Research project plan

Proforma 2011

1. Short Project Title (less than 15 words)

Project 4: Geochemical baseline monitoring

Long Project Title	Monitoring of geochemical and isotopic characteristics of CSG formation waters, adjacent aquifers and springs
GISERA Project Number	W4 1114
Proposed Start Date	July 2011
Proposed End Date	June 2014
Project Leader	Fred Leaney

2. GISERA Research Program

☐ Biodiversity Research ☐ Marine Research ☐ Land Research

☒ Water Research ☐ Social & Economic Research

3. Research Leader, Title and Organisation

Fred Leaney
Research Scientist
CSIRO Land and Water

4. Summary (less than 300 words)

This project is aimed at: (i) a comprehensive geochemical and isotopic characterisation of groundwater and formation water within the proposed CSG extraction area prior to development; (ii) developing protocols for monitoring aquifers and formation water over the time period of extraction and post-development and; (iii) establishing a set of criteria for ongoing assessment of the monitoring program and implications for aquifer interactions.

A practical aim of the project is to provide a means of monitoring the progress and impact of large scale pumping and to inform potential modification of the pumping process to minimise potential impacts on spring-fed or base flow ecosystems.

5. Budget Summary (From Excel Budget Pack worksheet "Project Plan Summary")

Expenditure	2011/12 Year 1	2012/13 Year 2	2013/14 Year 3	2014/15 Year 4	Total
Labour	106,399	208,837	124,414		439,650
Operating	48,403	101,000	78,000		227,403
Total Costs	**154,802**	**309,837**	**202,414**		**667,053**
CSIRO	154,802	309,837	202,414		667,053
Total Expenditure	**154,802**	**309,837**	**202,414**		**667,053**

Expenditure per Task	2011/12 Year 1	2012/13 Year 2	2013/14 Year 3	2014/15 Year 4	Total
Task 1	112,058	113,101	90,525		315,684
Task 2	42,744	122,412			165,156
Task 3		74,324	111,889		186,213
Total Expenditure	**154,802**	**309,837**	**202,414**	**-**	**667,053**

Cash Funds to Project Partners	2011/12 Year 1	2012/13 Year 2	2013/14 Year 3	2014/15 Year 4	Total
CSIRO	123,841	247,870	161,931		533,642
Sub Total	123,841	247,870	161,931		533,642
Total Cash to Partners	**123,841**	**247,870**	**161,931**		**533,642**

Source of Cash Contributions	2011/12 Year 2	2012/13 Year 3	2013/14 Year 4	2014/15 Year 5	Total
Australia Pacific LNG	123,841	247,870	161,931		533,642
Total Cash Contributions	**123,841**	**247,870**	**161,931**		**533,642**

In-Kind Contribution from Partners	2011/12 Year 1	2012/13 Year 2	2013/14 Year 3	2014/15 Year 4	Total
CSIRO	30,961	61,967	40,483		133,411
Total In-Kind Contribution from Partners	**30,961**	**61,967**	**40,446**		**133,411**

	Total funding over all years	Percentage of Total Budget
Australia Pacific LNG Investment	533,642	80%
CSIRO Investment	133,411	20%
Total Other Investment		
TOTAL	**667,053**	**100%**

Task	Milestone Number	Milestone Description	Funded by	Participant Recipient	Start Date (mm-yy)	Delivery Date (mm-yy)	Fiscal Year	Fiscal Quarter	Payment $
Task 1	1.1	Sampling protocols and conceptual model completed	GISERA	CSIRO	Sept-11	Jun-12	2011/12	Q 4	154,802
Task 2	2.1	Report on isotopic and geochemical distributions including maps and depth profile	GISERA	CSIRO	Jul-12	Jun-13	2012/13	Q 4	309,837
Task 3	3.1	Final report incorporating all geochemical data and integration with hydraulics and inferred impacts on groundwater flow systems and spring discharge	GISERA	CSIRO	Jul-13	Jun-14	2013/14	Q 4	202,414

6. Other Researchers (include organisations)

Researcher	Time Commitment	Principle area of expertise	Years of experience	Organisation
Fred Leaney	0.37 FTE over 3 years	Project leader, isotope hydrology sampling and analysis	30+	CSIRO
Leif Wolf	0.15 FTE over 3 years	GISERA integration, project management & capacity building	15+	CSIRO
Axel Suckow	0.75 FTE over 3 years	Groundwater modelling incorporating isotope hydrological data	25+	CSIRO
Phil Davies	0.15 FTE over 3 years	GIS support	15+	CSIRO

7. GISERA Objectives Addressed

Research that improves and extends knowledge of environmental impacts and opportunities of CSG-LNG projects, enabling the CSG-LNG industry to better meet the expectations of relevant communities and the broader public.

Informing government, regulators and policy-makers on key issues regarding policy and legislative framework for the CSG-LNG industry.

8. Program Outcomes Achieved

The outcomes of this project will provide a baseline of the isotope/hydrochemistry of the groundwater and thereby provide a means of monitoring the impact of large scale pumping. If necessary, this can inform potential modification of the pumping process to minimise possible impacts on spring-fed or base flow ecosystems. This will help inform government regulators and policy makers on the potential for detrimental environmental outcomes as a result of CSG development in the region.

9. Program Outputs Achieved

Details are provided in *Section 13. Project Objectives and Outputs.*

10. What is the knowledge gap that these research outputs will address?

The main knowledge gap that this project will address is an improved understanding of the current groundwater flow systems and potential for inter-aquifer leakage.

11. How will these Research outputs and outcomes be used in State Government and other water managers to achieve Adaptive Management of Water Resources?

The research outputs and outcomes will help to inform government, regulators and policy-makers on key issues regarding policy and legislative framework for the CSG-LNG industry, particularly in the area of water quality in aquifers as a result of pumping large quantities of water from coal seams. The project will improve understanding of the current groundwater flow systems and potential for inter-aquifer leakage.

12. Project Development (1 page max.)

The project was developed after consultation with key Australia Pacific LNG staff that identified the need for a better understanding of current groundwater residence time and inter-aquifer leakage. This would enable early identification of changes to the hydrological system as a result of pumping large volumes of groundwater.

This project will utilise the groundwater dating and "fingerprinting" tools available in the field of isotope hydrology to support or refute the current conceptual model and constrain estimates of groundwater flow and potential for inter-aquifer leakage.

13. Project Objectives and Outputs

Year 1: A set of sampling protocols for baseline monitoring of geochemical and isotopic parameters in groundwater and surface water systems. Qualitative conceptual model of groundwater flow systems inferred from geochemistry and hydraulics.

Year 2: Initial maps and depth distribution of geochemical and isotopic characteristics. Report on interpretation of geochemical and isotopic data in the hydrogeological framework.

Year 3: Final report including: assessment of changes in geochemistry of key aquifer systems, criteria for assessment of changes to groundwater flow dynamics and assessment of changes to discharge to surface water systems.

14. Project Plan

14.1. Project Schedule

ID	Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
1	Sampling protocols and conceptual model completed	Fred Leaney	Sept 2011	End June 2012	
2	Report on isotopic and geochemical distributions including maps and depth profile	Axel Suckow	July2012	June 2013	
3	Final report incorporating all geochemical data and integration with hydraulics and inferred impacts on groundwater flow systems and spring discharge	Axel Suckow	July 2013	June 2014	

14.2. Task Name

See section 14.1. *Project Schedule*.

14.3. Task Leader

See section 14.1. *Project Schedule*.

14.4. Overall Timeframe

See section 14.1. *Project Schedule*.

14.5. Background

The pumping of formation water to facilitate CSG extraction from the Great Artesian Basin (GAB) will likely lead to entrainment and mixing of water from adjacent aquifers. The decrease in pressure from production wells may also affect discharge of deep groundwater to surface water systems and springs. Understanding the source and flux of water involved in these processes can be traced using distinct signatures of various end-member compositions to distinguish pathways and interactions that cannot be done through conventional hydrological monitoring.

Most effectively monitoring the evolution of these processes requires some a priori baseline sampling so that end-member compositions can be well characterised and to develop the most suitable suite of environmental tracers that can meet the criteria for ongoing monitoring. The ideal tracers are those that are conservative and do not react significantly with the aquifer solid matrix (e.g., 2H/1H, 18O/16O, Cl-, Br-, noble gases – Herczeg and Edmunds, 2000; Coplen et al, 2000; Stute, et al., 2000). There are other tracers that have well defined geochemical characteristics that can be used to distinguish the CSG formation water and production water (e.g., major and minor ions, 13C of DIC, 34S of SO4, 87Sr/86Sr, 37Cl/35Cl, and 226Ra). Furthermore, the use of age tracers such as 14C, 36Cl, 4He would also be an important component in establishing groundwater residence time and changes in the relative contribution of short and long flow-paths at various sites.

The age distribution of various aquifers and formation waters will likely evolve in response to pumping and depressurisation within and adjacent to CSG target sites. Careful monitoring at discrete depth intervals and appropriate spatial scale will allow assessment of altered groundwater flow systems, and the extent of entrainment of "old' formation water into the main aquifer systems.

14.6. Task Objectives

Task 1: Develop and demonstrate protocols to Australia Pacific LNG staff for sampling of formation water during drilling, and sampling groundwater and surface water. Meet with Australia Pacific LNG to discuss current conceptual model and decide on which environmental tracers to measure (i.e. those likely to be commensurate with groundwater ages and likely to give differentiation between different aquifers)

Task 2: Undertake analyses and present data in a report with maps and depth profiles where applicable. Interpret initial data set and use a combination of spatial patterns, geochemical, and isotopic and geochemical model such as PHREEQC2 to evaluate data in forward and inverse modelling framework.

Task 3: Incorporate all geochemical data and integration with hydraulics and inferred impacts on groundwater flow systems and spring discharge

14.7. Task Outputs

Task 1: Protocols demonstrated to Australia Pacific LNG staff to enable them to carry out sampling without CSIRO supervision. Conceptual model of groundwater flow to be shared and types of analyses to be undertaken decided.

Task 2: Analyses completed and data presented in a report with maps and depth profiles where applicable.

Task 3: Report incorporating all geochemical data and integration with hydraulics and inferred impacts on groundwater flow systems and spring discharge.

14.8. Specific Deliverables

Two reports as per section 14.7.

15. Budget Justification

The budget for this project has been approved by GISERA's Research Advisory Committee and Management Committee.

- Provision of background data for discussions regarding potential bores available for sampling groundwater samples from the different aquifers and (where possible) aquicludes.
- Collection and submission of samples for analysis.
- Detailing current conceptual model(s) for groundwater flow and inter-aquifer leakage (results from isotope hydrology studies to confirm/refute).
- Feedback on revised conceptual model(s) for groundwater flow/inter-aquifer leakage.

16. Project Governance

A project reference panel will be established. Twice a year, project meetings with Australia Pacific LNG and CSIRO staff will be held. Once a year, the project reference panel will be consulted. Modifications of the work plan may be discussed at these meetings.

Progress against milestones and tasks will be assessed twice a year within project meetings and reported in the minutes of these meetings. Beyond that, standard procedures defined in the overall GISERA management framework will be applied.

Users of the research output will be involved via the project reference panel.

17. Communications Plan

General communication will be managed by GISERA.

The pathway to impact for this project includes:

- This project will utilise isotope hydrology and "fingerprinting tools" to determine the age of groundwater for a large number of samples taken from the GAB. This is critical to understanding groundwater flow mechanisms in a system where water level measurements are only available for a few decades at best, but groundwater residence times are up to one million years.

- This project will establish a critical baseline dataset before large scale groundwater pumping occurs as part of CSG development.
- This project will produce primary data to assess the potential for inter-aquifer leakage.
- This project will help inform government regulators and policy makers on the potential for detrimental environmental outcomes as a result of CSG development in the region.
- Direct technical cooperation with the industry experts in the planning of sampling locations, the collection of samples and the analysis of the results ensures effective knowledge transfer.
- Other industry experts (Santos, Arrow, QGC) are in the process of conducting similar sampling campaigns and have indicated their interest in participating in this work in the near future. They process samples at the CSIRO Adelaide laboratories, which are unique in Australia in terms of the capabilities in isotope hydrology. A scientific interpretation framework developed as part of the current project will be of high value to other industry partners. Avenues for collaboration will continue to be pursued. By this means, the work is poised to extend its impact to the CSG-LNG industry as a whole, across a broader commercial and geographic base.
- For broader public benefit, stakeholder workshops with government agencies, interested communities and GISERA representatives will be organised.
- The results will be disseminated at national and international conferences as well as a number of peer reviewed journal papers.
- PhD students will be integrated into the work program to allow for direct capacity building. The research group in Adelaide is heavily involved in teaching for the National Centre for Groundwater Research and Training (NCGRT) at Flinders University.

18. Risks

At this stage no major risks particular to this project are foreseen.

19. Intellectual Property and Confidentiality

Background IP (clause 10.1, 10.2)	**Party**	**Description of Background IP**	**Restrictions on use (if any)**	**Value**
	CSIRO	CSIRO has IP insofar as accumulated experience and technical knowledge of undertaking such studies at a regional scale. These studies are published in the public domain.		
Ownership of Non-Derivative IP (clause 11.3)	As per head agreement			
Confidentiality of Project Results (clause 15.6)	Not confidential			
Additional Commercialisation requirements (clause 12.1)	Not Applicable			

<table>
<tr><td rowspan="1">Distribution of Commercialisation Income (clause 1.1)</td><td colspan="2">Not applicable</td></tr>
<tr><td rowspan="3">Commercialisation Interest (clause 1.1)</td><td>Party</td><td>Commercialisation Interest</td></tr>
<tr><td>Australia Pacific LNG</td><td></td></tr>
<tr><td>CSIRO</td><td></td></tr>
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