VOC monitoring and AQMS. In addition to providing important baseline air quality data for the project, the AQMS and VOC monitoring will also provide significant additional data to the current GISERA Surat Basin Ambient Air Quality Study and vice versa.

These data sets provide information on baseline air composition before the commencement of HF in the study region.

TASK OBJECTIVE: To analyse and summarise air quality data (passive and AQMS) measured near the study site before commencement of HF activity.

TASK OUTPUTS: Report summarising air quality data (passive and AQMS) measured near the study site before commencement of HF activity.

SPECIFIC DELIVERABLES: Report summarising air quality data (passive and AQMS) measured near the study site before commencement of HF activity.

Task 7

TASK NAME: Analysis of measurements of water and soil made before HF commenced (October 2016 to April 2017)

TASK LEADER: Simon Apte

OVERALL TIMEFRAME: 1 May 2017 to 30 June 2017

BACKGROUND:

In October 2016 Origin Energy secured the permission of landholders, and engaged SGS Leeder to undertake surface and groundwater sampling in the vicinity of the proposed study sites which will supplement previous data collected by Origin.

These data sets provide information on baseline water and soil composition before the commencement of HF in the study region.

TASK OBJECTIVE: To analyse and summarise water and soil data collected near the study site before commencements of HF activity.

TASK OUTPUTS: Report summarising water and soil data collected near the study site before commencement of HF activity.

SPECIFIC DELIVERABLES: Report summarising water and soil data collected near the study site before commencement of HF activity.

14. Communications Plan

Communication of the results of the project will be managed in accordance with GISERA’s communication strategy. This may include presentations at community and industry meetings, conferences and publication of reports, scientific articles and factsheets. In addition, communication with relevant state and federal government departments will be maintained to ensure that they are aware of the outcomes of the research and possible policy implications.

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. The final composition of the TRG will be determined during Phase 1 of the project.

15. Intellectual Property and Confidentiality

Background IP (clause 11.1, 11.2)	Party	Description of Background IP	Restrictions on use (if any)	Value
				\$
				\$
Ownership of Non-Derivative IP (clause 12.3)	CSIRO			
Confidentiality of Project Results (clause 15.6)	Project Results are not confidential.			
Additional Commercialisation requirements (clause 13.1)	Not Applicable			
Distribution of Commercialisation Income (clause 13.4)	Not applicable			
Commercialisation Interest (clause 1.1)	Party	Commercialisation Interest		
	APLNG	NA		
	QGC	NA		
	CSIRO	NA		







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
8/6/17	The delays are due the dynamic nature of the hydraulic fracturing program itself, the dynamic interactions of the study team with industry collaborator, issues around access and power availability in the HF field and instrument supply issues. These factors have resulted in a great deal more effort being put into the study designs.	Milestone 2 pushed back to Jul 17, milestone 3 pushed back to Jun 17, milestone 4 pushed back to Jul, milestone 5 pushed back to Jul 17, milestone 6 pushed back to Sept 17, milestone 7 pushed back to Sept 17	
29/6/17	Delay in the site familiarization.	Milestone 3 pushed back to Jul 17	
27/9/17	Revisions to task required due to inadequate power supply at site selected.	Milestone 6 pushed back to Dec 17	
4/10/17	Delays in carrying out the field work component resulting in a need to change delivery date.	Milestone 7 pushed back to Dec 17	





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 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	Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
Task 1	Establishment of Review Panel	Melita Keywood	Feb-17	Apr-17	
Task 2	Review of state of the knowledge about the potential sources of air pollutants associated with CSG extraction using hydraulic fracturing	Melita Keywood	Feb-17	Jul-17	
Task 3	Review of state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using hydraulic fracturing	Simon Apte	Feb-17	Jul-17	
Task 4	Study design for a measurement program to provide enhanced information of the impacts of HF on air quality.	Erin Dunne	Feb-17	Jul-17	
Task 5	Study design for a measurement program to provide enhanced information of the impacts of HF on soil, surface water and groundwater quality.	Simon Apte	Feb-17	Jul-17	
Task 6	Analysis of measurements of air made before HF commenced (i.e. October 2016 to April 2017)	Erin Dunne	May-17	Dec-17	
Task 7	Analysis of measurements of surface water, groundwater and soil made before HF commenced (i.e. October 2016 to April 2017)	Simon Apte	May-17	Dec-17	





Project Schedule Report

Task 1

TASK NAME: Establishment of peer review panel and community engagement

TASK LEADER: Melita Keywood

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND: There may be a perceived risk around conflict-of-interest associated with this project as Origin Energy will have involvement in enabling access to the well field. However, these risks will be managed through the establishment of an external Review Panel consisting of up to four independent external scientists of international reputation. The external Review Panel will

- Peer review the design of the of the air, surface water and groundwater and soil sampling and measurement program during Phase 1
- Peer review the final research report(s) and invite any other external and independent expert the Review Panel sees fit to invite to review documents during Phase 2
- In addition, a Stakeholder Panel of local representatives will be engaged through a GISERA 'Knowledge Transfer' session to examine the design and implementation of the measurement program during Phase 2 and provide feedback

TASK OBJECTIVE: to demonstrate independence in the design of the of the air, surface water, groundwater and soil sampling and measurement program

TASK OUTPUTS: Review panel members and terms of reference documented: summary of Knowledge Transfer Session

SPECIFIC DELIVERABLES: Short report documenting Review panel members and terms of reference and summary of Knowledge Transfer Session.

PROGRESS REPORT:

This task is 100% complete.

The peer review panel of 4 experts has been established. The panel includes Dr Thomas Ryerson (Program Lead at NOAA USA), Mr Hugh Malfroy (Director of Malfroy Environmental Strategies), Dr Thomas Borch (Professor at Colorado State University) and Dr David Jones (Director of Jones Environmental Excellence).

The terms of reference have been determined.

To assist in mitigating the perceived risk around conflict-of-interest associated with this project it is important that the study design is communicated to Stakeholders and their feedback considered in the final study design put forward for Phase 2. At the time of writing this proposal, a GISERA Knowledge transfer session was proposed as the mechanism for this communication. However, as this project progresses it is becoming clear that a Knowledge Transfer Session would produce more value if carried out at the end of Phase 2 of the project when the results of the HF monitoring study proposed in the study design being generated as part of Phase 1 are available (i.e. late 2018).



To achieve our aim of communicating the study design to Stakeholders, we will instead undertake Stakeholders engagement. The Stakeholder engagement focuses on 3 groups, industry, government and community.

- The industry Stakeholder engagement session occurred on 6 April in Brisbane and involved the presentation of study, design and motivations to representatives from Origin, Santos and QFC. The three hour meeting generated valuable discussions and input from industry including the request to include experiments to investigate the influence of spills on soil quality. Industry were very supportive of the approaches being adopted and the study as a whole.
- The government Stakeholder engagement session occurred on 24 May at 1 Williams Street Brisbane and was hosted by the Department of Natural Resources and Mines (DNRM). In attendance were 15 staff from DNRM (CSGCU: Petroleum & Gas Inspectorate; Petroleum & Assessment Hub), Geological Survey of Qld, the Office of Groundwater Impact Assessment, the Department of Environment and Heritage Protection, Queensland Health, the Gas Fields Commission Qld and the Department of Science, information Technology and Innovation. There was a mix of senior and middle management, and technical experts in the room. Melita Keyword presented the rationale and proposed methodologies for the air, water and soil components of the study for 30 minutes, and this was followed by a question and answer session. The discussion focused on the groundwater sampling protocol and the low cost sensor methodologies being considered for the study. There was also interest in how the project will be communicated, with the Gas Fields Commission representative offering to facilitate community consultation in July as part of one of their planned activities. In addition DNRM offered to provide information on industry controls to assist one of our study goals to address issues of community concern around the adequacy of controls in place.
- The community Stakeholder engagement will occur once the study design has completed peer review. The project team will consult directly with GISERA regarding the approach to take for the knowledge transfer to the community, suggestions include presentation to representatives of community groups in the Surat Basin, distribution of a fact sheet, production of a video outlining the study design and motivations.

Task 2

TASK NAME: Review of state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

TASK LEADER: Melita Keyword

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND: The review will investigate the different processes involved in HF and for each process identify activities (e.g. use of chemicals, combustion etc) with the potential to release contaminants to the air.

The review will draw heavily on the previous work of the team including literature reviews (on Geogenic and Hydraulic fracturing Chemicals), Risk Assessment work (NICNAS) and existing air, water and gas composition data collected as part of GISERA Surat Basin ambient air quality study (CSIRO), where the project team has been involved over last three years. In addition, previous studies of community concerns around HF will be consulted in order to account for these aspects when designing a comprehensive air quality study.

Note that review of industry data pre-fracking air quality will be carried out as part of Task 6.

TASK OBJECTIVE: To review of state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

TASK OUTPUTS: Report on state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

SPECIFIC DELIVERABLES: Report on state of the knowledge about the potential sources of air pollutants associated with CSG extraction using HF

This review will be used to inform the design of the monitoring program (Task 4).

PROGRESS REPORT:

This task is 100 % complete and the report is undergoing review in Epublish.

This report presents a review of the state of the knowledge of the impacts of hydraulic fracturing (HF) and HF on air quality provides us with insights that inform the study design to assess the potential impacts of HF on air quality in the vicinity of well sites in the Surat Basin, Queensland.

The review includes a description of the hydraulic fracturing process applied to coal seam gas with emphasis on the activities that can lead to emissions to air. The review also includes a critical summary of previous studies reported in the peer reviewed literature that have investigated air quality impacts of HF.

The review of HF process itself described and the review of the potential pathways through which emissions from the different stages of the HF process can enter the atmosphere suggests the following HF stages that may result in emissions to the atmosphere include plant equipment and vehicles; use and storage of proppant, use and storage of HF fluids, flow-back fluids and fugitive emissions of the coal seam gas.

Air quality standards provide a framework in which to contextualise the atmospheric concentrations of different pollutants resulting from emissions during HF activities and the report includes information on the potential HF activity sources and the corresponding relevant ambient air quality standard. Of note is that exhaust from diesel powered equipment and vehicles can be compared to ambient air quality standards for all the NEPM and QLD EPP criteria pollutants as well as some of the NEPM for Air Toxics.

In order to understand the impact of HF activities on air quality it will be important to discern the influence of non-CSG sources including natural sources such as soil, dust and emissions from vegetation; traffic emissions; agricultural and farming emissions including feedlots; smoke from bushfires, prescribed burning and wood heaters; industrial, commercial and domestic emissions and other industry- quarries, mines, power stations.

The review of the peer reviewed literature highlighted the importance of emissions from combustion engines used in HF as emission sources in various inventories, indicating the need to measure CO, NO_x, VOCs and PM. In addition the peer reviewed literature provided suggestions for tools that can be used to distinguish the contribution of CSG activities from background influences e.g. iso-pentane/n-pentane ratios and the relationship between C9 aromatics and ethene with ethyne may enable the distinction between CSG and vehicle sources.

The report identifies the key pollutants that should be measured as part of the proposed study design. The information presented in this report has been used to devise the study design presented in Task 4.



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Task 3

TASK NAME: Review of state of the knowledge about the potential sources of surface water, groundwater and soil pollutants associated with CSG extraction using HF

TASK LEADER: Simon Apte

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND: The review will investigate the different processes involved in HF and for each process identify activities (e.g. use of chemicals, combustion etc) with the potential to release contaminants to the water or soil.

The review will draw heavily on the previous work of the team including literature reviews (on Geogenic and Hydraulic fracturing Chemicals), Risk Assessment work (NICNAS), Deep Groundwater (CSIRO) projects and existing air, water and gas composition data collected as part of GISERA Surat Basin ambient air quality study (CSIRO), where the project team has been involved over last three years. In addition, previous studies of community concerns around hydraulic fracturing will be consulted in order to account for these aspects when designing a comprehensive surface water, groundwater and soil quality study.

Note that review of industry data pre-fracking surface water, groundwater and soil quality will be carried out as part of Task 7.

This review will be used to inform the design of the monitoring program (Task 5).

TASK OBJECTIVE: To review of state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using HF

TASK OUTPUTS: A report summarising the familiarisation visit and implications for the study design

SPECIFIC DELIVERABLES: Report on state of the knowledge about the potential sources of surface water, groundwater and soil contaminants associated with CSG extraction using HF

PROGRESS REPORT:

This task is 100% complete

This report describes a site familiarisation visit to the Varidel property, Combabula, QLS. This activity was part of a study of the potential impacts of hydraulic fracturing on air, soil and water quality in the vicinity of coal seam gas well sites. The study is to be conducted at two locations in the Surat Basin, Queensland and will involve the collection of samples of surface waters, groundwater, fluids from the hydraulic fracturing (HF) operations, produced water and soils. The majority of the sampling activities will be conducted between August 2017 and early 2018. Sampling locations and the timing of sampling will be finalised through consultation with Origin Energy (the gas field operators) during the next stage of project development.

The visit involved visiting the Reedy Creek integrated operations centre (IOC) and making arrangements for access to laboratory facilities for use in sample processing. A site inspection of the Varidel property was then undertaken. The locations visited included various well pads, the air quality monitoring station and a general tour of the property. This information will be used to identify sampling sites on the Varidel property and also help assist field work logistics and planning.



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Task 4

TASK NAME: Study design for a measurement program to provide enhanced information of the impacts of HF on air quality.

TASK LEADER: Erin Dunne

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND: Based on the occurrence, environmental fate, toxicity profiles of the chemicals described in the Review produced in Task 2, a suite of target compounds will be identified for the monitoring study. In doing so, the guiding principle will be to represent different classes of chemicals rather than covering every possible compound that may naturally be present in the air given the practicalities of being able to measure the compound.

The HF process and therefore the recipe of HF fluid is continuously changing. The suite of target compounds selected for the monitoring study will be guided by the current practices of the industry and will be finalised in consultation with the industry.

The study design will be peer reviewed.

TASK OBJECTIVE: To design a measurement program that will produced information of the impacts of HF on air quality.

TASK OUTPUTS: Report detailing the design of a measurement program that will produced information of the impacts of HF on air quality.

SPECIFIC DELIVERABLES: Report detailing the design of a measurement program that will produced information of the impacts of HF on air quality.

PROGRESS REPORT:

This task is 100 % complete.

This report presents a methodology for an air quality study to investigate the impacts of hydraulic fracturing (HF) activities on local air quality in the vicinity of HF operations. The methodology comprises a suite of measurements of atmospheric gaseous and particle species to be undertaken before, during and after HF at a selected site in the Surat Basin. The aim of the proposed methodology is to satisfy the overall study objectives:

Objective 1: Quantify enhancements in air pollutant levels above background that occur during HF operations.

Objective 2: Provide information on the contribution of HF and non-HF-related sources of air pollutants to local air quality at the selected study site.

Objective 3: Provide comparisons of the air quality observed at a HF site with Australian federal and state air quality objectives, as well as data from other air quality studies undertaken in areas not directly impacted by HF operations both within the Surat Basin and in other locations in Australia.

The study location is a farmland property of approximately 600 ha. Roma, the largest nearby population centre is located approximately 80 km to the SSW. The property contains 10 coal seam gas wells, grid spaced at ~600-800 m intervals. The wells are operated by Origin Energy Resources Pty Ltd and were drilled and constructed in 2017 targeting the Walloon Coal Measures. All 10 wells are scheduled to undergo HF sometime between August and September 2017.

The measurement methodology is presented as two parts: two fixed air quality monitoring stations (AQMS) located within the HF field, and five battery-powered perimeter monitoring stations located

around the boundary of the property (perimeter monitoring sites). A three-tier hierarchy of air quality monitoring methods was established. If an air quality monitoring method was not available from the first tier, a subsequent tier was used.

Tier 1: Australian Standard methods as outlined in Schedule 3 of the Ambient Air Quality and Air Toxics NEPMs (NEPM 2011, 2015).

Tier 2: Appropriate internationally recognised methods or standard techniques.

Tier 3: Non-standard methods with appropriate calibration and validation procedures to assess their accuracy and precision. Validation of Tier 3 measurements against Tier 1 and 2 methods will be undertaken where possible.

The proposed sampling and analysis methodologies provide a measurement of all air pollutants listed in the National Environment Protection Ambient Air Quality and Air Toxics Measures as well as mercury and hydrogen sulphide listed in the Queensland Government EPP air objectives and radon listed in the ARPANSA recommendations. Additional species were included if the species was detected in measurements of air at the proposed study site; and/or the species may have a potentially negative impact on air quality; and/or the species can be used as a tracer providing information on the sources of other potential air pollutants at the study site; and/or the species was reported or detected as present in HF chemicals, flow-back fluids, CSG at the proposed study site.

The report provides details of the sampling and analysis methodologies, the sampling plan and how the data collected will be used to address the objectives of the study.

The outcomes of the project will be communicated to stakeholders (including industry, government and community) utilising the GISERA (Gas Industry Social and Environmental Research Alliance) communication and outreach facilities. Accompanying on-line report publication, communication of the results of this study is likely to include media interviews, information videos and fact sheets available on the GISERA website (gisera.org.au), and the sharing of this content on social media platforms.

Task 5

TASK NAME: Study design for a measurement program to provide enhanced information of the impacts of HF on water and soil quality.

TASK LEADER: Simon Apte

OVERALL TIMEFRAME: 1 February 2017 to 30 April 2017

BACKGROUND: Based on the occurrence, environmental fate, toxicity profiles of the chemicals described in the Review produced in Task 2, a suite of target compounds will be identified for the monitoring study. In doing so, the guiding principle will be to represent different classes of chemicals rather than covering every possible compound that may naturally be present in the water and soil given the practicalities of being able to measure the compound.

The HF process and therefore the recipe of HF fluid is continuously changing. The suite of target compounds selected for the monitoring study will be guided by the current practices of the industry and will be finalised in consultation with the industry.

The study design will be peer reviewed.

TASK OBJECTIVE: To design a measurement program that will produced information of the impacts of HF on water and soil quality.

TASK OUTPUTS: Report detailing the design of a measurement program that will produced information of the impacts of HF on water and soil quality.

SPECIFIC DELIVERABLES: Report detailing the design of a measurement program that will produced information of the impacts of HF on water and soil quality.

PROGRESS REPORT:

This task is 100% complete.

This document outlines a water and soil monitoring plan which underpins a study of the potential impacts of hydraulic fracturing on air, soil and water quality in the vicinity of coal seam gas well sites. The study is to be conducted at two locations in the Surat Basin, Queensland and will involve the collection of samples of surface waters, groundwater, and fluids from the hydraulic fracturing (HF) operations, produced water and soils.

The collection of 113 water samples and 40 soil samples is planned, with these samples undergoing 22 analytical procedures to determine the concentration of more than 150 potential contaminants including organics, inorganics and radionuclides. The number of samples for each category was dictated by the site conditions (number of wells, surface water bodies) as well as time and resource constraints. The list of contaminants for analysis was developed following a review of recent relevant published literature on CSG operations and covers both inorganic and organic chemicals (including those occurring naturally (geogenic)) that may be potential contaminants of soil and waters.

The majority of the sampling activities will be conducted between July 2017 and early 2018. Sampling locations and the timing of sampling will be finalised through consultation with Origin Energy (the gas field operators) during the next stage of project development. It is anticipated that refinements to the sampling plan will be made as the project progresses and water and soil quality information is accumulated.

CSIRO staff will make a number of site visits during the course of the study in order to: (a) undertake specialist sampling; (b) oversee sampling of operations conducted by contractors; and (c) gain familiarity with the study sites.

Given the unpredictable nature of spills, field sampling of spill-impacted soils was not deemed feasible. Hence a laboratory scenario study was preferred. The scenario-based study will involve exposing soil samples representative of the different soil types from across the region, to HF fluids and flowback waters. The degradation and stability of the added contaminants over time will then be measured. Biological indices such as respiration and nitrification will also be measured to provide key information on the consequences of chemical spills on soil quality, broadly defined as the continued capacity of soil to function as a vital living ecosystem that sustains plants, animals, and humans. Only a part of soil quality assessments, viz. microbiological functions, was feasible in this project.

The outcomes of the project will be communicated to stakeholders (including industry, government and community) utilising the GISERA (Gas Industry Social and Environmental Research Alliance) communication and outreach facilities. Accompanying on-line report publication, communication of the results of this study is likely to include media interviews, information videos and fact sheets available on the GISERA website (gisera.org.au), and the sharing of this content on social media platforms.

Task 6

TASK NAME: Analysis of measurements of air before HF commenced (October 2016 to April 2017)

TASK LEADER: Erin Dunne

OVERALL TIMEFRAME: 1 May 2017 to 30 June 2017

BACKGROUND:

In October 2016 Origin Energy secured the permission of landholders, and engaged SGS Leeder to undertake passive monitoring of VOCs and H₂S at the proposed study site. In addition, Origin Energy is currently in final negotiations with Ecotech for the provision of a fixed air quality monitoring station (AQMS) also to be located at the study site. CSIRO O & A visited the proposed study sites in October 2016 and provided advice and oversight on the selection of sites for the VOC monitoring and AQMS. In addition to providing important baseline air quality data for the project, the AQMS and VOC monitoring will also provide significant additional data to the current GISERA Surat Basin Ambient Air Quality Study and vice versa.

These data sets provide information on baseline air composition before the commencement of HF in the study region.

TASK OBJECTIVE: To analyse and summarise air quality data (passive and AQMS) measured near the study site before commencement of HF activity.

TASK OUTPUTS: Report summarising air quality data (passive and AQMS) measured near the study site before commencement of HF activity.

SPECIFIC DELIVERABLES: Report summarising air quality data (passive and AQMS) measured near the study site before commencement of HF activity.

PROGRESS:

This task is 100% complete

A study of the ambient concentrations of a range of VOCs, aldehydes and hydrogen sulphide by Radiello passive sampling methods was undertaken at a site within a region of intensive Coal seam gas (CSG) production in the Surat Basin in Queensland from October 2016 to September 2017

Samples were collected at 7 locations within a property where 18 CSG wells underwent Hydraulic Fracturing (HF) treatments in late 2016 and mid-2017. Sampling occurred during HF periods as well as periods when HF was not occurring. There was a range of well development operations occurring at the study site during the measurement period including well integrity testing, perforation, HF site set-up, HF treatment, and well completions. It was not uncommon to observe several different activities well development, occurring simultaneously across different well pads.

Samples were exposed for ~14 days each and were likely to have been impacted by multiple emissions from multiple well development activities including HF as well as sources natural (e.g. smoke, vegetation) and other man-made sources (e.g. vehicles, industry, agriculture) of VOCs, aldehydes and H₂S from the surrounding area.

The maximum concentrations for all 22 compounds detected at the HF study sites during this study were tens to thousands of times below National (NEPM) and State (EPP) long-term (annual) air quality guidelines, and international air quality guidelines (Texas AMCV/ESL) referenced here. The maximum concentrations of the NEPM air toxics benzene, toluene, and xylenes measured at the HF study site were tens to thousands of times lower than their respective NEPM monitoring investigation levels. Only 24-hour goals are specified for formaldehyde in the Air Toxics NEPM and

the Radiello data reported levels of these pollutants cannot be assessed against these short-term guidelines. Instead the data, which had a maximum of 2.12 ppb, was compared against the annual Texas AMCV value for formaldehyde of 9ppb. There were 32 compounds including H₂S, that were not reported above the DL at the HF sites on any occasion and the maximum DLs for these compounds were tens to thousands of times lower than their relevant air quality guideline values.

Data from the HF study site were compared data with from 6 other sampling sites operated as part of the Surat Basin Ambient Air Quality (SBAAQ) Study (Lawson et al., 2017). Overall, the range of concentrations and detection frequencies observed for each compound at the HF site were similar to those observed at regional (>10km from CSG infrastructure) and other gas field sites which were not known to be directly impacted by HF activities, and were also equal to or less than those observed in the township of Chinchilla. The exceptions to this are described in detail in the report which also includes detailed analysis of the concentrations of the NEPM air toxics benzene, toluene, xylenes and formaldehyde and the potential factors that may have contributed to their observed concentrations during HF at the study site is presented in the report.

In summary, measurements of VOCs and aldehydes by passive Radiello monitoring at a HF site reported levels that were well below national, state and relevant international annual ambient air quality guidelines which are designed to protect human health, wellbeing and the environment, and were similar to those measured at other regional and gas field locations in the Surat Basin not known to be directly impacted by HF during the measurement period. While a regional smoke event was most likely responsible for a small peak in benzene concentrations, there was some indication that local sources including well development activities on site may have been associated with occasional peaks in the 14-day average concentrations of toluene, xylenes, ethylbenzene and formaldehyde, as well as higher concentrations and/or detection frequencies of propanal, butanal, n-undecane, and ethyl acetate. However the specific sources of these compounds remain unresolved. Further work to better understand the factors that influence the concentration of VOCs and aldehydes in the atmosphere during well development activities and the impact of HF on air quality more broadly is underway. VOCs and aldehydes are only one group of compounds that are relevant to air quality. The National Environment (ambient air quality) Protection Measure, like the air toxics NEPM, prescribes air quality objectives for several other air pollutants including carbon monoxide (CO), oxides of nitrogen (NO_x), ozone (O₃), sulphur dioxide (SO₂), airborne particles (PM) and lead (NEPM 2016).

Task 7

TASK NAME: Analysis of measurements of water and soil made before HF commenced (October 2016 to April 2017)

TASK LEADER: Simon Apte

OVERALL TIMEFRAME: 1 May 2017 to 30 June 2017

BACKGROUND:

In October 2016 Origin Energy secured the permission of landholders, and engaged SGS Leader to undertake surface and groundwater sampling in the vicinity of the proposed study sites which will supplement previous data collected by Origin.

These data sets provide information on baseline water and soil composition before the commencement of HF in the study region.

TASK OBJECTIVE: To analyse and summarise water and soil data collected near the study site before commencements of HF activity.

TASK OUTPUTS: A report summarising water and soil data collected near the study site before commencement of HF activity.

SPECIFIC DELIVERABLES: Report summarising water and soil data collected near the study site before commencement of HF activity.

Variation request to task 7

Request: change of scope to the collection of baseline soil and water samples at Combabula and a reference stream location and change of milestone date to 30 September 2017.

Reason: HF commences in the Condabri field in July, so collection of baseline samples from the Condabri reference stream and Combabula needs to occur in June, which is before the Phase 2 contracts are likely to be in place.

Revised Output: A report summarising water and soil data collected near the study site before commencement of HF activity.

PROGRESS: PROGRESS:

This task is 100% complete.

The aims of the water and soil study are as follows:

- I. To quantify the impacts of HF operations on the concentrations of contaminants in nearby surface waters, groundwater and soils.
- II. To assess the concentrations of HF chemicals and geogenic contaminants in flowback and produced waters resulting from CSG HF operations.
- III. To check compliance of contaminant concentrations in the collected water and soil samples with relevant Australian water and soil quality guidelines.
- IV. To conduct a laboratory assessment of various spill scenarios involving spillage of hydraulic fracturing fluid and produced waters onto various soils types representative of the Surat Basin.

During the planning phase of the study, two sites were selected in the Surat Basin at Condabri and Combabula. Both gas fields are operated by Origin Energy. A sampling and monitoring plan for waters and soils was subsequently developed (Apte et al. 2017).

In October 2016, Origin Energy secured the permission of landholders, and engaged SGS Leeder to undertake surface and groundwater sampling in the vicinity of the proposed study sites. The collected water samples were then analysed for a comprehensive range of inorganic and organic contaminants. The generated data sets provide useful information on baseline water quality before the commencement of HF in the study region.

This report provides a collation of the monitoring data and gives some preliminary interpretation of the data. The datasets will be used as an aid to interpret the results generated by the main part of the study which involves comprehensive sampling of surface waters and groundwater during and after HF operations.

The main findings were:



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1. Water samples collected from Dogwood Creek in October 2016, the major surface water feature draining the Condabri study site, indicated the Creek water was turbid and slightly alkaline. The water samples were monitored for 141 organic contaminants, all were below the limits of detection. Most trace metal concentrations were in the low $\mu\text{g/L}$ range.
2. Groundwater samples collected from the Combabula study site in April 2017 indicated the bore water was alkaline and of low hardness. The water samples were monitored for 41 organic contaminants (e.g. BTEX, TRH, PAH) and all were below the limit of detection aside from ethanol (2 mg/L). Ethanol is an unlikely groundwater contaminant and this result is believed to be in error (e.g. resulting from sample contamination). No exceedances of any water quality guidelines were detected.



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