Project Order, Variations and Research Progress

Project Title: Designing combined farming-gas enterprises to minimise costs and maximise benefits

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

1 Original Project Order

Project Order
Proforma 2011

1. Short Project Title (less than 15 words)

Project 3 – Gas-farm design

Long Project Title	Designing combined farming-gas enterprises to minimise costs and maximise benefits.
GISERA Project Number	A3 1215
Proposed Start Date	July 2012
Proposed End Date	Dec 2015
Project Leader	Neil Huth

2. GISERA Research Program

☐ Biodiversity Research ☐ Marine Research ☒ Land Research

☐ Water Research ☐ Social & Economic Research

3. Research Leader, Title and Organisation

Neil Huth
Senior Research Scientist
CSIRO Ecosystem Sciences

4. Summary (less than 300 words)

Some of the Darling Downs's farms will require change to provide layouts that enhance profit and sustainability as they transition from farming to mixed gas-farm enterprises. Modern farming has evolved layouts and practices designed to derive maximum long-term value from the soils and climate of the northern grains region. Techniques such as controlled traffic and conservation tillage, for example, have been developed to maintain soil

structure in heavy clay soils, increase storage of water from variable rainfall and, as a result, increase productivity. In many cases farm design, including the size and layout of paddocks, positioning of irrigate on infrastructure and farm roadways, and the purchase, adjustments to, and standardisation of farm machinery have all been designed to better facilitate modern farming best practice. The incorporation of gas infrastructure into such a farming landscape, and opportunities that may flow from this, will require efforts to design a farm that can best support a new mixed land use. Design rules will need to be developed to match the needs of a range of agricultural enterprises including dry land cropping, irrigated cropping, grazing or mixed farming.

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

Expenditure	2012/13 Year 1	2013/14 Year 2	2014/15 Year 3	2015/16 Year 4	2016/17 Year 5	Total
Labour	96,834	190,958	168,183	33,354		489,329
Operating	28,000	60,000	50,000	24,000		162,000
Total Costs	**124,834**	**250,958**	**218,183**	**57,354**		**651,329**
CSIRO	124,834	250,958	218,183	57,354		651,329
Total Expenditure	**124,834**	**250,958**	**218,183**	**57,354**		**651,329**

Expenditure per Task	2012/13 Year 1	2013/14 Year 2	2014/15 Year 3	2015/16 Year 4	2016/17 Year 5	Total
Task 1 Task 2 Task 3 Task 4 Task 5	124,834	250,958	218,183	57,354		651,329
Total Expenditure	**124,834**	**250,958**	**218,183**	**57,354**		**651,329**

Cash Funds to Project Partners	2012/13 Year 1	2013/14 Year 2	2014/15 Year 3	2015/16 Year 4	2016/17 Year 5	Total
CSIRO	79,880	166,880	145,160	43,000		434,920
Total Cash to Partners	**79,880**	**166,880**	**145,160**	**43,000**		**434,920**

Source of Cash Contributions	2012/13 Year 1	2013/14 Year 2	2014/15 Year 3	2015/16 Year 4	2016/17 Year 5	Total
Australia Pacific LNG	79,880	166,880	145,160	43,000		434,920
Total Cash Contributions	**79,880**	**166,880**	**145,160**	**43,000**		**434,920**

In-Kind Contribution from Partners	2012/13 Year 1	2013/14 Year 2	2014/15 Year 3	2015/16 Year 4	2016/17 Year 5	Total
CSIRO	44,954	84,078	73,023	14,354		216,409
Total In-Kind Contribution from Partners	**44,954**	**84,078**	**73,023**	**14,354**		**216,409**

	Total funding over all years	Percentage of Total Budget
Australia Pacific LNG Investment	434,920	66.7%
CSIRO Investment	216,409	33.3%
Total Other Investment		
TOTAL	**651,329**	**100%**

Task	Mile-stone Number	Milestone Description	Funded by	Participant Recipient	Start Date (mm-yy)	Delivery Date (mm-yy)	Fiscal Year	Fiscal Quarter	Payment $
Task 1	1.1	Initial Team Meeting	GISERA	CSIRO	Jul-12	Sep-12	12/13	Quarter 1	19,970
Task 1	1.2	Identify Case Study Sites	GISERA	CSIRO	Oct-12	Dec-12	12/13	Quarter 2	19,970
Task 1	1.3	Initial Literature Review	GISERA	CSIRO	Jan-13	Mar-13	12/13	Quarter 3	19,970
Task 1	1.4	Case Studies Benchmarked	GISERA	CSIRO	Apr-13	Jun-13	12/13	Quarter 4	19,970
Task 1	1.5	Case Study Site Monitoring Commenced	GISERA	CSIRO	Jul-13	Sep-13	13/14	Quarter 1	41,720
Task 1	1.6	Case Study Site Monitoring Complete	GISERA	CSIRO	Oct-13	Dec-13	13/14	Quarter 2	41,720
Task 1	1.7	Analysis of Monitoring Data	GISERA	CSIRO	Jan-14	Mar-14	13/14	Quarter 3	41,720
Task 1	1.8	First farmer discussions	GISERA	CSIRO	Apr-14	Jun-14	13/14	Quarter 4	41,720
Task 1	1.9	Analysis of issues arising from farmer discussions	GISERA	CSIRO	Jul-14	Sep-14	14/15	Quarter 1	36,290
Task 1	1.10	Second iteration of farmer discussions	GISERA	CSIRO	Oct-14	Dec-14	14/15	Quarter 2	36,290
Task 1	1.11	Synthesis of Results	GISERA	CSIRO	Jan-15	Mar-15	14/15	Quarter 3	36,290
Task 1	1.12	Draft Scientific Manuscript	GISERA	CSIRO	Apr-15	Jun-15	14/15	Quarter 4	36,290
Task 1	1.13	Thesis Production (PhD)	GISERA	CSIRO	Jul-15	Sep-15	14/15	Quarter 1	21,500
Task 1	1.14	Thesis Submitted (PhD)	GISERA	CSIRO	Oct-15	Dec-15	15/16	Quarter 2	21,500

6. Other Researchers (include organisations)

Researcher	Time Commitment (project as a whole)	Principle area of expertise	Years of experience	Organisation
Neil Huth	0.6 FTE	Farming Systems Research, Modelling, Trade-off Analysis	>20	CSIRO
Perry Poulton	0.5 FTE	Farming Systems, Modelling, Farmer Engagement	>20	CSIRO
Brett Cocks	0.4 FTE	Field operations, soil characterisation, farmer engagement, agronomic technical support	>15	CSIRO
Justin Fainges	0.35 FTE	Mathematics, programming, data analysis	2	CSIRO

7. GISERA Objectives Addressed

Research that improves and extends knowledge of agricultural and 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 farm managers and gas industry professionals on improved methods for gas-farm design and operation.

GISERA performance indicators addressed in this work include:

- Publication of results
- Involvement of a university local to CSG and LNG activity participating in research projects
- PhD studentship
- Engagement with local gas and agricultural industries.

8. Program Outcomes Achieved

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

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?

Currently there are no clear and publicly available principles to guide the re-design of farm enterprises and operations to include CSG production systems. Nor is there a method for a wide range of farmers and gas developers to pool their design and layout experiences. This impairs the ability to continually improve the capacity to minimise disturbance and to maximise the opportunities from gas development on farms through knowledge sharing and mutual learning as development unfolds. This project will address these knowledge gaps by:

- developing methods for evaluating farm designs and the operations that inform them and emanate from them
- applying these methods to the analysis of the impacts of gas infrastructure and operations on farm layout and operations
- developing design principles for mixed gas-farm enterprises that minimise disturbance and maximise the opportunities from gas development on farms
- applying these design principles to evaluate alternative gas-farm designs for dry land cropping, irrigated cropping, grazing and mixed farming enterprises
- making publicly available principles to guide the design, layout and operation of mixed gas-farm enterprises.

11. How will these Research outputs and outcomes be used by farmers or the CSG-LNG industry?

The design principles and lessons from this project will be documented and communicated to the farming and gas industries for use in negotiations and discussions between gas and farm managers before farms undergo redevelopment to include a gas production system. Some of the information may also help farmers to better manage their agricultural enterprise around existing gas production (and other) infrastructure such as roads, pipes and wells. The generic aspects of the work will also enable it to be used to inform farm design and management responses to the emergence of new technologies.

12. Project Development (1 page max.)

The project was developed in consultation between Australia Pacific LNG and CSIRO staff. The proposed activity was discussed with members of various farmer/stakeholder groups and was endorsed as an important research need.

Controlled traffic in combination with conservation tillage has been shown to increase plant available water holding capacity and decrease runoff leading to increased production on clay soils in the northern grains region (Li et al 2001, 2007; Thomas et al 2007). Furthermore, decreased compaction increases the efficiency of other farming operations. Tullberg (2000) demonstrated the reduction in tillage energy which occurs in controlled traffic systems because approximately 50% of a tractor's power output can be dissipated in the process of creating and disrupting its own wheel compaction. As a result, controlled traffic/conservation tillage has been widely adopted across the northern grain belt and farm design has changed to suit it. Similarly, irrigation systems have been carefully designed to minimise deep drainage losses which not only represent an inefficient use of

water, but are also an environmental hazard (Moss et al 2001, Smith et al 2005). Similarly, agronomy has evolved to make better use of available irrigation water supply through better understanding of soils (Dalgliesh et al 2006), crops and crop management (Peake et al 2008). In these various ways, farming and farm designs have evolved to suit best practice in addressing important issues.

Gas-farms will need to be designed to address a wider range of needs. The need to design farms to suit different needs from mixed enterprises is not new. In particular, design principles have been pursued for farming systems when landholders have looked to incorporate forestry, carbon sequestration or conservation components into their farm enterprise. House et al (2008) investigated the costs and benefits of various farm designs in case studies looking at integrating natural resource management into farm configuration. House et al (2008) were able to identify threats and mitigating options, identify opportunities for enhancing farm configuration and explore options to offset financial losses. In a similar way, Huth (2010) explored costs and benefits of various configurations and placement of woodlots on farm and found options which reduced costs by a factor of eight, often without significant loss of other benefits of the trees. Much of the gains here were made by identifying better locations for the new enterprise within the existing farm. These same approaches could be employed to identify farm designs that minimise costs but maximise benefits of a mixed gas-farm enterprise.

The local farming community has also sought ways to increase efficiency in the use of scarce irrigation water supply. In some locations, new water supplies may be available for a period of time due to the development of the coal seam gas industry. The availability of this resource may influence farmers in changing from existing land use strategies but the exact long-term value of this water for various cropping scenarios is unknown. Farming systems models, such as APSIM (Keating et al 2003) can be used to explore these options. This knowledge will also prove invaluable in considering wider gas-farm design issues.

The work builds strongly on past and ongoing research activities of the project team in farming systems research based upon strong stakeholder engagement. Team members are currently involved on cross-disciplinary studies at the farm level in Australia, Asia and Africa. Such a farming "systems focus" will assist in the untangling of issues within a combined gas-farm enterprise.

References

Dalgliesh N, Wockner G, Peake A (2006) Delivering soil water information to growers and consultants. In proceedings of the 13th Australian Agronomy Conference, Perth WA.

House APN, MacLeod ND, Cullen B, Whitbread AM, Brown SD, McLvor JG (2008) Integrating production and natural resource management on mixed farms in eastern Australia: The cost of conservation in agricultural landscapes. *Agriculture Ecosystems & Environment* **127**, 153-165.

Huth, NI (2010) Measuring, modelling and managing tradeoffs in low rainfall agroforestry for Australia's subtropics.. PhD thesis, University of Queensland.

Keating BA, Carberry PS, *et al.* (2003) An overview of APSIM, a model designed for farming systems simulation. *European Journal of Agronomy* **18**, 267-288.

Li YX, Tullberg JN, Freebairn DM (2001) Traffic and residue cover effects on infiltration. *Australian Journal of Soil Research* **39**, 239-247.

Li YX, Tullberg JN, Freebairn DM (2007) Wheel traffic and tillage effects on runoff and crop yield. *Soil & Tillage Research* **97**, 282-292.

Moss, J., Gordon, I.J. and Zischke, R., 2001. Best management practices to minimise below root zone impacts of irrigated cotton. Final report to the Murray-Darling Basin Commission (Project I6064). Department of Natural Resources and Mines, Queensland.

Peake A, Robertson M, Bidstrup R (2008) Optimising maize plant population and irrigation strategies on the Darling Downs using the APSIM crop simulation model. *Australian Journal of Experimental Agriculture* **48**:313-325

Smith RJ, Raine SR, Minkevich J (2005) Irrigation application efficiency and deep drainage potential under surface irrigated cotton. *Agricultural Water Management* **71**, 117-130.

Thomas GA, Titmarsh GW, Freebairn DM, Radford BJ (2007) No-tillage and conservation farming practices in grain growing areas of Queensland - a review of 40 years of development. *Australian Journal of Experimental Agriculture* **47**, 887-898.

Tullberg JN (2000) Wheel traffic effects on tillage draught. *Journal of Agricultural Engineering Research* **75**, 375-382.

13. Project Objectives and Outputs

This project aims to provide a set of design principles for combined gas-farm enterprises as well as tools for evaluating a set of alternative farm designs. Design principles will allow for consideration of the differing issues of dry land and irrigated cropping, grazing or mixed farming systems.

Outputs include:

- A literature review into issues and approaches identified in previous research in gas-farm systems or other multiple enterprise farming systems
- A set of design principles that can be used by farm and gas professional to better design mixed gas-farm systems
- Demonstration of these principles, and methods for evaluating various designs, on a suite of diverse case study farms
- Publications documenting the findings of the surveys, including a list of existing knowledge gaps.

14. Project Plan

14.1 Project Schedule

ID	Task Title	Task Leader	Scheduled Start	Scheduled Finish	Predecessor
1	Initial Team Meeting	Neil Huth	Jul-12	Sep-12	
2	Identify Case Study Sites	Neil Huth	Oct-12	Dec-12	Task 1
3	Initial Literature Review	Neil Huth	Jan-13	Mar-13	Task 2
4	Case Studies Benchmarked	Neil Huth	Apr-13	Jun-13	Tasks 2,3
5	Case Study Site Monitoring Commenced	Neil Huth	Jul-13	Sep-13	Task 4
6	Case Study Site Monitoring Complete	Neil Huth	Oct-13	Dec-13	Task 5
7	Analysis of Monitoring	Neil Huth	Jan-14	Mar-14	Task 6

	Data				
8	First farmer discussions	Neil Huth	Apr-14	Jun-14	Task 7
9	Analysis of issues arising from farmer discussions	Neil Huth	Jul-14	Sep-14	Task 8
10	Second iteration of farmer discussions	Neil Huth	Oct-14	Dec-14	Task 9
11	Synthesis of Results	Neil Huth	Jan-15	Mar-15	Task 10
12	Draft Scientific Manuscript	Neil Huth	Apr-15	Jun-15	Task 11
13	Thesis Production (PhD)	Neil Huth	Jul-15	Sep-15	
14	Thesis Submitted (PhD)	Neil Huth	Oct-15	Dec-15	Task 13

Task 1.

TASK NAME: Initial team meeting

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

TASK OBJECTIVES:

- Establish a project team
- Establish contact with GISERA collaborators
- Refine work plan according to Australia Pacific LNG-CSIRO discussions

SPECIFIC DELIVERABLE: Short report providing information about initial team meeting, established relationships, processes for choice of case study sites.

Task 2.

TASK NAME: Identify case study sites

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

BACKGROUND: Case studies on different farm enterprises will be undertaken to consider the various costs and benefits of various gas-farm designs.

TASK OBJECTIVE: A manageable number of case study farms will be chosen to support research and later discussions. These should include grazing, dry land cropping, and irrigated cropping. The exact number and locations will arise from team discussions, interaction with farming community and gas industry operatives.

SPECIFIC DELIVERABLE: A short report outlining the chosen case study sites and the rationale behind their choice.

Task 3.

TASK NAME: Initial literature review

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

BACKGROUND: An extensive search of the existing literature is always required to avoid duplication of previous work and to accelerate progress.

TASK OBJECTIVE: To collate as much relevant background information on farm, especially gas-farm, design for use in ongoing research. Information should be relevant to the case studies where possible. Information should include design principles, models for evaluating designs, data on gas production, and background information on the agricultural systems of the case study regions.

SPECIFIC DELIVERABLE: A document describing and analysing the relevant findings of the literature review.

Task 4.

TASK NAME: Case studies benchmarked

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

BACKGROUND: Case study sites need to be adequately benchmarked in terms of current or potential agricultural and gas production before alternative scenarios can be evaluated.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A document briefly describing the case study sites in terms of their location, area, history, production and opportunities. If possible this should include maps of enterprise design, soil types, production areas, and areas of environmental significance.

Task 5.

TASK NAME: Case study site monitoring commenced

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: Once benchmarked, further information regarding production, impacts of gas developments, soil types or other issues identified during benchmarking may need to be evaluated via on site measurement and monitoring.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief document describing the measurement and/or monitoring regimes implemented at each case study site.

Task 6.

TASK NAME: Case study site monitoring complete

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: Data from on-farm measurement and monitoring needs to be gathered to allow meaningful exploration of options for gas-farm design. Such monitoring should be almost complete at this time to allow collation of results and analysis for use in later farmer discussions.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A report briefly showing the raw results of the on-farm measurement and monitoring for each of the case study sites.

Task 7.

TASK NAME: Analysis of monitoring data

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: Data from the on-farm measurement and monitoring needs to be analysed and converted into knowledge or simple models/relationships which can be used in the evaluation of alternative gas-farm designs.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A report briefly describing the findings of the case study monitoring and how these data will be used to inform discussions on gas-farm design.

Task 8.

TASK NAME: First farmer discussions

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: The findings of the monitoring and literature review will be used in discussions with case study farmers to explore a preliminary set of gas-farm design principles and likely options for improved gas-farm designs on the chosen farms. Issues (lessons, information gaps, risk and opportunities) identified during these discussions will be documented and will become the basis of further refinement of models and design principles.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report describing the outcomes of the preliminary discussions with the various case study farmers regarding farm design principles.

Task 9.

TASK NAME: Analysis of issues arising from farmer discussions

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Preliminary discussions with farmers will have identified methods for improving or expanding the gas-farm design principles and models used. Work must be undertaken to account for these lessons.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report demonstrating progress toward addressing the concerns or opportunities identified in the preliminary discussions with farmers.

Task 10.

TASK NAME: Second iteration of farmer discussions

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Preliminary discussions with farmers will have identified methods for improving or expanding the gas-farm design principles and models used. Once these have been addressed, a second round of discussions will be undertaken to gauge the effect of further development aimed at these issues.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report demonstrating progress toward addressing the concerns or opportunities identified in the secondary discussions with farmers.

Task 11.

TASK NAME: Synthesis of results

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Case studies completed. The findings from all these efforts need to be synthesised into a coherent set of findings including data, design guidelines and calculated outcomes.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A report briefly outlining the results and lessons learned from the case study sites.

Task 12.

TASK NAME: Draft Scientific Manuscript

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Communication of findings to the scientific community.

TASK OUTPUTS & SPECIFIC DELIVERABLES: Draft manuscript(s) prepared for journal(s) and/or conference proceedings.

Task 13.

TASK NAME: Thesis production (PhD)

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2015/16

BACKGROUND: Final preparation of thesis document will take some time. The exact form of the thesis will depend on arrangements between the student and the university.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report on progress to final thesis production.

Task 14.

TASK NAME: Thesis submitted (PhD)

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2015/16

BACKGROUND: Finalising thesis of PhD student.

TASK OUTPUTS & SPECIFIC DELIVERABLES: PhD thesis and/or publication(s) related to PhD thesis.

15. Budget Justification

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

16. Project Governance

Project management tasks and dissemination activities are specified in *Section 14 Project Plan*.

17. Communications Plan

General communication will be managed by GISERA.

18. Risks

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

Capacity to deliver: all project staff have sufficient experience to lead and supervise the various activities and ascertain the research outcomes. Therefore the impact of unplanned key staff departure is low and could be mitigated.

There are risks inherent with working closely with human research subjects. Though the risks in this project are considered to be low, the project will be managed in accordance with CSIRO Human Research Ethics policies.

19. Intellectual Property and Confidentiality

Background IP (clause 10.1, 10.2)	**Party**	**Description of Background IP**	**Restrictions on use (if any)**	**Value**
Ownership of Non-Derivative IP (clause 11.3)	CSIRO			
Confidentiality of Project Results (clause 15.6)	Project results are not confidential.			
Additional Commercialisation requirements (clause 12.1)	Not Applicable			
Distribution of Commercialisation Income (clause 1.1)	Not applicable			
Commercialisation Interest (clause 1.1)	**Party**		**Commercialisation Interest**	
	Australia Pacific LNG			
	CSIRO			

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
19/04/13	Research project start date delayed; milestone dates require rescheduling	All milestone dates rescheduled to reflect later project start date; timing of milestones relative to start date not altered.	Peter Stone
07/04/16	Anticipated submission date of thesis is September 2016.	Milestone 14 will be pushed back to September 2016 to coincide with PhD student's thesis submission date.	
15/11/16	Submission date of thesis is March 2017.	Milestone 14 will be pushed back to March 2017 to coincide with PhD student's submission date.	

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

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Project Schedule Report

Task 1

TASK NAME: Initial team meeting

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

TASK OBJECTIVES:

- Establish a project team.
- Establish contact with GISERA collaborators.
- Refine work plan according to Australia Pacific LNG-CSIRO discussions.

SPECIFIC DELIVERABLE: Short report providing information about initial team meeting, established relationships, processes for choice of case study sites.

PROGRESS REPORT:

Initial team meeting was conducted in Toowoomba with representatives of the other GISERA agriculture projects also in attendance. Project outline was discussed again, including the rationale for using joint field case study sites across projects for increased efficiency and depth of study. Case study sites will be identified during wider engagement and detailed discussions with farmers in the *Shared Space* project. Case study sites will seek to cover enterprise changes from grazing dominated systems on the Western Downs, to dry land cropping systems in the Dalby region, through to intensive cropping/irrigated systems on the Inner Downs. Some key papers from the literature were presented showing the current leading research in this area as a means of prompting further thinking amongst team members.

Task 2

TASK NAME: Identify case study sites

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

BACKGROUND: Case studies on different farm enterprises will be undertaken to consider the various costs and benefits of various gas-farm designs.

TASK OBJECTIVE: A manageable number of case study farms will be chosen to support research and later discussions. These should include grazing, dry land cropping, and irrigated cropping. The exact number and locations will arise from team discussions, interaction with farming community and gas industry operatives.

SPECIFIC DELIVERABLE: A short report outlining the chosen case study sites and the rationale behind their choice.

PROGRESS REPORT:

Three case study sites have been chosen for deliberations within this project.

(i) An Origin Energy farm south west of Chinchilla. Wells are about to be installed this site and site disturbance and rehabilitation will be monitored during this phase. Monitoring will be undertaken for wells on two soil types (Grey clay and red sand).

(ii)

(iii) The site also has existing wells from two companies with different installation

methods and also has larger water pipelines crossing the property and so there is an opportunity to look at impacts of different part of the gathering system on farm land.

(iv) A private farm west of Dalby. This farm has existing wells and a well-documented history of development and issues by the landholder. This farm is a mixed enterprise of irrigation and dry land cropping and grazing and so has elements indicative of much of the Darling Downs.

(v) Intensive irrigation district near Cecil Plains. This area is yet to be developed for CSG but represents the intensively farmed areas for which well placement may require innovative solutions. This case study area will likely include use discussions of scenarios and data gathered from the other sites given the lack of existing CSG development. This will change if development were to start within the life of this project.

High resolution aerial or satellite data is available for all three sites, and further targeted imagery is being acquired through various channels.

Task 3

TASK NAME: Initial literature review

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

BACKGROUND: An extensive search of the existing literature is always required to avoid duplication of previous work and to accelerate progress.

TASK OBJECTIVE: To collate as much relevant background information on farm, especially gas-farm, design for use in ongoing research. Information should be relevant to the case studies where possible. Information should include design principles, models for evaluating designs, data on gas production, and background information on the agricultural systems of the case study regions.

SPECIFIC DELIVERABLE: A document describing and analysing the relevant findings of the literature review.

PROGRESS REPORT:

Literature review has identified several sources of farm design principles that parallel those required for gas farms. These include wind farms (Europe, Southern and Western Australia), tree farming or agroforestry, or tree plantings for hydrological or ecological benefits (Britain, Europe, and Australia). In these there are principles for placing elements where they minimise costs and maximise benefits. In some studies these are evaluated using GIS, though many use simple distance-from-source measures to provide calculations of total impact. Discussions with farmers (Project 2 – *A Shared Space*) has identified traffic impacts, in particular dust, as a major issue for land holders. There is a great deal of literature on pollution levels away from roadways but there is a great deficiency in the literature about the impact of dust on agriculture. There is only one adequately detailed study from New Zealand and this is now nearly three decades old. There is nothing published within the scientific literature data on crop and pasture production losses due to CSG gathering systems, though there are now some good studies on hydrologic impacts of gas access track networks in Pennsylvania in the USA.

Task 4

TASK NAME: Case studies benchmarked

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2012/13

BACKGROUND: Case study sites need to be adequately benchmarked in terms of current or potential agricultural and gas production before alternative scenarios can be evaluated.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A document briefly describing the case study sites in terms of their location, area, history, production and opportunities. If possible this should include maps of enterprise design, soil types, production areas, and areas of environmental significance.

PROGRESS REPORT:

One case study site has been surveyed prior to well installation. A 2.5ha site, on "Monreagh" farm, encompassing a future gas well site has been mapped using EM38 to look for existing soil variation. Aerial photos of the site, showing management over the past 50 years, have been collated. Soil cores to 1.8m from across the site have been collected for analysis of soil chemical properties and soil profile description. Soil samples have been taken for determining mechanical properties that may affect future damage due to compaction (in conjunction with USQ staff involved in Project 5 – Without a Trace). The location of soil surface features, such as existing contour banks, have also been mapped. Multiple wells were to be studied in this way on this farm. However, logistical problems have resulted in the likely date for well installation to be delayed to 2014. This delay may cause problems for the delivery of this project. Therefore, the decision has been made to divert the rest of our survey effort to sites with existing wells, using a paired-site approach where, rather than studying sites before and after installation, we shall study inside and outside the lease area to look for impacts.

A first paired-site study has been commenced on a farm between Chinchilla and Condamine. EM38 surveys and some mapping of surface conditions are complete for one well site showing soil disturbance impacts on crop production around wells and along pipelines. Analysis of soil properties within and outside the areas of disturbance are being coordinated with collaborators in Project 5. A wider range of paired-site case studies are also being pursued with several landholders. Airborne and satellite imagery is being collated for this same region to allow scaling-up of our findings.

Task 5

TASK NAME: Case study site monitoring commenced

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: Once benchmarked, further information regarding production, impacts of gas developments, soil types or other issues identified during benchmarking may need to be evaluated via on site measurement and monitoring.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief document describing the measurement and/or monitoring regimes implemented at each case study site.

PROGRESS REPORT:

Monitoring at the Monreagh site has not yet proceeded beyond the pre-development survey as drilling at the site has not yet commenced. Development is now estimated for the first quarter of 2014.

Monitoring will be undertaken if this occurs, but results from this may now only be fully realised after the timeframe of this project. Crop monitoring at a nearby mixed cropping-grazing farm was sought (as outlined in the previous milestone report) but results were compromised due to extended drought conditions which resulted in crop failure. Several approaches were made to other landholders in the area regarding monitoring on their properties but these were unsuccessful. To date, CSG development on cropping fields has been limited and identifying further case study sites for which crops have been sown around CSG wells has been difficult. With ongoing dry conditions, the outlook for the coming summer growing season is also mixed. Therefore, an alternate approach is now being sought. Yield data from the Origin property "Lower Heatherly" has been obtained via hand-sampling of small plots, each of which was GPS located. These data, and on-farm header yield maps will be compared to satellite imagery. If the variation in the measures of yield can be accounted for via remote sensing this will provide a possible method for broad scale analysis of CSG impacts on crop production over the coming season. In this way we hope to increase the likelihood of observing impacts.

Other impacts on farm operation and production have been identified in the field and data required to evaluate these have been sought. These include GIS datasets on gathering networks, vents and signage. If these cannot be obtained, methods are being considered to detect these using remote sensing once again.

Task 6

TASK NAME: Case study site monitoring complete

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: Data from on-farm measurement and monitoring needs to be gathered to allow meaningful exploration of options for gas-farm design. Such monitoring should be almost complete at this time to allow collation of results and analysis for use in later farmer discussions.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A report briefly showing the raw results of the on-farm measurement and monitoring for each of the case study sites.

PROGRESS REPORT:

Ground survey of the property "Monreagh" is essentially now complete. All above-ground infrastructure (wells, vents, signs, etc.) have now been mapped. However, infrastructure is not yet fully installed and so ongoing updating or records will be undertaken whenever possible. GIS data for CSG infrastructure on the property "Lower Heatherly" has been provided by Origin in conjunction with Project 1. Some data on machinery operation around CSG infrastructure has been obtained with the assistance of a local farming contractor. Availability of further data is being investigated. Satellite data for estimating impacts of CSG infrastructure on crops has been obtained for the study region for the current winter cropping season. Ongoing drought conditions have yet again restricted plantings in the area but some crops sown around and above infrastructure are showing visible impacts on production. Remote sensing approaches will be investigated for quantifying losses in these fields.

Task 7

TASK NAME: Analysis of monitoring data

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: Data from the on-farm measurement and monitoring needs to be analysed and converted into knowledge or simple models/relationships which can be used in the evaluation of alternative gas-farm designs.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A report briefly describing the findings of the case study monitoring and how these data will be used to inform discussions on gas-farm design.

PROGRESS REPORT:

As reported for Task 6, spatial data for infrastructure and crop and machinery impacts are being assembled. As this continues, so will analysis of data. Mapped data will be summarised to provide metrics for use in Project 1, and maps are already being used in a series of farmer discussions (Task 8) as discussion starters.

Task 8

TASK NAME: First farmer discussions

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2013/14

BACKGROUND: The findings of the monitoring and literature review will be used in discussions with case study farmers to explore a preliminary set of gas-farm design principles and likely options for improved gas-farm designs on the chosen farms. Issues (lessons, information gaps, risk and opportunities) identified during these discussions will be documented and will become the basis of further refinement of models and design principles.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report describing the outcomes of the preliminary discussions with the various case study farmers regarding farm design principles.

PROGRESS REPORT:

Discussions with farmers and farm workers has commenced. Firstly, discussions have commenced with a grazier in the Chinchilla district who is negotiating with two gas companies for placement of wells in pasture land. Discussions covered topics such as personal preferences, possible risk, and methods to improve infrastructure design. High resolution water flow maps developed in Project 4 – "*Making Tracks*" were used to predict likely impacts on stock watering points and overland flow in general. Secondly, a basic interview with a farming contractor who has operated on several Gas-Farms has looked into the impacts of CSG infrastructure such as signs, vents, roads and pads on machinery efficiency. More farmer meetings are planned, pending availability of the landholders. These farmers currently operate mixed cropping-grazing and sole cropping enterprises in the Chinchilla-Miles district.

Task 9

TASK NAME: Analysis of issues arising from farmer discussions

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Preliminary discussions with farmers will have identified methods for improving or expanding the gas-farm design principles and models used. Work must be undertaken to account for these lessons.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report demonstrating progress toward

addressing the concerns or opportunities identified in the preliminary discussions with farmers.

PROGRESS REPORT:

Discussions with farm contractors indicated a possible significant impact of CSG infrastructure on farm machinery movements and efficiency (see Task 8). Data from GPS units on farm machinery operating around CSG infrastructure was sourced from the Chinchilla area. These data included two different types of machinery (fertiliser vs spray boom) to account for differences in implement width. As expected, preliminary results indicate differences in the amount of time spent working around the edges of lease area depending on the position of the well within the farm paddock.

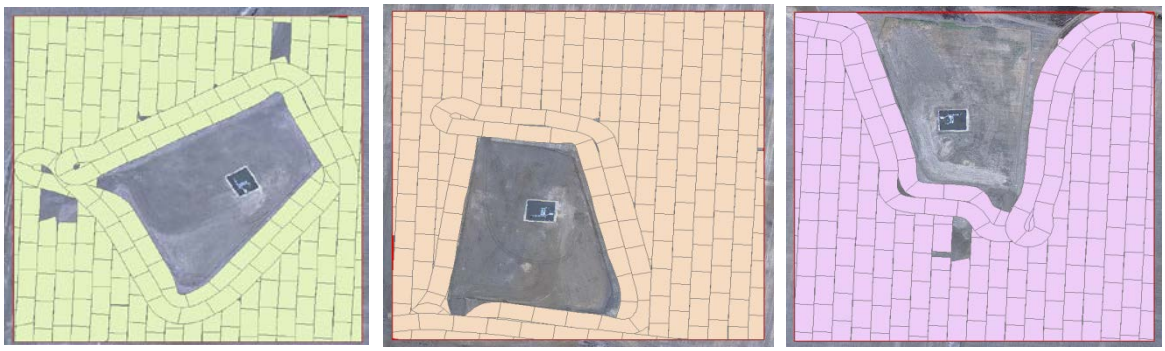

Figure. Examples of data from tractor GPS units showing movement of farm machinery around CSG infrastructure.

Task 10

TASK NAME: Second iteration of farmer discussions

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Preliminary discussions with farmers will have identified methods for improving or expanding the gas-farm design principles and models used. Once these have been addressed, a second round of discussions will be undertaken to gauge the effect of further development aimed at these issues.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report demonstrating progress toward addressing the concerns or opportunities identified in the secondary discussions with farmers.

PROGRESS REPORT:

Discussions with a farm manager and contractor were held regarding two of the datasets generated within the GISERA land management projects (water flow mapping (see Making Tracks project) and vehicle movement mapping (see Task 9)). Further work will flow from these discussions. First, GPS mapping of possible erosion risk areas and existing water flow routes will be continued to test the flow modelling and provide further proof of concept. Second, more data on vehicle movements will be required. Existing data on farm vehicle movement around CSG infrastructure only includes fenced lease areas. This is because most wells in cropping land are fairly new. Some data may now be available on completed well pads which now include gathering, vents, signs and access tracks. Operations around all these obstacles may be impacted more than simple fenced-off areas. These extra data will be collated and incorporated into the analysis for a more complete picture of farm impacts.

Task 11

TASK NAME: **Synthesis of results**

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Case studies completed. The findings from all these efforts need to be synthesised into a coherent set of findings including data, design guidelines and calculated outcomes.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A report briefly outlining the results and lessons learned from the case study sites.

PROGRESS REPORT:

A brief outline of the lessons of this project has been collated and this will serve as a structure upon which the final report/scientific paper will be constructed. These ideas have been discussed with several leading farmers who have CSG infrastructure on their properties. These lessons will be formulated into three main areas: 1) Developing a plan for your farm, 2) Knowing how to communicate with the CSG company, and 3) Negotiating a farm design that will work for you. Into each of these 3 topics we intend to insert a summary of all information gathered across the entire agricultural land management portfolio as a way to synthesise the broad range of information. The only outstanding work on data gathering involves information on farm machinery movements and the placement of signs on farms. These are currently being sought from contacts in Origin Energy.

Task 12

TASK NAME: Draft Scientific Manuscript

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2014/15

BACKGROUND: Communication of findings to the scientific community.

TASK OUTPUTS & SPECIFIC DELIVERABLES: Draft manuscript(s) prepared for journal(s) and/or conference proceedings.

PROGRESS REPORT:

Reporting of project findings has been undertaken. The evaluation of the aerial survey techniques have been reported as follows:

- International Farming Systems Design Conference (Montpellier, France)
- Australian Agronomy Conference (Hobart, Tasmania)
- Australian Modelling and Simulation Society (Gold Coast, Queensland)

A draft of article with information for landholders is under preparation

Task 13

TASK NAME: Thesis production (PhD)

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2015/16

BACKGROUND: Final preparation of thesis document will take some time. The exact form of the thesis will depend on arrangements between the student and the university.

TASK OUTPUTS & SPECIFIC DELIVERABLES: A brief report on progress to final thesis production.

PROGRESS REPORT:

Final aspects of the modelling work undertaken within this PhD thesis are being undertaken. Collation of work into a final thesis document has been commenced, including documenting all data processing and analysis. Estimated final submission date is September 2016 (i.e. 3 years after enrolment).

Task 14

TASK NAME: Thesis submitted (PhD)

TASK LEADER: Neil Huth

OVERALL TIMEFRAME: 2015/16

BACKGROUND: Finalising thesis of PhD student.

TASK OUTPUTS & SPECIFIC DELIVERABLES: PhD thesis and/or publication(s) related to PhD thesis

PROGRESS REPORT:

Final aspects of this PhD thesis and submission of thesis for examination are unlikely to be completed in the near future for personal reasons of the student. Therefore after much discussion and consideration by the supervisory team it has been decided to not pursue submission at this stage, with components of the thesis already captured in existing publications such as:

- Assessing erosion processes associated with establishment of coal seam gas pipeline infrastructure in Queensland, Australia CA Vacher, DL Antille, NI Huth, SR Raine - 2016 ASABE Annual International Meeting, 2016, and
- Quantifying the impacts of coal seam gas (CSG) activities on the soil resource of agricultural lands in Queensland, Australia, CA Vacher, S White, J Eberhard, E Schmidt, NI Huth, DL Antille, 2014 Montreal, Quebec Canada July 13–July 16, 2014, 1

The project leader assisted in developing a work plan and chapter summary for the thesis however due to the external factors the project leader recommends that this project be closed.

Re-enrolment and completion could be possible at some stage in the future and the supervisory team will find means to resource this at that time.