



# Volume 1 of 7: Waukivory Pilot Project

1

## Review of Environmental Factors

October 2013

Executive Summary

## **AGL Quick Reference Guide**

### **Waukivory Pilot Project — Review of Environmental Factors**

#### **Volume 1 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

Executive Summary

#### **Volume 2 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Chapters 1 to 4

#### **Volume 3 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Chapters 5 to 14

#### **Volume 4 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix A

#### **Volume 5 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix B to G

#### **Volume 6 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix H to K

#### **Volume 7 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix L to O

---

## Waukivory Pilot Project Review of Environmental Factors

Prepared for AGL Upstream Investments | 27 September 2013

---

L22, 101 Miller Street  
North Sydney, NSW, 2060

T +61 2 9921 2563  
F +61 2 9921 2395

[agl.com.au](http://agl.com.au)

Ground Floor, Suite 01, 20 Chandos Street  
St Leonards, NSW, 2065

T +61 2 9493 9500  
F +61 2 9493 9599  
E [info@emgamm.com](mailto:info@emgamm.com)

[emgamm.com](http://emgamm.com)

---

## Waukivory Pilot Project

Final

Report J13005RP1 | Prepared for AGL Upstream Investments | 27 September 2013

---

Prepared by **Robert Janssen**

Approved by **Duncan Peake**

Position Environmental Scientist

Position Associate Director

Signature



Signature



Date 27 September 2013

Date 27 September 2013

---

This report has been prepared in accordance with the brief provided by the client and has relied upon the information collected at or under the times and conditions specified in the report. All findings, conclusions or recommendations contained in the report are based on the aforementioned circumstances. The report is for the use of the client and no responsibility will be taken for its use by other parties. The client may, at its discretion, use the report to inform regulators and the public.

© Reproduction of this report for educational or other non-commercial purposes is authorised without prior written permission from EMM provided the source is fully acknowledged. Reproduction of this report for resale or other commercial purposes is prohibited without EMM's prior written permission.

### Document Control

Version	Date	Prepared by	Reviewed by
V1	3 May 13	R. Janssen	D. Peake
V2	17 May 13	R. Janssen	D. Peake
V3	03 June 13	R. Aitken-Smith	D. Peake
V4	05 July 13	R. Aitken-Smith	D. Peake
FINAL	16 Aug 13	R. Aitken-Smith	D. Peake
FINAL_V2	27 Sept 13	R. Aitken-Smith	D. Peake



T +61 (0)2 9493 9500 | F +61 (0)2 9493 9599

Ground Floor | Suite 01 | 20 Chandos Street | St Leonards | New South Wales | 2065 | Australia

[emgamm.com](http://emgamm.com)

## Executive Summary

**The Executive Summary provides a detailed overview of the proposed activity and conclusions of the environmental impact assessment.**

### ES1 Background

Petroleum Exploration Licence (PEL) 285 is a natural coal seam gas exploration project within the local government areas (LGA) of Great Lakes, Dungog and Gloucester. AGL Upstream Investments Pty Ltd (AGL) is the sole owner and operator of this PEL.

AGL is obliged under the conditions of the PEL to appraise and evaluate the quantity and quality of the natural gas resource.

There are several components of exploration, one of which is pilot testing of gas wells. The proposed activity that is the subject of this review of environmental factors (REF) is the fracture stimulation and pilot testing of four existing vertical exploration wells on two properties in PEL 285. AGL refers to the project as 'Waukivory Pilot'.

The Waukivory Pilot is on 20 Grantham Road (Lot 11 DP 841445) in Forbesdale, 197 Fairbairns Road (Lot 251 DP 785579) in Forbesdale; including the area between these two properties and AGL's the Tiedmans property where a water pipeline will be laid.

The purpose of fracture stimulation and pilot testing is to identify potential gas resources by testing the composition, flow rate and volume of gas in target coal seams. The fracture stimulation and pilot testing program is also important to assess water production volumes and whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones. The activity will be temporary with the wells suspended and the surplus disturbed land rehabilitated to its pre-existing state at completion of the activity.

EMGA Mitchell McLennan Pty Ltd (EMM) was engaged by the proponent, AGL, to prepare this REF for pilot testing. It will be lodged with the Department of Trade and Investment, Regional Infrastructure and Services – Office of Coal Seam Gas (DTIRIS-OCSG) for assessment and approval under Part 5 of the NSW *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). It should be noted that these four exploration wells were drilled in 2012 in accordance with an activity approval granted by the then DTIRIS-DRE in 2011.

### ES2 Description of proposed activity

#### ES2.1 General

The Waukivory Pilot includes:

- conversion of four existing exploration wells to pilot wells using perforating and fracture stimulation techniques;
- pilot testing of four wells WK11, WK12, WK13 and WK14;
- construction of water storages for flowback and produced water;

- construction of associated infrastructure including a water pipeline and water and gas gathering lines;
- enclosed central gas flare/s;
- delivery of equipment (and water) to undertake the activity;
- lawful disposal of flowback water;
- lawful disposal of produced water;
- suspension of exploration wells following completion of pilot testing; and
- site rehabilitation of disturbed land including construction laydown areas, access tracks, water pipeline and water and gas gathering pipelines verges.

Two options for the location of ancillary infrastructure of the Waukivory pilot testing program are being evaluated by AGL.

Both options will require the construction of a water staging point at WK13 to minimise truck movements on site. The water staging point will be either a double-lined dual compartment turkeys nest dam or a temporary above-ground water storage tank. The water staging point will require the construction of two water gathering lines, connecting WK14 and WK12 to WK13. One gathering line will transport source water to the wells and the other gathering line will collect flowback/produced water from the wells. The water gathering lines will be laid east from WK13 alongside an access track and cross the Avon River at the existing road bridge before turning north to WK14 and WK12 alongside existing access tracks.

Both options will require a central flare at WK12 (which was assessed to result in the least visual and noise impact) for WK12, WK14 and WK13. Gas gathering lines will connect the flares with their respective well locations.

#### i Option 1

Option 1 would include the addition of an underbored gathering line under the Avon River originating near WK11, to the west of a point between WK12 and WK14. The underbore would connect WK11 to the water staging point at WK13 and the central flare at WK12. All produced water and flowback water for all pilot wells would be piped to and from the water staging area at WK13.

The central flare/s at WK12 would be implemented for all pilot wells (WK11, WK12, WK13 and WK14). In the event that gas production appears likely to exceed the single flare's operating capacity through information gathered via telemetry systems, a secondary smaller flare would be installed beside the central flare at WK12.

#### ii Option 2

Option 2 would require the construction of water storage tanks and the implementation of a second flare at WK11. Under this option, water and gas gathering lines would still connect WK12, WK13 and WK14 with the water staging point at WK13 and an enclosed flare at WK12. However, there would be no underbore of the Avon River.

## ES2.2 Construction phase: site establishment

Site preparation is expected to be performed over 8-12 weeks. Minor earthworks may be required to upgrade existing tracks to enable equipment access. Works will also include the development of a 5 megalitre (ML) dual compartment turkeys nest dam or a temporary above-ground storage facility, water and gas gathering pipelines and water pipeline between the Tiedmans property and WK13.

Pilot testing will use existing exploration wells so drilling of new holes will not be required as part of the application.

## ES2.3 Operational phase: pilot testing and maintenance

The operational phase works is expected to be completed in 12-18 months. Pilot testing and flowback will occur 24 hours a day, seven days a week. Standard work hours for noise generating activities will be Monday to Friday 7 am to 6 pm and Saturday 8 am to 1 pm.

Operational phase works include:

- hydraulic fracture stimulation (including fracture stimulation fluid, use of raw water, flowback and water management);
- pilot testing of wells; and
- flaring.

The volume of water required for fracture treatment is estimated to be between 0.9 ML and 2.4 ML per well and around 6 ML in total for the whole fracture stimulation program for these four wells. Source water for hydraulic fracture stimulation will be sourced from licensed water supply works from either Pontilands or Tiedmans dams, on nearby properties owned by AGL.

There are two options for supplying source water for hydraulic fracturing at exploration wells at the site. Both options require a water staging area at WK13 and both options involve supplying source water to WK14 and WK12 by buried gathering lines from the water staging area at WK13. The two options relate to the supply of source water for hydraulic fracturing at WK11 and include:

- Option 1 - source water for hydraulic fracturing will be delivered from the water staging area to WK11 by buried gathering lines (and an underbore of the Avon River) from the water staging area at WK13; and
- Option 2 - source water for hydraulic fracturing will be supplied to a turkeys nest dam or temporary above-ground storage tank at WK11 by truck.

The maximum volume of flowback water and produced water likely to be pumped for the four gas wells is 20 ML (14 ML of produced water and 6 ML of flowback water). All flowback water and produced water will be pumped through water gathering lines to the water staging area at WK13. The flowback water will be lawfully transported and disposed of at an appropriate facility. The produced water will be transported by truck or via a buried pipeline to the Tiedmans property, and then blended to achieve a final salinity acceptable for irrigation. The transportation of the produced water to the Tiedmans property has been assessed as part of this REF, but the irrigation of the produced water has been assessed under, and will form part of, an irrigation trial program approved in July 2012 by DTIRIS-DRE.

Pilot test wells and central flares have various automated and remotely controlled functions including shutdown features for improved site safety. The flaring method proposed for pilot testing is an enclosed horizontal flare/s, designed to mitigate potential visual and noise impacts.

#### ES2.4 Site closure and rehabilitation

Rehabilitation of pilot test wells is generally undertaken in two stages: initial rehabilitation of surplus construction area following the completion of site establishment and to cap and suspend the test wells at the completion of gas flow testing.

If the results of the proposed exploration activities prove a viable resource, the wells will be capped and suspended pending the commencement of the Gloucester Gas Project Part 3A production approval. Alternatively, the wells will be plugged and abandoned in accordance with the *EDG01: Borehole Sealing Requirements on Land: Coal Exploration* (Department of Trade & Investments Resources and Energy, April 2012), and the site rehabilitated.

On completion of activities, all equipment used for pilot testing will be removed from the site and rehabilitation, contouring, and re-vegetation will occur.

#### ES2.5 Access arrangements

Access will be via existing public roads and then private tracks in the subject properties. WK11 and WK13 are currently accessed via Fairbairns Road and WK12 and WK14 via a track off Fairbairns Road for light vehicles and Maslens Lane for heavy vehicles. Access arrangements with the landowner are currently in place in relation to these properties.

### ES3 Mitigation strategy

The strategy outlined in the REF represents AGL's statement of commitments to carry out best practice mitigation measures for the proposed activity. These commitments are likely to become conditions of approval.

DTIRIS-DRE may audit the Waukivory Pilot at any time to check for compliance with the activity described in the REF and conditions of approval. They may also perform an audit to determine if the actual impacts are consistent with those described in the REF. Failure to comply with terms of approval may trigger enforcement action.

AGL's mitigation strategy for the pilot testing project has been developed to address the requirements outlined in the ESG2 guidelines, the supplement to ESG2 guidelines for petroleum prospecting and the recently released Codes of Practice for gas, Fracture stimulation activities and Well integrity. The mitigation strategy consists of an industry best practice environmental management system and measures that eliminate or minimise potential environmental impacts.

The environmental management system consists of an environmental management plan (EMP), water management plan and fracture stimulation management plan.

The EMP establishes AGL's environmental management framework, sets out environmental requirements for the proposed activity and establishes the processes for implementation, monitoring and review so that all potential environmental impacts are effectively minimised, mitigated and managed. These processes are also designed to ensure compliance and achieve continuous improvement.



The water management plan provides management measures to mitigate the risk of pilot testing activities. The water management plans consist of two sub-plans including:

- Part 1: Surface water and groundwater management plan (Appendix D), which outlines the groundwater monitoring program for the Waukivory Pilot fracture stimulation and pilot testing activities; and
- Part 2: Water management plan for the Tiedmans Irrigation Program – Gloucester (dated 14 May 2012), which outlines the strategy for containment, mixing, and re-use of produced water in accordance with the existing approval granted by DTIRIS-DRE in 2012.

The Part 2 plan was submitted and approved under a separate approval for the irrigation trial at the Tiedmans property.

The fracture stimulation management plan (FSMP) has been prepared to meet the mandatory and leading practice requirements of the Code of Practice for Coal Seam Gas: Fracture stimulation activities (Department of Trade & Investment Resources & Energy, September 2012). The FSMP:

- includes a description of the additives (including quantity) to be used in the fracture stimulation activity;
- includes a full risk assessment of the fracture stimulation activity, including a groundwater risk assessment, community risk assessment and Human Health and Environment Risk Assessment of the additives to be used;
- describes the fracture stimulation process, including fluid selection, water use, equipment use, modelling of the fracture geometry, monitoring and mitigation/management controls; and
- attaches the Emergency Response Plan, Safety Management Plan and Environmental Incident Response Plan for the Waukivory Pilot.

The environmental impact avoidance and minimisation measures outlined in the REF have been considered in the development of the environmental management system.

## ES4 Assessment and approvals process

AGL will lodge an activity application for the Waukivory Pilot with DTIRIS-OCSG, supported by this REF, which includes commitments intended to achieve desired environmental outcomes.

The REF provides a summary of the primary environmental legislative reporting requirements and policies applicable to the proposed activity. The approvals and licences required for the pilot testing project are:

- Part 5 approval under the EP&A Act;
- an environment protection licence under the *Protection of the Environment Operations Act 1997*; and
- water licences under both the *Water Act 1912* and the WMA for water extracted during fracture stimulation and pilot testing.

During their assessment period, DTIRIS-OCSG will seek comment from other NSW agencies including:

- Office of Water;
- Environment Protection Authority;
- Department of Planning and Infrastructure; and
- Department of Primary Industries.

During the assessment, DTIRIS-OCSG will make a determination on whether the Waukivory Pilot is likely to have a significant impact on the environment or threatened species (this is the test under Part 5 of the EP&A Act). Following completion of the assessment process, DTIRIS-OCSG may issue a written approval. In most cases, the approval will be subject to conditions. These conditions will usually require compliance with commitments made in the REF. They may also include preparing additional plans, taking prescribed actions or limiting the proposed activity.

No significant impacts are expected to matters of national environmental significance or Commonwealth land or groundwater.

## ES5 Impact assessment

The impacts of the pilot testing activities have been assessed in accordance with the ESG2 guidelines and the supplement for petroleum prospecting. These guidelines are comprehensive and among other things, require consideration of the size, scope, intensity and duration of each impact to determine its magnitude. Impacts can be categorised as negligible, low adverse, medium adverse, high adverse or positive in accordance with the matrix contained within the ESG2 guidelines.

The REF documents a detailed analysis of the potential impacts of the Waukivory Pilot. A condensed summary of impacts is provided in Table ES.1.

**Table ES.1 Summary of potential impacts**

<b>Impacts</b>	<b>Level of potential impact</b>
Physical and chemical	Negligible to low adverse
Biological	Negligible
Community	Negligible to low adverse (mostly low adverse)
Natural resource	Negligible to low adverse
Aboriginal heritage	Negligible
Historic cultural heritage	Low adverse
Cumulative	Negligible
Physical and chemical	Negligible to low adverse

Potential impacts are expected to be negligible to low adverse across all impact categories. The overall impact of the proposed activity is considered to be low adverse.

The area of potential impacts of the proposed activity is restricted to a defined footprint which is minimised during the operational phase. In terms of timeframe, impacts are short term, and will be completed in a maximum of 36 months, but may be completed sooner. The construction period will likely be completed in 8 to 12 weeks. The fracture stimulation and well completion activities will be of temporary duration, likely to be completed in approximately 3-6 months. Dewatering and pilot testing will then be undertaken over 12 to 18 months. After this time, the activity footprint will be minimised and rehabilitation completed.

Environmentally sensitive areas relevant to the proposed activity which have been evaluated include shallow alluvial aquifers in use by the community, and threatened species and communities listed under the NSW *Threatened Species Conservation Act 1995* (TSC) and/or *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* (EPBC) Acts (collectively, threatened biodiversity). Impacts to these environmentally sensitive areas are considered to be low adverse as beneficial aquifers are not expected to be impacted, and impacts to threatened biodiversity are unlikely to be significant given their small scale and lack of suitable habitat. Additionally, these environmentally sensitive areas will be monitored to identify any unexpected impacts, with appropriate mitigation/remedial actions applied as necessary.

An enclosed flare/s will be utilised to burn all produced gas during the production test. The enclosed flare is designed to eliminate the visual burning of the natural gas. Air quality impacts are expected to be negligible.

Impacts to the community are considered to be negligible to low adverse as the works are short-term and temporary. The proposed activity does not affect access to important community facilities or services. Minor increases in local traffic are expected during the construction period and the use of AGL-owned nearby properties for water source and disposal minimise the effect on the local road network. No significant adverse socio-economic impacts are expected due to the short-term nature of the proposed activity. Additionally, impacts to community safety are considered to be low adverse after environmental safeguards have been applied.

This REF has also considered potential cumulative impacts of the proposed activity. A number of environmental investigations were undertaken as part of this REF. Consideration has been given to the wider area within the environmental assessments prepared as part of this REF.

The site is south of Gloucester in the Avon River Valley and is currently used for light cattle grazing and the growth of pasture and cultivation of fodder crops. The proposed activity is short-term and all surplus land will be rehabilitated to its pre-existing state at completion of the activity. There are no expected significant cumulative effects as the environmental impacts and all works are mostly contained within designated work areas.

## ES6 Justification and conclusions

### ES6.1 Project need

The exploration for and development of natural coal seam gas is considered to be a cost effective method of meeting future gas and energy needs in NSW. Electricity generated from gas produces up to 55% less greenhouse gas emissions and uses up to two thirds less water than conventional coal-fired electricity generation.

State government strategic plans recognise that gas development could play a significant role in the delivery of reliable energy in a carbon constrained economy, provide security of supply for domestic gas users and alleviate the state's reliance on gas from other states.

AGL is required to fulfil its work program commitment with the DTIRIS-OCSG under PEL 285 to explore for potential gas resources. The proposed activity helps AGL meet this obligation.

As the REF outlines, ecologically sustainable development principles have been considered for the proposed activity. The consideration of these principles justifies the proposed activity because it has the potential to deliver social benefits through reduced contribution to greenhouse gas emissions and, with appropriate management and operation, presents no threat of serious or irreversible damage to the environment, biodiversity or ecological integrity.

Gas contracts currently supplying customers in NSW are sourced from other states' gas, and these contracts will start dropping off in 2014.

In addition, the development of export liquefied natural gas projects in Queensland could increase the demand for gas and this could impact on the available supply of gas to NSW. The State must start to develop its own resources to secure gas for NSW homes and businesses. If the proposed activity does not proceed, there may be consequences for energy supply in the Hunter region and across the state.

The economic prosperity of NSW and the energy supply security of NSW will be enhanced through the development of a natural gas production industry in the state. The Waukivory Pilot will be a key indicator to determining the level of contribution that gas wells in the Gloucester Basin can be used to achieve this outcome.

## ES6.2 Stakeholder consultation

AGL has consulted with various state and local government agencies, industry, local Indigenous groups, the general community and the Gloucester Community Consultative Committee (GCCC). Information about the activity has been provided through community information sessions, advertisements, media releases, the Gloucester Gas Project website and the AGL office in Gloucester.

A record of consultation with stakeholders about the Waukivory Pilot is provided in the REF. The REF also outlines AGL's proposed commitments to issues discussed with stakeholders. It is of key importance to stakeholders that AGL continues to communicate with the community about the pilot testing program and provide notifications to those interested.

Complaint mechanisms are in place to capture any complaints made prior and during the proposed activity. AGL has made a commitment in the REF to ensure that all community feedback is addressed.

AGL has engaged with stakeholders to identify potential conflicts before final decisions are made so plans can be designed to address concerns and mitigate any impacts. This approach enables early intervention with regard to community conflict.

The REF outlines the AGL protocol for managing enquiries and complaints about the activity. AGL will continue to provide opportunities for the community to comment or raise concerns during the pilot testing project through information sessions, the GCCC, and the community hotline.

## ES6.3 Conclusion

The REF has assessed the potential environmental impacts of the Waukivory Pilot. The REF also considers potential cumulative impacts of the proposed activity on existing nearby coal mines and agriculture. The extent of potential impacts has been determined using the criteria outlined in ESG2 guidelines, and impact avoidance and mitigation strategies have been outlined in the REF.

In addition, the REF also considers the factors to be taken into consideration by the determining authority under clause 228 of the Environmental Planning and Assessment Regulation 2000 (NSW).

Overall, with AGL's commitment to best practice environmental, water and fracture stimulation management, and with the implementation of the recommendations outlined in this REF and current environmental standards and guidelines (which are described as the strictest in Australia), potential impacts of the proposed activity are expected to be low adverse.

Potential impacts to the community are considered to be negligible to low adverse as the works are short-term and temporary.

For the purposes of Part 5 of the EP&A Act, the proposed activity is not expected to have a significant impact on the environment.







[www.emgamm.com](http://www.emgamm.com)

**SYDNEY**  
Ground Floor, Suite 1, 20 Chandos Street  
St Leonards NSW 2065  
T 02 9493 9500 F 02 9493 9599

**NEWCASTLE**  
Level 1, 6 Bolton Street  
Newcastle NSW 2300  
T 02 4927 0506 F 02 4926 1312

**BRISBANE**  
Suite 1, Level 4, 87 Wickham Terrace  
Spring Hill Queensland 4000  
T 07 3839 1800 F 07 3839 1866





# Volume 2 of 7: Waukivory Pilot Project

2

## Review of Environmental Factors

October 2013

REF Chapters 1 to 4

## **AGL Quick Reference Guide**

### **Waukivory Pilot Project — Review of Environmental Factors**

#### **Volume 1 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

Executive Summary

#### **Volume 2 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Chapters 1 to 4

#### **Volume 3 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Chapters 5 to 14

#### **Volume 4 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix A

#### **Volume 5 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix B to G

#### **Volume 6 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix H to K

#### **Volume 7 of 7:**

### **Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix L to O

# Table of Contents

---

<b>Chapter 1</b>	<b>Introduction</b>	<b>1</b>
1.1	Background	1
1.2	Project approval for gas production – Gloucester Gas Project	3
1.3	Current approvals	3
1.3.1	Approvals, licences, permits and leases for exploration	3
1.4	Approach to this assessment	6
1.5	The proponent	7
<hr/>		
<b>Chapter 2</b>	<b>The proposed activity</b>	<b>9</b>
2.1	Overview of activity	9
2.2	Local context	10
2.3	Regional context	11
2.4	Ownership	13
2.5	Stakeholder consultation	13
2.5.1	Approach to consultation	13
2.5.2	Identification of stakeholders	16
2.5.3	Consultation to date	16
2.5.4	Summary of consultation undertaken	18
2.5.5	Pre and during activity consultation	24
2.5.6	Stakeholder conflict management	25
2.5.7	Protocols for complaint management	25
2.6	Justification of activity	26
2.6.1	Increased demand for clean energy	26
2.6.2	Obligations under PEL	27
2.6.3	Environmentally-friendly methods	27
2.6.4	Ecologically sustainable development	27
2.7	Analysis of alternatives	28
2.8	Detailed description of proposed activity	29
2.8.1	General	29
2.8.2	Activity footprint	31
2.8.3	Works timetable, scheduling and milestones	33
2.8.4	Hours of operation and employees	33
2.8.5	Security	36
2.8.6	Construction phase: site establishment	36
2.8.7	Operational phase: pilot testing and maintenance	38
2.8.8	Maintenance activities, future expansions or additions	53
2.9	Site closure and rehabilitation	53
2.9.1	Initial rehabilitation	54

## Table of Contents *(Cont'd)*

2.9.2	Final rehabilitation and suspension	54
2.10	Access arrangements	54
2.11	Mitigation strategy	54
2.11.1	Overview	54
2.11.2	Environmental management system	55
2.11.3	Impact avoidance and minimisation measures	56
2.12	Approval and policy requirements	69
<b>Chapter 3</b>	<b>The site</b>	<b>75</b>
<b>Chapter 4</b>	<b>The existing environment</b>	<b>77</b>
4.1	General description	77
4.1.1	Climate and weather	77
4.1.2	Topography	77
4.1.3	Vegetation cover, type, density and condition	78
4.1.4	Soil types and properties	78
4.1.5	Existing land uses	81
4.1.6	Availability of services	81
4.2	Description of surface water and groundwater sources	82
4.2.1	Surface water resources	82
4.2.2	Groundwater resources	83
4.2.3	Groundwater bores at the Waukivory Pilot area	83
4.2.4	Groundwater productivity	83
4.2.5	Waukivory conceptual groundwater model	84
4.2.6	Groundwater dependent ecosystems	85
4.3	Description of threatened species, populations and ecological communities	85
4.3.1	Threatened species	85
4.3.2	Threatened populations	85
4.3.3	Threatened ecological communities	85
4.3.4	Migratory species	86
4.4	Description of Aboriginal cultural heritage values	87
4.4.1	Background	87
4.4.2	Existing environment	87
4.5	Description of historic cultural or natural heritage values	88
<b>Chapter 5</b>	<b>Impact assessment method</b>	<b>89</b>
<b>Chapter 6</b>	<b>Physical and chemical impacts</b>	<b>91</b>
6.1	Soil quality and land stability	91
6.2	Water bodies, watercourses, wetlands and natural drainage systems	92

## Table of Contents *(Cont'd)*

---

6.2.1	Surface water bodies	92
6.2.2	Groundwater	92
6.2.3	Groundwater dependent ecosystems	95
6.3	Coastal processes	95
6.4	Flooding	95
6.5	Hazardous materials or chemical use	96
6.5.1	Human health and ecological risk assessment	96
6.5.2	Potential groundwater impacts	98
6.5.3	Emergency and other unplanned discharge	99
6.6	Disposal of waste and emissions	99
6.6.1	Flowback water	99
6.7	Emissions	100
6.7.1	Background	100
6.7.2	Assessment	101
6.7.3	Greenhouse gas assessment	103
6.7.4	Fugitive emissions	104
6.7.5	Dust and odour	104
6.8	Noise, and vibration	104
6.8.1	Assessment criteria	104
6.8.2	Assessment	107
<b>Chapter 7</b>	<b>Biological impacts</b>	<b>113</b>
7.1	Vegetation	113
7.2	Groundwater dependent ecosystems	113
7.3	Threatened ecological communities	113
7.4	Threatened populations	114
7.5	Threatened species	114
7.6	Migratory species	114
7.7	Displacement and fragmentation of fauna and their habitats	114
7.8	Introduced species	115
7.9	Key threatening processes, threats to biodiversity and ecological integrity	115
<b>Chapter 8</b>	<b>Community impacts</b>	<b>117</b>
8.1	Community services and infrastructure	117
8.2	Access to important community sites	117
8.3	Traffic and local roads	117
8.4	Economic factors	118
8.5	Community safety	118
8.6	Fire risk	119
8.7	Visual and scenic impacts	120

---

## Table of Contents *(Cont'd)*

8.8	Other	125
<b>Chapter 9</b>	<b>Natural resource impacts</b>	<b>127</b>
9.1	Impact on conservation areas	127
9.2	Impact on community resource use	127
<b>Chapter 10</b>	<b>Aboriginal and cultural heritage impacts</b>	<b>129</b>
10.1	Aboriginal cultural heritage impacts	129
10.1.1	Impact on ground surface and culturally modified trees	129
10.1.2	Impact on objects and places	129
10.1.3	Impact on local landscape features	129
10.1.4	Impact on areas subject to native title claims, indigenous land use agreements or joint management	130
10.1.5	Can harm be avoided?	130
10.2	Historic cultural heritage impacts	130
<b>Chapter 11</b>	<b>Matters of national environmental significance</b>	<b>131</b>
<b>Chapter 12</b>	<b>Cumulative impacts</b>	<b>133</b>
12.1	Cumulative impacts	133
<b>Chapter 13</b>	<b>Summary of impacts</b>	<b>135</b>
<b>Chapter 14</b>	<b>Conclusions</b>	<b>141</b>
<b>References</b>		<b>143</b>
<b>Definitions, abbreviations and units of measure</b>		<b>145</b>

## Appendices

A	Agricultural impact statement
B	Fracture stimulation management plan
C	Air quality impact assessment
D	Surface water and groundwater management plan
E	Environmental management plan
F	Health and safety management plan
G	Emergency response plan
H	Minimum impact considerations for less productive aquifers
I	Ecological assessment of wells
J	Ecological assessment of water pipeline
K	Assessment of significance for migratory species

## Appendices

L	Risk assessment
M	Human health and ecological risk assessment
N	Environmental incident response plan
O	Noise assessment

## Tables

ES.1	Summary of potential impacts	ES.6
1.1	Summary of approvals, licences and permits	3
2.1	Activity summary	10
2.2	Consultation activities undertaken	17
2.3	Consultation record	19
2.4	Consideration of ESD principles	28
2.5	Timetable, scheduling and milestones	33
2.6	Estimated cost of water re-use versus water disposal	45
2.7	Water quality after development of the monitoring bores	46
2.8	Groundwater monitoring at well sites, suites and frequencies	49
2.9	Impact avoidance and minimisation measures	57
2.10	Summary of project approval requirements for the Waukivory Pilot	69
3.1	Location of sites	75
4.1	Climate at Taree Airport	77
4.2	Avon River water quality	82
4.3	Groundwater monitoring results	83
4.4	Groundwater characteristics	83
5.1	Guide to categorising the extent of impact	89
5.2	Summary of impacts	90
6.1	Calculated estimation of GHG emission	103
6.2	Residential construction noise criteria	105
6.3	ICNG residential criteria	105
6.4	OEH environmental criteria for road traffic noise	107
6.5	Noise sensitive receivers	107
6.6	Water transfer pipeline trenching/installation noise levels	108
6.7	Predicted fracture stimulation noise levels	109
6.8	Predicted pilot testing noise levels	110
6.9	Predicted traffic noise levels	112
7.1	Key threatening processes	115

## Tables

8.1	Sensitive residential receivers	122
8.2	Visual impact assessment results	123
13.1	Summary of impacts	136
13.2	Assessment outcomes with regards to Clause 228 of the EP&A Regulation	139

## Figures

1.1	PEL 285	2
2.1	Landuse zoning plan	12
2.2	Regional context	14
2.3	Geology of the Gloucester Basin	15
2.4	Proposed layout for Option 1	34
2.5	Proposed layout for Option 2	35
2.6	Water sourcing and management options	43
2.7	Site access plan	68
6.1	Closest residences to the pilot well flare site	101
6.2	Sensitive receivers and pilot testing noise levels	111
8.1	Viewpoints	121

## Photographs

2.1	AGL 20 ft flare facility – raised and enclosed around the flame	51
2.2	AGL 20 ft flare facility – painted a colour to blend with the surrounding landscape	51
2.3	AGL flare facility – internal view	52
2.4	AGL flare facility – operating at night with screening barrier in foreground on right	52



# 1 Introduction

**This section describes the project background, current approvals and approach to the environmental impact assessment for the proposed activity**

## 1.1 Background

Petroleum Exploration Licence (PEL) 285 is a natural coal seam gas exploration project within the local government areas (LGA) of Great Lakes, Dungog and Gloucester (Figure 1.1). AGL Upstream Investments Pty Ltd (AGL) is the sole owner and operator of this PEL.

AGL is obliged under the conditions of the PEL to appraise and evaluate the quantity and quality of the natural gas resource.

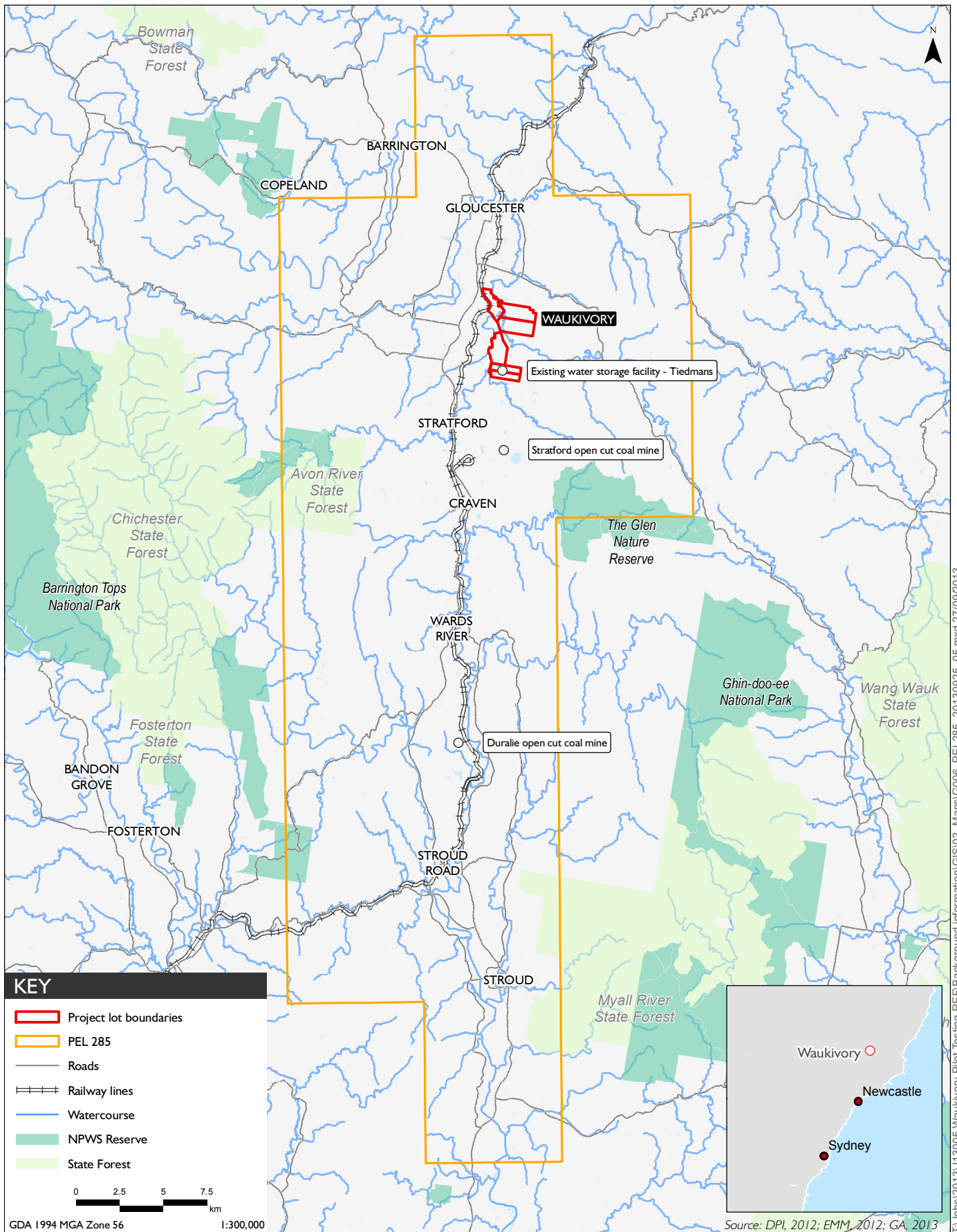
There are several components of exploration, one of which is pilot testing of gas wells. The proposed activity that is the subject of this review of environmental factors (REF) is the fracture stimulation and pilot testing of four existing vertical exploration wells (also known as stratigraphic holes). The proposed activity is called on 'the Waukivory Pilot'. The Waukivory Pilot is on 20 Grantham Road (Lot 11 DP 841445) in Forbesdale, 197 Fairbairns Road (Lot 251 DP 785579) in Forbesdale, and the area between these two properties and the Tiedmans property owned by AGL where the water pipeline will be laid.

The purpose of fracture stimulation and pilot testing is to identify potential gas resources by testing the composition, flow rate and volume of gas in target coal seams. The fracture stimulation and pilot testing program is also important to assess water production volumes and whether there is any connectivity between shallow aquifers and deep coal seam water bearing zones. The activity will be temporary with the wells suspended and the surplus land rehabilitated to its pre-existing state at completion of the activity.

EMGA Mitchell McLennan Pty Ltd (EMM) was engaged by the proponent, AGL, to prepare the REF for the proposed activity. It will be lodged with the Department of Trade and Investment, Regional Infrastructure and Services – Office of Coal Seam Gas (DTIRIS-OCSG) for assessment and approval under Part 5 of the *Environmental Planning and Assessment Act 1979* (NSW) (EP&A Act). It should be noted that these four exploration wells were drilled in 2012 in accordance with an activity approval granted by the DTIRIS-DRE in 2011.

This REF outlines the proposed activity, its methods and environmental assessments. The REF has considered the potential impacts of the proposed activity on the environment and commits to measures to minimise these. The recently created NSW Office of Coal Seam Gas (OCSG) will be responsible for administering the activity approval under the EP&A Act, should it be granted.

The REF is accompanied by an agricultural impact statement (AIS), as required by DTIRIS-OCSG and under the NSW *Strategic Regional Land Use Policy* (DP&I, 2012) (Appendix A). The site is not mapped as strategic agricultural land (SAL), however a full agricultural impact assessment has been carried out due to community interest in natural coal seam gas.



T:\jobs\2013\13005 Waukivory Pilot Testing REF\Background information\GIS\02\_Maps\G006\_PEL285\_20130925\_05.mxd 27/09/2013

The broader Gloucester Gas Project (GGP) has received approval for the construction and operation of a gas producing development by the NSW Government under Part 3A of the EP&A Act and the Commonwealth Government under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth) (EPBC Act). The Waukivory Pilot is part of the PEL 285 exploration program and although the exploration program is in the approved GGP development area, the proposed activity is not part of those approvals.

## 1.2 Project approval for gas production – Gloucester Gas Project

Activities assessed in this REF are being conducted in accordance with PEL 285. As stated in the previous section, the broader GGP has received State and Commonwealth approval for the construction and operation of a gas producing development and does not include the proposed activity. The approved, but yet to be constructed, gas production project involves four integrated components:

- Gas Field Development Area (GFDA) – development of up to 110 producing wells and associated infrastructure within the Concept Area and Stage 1 GFDA;
- Central Processing Facility (CPF) – compression of gas up to 30 petajoules (PJ) per year with an 80 terajoules (TJ) per day average, water treatment facility including associated storage and management system, small scale ancillary power generation facility and other ancillary infrastructure; and
- Gas Transmission Pipeline (GTP) – high pressure gas pipeline from Stratford to Tomago/Hexham.

Gas from the GGP would produce at 20 to 30 PJ per annum, which is more than 10% of the existing NSW market. This represents the additional gas demand growth projected for the underlying NSW gas market over the next three to four years (excluding fuel for power generation).

## 1.3 Current approvals

### 1.3.1 Approvals, licences, permits and leases for exploration

The approvals, licenses and permits with which the AGL is currently required to comply are outlined in Table 1.1.

**Table 1.1 Summary of approvals, licences and permits**

Name / No.	Issued by	Description	Date of Issue
<b>PEL</b>			
PEL 285	DII Minerals (now DTIRIS-OCSG)	Licence granted under Part 3 of the <i>Petroleum (Onshore) Act 1991</i> (PO Act) to undertake exploration activities.	15 September 2008
<b>Part 5 Approvals</b>			
PEL 285 Approval to conduct Seismic Exploration Activities on PEL285	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to conduct a seismic survey in PEL 285.	14 November 2011

**Table 1.1 Summary of approvals, licences and permits**

<b>Name / No.</b>	<b>Issued by</b>	<b>Description</b>	<b>Date of Issue</b>
PEL 285 Approval to undertake drilling of the Waukivory Pilot exploration wells and piezometer	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to conduct drilling of exploration wells and installation of piezometer.	6 October 2011
PEL 285 Approval to conduct Gloucester Seismic Survey	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to conduct Gloucester Seismic Survey.	13 October 2009
PEL 285 Approval to Drill Coal Seam Methane Exploration Boreholes	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill boreholes at Gloucester 1 and 2, Craven 7 and Wards River 1, 2, 3, 4 and 5.	17 July 2009
PEL 285 Approval to drill, test and fracture stimulate gas exploration wells Waukivory 3, Waukivory 4, Stratford 7, Stratford 10 and Faulkland 2	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill, test and fracture stimulate five wells.	9 December 2008
PEL 285 Approval to fracture stimulate coal seam methane exploration wells Weismantel 3, Faulkland 3 and Craven 6	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to fracture stimulate three test wells.	30 October 2008
PEL 285 Approval to relocate, drill and flow test coal seam methane exploration core hole Faulkland 3	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to relocate, drill and flow test the Faulkland 3 core hole.	2 April 2008
PEL 285 Approval to drill, fracture stimulate, dewater and flow test coal seam methane exploration core holes LMG03, LMG04, LMG05, LMG06, LMG08 and Optional Well	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill, fracture stimulate, dewater and flow test six wells.	31 July 2007
PEL 285 Approval to drill and test coal bed methane exploration wells LMG09, LMG10, LMG12, LMGC04, LMGC10, LMGC11, LMGW02, LMGW03, LMGWL01, LMGWL02 and LMGWL03	DII Minerals (now DTIRIS-OCSG)	Approval granted in accordance with Condition 1 of PEL 285 and the PO Act to drill and test 11 wells.	27 March 2007

**Table 1.1 Summary of approvals, licences and permits**

<b>Name / No.</b>	<b>Issued by</b>	<b>Description</b>	<b>Date of Issue</b>
<b>Bore licences</b>			
20BL168850 and 20BL168851	DII (now NSW Office of Water)	Approval granted to construct, test and irrigate from two gas wells (Stratford 1 and 3).	16 October 2008
20BL172554, 20BL172555 and 20BL172556	DII (now NSW Office of Water)	Approval granted to construct and test three gas wells (Stratford 2, 7 and 10).	11 August 2010
20BL172557, 20BL172558, 20BL172559, 20BL172560 and 20BL172561	DII (now NSW Office of Water)	Approval granted to construct, test and irrigate from five gas wells (Stratford 4, 5, 6, 8 and 9).	8 October 2010
20BL172619 and 20BL172626	DII (now NSW Office of Water)	Approval granted to install 18 groundwater monitoring bores (S4MB01, S4MB02, S4MB03, TMB01, TTPB, TTMB01, TTMB02, TTMB03, TMB02, TMB03, TMB04, TMB05, TGMB01, TGMB02, TCMB01, TCMB02, TCMB03 and TCMB04).	1 November 2010
Works approval - 20CA204347 WAL 19521 (20AL204346)	DII (now NSW Office of Water)	Approval for a pump on an unregulated river and to use the water for irrigation purposes. Water access licence with the volumetric entitlement.	-
20BL172631 and 20BL172632	DII (now NSW Office of Water)	Approval granted to install two groundwater monitoring bores (AMB01 and AMB02).	22 November 2010
20BL173274	DII (now NSW Office of Water)	Approval granted to install a groundwater monitoring bore at PL03 (conversion to core hole to vibrating wire piezometers - VVWs).	5 September 2012
20BL172682	DII (now NSW Office of Water)	Approval granted to install, test and monitor two groundwater monitoring bores (RMB01 and RMB02).	24 January 2011
20BL172667	DII (now NSW Office of Water)	Approval granted to install two groundwater monitoring bores (BMB01 and BMB02).	23 December 2010
20BL172670	DII (now NSW Office of Water)	Approval granted to install four groundwater monitoring bores (WMB01, WMB02, WMB03 and WMB04).	13 January 2011

**Table 1.1 Summary of approvals, licences and permits**

Name / No.	Issued by	Description	Date of Issue
20BL172550, 20BL172551, 20BL172552 and 20BL172553	DII (now NSW Office of Water)	Approval granted to test four pilot wells (Craven 6, Waukivory 3, Faulkland 3 and Weismantel 3).	11 August 2010
20BL172223, 20BL172224, 20BL172225, 20BL172226, 20BL172227, 20BL172228 and 20BL172229	DII (now NSW Office of Water)	Approval granted to test seven wells (Gloucester 1, Gloucester 2, Craven 7, Wards River 1, Wards River 2, Wards River 4 and Wards River 5).	2 July 2009
20BL172258	DII (now NSW Office of Water)	Approval granted to test Wards River 3 well.	9 July 2009
20BL173094	DII (now NSW Office of Water)	Approval granted to drill two wells (Waukivory 11 and Waukivory 13).	1 December 2011
20BL173038	DII (now NSW Office of Water)	Approval granted to install four groundwater monitoring bores (WKMB01, WKMB02, WKMB03 and WKMB04).	15 November 2011
20BL172854	DII (now NSW Office of Water)	Approval granted to drill two wells (Waukivory 12 and Waukivory 14).	9 June 2011
To be issued - application lodged	DII (now NSW Office of Water)	Application to install and test a geophone/VWP water monitoring bore (WKmb05).	No issue date.

## 1.4 Approach to this assessment

Since the granting in 2011 of approvals for construction, drilling and use of exploration wells at the Waukivory Pilot described in Table 1.1, the REF requirements under Part 5 of the EP&A Act have been updated and are described in *ESG2: Environmental Impact Assessment Guidelines* (Mineral Resources Environmental Sustainability Unit, 2012) (the ESG2 guidelines) and its draft supplement for petroleum prospecting, which came into force in April 2012.

To ensure consistency with the ESG2 guidelines, its supplement and to ensure that the proposed activity is assessed to the fullest extent possible, the approach for this REF was to:

- revisit the 2011 REF and update and incorporate relevant sections into this REF; and
- assess environmental impacts for the proposed activity in accordance with the ESG2 guidelines and its petroleum prospecting supplement.

The REF describes the activity, potential environmental impacts and environmental management measures. It is in accordance with section 111 of the EP&A Act, clause 228 of the NSW Environmental Planning and Assessment Regulation 2000 (EP&A Regulation) and the ESG2 guidelines and its draft supplement.

This REF has also assessed the proposed activity against the additional criteria outlined in clause 228 of the EP&A Regulation, with a summary table provided in Chapter 13.

In addition, in September 2012 the *NSW Strategic Regional Land Use Policy* (SRLUP) was introduced. The SRLUP considers the *NSW Code of Practice for Coal Seam Gas - fracture stimulation activities* (CoP - fracture stimulation activities), the *NSW Code of Practice for Coal Seam Gas – well integrity* (CoP - well integrity) and the *NSW Aquifer Interference Policy* (AIP).

This REF and supporting plans address the requirements of those documents. The CoP – fracture stimulation activities requires approval of a detailed Fracture Stimulation Management Plan (FSMP) before the proposed activity can commence. The FSMP is contained in Appendix B.

Other relevant legislation has also been considered, including but not limited to the *NSW Threatened Species Conservation Act 1995* (TSC Act), *NSW National Parks and Wildlife Act 1974* (NPW Act), *NSW Protection of the Environment Operations Act 1997* (POEO Act) and the EPBC Act.

It is noted that *State Environment Planning Policy Mining, Petroleum Production and Extractive Industries Amendment (Coal Seam Gas Exclusion Zones)* (Mining SEPP gas Amendment) was put on exhibition in March 2013. There are no zoned parcels of land classified as either R1 (General Residential), R2 (Low Density Residential), R3 (Medium Density Residential), R4 (High Density Residential) and RU5 (Village) within 2 km of the area subject to the proposed activity.

The REF describes the activity, potential environmental impacts and environmental management measures. The REF has been prepared in accordance with relevant legislative requirements and guidelines so that the responsible determining authority, in this case the DTIRIS-OCSG, can examine and take into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity in determining the proposal.

## 1.5 The proponent

The proponent is AGL and its successors and assigns. AGL is the holder of PEL 285 which applies to the land on which the proposed activity will be undertaken.





## 2 The proposed activity

**This section gives an overview of the proposed activity (a detailed description is provided in Section 2.7), summarises the local and regional contexts, outlines the community consultation, provides justification for the activity and an analysis of alternatives.**

### 2.1 Overview of activity

The site of the proposed activity is south of Gloucester in the Avon River Valley and is currently used for light cattle grazing and the growth of pasture and cultivation of fodder crops. There are four existing exploration wells on the site, known as WK11, WK12, WK13 and WK14 which were approved by DTIRIS-DRE in 2011 and drilled in 2012.

Ancillary infrastructure is required for the activity. This includes the construction of water storages for fracture stimulation flowback water, water gathering lines to deliver water to and from the water staging area and gas gathering lines to deliver gas to the central enclosed flare/s. Depending upon operational needs and requirements, a second water staging point will be established at WK11 servicing this site only.

An underground pipeline to transport water from a nearby dam on land owned by AGL (Tiedmans property) to WK13 is also part of the application. The pipeline would be used to transfer source water for fracture stimulation activities from the Tiedmans property to WK13, and produced water from WK13, to the Tiedmans property. The pipeline would be installed on land owned by AGL and also land owned by another landholder (with which AGL has agreed an access arrangement). The pipeline works would include an underbore of Fairbairns Road, for which a section 138 approval under the *Roads Act 1993* (NSW) and access arrangement with Gloucester Shire Council will be required.

Water will be sourced from either one or both nearby dams on properties owned by AGL: Pontilands or the Tiedmans property. The transportation of the produced water to the Tiedmans property is assessed in this REF, but the irrigation works (including on-site transportation) were assessed and approved under the 2012 approval.

A double-lined dual compartment turkey nest or temporary above-ground water storage will be constructed at a water staging point at WK13 to hold flowback water and produced water. Flowback water will be pumped into tanks prior to transport to an appropriate facility by truck for lawful disposal. Produced water will be pumped into tanks and then transported to AGL's Tiedmans property, where it be stored and blended with freshwater for irrigation in accordance with the approval issued by DTIRIS-DRE in 2012 to undertake a trial irrigation program at the Tiedmans property.

Equipment including a wellhead, pump, generator, horizontal flare, flaring container, flowback and produced water tanks and water will be delivered to site.

The expected activity duration is approximately 12-18 months. However, AGL seeks approval for an activity duration of 36 months to account for any unexpected delays in the program (Table 2.1).

**Table 2.1 Activity summary**

<b>Activity</b>	<b>Description</b>
Authorisation/title number	PEL 285
Titleholder and operator	AGL
Activity type	Pilot testing
Activity scope	<ul style="list-style-type: none"> <li>• Conversion of four existing exploration wells to pilot wells using perforating and fracture stimulation techniques.</li> <li>• Pilot testing of four wells.</li> <li>• Construction of water storages for flowback and produced water.</li> <li>• Construction of associated infrastructure including water and gas gathering lines and a water pipeline between the Tiedmans property and WK13.</li> <li>• Enclosed central gas flare/s.</li> <li>• Delivery of equipment (and water) to undertake the activity.</li> <li>• Lawful disposal of flowback water.</li> <li>• Lawful disposal of produced water.</li> <li>• Suspension of exploration wells following completion of pilot testing.</li> <li>• Site rehabilitation.</li> </ul>
Activity duration	The expected activity duration is 12-18 months. However, AGL seeks approval for an activity duration of 36 months to account for any unexpected delays in the program.
Type of approval being sought	Approval from DTIRIS-OCSG under Part 5 of the EP&A Act.

## 2.2 Local context

The well sites are on land zoned E3 Environmental Management in the Gloucester Local Environmental Plan 2010 (LEP) as shown in landuse zoning plan in Figure 2.1.

The objectives of the E3 zone are:

- to protect, manage and restore areas with special ecological, scientific, cultural or aesthetic values;
- to provide for a limited range of development that does not have an adverse effect on those values; and
- to conserve biological diversity and native vegetation corridors, and their scenic qualities, in a rural setting.

The proposed water pipeline between WK13 and the Tiedmans property is partially on land zoned RU1 Primary production in the Gloucester Local Environmental Plan 2010 (LEP) as shown in landuse zoning plan in Figure 2.1.

The objectives of the RU1 zone are:

- to encourage sustainable primary industry production by maintaining and enhancing the natural resource base;
- to encourage diversity in primary industry enterprises and systems appropriate for the area;
- to minimise the fragmentation and alienation of resource lands;

- to minimise conflict between land uses within this zone and land uses within adjoining zones; and
- to encourage eco tourism enterprises that minimise any adverse effect on primary industry production and the scenic amenity of the area.

An assessment of the ecological and biodiversity impacts is in Section 8 which identifies that the proposed activity would not have a long term significant impact on the environment. An assessment of cultural and aesthetic impacts is in Section 10 and Section 8 respectively. The assessment identifies that the proposed activity would not have a significant impact on potential cultural values and would not have a significant impact on aesthetic values.

It is considered that the majority of the site is zoned E3 Environmental Management due to the environmental as well as the scenic qualities of the location. There is a significant ridgeline to the east of the subject lots. The activity will not have a significant impact upon the scenic or aesthetic qualities of the area. All works are for exploration purposes and are short term in nature.

*State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007* (Mining SEPP) prevail over LEPs in the event of an inconsistency. Under the Mining SEPP the proposed exploration activities are permitted without development consent and approval for the activity is required by a determining authority. Therefore, the assessment is subject to an assessment under Part 5 of the EP&A Act. The Minister for Mineral Resources and Energy (or delegate) will be the determining authority.

Notwithstanding the above, the proposed activity will adhere to the principles and objectives of the LEP zones. Pilot testing of the potential gas resource is the last part of the exploration process and determines the flow characteristics and quantities of the gas resource. AGL has committed to best practice environmental and fracture stimulation management techniques. The activity is temporary and will implement measures to protect and conserve agricultural land, co-exist with existing agricultural practices, avoid impacts on natural ecological systems and processes and will only have a transient effect on aesthetic values.

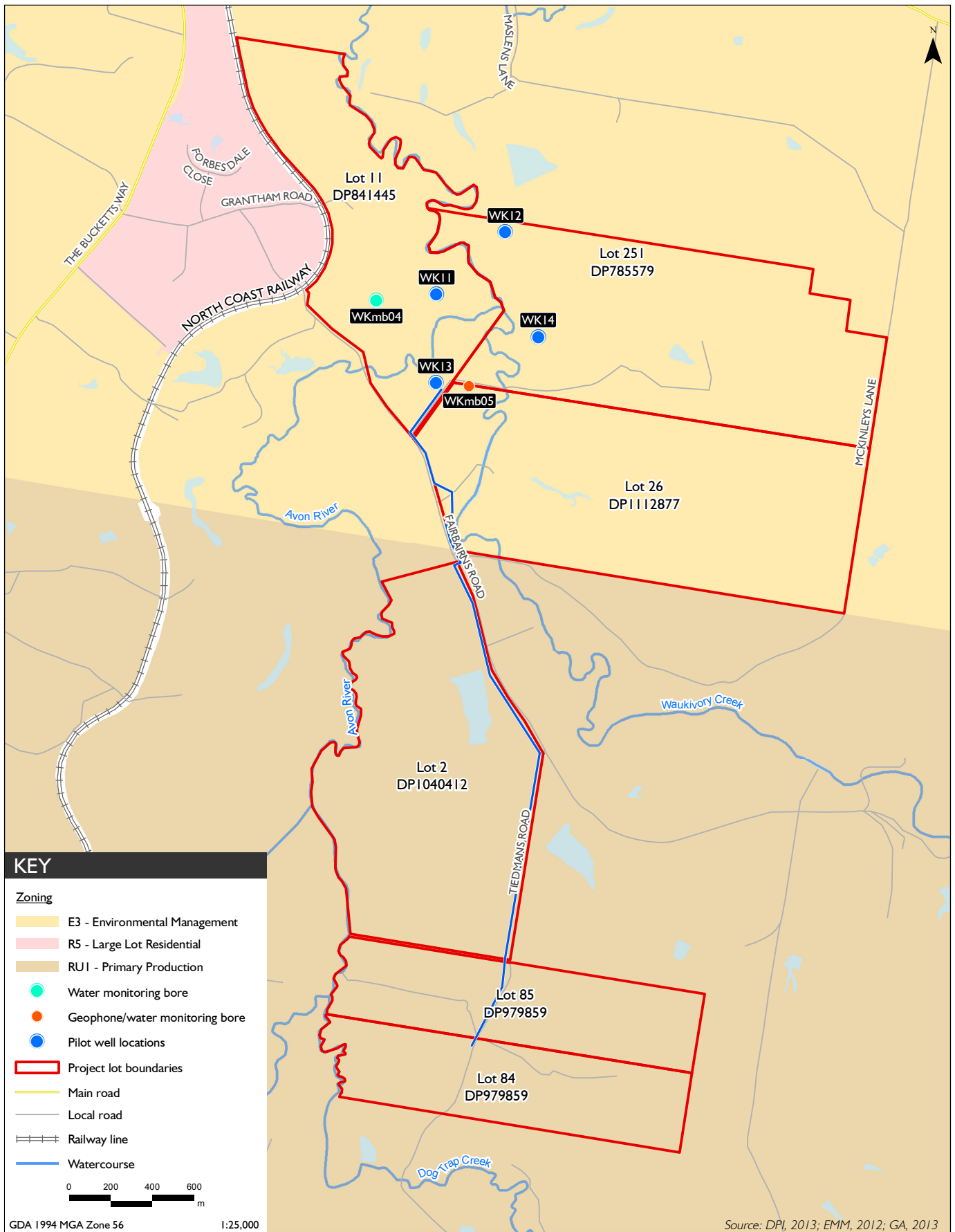
## 2.3 Regional context

PEL 285 (Figure 1.1) is bound generally by Copeland Tops State Conservation to the north west; The Glen Nature Reserve and Ghin-doo-ee National Park to the east; Karuah National Park to the south; and Black Bulga State Conservation Area and Avon River State Forest to the west. The PEL covers parts of Gloucester, Great Lakes and Dungog LGAs (Figure 2.2).

The activity is in the northern section of the PEL, south of Gloucester and in the Gloucester LGA. The site is in the Gloucester Basin Coalfield. Stratford and Duralie coal mines are in the PEL, to the south of the site.

There are alluvial deposits in the area associated with the Avon River, which runs in a mostly south to north direction through the site, and Waukivory Creek, which flows into the Avon River between WK13 and WK14. These alluvial deposits are near the surface and contain shallow aquifers with variable water quality.

The wells intersect the Gloucester Coal Measures. This unit comprises two important coal bearing sub-groups; the Craven Sub-Group and Avon Sub-Group. Coal seams include the Linden; Marker M6 and M7; Bindaboo; Deards; Cloverdale; Roseville; Marker M3, M8 and M1; Bowens Road; Bowens Road Lower; Glenview; Marker 2; Avon; Triple; Rombo; Glen Road; Valley View; and Parkers Road. The geology of the Gloucester Basin is shown in Figure 2.3.



## 2.4 Ownership

Lot 251 DP 785579 and Lot 11 DP 841445 are currently owned by Gloucester Resources (Agriculture) Pty Limited (Gloucester Resources). Access arrangements between AGL and Gloucester Resources are in place. In addition to the subject site, the water pipeline to the Tiedmans property traverses three Gloucester Resources properties (Lot 2, DP 1040412, Lot 1 DP 196054 and Lot 26, DP 1112877); two AGL owned properties (Lot 2 DP 1040412 and Lot 85 DP979859) and a local road (Fairbairns Road) for which an access arrangement will be required with the Gloucester Shire Council.

## 2.5 Stakeholder consultation

### 2.5.1 Approach to consultation

AGL began consultation with stakeholders when the Waukivory pilot project was first proposed in 2010. The consultation program was designed to ensure it was effective and genuine and involved identification of relevant stakeholders, informing stakeholders of the proposed program of work, notifying stakeholders of potential impacts, establishing channels of communication, providing feedback on how issues had been addressed and maintaining consultation records. Although the early consultation program was focused on site establishment, construction and drilling activities, there were many lessons learned which are relevant to the perforation, fracturing and flow testing component of the pilot project. These lessons include lighting orientation, sound wall location and the requirement for ongoing consultation with nearby residences and local landowners.

For the perforation, fracturing and flow testing component of the pilot project AGL has completed preliminary consultation with relevant government agencies and local landholders, and has held a number of community information sessions and an open house information day. The nearby residents and neighbours of the activity have received a project update in the mail, and local information sessions were held specifically for landholders neighbouring the activity.

The broader community has been informed by regular media notices which were placed in local newspapers. The GGP website also contains community updates and fact sheets related to the proposed exploration activity and are accessible to the general public.

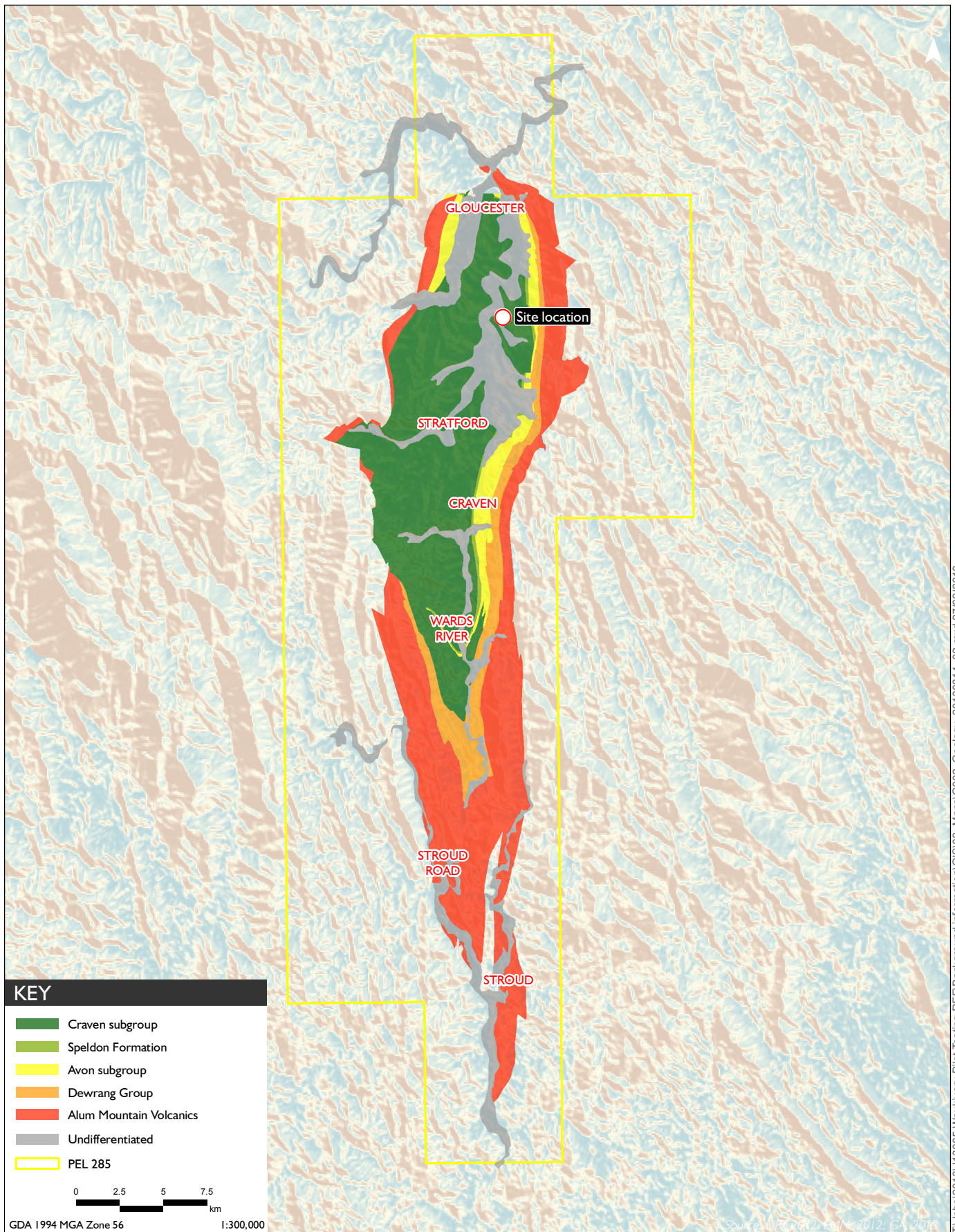
AGL has an office in Gloucester, which is the central hub of GGP activities. Members of the community are able to directly speak with AGL project officers at the local office and view the information display and fact sheets.

AGL's Community Relations Manager will continue to communicate and engage relevant stakeholders throughout the project. AGL has taken a proactive approach to dispute resolution, in assigning key team members to liaise directly with landholders and adjacent residents. These team members will work proactively with stakeholders to identify issues early, address issues in an appropriate and timely manner, and to keep the affected stakeholders informed throughout the resolution process.



Source: DPI, 2012; EMM, 2012; GA, 2013





## 2.5.2 Identification of stakeholders

AGL has been proactive and effective in identifying the relevant stakeholders requiring engagement throughout different stages of the exploration process. With regard to the pilot well activities, relevant stakeholders can be categorised into the following:

- government agencies;
- Gloucester Shire Council;
- the landowner, Gloucester Resources;
- surrounding landowners;
- indigenous landholders;
- community groups; and
- regional community.

## 2.5.3 Consultation to date

AGL began consultation with stakeholders when the Waukivory pilot project was first proposed in 2010. The early consultation program was focused on site establishment, construction and drilling activities.

For the perforation, fracturing and flow testing component of the pilot project, AGL has consulted with various state and local government agencies, surrounding landholders, industry, local indigenous groups, the general community and the Gloucester Community Consultative Committee (GCCC). Table 2.3 summarises the stakeholders consulted, details of the consultation, and issues raised and the proposed resolution measures.

In addition to the consultation outlined in Table 2.2 there has been ongoing communication between AGL and the landowner, Gloucester Resources since late 2010. Regular meetings have been held between AGL and the landowner as well as the lessees of the land to discuss access options, water bore licence applications and to develop access and compensation agreements. During site construction and drilling of wells, AGL consulted with the landowner and lessees keeping them up to date on all activities on site via phone calls and emails at management level and during on-site discussions at the field level.

Consultation with Gloucester Resources influenced the location of the proposed activity. During the well construction activities, consultation with Gloucester Resources guided the location of the access tracks, the timing of access for all heavy vehicles (ie through the dairy sheds to avoid the main milking time).

Meetings are ongoing with Gloucester Resources to discuss the logistics for the pilot testing program (in particular the vehicle movements and water management on site).

Feedback from stakeholder consultation has informed the project design process, with AGL having regard for community concerns on aspects of the proposed activity. AGL has also considered feedback from residents received both before and during the drilling program, which was previously approved under Part 5 of the EP&A Act.



Examples of design measures taken in response include:

- enclosure of the central flare and location of the water staging area to optimise transport efficiency to and from site; and
- the installation of pipelines for water delivery and removal from the well sites was included to minimise the amount of truck movements through the lessee’s activities on the land, and also as a consequence of feedback from the nearby residents on the disturbance from traffic in particular heavy truck movements along both Jacks Road and Fairbairns Road.

AGL will also continue to work with all employees and contractors to ensure that any traffic movements along Fairbairns Road and Jacks Road are minimised and all are aware of the school bus times, reduce speed limits through the nearby rural residential zone and no vehicles are to convoy through these areas. These measures will be implemented during the proposed activity ensuring that the activities co-exist with agriculture and other existing land uses.

Consultation with immediate landowners will continue to be targeted to ensure that affected parties have a clear understanding of the activity. Information provided to these landowners will clearly define the details of the pilot well testing, including location, duration, hours of operation and any other relevant information related to the activity.

In addition to targeted community stakeholder consultation, AGL has demonstrated a commitment to informing the wider regional community about the exploration activities associated with the GGP. AGL has and will continue to provide a range of communication media with which it is able to disseminate information about current and upcoming activities and receive feedback and input from any member of the community.

AGL has implemented a wide reaching, inclusive approach to consultation which seeks to inform all aspects of the local and wider community as to current and future exploration activities associated with the GGP. The approach to communication through a range of options is detailed in Table 2.2.

**Table 2.2 Consultation activities undertaken**

Item	Summary
Project website <a href="http://www.agl.com.au/gloucester">www.agl.com.au/gloucester</a>	Website includes regular project updates to keep all member of the community informed of current and planned future activities. A variety of Project Factsheets, including the Waukivory Pilot Program Fact Sheet, were issued in September 2012.
Project telephone line and email address 1300 886 170 <a href="mailto:gloucester@agl.com.au">gloucester@agl.com.au</a>	The project telephone and answering is staffed 24 hours per day to respond to community enquiries. A dedicated email address has also been established to respond to community queries or concerns.
Gloucester office 22 Tate Street Gloucester 02 6558 1166	AGL’s Gloucester office is in Gloucester and staffed by AGL personnel who are available to discuss and answer enquiries about the GGP and the proposed activity.
Community information sessions	Community information sessions have been undertaken by AGL and will continue as requested by local community groups or organised by AGL to provide specific works program information.

**Table 2.2 Consultation activities undertaken**

Item	Summary
Stakeholder meeting	Meetings with stakeholders include government agencies, indigenous groups, local community groups, Gloucester Resources and surrounding landowners.
Communication materials	<p>Community updates –Information placed in local newspapers.</p> <p>Surrounding landowners will be provided with written information which details the location, duration and hours of operation of the pilot well testing activities.</p> <p>Contact details will also be provided to surrounding landowners to provide a direct form of contact to AGL in the event of a concern/impact during pilot well testing activities.</p> <p>Communication with Gloucester Resources regarding the proposed activity is governed by AGL’s access and compensation agreements with this landowner.</p>
Gloucester Community Consultative Committee (GCCC)	<p>The GCCC provides a direct line of communication to a number of community representatives and allows direct feedback to AGL as to community issues related to the GGP and to the proposed activity. This direct line of communication allows AGL to make informed decisions for their exploration activities that has regard for, and mitigates wherever possible, community concerns around the activity.</p> <p>GCCC members include local government, MidCoast Water, local business, agriculture, Industry, landowners, community groups and AGL. The GCCC meets every two months and minutes of these meetings are posted on AGLs website.</p>

**2.5.4 Summary of consultation undertaken**

AGL has undertaken targeted consultation with a range of stakeholders with respect to the proposed activity. Table 2.3 outlines the consultation activities undertaken during the past 12 months from the commencement of the initial drilling program through to the design/planning for the proposed pilot testing activity and how the issues raised have informed the project design.

**Table 2.3 Consultation record**

<b>Key stakeholder</b>	<b>Details</b>	<b>Issues discussed</b>	<b>Proposed resolution measures</b>
<b>Landowner and lessees</b>	<b>During onsite activities (ongoing)</b>	AGL have consulted with both the landowner and their lessees throughout the planning process and this remains ongoing.	The layout of the wells and ancillary infrastructure has been developed with input from the landowner and their lessees. Planning for and location of pipelines to minimise heavy vehicle movements through the dairy shed and along roads, implementation of restrictions on movements to avoid milking period in morning and evening; location of a central flare, use of noise walls and directional lighting.
	<b>January 2012</b>	Access and compensation agreements between AGL and Gloucester Resources were entered into for WK11 and WK13.	
	<b>November 2011</b>	Access and compensation agreements between AGL and Gloucester Resources were entered into for WK12 and WK14.	
	<b>May 2011</b>	Water bore licence applications were signed by Gloucester Resources for AGL to submit to the NSW Office of Water for each of the four wells.	
<b>Adjoining landowners</b>	<b>During the planning process</b>	Adjoining landholders have been kept informed through consultation with the GCCC, community newsletters and updates.	Lighting and traffic movement and timing of traffic movement considerations.
	<b>5 October 2012</b>	Discussions with tourist operator on Fairbairns Road re heavy vehicle movements.	Developed notification process, heavy vehicles inducted to lower speed limits, no convoys, awareness of school bus times and minimise movements during particular times as required.
<b>Gloucester Shire Council/Mid Coast Water</b>	<b>19 February 2013 Briefing</b>	Briefing with Gloucester Shire Council (GSC) and MidCoast Water Board. Discussion of Waukivory pilot flow testing/hydraulic fracture stimulation. AGL advised Council that flow testing for Waukivory pilot program expected to occur July 2013. Included discussion of Waukivory pilot flow testing/hydraulic fracture stimulation.	No issues requiring resolution.
	<b>28 June 2012 briefing to GSC.</b>	Mike Roy (AGL) presented to GSC - gas operations and the techniques for gas extraction, including hydraulic fracturing.	No issues requiring resolution.
	<b>7 June 2012 briefing to GSC</b>	Independent Peer Reviewer Dr Rick Evans provided overview of water studies review which specifically addressed the Waukivory Pilot flow testing program.	Request for AGL's head of gas operations to attend future GSC meeting and discuss hydraulic fracturing and gas extraction process.

**Table 2.3 Consultation record**

<b>Key stakeholder</b>	<b>Details</b>	<b>Issues discussed</b>	<b>Proposed resolution measures</b>
<b>GCCC</b>	<b>27 June 2013</b> GCCC meeting	The GCCC were provided with another update regarding the lodgement of the REF. There was discussion amongst the GCCC members if AGL would conduct any baseline data gathering (for fugitive emissions) prior to fracture stimulation of the Waukivory pilot wells.	From the GCCC member discussions, AGL implemented baseline measurements in July. Emissions monitoring program to be developed and rolled out prior to the hydraulic fracturing of the wells.
	<b>May 2013</b> GCCC update	The GCCC was advised that water monitoring was occurring at the Waukivory pilot site 'in front of the proposed fracture stimulation and flow testing program'.  It was clearly stated that fracture stimulation would be used on wells in the basin.	No issues requiring resolution.
	<b>February 2013</b> GCCC update	John Ross (AGL) spoke about the upcoming water program which included a slide about the Waukivory pilot and the proposed fracture stimulation and flow testing program (that presentation is included in the minutes and available on the website).	No issues requiring resolution.
	<b>20 December 2012</b> discussion with GCCC.	The GCCC was advised that as part of the project update that preparation of the REF for the fracture stimulation and flow testing for the Waukivory pilot under the new codes of practice was underway and that the timeframe to submit the REF was approximately February.	There was a question at this meeting from the GCCC member on whether the REF would be open to submissions from the community. AGL outlined the public consultation process for Part 5 REFs.
	<b>30 November 2012</b> GCCC update	Community update forwarded to GCCC members (Waukivory pilot/Aeromag session) and also provided an update on the completion of drilling the Waukivory pilot.	
	<b>13 November 2012</b> GCCC update	Provided a copy of a letter box drop to Forbesdale residents regarding a mock rescue exercise being conducted near WK11.	AGL and Ensign (the drilling contractors) co-operated with the local Emergency Management Committee to stage a mock rescue exercise near the WK11 drill site. The exercise provided local emergency services with a valuable training opportunity.
	<b>2 November 2012</b> GCCC update	Project update regarding Waukivory pilot testing program schedule. GCCC meeting action item regarding water monitoring bores associated with the Waukivory pilot testing program.	No issues requiring resolution
	<b>25 October 2012</b> GCCC update	Project update regarding Waukivory pilot testing program and site visit to WK14 for GCCC members.	No issues requiring resolution.

**Table 2.3 Consultation record**

<b>Key stakeholder</b>	<b>Details</b>	<b>Issues discussed</b>	<b>Proposed resolution measures</b>
	<b>24 October 2012</b> GCCC update	Copy of community update (What AGL has done to protect water).	No issues requiring resolution.
	<b>10 October 2012</b> GCCC update	Emailed copy of finalised Waukivory pilot testing program fact sheet to GCCC members and advised it was also available on project website.	No issues requiring resolution.
	<b>28 September 2012</b> GCCC update	Copy of newsletter/community update regarding Waukivory pilot testing program and community update (why AGL is pursuing gas in Gloucester) provided to the GCCC prior to mail out and publication.	No issues requiring resolution.
	<b>27 September 2012</b> Fact sheet distributed to GCCC.	Fact sheet talks about flow testing/hydraulic fracture stimulation of the Waukivory wells – distributed to the GCCC, placed on website.	No issues requiring resolution.
	<b>25 September 2012</b> GCCC update	Community update forwarded to GCCC members (What is the Waukivory Pilot).	No issues requiring resolution.
	<b>17 September 2012</b> GCCC update	Advising of commencement of Waukivory pilot testing program site works on Monday September 24.	No issues requiring resolution.
	<b>28 August 2012</b> Media release issued	Regarding the GGP Land and Environment Court decision also issued to the GCCC members.	No issues requiring resolution.
	<b>28 June 2012</b> GCCC and GSC briefing	Briefing was provided to the GCCC and GSC specifically in relation to hydraulic fracture stimulation by AGL's Head of Gas Operations Mike Roy.	Request to circulate Mike Roy's presentation to CCC members and place on project website. Presentation included in CCC minutes and placed on project website to allow broader community to access the information presented.
	<b>7 June 2012</b> briefing to GSC	Independent Peer Reviewer Dr Rick Evans provided overview of water studies review which specifically addressed the Waukivory Pilot flow testing program.	Request for AGL's Head of Gas Operations to attend meeting and discuss hydraulic fracturing and gas extraction process.
<b>General community</b>	<b>28 March 2013</b> Stakeholder briefing (to a local interest group).	Discussion of Waukivory pilot/hydraulic fracture stimulation.	Queries raised on the number of wells that have been previously hydraulically fractured and the differences between these pilot wells and core holes. Information supplied to stakeholder to address these questions.
	<b>5 December 2012</b> Community update	Completion of drilling Waukivory pilot testing program (and thanks to residents).	No issues requiring resolution.
	<b>17 November 2012</b> Rig inspection	Four interested community members to Rig 67 at WK11.	No issues requiring resolution.

**Table 2.3 Consultation record**

<b>Key stakeholder</b>	<b>Details</b>	<b>Issues discussed</b>	<b>Proposed resolution measures</b>
	<b>13 November 2012</b> Letterbox drop	All Fairbairns Road, Forbesdale Estate, and Grantham Road re: emergency service exercise planned for drill rig lease on November 14.	No issues requiring resolution.
	<b>13 November 2012</b> Door knocking	Residents in Fairbairns, Grantham and Jacks Road re night lighting. Residents in Forbesdale Estate advised visits were not necessary.	Refinement of light mitigation measures at the site.
	<b>2 November 2012</b> Door knocking	Residents in Fairbairns, Grantham Roads, parts of Forbesdale Estate and Jacks Road to assess impact of rig lighting at their properties.	Refinement of light mitigation measures at the site.
	<b>31 October 2012</b> Letterbox drop	Letter box drop to residents in Fairbairns Road, Grantham Road and part of Forbesdale Estate regarding rig move and to set up follow up light inspection at their property.	Refinement of rig set up activities at the site.
	<b>24 October 2012</b> Community update	Protecting water/water studies.	No issues requiring resolution.
	<b>20 October 2012</b> Door knocking	Follow up visit to residents in Fairbairns Road, Grantham Road, part of Forbesdale Estate, one resident Jacks Road to assess impact of lighting (evening visit).	Refinement of light mitigation measures at the site.
	<b>18 October 2012</b> Letterbox drop	Letter box drop to residents in Fairbairns Road, Grantham Road and part of Forbesdale Estate re rig move and to set up follow up light inspection at their property.	Refinement of rig set up activities at the site.
	<b>16 October 2012</b> Media release	Comprehensive water studies already undertaken in Gloucester.	No issues requiring resolution.
	<b>12 October 2012</b> Radio interview	AGL interview on ABC Radio regarding planned protest outside AGL office following week.	No issues requiring resolution.
	<b>12 October 2012</b> Site visit	Representatives of Norco and two local community members provided with a rig inspection at WK12.	No issues requiring resolution.
	<b>11 October 2012</b> Site visit	Site visit to WK12 with editor of Gloucester Advocate for picture and interview – story published following week.	No issues requiring resolution.
	<b>11 October 2012</b> Site visit	Two neighbours (four people) attended a site visit to Rig 67 on WK12, offer extended to impacted residents in Fairbairns, Grantham Road and Forbesdale Estate.	No issues requiring resolution.
	<b>10 October 2012</b> Radio interview	AGL interview on Bucketts Radio regarding Waukivory pilot testing program.	No issues requiring resolution.

**Table 2.3 Consultation record**

<b>Key stakeholder</b>	<b>Details</b>	<b>Issues discussed</b>	<b>Proposed resolution measures</b>
	<b>9 October 2012</b> Door knocking	Site visit to resident in Jacks Road to assess lighting impact of rig at their property after complaint received (evening visit).	Alterations made to lights re orientation and screening erected around mud tanks as a result.
	<b>6 October 2012</b> Door knock	Doorknocking of residents in Fairbairns Road, Grantham Road, part of Forbesdale Estate to assess impact of lighting (night visit). Residents were happy with orientation of lighting and site visit (also included company man on initial evening visit to further explain rig operation and address lighting questions).	No issues requiring resolution.
	<b>5 October 2012</b> Letterbox drop/Door knock	To residents in Fairbairns Road, Granthams Road and part of Forbesdale Estate about rig lights being turned up, making appointment to return for site inspection.	No issues requiring resolution.
	<b>3 October 2012</b> Community update	Why AGL is pursuing gas in Gloucester.	No issues requiring resolution.
	<b>2 October 2012</b> Newsletter/Community update	Information on Gloucester Gas Project and Waukivory pilot letterbox dropped by Australia Post to all of 2422 post code area and mail delivery to the north of Stroud Hill Road (in total more than 2300 households).	No issues requiring resolution.
	<b>26 September 2012</b> Community update	Gloucester Advocate & Dungog Chronicle – What is the Waukivory pilot.	No issues requiring resolution.
	<b>19 September 2012</b> Community update	Waukivory pilot testing program full page update Gloucester Advocate, Dungog Chronicle /website/letterbox dropped to Waukivory pilot neighbours – Regarding Waukivory pilot flow testing program.	No issues requiring resolution.
	<b>18 September 2012</b> Media release	Re commencement of site works Waukivory pilot testing program.	No issues requiring resolution.
	<b>18 September 2012</b> Letterbox drop	To households on Jacks Road (plus both residential estates), Fairbairns Road, Grantham Road, Bucketts Way between Jacks Road and Fairbairns Road, McKinley’s Lane regarding the commencement of works associated with the Waukivory pilot program on Monday September 24.	No issues requiring resolution.

**Table 2.3 Consultation record**

<b>Key stakeholder</b>	<b>Details</b>	<b>Issues discussed</b>	<b>Proposed resolution measures</b>
	<b>June 2012</b> Community information sessions	Findings of the Independent Peer Review of AGL’s water studies by Rick Evans (SKM) were presented. Rick Evans also highlighted the importance of the Waukivory pilot, the need to gather data from the pilot and how this would be achieved – fracture stimulation of the wells and flowing gas. Two of those three information sessions included extensive questions on fracture stimulation.	Published Rick Evan’s presentation to the project website to allow the broader community to access the findings of the work, the recommendations, and AGL’s response to the recommendations Development of a water fact sheet to highlight work undertaken by AGL in regard to water studies and published to website. Water study information to be included in future Community Updates. Water updates provided to GCCC at each meeting as a standing agenda item.
<b>All stakeholders</b>	<b>July 2013</b>	ABC Radio Mid North Coast – interview with AGL Group General Manager Upstream Gas Mr Mike Moraza. Discussed the Waukivory Pilot program and the proposed Hydraulic fracturing and flow testing program.	-
	<b>17 May 2013</b>	The day after a community meeting in Gloucester the Newcastle Herald stated in the page 3 heading that “Fracking will be used”.	-
	<b>16 May 2013 Gloucester Community Meeting</b>	AGL presentations included the Waukivory Pilot program and hydraulic fracturing.	Question from the audience to AGL on the use/need for Hydraulic fracturing in Gloucester – it was confirmed during this meeting that AGL would use hydraulic fracturing for the Waukivory Pilot Project.
	<b>January 2013</b>	AGL quoted in the Gloucester Advocate as saying “fracture stimulation will be used in the Gloucester Basin”.	All stakeholders have been informed of the proposed program of works through media coverage.

### 2.5.5 Pre and during activity consultation

AGL is committed to undertaking a comprehensive approach to stakeholder consultation which extends through the entire exploration process. The commitment is designed to identify community concerns and feedback to assist in the development and planning of the proposed pilot well activity. Complaint mechanisms are in place to capture any complaints made prior and during the activity. AGL is committed to ensuring that all community feedback is valued.



Future stakeholder consultation activities planned during the proposed activity include:

- surrounding landowner information sessions;
- community information sessions related to the proposed activity; and
- GCCC meetings.

AGL is committed to ongoing consultation with surrounding landowners and relevant stakeholders throughout the proposed activity. This consultation will provide an avenue for community input into the design and implementation of the exploration activities associated with the GGP.

To ensure all relevant stakeholders are consulted as part of the exploration activities, AGL will ensure at a minimum that the following stakeholder consultation is undertaken before and during the proposed activity:

- notifications to landowners and neighbours, with reasonable notice provided prior to the activities being undertaken and regular notifications and updates during the activities;
- traffic management measures notified as required;
- community updates through newspapers and the GGP website, both prior to the activity and during works;
- dedicated telephone and email addresses. The community telephone number will be promoted on all communication material;
- GCCC meetings; and
- AGL personnel available at the GGP office open Monday to Friday 8.30am to 5.00pm, at 22 Tate Street, Gloucester.

### 2.5.6 Stakeholder conflict management

AGL's approach to conflict management is to engage with stakeholders with a view to identifying any potential conflicts at an early stage that can be incorporated into the design to mitigate any impacts. To enable early intervention with regard to community concern, AGL:

- empowers team members to respond to community enquiries and resolve concerns and complaints. AGL will strive to resolve all community enquiries or update the complainant within 24 hours;
- ensure a consistent approach to stakeholder engagement across the GGP; and
- encourages team members to address community concerns which could lead to delays in the project timeline.

### 2.5.7 Protocols for complaint management

AGL provides a range of avenues for the community to comment or raise any concerns with the GGP through information sessions, the GCCC, website and newsletter updates and the community hotline.

The following protocols have been implemented by AGL for processing and managing enquiries and complaints on the GGP:

- complaint or enquiry is received from one of the communication forums employed by AGL;
- enquiry or complaint is recorded and logged;
- details recorded to include time and date of call/ email received, contact name, phone number, nature of enquiry/ complaint and any response given;
- access and investigate complain/ issue – escalate if unable to resolve;
- update complainant within 24 hours – during the process of the investigation the relevant stakeholder is to be kept informed of the progress of the enquiry/ complaint and provided with an estimated response time;
- finalise the complaint and update records – close out complaint/ enquiry and record all communications and responses; and
- report outcomes/issues/ responses in monthly report to project team.

## 2.6 Justification of activity

### 2.6.1 Increased demand for clean energy

Natural gas in coal seams production is an established industry in Australia and overseas for example, over 90% of Queensland's gas comes from natural gas in coal seams within Queensland. By comparison, only 5% of NSW's gas comes from indigenous (NSW) gas resources at this point in time. The exploration for, and development of, gas reserves is considered to be vital and a cost effective method of meeting increasing future gas and energy needs in NSW.

The natural gas industry in the Gloucester area is in its infancy, with no existing commercial production. However, the area contains large reserves of natural gas in coal seams and is highly prospective for conventional gas which, in combination, has the potential to play a significant role in the delivery of reliable energy in a carbon constrained economy, provide security of supply for domestic gas and alleviate the state's reliance on imported gas (NSW Government, 2012a).

Energy consumed in NSW is mainly from the combustion of black coal. Gas in coal seams and other natural gases produce around 55% of greenhouse gas emissions (GHG) per gigajoule of energy relative to coal and are considered to be the cleanest fossil fuel. Electricity generated from gas uses up to two thirds less water than conventional coal-fired electricity generation.

Natural gas in coal seams is therefore considered to be an important energy resource for NSW which is indigenous and cost-effective and has environmental benefits over coal combustion. The identification of potential new gas resources through exploration is therefore important to guarantee ongoing supply to the NSW market.

## 2.6.2 Obligations under PEL

AGL is required to fulfil its work program commitment with the DTIRIS under PEL 285 to explore for potential gas resources. To achieve this AGL (and its predecessors) have done three seismic surveys and drilled approximately 61 gas exploration wells (including core holes, stratigraphic holes and test wells) and 25 piezometers within PEL 285. The proposed activity would continue this exploration in order to meet AGL's obligations under the PEL requirements.

## 2.6.3 Environmentally-friendly methods

Flaring is considered the most environmentally friendly method to dispose of pilot well gas during testing. The carbon dioxide (CO<sub>2</sub>) produced from the burning process (ie the burning of methane gas) has less than one-twentieth of the impact on the Earth's atmosphere compared to simply releasing methane (Queensland Government, 2010) into the atmosphere. An assessment of emissions for the proposed activity has been undertaken for the Waukivory pilot testing program and is summarised in Section 7.7 and produced in full in Appendix C. The gas flare will be enclosed to mitigate noise and visual impacts.

Additional environmental considerations include the use of minor additives during hydraulic fracture stimulation. The hydraulic fracture stimulation fluid will be 99.5% water and sand.

## 2.6.4 Ecologically sustainable development

The Ecologically Sustainable Development (ESD) Steering Committee's *National Strategy for Ecologically Sustainable Development* (1992) defines ESD as 'using, conserving and enhancing the community's resources so that ecological processes, on which life depends, are maintained, and the total quality of life, now and in the future, can be increased'.

The NSW *Protection of the Environment Administration Act 1991* (POEA Act) states that ESD can be achieved through the implementation of the following:

- the precautionary principle—namely, that if there are threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation;
- inter-generational equity—namely, that the present generation should ensure that the health, diversity and productivity of the environment is maintained or enhanced for the benefit of future generations;
- conservation of biological diversity and ecological integrity; and
- improved valuation and pricing of environmental resources.

Table 2.4 shows how ESD principles have been considered for the proposed activity.

**Table 2.4**      **Consideration of ESD principles**

<b>Principle</b>	<b>Consideration of principle</b>
Precautionary principle	If an action has associated threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation (ESD Steering Committee, 1992). This REF identifies and assesses potential environmental impacts, and appropriate mitigation, management and monitoring measures have been developed in response. Risk assessments (Appendix L) have been carried out to determine specific environmental risks, prior to mitigation measures being formulated. The outcome of the risk assessment guided mitigation measures to avoid, wherever practicable, minimise and manage impacts to the environment. Taking these measures into account, no threat of serious or irreversible damage to the environment is expected as a result of the proposed activity.
Social equity including intergenerational equity	<p>The proposed activity is for a short duration and a temporary land use for exploration purposes. If the gas resource is deemed to be viable and then form part of a future production component of the GGP, the activity will likely contribute to social equity through the creation of additional employment opportunities, facilitate up-skilling of the local work force. It can also promote diversification of the local economy through ancillary businesses. The use of natural gas in coal seams as a resource in comparison with coal will deliver intergenerational equality, through reduced contribution to greenhouse gas emissions and climate change.</p> <p>Natural gas in coal seams has the potential to act as a viable, cleaner transitional energy source as society moves toward renewable energy sources.</p> <p>AGL supports local community groups and sources material from local suppliers and investigates the procurement of local services, where possible.</p> <p>These benefits would extend not only to existing generations but to future generations as well.</p>
Conservation of biological diversity and maintenance of ecological integrity	Technical studies including groundwater and ecology have been undertaken to establish the existing environment, and potential impacts of the activity to this environment. Suitable mitigation strategies including a rehabilitation program and groundwater monitoring program have been identified for implementation and incorporated into the project design such that biodiversity is conserved and ecological integrity is maintained.
Improved valuation and pricing of environmental resources	The objective of the activity is to explore a valuable resource in an environmentally responsible manner. AGL has placed an appropriate value on natural resources such that technical studies have been undertaken and mitigation strategies designed to safeguard the environment against irreversible damage.

## 2.7 Analysis of alternatives

Under-reaming (horizontal drilling) requires high permeability coal and was considered in the initial stages of design. However, further investigation revealed that the target zones are all very low permeability and as a result under-reaming was not considered further. Hydraulic fracture stimulation is necessary to increase the pilot wells productivity in order to assess the gas resource and gather the information necessary to carry out a successful exploration project as no lower impact alternatives to the proposed activity are available.

The ‘do nothing’ alternative has been considered in comparison with conducting the proposed activity. Doing nothing carries consequences for the development of indigenous natural gas sources and energy supply in the Gloucester region and NSW. The main existing gas supply for NSW comes from South Australia’s Cooper Basin and Victoria’s Gippsland Basin. These resources are predicted to decline in a few years’ time and could lead to a reduction in energy supply to NSW (Australian Energy Regulator, 2010).

In the past five years there has been a growing interest in using Queensland's natural gas in coal seams resources to produce liquefied natural gas (LNG) for export, taking advantage of increasing global demand for gas. Three export LNG projects based on Queensland natural gas in coal seams resources are under construction on Curtis Island near Gladstone with first cargoes expected in late 2014.

A further five proposals to develop export LNG projects are under consideration. If all current projects and proposals are developed to full capacity, this would represent a potential LNG export market for Queensland of more than 50 million tonnes per annum (Queensland Government, 2012).

The export of this LNG may impact on the local supply of natural gas in coal seams to NSW. These resources are a largely untapped resource in NSW with potential for establishment of productive indigenous supply. The location of the activity is considered appropriate and cost-effective. The activity will make use of four existing bores in an agricultural setting, negating the need for additional drilling and ground disturbance at the pilot well sites (with the exception of disturbance for temporary water storage and temporary gas/water gathering lines). In addition, disturbed land will be rehabilitated to its pre-existing state at completion of the activity.

Additionally, the proposed activity is consistent with AGL's obligations as holder of PEL 285 to explore the petroleum resource potential.

An analysis of alternative raw water sources and produced water disposal methods is provided in Section 2.8.7.

## 2.8 Detailed description of proposed activity

**This section provides a detailed description of each component of the proposed activity during the construction phase, operational phase and rehabilitation. Section 2.8.7 describes the hydraulic fracture stimulation process, fracture fluids and options analysis of water sources and potential produced water end uses.**

### 2.8.1 General

The proposed activity includes:

- conversion of four existing exploration wells to pilot wells using perforation and fracture stimulation techniques;
- pilot testing of four wells WK11, WK12, WK13 and WK14;
- construction of water storages for flowback and produced water;
- construction of associated infrastructure including a water pipeline and water and gas gathering lines;
- enclosed central gas flare/s;
- delivery of equipment (and water) to undertake the activity;
- lawful disposal of flowback water;

- lawful disposal of produced water;
- suspension of exploration wells following completion of pilot testing; and
- site rehabilitation of disturbed land including construction laydown areas, access tracks and gas gathering pipelines verges.

Two options for location of ancillary infrastructure of the proposed activity are being evaluated by AGL and are shown in Figure 2.4 and Figure 2.5.

Both options will require the construction of a water staging point at WK13 to minimise truck movements onsite. The water staging point will be either a double-lined dual compartment turkeys nest dam or a temporary above-ground water storage tank. The water staging point will require the construction of two water gathering lines, connecting WK14 and WK12 to WK13. One gathering line will transport source water to the wells and the other gathering line will collect flowback/produced water from the wells.

The water gathering lines will be laid east from WK13 alongside an access track and cross Waukivory Creek at the existing road bridge (owned by Gloucester Resources) before turning north to WK14 and WK12 alongside existing access tracks. The water and gas gathering lines will be buried, except across the Waukivory Creek, where they will cross the existing road bridge. At that point, the HDPE gathering lines will be fully encased in steel to provide extra support and protection.

Both options will require a central flare at WK12 (which was assessed to result in the least visual and noise impact) for WK12, WK14 and WK13. Gas gathering lines will connect the flares with their respective well locations.

Both options may also include an underground pipeline to transport water from a nearby dam on land owned by AGL (Tiedmans property) to WK13. The pipeline would be used to transfer source water for fracture stimulation activities from the Tiedmans property to WK13, and produced water from WK13 to the Tiedmans property.

#### i Option 1

Option 1 would include the addition of an underbore of a gathering line under the Avon River originating near WK11, to the west of a point between WK12 and WK14 (Figure 2.4). The underbore would connect WK11 to the water staging point at WK13 and the central flare at WK12. All produced water and flowback water for all pilot wells would be piped to and from the water staging area at WK13.

The central flare/s at WK12 would be implemented for all pilot wells (WK11, WK12, WK13 and WK14). In the event that the telemetry system identifies that gas production is likely to exceed the single flare's operating capacity, a secondary smaller flare would be installed beside the central flare at WK12.

#### ii Option 2

Option 2 would require the construction of water storage tanks and the implementation of a second flare at WK11. Under this option, water and gas gathering lines would still connect WK12, WK13 and WK14 with the water staging point at WK13 and an enclosed flare at WK12. However, there would be no underbore under the Avon River.

## 2.8.2 Activity footprint

The pilot testing compound surrounding the existing exploration wells requires a maximum area of 100 x 100 m. A previously assessed (EMM 2011) activity footprint of 100 x 100 m is allowed for manoeuvring and placement of construction plant around each of the existing exploration wells.

The central flare at WK12 will have a small additional footprint of 10 x 10 m and remain within the 100 x 100 m allowed. Gas will be delivered to the flare/s from the pilot wells via buried gathering lines.

Water will be managed by pumping flowback and produced water in buried gathering lines from WK12 and WK14 to a double-lined dual compartment turkeys nest dam or temporary above-ground water storage tanks at the water staging point at WK13. Water will be transported from WK13 by either truck or buried water pipeline to the Tiedmans property. The water pipeline from WK13 to the Tiedmans property would be buried to a depth of 450 mm to 1,000 mm for a distance of approximately 3.5 km. The pipeline traverses the Waukivory Pilot site and AGL-owned properties with an underbore section across of Fairbairns Road.

AGL will lawfully dispose of flowback water at an appropriate facility. Subsequent production of natural produced water will be transported to the Tiedmans property for storage and blending by truck or buried water pipeline and then used for irrigation. The transportation of produced water to the Tiedmans property has been assessed as part of this REF, but the storage, blending and irrigation works have previously been assessed as part of the irrigation trial activity, and is currently subject of an approval under Part 5 of the EP&A Act.

Some minor levelling activities will occur in the vicinity of the drilled wells to ensure stability of equipment and plant.

The equipment to be delivered and installed at each of the pilot test wells includes:

- wellhead equipment, gas and water separator;
- a pump lowered into the well;
- gas and water gathering lines; and
- an acoustically treated hydraulic power unit (HPU) with hospital grade noise suppression to run the pump, to ensure that noise from this unit is as low as practicably possible.

Equipment and supplies required for well maintenance, including tubing and replacement items would also be delivered at this stage. A transportable laboratory/office (approximately 2.4 x 3.6 m) will be placed onsite within the previously assessed 100 m x 100 m footprint.

The water staging point will include the construction of either a double-lined dual compartment turkeys nest dam or a temporary above ground water storage within the 100 x 100 m footprint at WK13. The turkeys nest dam will be constructed with in-situ materials and dual lined in accordance with the requirements of DTIRIS-OCSG. Alternatively a temporary above ground water storage facility will be constructed to a high level specification (generally using high density polyethylene (HDPE)) to ensure safety and the integrity of the structure.

The turkeys nest dam/storage facility will have a capacity of 5 ML (3ML and 2ML compartments) (or 5,000 m<sup>3</sup>).

An operational freeboard of approximately 450 mm will be maintained at all times to allow for unexpected heavy rainfall. Nonetheless, should this freeboard level be reached, no pumping of water to the dam will be permitted. The anticipated storage capacity of the dam is an approximation only. The average exploration well in the Gloucester Basin can produce between 5 m<sup>3</sup> and 100 m<sup>3</sup> of water per day. As such, the proposed size of the dam will provide sufficient capacity for this range. Once the water from the wells has reduced, the lined pit will be removed and rehabilitated and replaced by an onsite storage tank.

AGL proposes to re-use a portion of the produced water for irrigation of crops at the Tiedmans property, a property owned by AGL provided the irrigation water achieves prescribed water quality criteria as outlined in the Water Management Plan for the Tiedmans Irrigation Program as approved by DTIRIS-DRE in 2012. The irrigation activity is not subject to this REF. The transportation of produced water from the proposed activity to the Tiedmans property has been assessed as part of this REF. The on-site transportation of that produced water within the Tiedmans property, its storage, blending and irrigation activities (described below) will be subject to the conditions of the irrigation approval of the Tiedmans property.

On the Tiedmans property, the produced water from this pilot testing program will be blended with existing fresh water, to achieve final irrigation water quality expected to be in the range 1,500 to 2,000 µS/cm (for the Stage 1A irrigation trial area), but up to 3,000 µS/cm for irrigation (of the Stage 1B area) of the property (PB 2012).

Should water quality (salinity levels) not be suitable for irrigation re-use, produced water will be lawfully disposed of by truck to an appropriate facility. These trucking movements will be scheduled accordingly to ensure minimal disruptions to local residents on the local road network. The impact of these truck movements on traffic and local roadways are assessed in Section 8.3.

Fencing would be installed for security of each of the compounds and the dam/storage facility at the water staging point. Further details of this are provided in Section 2.8.5.

#### i Option 1

Option 1 will include an additional length of buried gathering line connecting WK11 to the proposed gathering lines between WK12 and WK14 (Figure 2.4). The gathering line will cross under the Avon River through an underbore as indicated in Figure 2.4. Water will be managed by pumping flowback and produced water in buried gathering lines from WK11, WK12 and WK14 to the water staging point at WK13.

The central flare will be implemented at WK12 for all pilot wells (WK11, WK12, WK13 and WK14) with gas delivered by buried gathering lines (except across the Waukivory Creek).

#### ii Option 2

An additional flare will be implemented at WK11 and requires a small footprint of 10 x 10 m which will be within the previously assessed 100 m x 100 m footprint (EMM 2011).

Water at WK11 will be managed by capturing flowback and produced water in tanks adjacent to WK11. The tanks of flowback water will then be collected by trucks and transported for lawful disposal. Tanks of produced water will be delivered to the Tiedmans property along Fairbairns Road and Tiedmans Road, via truck or via underground water pipeline (from WK13), for storage and blending prior to irrigation in accordance with the Tiedmans property approval.



The additional equipment to be delivered and installed at WK11 would include:

- a central horizontal flare enclosed in a container; and
- sufficient tank capacity to collect the flowback water prior to water transport from well site at regular intervals.

AGL will make a final selection between Option 1 and Option 2 based on feedback from the regulatory agencies, the community, optimising costs and the proposed activity schedule. At this stage, Option 1 is AGL's preferred option.

### 2.8.3 Works timetable, scheduling and milestones

Perforation, hydraulic fracture stimulation, and well completion and installation of wellhead surface equipment are expected to take seven days each per well. Flowback is expected to last for between 4 to 16 weeks, while the flow testing process is expected to occur over 12 to 18 months. The timetable, scheduling and milestones are shown in Table 2.5.

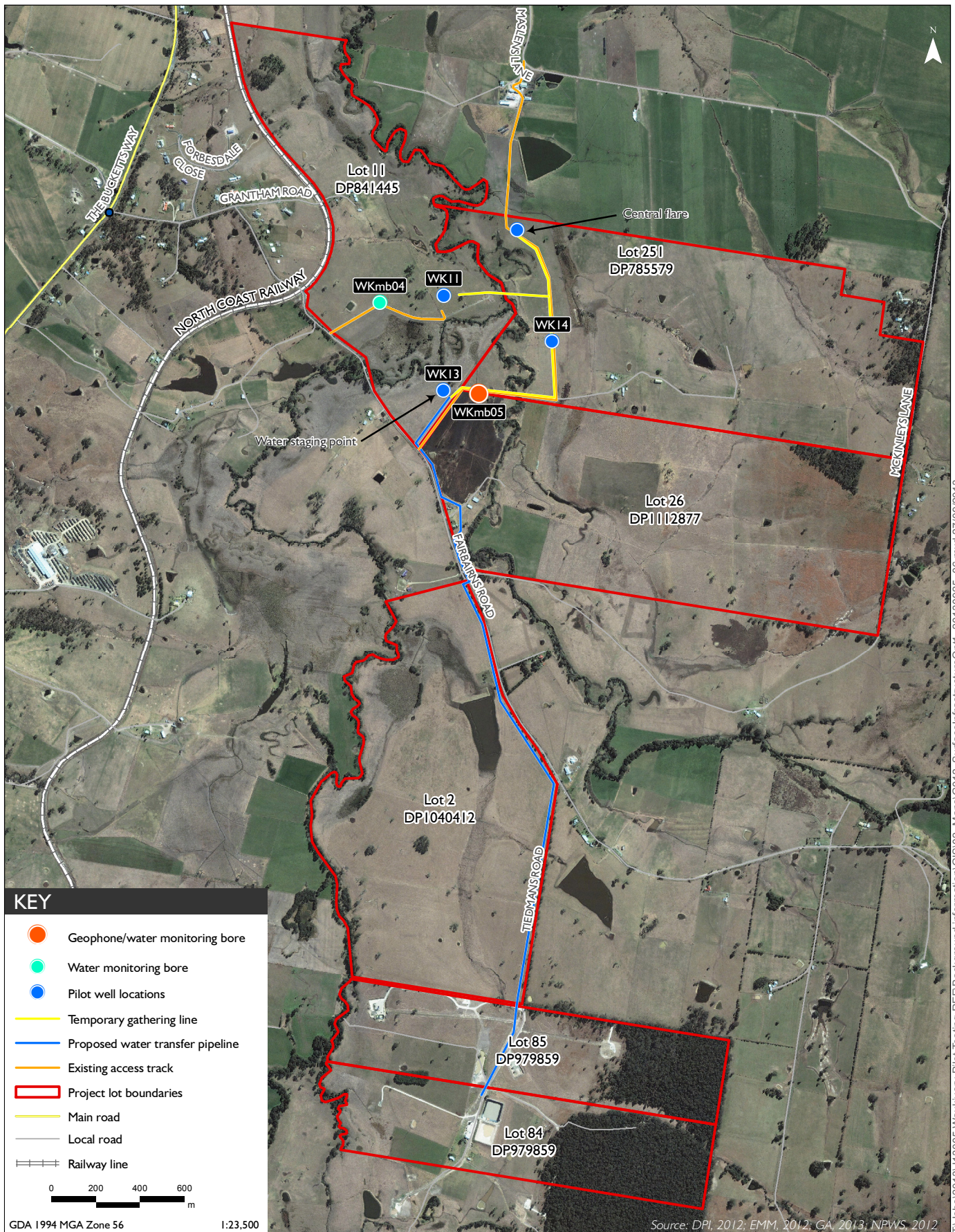
**Table 2.5 Timetable, scheduling and milestones**

Activity	Approximate duration
<i>Construction</i>	
Ancillary works, including dam construction, pipelines installation	8 – 12 weeks
<i>Operation</i>	
Perforation	7 days per well <sup>1</sup>
Hydraulic fracture stimulation	5-7 days per well <sup>1</sup>
Well completion and installation of wellhead surface equipment	7 days per well
Flowback	4 – 16 weeks
Pilot testing	12 – 18 months
<i>Decommissioning</i>	
Suspension of wells and rehabilitation of site footprint	2 –6 weeks

Note: <sup>1</sup> Perforation and hydraulic fracture stimulation at the four well sites is estimated to take around 60 days. This time includes securing the well, mobilising equipment between each well site and the delivery of materials to each well site.

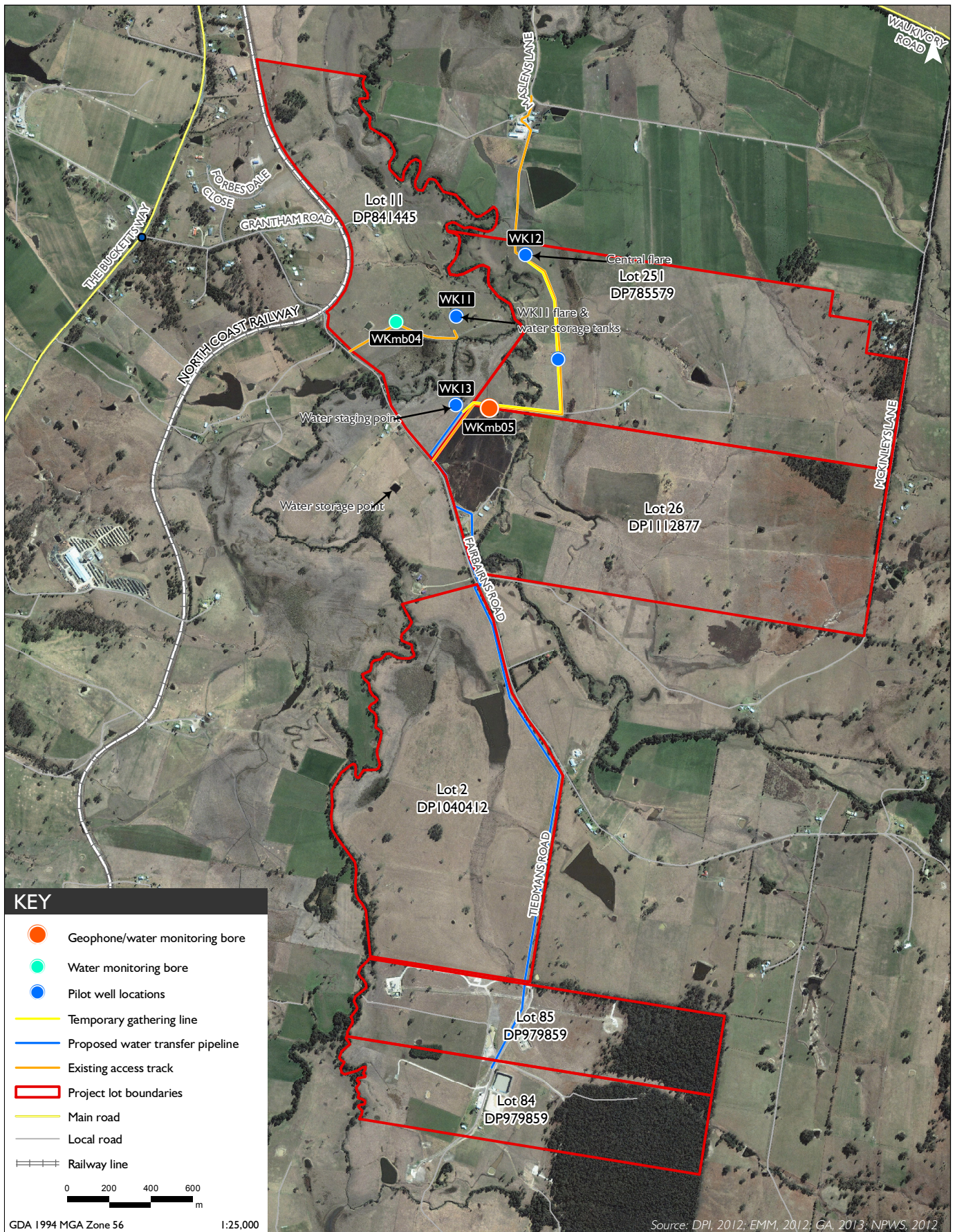
### 2.8.4 Hours of operation and employees

Pilot testing and flowback will occur 24 hours a day, seven days a week. Standard work hours for all other noise generating activities would be Monday to Friday, 7 am to 6 pm and Saturday 8 am to 1 pm, with no work on Sundays or public holidays in accordance with the *Interim Construction Noise Guideline* (DECC, 2009) and the licence conditions of PEL 285. Other activities, such as site set up, may occur outside those hours. The pilot testing project is expected to employ up to 20 people intermittently over the 12 to 18 month period of activity (noting that approval is sought for 36 months to account for unexpected delays).



T:\lobb\2013\13005 Waukivory Pilot Testing REF\Background information\GIS\02\_Maps\G012\_SurfaceInfrastructureOpt1\_20130925\_06.mxd 27/09/2013

**Proposed layout for Option 1**  
 Review of Environmental Factors  
 Waukivory Pilot Project  
 Figure 2.4



**Proposed layout for Option 2**  
 Review of Environmental Factors  
 Waukivory Pilot Project  
 Figure 2.5

## 2.8.5 Security

The pilot testing compounds will be fenced and the wellhead surface equipment surrounded by security fencing to prevent unauthorised access.

Water and gas gathering lines and the water pipeline will be HDPE pipe and trenched to reduce the risk of unauthorised access and interference with surface activities.

Appropriate signage, including details of safety risks along with company and emergency contacts will be provided on the compound and wellhead fencing. These contact details will also be provided at the entrance to the site and visible to the general public. The site compounds will be designed to restrict unauthorised access and contain all activities and equipment, including the workover rig and tanks; while the wellhead compound and the central flare/s are separately fenced and restricted areas.

Operator involvement during the pilot testing period is generally limited to day time only. The supervisory control and data acquisition (SCADA) system to be installed on the pilot wells will use a combination of short wave radio and 3G telecommunications in real time so that AGL can remotely monitor and control the pilot wells 24 hours a day.

The data is fed back to SCADA system server that is accessible to the relevant AGL staff with authorisation to remotely close the shutdown valve and stop the pumping stroke to cease gas and/or water production respectively. Remote start-up of the facility is not possible and operations staff must be onsite to recommence operations.

This telemetry and wellhead control system provides alarms to advise the AGL site field operations team of an alarm condition or failure. If the failure is not rectified, the control system will automatically shut down the wellhead in a failsafe configuration and an operator or technician will be sent immediately to site to rectify the issue.

Alternatively, the well may be closed down remotely until the issue is resolved. This system works to ensure site security and safety in the event of unauthorised access to the wellhead compound or the flare.

## 2.8.6 Construction phase: site establishment

### i Water storage

As part of the fracture stimulation and flow testing process, a water source (source water) is required in close proximity to the wells. Approximately 6 ML of water will be required. Likely sources include the Pontilands dam (an application has been submitted to use 20 ML per year for irrigation, industrial and stock purposes), Tiedmans dam or water purchased from the market (for example, town supply).

In addition, a water-holding facility is required for flowback water, which is expected to be produced immediately after the fracture stimulation program (and may flow back for several weeks or months). Volumes are not expected to exceed 6 ML in total. Produced water (natural groundwater generated from coal seams during flow testing and production dewatering) is also required to be stored before being transported to Tiedmans dam. The maximum volume of flowback water and produced water likely to be pumped for the four gas wells is 20 ML. Discounting this volume by 6 ML to account for the anticipated flowback water volume, this leaves a maximum of 14 ML of produced water.

#### a. Turkeys nest dam

It is proposed to construct a turkeys nest dam, with two compartments, in the vicinity of WK13. Each compartment will be double lined with a geo-membrane liner separated by a HDPE geonet membrane sheet for leak detection and collection.

It is intended that the dam will comprise:

- a 2 ML compartment for flowback water from each of the pilot test wells; and
- a 3 ML compartment for produced water (water from the target coal seams), from the four pilot test wells during the flow testing period.

The construction of a dam would generally involve the following activities:

- removal and stockpiling of topsoil onsite, for later use in rehabilitation;
- excavation and transport of sub-soil from 'cut' area to 'fill' area;
- formation of dam walls using excavated fill;
- compaction of soils to achieve desired permeability;
- bulk earthworks to form dam structure and addition of any required soil ameliorants to achieve structural stability of the dam walls;
- installation of dual HDPE lining to prevent leakage of stored water;
- re-spreading of topsoil on 'cut' area and dam wall; and
- planting of grasses onto re-spread topsoil for stability.

#### b. Temporary above-ground storage facility

Should the dam not be constructed, AGL may install a temporary above ground water storage facility to receive flowback water. Temporary storage facilities of this kind are common in exploration applications and are constructed to a high level specification (generally using HDPE) to ensure safety and the integrity of the structure. This storage facility would only be used as an interim measure until such time as the dam is constructed and commissioned, at which time the storage facility will be removed from site.

#### ii Upgrade of access roads and other ancillary works

Access will be via existing public roads and then private tracks in the subject properties. WK11 and WK13 are currently accessed via Fairbairns Road and WK12 and WK14 are accessed via Fairbairns Road for light vehicles and Maslens Lane for heavy vehicles. Minor earthworks may be required to upgrade existing tracks to enable equipment access. Water and gas gathering lines will be constructed.

#### iii Receipt, storage and onsite management of construction materials

Required equipment for the activity includes excavators to construct the pits. Excavated materials will be stockpiled appropriately nearby and subject to strict environmental safeguards to prevent erosion of the stockpile and sediment deposition on the floodplain and drainage lines.

#### iv Drilling and associated activities

No drilling of new holes is required as part of the activity as pilot testing will occur using existing exploration wells (WK11, WK12, WK13 and WK14).

#### v Water pipeline to the Tiedmans property

The construction of the water pipeline from WK13 to the Tiedmans property will take approximately 14 days to complete trenching. The pipeline will be made from butt-welded HDPE with a diameter of approximately 110mm and laid to a depth of between 450mm and 1000mm deep for a length of approximately 3.5 Km.

### 2.8.7 Operational phase: pilot testing and maintenance

The main activities within the operational phase are:

- hydraulic fracture stimulation (including fracture stimulation fluid, use of raw water, flowback and water management);
- pilot testing of wells; and
- flaring.

#### i Hydraulic fracture stimulation

Coal seams have thousands of naturally occurring fractures, also called cleats. Hydraulic fracture stimulation is a well established practice used in both the coal and gas industries for over 60 years, to widen the existing cleats in the coal to allow trapped gas to flow more easily out of the coal seams. The target coal measures for gas exploration at the Waukivory Pilot within the Gloucester Coal Measures range in depth from approximately 300 m to 1,000 m from the surface.

Hydraulic fracture stimulation refers to the process of pumping fluid (a mixture of 98-99.5% water and sand and 2% to 0.5% fracture stimulation chemicals) down a wellbore and into an isolated formation (ie targeted coal seam). The pumping fluid creates pressure as it encounters resistance to flow through the formation. When the fluid pressure building in the formation generates a stress which is greater than the stress required to fracture the formation, the existing coal fractures are widened.

Hydraulic fracture stimulations performed for AGL create fractures estimated to be 5 mm to 20 mm wide and extend laterally (fracture stimulation length) for 20 m to 60 m perpendicular to the minimum principal stress within the coal seam. The height of the fracture may vary from field to field. Fractures are usually contained within the coal seam.

The sealing rocks above and below the coal seam, which are significantly harder than coal, limit the vertical height growth of the fracture.

The exploration wells will require perforation of the steel casing within the target coal seams to connect the wellbore with the target coal seams. Once perforated, hydraulic fracture stimulation can proceed with the injection of a fluid mainly comprised of sand (otherwise known as the 'proppant') and water at high pressure. This process stimulates the reservoir by providing a highly conductive flow path for gas and water that extends away from the wellbore and into the seam. When pumping stops, the fracture closes, locking the proppant (sand) in place. The fracture stimulation fluid is allowed to flow back out of the seam to the well and to surface. This technique widens cleats and natural fractures in the coal seam to provide a conductive path for gas to flow freely to the well. As the water is removed, the resulting drop in reservoir pressure enables the gas to begin to desorb from the coal and flow to the wellbore. Hydraulic fracture stimulation at each pilot well is expected to take a maximum of seven days.

Fracture stimulations are specifically designed for each well and carefully managed in real time to avoid impacts on ground water resources, contain fractures within the targeted zones, and minimise additive or chemical use. The recipe used for hydraulic fracturing fluid was selected to represent the most basic, low risk recipe with the least number of chemical additives, to ensure potential impacts to subsurface coal seams are negligible to minor, while at the same time providing adequate physical properties to achieve the hydraulic fracturing design objectives. Each design fully complies with the requirements of the recently release DTIRIS-OCSG's CoP – fracture stimulation activities, and incorporate the following:

- known characteristics of geological formation, including the identification of rock types and conditions, aquifers and hydrocarbon-bearing zones;
- definition of distances to these aquifers from the target zones;
- identification of the characteristics of intervening strata, including porosity/ permeability and the extent of natural fracturing;
- determination of the geological stress fields and areas of faulting;
- determination of maximum pressures to be used for fracture stimulation, based on the characteristics of surrounding geology;
- modelling of the likely fracture propagation field, including extent and orientation; and
- discussion of any potential for the fracture propagation field to exceed the modelled field.

It is important to note that while the best information is used to design the fracture stimulation activity, the purpose of the exploration is to gain a more detailed understanding of geological formations, pressures and stresses.

Best practice well construction, hydraulic fracture stimulation design and methodology incorporate numerous contingencies to avoid impacts and ensure zonal isolation between target zones and other formations including aquifers. Aside from the important environmental considerations, zonal isolation is important for gas production, which is hindered by water migration.

In addition to the well design and construction, the following measures are undertaken to avoid and manage impacts as part of hydraulic fracture stimulation:

- as a starting point, before fracture stimulation is carried out, an injectivity test (sometimes called a diagnostic fracture injection test) will be undertaken. The deepest coal seam is targeted first and then fracture stimulations proceed progressively up the wellbore. This enables further information to be gathered and models to be refined before targeting shallower coal seams;

- a number of tests and logs are performed prior to undertaking the hydraulic fracture stimulation procedure, including review of the cement bond between the steel casing and the surrounding geological layers. Importantly, the final volume and composition of the hydraulic fracture stimulation fluid verified once the testing and logging is completed; and
- AGL is in the process of establishing a geophone borehole (WKmb05) at the Waukivory Pilot to assist in real-time diagnostics of the fracture geometry and fracture growth within the target coal seam during the fracture stimulation activity of WK13, thus enabling better design and control of the fracture stimulation program. This borehole, approximately 110 m east of WK13, will then be converted to a water monitoring location by installing a VWP into the borehole immediately after the fracture stimulation program and prior to the flow testing program. The geophone monitoring bore is not part of this REF.

Hydraulic fracture stimulation operations will be carried out by specialised contractors over 5 to 7 days per pilot test well depending on the number of seams to be perforated and fractured. Hydraulic fracture stimulation would only take place over 11 hours during the daytime. No night-time hydraulic fracture stimulation is proposed.

The lease area provides adequate space for the contractor's equipment and water storage area as identified in Section 2, and as such further ground disturbance beyond the lease area is not required.

Further information about hydraulic fracture stimulation is detailed in the FSMP (Appendix B).

Dewatering pumps and associated equipment will be used to remove the hydraulic fracture stimulation water and the produced water (water from the coal seam), which reduces reservoir pressure and allows gas desorption to occur.

## ii Fracture stimulation fluids

An injectivity test will be carried out on selected coal seam zones to refine the fracture stimulation design, followed by the main fracture treatment by pumping water, sand and some additives into the target coal seams.

A number of tests and logs are performed prior to hydraulic fracture stimulation, including review of the cement bond between the steel casing and the surrounding geological layers to ensure zonal isolation.

The main fluid and additives used in the hydraulic fracture stimulation are:

- Treated water: a treated water fluid formation is a basic fluid for performing hydraulic fracture stimulations. The fluid is treated with a bactericide additive to minimise the risk of introducing foreign bacteria into the formation which can lead to the development of hydrogen sulphide (H<sub>2</sub>S) in the well. H<sub>2</sub>S often results from the bacterial breakdown of organic matter in the absence of oxygen and is a corrosive gas with potential to affect the steel casing of the well and production equipment. The use of treated water ensures that these risks are minimised.
- Linear gel: this linear gel fluid formulation is a viscosified (or thickened) treated water. The viscosifying agent is a naturally produced guar gum. Further additives include a breaker used to decrease the viscosity of the linear gel over time allowing more efficient flowback of the fracturing fluid following a hydraulic fracturing treatment. Linear gels are able to carry higher concentrations of proppant than water, thereby reducing the required volumes of water. They also reduce pumping friction and can reduce the required hydraulic pressure and therefore reduce the pumping horse power required.



- Cross-linked gel: this cross-linked gel fluid formulation is based on a linear gel. The cross-linked fluid has additional additives that cross-link the gel which further increases the viscosity of the gel. Cross-linked gels are used when high proppant concentrations are required or when low viscosity fluids are unable to maintain the desired fracture geometry.

It is expected that linear gel will be used as a primary fluid for the proposed activity, with a cross-linked gel to be used as an alternative if required.

### iii Water quality and source for hydraulic fracture stimulation

The volume of water required for hydraulic fracture stimulation of a pilot well depends on the design, the number of coal seams to be stimulated and geological parameters. However, it is expected that the volume of water required for fracture treatment is estimated to be between 0.9 ML and 2.4 ML per well and around 6 ML in total for the whole fracture stimulation program for these four wells.

Source water for hydraulic fracture stimulation will be sourced from licensed water supply works from either Pontilands dam, or Tiedmans dam (both properties owned by AGL), both on Fairbairns Road. Water will be transported to WK13 by either truck or via a buried water pipeline between WK13 and Tiedmans dam (Figure 2.6). AGL (in advance of the REF evaluation and approval process) has submitted an application to NOW to license Pontilands dam and to take water for 'stock, irrigation and industrial' purposes.

Pontilands dam contains about 50 ML of water and the Tiedmans north dam contains about 20 ML so there will be sufficient source water available for the proposed activity.

As noted above there are two options for supplying source water for hydraulic fracturing at exploration wells. Both options require a water staging area at WK13 and both options involve supplying source water to WK14 and WK12 by buried gathering lines from the water staging area at WK13. The two options relate to the supply of source water for hydraulic fracturing at WK11 and include:

- Option 1 - source water for hydraulic fracturing will be delivered from the water staging area to WK11 by buried gathering lines from the water staging area at WK13; and
- Option 2 - source water for hydraulic fracturing will be supplied to an above-ground storage tank at WK11 by truck.

### iv Water management

The maximum volume of flowback water and produced water likely to be pumped for the four gas wells is 20 ML. Discounting this volume by 6 ML to account for the anticipated flowback water volume, this leaves a maximum of 14 ML of produced water. Beneficial re-use of produced water is the preferred option. The full range of produced water re-use options considered for the proposed activity can be broadly categorised into:

1. Industrial and mining:
  - drilling water (no treatment required);
  - hydraulic fracture stimulation of gas wells (no treatment required);
  - dust suppression (no treatment required if used on a dirty water site with full capture of runoff); and

- other industrial uses (washdown, process water etc) (some treatment may be required).
2. Primary production:
- livestock watering (blending/treatment required); and
  - irrigation (blending/treatment required).
3. Raw water for public or private water supplies:
- additional water to supply others (treatment required).

Given the relatively small volumes of produced water expected from the proposed activity, the only viable options in this case are likely to be:

- drilling water, hydraulic fracture stimulation water required for future pilot testing programs;
- livestock stock water; and
- irrigation.

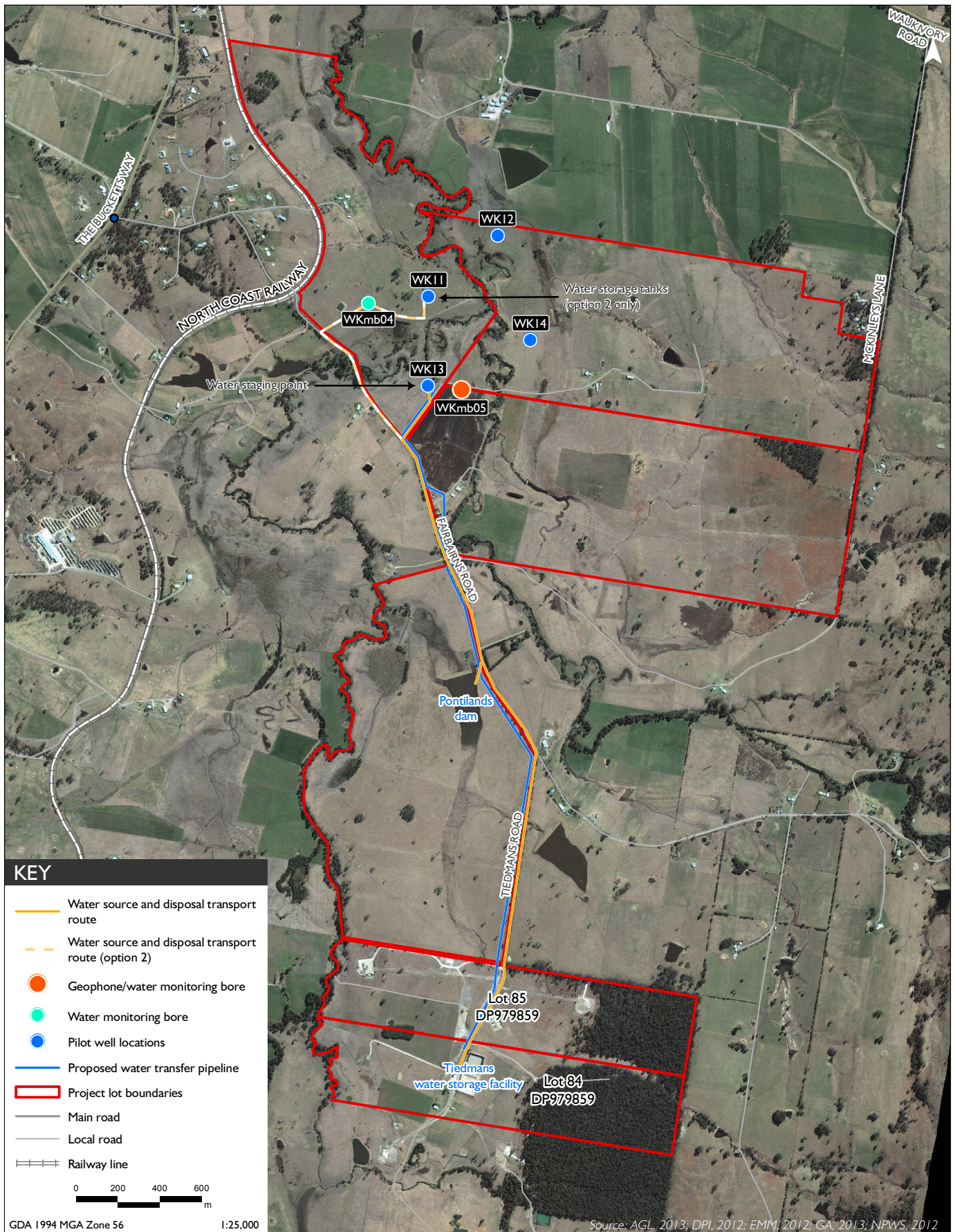
As described earlier, the Waukivory Pilot will utilise the water management strategy on the Tiedmans property which was approved by DTIRIS-DRE in 2012. This strategy involves blending the produced water generated from flow testing programs with fresh water sources and irrigating. The current pilot irrigation at the Tiedmans property demonstrates that produced water from pilot wells can be beneficially re-used for the irrigation of crops.

The overall produced water strategy allows:

- storage of produced water from AGL's offsite operations and transport of this water within the site;
- blending of produced water with freshwater for irrigation re-use;
- storage for blending and/or direct re-use for stock use;
- storage for blending and/or direct re-use for industrial uses such as dust suppression and firefighting; and
- storage for future drilling and hydraulic fracture stimulation purposes.

It is proposed to re-use produced water from the proposed activity unless the water quality exceeds a pre-blending salinity (ie electrical conductivity or EC) of 15,000  $\mu\text{S}/\text{cm}$ . The lower salinity produced water would be blended with fresh water sources (mostly river water) to obtain a blended water irrigation water mix (ie with a salinity level of up to 3,000  $\mu\text{S}/\text{cm}$ ) suitable for the irrigation of salt tolerant crops. Full details are provided in the Water Management Plan for the Tiedmans Irrigation Program as approved by DTIRIS-DRE in 2012.

The other proposed onsite uses are for stock use, dust suppression and fire fighting. These re-uses will only occur directly if the produced water salinity is less than 6,000  $\mu\text{S}/\text{cm}$ , and the water quality meets the relevant ANZECC criteria. If salinities are higher; the water will be blended, tested and re-used for these aforementioned activities, or lawfully disposed.



**Water sourcing and management options**  
 Review of Environmental Factors  
 Waukivory Pilot Project  
 Figure 2.6

For the water not re-used, the disposal options considered were:

1. Lawful disposal to an appropriate facility:
  - to a recycling facility or sewerage treatment plant (no treatment required).
2. Re-injection:
  - into abandoned underground mines or goaf areas (no treatment required);
  - into intermediate/deep aquifers with similar water qualities (some treatment may be required); and
  - into depleted coal seams (some treatment may be required).
3. Environmental flows:
  - disposal during high flow events (possible treatment required);
  - improved base flows in perennial streams (treatment required); and
  - into constructed wetlands (treatment required).
4. Evaporation:
  - open cut mining voids (no treatment required) (note that dedicated evaporation ponds are now banned).

Few of these were considered suitable options for the proposed activity, with lawful disposal to an appropriate facility being the only viable option for the likely small volumes.

#### v Cost –benefit comparisons

Cost benefit comparisons are only provided for the identified produced water options. Fracture stimulation water and flowback water will be lawfully disposed at an appropriate facility at an expected minimum cost of around 10 cents per litre (p/L) and no cost-benefit analysis or comparison is presented. This volume equates to about 6 ML of the maximum 20 ML of groundwater to be extracted from the four gas wells during the fracture stimulation and flow testing program.

For the remaining 14 ML that is produced water, the capital and operating cost of each of the nominated re-use options (ie irrigation and fracture stimulation re-use) plus the alternative disposal option is provided in Table 2.6. For beneficial re-use it is assumed that 13 ML is re-used for irrigation and 1 ML is re-used for fracture stimulation re-use. Estimated costs are only indicative and are provided as a '\$ per KL' and 'total cost' basis for the proposed flow testing program.

The cost of the older irrigation dams on the Tiedmans property are not included as these works were required for previous exploration and irrigation programs, however the cost of the new (double-lined) 20 ML Tiedmans east dam is included as it was primarily built for this flow testing program (PB 2012). The value of the crops irrigated using these volumes is not included as the water is to be used as part of the Tiedmans irrigation trial which is solely to assess the sustainability of irrigating blended water on treated soils.

There are no capital cost components for the disposal option.

Water gathering lines and pumping to the water staging point near WK13 have not been factored into the costs as they are common to all re-use and disposal options and have therefore been ignored. Additionally, it is assumed blended irrigation does not require expansion or changes to the current irrigation practices.

**Table 2.6 Estimated cost of water re-use versus water disposal**

Option	Likely volume (KL)	Capital costs (\$)	Operating costs (\$/KL)	Total Cost (\$)
Fracture stimulation re-use #	1,000		30	30,000
Irrigation re-use ^	13,000	-	10	130,000
Offsite disposal *	14,000	-	100	1,400,000

Key: \* includes both trucking and disposal (at 10c per L); # assumed cost for trucking to a site within 30kms (at 3c per L); ^ assumed cost for trucking or piping the short distance to the Tiedmans property (at 1c per L).

The total costs for beneficial re-uses are less than disposal to an appropriate facility, and there are also substantial advantages associated with the re-use options which include:

- no need to purchase additional water for future fracture stimulation program (if proposed programs to the south proceed); and
- substantially reduced traffic movements if most of the produced water is re-used as part of the Tiedmans irrigation trial.

The water management strategy for the Waukivory Pilot is to demonstrate that produced water generated from the flow testing program of the four gas wells can be beneficially re-used for the irrigation of salt tolerant crops.

The raw produced water quality may vary slightly from each of the gas wells however the degree of variability is uncertain at this time. The water salinity from the monitoring bores on the site varies between 1,000 and 5,500  $\mu\text{S}/\text{cm}$  (see Table 2.7) Overall the produced water quality is expected to be brackish and be between 2,000 and 7,000  $\mu\text{S}/\text{cm}$ .

**Table 2.7 Water quality after development of the monitoring bores**

Bore number	Screened aquifer	Depth (mBGL)	pH	EC ( $\mu\text{S}/\text{cm}$ ) (Field/lab)	ORP (mV)	Temperature ( $^{\circ}\text{C}$ )
WKmb01	Leloma - sandstone	47-53	7.9	5436/6100	-338	17.8
WKmb02	Leloma - Siltstone	51-60	9.2	1013/1030	22.7	17.3
WKmb03	Deards – fault zone	200-209	10.0	1563/3050	-19.6	18.02
WKmb04	Roseville Coal Seam	335 - 347	-	-	-	-

*Note WKmb04 not sampled at this time (May 2013).*

The proposed re-use strategy at the Waukivory Pilot is to capture and pump all the produced water through water gathering lines to either a double-lined dual compartment turkeys nest dam or temporary above ground storage tanks at WK13. This water staging point will be adjacent to the existing well at WK13 within the 100 x 100 m footprint.

The water will then be transported to the Tiedmans property by truck or water pipeline, and then blended to achieve a final salinity acceptable for irrigation under the current Part 5 approval. The target is to have blended irrigation waters at a salinity of 1,500  $\mu\text{S}/\text{cm}$ .

#### vi Water management logistics

The onsite water management strategy involves:

- water gathering lines from pilot wells to the water staging point at WK13 (Option 1) or water gathering lines from pilot wells to the water staging point at WK13 and water gathering lines from WK11 to adjacent temporary water storage tanks (Option 2);
- storing water in dual lined dams at WK13 and monitoring storage levels (it is expected that up to 6 ML in total will be produced from the activity);
- monitoring the salinity of the flowback water – water quality is unlikely to exceed 5,000  $\mu\text{S}/\text{cm}$  and it will be assessed for suitability for different re-uses;
- transportation of flowback water for lawful disposal at an appropriate facility;
- monitoring the salinity of the produced water– water quality is unlikely to exceed 15,000  $\mu\text{S}/\text{cm}$  and more likely to be around 7,000  $\mu\text{S}/\text{cm}$ ; and
- transportation of produced water via water pipeline or trucks to the Tiedmans property for storage, blending and re-use.

The raw produced water quality will vary slightly from each of the pilot wells (with the deeper zones in each well expected to have the highest salinities).

Flowback water will be transported by truck to an appropriate facility for lawful disposal.

The produced water will be transported by truck or pumped via the proposed water pipeline to the Tiedmans property for storage, blending and re-use for irrigation of that property. The storage, blending and re-use of produced water from AGL exploration operations at the Tiedmans property is subject of an existing approval granted by DTIRIS-DRE in 2012.

The proposed water pipeline between the Waukivory Pilot and the Tiedmans property is illustrated in Figure 2.6.

#### vii Contingency response

A total of four monitoring bores (WKmb04, WKmb03, WKmb02 and WKmb01) have been installed in the area for the purposes of baseline groundwater monitoring. A further geophone water monitoring bore (Wkmb05) has been assessed as a Category 1 activity under the conditions of PEL 285 and if approved will be drilled in advance of the proposed activity. Wkmb05 does not form part of this REF. Wkmb05 is east of WK13 and will constantly measure water pressure and levels. The monitoring bore network enables the collection of water level data and the sampling of groundwater in four aquifers/water bearing zones of varying depths.

For baseline purposes, water levels are monitored continuously and there will be two water sampling events. For the fracture stimulation and pilot testing programs, water levels are monitored continuously and water quality is monitored more frequently depending on the activity. Full details of the groundwater monitoring program are provided in the Surface Water and Groundwater Management Plan (SWGMP) provided in Appendix D.

#### viii Pilot testing

##### a. Process

Pilot testing involves pump testing, flaring and the use of gas gathering lines. During pump testing, a hydraulic or electric surface dewatering pump is mounted on the wellhead to drive the downhole pump. A hydraulic skid is connected to the hydraulic pump which provides the hydraulic power to the pump. A silenced electrical generator or mains supply is connected to the hydraulic skid to provide power (electrical over hydraulic) to operate the hydraulic skid. Electricity from the mains supply is supplied through above or below ground connections.

At the surface the pumped water is directed to a gas/water separator where any remaining entrained gas is removed from the pumped water. The gas separating chamber has inlets for both the water and the gas streams coming from the gas well. Similarly it has outlets for both the water and the gas streams, with the produced formation water going (in some cases via water lines) to the tanks and the gas via gas gathering lines to the enclosed central flare.

Ideally a 1:1 gas to water ratio is maintained in the chamber that allows most of the remaining gas dissolved in the pumped water to be released. The water is sent out from the base of the chamber by the gas pressure and directed through water lines to storage tanks on site.

The gas is forced through the top of the separating chamber through an electrical instrument flow meter (FloBoss) and directed to the enclosed central flare. A telemetry system is connected to the FloBoss to send data to its server so that the well performance can be monitored remotely. The gas line from the separator is fitted with an adjustable choke that allows the flow of gas to be regulated or stopped. An automatic shut-down valve (SDV) is installed to respond to abnormal well behaviours or emergency situations. The SDV can be controlled remotely via the telemetry system thus providing protection to the surface equipment in case of high pressure gas spike events.

During flaring, a steel gas line is installed to the inlet of the horizontal enclosed flare to ensure that gas can be safely flared with minimal visual impact to the closest residents. Enclosing the flare has been an important measure adopted by AGL, particularly if sufficient quantities of gas are produced during flow testing.

Gas gathering lines are used during flow testing of the pilot test wells. The gas gathering lines are designed, constructed and operated in accordance with the requirements of *Australian Standard AS 4645.3 – 2008 Gas Distribution Networks Part 3: Plastics Pipe Systems*. Gas gathering lines are buried to a minimum depth of 750 mm and up to 1,200 mm in some areas, including unsealed and sealed road crossings and creek and drainage line crossings. The gas gathering lines are buried with marker tape and tracer cable. The routes of the gas gathering system are generally selected to utilise previously or currently disturbed land areas wherever possible. The route of the gas gathering system is registered with 'Dial Before You Dig' and is clearly signposted.

#### b. Management of environmental interactions

The beneficial aquifers at the Waukivory Pilot area and its surrounds are all shallow aquifers that occur in the shallow alluvial sediments or shallow fractured bedrock. The fractured rock aquifer zones rarely extend below depths of 75 m from surface. The deepest water supply bore known in the local area is 66 m (AGL 2013). AGL is also monitoring deeper water bearing zones to assess connectivity in this thrust faulted area.

One of the important objectives of this pilot testing program is to assess water production volumes, and to assess if there are any drawdowns associated with connectivity issues in proximity of this thrust fault.

The target seams are in the Gloucester Coal Measures. Overlying and in-between these coal seams are cemented sandstones, siltstones and claystones of the Craven and Avon Sub Group. These low permeability formations, together with effective separation intervals of more than 200 m between the target coal measures and the shallow beneficial aquifers, means there is negligible risk of fractures propagating from the targeted coal seams to these shallow aquifer zones.

The potential environmental impacts of the different activities will be managed by:

- monitoring of groundwater levels in the shallow monitoring bore network;
- monitoring of groundwater quality at the gas wells and shallow monitoring bores;
- monitoring of pressure levels at each gas well;
- metering of flowback and produced water volumes at the gas wells; and
- tracking of water level and water quality trends (ie measure the significance of pressure responses in shallow fractured rock monitoring bores).



These activities will be managed and controlled by the SWGMP (Appendix D).

The purpose of the SWGMP is to provide a framework for assessing changes to the different groundwater systems in the vicinity of pilot testing area. This is particularly for monitoring changes in shallow rock aquifers due to dewatering of the deep coal seams, and managing the storage of produced water at site. The primary risks to be assessed are:

- the connectivity of shallow aquifers and the deep water bearing zones; and
- the contamination of shallow aquifers.

For the hydraulic fracture stimulation program, the following water quality sampling program is proposed for each water type at each pilot well location:

- raw (source) waters to be used for hydraulic fracture stimulation;
- fracture stimulation fluid mixture (ie the raw water plus sand and any chemical additives) to be injected into each pilot well (if there are multiple stimulations per well and all are the same recipe then just one event will be sampled);
- flowback water (ie return water when less than 100% of the fracture stimulation fluid water volume is being pumped back to the surface); and
- produced water (natural groundwater from the coal seam/s when sufficient fracture stimulation fluid water volume is pumped back to surface) which is expected to be within the first month of the pilot test program.

AGL has several tiers of water quality monitoring, sampling and reporting. The comprehensive suite is used for important sampling events. The basic suite is mainly used for tracking major salinity/ chemistry changes in the produced water during the pilot test. A list of the parameters which are tested under AGL’s analytical suites is provided in the SWGMP (Appendix D).

The indicative frequency of monitoring for each pilot well location is shown in Table 2.8.

**Table 2.8 Groundwater monitoring at well sites, suites and frequencies**

Pilot well/ suite (WK11, WK12, WK13 and WK14)	Baseline	Hydraulic fracture stimulation				Start	Pilot testing		
		Raw	Mix	Flowback	Produced		Month 2	Month 4	Month 6
Basic						X	X	X	
Comprehensive	X	X	X	X	X				X

The gas flow testing will be ongoing until production profiles for both gas and water are determined, at which time the pilot test is terminated and each of the wells is suspended. It is expected that flow testing of the four pilot test wells will occur concurrently for about 12 to 18 months for each well.

Once the pilot testing program is under way, weekly water samples from each gas well will be taken to track field parameters (mainly salinity (EC) and pH). At the beginning of the pilot testing program, and then at periods of two months, regular water samples (basic suite) will be taken for laboratory analysis to check that there are no apparent changes in the produced water chemistry. A sample for comprehensive analysis will be taken from each well at the end of the pilot testing program.

Activities at each pilot well site during flow testing would include:

- routine daily operator inspections of gas flow rates and equipment;
- monitoring of water quality and quantity; and
- workover maintenance (described below).

During the gas flow testing phase, gas will be diverted to an enclosed horizontal flare and burnt safely. Operator involvement at the pilot test well surface location is minimised by the installation of various automated and remotely operated functions.

Telemetry is connected to all wells undergoing testing so the pilot test data can be accessed and reviewed. In this case, the pilot test wells have numerous alarms and automatic shutdown functions which are based on a 'cause and effect' design. Any pilot test well under gas flow testing can be shut-in or opened remotely, provided the SDV has not been activated, from the gas plant control room once the communication equipment has been installed at the site.

The wellhead will be contained within a chain wire mesh or other more aesthetic fencing compound with metering, telemetry, separator, compressor and tank (if required), which is appropriate for an open paddock environment.

#### ix Venting, flaring and fugitive emissions

The flaring method proposed for pilot testing is an enclosed horizontal flare/s, designed to mitigate potential visual and noise impacts. A description of this flaring method is provided in Section 3.6.3 of the AGL Gloucester Gas Project Exploration Environmental Management Plan (EMP) (Appendix E).

The flare/s consists of a walled 20 or 40 ft container, manufactured and treated with fire retardant material, placed a safe distance from the pilot test well. The gas generated during the flow test can then be ignited safely. The flare is type B compliant (AGL 2012). The flare will ignite when there is continuous and measurable flow of gas from the well. The pilot light will re-ignite the flare if it goes out. Should the flare not re-ignite, fail-safe will shut in the well(s). In this way risk of venting is minimised. The insulation also partially attenuates combustion noise. The burner trains have been designed to maintain gas velocity to acceptably low levels, such that combustion noise is maintained at or near ambient levels. Photographs of samples of an AGL enclosed central flare facility are provided in Photographs 2.1 to 2.4.



**Photograph 2.1** AGL 20 ft flare facility – raised and enclosed around the flame



**Photograph 2.2** AGL 20 ft flare facility – painted a colour to blend with the surrounding landscape



**Photograph 2.3** AGL flare facility – internal view



**Photograph 2.4** AGL flare facility – operating at night with screening barrier in foreground on right

The container is elevated approximately 0.5 m from the ground to allow combustion air to enter from below the horizontal burners inside. A steel gas line installed to the horizontal enclosed flare allows gas to be safely flared. Combustion occurs with no naked flame expected to be visible above the container, subject to the volume of gas being flared. The internal walls of the container are thermally insulated to reduce the external wall surface temperature.

A faint glow may be visible at night during the flow testing period. In the case of higher than expected gas flow rates to the flare, an additional thermally insulated container would be placed on top to create the two-tier flare system to mitigate any potential visual impacts.

It is considered that the use of an enclosed central flare will remove potential community and motorist concern about a naked flame that may result in calls to emergency services. The enclosed central flare and SCADA system provides greater security, noise attenuation and minimises light to residences during the night.

A flame arrester would be installed at the beginning of the burner train, outside of the container, to prevent the flash back or ignition of gas into the gas gathering line. Each burner train will be fitted with a flame detection device that re-ignites the gas following flame failure.

A flame failure is rectified by the pilot light which will automatically re-ignite the flare. If the flare does not re-ignite, fail-safe shuts in the well. In this way, risk of venting is minimised. It is the intention of the operator to keep the flare online at all times to minimise the environmental footprint by reducing greenhouse gas emissions from the flare (see the EMP at Appendix E).

This system works to ensure site security and safety in the event of unauthorised access to the wellhead compound or the flare. The entire gas flaring system and flow testing compound would be surrounded by a compound fence topped with barbed wire and appropriate signage for security purposes.

### 2.8.8 Maintenance activities, future expansions or additions

During flow testing or long-term data collection from the pilot test wells, an occasional 'workover' or other maintenance may be required. The workover involves a rig to run or remove a pipe for clearing the hole of fill, obstructions, pumps or other issues. Workover and maintenance activities are undertaken on a case-by-case basis as needed at individual holes; when an issue has been identified.

Workover activities may be required from time to time to perform maintenance activities on the wells.

## 2.9 Site closure and rehabilitation

Rehabilitation of pilot test wells is generally undertaken in two stages: initial site rehabilitation of disturbed land (including construction laydown areas, access tracks and gas gathering pipeline verges) following the completion of site establishment and to cap and suspend the test wells at the completion of gas flow testing. On completion of activities, all areas will be rehabilitated to return the land to its pre-existing use and condition, or better. The water pipeline and gas and water gathering lines will be rehabilitated as will access tracks that are no longer required by the landholder.

Prior to suspending the pilot test wells AGL would seek approval through DTIRIS – OCSG by providing information in accordance with section 521 of the Schedule of Onshore Petroleum Exploration and Production Safety Requirements.

### 2.9.1 Initial rehabilitation

This stage of the works generally involves the following activities:

- emptying pit(s), tanks or pipelines of water and backfill;
- reshape the land if required (cut and fill works);
- spread topsoil;
- re-vegetation by spreading seed; and
- relocation of compound fence and sediment controls.

Variations to the above activities may be required subject to site constraints, new technical information or to fit with future land uses. Screening may be provided where appropriate using vegetation sourced from the local area including drought tolerant species endemic to the local area.

The wells will be secured, capped and suspended in accordance with the CoP – well integrity. Well suspension is done in such a way to ensure that the well is sealed to prevent leakage.

### 2.9.2 Final rehabilitation and suspension

The final rehabilitation works will involve the following activities:

- suspension of test wells in accordance with DTIRIS-OCSG guidelines and the PEL conditions;
- removing plant and equipment and relocation of fenced compounds; and
- rehabilitation, contouring, and re-vegetation of surplus area.

## 2.10 Access arrangements

Access will be via existing public roads and then private tracks in the subject properties. WK11 and WK13 are currently accessed via Fairbairns Road and WK12 and WK14 are accessed via a track off Fairbairns Road for light vehicles and Maslens Lane for heavy vehicles. Access arrangements with Gloucester Resources are currently in place in relation to these properties. Access will also be required from Gloucester Shire Council where the proposed pipeline crosses Fairbairn's Road.

## 2.11 Mitigation strategy

### 2.11.1 Overview

The draft supplement to ESG2 guidelines for petroleum prospecting requires that the mitigation strategy addresses risk management for the following activities:

- drilling or associated activities;
- well stimulation;
- interference to the groundwater regime;

- use of chemicals;
- venting, flaring and fugitive emissions; and
- wastes.

ESG2 guidelines also stipulate the environmental attributes that require a mitigation strategy, such as groundwater. Mitigation strategies for some environmental attributes, such as groundwater, will address several of the activities listed above.

This mitigation strategy represents AGL's statement of commitments for the proposed activity.

## 2.11.2 Environmental management system

### i Environmental Management Plan

An EMP has been prepared for the exploration activities of the GGP. The objective of the EMP is to establish an environmental management framework, set out environmental requirements for the proposed activities and establishes the processes for implementation, monitoring and review. These processes are designed to ensure compliance, continuous improvement and to minimise the potential environmental impacts of proposed activities.

The EMP (Appendix E) establishes the following for exploration activities:

- roles and responsibilities for environmental management;
- inductions, training and competencies;
- external and internal communication;
- complaints management procedures;
- reporting procedures;
- incident management and corrective/preventative action;
- monitoring and compliance procedures;
- change management; and
- review and continual improvement.

The following sub plans provide specific detail and fall under the EMP framework:

- Aboriginal cultural heritage;
- air quality;
- dangerous good and hazardous materials;
- European heritage;
- fire;

- flood;
- flora and fauna;
- landscape and rehabilitation;
- noise;
- traffic; and
- waste.

## ii Water Management Plan

The Water Management Plan (WMP) for Waukivory comprises:

- Part 1: SWGMP (Appendix D), which outlines the groundwater monitoring program for the fracture stimulation and pilot testing activities; and
- Part 2: Water Management Plan for the Tiedmans Irrigation Program – Gloucester (dated 14 May 2012), which outlines the strategy for containment, mixing, and re-use of produced water in accordance with the existing approval granted by DTIRIS-DRE in 2012.

The Part 2 plan was submitted and approved under a separate approval for the irrigation trial at the Tiedmans property.

## iii Fracture Stimulation Management Plan

AGL has developed a FSMP to identify risks (health, safety and environmental) and risk mitigation methods to facilitate safe execution of fracture stimulation. The FSMP has been developed by AGL in accordance with the CoP – fracture stimulation activities.

### 2.11.3 Impact avoidance and minimisation measures

Measures to avoid potential environmental impacts from the activities are summarised in Table 2.9. Where impacts cannot be avoided, measures to minimise them have been proposed.



**Table 2.9 Impact avoidance and minimisation measures**

Aspect	Proposed measures
<b>Aboriginal heritage</b>	
Pre-activity	<ul style="list-style-type: none"> <li>• Locations of wells, access roads and gas gathering lines have been selected to avoid Aboriginal objects by redesign or relocation of proposed infrastructure and/ or activities.</li> </ul>
Construction operation and rehabilitation	<ul style="list-style-type: none"> <li>• Brief personnel/ contractors prior to excavation during the site specific induction on the Aboriginal heritage of the area and on the appropriate course of action if any Aboriginal objects are discovered.</li> <li>• All works will be confined to the exploration compound, water pipeline route and designated access routes.</li> <li>• Maintain existing vegetation which provides screening of works and minimise removal of vegetation where possible.</li> <li>• Implement the recommendations of Aboriginal heritage assessments, where relevant.</li> <li>• Known Aboriginal objects or locations will be identified in the vicinity of proposed exploration areas prior to activity commencing.</li> <li>• If unanticipated Aboriginal artefacts are found during construction works, work will cease in the immediate vicinity and the site assessed by an archaeologist.</li> <li>• If skeletal remains are found during construction works, work will cease immediately in the area and the NSW Police Coroner called to determine if the material is of Aboriginal origin. If determined to be Aboriginal, the OEH and relevant Aboriginal community stakeholders will be contacted to determine management for the remains prior to works re-commencing.</li> </ul>
<b>Air quality</b>	
General	<ul style="list-style-type: none"> <li>• The hierarchy of control for air quality management (ie avoid, recycle, minimise and manage) should be fully applied during procurement.</li> <li>• The workforce induction program shall inform site personnel of required procedures for the protection of air quality.</li> </ul>
Air quality and greenhouse gases	<ul style="list-style-type: none"> <li>• Greenhouse gas emissions associated with pilot testing shall be minimised as far as practicable with adoption of strict operating procedures outlined Section 2.8.7 of this REF.</li> <li>• Plant and equipment shall be regularly maintained and serviced.</li> <li>• The venting of gas shall be minimised where possible.</li> <li>• The flaring of gas from pilot wells shall be limited to that necessary as part of the production evaluation process, following which flaring will be halted.</li> <li>• Leak detection surveys shall be periodically performed along any pipeline as per Australian Standard (AS2885.3) requirements.</li> </ul>
Venting, flaring and fugitive emissions	<ul style="list-style-type: none"> <li>• Fugitive methane monitoring campaign both prior to and during the pre-production process.</li> <li>• Flares must be operated so that no visible smoke emissions other than for a total period of no more than five minutes in any two hours occur in accordance with the <i>Protection of the Environment Operations (Clean Air) Regulation 2005</i>.</li> <li>• A flame arrester would be installed at the beginning of the burner train, outside of the container, to prevent the flash back or ignition of gas into the gas gathering line. Each burner train will be fitted with a flame detection device that re-ignites the gas following flame failure.</li> <li>• It is expected that no naked flame will be visible from the flare. In the case of higher than expected gas flow rates to the flare, an additional thermally insulated container would be placed on top to create the two-tier flare system to mitigate any potential visual impacts.</li> </ul>

**Table 2.9 Impact avoidance and minimisation measures**

<b>Aspect</b>	<b>Proposed measures</b>
Dust emissions	<ul style="list-style-type: none"> <li>• Dust control measures such as the use of water carts shall be implemented where necessary.</li> <li>• Designated internal access roads will be utilised and vehicles are to adhere to the sign-posted speed limit.</li> <li>• Vehicles that carry a potentially dust generating load, such as movement of material for the construction of the double-lined dual compartment turkeys nest dam at WK13, will be covered at all times, except during loading and unloading.</li> <li>• Disturbed areas will be re-instated following exploration activities.</li> </ul>
<b>Dangerous goods and hazardous materials</b>	
Purchasing	<ul style="list-style-type: none"> <li>• Material safety data sheets (MSDS) will be obtained for all chemicals proposed to be used on site.</li> <li>• New dangerous goods and hazardous materials shall be purchased in accordance with the AGL purchasing procedure, a risk assessment undertaken and MSDS obtained.</li> </ul>
Storage, use and transport	<ul style="list-style-type: none"> <li>• All dangerous goods and hazardous materials shall be stored and where practicable handled within containment facilities (eg bunded areas, leak proof trays) designed to prevent the release of spilt materials to the environment.</li> <li>• The storage, handling and transport of dangerous goods and hazardous materials shall comply with legislation and Australian Standards, including but not limited to containment, placarding and segregation from incompatible materials.</li> <li>• All vehicles and equipment shall be adequately maintained so as to minimise drips or leaks of dangerous goods and hazardous materials (Appendix E).</li> <li>• All storage and handling equipment (including transfer hoses) shall be kept in a well maintained condition.</li> <li>• Where it is necessary to refuel heavy equipment onsite, adequate spill prevention and containment measures (eg drip trays) will be implemented and a spill kit will be nearby.</li> <li>• Spill kits will be available at all times.</li> <li>• Leak protection will be installed around work areas to prevent potential chemical runoff, in the event of a spill.</li> <li>• All chemicals and fuels will be stored in bunded areas away from drainage lines.</li> <li>• The capacity of the bunded area will be at least 110% of the largest chemical container stored within the bunded areas.</li> <li>• Equipment will not be refuelled within 40 m of any waterbody, water course or drainage line.</li> <li>• Transport of dangerous goods to be undertaken under appropriate licence.</li> </ul>
Risk assessment	<ul style="list-style-type: none"> <li>• Job safety and environment analysis shall incorporate storage and handling of dangerous goods and hazardous materials and reference the relevant MSDS.</li> <li>• Prior to commencing construction, operations or maintenance, the planned arrangement of all dangerous goods and hazardous materials storage areas should be reviewed to eliminate potentially hazardous conditions.</li> </ul>
Labelling	<ul style="list-style-type: none"> <li>• All dangerous goods and hazardous materials should be stored in approved containers and properly labelled.</li> <li>• All packaged dangerous goods will be labelled in accordance with the Australian Dangerous Goods code.</li> <li>• If unmarked drums arrive on location or if in doubt as to the constituents of a chemical substance, treat as a hazardous, toxic substance until found otherwise.</li> </ul>

**Table 2.9**      **Impact avoidance and minimisation measures**

<b>Aspect</b>	<b>Proposed measures</b>
Training	<ul style="list-style-type: none"> <li>• The workforce induction program shall inform site personnel of the required chemical storage and handling procedures and the required spill prevention and response procedures.</li> <li>• The MSDS will be read prior to using any substance and available during storage and use of dangerous goods and hazardous materials.</li> <li>• Training records will be maintained by AGL.</li> </ul>
Decanting	<ul style="list-style-type: none"> <li>• Any dangerous goods or hazardous materials decanted into a second container will be clearly labelled with name and safety risk phrases (for example flammable or toxic). The second container will be of good integrity, thoroughly cleaned, and compatible with the intended product to be stored.</li> </ul>
Disposal	<ul style="list-style-type: none"> <li>• Waste dangerous goods and hazardous materials, including empty drums and containers, will be stored in assigned storage areas until they are disposed of in accordance with the MSDS.</li> <li>• Waste dangerous goods and hazardous materials shall be managed and disposed in accordance with the requirements of relevant legislation and industry standards.</li> </ul>
Spill response	<ul style="list-style-type: none"> <li>• In the event of a spill or leak of dangerous goods and hazardous materials the safety of personnel and third parties will be protected as the first priority in accordance with the relevant pollution incident response plan.</li> <li>• All spills of dangerous goods and hazardous materials will be addressed promptly and stopped at source as soon as practicable and contained to the smallest possible area.</li> <li>• During activities, appropriate strategies and equipment will be in place to deal with a spill of all types and volumes of dangerous goods and hazardous materials to be used onsite.</li> <li>• Containment and recovery equipment will include, but not be limited to absorbent materials (eg pads and straw bales), shovels and sand bag sacks and protective clothing (eg gloves, overalls, and boots).</li> <li>• Pollution incidents causing or threatening material harm to be notified to the Environment Manager, EPA, and other necessary government agencies as per the POEO Act and the pollution incident response plan immediately.</li> <li>• Spilt material will be recovered as soon as possible, using appropriate equipment.</li> <li>• Contaminated soil, or spill recovery materials (such as sawdust and absorbent pads) will be disposed of to appropriately licensed facilities.</li> <li>• Spill response equipment will be maintained onsite and replaced as required.</li> <li>• All spillages involving dangerous goods and hazardous materials from any part of the activities will be treated as toxic materials.</li> </ul>
<b>Flora and fauna</b>	
General	<ul style="list-style-type: none"> <li>• The AGL employee and contractor induction will inform all site personnel about flora and fauna management measures and the designated work areas and access routes.</li> <li>• The construction footprint has been minimised to avoid impacts to flora and fauna.</li> <li>• The gas gathering line routes will be selected to use previously or currently disturbed areas of land wherever possible. The AGL biodiversity register will be used for guidance during site planning and site selection.</li> <li>• No trees or remnant native vegetation will be removed for the proposed water pipeline.</li> </ul>
Access	<ul style="list-style-type: none"> <li>• All construction and maintenance activities will be restricted to the well compound area, the water pipeline route and designated access routes.</li> <li>• All vehicles will obey speed limits and remain on designated vehicle tracks and in designated work areas.</li> </ul>

**Table 2.9 Impact avoidance and minimisation measures**

<b>Aspect</b>	<b>Proposed measures</b>
Construction	<ul style="list-style-type: none"> <li>• The site design and layout process will determine which trees / vegetation to clear to minimise disturbance.</li> <li>• Significant habitat areas will be designated as ‘no-go’ areas to construction staff and vehicles.</li> <li>• Stockpiles and vehicles will not be kept within the drip line of any trees.</li> <li>• No works will be undertaken within the drip line of native trees, unless hand digging is used to identify any structural roots by a qualified arborist. If structural roots are uncovered, the pipeline alignment should be diverted to minimise any impacts to the health of the tree.</li> <li>• If Grey-crowned Babblers are identified foraging in proximity to the construction area (within 100m), works should cease and the Environmental Manager advised.</li> <li>• The Environment Manager and Land and Approvals Manager will be notified in the event that damage occurs to vegetation outside of the designated work area.</li> <li>• All open trenches will be checked daily for trapped animals, and those found will be removed, recorded and relocated to appropriate areas away from construction activities by qualified personnel.</li> <li>• Trenches will generally not be left open overnight on public land. Where this is necessary, bunding will be installed.</li> <li>• Any noxious weed material cleared will be disposed of at a facility licensed to receive green waste.</li> <li>• Vehicles should be in a clear and free of vegetation state before entering the work site.</li> </ul>
<b>Fire</b>	
General	<ul style="list-style-type: none"> <li>• The AGL employee and contractor induction will inform all site personnel of required procedures to prevent fire.</li> <li>• The AGL employee and contractor induction will inform all site personnel of and emergency procedures in the event of a fire or bushfire.</li> </ul>
Risk management	<ul style="list-style-type: none"> <li>• Implement measures from the AGL Health and Safety Management Plan (Appendix F) for the Gloucester Region.</li> <li>• Implement measures from the Emergency Response Plan (ERP) for the GGP (Appendix G).</li> <li>• No smoking on site, except in prescribed areas.</li> <li>• All vehicles are to carry emergency communications equipment and a minimum of one fire extinguisher.</li> <li>• All mobile plant will have a minimum of one fire extinguisher.</li> <li>• During extreme or catastrophic fire danger, operations will cease. All activities with less than three escape routes will cease in bushfire prone lands (vegetation category 1, 2 or buffer zone), and all staff will evacuate. Hot work generators will cease operation and all possible ignition sources will be shut down.</li> <li>• There is a dispensation within the <i>Rural Fires Act</i> to enable flares to continue burning on Total Fire Ban days.</li> </ul>
Bushfire	<ul style="list-style-type: none"> <li>• Vehicles will remain on designated roads and access tracks and adhere to project vehicle speed limits. This will prevent accidental fire ignition in tall grasses.</li> <li>• AGL will maintain fire fighting equipment and capabilities such as (but not limited to) fire extinguishers, fire blankets and small fire fighting pumps.</li> </ul>
<b>Flooding</b>	
General	<ul style="list-style-type: none"> <li>• Weather will be monitored and reasonable precautions taken when flooding is predicted.</li> <li>• Safety standards will be maintained to reduce the risk of potential flooding events.</li> <li>• Any above ground piping (ie, across Fairbairns Road bridge) will be steel or steel encased.</li> </ul>

**Table 2.9**      **Impact avoidance and minimisation measures**

<b>Aspect</b>	<b>Proposed measures</b>
<b>Groundwater</b>	
Hydraulic fracture stimulation and flow testing	<ul style="list-style-type: none"> <li>Hydraulic fracture stimulation water (ie flowback water) will be tested and contained in lined water storages/ tanks. Flowback water received from the pilot test well will be transported via water gathering lines to temporary above-ground water storage and lawfully disposed.</li> <li>Produced water will be fully contained, and directly pumped to the temporary above-ground water storage and then transported to the Tiedmans property.</li> <li>To ensure protection of shallow beneficial aquifers, baseline groundwater monitoring networks have been installed at the Waukivory Pilot. AGL will continue to monitor groundwater levels and quality through this network during and after pilot testing. Details of the existing monitoring bores and the monitoring programs are provided in Section 2.8.7 of this REF.</li> </ul>
<b>European heritage</b>	
Pre-activity	<ul style="list-style-type: none"> <li>Locations of wells, access roads and gas gathering lines have been selected to avoid items of heritage significance.</li> </ul>
Construction, operation and rehabilitation	<ul style="list-style-type: none"> <li>Brief personnel/ contractors prior to excavation during the site specific induction on heritage issues and on the appropriate course of action if any historic relics are discovered.</li> <li>All works will be confined to the exploration compound, water pipeline route and designated access routes.</li> <li>Maintain existing vegetation which provides screening of works and minimise removal of vegetation where possible.</li> <li>Implement the recommendations of heritage assessments, where relevant.</li> <li>If any historic relics, as defined by the <i>Heritage Act 1977</i> are identified in the course of activities, then works in the immediate vicinity of the finds will cease immediately, and an archaeologist from the NSW Heritage Branch is to be contacted, and an appropriate course of action implemented.</li> <li>If required for the above, a suitably qualified archaeologist will assess the item/s or site and provide a report to the Project Manager with recommendations. The report will be submitted to OEH for assessment. No work will recommence without approval from OEH and the Project Manager.</li> </ul>
<b>Landscape and rehabilitation</b>	
General	<ul style="list-style-type: none"> <li>Following completion of the activity, the surplus area at each exploration site will be reinstated to its pre activity state or better.</li> <li>The site specific induction will inform all employees and contractors about rehabilitation management measures, control procedures for weeds, pathogens and pest species and the designated work areas and access routes and procedures.</li> </ul>
Access roads	<ul style="list-style-type: none"> <li>All activities to will be restricted to the compound area, water pipeline route and designated access routes (where possible).</li> </ul>
Visibility (construction)	<ul style="list-style-type: none"> <li>The flare container is to be of a natural mid-green tone or similar colour to blend with the surrounding landscape.</li> <li>No naked flame will be visible from the flare. In the case of higher than expected gas flow rates to the flare, an additional thermally insulated container would be placed on top to create the two-tier flare system to mitigate any potential visual impacts.</li> </ul>

**Table 2.9 Impact avoidance and minimisation measures**

Aspect	Proposed measures
Initial rehabilitation	<ul style="list-style-type: none"> <li>• All waste materials and equipment will be removed from the area once backfilling and tie-ins are completed.</li> <li>• Topsoil and vegetation material will be re-spread in the immediate vicinity of the area of origin to limit the potential spread of weeds and pathogens.</li> <li>• Waste management will be implemented to avoid attracting vertebrate pests (see Waste Management Sub Plan).</li> <li>• Sediment control measures will be implemented where necessary to prevent erosion and manage sedimentation and are described in the EMP (Appendix E).</li> <li>• All fences which were cut and replaced by gates during activities will be repaired to at least the equivalent pre-operations condition, unless permanent gates or other arrangements are agreed with the landholder.</li> <li>• Initial rehabilitation of the exploration compound will be consistent with the established character of the surrounding land.</li> <li>• All flagging and bunding installed for environmental or safety reasons will be removed.</li> </ul>
Stockpiles	<ul style="list-style-type: none"> <li>• Disturbed areas will be progressively reinstated as soon as practicable.</li> </ul>
Weeds and pathogens	<ul style="list-style-type: none"> <li>• All vehicles will be in a clean state, free of vegetation, prior to coming to site. This will be done prior to mobilisation to site.</li> <li>• Pilot test wells, restored access tracks and gathering line routes will be inspected following the completion of rehabilitation, for evidence of soil settlement, weeds and pest animals.</li> <li>• Active weed control and monitoring will be required at sites identified as infested.</li> <li>• Herbicides will be used to kill noxious weeds. Drift, drip or run-off to surface waters or non-target species will be avoided. Personnel using herbicides will be appropriately trained and qualified.</li> </ul>
Final rehabilitation	<ul style="list-style-type: none"> <li>• All rehabilitation works will be undertaken with maximum regard to environmental protection and rehabilitation, vegetation, subsoil and topsoil management, weed control, erosion and sedimentation management and revegetation in accordance with the EMP (Appendix E).</li> <li>• Earthworks, vegetation clearing and soil disturbance will be limited to the construction and operational footprint as appropriate.</li> <li>• Existing vegetation will be maintained wherever possible.</li> <li>• Revegetation will include broadcast of seed and ongoing maintenance and monitoring activities.</li> <li>• All private tracks used during activities will be returned to their pre-operations state, or to a condition agreed by the landholder.</li> <li>• Upgraded access tracks and their associated erosion and sediment controls will be maintained for access through the site.</li> <li>• Pilot test wells will be capped and suspended in line with DTIRIS-OCSG requirements.</li> <li>• Surplus compound areas will be partly rehabilitated at the completion of drilling and testing activities. This includes emptying and backfilling pits (if any) and rehabilitating any disturbed areas outside the compound.</li> <li>• All plant and equipment (eg portable toilets), tanks and fenced compounds will be removed.</li> <li>• Silt fences and other environmental controls will be removed.</li> <li>• Excavated areas will be filled in, including diversion drains.</li> <li>• Displaced soil will be contained in a designated bunded area for use as backfill.</li> </ul>

**Table 2.9**      **Impact avoidance and minimisation measures**

Aspect	Proposed measures
	<ul style="list-style-type: none"> <li>• Rehabilitation, contouring and revegetation will be undertaken (if required) as soon as practicable after completion.</li> <li>• Revegetation will include species agreed to by the landowner.</li> <li>• In the case of capped and suspended wells, the surplus area will be revegetated as soon as practicable.</li> </ul>
<b>Noise</b>	
Induction	<ul style="list-style-type: none"> <li>• The AGL employee and contractor induction will inform all site personnel about noise management measures, construction hours and nearest sensitive receivers. All employees are responsible for managing noise from their work activities and working in a manner that minimises noise.</li> </ul>
Hours of operation	<ul style="list-style-type: none"> <li>• Work hours for noise generating activities will be limited to 7:00 am to 6:00 pm Monday to Friday and 8:00 am to 1:00 pm on Saturday (with the exception of pilot testing which will occur 24 hours a day, seven days a week) and AGL’s heavy vehicle traffic use of local Gloucester roads for delivery of plant and equipment (including water) which will occur between 6 am to 6 pm Monday to Saturday).</li> </ul>
Equipment	<ul style="list-style-type: none"> <li>• Plant and equipment will be maintained regularly.</li> </ul>
Site design and planning	<ul style="list-style-type: none"> <li>• All reasonable and feasible noise source controls to minimise noise from plant and equipment during construction will be investigated and applied during the site design and planning process.</li> <li>• The location of work sites has been determined in consideration of nearby sensitive receivers to minimise noise impacts.</li> <li>• Equipment will be positioned away from sensitive areas where practical.</li> <li>• Consultation will be undertaken with potentially affected residences about the timing of any acoustically significant event.</li> <li>• Potentially affected residents will be informed of:               <ul style="list-style-type: none"> <li>– the nature and duration of the works;</li> <li>– expected noise levels; and</li> <li>– relevant contact details for site personnel.</li> </ul> </li> </ul>
Construction and operation phase	<ul style="list-style-type: none"> <li>• Temporary noise barriers will be erected where required.</li> <li>• Where practicable, noisy equipment will be oriented in such a way that the ‘high noise’ side is directed away from sensitive noise receivers.</li> <li>• Trenching/tunnelling machinery will not be permitted to ‘warm-up’ before the nominated working hours.</li> <li>• Where possible, trenching/tunnelling machinery will be located / orientated to direct noise away from the closest sensitive receivers.</li> <li>• Undertake regular maintenance of trenching/tunnelling machinery to minimise noise emissions. Maintenance will be confined to standard daytime construction hours and where possible, away from noise sensitive receivers.</li> <li>• The quietest suitable machinery reasonably available will be selected for each work activity.</li> <li>• All trenching/tunnelling machinery will have efficient low noise muffler design and be well-maintained.</li> <li>• The offset distance between noisy items of plant/machinery and nearby sensitive receivers will be maximised.</li> <li>• Queuing of vehicle is not to occur adjacent to any residential receiver.</li> </ul>

**Table 2.9 Impact avoidance and minimisation measures**

Aspect	Proposed measures
	<ul style="list-style-type: none"> <li>• Where queuing is required, for example due to safety reasons, engines are to be switched off to reduce their overall noise impacts on receivers.</li> <li>• Truck drivers will be briefed to minimise air braking and gear shifting noise in the vicinity of the intersection between Fairbairns Road and Buckets Way.</li> <li>• Where practicable, ensure those noisy plant/machinery are not working simultaneously in close proximity to sensitive receivers.</li> <li>• Responses to any noise complaints will be prompt.</li> </ul>
Monitoring	<ul style="list-style-type: none"> <li>• Environmental noise monitoring and record keeping will be undertaken in accordance with the Noise Management Sub Plan.</li> </ul>
<b>Soil and water</b>	
General	<ul style="list-style-type: none"> <li>• Vehicle access to and within the site will be clearly defined and communicated to all personnel.</li> <li>• Employees and contractors are required to attend a site specific induction prior to commencing work at each site to ensure that all personnel are aware of their HSE responsibilities and have the necessary knowledge and skills to fulfil them.</li> <li>• It is the responsibility of the contractors to consult with AGL to prepare and implement an induction and job specific training program applicable to their work scope. Approval from AGL shall be obtained prior to implementation.</li> <li>• The exploration site and access routes will avoid, where practicable, low-lying areas that are subject to water inundation and flooding.</li> <li>• Vehicle and equipment movement in water inundated areas will be minimised subject to a safety and environmental risk assessment.</li> <li>• Measures will be implemented to reduce soil transfer to public roads.</li> </ul>
Diversion drains	<ul style="list-style-type: none"> <li>• Diversion drains will be constructed as necessary to divert surface water drainage away from soil stockpiles, lined drill pits and other disturbed areas in accordance with this plan. No area requiring diversion drains shall be left overnight without diversion drains unless approved.</li> <li>• Diversion drains and other constructed waterways shall consider the design guidelines provided in Section 5.4.4 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).</li> </ul>
Silt fences and hay bales	<ul style="list-style-type: none"> <li>• Silt fences and/or hay bale filters as appropriate will be installed prior to the commencement of works, in order to minimise sediment movement. They will be installed parallel with the contours, on the immediate down slope perimeter of disturbed areas where potential for significant sediment migration is identified by the site planning process and in accordance with Chapter 6.3.7 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).</li> <li>• Additional control devices will be installed upslope of areas of disturbance where there is a probability of clean surface water flows flowing across the surface and exacerbating surface erosion.</li> <li>• Silt fences will be used for low energy flows when filtering is the main aim.</li> <li>• Hay bale filters will be used where a degree of ponding or energy loss is required.</li> <li>• Silt fences will:               <ul style="list-style-type: none"> <li>– be of Siltfence2000 or equivalent;</li> <li>– be no more than 0.6 m high;</li> <li>– be securely attached (eg by staples or plastic or wire ties) to support stakes (for example wooden stakes or star pickets) placed no more than three metres apart, driven into the ground or until firmly embedded;</li> </ul> </li> </ul>



**Table 2.9 Impact avoidance and minimisation measures**

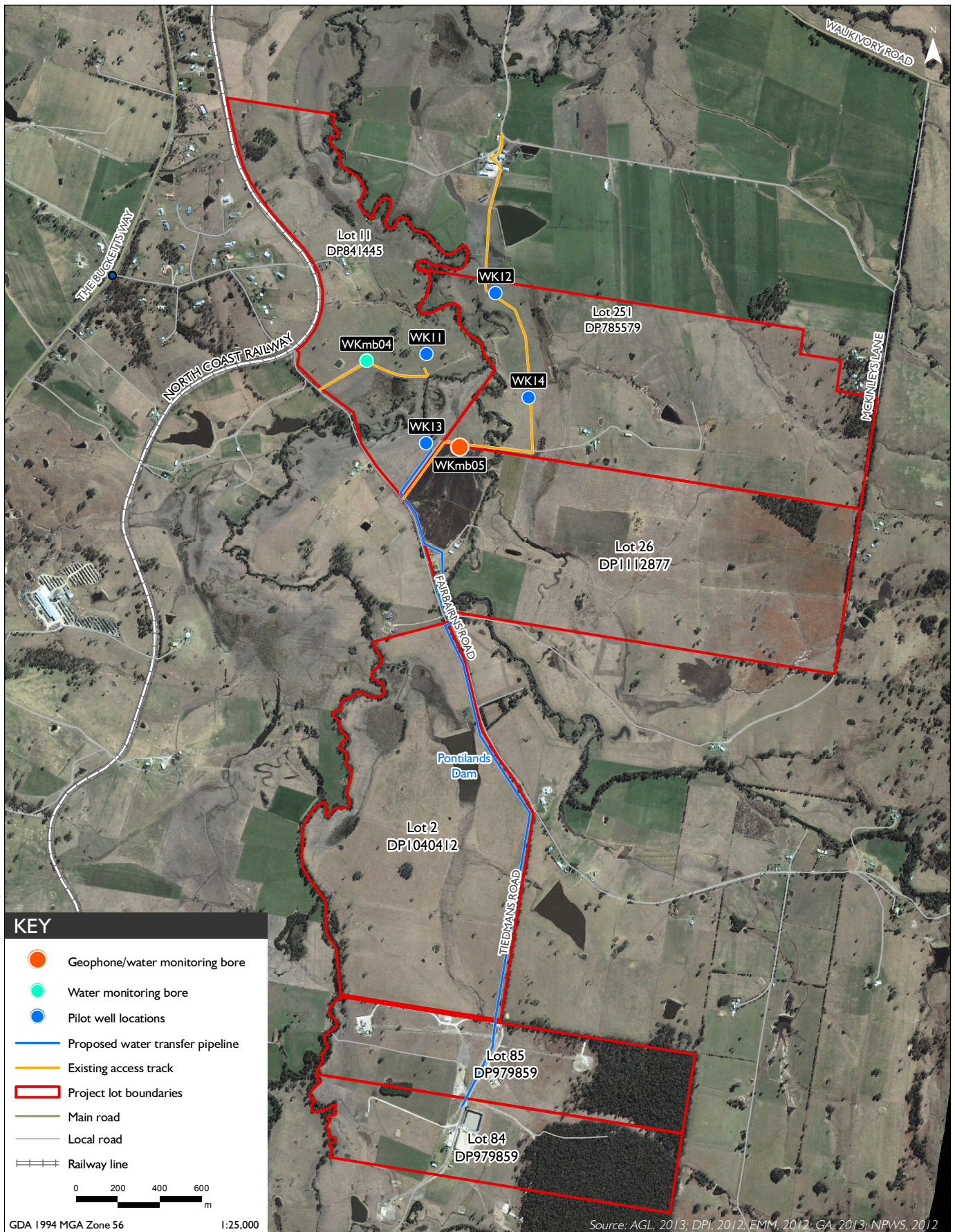
Aspect	Proposed measures
	<ul style="list-style-type: none"> <li>- extend 0.15 m below ground surface via a disc opener or excavation of a narrow trench which is backfilled after placement of the filter fabric;</li> <li>- comprise a continuous roll where practicable. When joints are necessary, the filter fabric will be spliced, or connected with plastic or wire ties or clips, with a minimum 0.15 m overlap and securely fastened at both ends to posts; and</li> <li>- be removed when no longer required.</li> </ul>
Water crossings	<p>The following measures will be followed for drainage line crossings for access and egress:</p> <ul style="list-style-type: none"> <li>• Installation of filter fence either side of the area of works, providing sufficient space between the filter fences for the works to be undertaken.</li> <li>• Temporary waterway crossings will be constructed where roads traverse natural drainage lines in accordance with Chapter 5.3.4 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).</li> <li>• Where appropriate, barrier mesh (upslope) and sediment fencing (down slope) or similar materials will be installed in accordance with details in Chapter 5.4.4 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).</li> </ul>
Soil stockpiles	<ul style="list-style-type: none"> <li>• Soil stockpiles will be constructed in accordance with details in Chapter 4.3 of Managing Urban Stormwater – Soils and Construction (Landcom, 2004).</li> <li>• Stockpiles will not exceed a height of 3 m.</li> <li>• Soil stockpiles will be placed away from drainage lines.</li> <li>• Soil stockpiles will be used as backfill at the conclusion of drilling operations.</li> <li>• Soil contaminated through contact with drilling fluids, fuels or lubricants will be removed from site and disposed of at a licensed facility.</li> </ul>
Construction pads	<p>Where temporary construction pads are proposed, the following steps will be undertaken:</p> <ul style="list-style-type: none"> <li>• Construct a diversion drain upslope from any cut batters to intercept any surface run-off and direct it to safe disposal points.</li> <li>• Install a silt fence on the down slope side of the work area and at least 50% of the sides adjacent to the down slope edge of the work area.</li> <li>• Topsoil will be progressively stripped from areas to be disturbed and stockpiled separately from other excavated material.</li> <li>• Form cut and fill batters with a grade no steeper than 3(H):1(V).</li> <li>• Progressively re-instate excavated material once activities associated with the pad have been completed.</li> <li>• Where permanent construction pads are proposed, berms or benches are recommended on batters with a vertical height greater than 5 m.</li> </ul>
Access roads / tracks	<ul style="list-style-type: none"> <li>• Access will be restricted to formed tracks, either via existing tracks where possible, or new tracks to be constructed.</li> <li>• A speed limit will be set on access tracks to prevent excess dust.</li> <li>• Any sections of track will be constructed, wherever possible, by stripping the surface vegetation and topsoil. To limit erosion, track grades will be generally less than 10°. However, short lengths of steeper grades may occur on existing tracks or may be needed to negotiate difficult sections where unavoidable. Such sections would need to be shaled to allow free surface drainage and to avoid excessive ponding in wheel tracks.</li> <li>• Where run-off cannot be controlled by crossfall drainage, cross drains or cross-banks may need to be used.</li> <li>• All formed batters will have a grade no steeper than 1(V): 3(H).</li> </ul>

**Table 2.9**      **Impact avoidance and minimisation measures**

<b>Aspect</b>	<b>Proposed measures</b>
	<ul style="list-style-type: none"> <li>• Access roads shall be constructed at an appropriate slope along contours where practicable.</li> <li>• Spoon drains and diversion drains will be used to control surface runoff from roads as appropriate.</li> <li>• Sediment filters (silt fences or hay bale filters, as appropriate) will be installed down slope of disturbance associated with construction of the internal main access road where the potential for significant sediment migration is identified.</li> <li>• Temporary diversion drains will be designed and constructed upslope of disturbed areas where the potential for significant runoff from the upslope undisturbed areas to the disturbed area is identified.</li> <li>• Access road batters will be stabilised through revegetation.</li> </ul>
Gas and water gathering line construction, including under boring of Avon River	<ul style="list-style-type: none"> <li>• Spoil from trenching will be temporarily stockpiled adjacent to the trench on the upslope side of the trench where possible. Where a chain trencher is used, spoil may be stockpiled on both sides of the trench.</li> <li>• Topsoil will be stockpiled separately to the underlying soils. This means that there will be two windrows of material adjacent to the trench.</li> <li>• Silt fencing around the trench will only be required in areas within 50 m of watercourses or other sensitive areas, eg upslope of native vegetation or near riparian corridors, as identified by AGL or their contractor.</li> <li>• The trench will be backfilled as soon as practical using the excavated spoil. If the trench is not backfilled on the day of excavation, consideration will be given to upslope protection of the stockpiled spoil.</li> <li>• Stormwater caught in the trench may be used for dust suppression on adjacent areas. Stormwater will not be discharged to existing waterways. Stormwater may be discharged across adjacent vegetated areas.</li> <li>• Careful monitoring of surface and equipment pressure during under boring of Avon River.</li> </ul>
<b>Traffic</b>	<ul style="list-style-type: none"> <li>• The use of any road or track will be restricted during wet weather to prevent damage to such road or track.</li> <li>• Transportation of equipment and machinery likely to cause delays to traffic flows will be timed to avoid peak traffic flows, wherever possible. Vehicle operators will be advised of designated access routes and roadways during the site specific induction. These specific routes will be used to access sites to minimise potential impacts on larger areas of the locality.</li> <li>• Transportation of water will be timed to avoid peak traffic flows, wherever possible. Vehicle operators will be advised of designated access routes and roadways during the site specific induction. These specific routes will be used to access sites to minimise potential impacts on larger areas of the locality. All personnel will adhere to site vehicle speed limits and walking speed close to stock.</li> <li>• The use of oversized vehicles will be in accordance with relevant regulations and RMS guidelines.</li> </ul>

**Table 2.9**      **Impact avoidance and minimisation measures**

<b>Aspect</b>	<b>Proposed measures</b>
<b>Waste</b>	
General	<ul style="list-style-type: none"> <li>• Activities will be carried out to minimise waste where possible, and any waste generated is disposed in a correct manner.</li> <li>• Specific waste management strategies will be developed for each waste stream based on the principles of avoidance, resource recovery and appropriate disposal.</li> <li>• The AGL employee and contractor induction will inform all site personnel about correct waste management procedures based on the principles of avoidance, resource recovery and appropriate disposal.</li> <li>• Waste containers will be provided at all work sites.</li> <li>• All work areas will be maintained in a neat, tidy condition, litter bins will be used at all times and regular emptying shall prevent accumulation of litter onsite.</li> <li>• Waste identified for recycling will be stored separately from other waste.</li> <li>• Temporary portable sanitation or ablution facilities will be provided where existing facilities are not present. A licensed contractor will empty such ablution facilities and the waste lawfully disposed of at an appropriate facility.</li> </ul>
Disposal	<ul style="list-style-type: none"> <li>• Any waste generated will be disposed of in an appropriate manner in accordance with relevant standards and guidelines.</li> <li>• General refuse will be collected and transported to EPA approved recycling or disposal sites.</li> <li>• Hazardous waste will be managed in accordance with existing guidelines and standards.</li> <li>• Waste oil, solvents and other toxic material, will be collected for safe transport offsite for re-use, recycling, treatment or disposal.</li> </ul>



## 2.12 Approval and policy requirements

Table 2.10 provides a summary of the primary environmental legislative reporting requirements and policies applicable to the proposed activity.

**Table 2.10 Summary of project approval requirements for the Waukivory Pilot**

Legislation/policy and relevant regulatory body	Approval/ reporting requirements	Summary of key aspects for GGP	Is an approval required?
EP&A Act (DTIRIS under Part 5)	Part 5 –REF to obtain approval from Minister for Mineral Resources and Energy for certain activities within a PEL.	Part 5 approvals have been issued for drilling of WK11, WK12, WK13 and WK14 in PEL 285.  Part 5 approval being sought for pilot testing of the above wells.	Yes.  Approval is being sought under Part 5 of the EP&A Act.
<i>Petroleum (Onshore) Act 1991</i> (DTIRIS-OCSG)	Requires consideration to be given to protection of the environment before a petroleum title is granted.	AGL holds PEL 285 for the GGP.  Natural gas exploration activities can only be carried out under the authority of a petroleum title.	No.  Following the removal of the moratorium on PEL renewals, AGL has applied for PEL 285 to be renewed.  These activities will be carried out in accordance with the relevant conditions of the PEL.
<i>Protection of the Environment Operations Act 1997</i> (POEO Act) (OEH)	The POEO Act consolidates the key pollution statutes relating to air, water, noise, soil and environmental offences.	AGL, its employees and agents have an obligation to conform to the requirements of the Act and any associated licences issued under the Act.	Yes.  gas exploration activities need an EPL issued under the POEO Act.
<i>Heritage Act 1977</i> (OEH - Heritage Office)	Approval is required to disturb/destroy relics or do certain things that will affect an object subject to an Interim Heritage Order or listed on the State Heritage Register.  An excavation permit is required under certain circumstances.	Approval may be required if works will disturb a relic or an object subject to an Interim Heritage Order or listed on the State Heritage Register.	No.  No heritage items will be disturbed.
NPW Act (OEH)	Section 86 of the NPW Act requires that a person must not harm an Aboriginal object or place. If harm is likely then an Aboriginal heritage impact permit is required under section 90.  A person can apply for an Aboriginal Heritage Impact Permit (AHIP) under section 90A of the Act.	The NPW Act is relevant if Aboriginal objects or sites are discovered during the course of the works.	No.  The activity will not impact any known Aboriginal objects or archaeologically sensitive areas.

**Table 2.10 Summary of project approval requirements for the Waukivory Pilot**

<b>Legislation/policy and relevant regulatory body</b>	<b>Approval/ reporting requirements</b>	<b>Summary of key aspects for GGP</b>	<b>Is an approval required?</b>
<p><i>Native Vegetation Act 2003</i> OEH</p>	<p>Clearing of native vegetation (outside urban zoning) must be carried out in accordance with a development consent or a site vegetation plan (section 12(1)); unless it is permitted clearing or activities listed as excluded clearing.</p>	<p>Clearing is avoided, and is a rare event for the project.</p>	<p>No. In any event, Section 25(h) states that the Act does not apply to any clearing that is carried out as a part of an activity undertaken in accordance with Part 5 of the EP&amp;A Act. If Part 5 approval is granted for the proposed activity the Act will not apply to any clearing.</p>
<p>EPBC Act (DSEWPaC)</p>	<p>All activities must consider matters of national environmental significance (MNES) as well as any Commonwealth land. If a significant impact is proposed, the approval of the Commonwealth Minister for Sustainability, Environment, Water, Population and Community is required.</p>	<p>Consideration of the EPBC Act must be given for all action that have, will have or are likely to have a significant impact: - on a MNES; or - on Commonwealth land (whether action takes place inside or outside Commonwealth land.</p>	<p>Unlikely. No significant impacts are expected to MNES or Commonwealth land or water resources</p>
<p><i>Work Health &amp; Safety Regulation 2011</i> (WHS Regulation) (NSW WorkCover Authority)</p>	<p>Chapter 6A deals with Dangerous Goods. Dangerous goods are required to be placarded and quantities notified to WorkCover NSW when stored above certain levels.</p>	<p>Dangerous Goods are required to be stored in accordance with this regulation. The GGP does not require a Dangerous Goods Notification.</p>	<p>No. AGL need only comply with the provisions of the Act.</p>
<p>TSC Act (OEH)</p>	<p>The Act provides for the protection of threatened flora and fauna (other than fish and marine vegetation) native to NSW and threatened populations, communities and critical habitat.</p>	<p>The Act applies if any threatened species, populations, communities and/or critical habitat listed under the Act is potentially affected by the activity or impacted on or off the work site, as a consequence of the activity. Part 5 requires consideration of an activity's impact on threatened species to determine whether that impact is significant.</p>	<p>No. No significant impacts are expected to threatened species, populations or communities.</p>

**Table 2.10 Summary of project approval requirements for the Waukivory Pilot**

<b>Legislation/policy and relevant regulatory body</b>	<b>Approval/ reporting requirements</b>	<b>Summary of key aspects for GGP</b>	<b>Is an approval required?</b>
<i>Water Management Act 2000</i> (WMA) (NOW)	Subject to certain exemptions controlled activity approval is required for controlled activities when working on 'waterfront land' within 40 m of a watercourse.	The Act applies to non-exempt actions if working on or under 'waterfront land' ie within 40 m of a watercourse, or undertaking interference activities, and then approvals may be required.	No. This REF includes the option of an underbore of the Avon River, which is defined as being waterfront land. However, activities carried out in accordance with a PEL are exempt from the controlled activity approval provisions under the WMA and its regulation (refer to Part 2 of Schedule 5).
<i>Water Act 1912</i> and WMA (NOW)	Water licences are required for drilling activities under both the Water Act 1912, which applies in areas where no Water Sharing Plan is in place and the WMA which applies where there is a Water Sharing Plan.	Water licences are required under Part 5 of the Water Act for all gas exploration and water monitoring holes because there is not a water sharing plan for the deeper sedimentary basin groundwater systems.	Yes. AGL currently holds four bore licences existing/new monitoring bores for the gas exploration wells. New licences under the Water Act will be required to convert the exploration wells to pilot test wells with a collective allocation of 20 ML per annum.
<i>Roads Act 1993</i> (NSW Roads and Maritime Services -RMS)	Section 138 of the Roads Act requires roads authority consent for any activities in, on or over a public road, or likely to disturb the road.	Obtain Road Occupancy Licence if the water pipeline between the Tiedmans property and the Waukivory Pilot is constructed (and not subject to the <i>Pipelines Act 1967</i> ) or construction activities likely to impact on traffic.	Yes. The proposed underbore of Fairbairns Road will require a permit from the roads authority (GSC).

**Table 2.10 Summary of project approval requirements for the Waukivory Pilot**

<b>Legislation/policy and relevant regulatory body</b>	<b>Approval/ reporting requirements</b>	<b>Summary of key aspects for GGP</b>	<b>Is an approval required?</b>
<i>Pipelines Act 1967</i>	Section 5(1)(d)	A licence is not required for a pipeline constructed or to be constructed for the purpose of the supply of water (including for irrigation), the drainage of land or the conveyance of waste water, mine water, aqueous slurries of minerals, mineral concentrates or mineral tailings.	No.
<i>Contaminated Land Management Act 1997</i> (EPA)	Must report to EPA if land is contaminated in accordance with section 60 of the Act.	The Act is relevant if contaminated land is found or suspected.	No. AGL need only comply with the provisions of the Act.
<i>Rural Fires Act 1997</i> (NSW Rural Fire Services – RFS)	The district fire control office in charge of the local fire station must be informed before the lighting of any fires.  No open flame on total fire ban days.  Duty to take steps to prevent bushfires.	The Act is relevant if fires are to be lit or if undertaking activities with fire risk.  Fires lit, maintained or used to dispose of gaseous exhaust emissions through a chimney in connection with the exploration, collection, drainage, refining, manufacture or purification of gas, oil or metal provided that: the fire is lit and maintained in a manner which will prevent the escape of fire, sparks or incandescent or burning materials from the site of the exploration, collection, drainage, refining or manufacturing facility.	No. AGL need only comply with the provisions of the Act.
<i>Noxious Weeds Act 1993</i> (DTIRIS)	Must notify relevant control authority within 3 days of becoming aware that a notifiable weed is on AGL land. Must control spread of noxious weeds on adjoining land.	The Act is relevant if listed weeds area found or imported on site.	No. AGL need only comply with the provisions of the Act.
<i>National Greenhouse and Energy Reporting Act 2007</i> (Cth)  Commonwealth Department of Climate Change and Energy Efficiency (DCCEE)	Must report greenhouse gas emissions, energy consumption and production if the corporate group emits 125 kilotonnes or more greenhouse gases (CO <sub>2</sub> equivalent), or produces or consume 500 TJ or more of energy for the 2008-2009 reporting year. Note these reporting thresholds decrease for the 2009-2010 and 2010-2011 reporting years.	The Act is relevant to the AGL Energy group of companies, including the GGP. It is required to report all greenhouse gas emissions, energy consumption and production on a financial year basis.	No. AGL need only comply with the provisions of the Act.



**Table 2.10 Summary of project approval requirements for the Waukivory Pilot**

Legislation/policy and relevant regulatory body	Approval/ reporting requirements	Summary of key aspects for GGP	Is an approval required?
Guidelines and policy			
NSW AIP	Aquifer interference approvals are required for mining activities where water is extracted (including gas), extractive industries, dewatering, injection works and activities that may contaminate an aquifer.	This policy is relevant to gas exploration projects where water will be extracted from an aquifer. Minimal impact considerations within the policy need to be assessed with respect to the proposed exploration activities.	<p>Maybe.</p> <p>NOW will provide advice to DTIRIS-OCSG based on the minimal impact considerations in the AIP. DTIRIS-OCSG will consider advice and the additional considerations (Section 3.2.2 of the policy) in their decision-making process.</p> <p>AGL has provided an assessment against the minimal impact considerations is provided in Appendix H.</p>
Draft Code of Practice for Coal Seam Gas Exploration	The explorer must maintain a record of community engagement. Where no exploration activity is occurring, an annual report must be submitted by the end of January. Where exploration activity is occurring, a quarterly report must be lodged within one month of the end of each quarter.	This policy is relevant to all gas-related activities.	<p>No.</p> <p>AGL must only comply with reporting requirements.</p>
Code of Practice for Coal Seam Gas Well Integrity	<p>The titleholder must record accurate information on drilling, completion, workover and well abandonment. These records must be maintained in an accessible way for the five years following abandonment of a well.</p> <p>Titleholders must keep geological plans, map and records for work relating to the title, and submit plans and reports on the progress of operations, in accordance with the PO Act (section 131) and Regulations (parts two and three).</p>	This policy is relevant to all gas-related activities.	<p>No.</p> <p>AGL must only comply with reporting and mandatory requirements of the code of practice.</p>

**Table 2.10 Summary of project approval requirements for the Waukivory Pilot**

<b>Legislation/policy and relevant regulatory body</b>	<b>Approval/ reporting requirements</b>	<b>Summary of key aspects for GGP</b>	<b>Is an approval required?</b>
Code of Practice for Coal Seam Gas Fracture Stimulation	A completed fracture stimulation completion report must be submitted to DTIRIS (Mine Safety Operations and Environment Sustainability Unit) in the approved form within 30 days of the cessation of the fracture stimulation activity. Mandatory reporting requirements are detailed in Section 14.2 of the code of practice.	This policy is relevant to all gas-related activities.	No. AGL must only comply with reporting and mandatory requirements of the code of practice.
Strategic Regional Land Use Policy	An agricultural impact statement is a new state-wide requirement for all mining, gas exploration and production proposals.	This policy is relevant to all gas-related activities. An agricultural impact statement is provided in Appendix A.	No. AGL must comply with the requirements of an agricultural impact statement, which is included in the REF.

### 3 The site

The sites are at the privately-owned properties in Table 3.1. These properties are near Forbesdale in the Gloucester LGA.

**Table 3.1** Location of sites

Site	Address	Lot	DP	Coordinates
WK11	20 Grantham Road, Forbesdale	11	841445	56H 402419E 6452590S
WK12	197 Fairbairns Road, Forbesdale	251	785579	56H 402748.92E 6452883.77S
WK13	20 Grantham Road, Forbesdale	11	841445	56H 402416.74E 6452164.46S
WK14	197 Fairbairns Road, Forbesdale	251	785579	56H 402906.1E 6452384.08S
Pipeline	237 Fairbairns Road, Forbesdale.	26	1112877	Linear
Pipeline	306 Fairbairns Road, Forbesdale.	2	1040412	Linear
Pipeline	100 Tiedmans Road Forbesdale	85	979859	Linear
Pipeline	100 Tiedmans Road, Forbesdale	84	979859	Linear
Pipeline	Road reserve	1	196054	Linear

Access will be via existing public roads and private tracks in the subject properties. WK11 and WK13 are currently accessed via Fairbairns Road and WK12 and WK14 via Fairbairns Road for light vehicles and Maslens Lane for heavy vehicles.

The area is relatively flat and the sites are between 99 m and 105 m above sea level. The sites are between approximately 100 m to 260 m from Avon River and WK13 and WK14 is approximately 150 m and 245 m from Waukivory Creek, respectively. The other sites are over 300 m from Waukivory Creek. There is minimal remnant native vegetation in the area other than some riparian vegetation along water ways.



## 4 The existing environment

### 4.1 General description

Section 4.1 provides general information on the existing climate, topography of the site, vegetation cover and soils/geology.

#### 4.1.1 Climate and weather

The climate of the Gloucester region is characterised by hot summers and cool, dry winters. The highest rainfall is during summer and is usually associated with thunder storms and east coast low pressure systems. The windiest months are in spring and the calmest are in autumn and winter.

The climate averages for Taree Airport automatic weather station, which is the closest comprehensive weather station (approximately 53 km north east) to the Waukivory Pilot, are shown in Table 4.1.

**Table 4.1** Climate at Taree Airport

Statistic	Measurement	Month
<b>Maximum Temperature</b>	(°C)	
Annual average	23.9	-
Highest monthly maximum	28.7	January
Lowest monthly maximum	6.7	August
<b>Rainfall</b>	(mm)	
Annual	1136.5	-
Highest monthly	149.0	February
Lowest monthly	51.7	September
<b>Wind (3pm)</b>	(km/h)	
Annual	17.9	-
Highest monthly	21.5	January
Lowest monthly	13.3	June

Source: Bureau of Meteorology (accessed 4/2/2013).

#### 4.1.2 Topography

The site is in an approximately 8 km wide valley formed by a range in the east that peaks at approximately 370 m (Mount Mograni) and the Gloucester Bucketts in the west that peak at approximately 500 m. The valley declines to the centre, where the Avon River flows north to south. The Avon River is the lowest point in the valley at approximately 98 m (AHD).

### 4.1.3 Vegetation cover, type, density and condition

The site was inspected by Alison Hunt and Associates on 17 November 2010 (Alison Hunt and Associates 2010), a trained and experienced ecologist. The report (2010) described native vegetation at the site as heavily cleared and modified for agriculture. Remnant vegetation comprised large paddock trees (predominantly forest red gum (*Eucalyptus tereticornis*) and grey box (*Eucalyptus moluccana*), which are scattered across the landscape, and a 20 m wide vegetated corridor along the Avon River and Waukivory Creek.

The wells and access tracks have been constructed and are in paddocks vegetated with native and introduced pasture species. The sites do not contain any native trees or shrubs.

### 4.1.4 Soil types and properties

#### i Regional geology

The Gloucester Basin is a synclinal structure formed by Permian consolidated sediments. The Permian Rocks display steep dips of up to 70° on the edge of the basin, dipping towards the north south axis, and flattening towards the basin centre. They lay on a basement composed of early and late Carboniferous sedimentary and volcanic units that are part of the New England Fold Belt. The geology of the region comprises Quaternary sediments along the valley floor and Permian rocks along the flanks and over most of the catchment. Carboniferous volcanics form the major east and west ridgelines.

The geological strata of the Gloucester Basin (from youngest to oldest) on a local scale can be summarised as:

- unconsolidated alluvial deposits and swamp sediments along the Avon River (Quaternary in age);
- sedimentary rocks (including substantial coal measures at depth) of the Gloucester Coal Measures (Permian in age); and
- fractured basement rocks of the New England Fold Belt below the sedimentary rocks (Palaeozoic age).

#### ii Lithology

The Gloucester Basin is divided into three major stratigraphic units: the Alum Mountain Volcanics, the Dewrang Group and the Gloucester Coal Measures. These are described below. The stratigraphic nomenclature used for the Gloucester Basin in this report is based on Lennox, M., 1991, which is contained in Roberts, J., and Chapman, J., 1991.

#### a. Alum Mountain Volcanics

The Alum Mountain volcanics lie unconformably over the carboniferous Johnsons Creek Conglomerate. The volcanics commence with a basal coal measure sequence of pebble conglomerate which is overlain by the 12 m Basal Coal Seam. This seam is overlain by basalt flows, rhyolites, and acid tuffs. Towards the top of the sequence conglomerates are more prevalent and the Clareval Seam, along with several thinner coals is present.

## b. Dewrang Group

The Duralie Road Formation contains two distinct facies. The lower part of the formation is predominantly a well sorted fine grained sandstone, while further up this becomes coarser grained. Overlying this is a conglomerate which is particularly prevalent on the eastern side of the basin. The formation is both alluvial and marine influenced and likely represents a near shore environment where braided alluvium such as conglomerate has flowed directly into the sea.

The Weismantel Formation was deposited in a back-barrier lagoonal environment during a regressive phase. The formation's major feature is the thick Weismantel Seam which lies at its base. The seam is an average of 10 m thick along the flanks of the basin increasing to 25 m in the south. The seam continues north along the eastern flank of the basin. The seam is overlain by bioturbated siltstone and sandstone.

The Mammy Johnsons Formation consists of fine to medium grained sandstones with laminated siltstone at its top and base. These sandstones are bioturbated in parts and are considered to have been deposited in a shallow marine environment. The Intra Mammy Johnsons Coal is up to 5 m thick and was most likely formed in a back barrier swamp or lagoon.

## c. Gloucester Coal Measures

### Avon Subgroup

The Waukivory Creek Formation represents a change in depositional environment from marginal marine setting of the underlying Dewrang Group to a terrestrial coastal plain. Deposited in a coastal plain environment and represents a shift away from marine influenced sediments. Units generally fine grained but with occasional 10 m thick medium grained beds which are most likely from a meandering river system. The formation contains several substantial coal seams in the Parkers Road, Rombo, Triple and Avon coal seams. These coal seams are best developed on the eastern side of the basin.

The Dogtrap Creek Formation is identified by its coarsening upward sequences, bioturbated mudstones and crevasse splays. The Dogtrap Creek Formation represents the start of a transgressive phase of deposition. The depositional environment was most likely lower delta plain. The Glenview Coal Seam is well developed near the top of the sequence.

The Speldon Formation represents the culmination of the marine transgression seam in the Dogtrap Creek Formation. The formation contains well bedded medium to fine grained sandstone with minor siltstone and becomes darker and siltier towards its top. The formation is heavily bioturbated and the north eastern part of the basin contains marine fossils.

### Craven Subgroup

The Wenham Formation contains the Bowens Road Lower Seam at its base and the Bowens Road Seam at the top. The Bowens Road Lower is generally thin (~2 m) while the Bowens Road is up to 14 m in the Stratford area. Between the seams is fine grained sandstone which is interspersed with plant debris. The main Bowens Road seam is characterized as being bright at the base and considerably duller and banded towards the top. This is believed to have been caused by a lowering of the water table which led to sub-aerial oxidation. The formation represents a hiatus after regression.

The Wards River Conglomerate is a major feature of the Gloucester Basin. While it is considered to lie stratigraphically above the Wenham formation and below the Jilleon Formation, this is only the case in its type section in the eastern part of the basin. The conglomerate was deposited as several large alluvial fans whose sediment source was the carboniferous sequence which outcrops to the west of the Gloucester Basin. On the western side of the basin the conglomerate forms the lateral equivalent of all the formations above the Bowens Road seam. In this area at its thickest it consists of matrix supported conglomerate and becomes thinner and finer grained (but generally still conglomeratic) moving east through a braided river system into an interfan or overbank deposit.

The Jilleon Formation onlaps and is eventually replaced by the Wards River Conglomerate in the west of the basin. This formation contains the Roseville seam and Cloverdale seam (at its top), as well as the less consistent Tereel (or Fairbairns Road) coals. The Jilleon Formation consists of coarsening upward sandstones with occasional upward fining siltstone. It was deposited in an alluvial plain environment, and was subsiding rapidly which has led to a lot of thin coal seams forming. The Roseville and Cloverdale seams can be traced across a wide area on the eastern flank. Both seams are several metres thick, and the Cloverdale contains a distinct tuff band which proves useful when correlating wells.

The Leloma Formation outcrops only in the middle of the basin. It contains the Deards, Bindaboo, and Linden seams as well as several thin unnamed coals. These are overlain by a 300 m thick homogeneous fine to medium grained sandstone layer deposited in an upper alluvial plain environment. Correlation of coal seams is particularly difficult as they vary in thickness and split across relatively short distances. The coals of the Leloma formation are best developed in the Clear Hill sub basin area on the western flank of the basin. There are several tuff bands throughout the sequence, the largest being the Jo Doth Tuff. The Jo Doth Tuff is 15 to 30 m thick and is consistent across the formation until it is replaced by the Wards River Conglomerate in the east.

The Crowthers Road Conglomerate marks the top of the Gloucester basin stratigraphy and as such is the present day erosion surface. It consists of pebble conglomerate and medium to coarse grained sandstone derived from the carboniferous formations to the west and north of the basin. As such it is generally confined to the western and northern part of the basin and imbricated clasts show flow was in an easterly direction. Deposition was due to several large alluvial fans.

### iii Site geology

The geology at the sites is complex. It is near the centre of the basin and the strata shallowly dips at approximately 20° to the west. There is a major north-south low angle thrust fault with a vertical throw of over 200 m which dips east to west in the area. WK12 and WK14 are in the stable block of the fault and WK11 and WK13 are in the upthrust block.

### iv Soils

WK11 is in the 'ERgo' soil landscape and the other wells and the proposed water pipeline are in the 'STgu' soil landscape (Henderson, 2000).

The ERgo landscape has the following soils:

- moderately deep to deep, moderately well drained Brown Sodosols (Yellow Soloths) and shallow to deep, moderately well drained Grey Kurosols (Yellow Soloths) on imperfectly to moderately well drained side slopes and crests; and
- shallow, moderately well drained Bleached-Leptic Tenosols (Lithosols) on creasts and steeper side slopes.



These soils have a sheet erosion risk, gully erosion risk, seasonal waterlogging on lower slopes and tree dieback. They are strongly acidic soils with high potential aluminium toxicity, low permeability, low fertility, low wet-bearing strength and high dispersibility/sodicity.

The STgu landscape has the following soils:

- deep, imperfectly drained Yellow Chromosols (Soloths) on plains with deep very poorly drained Redoxic Hydrosols (Gleyed Podzolic Soils) on small swampy oxbows.

These soils have a flood hazard, seasonal waterlogging, poor drainage and permanently high water tables resulting in local swamps. They are low permeability soils of low wet bearing strength.

#### 4.1.5 Existing land uses

The main land uses in the Gloucester/Dungog/Great Lakes area are agriculture; mining; conservation areas and forestry; and residential development. The main agricultural activity in the region is grazing with a small amount of horticulture, intensive animal production and dairying (ABARE, 2004). Approximately 36% of the Gloucester and Great Lakes region is agricultural land and the total value of agricultural production in 2006 was approximately \$63.7 million (ABS 2007). Total employment in the agricultural industry in the Gloucester and Great Lakes LGAs is 829, with the main agricultural employment being in specialised beef cattle farming (ABS 2007).

The main land use near the site is beef and dry dairy cattle grazing on improved and semi improved pastures (Henderson, 2000). Other land uses in the wider area include residential development and coal mining, with the Stratford and Duralie coal mines approximately 5 km and 24 km south, respectively.

The nearest conservation areas are The Glen Nature Reserve and Avon River State Forest, which are approximately 9 km south east and 10 km south west, respectively.

The nearest locality is Forbesdale, which is approximately 1 km west.

#### 4.1.6 Availability of services

No services will be required during the activities as electricity will be provided by generators, water will either be supplied via truck from offsite sources (with preferred options being the nearby Pontilands dam and Tiedmans dam) or via the water pipeline between Tiedmans dam and WK13 and communications will be via mobile phone and citizens band radio.

The main public utilities near the sites are electricity and telephone which run parallel to the Bucketts Way. There is no public potable water or sewerage supply near the sites; residences use water tanks and septic systems for these purposes.

## 4.2 Description of surface water and groundwater sources

**Section 4.2 describes the surface (catchment area) and groundwater resources relevant to the area subject of the proposed activity.**

**The depth of existing bores in the area varies between around 4 m and 60 m below ground level (BGL). The shallow alluvium is the main beneficial aquifer in the area and has a maximum depth of 75 mBGL.**

### 4.2.1 Surface water resources

The existing well sites are between approximately 100 m to 260 m from the Avon River and WK13 and WK14 are approximately 150 m and 245 m from Waukivory Creek, respectively. The other sites are over 300 m from Waukivory Creek. The water pipeline (from WK13) is mainly in a creek-flat open cattle paddock. The proposed alignment comes within 50 m of Waukivory Creek at one point. At this point, Waukivory creek is part of a gentle open depression. The proposed alignment also crosses two ephemeral drainage lines that are tributaries to the Avon River.

The Avon River and Waukivory Creek are in the Hunter-Central Rivers Catchment Management Authority (CMA) administered Manning River Catchment. Waukivory Creek flows into the Avon River near the site and the Avon River flows into the Gloucester River north of Gloucester. The Avon River is fed by numerous small ephemeral and permanent streams.

Much of the middle and lower sections of the catchment are highly fertile due to the weathering of volcanic deposits in elevated areas. The impact of human activity on the Manning River Catchment includes both point source and non-point source (diffuse) pollution of waterways. Other human impacts include the changed patterns of vegetation cover caused by altered land use patterns and specific land management practices, and flow manipulation through storage and consumptive use of the waters.

About 22% of the catchment is heavily timbered and managed by NSW State Forests for forestry, recreation, education, research and environmental purposes. Most of the forested areas are on relatively steep country.

Water quality was monitored in the Avon River between 1994 and 2011 for the Stratford Coal Mine Extension Project (see Table 4.2) and since 2010 at the Tiedmans property. Salinity levels are known to be highly variable from low to high stream stages.

**Table 4.2 Avon River water quality**

Site W1	pH	EC (µS/cm)	Alkalinity (mg/L)	Turbidity (NTU)	Total nitrogen (mg/L)	Total phosphorus (mg/L)
Average	7	332	67.3	64.9	1.71	0.15
% exceedance	9	0	-	37	74	49

*Notes: exceedance is the amount of samples (%) that exceed the Australian and New Zealand Environment and Conservation Council's (ANZECC) aquatic ecosystem guideline for slightly disturbed lowland rivers in south east Australia.*

*Source: Gilbert and Associates (2012).*

#### 4.2.2 Groundwater resources

Groundwater in the area is a low value water resource rarely used for agricultural or other consumptive purposes. The main beneficial aquifers are associated with the alluvium and the underlying fractured rock to around 75 mBGL. Bore yields in the alluvium, weathered rocks and fracture zones are very low and water quality is generally brackish to saline. The best water quality and yields are generally found in the shallow alluvium. Further information on the groundwater resources in the vicinity of the proposed pilot activity is provided in the SWGMP in Appendix D.

#### 4.2.3 Groundwater bores at the Waukivory Pilot area

There are four registered water bores within 5 km of the well sites. The details of these water bores are provided in Table 4.3. The bores within 2 km of WK11 and WK13 will be surveyed (for water levels and water quality) before hydraulic fracture stimulation and flow testing commences to determine baseline conditions.

**Table 4.3 Groundwater monitoring results**

Bore / Well regulation number	Type and date of construction	Depth (mBGL)	Aquifer zone (m)	Water level (mBGL)	Geology	Distance to closest gas well
GW054940	Excavation 1981	4	2.5 to 4	Not known	Alluvium	~600 m to WK13
GW080357	Bore 2002	40.5	22 to 22.2 29 to 29.3 37 to 37.2	14	Sandstone	~3.6 km to WK11
GW080487	Bore 2004	Approx. 60	17 to 18	17	Shale	~1.5 km to WK11
GW200330	Bore 2006	50	Not known	Not known	Shale	~1.8 km to WK13

#### 4.2.4 Groundwater productivity

Highly productive groundwater sources' are defined in the NSW AIP as having the following characteristics:

- total dissolved solids (TDS) of less than 1,500 mg/L; and
- water supply works that can yield water at a rate greater than 5 L/sec.

Groundwater productivity characteristics of aquifers in the local area based on water bore and monitoring data are shown in Table 4.4.

**Table 4.4 Groundwater characteristics**

Aquifer	Yield (L/s)	EC	(approx) TDS (mg/L)
Alluvium	<2	2,000 to 7,500	1,500 to 6,000
Fractured rock	<0.5	3,500 to 5,000	3,000 to 4,250

Aquifers near the sites are 'less productive groundwater sources' under the NSW AIP as they have low yields and high TDS compared to the criteria for highly productive groundwater sources.

#### 4.2.5 Waukivory conceptual groundwater model

The broader (ridgeline) areas of the Gloucester Basin south of Gloucester are underlain by Carboniferous volcanics, the hillsides by a variety of Permian sedimentary rocks while the valley floors are underlain by Quaternary alluvium associated with the Avon River and other minor tributaries.

Groundwater in the Permian rocks is a low value water resource and is rarely used for agricultural and other consumptive uses. Rock permeabilities are generally low, aquifers are mostly bedding and fracture zones, bore yields in rocks and fracture zones are very low and water quality is generally brackish to slightly saline.

Based on the latest water level, water quality and isotope data from the Phase 2 studies (PB 2012), there is a good appreciation of groundwater recharge, discharge and flow processes through the different hydrogeological units of the Gloucester Basin. These units (based on SRK Consulting, 2010) are confirmed as:

- alluvial aquifers;
- fractured bedrock aquifers;
- coal seam water bearing zones; and
- confining units.

Only the first two units are aquifers. The deeper rock types being either very poor aquifers/aquitards (coal seams, siltstones and sandstones) or confining aquitard/aquiclude layers (claystones or indurated sandstones).

The alluvium is relatively shallow (maximum 15 m thickness) and in some areas contains an unconfined (sand and gravel) aquifer. Water tables are generally less than 5 m below surface. Groundwater flow processes are relatively simple with rainfall being the predominant recharge source on the floodplain. Flooding occasionally adds additional recharge water to the alluvial water table. Groundwater discharge from the alluvium is to the rivers as baseflow and shallow groundwater is also expected to be transpired by riparian vegetation.

The bedrock contains mostly tight siltstone and indurated sandstone rock types with occasional thin semi-confined sedimentary/fractured aquifers (to around 75 m depth). Water tables are generally greater than 10 m below surface with deepest levels at elevated sites and in areas of active coal mining. Rainfall is the only recharge source to the bedrock aquifers and recharge does not occur everywhere in the landscape. Recharge mostly occurs in areas of rock outcrop. In areas where there is a weathered (clayey) profile, brackish to saline water quality suggests there is negligible (vertical) rainfall recharge. Groundwater flow in bedrock aquifers is lateral, either within local fracture zones or individual strata if there are no interconnecting and open fracture zones. Groundwater discharge is via seepage to springs and to the alluvium (and indirectly to creeks and rivers) along the floor of the valley.

The groundwater in the deeper bedrock units is moving very slowly with lateral movement within each rock unit predominating. Confining rock permeabilities are very low; coal seam permeabilities are slightly higher (but are still not high enough to be considered aquifers).

Therefore, the only beneficial aquifers in the region are the shallow alluvial groundwater source and shallow semi-confined sedimentary/fractured aquifers to around 75 m depth. Deeper zones are water bearing zones but rarely aquifers (beneficial or otherwise).

#### 4.2.6 Groundwater dependent ecosystems

There are no known GDEs (apart from stream base flow accessions) in the vicinity of the Waukivory pilot wells and pipeline. Whilst impacts to any GDEs are not expected to result from the proposed activity, AGL will continue to monitor groundwater at the site. The geophone/water monitoring bore (WKmb05) at the site (which is subject of a separate pending application with NOW) will be incorporated into the broader groundwater monitoring network and ensure there are no adverse impacts on the shallow aquifers in the northern part of the Gloucester Basin and as result of depressurisation of the deeper coal seam water bearing zones.

#### 4.3 Description of threatened species, populations and ecological communities

**This section identifies threatened species, populations and ecological communities listed under the TSC Act and EPBC Act recorded or considered likely to occur at the Waukivory Pilot (Appendix I and Appendix J).**

**The ecological assessments consisted of desktop assessments and field surveys. The likelihood of threatened species within a 10 km radius was assessed giving consideration of habitats within sites and availability of field surveys.**

##### 4.3.1 Threatened species

The OEH *Atlas of NSW Wildlife* was analysed for the original Waukivory REF in March 2011, December 2012 and again in August 2013 for this REF.

Sixty-three TSC Act listed threatened species have been recorded within 10 km of the proposed activity. These comprise ten plant, one reptile, four amphibian, 25 bird and 23 mammal species. Given the level of previous clearing, the sites lack the structural diversity and foraging resources to provide habitat for many threatened species that occur locally. An exception is the grass owl (*Tyto capensis*), which may forage in tall grass surrounding the well sites. Shrubs and juvenile Eucalypts in road reserves may provide habitat for the Grey-crowned Babbler (*Pomatostomus temporalis temporalis*).

##### 4.3.2 Threatened populations

There is a broad-toothed rat (*Mastacomys fuscus*) endangered population at Barrington Tops in the Gloucester LGA (OEH, 2013a). Preferred habitat (subalpine woodlands, tableland clay grassy woodlands and temperate montane grasslands) does not occur at the site.

##### 4.3.3 Threatened ecological communities

A threatened ecological communities (TEC) search done for the original REF (EMM 2011) identified 13 listed TECs as occurring in the Manning River Catchment. The following 16 TECs occur in the Gloucester LGA (OEH, 2013b):

- carex sedgeland of the New England Tableland, Nandewar, Brigalow Belt South and NSW north coast bioregions;
- coastal saltmarsh in the NSW North Coast, Sydney Basin and south east corner bioregions;
- freshwater wetlands on Coastal Floodplains of the NSW North Coast, Sydney Basin and south east corner bioregions;

- Hunter lowland redgum forest in the Sydney Basin and NSW north coast bioregions;
- Hunter Valley vine thicket in the NSW north coast and Sydney basin bioregions;
- littoral rainforest in the NSW north coast, Sydney Basin and south east corner bioregions;
- lowland rainforest in the NSW North Coast and Sydney Basin bioregions;
- lowland rainforest on floodplain in the NSW north coast bioregion;
- montane peat lands and swamps of the New England tableland, NSW north coast, Sydney Basin, south east corner, south eastern highlands and Australian alps bioregions;
- ribbon gum-mountain gum-snow gum grassy forest/woodland of the New England tableland bioregion;
- river-flat eucalypt forest on coastal floodplains of the NSW north coast, Sydney Basin and south east corner bioregions;
- subtropical coastal floodplain forest of the NSW north coast bioregion;
- swamp oak floodplain forest of the NSW north coast, Sydney Basin and south east corner bioregions;
- swamp sclerophyll forest on coastal floodplains of the NSW north coast, Sydney Basin and south east corner bioregions;
- Themeda grassland on seacliffs and coastal headlands in the NSW North Coast, Sydney Basin and south east corner bioregions; and
- Carex sedgeland of the New England tableland, Nandewar, Brigalow Belt south and NSW north coast bioregions.

EMM's August 2013 survey identified Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions endangered ecological community (Hunter Lowland Redgum Forest EEC) in the drainage flats and lower slopes in the area of the water pipeline between the Tiedmans property and WK13. However, stands were assessed as being highly degraded with few characteristic understorey species remaining including Tall sedge (*Carex apressa*) and Blady Grass (*Imperata cylindrica*) in areas.

#### 4.3.4 Migratory species

Twelve migratory bird species and their habitats are predicted to occur within 10 km of the site (DSEWPac 2012). A habitat assessment was completed for all migratory bird species with potential to occur within 10 km of the site (Appendix I and Appendix J).

It was concluded that the proposed activity is not expected to result in significant impacts to the migratory bird species as an ecologically significant proportion (as defined under the guidelines (DEH, 2006)) of their populations do not reside in the study area, no breeding occurs in the area, it is not at the limit of their range and they are not known to be declining. Furthermore, foraging habitat was found to be sub-optimal and the proposed activity is unlikely to disrupt their migration patterns.

## 4.4 Description of Aboriginal cultural heritage values

**This section describes the site's and local area's cultural heritage values.**

### 4.4.1 Background

An Aboriginal cultural heritage assessment was conducted in support of the original REF (EMM 2011) for the establishment of the exploration wells WK11, WK12, WK13 and WK14 and their respective access tracks. A survey of the water pipeline alignment between the Tiedmans property and WK13 was done by EMM in August 2013. Both assessments were done in accordance with the DECCWs *Due Diligence Code of Practice for the Protection of Aboriginal Objects*.

The aim of the studies was to identify the Aboriginal cultural heritage values pertaining to the specific areas to be impacted by the establishment of the exploration wells and the water monitoring piezometer (WKmb04) and the water pipeline between the Tiedmans property and WK13. No Aboriginal sites were found to occur within the impact area.

### 4.4.2 Existing environment

The established wells are between 100 m and 150 m from the junction of the Avon River and Waukivory Creek (Figure 2.4 and Figure 2.5). Land disturbance is limited to past land clearing for cattle grazing and for the establishment of WK11, WK12, WK13 and WK14. The land form is creek-flat open cattle paddocks on soils derived from the Gloucester Coal Measures geology within the Gloucester Vale. The exception to this is at WK11 which is situated on the top of a low spur.

The area was initially occupied by people of the Birpai language group, also known in the various literature as Biribay, Biribi, Birippi, Birrapee, Birripai, Birripi, Bripi, Brippai and Waw-wyper. According to Tindale (1974) this territory covered an area of some 7,300 km<sup>2</sup>, extending from the Manning River at Taree south to Cape Hawke (near Forster) on the coast, and inland to the dividing range around Gloucester in the south west and the head of the Hastings River in the northwest.

Archaeological investigations have been limited in the area to a few coal mine assessments, a previous AECOM assessment and the EMM Aboriginal cultural heritage assessment conducted in support of the REF for the establishment of the exploration wells. AECOM (2009) report that only a few open stone artefact sites comprising small numbers of flaked stone tools have been recorded. The thick grass cover through this well-watered country is an obstacle to identifying open stone artefact sites. Such sites usually comprise flaked stone artefacts distributed within the topsoil, and therefore are readily hidden in a grassed paddock.

One AHIMS record, 38-1-49 (site name LEA1) listed as a possible Aboriginal scarred tree, was identified on the edge of the Avon River bank. During the EMM (2011) investigation the tree was identified in the field and assessed as not an Aboriginal scarred. Regardless of the tree's status as an Aboriginal object, it is over 200 m south east of the nearest well (WK11).

The EMM (2011) study also identified a single stone artefact (site WK-IF-1), on a disturbed gravelled track 160 m east of WK11. The single indurated mudstone thick blade flake occurred in a disturbed context of introduced gravel on a rehabilitated access track and may have been introduced with the gravel.

The EMM 2013 survey of the proposed alignment for the water pipeline from the Tiedmans property to WK13 found the area to be highly disturbed and did not identify any archaeologically sensitive landforms or Aboriginal objects. No carved trees or scarred trees were found within or adjacent to the water pipeline alignment.

No Aboriginal socio-cultural heritage values specific to the areas or to the creek valley generally have been identified, but this does not diminish the overall value that Aboriginal people place on the landscape generally.

#### 4.5 Description of historic cultural or natural heritage values

A search of the NSW Heritage database and the Gloucester LEP revealed no items of state or local heritage significance within the vicinity of the proposed activity. The Stroud Gloucester Valley is a nominated place on the National heritage list.







[www.emgamm.com](http://www.emgamm.com)

**SYDNEY**  
Ground Floor, Suite 1, 20 Chandos Street  
St Leonards NSW 2065  
T 02 9493 9500 F 02 9493 9599

**NEWCASTLE**  
Level 1, 6 Bolton Street  
Newcastle NSW 2300  
T 02 4927 0506 F 02 4926 1312

**BRISBANE**  
Suite 1, Level 4, 87 Wickham Terrace  
Spring Hill Queensland 4000  
T 07 3839 1800 F 07 3839 1866



# Volume 3 of 7: Waukivory Pilot Project

3

## Review of Environmental Factors

October 2013

REF Chapters 5 to 14

**AGL Quick Reference Guide**

**Waukivory Pilot Project — Review of Environmental Factors**

**Volume 1 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

Executive Summary

**Volume 2 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

REF Chapters 1 to 4

**Volume 3 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

REF Chapters 5 to 14

**Volume 4 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix A

**Volume 5 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix B to G

**Volume 6 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix H to K

**Volume 7 of 7:**

**Waukivory Pilot Project — Review of Environmental Factors**

REF Appendix L to O

## 5 Impact assessment method

**Chapters 6 to 12 include an analysis of the impacts of the proposed activity on the environment, including cumulative impacts. In accordance with the ESG2 guidelines, the extent, size, scope, intensity and duration of each impact has been assessed to determine the extent. Impacts are categorised as negligible, low adverse, medium adverse, high adverse or positive. The extent and nature of the impact assists in determining whether or not significant impacts are likely.**

Chapters 6 to 12 include an analysis of the impacts of the proposed activity on the environment, including cumulative impacts, in accordance with section 111 of the EP&A Act, clause 228 of the EP&A Regulation and the ESG2 guidelines and the draft supplement. The extent, size, scope, intensity and duration of each impact has been assessed so that the responsible determining authority, in this case the DTIRIS-OCSG, can examine and take into account to the fullest extent possible, all matters affecting or likely to affect the environment by reason of the activity in determining the proposal. Impacts are categorised as negligible, low adverse, medium adverse, high adverse or positive. The extent and nature of the impact will assist in determining whether or not significant impacts are likely.

Table 5.1 describes the method for characterising the extent of negative impacts provided in the ESG2 guidelines (ie from low adverse to high adverse).

**Table 5.1 Guide to categorising the extent of impact**

<b>Analysis of impact</b>	<b>Low adverse</b>	<b>High adverse</b>
Size	Small scale size/volume	Large scale/volume
Scope	Localised	Extensive
Intensity	Small impact dispersed over a long period	Large impact over a short or long period
Duration	Short term	Long term
Level of confidence in predicting impacts	High confidence/knowledge and past experience	Low confidence, numerous uncertainties and unknowns
Level of reversibility of impacts	Impacts are reversible and rehabilitation likely to be successful	Reversibility impossible or unlikely due to cost or other factors
Ability to manage or mitigate impacts	Effective mitigation measures available	Mitigation measures untested or unavailable
Ability of the impacts to comply with standards, plans or policies	Total compliance	Uncertain or part compliance
Level of public interest	Low interest and predictable impacts on community	High interest and uncertain impacts on community
Requirement for further information on the impacts of the activity or mitigation	High level of understanding and information on the impact	Low level of information and understanding of key issues

Table 5.2 summarises the impacts of the proposed activity and the extent of such impacts. A more detailed summary of the impacts is presented in Table 13.1.

**Table 5.2**      **Summary of impacts**

<b>Impacts</b>	<b>Level of impact</b>
Physical and chemical	Negligible to low adverse
Biological	Negligible
Community	Negligible to low adverse (mostly low adverse)
Natural resource	Negligible to low adverse
Aboriginal heritage	Negligible
Historic cultural heritage	Low adverse
Cumulative	Negligible
Physical and chemical	Negligible to low adverse

## 6 Physical and chemical impacts

**Section 6 assesses the potential physical and chemical impacts of the proposed activity, taking into account the previous sections of the REF and supporting information in the management plans.**

### 6.1 Soil quality and land stability

Potential impacts from the proposed activity include the loss of soil or soil degradation from wind or water erosion during excavation and disturbance of soil for the installation of temporary gathering lines, water storages and the proposed water pipeline. Soil disturbance will mainly occur within the previously disturbed site at four wells (100 x 100 m), adjacent to existing vehicle access tracks and along the route of the water pipeline. One of the temporary gas/water pipeline options would involve a new area of soil disturbance between WK11 and a pipeline between WK12 and WK14 with an underbore connection. However, soil disturbance from this option would be reduced by using directional drilling to cross the Avon River. The area of disturbance at some wells may increase in dimension by 10 m from the installation of temporary water storage tanks. The area of disturbance remains within the 100 m x 100 m footprint previously assessed in the original REF (EMM 2011). Construction of the proposed water pipeline will involve trenching and installation of approximately 3.5km of pipeline from the Tiedmans property, along Fairbairns Road.

Much of the site where the proposed activity will occur has been previously cleared and used for grazing. There is no obvious evidence of contamination (eg illegally dumped waste, fuel containers). A search of orders issued by the EPA under the *Contaminated Land Management Act 1997* and actions taken under the *Environmentally Hazardous Chemicals Act 1985* revealed no orders or actions have been issued for the subject sites within the immediate vicinity (EMM 2011).

The proposed activity will occur near the Avon River and Waukivory Creek. Soils at the site are erodible, dispersible and subject to seasonal waterlogging. The areas of disturbance are relatively flat and would not be subject to high intensity runoff during a rain event. The land is not considered to be at increased risk of land instability.

A search of the Natural Resource Atlas revealed that the proposed activity is in an area with low probability of acid sulphate soils (ASS) (EMM 2011).

Groundwater in the shallow aquifer is moderately saline with salinity (EC) values between 2,000  $\mu\text{S}/\text{cm}$  and 7,500  $\mu\text{S}/\text{cm}$ . The watertable of the shallow aquifer is usually more than 2 m deep. Therefore, the land is not forecast to be at a risk to dryland salinity (Commonwealth of Australia 2001).

Given the low potential for land instability, contamination, ASS and dryland salinity together with the implementation of the measures outlined in Table 2.9 and the EMP, the impacts to soil quality and land stability are expected to be low adverse.

Furthermore, the proposed activity is unlikely to occur in an area with buried building foundations, sub-surface archaeological remains, on-ground scatters or features. Therefore, the impacts to such features are considered negligible.

## 6.2 Water bodies, watercourses, wetlands and natural drainage systems

### 6.2.1 Surface water bodies

There are two watercourses in the vicinity of the pilot wells as shown in Figure 2.1. The Avon River dissects the area of the wells, with WK11 on the western side of the river with WK12, WK13 and WK14 to the east. Waukivory Creek is a tributary of the Avon River which dissects WK13 and WK14. The confluence of Waukivory Creek and Avon River is south of WK11 and WK12.

One of the temporary water/gas gathering line options would involve crossing under the Avon River east of WK11. This would be done by directional drilling under the Avon River from a drill pad sited more than 40 m away from the river. Drilling fluid would be contained in a temporary storage tank or small lined pit followed by transportation for lawful disposal at an appropriate facility. There would be no disturbance of the bed or banks of the Avon River or the natural movement of water.

As discussed earlier, water required for the proposed activity will be sourced from either Pontilands dam or Tiedmans dam both properties owned by AGL. Should water be unavailable from these sources, it will be purchased on the open market. No water will be taken directly from the Avon River or Waukivory Creek. The well pads are more than 40 m away from the Avon River or Waukivory Creek and the proposed activity would not interfere with the natural movement of water, either in direction, flow or volume.

The proposed water management strategy at the Waukivory Pilot is to capture produced water in temporary above-ground storage tanks or the turkey's nest dam followed by transportation by road or water pipeline to the Tiedmans property for storage, blending and irrigation on the Tiedmans property in accordance with the existing approval granted by DTIRIS-OCSG in 2012 for an irrigation trial of produced water from gas exploration activities. Produced water will not be used for irrigation on the properties subject to the proposed activity.

The gas production wells will be perforated against deep coal seams, and the beneficial aquifers in the alluvium and shallow fractured rock are isolated. Consequently there is not expected to be any impact on shallow water resources including flows in the Avon River. Monitoring of groundwater levels and the inspection of stream flow will be carried out periodically to confirm any shallow water resource trends. Further monitoring details are provided in the SWGMP at Appendix D.

Measures will be implemented to reduce the potential for contamination of surface water bodies by chemical spills. These measures include procedures and installation of temporary bunding. A detailed description of mitigation measures are presented in Table 2.9 and in the EMP.

With the application of the measures in the EMP at Appendix E the potential impacts from the proposed activity on surface water bodies including water quality are considered to be low adverse.

### 6.2.2 Groundwater

The CoP - fracture stimulation activities requires a quantitative risk assessment of connectivity between coal seams and shallow aquifers, changes to groundwater pressure and levels, changes to surface water levels and changes to water quality. A full risk assessment has been carried out, and is attached in Appendix L.

This section takes into account the proposed fracture stimulation activity (including proposed mitigation measures), the existing groundwater resources and the FSMP risk assessment, and summarises the potential impacts from the proposed activity on groundwater. This section addresses the requirements of the ESG2 Guidelines and its draft supplement relevant to fracture stimulation and groundwater.



As outlined in Section 5.2.2, the beneficial aquifers at the area subject of the Waukivory Pilot are all shallow aquifers that occur either in the very shallow alluvial sediments or the shallow fractured bedrock. The bedrock contains mostly tight siltstone and indurated sandstone rock types with occasional thin semi-confined sedimentary/fractured aquifers (to around 75 m depth).

The target coal measures for gas exploration at the Waukivory Pilot are within the Permian Gloucester Coal Measures at depths ranging from approximately 300 m to 1,000 m from the surface. The formations to be targeted are the Leloma, Jilleon, Wenhams, Dogtrap Creek and Waukivory Creek Formations. These formations contain cemented sandstones, siltstones and claystones interbedded with the coal seams.

The formations to be targeted are low permeability formations and have an effective separation interval of over 200 m to the shallow beneficial aquifers. Therefore, the risk of fractures propagating from the targeted coal seams to the shallow beneficial aquifer zones is considered to be negligible.

Shallow aquifers are also protected by four barriers within the well construction: two steel and two cement barriers. The well construction design incorporates numerous contingencies to ensure zonal isolation between coal seams and other formations including aquifers. Water quality in the shallow aquifer will be protected during the proposed activity through the construction and design of the well, preventing any leakage of fluids.

Additionally, the potential for gas and fluid migration is unlikely. The CoP - well integrity has been adopted in the design of wells that will be hydraulically fracture stimulated. Wells will be completed with multiple casings (and pressure cemented in place) to ensure that aquifers remain isolated. Cement bond logs (CBL's) have been conducted on the wells currently proposed to be hydraulically fracture stimulated at the Waukivory Pilot. The CBLs confirm that cement quality and bond are acceptable for the hydraulic fracture stimulation of these wells. This also minimises the potential for the migration of fluids and gas.

To check the integrity of well construction and any potential impacts associated with targeted hydraulic fracture stimulation, a groundwater monitoring network (mostly in shallow aquifers) is established in proximity to selected gas wells to assess whether there are water level drawdown or water quality changes that would indicate connectivity. Monitoring details are provided in the SWGMP at Appendix D. In addition to the shallow groundwater monitoring network, AGL is in the process of establishing a geophone monitoring borehole (WKmb05) at the Waukivory Pilot to monitor the fracture geometry during the hydraulic fracture stimulation program. This borehole will be converted to a number of VWPs immediately after the hydraulic fracture stimulation program and prior to the flow testing program.

The fluid used during hydraulic fracture stimulation is recovered from the well through the flowback and dewatering processes. This is done by using a 'breaker' to react with the gel, breaking down its viscosity back to water so that the fluid's ability to flow is increased so it can be produced back to surface.

The flowback water is then captured into either the smaller compartment of the double-lined dual compartment turkeys nest dam or in temporary above-ground storage tanks at WK13 (and in tanks at WK11 under Option 2) and lawfully disposed of at an appropriate facility.

The targeted coal seams are interbedded with sandstones, siltstones and mudstones with similar lithologies above and below the target coal seams. These intervening strata are considerably tighter and harder than the target reservoir and should limit vertical fracture growth into these zones.

To identify faulted areas prior to drilling AGL conducted a 3D seismic survey to assist in well placement. This allowed AGL to place wells away from high angle vertical faults and only intersect low angle faults. The several large fault zones intersected by the Waukivory pilot wells have been confirmed by image logs acquired as part of the logging of the wells. These image logs allow accurate identification of the location of faults and their dip, therefore enabling AGL to manage any risks associated with the presence of these faults as follows:

- Target coal seams for fracture stimulation were selected away from these faults.
- As a further mitigation for minimising the potential for fracture stimulation treatments to migrate up faults, real-time pressure monitoring will occur throughout the program. This allows AGL and principal contractor engineers to assess whether the hydraulic fracture treatment is migrating up faults due to reduced treating pressure.
- This method will also be validated through the concurrent geophone monitoring program in the nearby geophone monitoring well. Stress generally increases with depth, leading to a preference for the fracture to propagate upwards rather than downwards. Monitoring the fracture geometry in real time allows adjustments to be made to the treatment to reduce the potential for vertical growth, and achieve a longer fracture within the coal seam.

After 4 to 16 weeks of flowback water, this water will transition to formation water (otherwise known as produced water), meaning that there is little or no remaining trace of fracturing fluids. Once this has been confirmed through testing, produced water will then be directed into separate temporary above-ground storage tanks or the turkey's nest dam at WK13 (and into separate tanks at WK11 under Option 2). Produced water will then be transported by truck or via the pipeline to the Tiedmans property for storage, blending with fresh water and then irrigation in accordance with the existing approval at the Tiedmans property.

No impacts to the water table in the shallow beneficial aquifers are anticipated during coal seam depressurisation/dewatering. The maximum volume of water extracted during the pilot testing program is expected to be 20 ML per annum. This water is expected to be mostly derived from storage within the targeted coal seams and slowly replaced by lateral water movement within the coal seams. This was the process that was demonstrated to apply in the gas wells flow tested as part of the nearby Stratford pilot testing program between 2006 and December 2009 (PB 2012).

Overall therefore, potential impacts to groundwater quality and the shallow beneficial aquifers are considered to be low adverse. Water levels will be monitored in the pilot test wells and continue to be monitored in the established monitoring network during and after hydraulic fracture stimulation, and during the pilot testing program.

## ii [Assessment against the minimal impact considerations for aquifer interference activities](#)

An aquifer impact assessment was undertaken against the minimal impact considerations for aquifer interference activities, in line with Table 1 of the NSW AIP. Alluvial, fractured and porous rock aquifers at the Waukivory Pilot were assessed. Predicted effects are less than the Level 1 minimal impact considerations for all beneficial aquifers, and across all categories (ie water table, water pressure and water quality). The full assessment is provided in Appendix H.

### iii Irrigation

Produced water will be transported to the Tiedmans property for storage and blended with fresh water prior to irrigation. No flowback water will be used either onsite or at the Tiedmans property for irrigation. Therefore, there is no potential for irrigation to influence water levels in the shallow alluvial aquifers in the area of the activity.

#### 6.2.3 Groundwater dependent ecosystems

The proposed activity would be undertaken in the fractured rock groundwater system of the Gloucester Basin. Groundwater resources in the area of the proposed activity are associated with the alluvial groundwater of the tributaries of the Avon River.

There are no known GDEs (apart from stream base flow accessions) in the vicinity of the Waukivory pilot wells and water pipeline. GDEs are unlikely to occur as Parsons Brinckerhoff (2012) noted, there are no known wetlands, lakes or other surface features that are indicative of shallow groundwater processes and GDEs and the brackish-saline nature of groundwater base flow in the vicinity is unlikely to be conducive to the sustenance of GDEs. A search of the GDE Atlas confirms this view (BoM 2013).

Measures will be implemented by AGL to minimise potential impacts to the upper alluvial and shallow fractured rock aquifers during the proposed activity including the appropriate management of fracture stimulation fluid to prevent contamination. These measures are outlined in the EMP at Appendix E. The site groundwater monitoring network will also be incorporated into the broader groundwater monitoring network and a groundwater management plan for PEL 285. The purpose of the monitoring network and management plan is to assess connectivity and ensure there are no adverse impacts on the groundwater aquifers in the northern part of the Gloucester Basin.

Therefore, the potential for impacts on any GDEs are considered to be negligible.

### 6.3 Coastal processes

The proposed activity is not on land along the coastline, beaches, coastal lakes, estuaries, tidal reaches of coastal rivers and low-lying land surrounding these areas.

Therefore, the potential impacts on any coastal processes are considered to be negligible.

### 6.4 Flooding

The subject lots are not within the flood planning area identified in the Gloucester LEP. However, AGL's consultation with nearby landholders has identified that some of the land within the subject lots is inundated during flood events.

The layout of the water management system (ie temporary secure water storage and temporary water gathering lines) has been designed in consideration of the potential for localised flooding within these lots.

Where possible, work sites have been situated above areas identified by landholders as being flood-prone. Environmental safeguards including the implementation of a flood management procedure in the event of flooding and monitoring of weather conditions to prevent impacts from flooding will be implemented during the proposed activity.

The temporary water storage facilities and temporary water gathering lines will be managed in accordance with the EMP (Appendix E), the environmental incident response plan (EIRP) (Appendix N) and the ERP (Appendix G). In particular water storage levels will be monitored (and kept to a minimum), with water management facilities being removed as soon as they are no longer required.

Further information on measures to deal with emergency and other unplanned discharges is provided in Section 6.5.3.

Therefore, following the implementation of mitigation measures, potential impacts from the activity resulting from flooding are considered to be low adverse.

## 6.5 Hazardous materials or chemical use

### 6.5.1 Human health and ecological risk assessment

An assessment of using chemical additives in fracturing fluids was undertaken by AGL (refer to the FSMP at Appendix B). Fracturing fluids are screened to identify chemical additives that are proposed to be used (refer to Appendix B).

Environmental Risk Sciences (ERS) was commissioned by AGL to conduct a human health and ecological risk assessment (HHERA) for hydraulic fracture stimulation. The HHERA analysed key risks associated with the proposed activity and these are outlined in the sections below.

#### i Vertical fractures

The potential for vertical fractures due to hydraulic fracture stimulation was analysed. Vertical fractures can lead to increased permeability or interconnectivity between target coal seams and upper aquifers and the upper aquifer could become contaminated. As there is more than 200 m of separation between the shallowest target coal seam and the deepest beneficial aquifer, the underlying low permeability formations geology create a hydraulic barrier between the target coal measures and the upper alluvial and naturally fractured rock aquifers. The fracture is designed to stay within the target zone and thus will not grow upwards this distance through the rock layers to the beneficial aquifer.

The well design is such that groundwater contained in the upper alluvial and shallow fractured rock aquifers would not be impacted by hydraulic fracture stimulation activities. These zones are cased and cemented off during the construction of the wells to ensure there is no groundwater contaminated by hydraulic fracture stimulation fluids.

#### ii Fracture fluid storage.

Storage and handling of hydraulic fracture stimulation fluids with potential to result in exposure by workers involved in fracture stimulation activities was also analysed. AGL occupational health and safety procedures are employed to manage and mitigate workplace exposure risks. As a result the risk of exposure of workers to chemicals is considered to be negligible.

Accidental spillage of hydraulic fracture stimulation fluids may result in exposures by workers and/or runoff to the adjacent environment. AGL operational procedures are in place to minimise the potential for these impacts to occur including;

- operations are in accordance with the AGL Dangerous Goods and Hazardous Materials Sub Plan;
- fluids are stored in bunded areas with onsite spill kits;

- all onsite personnel wear necessary personal protective equipment (PPE);
- well siting requirements ensures that fracture stimulation wells are not within 40 m of a creek;
- flowback water is stored within lined ponds or aboveground tanks that are not affected by rainfall (including flooding);
- a Soil and Water Management Plan is developed and implemented;
- an ERP is developed and implemented; and
- a Flood Management Plan is developed and implemented.

Based on the implementation of these risk management measures by AGL, accidental spills and release of chemicals is considered to be a negligible risk.

### iii Additives

A full list of the potential additives including concentrations and indicative volumes, are included in the HHERA (Appendix M). The volumes of each fluid are indicative only and actual volumes cannot be determined until fracture treatment occurs. Monitoring of the fracture growth using a variety of diagnostic tools occurs during the fracture stimulation. This provides a better understanding of the fracture geometry and allows fine-tuning of the fracture design. In addition, as this is an exploration project, information will be gained from the initial treatments, which will enhance design of subsequent treatments.

The risk assessment of these chemicals indicated that most of the chemicals used in hydraulic fracture stimulation are associated with negligible to low hazards to human health and the environment. A small number of chemicals (sodium hypochlorite, sodium hydroxide monoethanolamine borate, hydrochloric acid, tetrakis (hydroxymethyl) phosphonium sulfate, and choline chloride) may present a risk to human health and the environment should they be released directly to an environment where exposure may occur. However the likelihood that any of these chemicals will be discharged into an environment where any level of exposure may occur has been evaluated as highly unlikely (no exposure pathway is present) or unlikely (in relation to the potential for accidental spills or releases of chemicals in fluids or flowback water).

### iv Summary

Risks to human health and the environment are considered to be negligible to low adverse and can be adequately managed through the implementation of existing operational management measures. This is currently conducted as outlined in the FSMP and associated management plans. The identified level of risk is supported by review of former operations where controls have been implemented to ensure that should a spillage occur it would be minor in nature.

The fracture stimulation contractor will transport all chemicals to the well site in a specifically designed chemical trailer. The trailer has a containment area underneath to catch any spills in the unlikely event that spills will occur in transportation. Chemicals will remain stored on the trailer until use. Any areas beneath equipment where chemicals are transferred will have spill mats. A vacuum truck will be onsite during fracture stimulation operations for quick response in case of any spills.

As a further safety measure AGL will also ensure:

- that a vacuum truck is present onsite at all times during fracture stimulation activities to deal with any spills;
- a spare water storage tank is present onsite and available to receive flowback/produced water should a leak to another tank occur; and
- the area to be used for the storage of chemicals will be fully bunded to prevent any leaks beyond this area.

### 6.5.2 Potential groundwater impacts

The well design is such that groundwater contained in the alluvial and shallow fractured rock aquifers would not be impacted by hydraulic fracture stimulation activities. These zones are cased with steel pipe and pressure cemented off during the construction of the wells to ensure there is no groundwater contaminated by hydraulic fracture stimulation fluids.

Based on the available information and well design there are no pathways by which fracturing fluids injected into the well can migrate to any freshwater body that may be of importance with respect to future beneficial uses of aquifers or the discharge of water into aquatic environments. Hence there is no specific requirement identified for the detailed assessment of chemical recovery in flowback water. However, good environmental practice in gas operations requires a suitable approach to demonstrate chemical recovery in flowback water. Flowback water quality will be tested to determine the transition from flowback water to produced water. Further detail is available in the Water Management Plan for the Tiedmans Irrigation Program – Gloucester (dated 14 May 2012) approved by DTIRIS-DRE in 2012.

The potential interaction of the fluids with deep groundwater during the fracture stimulation process was analysed. In particular, the additives used in the hydraulic fracture stimulation fluid may enter the coal seam water bearing zones affecting the quality of this deep groundwater. However, this stratum contains groundwater that is too low in yield and too high in salinity to be considered a beneficial aquifer. Additionally, the fluids will be recovered from the well through the flowback and dewatering processes.

Potential leaching of fluids from the surface into the shallow groundwater aquifer was analysed. Fluids used in the hydraulic fracture stimulation process are pumped out of the wells into lined and secure water storages. Appropriate measures will be implemented to ensure there is no leakage from these secure water storages and any contaminated water is lawfully disposed of at an appropriate facility. Appropriate controls would also be put in place at the surface as described in Table 2.9. Full details of the measures storage and disposal of these fluids are contained in the FSMP (Appendix B).

It is possible that increased permeability may be experienced within the deep coal seam zones following hydraulic fracture stimulation of the target coal seams. As these seams are dewatered, there is potential for lowering of hydrostatic pressure and water levels in the deep coal seams. However, these are not beneficial use aquifers as noted above.

Therefore, impacts to the environment from hazardous materials and chemicals are considered to be low adverse.

### 6.5.3 Emergency and other unplanned discharge

Direct disposal of either flowback or produced water to ground is not proposed and would only occur if there was accidental spillage or discharge.

Water pipelines will be hydraulically pressure tested to identify any leaks requiring repair prior to operation.

Based on consultation with landholders, some land within the subject lots is potentially subject to localised flooding. As stated in Section 6.4, the layout of the water management system and water staging point has been designed in consideration of the potential for localised flooding in the area. WK13 is the preferred location of the water staging point.

Minor spillages of flowback and produced water could occur if tanks, temporary storages and pipelines were damaged during a flood event. In the event of an impending flood, the pilot testing well would be shut down if it was considered a risk to surface infrastructure (ie it was likely to be damaged or breached). Although considered extremely unlikely, the consequences of an unplanned water release during a flood event are considered minimal because the volume of water stored at each site would be low and the dilution effect of the floodwaters would negate any risks to downstream water users or environment.

Table 2.9 outlines some of the contingency plans that would be adopted in the event of an emergency or unplanned discharge. Any emergency and other unplanned discharges will be managed in accordance with the ERP (Appendix G), EIRP (Appendix N) and the EMP (Appendix E).

In consideration of the above, impacts to the environment from emergency and other unplanned discharge is considered to be low adverse.

## 6.6 Disposal of waste and emissions

### 6.6.1 Flowback water

The flowback water is captured into open tanks at each well and then piped via buried gathering lines to either the double-lined dual compartment turkeys nest dam or into temporary above ground water storage at WK13 (and into tanks at WK11 under Option 2). Flowback water would be trucked from WK13 (and WK11 under Option 2) and lawfully disposed of at an appropriate facility.

Produced water is natural groundwater suitable for re-use (once salinity aspects are addressed through blending). Produced water will be transported to the Tiedmans property by either trucks or water pipeline, provided the irrigation water achieves prescribed water quality criteria as outlined in the existing approval granted by DTIRIS-OCSG in 2012 for the trial irrigation of produced water from gas exploration. On the Tiedmans property, in accordance with the existing approval for this activity, produced water will be blended (ie mixed) with fresh water to achieve water quality parameters (ANZECC 2000) suitable for irrigation application to land for agricultural purposes. The application to land of produced water following blending would be in accordance with ANZECC guidelines (ANZECC 2000) and the CoP - CSG extraction (NSW Government 2012b). As such, the activity would not have a long-term impact and is not expected to cause significant impacts to water quality, or cause economic, health, ecosystem or amenity impacts.

Therefore, impacts to the receiving environment from flowback water are deemed to be low adverse.

## 6.7 Emissions

### 6.7.1 Background

There are two possible flaring scenarios for the pilot testing program, with the final option being dependent upon operational needs and requirements to construct an underbore. Both scenarios were evaluated by the air quality and greenhouse gas (GHG) assessment.

In Option 1 (as outlined in Chapter 2), gas from WK11, WK12, WK13 and WK14 will be directed to a flare at WK12. In this option an additional contingency flare may be installed at WK12 should the telemetry identify higher than expected gas flows (refer to Section 2.7.7viii). In Option 2, there are two operating flares, one each at WK11 and WK12.

Overall, air emissions following hydraulic fracture stimulation are expected to be very minimal. Pilot testing will result in emissions associated with the gas management, including flaring and venting. Flaring is used to dispose of low-volume emissions during pilot testing and is a high temperature oxidation process which burns combustible components, mostly hydrocarbons from the gas extracted.

The venting of gas will be minimised where possible. Venting is associated with emissions of GHG, principally methane (CH<sub>4</sub>). Flaring will emit quantities of criteria air pollutants, principally nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO) and volatile organic compounds (VOCs).

Flare systems comprise the following components:

- gas collection header and piping for collection gases;
- a knockout drum (disentrainment drum) to remove and store condensables and entrained liquids;
- a proprietary seal, water seal or purge gas supply to prevent flash-back;
- a burner unit and flare stack;
- gas pilots and an ignitor; and
- a provision for external momentum force (steam injection or forced air) for smokeless flaring.

Complete combustion requires sufficient combustion air and proper mixing of air and waste gas. Smoking is not expected to be an issue that results from combustion, based on the clean gas components (ie methane).

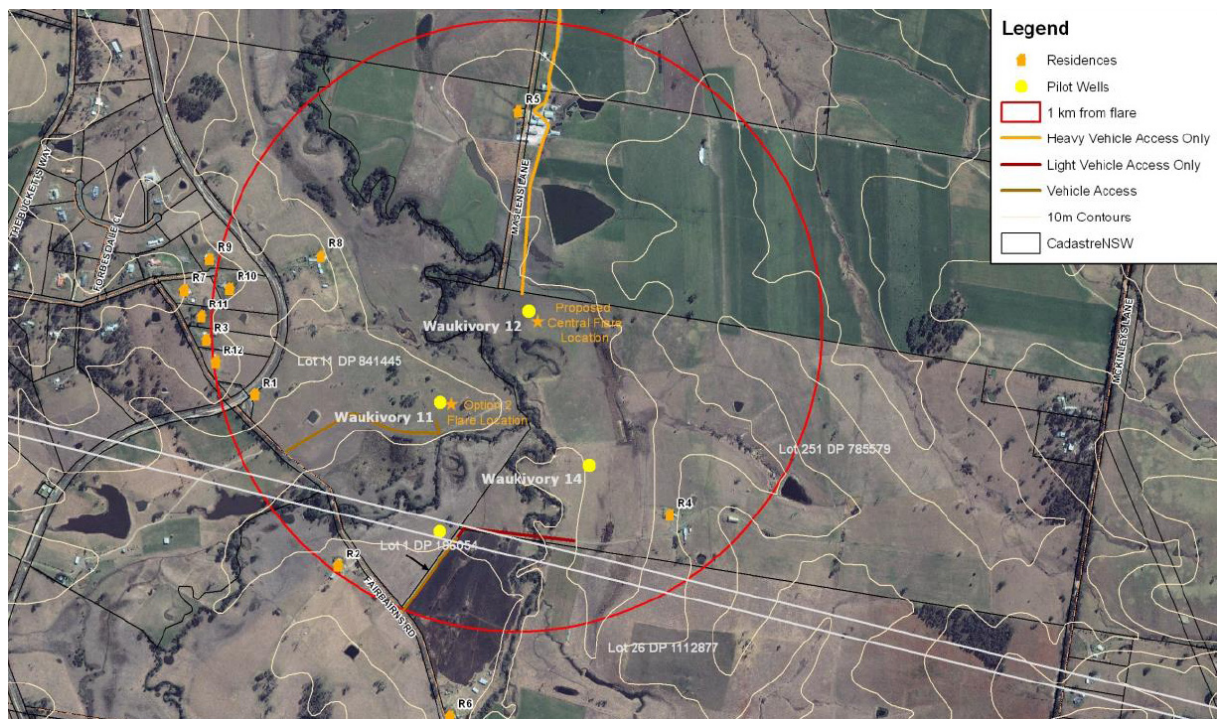
An enclosed flare will be utilised to burn all produced gas during the production test. The enclosed flare is designed to eliminate the visual impact and reduce noise impact of the burning of the gas and the turn down ratio of the flare is effective to burn low quantities of gas during the initial phases of the production test up to larger flows of gas as the well dewateres and gas production increases.



## 6.7.2 Assessment

An air quality and GHG assessment was undertaken by Pacific Environment Limited (Appendix C) in 2013 to assess the potential air quality impacts from the proposed gas extraction and flaring and to assess the potential GHG emissions, putting them in context in terms of national and NSW emissions. This assessment was undertaken in accordance with the *Approved Methods for Modelling and Assessment of Air Pollutants in NSW* (EPA, NSW 2005), *Protection of the Environment Operations (Clean Air) Regulation 2010* and the *DCCEE National Greenhouse Accounts Factors 2012* and also considered the ESG2 draft supplement for petroleum prospecting.

The assessment identified the closest sensitive receivers (ie residences) to the proposed activities and these are shown in Figure 6.1. All identified receivers are over 500 m from the proposed flare at WK12 (and WK11 under Option 2).



**Figure 6.1** Closest residences to the pilot well flare site

The closest EPA air quality monitoring sites to the proposed activities are Wallsend, Newcastle, Beresfield, Muswellbrook and Singleton. NO<sub>2</sub> and CO data have been collated from the EPA's database to determine current ambient concentrations of these parameters. The assessment used climatic information collected from Chichester Dam Automatic Weather Station (AWS) (approximately 38 km from the site) and Taree Airport AWS (approximately 52.3 km from the site) to determine the prevailing meteorology.

The atmospheric dispersion modelling used for this assessment was based on the CALPUFF modelling which is being done as part of AGL's application to undertake pilot testing at Windermere in the Hunter Valley and is presented in the Windermere gas pilot well air quality and greenhouse gas investigations (hereafter Windermere report - Pacific Environment 2013). (Note however that the application to undertake pilot testing at Windermere in the Hunter Valley has not been lodged, due to uncertainty over current government policy).

A qualitative assessment of the factors affecting dispersion was undertaken to compare Windermere with the Waukivory Pilot. Given the analysis showed similarities in the local terrain and meteorology between the two sites, it was considered that the modelling predictions generated within the Windermere report would be similar in concentration and extent as those expected from the operation of flares at the four Waukivory pilot wells. Some ten sensitive receptors were analysed in the Windermere report with the closest (AGL's site office – R9) being around 150 m from the central flare.

A summary of the dispersion modelling results for the operation of the central flare evaluated within the Windermere report is provided as follows:

- the predicted 1-hour and annual average NO<sub>2</sub> concentrations are well below the NO<sub>2</sub> criteria at all selected receptor locations;
- the maximum predicted 1-hour and 8-hour concentrations of CO represent only a small fraction of the relevant air quality criteria;
- there are no impact assessment criteria specified for total VOCs, however results for total VOCs can be compared to the 1-hour impact assessment criteria for individual hydrocarbons that may be present in the extracted gas;

For example, comparing the total VOC concentration to impact assessment criterion of 30 mg/m<sup>3</sup> for n-pentane, indicates that compliance is easily achieved, assuming that all VOCs are comprised of this parameter. To further contextualise, even when the total VOC concentration is compared to impact assessment criteria for principal toxic air pollutants such as benzene (0.029 mg/m<sup>3</sup>) compliance is also achieved, except at a sensitive receptor (R9 of the Windermere report – 0.046 mg/m<sup>3</sup>). It is noted that benzene is unlikely to be present and if it was would make up only a very small percentage of the total VOCs, as opposed to 100% as presented in this example; and

- a Level 1 cumulative assessment (as defined in NSW DEC, 2005) uses the maximum measured background concentration added to the 100th percentile dispersion modelling prediction to obtain a worst case total potential impact. Even using this worst-case approach, cumulative impacts would still be well below the relevant impact assessment criteria for all pollutants and averaging periods.

The modelling predictions generated from flaring the gas from the three proposed Windermere pilot wells are anticipated to be similar in concentration and extent as those expected from the four wells at the Waukivory Pilot. However, for conservatism, the maximum ground level concentrations at receptors for the Waukivory Pilot flare(s) has been estimated on the basis that four wells will be tested, whereas the assessment for proposed pilot testing at Windermere was calculated for three wells. The maximum (reasonable worst-case) ground level concentrations at receptors at the Waukivory Pilot adopting a 4:3 ratio of the results predicted for the proposed flaring at Windermere – would still not approach EPA air quality criteria, particularly given the larger distances from the proposed flares to identified sensitive receivers

Considering the modelling predictions, adverse air quality effects are not expected during gas flow testing. In addition, the EMP at Appendix E includes measures to minimise the generation and disposal of gaseous wastes and greenhouse gas emissions.

The activity is not expected to affect air quality, or have economic, health, ecosystem or amenity impacts. The activity is not expected to have a long-term impact as low emissions are expected with a minor amount of pollutants expected to escape to atmosphere. For these reasons, impacts to the receiving environment from emissions are considered to be low adverse.

### 6.7.3 Greenhouse gas assessment

An estimate has been made of the GHG emissions associated with the operation of either the flare at WK12 (Option 1) or the two flares at WK11 and WK12 (Option 2). It is noted that the GHG emissions have been estimated the same regardless of the option selected. Estimates have been compared with the estimated GHG emissions if this gas were to be vented direct to the atmosphere. GHG emissions have been estimated based upon the methods outlined in the DCCEE *National Greenhouse Accounts (NGA) Factors 2012* (DCCEE 2012).

The gas flow rate at the Waukivory Pilot is expected to be approximately 983 L/s for the operation of four wells. The gas content is assumed to be approximately 98% methane and 2% CO<sub>2</sub> based on test well measurements, which is considered conservative.

The estimated GHG emissions (t CO<sub>2</sub>-e / annum) are presented in Table 6.1. The flaring of extraction gas compared to direct gas venting is estimated to result in a reduction of approximately 1,307.1 kt CO<sub>2</sub>-e/annum. The GHG emissions from gas flaring for the life of the project (anticipated to be approximately 18 months) are estimated to be 93.5 kt CO<sub>2</sub>-e.

**Table 6.1** Calculated estimation of GHG emission

Items	tonnes CO <sub>2</sub> -e/annum – gas venting	tonnes CO <sub>2</sub> -e/annum - flare	GHG reduction of flaring over venting
Central flare	1,369,432	62,304	1,307,128

Based on the above estimates, the annual GHG emissions associated with flaring at the central flare would represent a one-off increase of 0.011% on Australia’s national GHG emissions in 2012 of 546.1 Mt CO<sub>2</sub>-e (DCCEE 2013).

The annual greenhouse emissions for NSW in 2009/10 were 157.4 Mt (DCCEE 2012a). The additional Scope 1 emissions from the program represent an approximate increase of 0.040% of the NSW 2009/10 total.

In summary, GHG emissions from flaring at the central flare/s were calculated to represent 0.011% of Australia’s national GHG emissions for the baseline year 2012. Accordingly, emissions are minor when compared to national and NSW annual GHG emissions and impacts resulting from emissions are expected to be negligible. The act of flaring emissions as opposed to venting them directly is highlighted as good practice in terms of carbon management. This is due to the relative potency of methane as a greenhouse gas.

It is noted that GHG emissions from all AGL exploration projects are accounted for under the National Greenhouse Gas and Energy reporting guidelines and reported on an annual basis in accordance with its obligations under the *Clean Energy Act 2011*.

#### 6.7.4 Fugitive emissions

The principle types of fugitive emissions in gas activities relate to vented emissions, leakages and the flaring of gas. The impacts from venting, flaring and leakage during the project have been assessed and are discussed in the air quality and GHG assessment, undertaken by Pacific Environment Limited in 2013 (Appendix C). The assessment concluded that due to well design and construction procedures any fugitive gas emissions are likely to be minimal, of short duration and localised.

A fugitive methane monitoring program both prior to and during the pilot testing process will be undertaken. A similar fugitive methane monitoring program for the Camden Gas Project, has been evaluated by the NSW EPA, the NSW Office of the Chief Scientist and Engineer, and the Department of Planning and Infrastructure.

#### 6.7.5 Dust and odour

The main source of potential dust issues are likely to come from construction works. These works would include the modification of existing drill pads and include some earthworks for the development of double-lined dual compartment turkeys nest dam and gathering lines. A source of dust emissions during construction works is likely to come from vehicle and equipment movements along access tracks. Access tracks have been upgraded with compacted gravel and dust generation is expected to be minor and similar to existing farm use. There are a number of water cart movements required over a relatively short period of time which may have some additional dust impacts.

With the application of the measures in the EMP at Appendix E the potential impacts from dust emissions are considered to be low adverse. Measures include dust control, limiting vehicle speed and rehabilitation.

Natural gas is odourless. The proposed activity does not involve the addition of odorant, which is generally added in the treatment process for sales gas production for detection and safety purposes. The potential impacts resulting from odours are expected to be negligible.

### 6.8 Noise, and vibration

An environmental noise assessment was undertaken in the original REF (EMM 2011) for the proposed activities including drilling and fracture stimulation, flaring and predicted traffic noise. Additionally, construction of the proposed water pipeline has also been considered in this assessment.

A copy of the noise assessment is contained in Appendix O.

#### 6.8.1 Assessment criteria

##### i Construction activities

The proposed activity was assessed according to *Interim Construction Noise Guidelines* (ICNG) (DECCW 2009) which provides guidelines for the assessment and management of noise from construction works. The INCG recommended approach is a quantitative assessment, a more complex approach than qualitative assessment, as the duration of the proposed exploration wells is greater than three weeks.

The ICNG recommends the following time restrictions for construction activities where resultant noise levels are audible at residential premises:

- Monday to Friday 7 am - 6 pm;

- Saturday 8 am - 1 pm; and
- no construction work to take place on Sundays or public holidays.

The ICNG noise level goals for activities during the above hours are 10 dB above the existing background levels (or RBL). For activities outside of the above hours the noise levels should be no more than 5dB above the existing background levels.

Prior to the drilling of the wells in 2012, background noise monitoring was undertaken to verify the existing noise levels in the area. The monitoring was undertaken at representative sensitive receiver locations surrounding the proposed activity (refer to Table 6.5). At each monitoring location, the existing noise levels were measured at below 30 dB(A). This monitoring confirmed conservative noise assessment approach of setting a background noise level characteristic of rural environments of 30 dB(A), which is consistent with the *Industrial Noise Policy* (DECCW 2000). The residential construction noise criteria for the proposal are provided in Table 6.2.

**Table 6.2 Residential construction noise criteria**

Location	LAeq, 15min noise criterion, dB(A)
Locations of residences	40 (ie background plus 10dB - during recommended hours) 35 (ie background plus 5dB - out of hours)

Table 6.3 is an extract from the ICNG, providing guidance for residential receivers only.

**Table 6.3 ICNG residential criteria**

Time of day	Management level (LAeq(15min))	How to apply
Recommended standard hours for noise generating activities: Monday to Friday (7.00am – 6.00pm), Saturday (8.00am – 1.00pm) and no work on Sundays or public holidays.	Noise affected RBL + 10 dB	<p>The noise affected level represents the point above which there may be some community reaction to noise:</p> <ul style="list-style-type: none"> <li>• Where the predicted or measured LAeq (15min) is greater than the noise affected level, the proponent should apply all feasible and reasonable work practices to meet the noise affected level.</li> <li>• The proponent should also inform all potentially impacted residents of the nature of works to be carried out, the expected noise levels and duration, as well as contact details.</li> </ul>

**Table 6.3 ICNG residential criteria**

<b>Time of day</b>	<b>Management level (LAeq(15min))</b>	<b>How to apply</b>
	Highly noise affected 75 dB(A)	<p>The highly noise affected level represents the point above which there may be strong community reaction to noise:</p> <ul style="list-style-type: none"> <li>• Where the noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account: <ul style="list-style-type: none"> <li>(i) times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences)</li> <li>(ii) if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times.</li> </ul> </li> </ul>
Outside recommended standard hours	Noise affected RBL + 5 dB	<ul style="list-style-type: none"> <li>• A strong justification would be required for works outside the recommended standard hours.</li> <li>• The proponent should apply all feasible and reasonable work practices to meet the noise affected level.</li> <li>• Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.</li> </ul>

**ii Operational activities**

Once the wells are established and water management infrastructure constructed, the wells will extract gas and flare. Flaring of gas will constitute the noisiest aspect of the operational phase of the proposed activity. The noise from flaring will be assessed against the NSW Industrial Noise Policy (INP).

The INP describes two separate criteria; intrusive and amenity criteria, which need to be satisfied. However, the more limiting of the two becomes the project specific noise criteria or operational criteria for the proposed activity. In this case, the intrusive criteria are the more limiting of the two and are equivalent to those shown in Table 6.2. Further detail on criteria is provided in Appendix O.

### iii Traffic

Potential noise impacts resulting from expected increases in traffic were assessed using the *Environmental Criteria for Road Traffic Noise* (DECCW 1999). To determine suitable traffic noise criteria for a particular project, the road or roads must be categorised with respect to the *Environmental Criteria for Road Traffic Noise* (ECRTN) definitions. The current project would potentially create additional traffic on existing collector (Bucketts Way) and local roads. The traffic noise criteria adopted for the proposed activities is provided in Table 6.4.

**Table 6.4 OEH environmental criteria for road traffic noise**

Type of development	Criteria		Where criteria are already exceeded
	Day (7 am–10 pm), dB(A)	Night (10 pm–7 am), dB(A)	
Land use developments with potential to create additional traffic on collector road	60Leq,15hr	55 Leq,9hr	Where feasible, existing noise levels should be mitigated to meet the noise criteria. Examples of applicable strategies include appropriate location of private access tracks; regulating times of use; using clustering; using ‘quiet’ vehicles; and using barriers and acoustic treatments. In all cases, traffic arising from the development should not lead to an increase in existing noise levels of more than 2 dB.
Land use developments with potential to create additional traffic on local roads	55 Leq,1hr	50 Leq,1hr	

Proposed sleep disturbance criteria for the proposed activities was adopted using the ECRTN. The proposed night time criterion for the representative locations adopted in the assessment is 45 dB(A) Lmax, for intermittent type of events from the proposed works.

## 6.8.2 Assessment

### i Noise assessment locations

The closest and potentially the most exposed noise sensitive receivers to the wells and the water pipeline construction are residences as listed in Table 6.5.

**Table 6.5 Noise sensitive receivers**

Location	Address
1	20 Grantham Road, Forbesdale, NSW 2422
2	Intersection of Fairbairns Road and North Coast railway
3	176 Fairbairns Road, Forbesdale, NSW 2422 (fracture stimulation and water pipeline construction)
4 <sup>1</sup>	237 Fairbairns Road, Forbesdale, NSW 2422 (fracture stimulation and water pipeline construction)
5	197 Fairbairns Road, Forbesdale, NSW 2422
6	114 Maslens Lane, Gloucester, NSW 2422
7	304 Fairbairns Road, Forbesdale, NSW 2422 (water pipeline construction only)
8	305 Fairbairns Road, Forbesdale, NSW 2422 (water pipeline construction only)
9	Lot 881 Fairbairns Road, Forbesdale, NSW 2422 (water pipeline construction only)
10	384 Fairbairns Road, Forbesdale, NSW 2422 (water pipeline construction only)

Notes 1. This property is owned by a neighbouring mining company.

## ii Water transfer pipeline trenching/installation

The proposed activity will involve trenching and installation of approximately 3.5 km of water pipeline from Tiedmans Road, along Fairbairns Road. Trenching would be undertaken during the daytime shift only.

Works associated with trenching will take approximately 14 days to complete. Noise levels resulting from the pipeline installation were modelled (unmitigated and mitigated) at the residential assessment locations identified in Table 6.5 and shown in Figure 6.2.

The results show that predicted daytime trenching noise would not meet criteria at all assessment as works pass the near point of residences. However, predicted noise levels are below the OEH highly affected level of 75 dB(A). It is anticipated that the 40 dB(A)  $L_{eq}$  criteria would be met at a distance of 900m from trenching works. Therefore, given the anticipated trenching duration of 14 days, each receiver would be exposed to noise above the criteria for approximately four days in total. Notwithstanding, the noise levels presented in Table 6.6 are maximum levels (at constructions closest point to each receiver) and it is anticipated that each receiver would experience levels of this amplitude for no more than one day throughout the period of the work.

**Table 6.6 Water transfer pipeline trenching/installation noise levels**

Receiver	Predicted Leq Noise levels for water pipeline trenching	$L_{eq}$ Noise criteria, dB(A) Day
3	52	40
4 <sup>1</sup>	71	40
7	52	40
8	59	40
9	58	40
10	58	40

Notes 1. This property is owned by a neighbouring mining company.

With the implementation of recommended mitigation measures (outlined in Table 2.9) the potential impacts of noise on sensitive receivers from trenching and pipeline construction activities are considered to be low adverse. Notwithstanding, noise management measures are recommended to be adopted during trenching, especially when in close proximity to receivers. The noise management measures are presented in Table 2.9.

## iii Fracture stimulation activities

The proposed activity will involve perforating and hydraulically fracturing selected coal seams (ie fracture stimulation). Fracture stimulation uses the hydraulic pressure of fluid pumped into gas wells to open coal seams and help increase gas flow to surface. Fracture stimulation would be undertaken during the daytime with noise generating activities being carried out in standard construction hours.

Importantly, works associated with fracture stimulation will generally occur over 5 to 7 days at each well during the daytime period only. Predicted noise levels resulting from fractures stimulation activities were modelled unmitigated and with mitigation methods applied at identified residential assessment locations and are presented in Table 6.7.



**Table 6.7 Predicted fracture stimulation noise levels**

	Receiver						Leq noise level criteria, dB(A)	
	1	2	3	4 <sup>1</sup>	5*	6	Daytime	Out of hours
<b>Fracture stimulation activities (Unmitigated)</b>								
WK11	62	62	62	58	58	52	40	35
WK12	60	57	57	56	61	63	40	35
WK13	58	60	69	66	62	54	40	35
WK14	56	56	59	60	68	57	40	35
<b>Fracture stimulation activities (Mitigated - Barrier)</b>								
WK11	52	52	52	48	48	42	40	N/A
WK12	50	47	47	46	51	53	40	N/A
WK13	48	50	59	56	52	44	40	N/A
WK14	46	46	49	50	58	47	40	N/A

Notes: 1. This property is owned by a neighbouring mining company.

With respect to predicted fracture stimulation noise, all daytime noise levels are well below the ICNG’s 75 dB(A) ‘highly affected’ level (refer to Table 6.3). Other findings include the following:

- without mitigation, the results show that predicted daytime fracture stimulation noise would not meet criteria at all assessment locations for any wells. However, predicted noise levels are below the OEH highly affected level of 75 dB(A); and
- with noise barriers in place, fracture stimulation noise levels as received at the assessment locations are significantly reduced. However, they remain above recommended daytime criteria for the six noise sensitive receivers. Given that this activity is not expected to exceed maximum of 12 weeks (5 to 7 days per well) during the daytime period only, impacts are considered manageable through the community consultation notification process, as identified in the ICNG (see Table 6.3).

Therefore, the potential impacts of noise on sensitive receivers from fracture stimulation activities are considered to be low adverse.

#### iv Pilot testing

Once fracture stimulation activities have finished, wells will be completed, wellhead surface equipment will be installed and pilot testing for gas flow will commence. During pilot testing, gas is brought to the surface via the well and sent to an enclosed flare where the gas is burned off.

Two standard shipping containers would be used to enclose the flare and reduce noise emissions by at least 5 dB. Predicted noise levels were modelled for the combined noise level of all four wells flaring simultaneously, as a worst-case scenario, and are provided in Table 6.8. The results show that the predicted noise from flaring satisfies noise criteria at all receivers and hence no noise impacts from flaring are expected.

**Table 6.8 Predicted pilot testing noise levels**

Receiver	Predicted Leq Noise levels for all four wells combined	L <sub>eq</sub> noise criteria, dB(A) Day/evening/night
1	21	35
2	20	35
3	27	35
4 <sup>1</sup>	23	35
5	25	35
6	20	35

Notes: 1. This property is owned by a neighbouring mining company.

The predicted operational noise levels, Leq, from all wells combined, and dB(A), are shown on Figure 6.2.

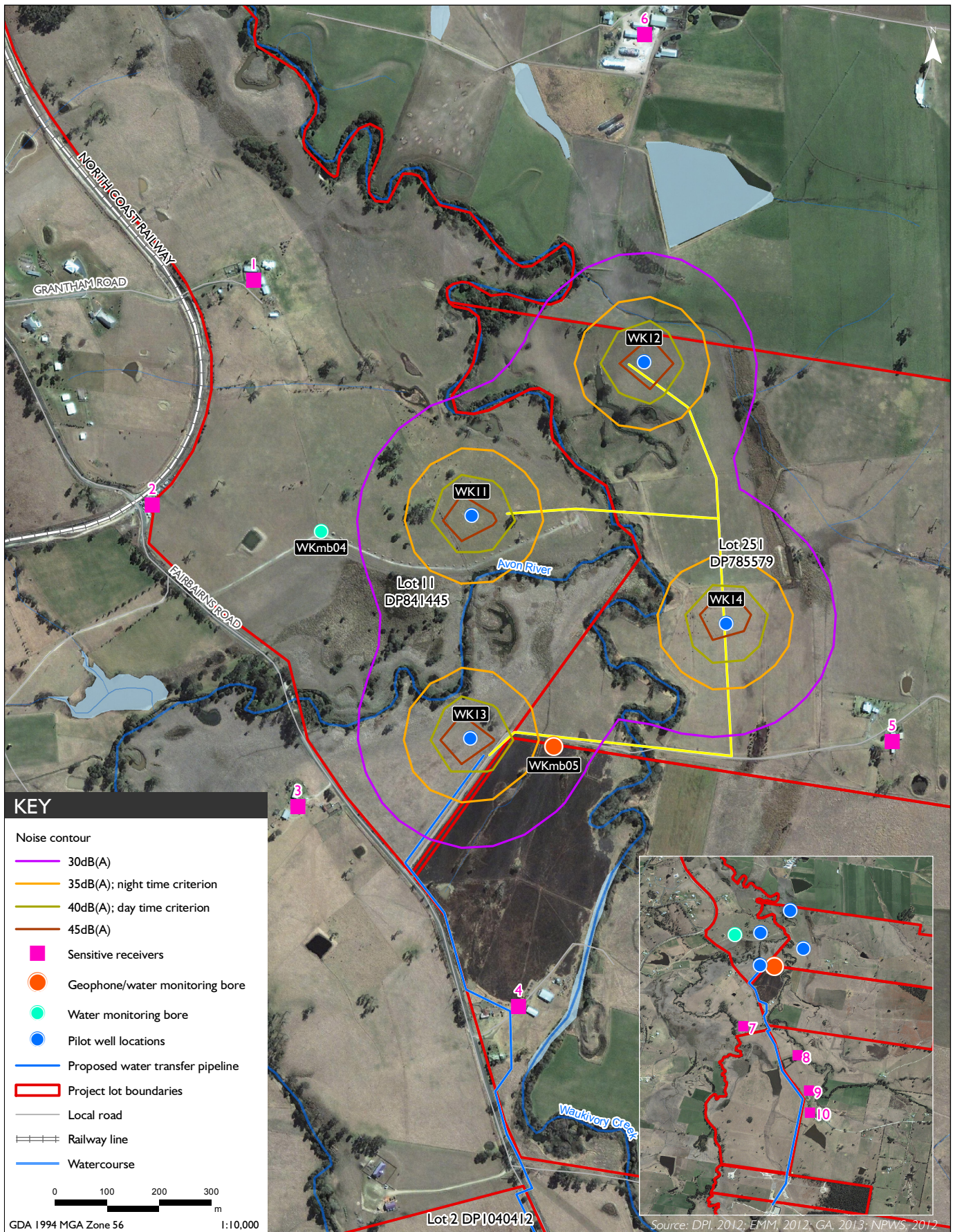
Therefore, the potential impacts of noise on sensitive receivers from pilot testing are considered to be negligible.

#### v Sleep disturbance

Due to the proximity of sensitive receivers to the wells, it is likely that any out of hours activities conducted without noise attenuation would result in exceedance of the sleep disturbance criterion (45 dB(A)) at a sensitive receiver. This is based on hammering, using hand tools, metal to metal contact having a usual source sound power (emission) level of 115 dB(A).

Pilot testing and flowback will occur 24 hours a day, seven days a week. Standard work hours for all other noise generating activities would be Monday to Friday, 7:00 am to 6:00 pm and Saturday 8:00 am to 1:00 pm, with no work on Sundays or public holidays. Noise emitted from out of hours activities will be controlled and managed by appropriate measures outlined in the EMP at Appendix E.

Therefore, the potential impacts of out of hours work on sensitive receivers are considered to be low adverse.



Sensitive receivers and pilot testing noise levels  
 Review of Environmental Factors  
 Waukivory Pilot Project  
 Figure 6.2

The calculation and prediction of road traffic noise adopts a standards-based approach to modelling, in that noise propagation calculations are carried out in accordance with accepted standards used in various countries. The adopted algorithm is the United Kingdom Calculation of Road Traffic Noise method.

The expected traffic generation for the project is two to three movements on average per hour with a maximum of about five. The average movements per hour include consideration of fracture stimulation equipment trucks which usually arrive in a convoy of up to 10 vehicles at the same time. This may happen up to once a week. Trucks for the disposal of flowback water will be dispersed over the pilot testing project, potentially being around 240 truck movements over the course of the flowback period of around 16 weeks. Flowback water will be taken to an appropriate facility for lawful disposal.

Based on these movements and an assumed average pass-by traffic speed of 50 km/hr, predicted noise levels for site related traffic at nominal setback distances are summarised against criteria in Table 6.9 and show no exceedances.

**Table 6.9 Predicted traffic noise levels**

Set Back Distance (m)	Bucketts Way				Local roads			
	Day Leq,15hr, dB(A)		Night Leq,9hr, dB(A)		Day Leq,1hr, dB(A)		Night Leq,1hr, dB(A)	
	Existing	Inc. proposed activities	Existing	Inc. proposed activities	Existing (negligible)	Inc. proposed activities	Existing (negligible)	Inc. proposed activities
20	59	59	54	54	39	52	36	50
40	56	56	51	51	36	48	33	47
60	54	54	49	49	33	46	30	45
80	52	52	47	47	32	45	29	43
100	51	51	46	46	31	44	28	42
150	49	49	44	44	29	41	26	40
<b>Criteria</b>	<b>60</b>	<b>60</b>	<b>55</b>	<b>55</b>	<b>55</b>	<b>55</b>	<b>50</b>	<b>50</b>

Therefore, the potential impact of traffic noise on sensitive receivers is considered to be negligible.

## 7 Biological impacts

An ecological assessment of the proposed exploration wells and supporting infrastructure was conducted by Alison Hunt and Associates (2010) for the original REF (EMM 2011) and is included at Appendix I. The ecological assessment was prepared in accordance with section of the EP&A Act, TSC Act and EPBC Act. While the 2010 report does not accurately reflect the proposed activity as described in the REF (eg drilling is included, water monitoring bore, under-reaming is included, twinning is proposed), the conclusions in the 2011 report continue to be applicable to the proposed activity.

Further ecological assessment was done by EMM to identify biodiversity features in the water pipeline route and its surrounds between the Tiedmans property and WK13, with the results included at Appendix J. This chapter provides a summary of the ecological assessment and an assessment of potential biological impacts.

### 7.1 Vegetation

The proposed activity is in a highly modified environment largely cleared of native vegetation and revegetated with introduced pasture species and used for the grazing of stock over a considerable number of years. Remnant vegetation comprises large paddock trees (predominantly Forest Red Gum (*Eucalyptus tereticornis*), Narrow-leaf Ironbark (*E. crebra*), Rough-barked Apple (*Angophora floribunda*) and Grey Box (*E. moluccana*), which are scattered across the landscape, particularly along the road reserves and associated with the Avon River and Waukivory Creek in proximity to the proposed water pipeline .

None of the well sites contain remnant native shrubs or trees and none are in riparian areas. In addition, roadside remnant vegetation will be avoided by the proposed water pipeline. Therefore, potential impacts on native vegetation communities are considered to be negligible.

### 7.2 Groundwater dependent ecosystems

There are no known GDEs (apart from stream base flow accessions) in the vicinity of the Waukivory pilot wells. Whilst impacts to any GDEs are not expected to result from the proposed activity, AGL will continue to monitor groundwater at the site. The geophone/water monitoring bore (WKmb05) at the site will be incorporated into the broader groundwater monitoring network and ensure there are no adverse impacts on the shallow aquifers in the northern part of the Gloucester Basin and as result of depressurisation of the deeper coal seam water bearing zones.

### 7.3 Threatened ecological communities

The proposed activity is within the Hunter-Central Rivers CMA. Alison Hunt and Associates (2010) identified 12 EECs as being listed within this CMA and the updated database search undertaken by EMM in 2013 for the proposed activity identified one additional EEC. None of the 13 listed EECs were present in the area of the well sites. However remnant trees likely to form part of the Hunter Lowland Redgum Forest in the Sydney Basin and New South Wales North Coast Bioregions endangered ecological community (Hunter Lowland Redgum Forest EEC), occur in three locations along the water pipeline route between the Tiedmans property and WK13. These areas are associated with drainage depressions and lower slopes where remnant canopy species exist with a highly degraded understorey. None of these characteristic trees will be removed for the proposed water pipeline.

An assessment of significance under section 5A of the EP&A Act was undertaken for the community, which concluded that the proposed activity would not significantly impact on the Hunter Lowland Redgum Forest EEC. Mitigation measures have been included in this report (Refer to Table 2.9) to minimise any potential impacts to this community from any water pipeline construction work between the Tiedmans property and WK13.

Therefore, potential impacts on TECs are considered to be negligible.

#### 7.4 Threatened populations

No threatened populations were identified at the site by Alison Hunt and Associates (2010) and EMM (2013). This finding is consistent with a landscape that has been extensively cleared for the establishment of pastures.

Therefore, the potential impacts on threatened populations are considered to be negligible.

#### 7.5 Threatened species

Assessments of significance were completed for the Grey-crowned Babbler and Grass Owl and Black-necked Stork in accordance with section 5A of the EP&A Act (Appendix I and Appendix J). The assessments concluded that the proposed activity would not impact on any known breeding habitat for these species and it is unlikely to have a significant impact on foraging resources as no clearing of habitat resources will be required. The assessments also identified that with management measures such as those listed in the EMP at Appendix E, it is unlikely that any of these species would be significantly impacted and a species impact statement is not required.

Therefore, potential impacts on threatened species are considered to be negligible.

#### 7.6 Migratory species

Twelve migratory bird species and their habitats are predicted to occur within 10 km of the site (Appendix I and Appendix J). It is likely that the Cattle Egret and Great Egret would occur when the grassland is flooded after heavy rain, and that the Rainbow Bee-eater may occasionally forage at the site as it is known to frequently use disturbed areas and creeks. An assessment of significance was completed for these three species (Appendix K) which concluded that impacts to the species are not likely to be significant.

Therefore, potential impacts on migratory species are considered to be negligible.

#### 7.7 Displacement and fragmentation of fauna and their habitats

The proposed works are situated in an agricultural landscape and most of the adjacent lands have been previously cleared, with only isolated pockets of remnant bushland remaining along the waterways, road sides and in the broader valley area around Gloucester. The Avon River and Gloucester River are considered to provide the strongest habitat corridors in the area. The proposed activity will not impact these corridors and is unlikely to affect movement and habitat connectivity for any species of flora or fauna.

Therefore, potential impacts on fauna corridors are considered to be negligible.

## 7.8 Introduced species

The proposed activity is in paddocks which currently contain pasture species or exotic grasses. No native trees or shrubs were recorded at the location of the wells (Appendix I). The pipeline corridor was found to contain a disturbed understorey which has been ploughed and is dominated by weeds including Purpletop (*Verbena bonariensis*), Fireweed (*Senecio madagascariensis*), Scotch Thistle (*Onopordum acanthium*) and Whisky Grass (*Andropogon virginicus*). Disturbance tolerant and pasture species include Kikuyu (Kikuyu spp.), White Clover (*Trifolium repens*), Couch (*Cynodon dactylon*) and Paspalum (*Paspalum dilantum*) (Appendix J).

Vehicle traffic and the importing of equipment creates potential for noxious weed species to colonise disturbance areas. However, the soil and ground stability and weed management procedure in the EMP (Appendix E), provide measures to prevent new weed species being introduced and minimise the spread of existing noxious weed species.

The proposed activity is not expected to promote conditions suitable for pest animal species or vermin (ie European red fox, black rat, house mouse). No new access tracks are planned and work will be undertaken according to the EMP (Appendix E) which includes measures for the management of waste and restrictions on workers bringing domestic animals (ie domestic cats and dogs) to the work sites.

The proposed activity does not involve the introduction of genetically modified organisms into the area.

Therefore, potential impacts on biological and community resources from introduced species are considered to be negligible.

## 7.9 Key threatening processes, threats to biodiversity and ecological integrity

Table 7.1 outlines key threatening processes potentially exacerbated by the proposed activity. Based on the impact assessment, the potential impacts to biodiversity and ecological integrity from key threatening processes are considered to be negligible.

**Table 7.1 Key threatening processes**

Key threatening process	TSC Act	EPBC Act	Potential impacts
Clearing of native vegetation	Listed	Listed	Native vegetation has previously been cleared from the sites. Notwithstanding, no additional land clearing is proposed other than burying the gathering line which was previously assessed in the original REF (EMM 2011) and the area of disturbance required for the underbore. The trenching areas for the water pipeline between the Tiedmans property and WK13 occur in highly disturbed vegetation and the proposed activity is not considered to meet the description of clearing of native vegetation.
Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands	Listed	Not listed	Whilst impacts to groundwater are not expected to result from the proposed activity, appropriate monitoring and mitigation measures will be implemented to minimise the operation of this key threatening process. The water pipeline between the Tiedmans property and WK13 will not impact the natural flow regimes of any streams or their floodplains or wetlands in the area.

**Table 7.1**      **Key threatening processes**

<b>Key threatening process</b>	<b>TSC Act</b>	<b>EPBC Act</b>	<b>Potential impacts</b>
Invasion of native plant communities by exotic perennial grasses	Listed	Not listed	Native plant communities were previously replaced with introduced pasture species used for the grazing of stock. Measures in the EMP will be implemented to prevent new weed species being introduced and minimise the spread of existing noxious weed species.
Predation by the European red fox	Listed	Listed	The proposed activity is not expected to increase the European red fox predation on native species as no new roads are being created which would allow them to spread into new areas.



## 8 Community impacts

### 8.1 Community services and infrastructure

The duration of the proposed activity is limited (ie up to approximately 36 months) and AGL is expected to employ a relatively small workforce during this time. Due to the small work force and short duration of the activity, even if this small workforce temporarily relocated to Gloucester, there would be no noticeable impacts on educational, medical or social services in the area.

The proposed activity is expected to generate some additional traffic movements from both work and employee vehicles. However, an analysis of the traffic volumes within the local road network (EMM 2011) found that there is sufficient capacity to accommodate the additional traffic movements. The amount of waste (eg gravel, empty containers) and sewerage generated by the proposed activity requiring local waste services is likely to be minimal. Generators will be used to meet on-site electricity demands removing the need to rely on local community power supply infrastructure.

On this basis, the potential impacts on community services and infrastructure as a result of the proposed activity is considered to be negligible.

### 8.2 Access to important community sites

The proposed activity is on private land used for agricultural purposes and access to the well sites will be restricted by a stock proof boundary fence. There is no conservation or historic heritage places in the area of the proposed activity and access will not be restricted to the Avon River or Waukivory Creek which are recognised as important Aboriginal heritage landscape features.

Therefore, the potential impacts on community sites as a result of the proposed activity are considered to be negligible.

### 8.3 Traffic and local roads

The maximum traffic scenario would occur if the water pipeline from the Tiedmans property to WK13 is not constructed and tankers are used to transport source and produced water between these two locations.

If the water pipeline from the Tiedmans property to WK13 is not constructed, during the operational phase, a number of tankers would visit the sites to deliver water (approximately 6 ML) required for fracture stimulation activity to the water staging point at WK13 (and WK11 under Option 2). The preferred sources of water for the proposed activity are the nearby Pontilands and Tiedmans dams. These properties are very close to the water staging point at WK13 (and WK11) requiring use of only around 1 km of Fairbairns Road to deliver source water.

Once fracture stimulation activity commences, tankers would continue to deliver water for up to three weeks, operating constantly during the standard hours of operation.

If the water pipeline is not constructed, then tankers would also be used to transport produced water to the Tiedmans property.

If the water pipeline from the Tiedmans property to WK13 is constructed, the transport of source and produced water by tanker via Fairbairns Road would only be done by exception.

Tankers will be used to transport flowback water, for lawful disposal, to an appropriate facility.

Tankers will operate from 6 am until 6 pm.

A workover rig and a crane will also be delivered to each well site following hydraulic fracturing for completion of the well and subsequently for maintenance works. The workover rig and a crane will be delivered on an infrequent basis and is not expected to result in interruptions to traffic flow on local roads. Limited plant will be delivered to site during the decommissioning stage and is not expected to result in interruptions to local traffic flow.

An analysis of traffic volumes within the local road network (EMM 2011) found that there is sufficient capacity to accommodate the additional traffic movements. However, traffic resulting from the establishment and operation phases may cause some minor interruptions to traffic flow on local roads.

Potential traffic impacts on local roads will be mitigated through the implementation of measures outlined in the EMP at Appendix E. This procedure includes restriction of heavy traffic use of local roads to the hours of 6 am to 6 pm Monday to Saturday and maintenance of a community phone hotline for any concerned residents.

On this basis, the potential impacts from traffic on local roads are considered to be low adverse.

#### 8.4 Economic factors

The proposed activity is limited in duration and AGL is not expected to employ a large workforce. It is anticipated that employee spending on items such as accommodation, food and entertainment will not be significant to the local economy.

Therefore, potential impacts on the local economy from the proposed activity are considered to be slightly positive.

#### 8.5 Community safety

All AGL employees, contractors and visitors to the site would receive a site induction including a briefing on the site management plan which addresses site safety and risk management. For AGL employees and contractors this would also include an induction into the manual of emergency response procedures.

Interactions with livestock and native animals (eg kangaroos) at the site will be limited by the installation of stock proof fencing around water storages and work areas, disposal of rubbish and the limiting of vehicle speed on site access tracks.

Measures will be implemented to mitigate road safety risks. AGL would specify that all vehicles required for the proposed activity are to comply with all relevant statutory and licence requirements. Access to the sites from local roads will have adequate visibility in both directions, where practical, or warning signage would be installed if this was not practical. Any locations used for obtaining water would be assessed for road safety for access by truck and during filling.

Therefore, the potential impacts on the community from traffic generated by the proposed activity are considered to be low adverse.

Gas blow out prevention equipment will be installed and operated to meet the requirements of the *Petroleum (Onshore) Act 1991* and the *Petroleum (Onshore) Regulation 2000*. Gas flaring is recognised as a very important safety measure during pilot testing as it safely disposes of gas during normal operations as well as in the event of an emergency, power failure, or equipment failure. Based on previous pilot testing in the PEL 285 (EMM 2011) and the prevention measures to be implemented at the Waukivory site, risk to the community from gas blowout during activities is considered unlikely.

Groundwater aquifers used for agricultural purposes (ie upper alluvial and shallow rock aquifers) are unlikely to be impacted by fracture stimulation as they are isolated by the installation of pressure rated steel casing and cemented off during the construction of the exploration wells. The potential for contamination of groundwater caused by fracture stimulation fluids leaching through the ground from the surface into the shallow aquifer would be mitigated by pumping fracture stimulation fluid from exploration wells into secure water storages. The EMP (Appendix E) requires AGL to ensure there is no leakage from the lined storages and that fracture stimulation fluid is lawfully disposed of at an appropriate facility. Therefore, the potential impacts on the community from groundwater contamination are considered to be low adverse.

As discussed in Section 7.5.1, a HHERA for the use of chemical additives used during the fracture stimulation process was commissioned by AGL. The assessment considered the potential impacts on human health and ecology to be low adverse.

The geophone/water monitoring bore (WKmb05) at the site (when approved by NOW) will be incorporated into the broader groundwater monitoring network and ensure there are no adverse impacts on the groundwater aquifers in the northern part of the Gloucester Basin.

Consolidated rock is not supported by pore pressure thus change of pressure in the coal seam will not result in subsidence in ground about this zone.

Overall, the potential impacts to community safety are considered to be low adverse.

## 8.6 Fire risk

The site is within agricultural land and could be impacted by bush fire burning through open pastures.

The *Gloucester Bush Fire Risk Management Plan* (GBFMC 2010) identifies one special fire protection asset, Avon View Stays which west of the site. This asset was assessed as having a medium level of bush fire risk from a scale which measures bushfire risk levels from low to extreme. The plan to mitigate bush fire risk at Avon View Stays involves proprietor education and fire relocation planning for occupants. The site of the proposed activity is identified as a land management zone (LMZ) in the *Gloucester Bushfire Risk Management Plan*. The bush fire risk management objectives of the LMZ can be achieved at the site by reducing vegetation adjacent to tracks, fences and other built assets through methods such as herbicide spraying, mowing and grazing.

Fire ignition sources at the site include failure of exploration activities and equipment and the act of flaring. Bushfire prevention measures in the EMP at Appendix E requires AGL to implement measures to prevent and respond to bushfire incidents and includes measures in other procedures (eg pipe stringing and welding), to minimise the risk of causing a bushfire.

The AGL employee and contractor site induction will inform all site personnel of the required procedure to prevent fire and respond to fire ignitions.

Following the implementation of measures described in the EMP at Appendix E, the fire risk is considered to be low adverse.

## 8.7 Visual and scenic impacts

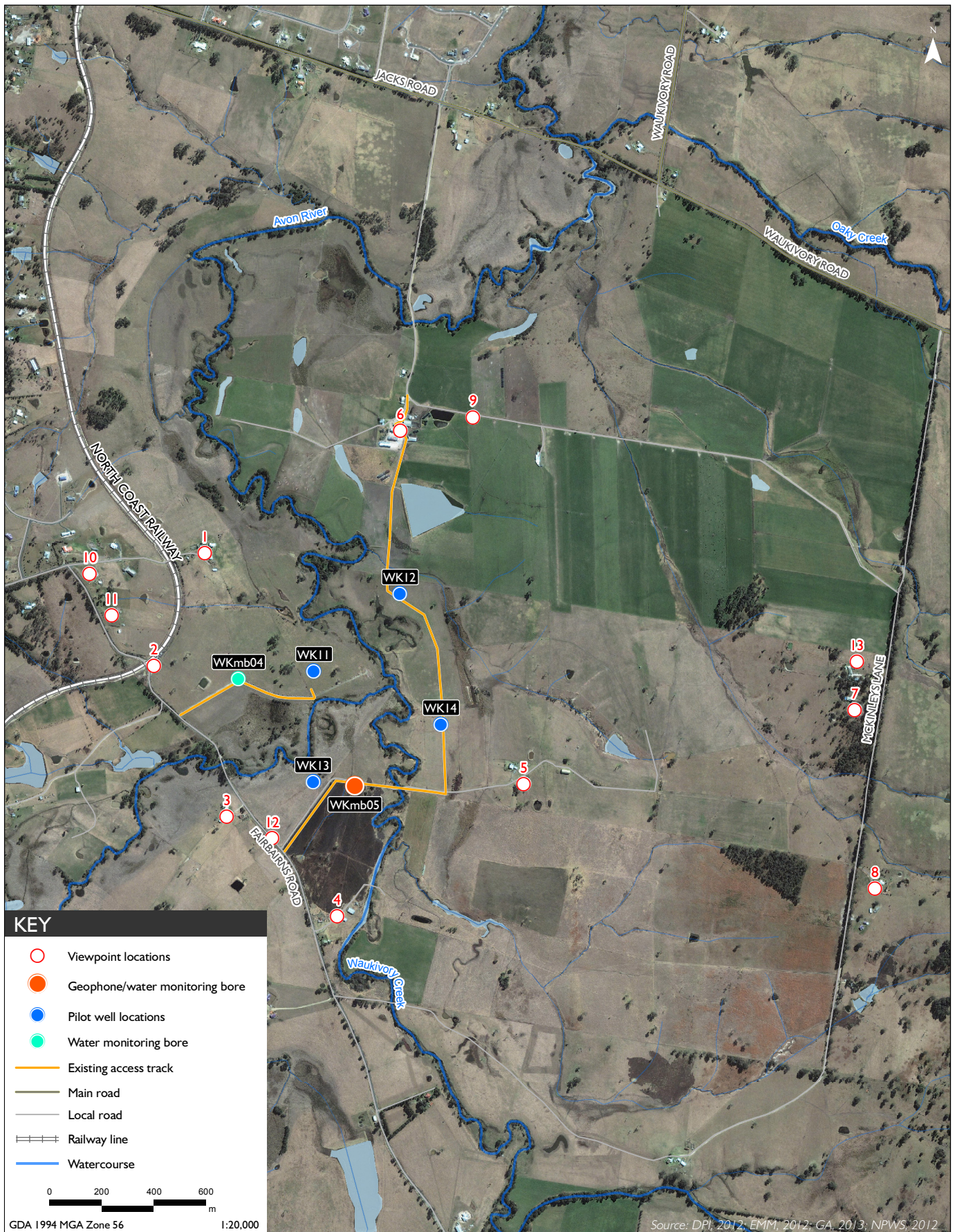
A visual and scenic impact assessment of the proposed activity was undertaken by EMM in 2010. The assessment included a site inspection of the locations of the proposed activity and the surrounding area and 13 viewscape locations were selected from which the proposed activity could be visible. Two of the viewscape locations were on public roads and the remainder at residences. No locations on Bucketts Way and McKinley's Lane were included as viewscape locations due to items obscuring views. These items include residences near The Bucketts Way and the trees lining the road, and remnant patches of vegetation west of McKinley's Lane. The viewpoints used for the visual assessment are shown on Figure 8.1.

Potential impacts were assessed by considering the visibility of the proposed activity from surrounding areas, the visual absorption capacity of the area with respect to the proposed activity, and the visual sensitivity of the viewscales.

The introduction of a proposed enclosed flare structures at WK12 (and possibly WK11 under Option 2) has potential to create visual impacts to the surrounding sensitive receivers. The flare unit consists of an enclosed container approximately 13 m long that acts as a visual barrier to the gas flame. The container stands approximately 3 m high and has an open roof for heat venting. A secondary flare measuring approximately 6 m long may be installed at WK12 should the flare at WK11 not be installed and gas production exceeds a single flare's operating capacity as indicated through the telemetry system. Potential impacts that may be associated with flaring include:

- visibility of infrastructure and facilities - during daytime operation light emissions from flaring will be negligible and the flare container should not be overly conspicuous in the landscape, provided that natural mid-green tones or similar colour is used for the flare container; and
- light emissions during night-time flaring - flaring results in a soft glow or flickering of light being emitted within the immediate locality. Exposed flare units can be visually prominent in a darkened landscape and may, depending on the flares distance and surrounding landscape, cause visual impacts and nuisance to nearby sensitive receivers. However, the enclosed nature of the flare and use of long BBQ style gas release burners reduces the potential for light flicker and naked flame exposure.

The locations of the viewscales and their approximate distance from proposed flare locations are detailed in Table 8.1.



**Table 8.1 Sensitive residential receivers**

Location	Residential receivers	Distance to flares (m)	
		WK11	WK12
1	20 Grantham Road, Forbesdale	600	820
2	Fairbairns Road, Forbesdale	590	1,030
3	176 Fairbairns Road, Forbesdale	650	1,100
4 <sup>1</sup>	237 Fairbairns Road, Forbesdale	970	1,250
5	197 Fairbairns Road, Forbesdale	912	790
6	114 Maslens Lane, Gloucester	960	645
7	146 McKinley's Lane, Forbesdale	2,040	1,682
8	211 McKinley's Lane, Forbesdale	2,310	2,065
9	Maslens Lane	1,143	734
10	18 Grantham Road, Forbesdale	918	1,253
11	77 Fairbairns Road, Forbesdale	794	1,168
12	Fairbairns Road, Forbesdale	605	1,042
13	1383 McKinley's Lane, Forbesdale	2,029	1,648

Notes: 1. This property is owned by a neighbouring mining company.

Potential impacts have been assessed by considering the visibility of the proposed activity from surrounding areas, the visual absorption capacity of the area with respect to the proposed activity, and the visual sensitivity of the viewscales.

Visual absorption capacity is the ability of a landscape to be changed and still retain its existing visual characteristics, such as rural, built or natural character. It is determined by considering the visibility of the proposed activity and the degree of contrast between them and the local regional viewscales.

Visual sensitivity is a measure of the level of concern attached by the surrounding land users to a change in the landscape character. It is based on factors including the number of people affected, landuse, visibility, the current degree of exposure to the style of development proposed, distance of viewers from the proposed activity, and the duration of viewing time.

The visual characteristics of each viewscale are described in terms of three horizontal sections. These are:

- foreground of the viewscale - this is the lowest horizontal section;
- mid-section of the viewscale - this is the middle section of the viewscale; and
- upper section of the viewscale - this is the top horizontal section of the viewscale.

Potential views to proposed flare locations are possible from most viewscape locations with some screening resulting from undulating topography, riparian vegetation associated with the Avon River and Waukivory Creek and roadside vegetation. A summary of potential visual impacts from the proposed flare units is presented in Table 8.2.

**Table 8.2 Visual impact assessment results**

<b>Viewscope locations</b>	<b>Viewscope descriptions</b>	<b>Potential visibility of flare units</b>	<b>Visual sensitivity</b>	<b>Visual absorption capacity</b>	<b>Significance of visual impacts</b>
1, 2, 10 and 11	<p>The foreground of these viewscape locations features relatively flat agricultural land. Additionally, the main northern railway features for locations 10 and 11. The mid-section of this viewscape comprises agricultural land and a narrow band of riparian vegetation associated with the Avon River and Waukivory Creek. The upper section of the viewscape features the woodland and mountain range associated with the Mograni range.</p> <p>These viewscales are on higher ground near the western extent of the visual catchment.</p>	<p>Each of the proposed flare sites are potentially visible from locations 10 and 11 given that these are between 24 m and 31 m higher in elevation than the proposed sites, with relatively uninterrupted views. However, the proposed flares at WK12, are unlikely to be visible from locations 1 and 2 given that there is little difference in elevation and there is intervening riparian vegetation obstructing views.</p> <p>Potential light flicker and naked flame exposure will be limited by the enclosed nature of the flare and the use of long BBQ style gas release burners.</p>	Low	High	Low
3, 4 and 12	<p>The foreground and mid-section of these viewscales features relatively flat agricultural land. The upper-section of the viewscape comprises riparian vegetation associated with the Avon River and Waukivory Creek.</p> <p>These viewscales are on relatively flat and low ground at the southern extent of the visual catchment.</p>	<p>The proposed flare units at WK13 would feature moderately in these viewscales given its relatively close proximity. The other proposed sites would not be visible given intervening riparian vegetation.</p> <p>Potential light flicker and naked flame exposure will be limited by the enclosed nature of the flare and the use of long BBQ style gas release burners.</p>	Low	High	Low

**Table 8.2 Visual impact assessment results**

<b>Viewscape locations</b>	<b>Viewscape descriptions</b>	<b>Potential visibility of flare units</b>	<b>Visual sensitivity</b>	<b>Visual absorption capacity</b>	<b>Significance of visual impacts</b>
5	<p>The foreground of this viewscape features relatively flat agricultural land. The mid-section of this viewscape comprises agricultural land and a narrow band of riparian vegetation associated with the Avon River and Waukivory Creek. The upper section of the viewscape features the woodland and mountain range associated with Gloucester Bucketts.</p> <p>This viewscape is at an area of elevated terrain at the centre of the visual catchment and is surrounded by low grazing land.</p>	<p>The proposed flare unit at WK12 would feature moderately in this viewscape given the lack of intervening vegetation. The proposed flare at WK11 is unlikely to be visible given the intervening riparian vegetation.</p> <p>Potential light flicker and naked flame exposure will be limited by the enclosed nature of the flare and the use of long BBQ style gas release burners.</p>	Low	Moderate	Minor
6 and 9	<p>The foreground of these viewsapes features relatively flat agricultural land. The mid and upper sections of these viewsapes comprise agricultural land and a narrow band of riparian vegetation associated with the Avon River and Waukivory Creek.</p> <p>These viewsapes are in an area of elevated terrain at the northern extent of the visual catchment and are surrounded by low grazing land.</p>	<p>The proposed flare unit at WK12 would feature moderately in this viewscape given the lack of intervening vegetation. The proposed flare at WK11 is unlikely to be visible given the intervening riparian vegetation.</p> <p>Potential light flicker and naked flame exposure will be limited by the enclosed nature of the flare and the use of long BBQ style gas release burners.</p>	Low	Moderate	Minor
7, 8 and 13	<p>The foreground of these viewsapes features relatively flat agricultural land. The mid-section of these viewsapes comprises agricultural land and a narrow band of riparian vegetation associated with the Avon River and Waukivory Creek. The upper section of the viewsapes features the woodland and mountain range associated with Gloucester Bucketts. Additionally, these locations have some vegetation in their immediate foreground.</p> <p>These viewsapes are at an area of elevated terrain at the eastern extent of the visual catchment.</p>	<p>Locations 7 and 13 would have filtered views of the proposed flare unit at WK12, they would not have views of WK11 due to intervening riparian vegetation. Location 8 is unlikely to see any of the proposed flare sites given intervening vegetation along McKinley's Lane and a stand of remnant vegetation to the west.</p> <p>Potential light flicker and naked flame exposure will be limited by the enclosed nature of the flare and the use of long BBQ style gas release burners.</p>	Low	High	Minor



The potential impact on visual amenity as a result of flaring gas during the night time is considered to be low adverse as the flame in each unit will be enclosed and direct views will not be possible.

It is expected that proposed infrastructure at WK13 (such as the water staging point) and WK14 would be moderately visible to residents at locations 3, 4 and 5 during daylight hours. This is because of the proximity of the locations to the exploration wells (ie  $\leq 500$  m) and the relatively flat topography with little screening vegetation. However, the proposed infrastructure is similar to that used in the existing agricultural landscape. Visual amenity would also be considered as part of the hardware selection process for the development of infrastructure (eg fencing material) and where practical, AGL will consider the existing design of infrastructure in the area and on adjoining properties. Therefore, potential impacts on visual amenity during the day time are considered to be low adverse.

It is expected that the proposed infrastructure would have a low level of visibility to traffic on public roads. The view towards the proposed infrastructure from Fairbairns Road is partially screened by undulating topography and riparian vegetation associated with the Avon River and Waukivory Creek. It is expected there would be some direct views of proposed infrastructure at WK13 from location 12 due to the close proximity of the road at this point (ie 301 m). However, the proposed infrastructure is similar to that used in an agricultural landscape and is not expected to have a significant impact on the scenic landscape.

The construction of the proposed buried water pipeline is short in duration (less than three weeks) and is not expected to result in adverse visual impacts.

Therefore, the potential impact on scenic amenity is considered to be low adverse.

## 8.8 Other

The purpose of the proposed activity is to examine the viability of the gas wells for production. If the wells are deemed viable, gas will potentially be developed and made available for sale to, and use by, the wider NSW community. Therefore, impacts for the use of gas in the longer term, should the exploration be successful, by the community are positive.



## 9 Natural resource impacts

### 9.1 Impact on conservation areas

There are no state or Commonwealth conservation areas within 10 km of the proposed activity. Ecological impacts from the proposed activity are likely to be confined to the vicinity of the wells (WK11, WK12, WK13 and WK14) and the proposed water pipeline. Therefore, potential impacts on conservation areas are considered to be negligible.

As stated in Section 2.2, the proposed activity is on land zoned E3 Environmental Management and RU1 Primary Production under the Gloucester LEP.

Notwithstanding that the Mining SEPP prevails over the Gloucester LEP an assessment of impacts presented in this REF conclude the proposed activity would not have a long-term significant impact on ecological, scientific, cultural or aesthetic values and that the proposed activity is generally consistent with the existing agricultural practices currently occurring on the site. Therefore, the potential impacts on achieving the objectives of the E3 and RU1 zones are considered to be negligible.

### 9.2 Impact on community resource use

The shallow alluvium is the main beneficial aquifer and supplies most of the groundwater sourced in the area. As a vertical connection between the shallow alluvial aquifers (used by the surrounding licensed/registered groundwater bores) and the deeper target aquifers (where water will be extracted for the proposed activity) is unlikely, drawdown of water levels in the shallow alluvial aquifer is unlikely.

Additionally, water quality in the shallow alluvial aquifer will be protected during the proposed activity through the concrete and steel casing of the well, preventing any leakage of fluids used during hydraulic fracture stimulation.

There are no known GDEs in the vicinity of the Waukivory Pilot. There are no known wetlands, lakes or other surface features that are indicative of shallow groundwater processes and possible GDEs. Even if GDEs were present, impacts are considered unlikely due to the absence of a connection with the deeper target aquifer and the environmental safeguards to be implemented.

Therefore, impacts to community use of groundwater are considered to be low adverse.

Soil would be disturbed for the installation of temporary water/gas gathering lines, construction of the double-lined dual compartment turkeys nest dam and the levelling of ground for the installation of temporary storage tanks. Areas of soil disturbance will be stabilised once construction is complete. Therefore, the proposed activity is expected to have a low adverse impact on land and soil following implementation of measures in the EMP at Appendix E.

An AIS was prepared in accordance with the AIS guidelines (DRE 2012) and SRLUP (DP&I 2012) for the proposed activity (Appendix A). The purpose of the AIS was to identify and assess any potential agricultural impacts caused by the proposed activity. The initial risk assessment under Section A of the AIS Guideline indicated that the proposed activity represented a medium risk to agriculture (due to it being a gas from coal seams activity and an activity of community interest) and required further assessment in accordance with Section B of the AIS Guidelines.

The AIS determined that the proposed activity presents minimal risk to agriculture as the site has not been mapped as SAL and is deemed to not be within a critical industry cluster (CIC). It also demonstrated the proposed activity will not result in significant impacts on agricultural resources or production of the site and surrounding area or agricultural enterprises in the surrounding area.

The land that is disturbed from the proposed activity including construction laydown areas, access tracks and gas gathering pipelines verges will be rehabilitated to their pre-existing state at completion of the activity. Subject to the results of pilot testing, this land will be available for agricultural activities. Further, the sourcing of water from either nearby Pontilands or Tiedmans dams reduces the usage of the wider road network by trucks. Similarly, the proposed disposal of produced water to the Tiedmans property reduces usage of the wider road network. Around 1 km of Fairbairns Road would be used to transport water between the Tiedmans property and the Waukivory Pilot. Trucks will then use Tiedmans Road to access the Tiedmans property.

Therefore, impacts to agricultural resources are considered to be low adverse.

Dust impacts are expected to be low adverse and restricted to traffic and the construction of water storages. Odour impacts will be negligible as gas is odourless. Potential dust and odour impacts will be mitigated through the implementation of the measures in the EMP at Appendix E.

The purpose of the proposed activity is to examine the viability of the gas wells for production. If the wells are deemed viable, natural gas will potentially be made available for sale to, and use by, the state.

## 10 Aboriginal and cultural heritage impacts

### 10.1 Aboriginal cultural heritage impacts

#### 10.1.1 Impact on ground surface and culturally modified trees

One AHIMS record, 38-1-49 (site name LEA1) listed as a possible Aboriginal scarred tree, is on the edge of the Avon River bank. This tree was previously identified in the field and assessed as not an Aboriginal scarred tree (EMM 2011). Regardless of the tree's status as an Aboriginal object, it is over 200 m south east of the nearest well location (WK11) and would not be impacted by proposed activity.

Activities such as excavations, trenching and vehicle movements will disturb the ground surface and have the potential to impact unidentified Aboriginal objects. Impact avoidance and minimisation measures are presented in Table 2.9.

#### 10.1.2 Impact on objects and places

No Aboriginal sites were found to occur within the area of disturbance from the proposed activity.

A single stone artefact, site WK-IF-1, is on a disturbed gravelled track east of WK11 (EMM 2011). The artefact occurs in a disturbed context of introduced gravel on a rehabilitated access track and may have been introduced with the gravel. The flake occurs 160 m east of the nearest well location (WK11) and would not be affected by the proposed activity as this section of road is not required to be used.

#### 10.1.3 Impact on local landscape features

The proposed activity is within 200 m of landscape features that indicate the potential existence of Aboriginal objects as defined by the *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales* (DECCW 2010). The relevant landscape features are the Avon River and Waukivory Creek. The proposed activities are in disturbed land and not expected to encroach on the creek valley.

Further investigation including a site inspection and a review of the 2009 AECOM ACHA indicate that the proposed activity areas do not occur within archaeologically sensitive areas. Although the water pipeline route from the Tiedmans property to WK13 is within 200 m of the Avon River and Waukivory Creek, these areas are either in water logged depressions or in areas previously disturbed by the farm buildings. There are no intact spurs within these areas that overlook a water course. Furthermore, the 2009 AECOM ACHA previously surveyed these sections of the Avon River and Waukivory Creek and did not identify any potential archaeological deposits.

The areas where the pipeline route intersects the ephemeral drainage lines adjacent to Tiedmans Road are not considered to be archaeologically sensitive. The drainage lines here were not flowing, but instead were broad and shallow within a vegetated depression. Due to unreliability of these water courses, they are considered unlikely to have attracted frequent or intensified Aboriginal occupation.

Considering the archaeological record of the local area, Aboriginal objects occur either as isolated finds or very low density artefact scatters in association with well drained, slightly elevated areas overlooking watercourses (particularly reliable watercourses). The area of the activity does not occur on these landform features. Therefore, it is unlikely that Aboriginal objects will be impacted. Isolated Aboriginal objects may occur sporadically throughout the landscape and are likely to be background scatter created from the isolated discard of objects during transitory movement.

Therefore, the local landscape features within the proposed activity area is not considered to be conducive to past Aboriginal occupation. As such, the potential for Aboriginal objects to occur on the ground surface or as subsurface deposits is considered to be negligible and no further impact assessment or investigation is considered to be required.

#### 10.1.4 Impact on areas subject to native title claims, indigenous land use agreements or joint management

The land affected by the proposed activity area is private freehold land and is not subject to native title claim, Indigenous Land Use Agreements (ILUAs) or joint management arrangements.

A search of the Native Vision GIS system on the [www.nntt.gov.au](http://www.nntt.gov.au) website on 12 August 2013 showed no application covering the activity area.

A search of the ILUA register was conducted on [www.nntt.gov.au](http://www.nntt.gov.au) on 12 August 2013. The search identified nine registered ILUAs in NSW, none of which occur in or near the area subject of the Waukivory Pilot or the broader Gloucester Region.

#### 10.1.5 Can harm be avoided?

Harm to known and discovered Aboriginal cultural heritage sites can be avoided. The proposed activity would be undertaken in accordance with the measures outlined in the EMP at Appendix E.

### 10.2 Historic cultural heritage impacts

A search of the National heritage list and the Australian heritage database identified the Stroud Gloucester Valley as being of significance as a 'nominated' place for the National heritage list. At this stage, the Minister has not formed an opinion that the area meets the criteria for listing. Therefore, for this assessment it has not been considered a matter of national environmental significance (MNES).

The proposed activity is within the Stroud Gloucester Valley which covers 50,000 ha of land from Kia Ora lookout in the north to the mouth of the Karuah River in the south and the proposed activity represents a very small proportion of the nominated area.

The nomination identifies that resource development projects (principally coal mines) have the potential to negatively impact the scenic qualities of the Stroud Gloucester Valley. As detailed in Section 8.7 the proposed activity will not feature significantly against the existing landscape, given the similarity to existing agricultural practices.

Therefore, potential impacts on scenic qualities of the Stroud Gloucester Valley are considered to be low adverse.

A search of the NSW Heritage database and the Gloucester LEP revealed no items of state or local heritage significance within the vicinity of the proposed activity.

## 11 Matters of national environmental significance

The proposed activity requires minimal land disturbance.

The REF has had regard for the following matters which are protected under Part 3 of the EPBC Act.

- World Heritage properties – the proposed activity will not impact on any property included on the World Heritage List;
- National Heritage places - the proposed activity will not impact on any property listed as a National Heritage place;
- Wetlands of international importance – the proposed activity will not impact on any wetlands of international significance;
- Listed threatened species and communities – the ecological assessment identified 14 fauna and 13 flora species listed under the EPBC Act that has the potential to occur in the locality. Site investigations concluded that there are no EPBC Act listed species with real potential to occur across the sites or directly adjacent. None of the 12 EECs which occur in the Hunter-Central Rivers CMA were found to be present in the area of the proposed activity. It is considered that the proposed activity is highly unlikely to be a controlled action under the EPBC Act due to significant impacts to listed threatened species and communities. The likelihood of occurrence assessment is provided in the reports included at Appendix I and Appendix J;
- Listed migratory species – The ecological assessment identified twelve migratory species listed under the EPBC Act that has the potential to occur in the locality. Site investigations concluded that there are no EPBC Act listed species with real potential to occur across the sites or directly adjacent. It is considered that this proposal is highly unlikely to be a controlled action under the EPBC Act due to significant impacts to listed migratory species. The likelihood of occurrence assessment is provided in the reports included at Appendix I and Appendix J. An assessment of significance for migratory species potentially occurring in the area of the activity is provided at Appendix K;
- Protection of the environment from nuclear actions – the proposed activity does not include a nuclear activity and therefore is not relevant;
- Commonwealth marine environment – the proposed activity will not impact on a water defined as the Commonwealth marine area;
- Great Barrier Reef Marine Park – the proposed activity is over 1,000 km for the Great Barrier Reef Marine Park and will therefore have no significant impact on its environment;
- Additional matter of national environmental significance – the proposed activity will not have any significant impact on any Commonwealth lands;
- Water resources – no drawdown impacts are expected to shallow beneficial aquifers due to the lack of connectivity between shallow aquifers and deep water bearing zones. A groundwater monitoring network is in place in reasonable proximity to selected gas wells to assess whether there are water level drawdown or water quality changes that would indicate connectivity;

- Protection of the environment from the proposed activity involving the Commonwealth – the landowner and applicant is a publicly listed company and does not involve any Commonwealth agency or Commonwealth lands; and
- Commonwealth Heritage places outside the Australian jurisdiction – the proposed activity will have no impact on any Commonwealth Heritage places overseas.

No MNES related to terrestrial ecology or cultural heritage will be significantly impacted by the proposed activity.

Based on the assessment undertaken in this REF, it is concluded that the proposed activity will not have a significant impact on any MNES.



## 12 Cumulative impacts

### 12.1 Cumulative impacts

This REF has considered the cumulative environmental impacts of the proposed activity. A number of environmental investigations were done as part of this REF. Consideration has been given to the wider area within the environmental assessments prepared as part of this REF and in the environmental investigations prepared as part of the wider PEL 285 area. For example, the ecology assessment provided in Appendix I and Appendix J and summarised in Section 4.3, examined the proposed sites in relation to proposed corridors and future wildlife movements in the area.

The proposed activity is in the Gloucester Basin which supports a variety of extractive industries including coal mining and other proposed pilot testing wells. The closest operating mine is the Stratford coal mine, approximately 5km south of the site. The proposed activity is on a rural property cleared of vegetation and used for agriculture. The proposed activity is short-term, with little offsite impacts. The site will be rehabilitated to pre-existing condition at completion of the activity. The schedule of the development of the GGP in accordance with the approval is not expected to coincide with the proposed activity at the Waukivory Pilot. Similarly, the proposed open-cut coal mine (known as Rocky Hill) adjacent to the east of the site is not expected to operate concurrently with the proposed activity as the environmental impact statement (EIS) for that project has only commenced public exhibition towards the end of August 2013. The environmental impacts of the proposed activity are negligible to low adverse with no significant interactions with these neighbouring operations expected.

The Gloucester Basin has a history in mining, farming, agriculture and tourism. The proposed activity has been designed and planned to ensure they are sympathetic to existing land uses. AGL has an extensive and ongoing community consultation program including a consultative committee, accessible project information, and regular consultation with landowners.

The site is not within the mapped area of the SRLUP for the Upper Hunter (DP&I 2012). Therefore, the site is not considered as either SAL or land in a CIC according to site verification criteria provided by the DP&I. The land has previously been used by AGL for the purposes of gas exploration and co-exists simultaneously with cattle grazing and crops. However, pilot well testing is a temporary land use, and would not affect the land being used for agricultural land uses now or in the future.

The proposed activity is unlikely to contribute to cumulative biodiversity impacts for the region. Significant impacts are considered unlikely to threatened flora and fauna species and populations.

Surface water is used for most land uses across the catchment given the reliable coastal rainfall patterns and falls averaging about 1,000 mm per year. Low groundwater yields to bores and wells, and marginal to poor water quality also preclude widespread groundwater use across the area. There are only three groundwater works within 2 km in shallow aquifers with the very closest site at approximately 4 m into the shallow alluvium. The proposed dewatering activities will extract a maximum of 20 ML (including the flowback water) from non-beneficial deep groundwater storage in the coal seams. The proposed activity would therefore have a negligible cumulative impact on the local groundwater resources.

This REF has examined the impact of the proposed activity and recommended a number of mitigation and management controls to ensure that the proposed activity has a low adverse to negligible impact on the local environment and community. For example, a number of erosion and sediment controls would be put in place to ensure there is no impact on watercourses in the area. AGL and its contractors will also be required to undertake works in accordance with AGL's EMP and the commitments contained within this REF, to ensure the wells would have a negligible impact on the local environment.

Overall, it is considered that if the recommendations of this report and appropriate controls are in place during the works, the proposed activity is unlikely to have any cumulative environmental impact.

## 13 Summary of impacts

This REF has assessed the potential environmental impacts of the proposed activity in accordance with section 111 of the EP&A Act, clause 228 of the EP&A Regulation and the ESG2 guidelines and its supplement. The impacts are summarised below in Table 13.1. Furthermore the factors to be taken into consideration by the determining authority under clause 228 of the EP&A Regulation are provided in Table 13.2.

The extent of potential impacts was determined using the criteria in Table 5.1 and also considered the implementation of the impact avoidance and mitigation strategy (Table 2.9). Potential impacts are expected to range between negligible and low adverse. The overall impact of the proposed activity is considered to be low adverse.

Potential impacts of the proposed activity are not spatially extensive, and are restricted to a defined footprint which is minimised during the operational phase. Additionally, impacts are not temporally extensive as they will be completed in a maximum of 36 months, but may be completed sooner. The construction period will be completed in 8 to 12 weeks after which time the activity footprint will be minimised and rehabilitation will be undertaken. The operational period (pilot testing) will be undertaken over 12 to 18 months.

Environmentally sensitive areas relevant to the proposed activity include shallow alluvial aquifers in use by the community. Impacts to this environmentally sensitive area are considered to be low adverse as beneficial aquifers are not expected to be impacted. Additionally, this environmentally sensitive area will be monitored to identify any unexpected impacts, with appropriate mitigation/remedial actions applied as necessary.

Impacts to the community are considered to be negligible to low adverse as the works are short-term and temporary. The proposed activity does not affect access to important community facilities or services.

Minor increases in local traffic are expected during the construction period with transportation of water for delivery and disposal mostly limited to a small length of Fairbairns Road, should the water pipeline between the Tiedmans property and WK13 not be constructed. No significant adverse socioeconomic impacts are expected due to the short-term nature of the proposed activities. Additionally, impacts to community safety are considered to be low adverse after environmental safeguards have been applied.

This REF has also considered potential cumulative impacts of the proposed activity. A number of environmental investigations were undertaken as part of this REF. Consideration has been afforded to the wider area within the environmental assessments prepared as part of this REF, including the environmental investigations prepared as part of the wider GGP.

The proposed activity is on rural properties which are predominantly cleared and subject to current agricultural uses. The proposed activity is short-term and the site will be rehabilitated to its pre-existing state at completion of the activity. There are no expected significant cumulative effects as the environmental impacts and all works are contained within designated work areas. Overall, with the implementation of the recommendations outlined in this REF, and the proposed activity is implemented in accordance with current environmental standards and guidelines, including AGL's EMP, it is not expected to have a significant impact on the environment.

**Table 13.1 Summary of impacts**

<b>Impacts</b>	<b>Response based on REF assessment</b>	<b>Impact level</b>
<b>Physical and chemical impacts</b>		
1. Is the proposal likely to impact on soil quality or land stability?	The proposed activity are unlikely to impact on soil quality or land stability as the land is currently grazed and has a low potential for ASS. Suitable mitigation measures will be implemented to minimise these potential impacts.	Negligible to low adverse
2. Is the activity likely to affect a waterbody, watercourse or wetland or natural drainage system?	Produced water will be transported to Tiedmans, either by water pipeline or trucks. The irrigation of produced water on the Tiedmans property is managed under a separate approval issued by DTIRIS-DRE in 2012. No drawdown impacts are expected to shallow beneficial aquifers due to the lack of connectivity between shallow aquifers and deep water bearing zones. A groundwater monitoring network is in place in reasonable proximity to selected gas wells to assess whether there are water level drawdown or water quality changes that would indicate connectivity.	Low adverse
3. Is the activity likely to change flood or tidal regimes, or be affected by flooding?	No flood mapping is available for the site. However, the layout of the water management system has been designed in consultation with landowners experience of localised flooding events.	Negligible
4. Is the activity likely to affect coastal processes and coastal hazard, including those under projected climate change conditions?	The exploration activities are not near the coast and will not affect coastal processes.	Negligible
5. Does the proposal involve the use, storage or transport of hazardous substances or the use or generation of chemicals which may build up residues in the environment?	A HHERA was undertaken for the use of chemical additives in the hydraulic fracture stimulation process. Risks to human health and the environment were considered to be low.	Negligible to low adverse
6. Does the activity involve the generation or disposes of gaseous, liquid or solid wastes or emissions?	Flowback water will be lawfully disposed of at an appropriate facility.	Low adverse
7. Does the activity involve the emission of dust, odours, noise, vibration, or radiation in proximity of residential/urban areas or other sensitive locations?	Minor dust, noise and vibration impacts could potentially occur during the proposed activity. Odours and radiation will not occur. The flaring method is designed to minimise potential visual and noise impacts. A description of the flaring method is provided in the EMP (Appendix E).	Negligible to low adverse
<b>Biological impacts</b>		
1. Is any vegetation to be cleared or modified (including vegetation of conservation significance)?	Where possible, the proposed activity is in previously disturbed or cleared areas, and existing access tracks will be used wherever possible, to reduce the need for additional clearing.	Negligible
2. Is the activity likely to have a significant effect on threatened flora or fauna species, populations, or their habitats, or critical habitat; or an endangered ecological community or its habitat?	Where possible, the proposed activity is in previously disturbed or cleared areas, and existing access tracks will be used wherever possible, to reduce the need for additional clearing.	Negligible
3. Is the activity likely to impact on an ecological community of conservation significance?	Where possible, the proposed activity is in previously disturbed or cleared areas, and existing access tracks will be used wherever possible, to reduce the need for additional clearing.	Negligible

**Table 13.1 Summary of impacts**

<b>Impacts</b>	<b>Response based on REF assessment</b>	<b>Impact level</b>
4. Is the activity likely to cause a threat to the biological diversity or ecological integrity of an ecological community?	Where possible, the proposed activity is in previously disturbed or cleared areas, and existing access tracks will be used wherever possible, to reduce the need for additional clearing.	Negligible
5. Is the activity likely to introduce noxious weeds, vermin, feral species or genetically modified organisms into an area?	The disturbance of topsoil for construction of the water storage and pipeline has the potential to introduce and spread weeds. However the potential for weeds to significantly impact on surrounding native vegetation is low with the implementation of the proposed mitigation measures. The proposed activity will not introduce any genetically modified organisms into the site.	Negligible
<b>Community impacts</b>		
1. Is the activity likely to affect existing community services or infrastructure?	The proposed activity will have negligible adverse impacts on roads, power, water, drainage, waste management, or education, medical and social services. This is due to minor traffic generation associated with work and employee vehicles, provision of independent power supply at each drill site, the small volumes of water potentially drawn from the local water supply, the minor alterations to drainage paths at the wells, the minor amounts of waste generation and the small workforce associated with the exploration activities.	Low adverse
2. Is the activity likely to affect economic factors?	No significant adverse socio-economic impacts will arise from the proposed activity due to its limited scale and short duration. There will be some minor positive impacts associated with short term employment for local contractors and accommodation, food and entertainment expenditure by non-local contractors for the duration of the exploration activities.	Positive
3. Is the activity likely to cause a bushfire risk?	An ERP will be developed that details specific safety procedures in the event of a fire or bushfire. Fire hazard at the site can be managed by herbicide application, mowing and grazing. In addition, inductions will inform all site personnel of fire prevention procedures.	Low adverse
4. Is the activity likely to cause impacts on the visual or scenic landscape?	Potential impacts are possible from flaring and due to moderate visibility of infrastructure to residents. Appropriate mitigation measures including complete enclosure of the flare will make visual impacts negligible.	Low adverse
<b>Natural resource impacts</b>		
1. Is the activity likely to result in the degradation of an area reserved for conservation purposes?	The proposed activity will not affect any areas reserved for conservation purposes.	Negligible
2. Is the activity likely to involve the use, wastage, destruction or depletion of natural resources including water, fuels, timber or extractive materials?	The proposed activity involves the use of groundwater, but not from beneficial aquifers used by the community. Soil will be disturbed for installation of activity infrastructure, however these impacts are considered temporary.	Low adverse
<b>Aboriginal and cultural heritage impacts</b>		
1. Will the activity disturb the ground surface or any culturally modified trees?	No culturally modified trees have been identified within the proposed activity footprint.	Negligible

**Table 13.1 Summary of impacts**

<b>Impacts</b>	<b>Response based on REF assessment</b>	<b>Impact level</b>
2. Does the activity affect known Aboriginal objects or Aboriginal places?	The proposed activity will not impact any identified Aboriginal sites.	Negligible
3. Is the activity located in areas where landscape features indicate the presence of Aboriginal objects?	The proposed activity is within 200 m of sensitive landscape features as identified in the due diligence guidelines (Avon River and Waukivory Creek). However, the proposed activity is in disturbed land and not expected to encroach on the creek valley.	Negligible
4. Can harm to objects or disturbance of landscape features be avoided?	Harm to known and discovered Aboriginal cultural heritage sites can be avoided. The proposed activity would be undertaken in accordance with the measures outlined in the EMP at Appendix E. The measures include marking/barricading Aboriginal cultural heritage sites, training field operations staff in Aboriginal heritage issues and management and continued consultation with traditional owners.  Impact avoidance and minimisation measures (Table 2.9) will be applied to avoid potential harm to unknown Aboriginal cultural heritage sites.	Negligible
5. Does the proposal affect areas subject to native title claims, indigenous land use agreements or joint management?	No native title claims, ILUAs or joint management arrangements have been identified as covering the study area and will not be affected by the proposed activity.	Negligible
<b>Historic cultural heritage impacts</b>		
1. What is the impact on places, buildings, landscapes or moveable historic heritage items?	No historic heritage sites were identified in the area and no additional measures apart from those outlined in the REF and EMP are required to be implemented.	Negligible
2. Is the proposal likely to impact on matters of national environmental significance under the Environmental Protection and Biodiversity Conservation Act 1999?	Significant impacts are not expected to any matters of national environmental significance including threatened species, populations, communities, Ramsar wetlands or listed heritage items. The Australian heritage database identified the Stroud Gloucester Valley as being of significance as a nominated place for the National heritage list. At this stage, the Minister has not formed an opinion that the area meets the criteria for listing. Therefore, for this assessment it has not been considered a matter of national environmental significance (MNES). Negative impacts to the scenic qualities of the valley are not inconsistent with existing agricultural land uses.	Low adverse

**Table 13.2 Assessment outcomes with regards to Clause 228 of the EP&A Regulation**

<b>Factors that must be taken into consideration</b>	<b>Assessment of the proposed activity</b>
<b>(1) For the purposes of Part 5 of the Act, the factors to be taken into account when consideration is being given to the likely impact of an activity on the environment include:</b>	
(a) for activities of a kind for which specific guidelines are in force under this clause, the factors referred to in those guidelines, or	The activity is a petroleum prospecting (exploration) activity subject to assessment under Part 5 (and has not been approved under Parts 3A or 4). The activity has been assessed in accordance with ESG2 guidelines and its draft supplement for petroleum prospecting, as well as the CoPs (fracture stimulation activities and well integrity).
(b) for any other kind of activity:	N/A
<i>(i) the factors referred to in the general guidelines in force under this clause, or</i>	N/A
<i>(ii) if no such guidelines are in force, the factors referred to subclause (2)</i>	The proposed activity has been assessed in accordance with the guidelines and the factors referred to in the subclause (2) as indicated below.
<b>(2) The factors referred to in subclause (1) (b) (ii) are as follows:</b>	
(a) any environmental impact on a community,	The proposed activity was assessed in Chapter 8 and found to result in low adverse to positive impacts.  The proposed activity will be short-term and can co-exist with existing agricultural practices and will result in minimal transformation to the locality.
(b) any transformation of a locality,	The proposed activity is complementary to the current landuse of the locality and is temporary. Section 2.8 describes proposed rehabilitation activities and rehabilitation objectives.
(c) any environmental impact on the ecosystems of the locality,	Negligible biological impacts were assessed to result from the proposed activity.
(d) any reduction of the aesthetic, recreational, scientific or other environmental quality or value of a locality,	A visual and scenic assessment (Section 8.7) was undertaken and assessed the proposed activity would have low adverse impacts and be short term. Nature heritage assessment (Section 9.2) concluded that the Stroud Gloucester Valley would also not be significantly affected by the proposed short-term activity.
(e) any effect on a locality, place or building having aesthetic, anthropological, archaeological, architectural, cultural, historical, scientific or social significance or other special value for present or future generations,	Aboriginal and cultural heritage impacts have been assessed in Chapter 10. The assessment found the proposed activity will result in negligible impacts on aboriginal cultural heritage and negligible impacts on places, buildings, landscapes or moveable historic heritage items.
(f) any impact on the habitat of protected fauna (within the meaning of the NPW Act),	The biological impacts of the proposed activity are assessed in Chapter 7. As the proposed activity will occur in previously disturbed or cleared areas negligible impacts are expected on the habitat of protected fauna. Negligible impacts are expected (if any) to any matters of national environmental significance including threatened species, populations, communities or Ramsar wetlands.

**Table 13.2 Assessment outcomes with regards to Clause 228 of the EP&A Regulation**

<b>Factors that must be taken into consideration</b>	<b>Assessment of the proposed activity</b>
(g) any endangering of any species of animal, plant or other form of life, whether living on land, in water or in the air,	The proposed activity will include several security and safety measures (ie telemetry system and SDV geophone/VWP) with regard to the environment and community. Further, a HHERA was undertaken and in accordance with relevant risk assessment methodologies to inform the proposed activities. The implementation of these safeguards as well as the ERP will ensure the appropriate and necessary requires levels of safety to the environment and community.
(h) any long-term effects on the environment,	Physical and chemical impacts of the proposed activity including soil quality and land stability, water bodies, coastal processes, flooding, chemical use, waste and emissions and noise and vibration were discussed and assessed in Chapter 6. The impact level was assessed as negligible to low adverse.
(i) any degradation of the quality of the environment,	A visual and scenic assessment (Section 8.7) was undertaken and assessed the proposed activity would have low adverse impacts and be short term. Nature heritage assessment (Section 9.2) concluded that the Stroud Gloucester Valley would also not be significantly affected by the proposed short-term activity.
(j) any risk to the safety of the environment,	The proposed activity will include several security and safety measures (ie telemetry system and SDV geophone/VWP) with regard to the environment and community. Further, a HHERA was undertaken and in accordance with relevant risk assessment methodologies to inform the proposed activities. The implementation of these safeguards as well as the ERP will ensure the appropriate and necessary requires levels of safety to the environment and community.
(k) any reduction in the range of beneficial uses of the environment,	Community impacts including community services and infrastructure and visual and scenic impacts were assessed in Chapter 8. The proposed activity will have low adverse to positive impacts on beneficial uses of the environment by the community.
(l) any pollution of the environment,	The disposal of wastes and emissions including flowback water is addressed in Section 6.6 and Section 6.7 respectively. Risks to human health and the environment were considered to be negligible to low adverse.
(m) any environmental problems associated with the disposal of waste,	As above.
(n) any increased demands on resources (natural or otherwise) that are, or are likely to become, in short supply,	Impacts on community resource use is addressed in Section 9.2 and will have negligible adverse impacts on roads, power, water, drainage, waste management, or education, medical and social services.
(o) any cumulative environmental effect with other existing or likely future activities.	Cumulative impacts have been addressed in Chapter 12 and were found to have a negligible to low adverse impact.



## 14 Conclusions

This REF has been prepared in accordance with the ESG2 guidelines and its supplement.

AGL has sought to avoid adverse impacts on the natural environment and communities to the fullest extent practicable. Where avoidance was not possible, best practice environmental safeguards and mitigation strategies have been applied to minimise potential impacts.

Following the implementation of the mitigation strategy and the EMP, all impacts for the proposed activity are expected to be negligible to low adverse, as summarised below:

- physical and chemical impacts – water management plans have been prepared for water management (see SWGMP). Impacts to beneficial aquifers are not expected as there is unlikely to be a vertical connection between shallow alluvial and deeper target coal seam water bearing zones however this connectivity issue is one of the issues to be addressed by the flow testing program. A SWGMP (Appendix D) has been developed to guide the monitoring of groundwater levels and quality at the Waukivory site;
- biological impacts – the proposed activity is in a highly modified environment largely cleared of native vegetation and revegetated with introduced pasture species and used for the grazing of stock over a considerable number of years. Potential impacts on native vegetation, threatened species, populations and communities are considered to be negligible;
- community impacts – bushfire risk is considered to be minor due to the consideration of the LMZ and the preparation of an ERP. Visual impacts are considered minor due to the level of screening from surrounding vegetation and topography, and measures including temporary barriers to prevent glow from the flare at night. Only minor impacts to traffic will occur on local roads. Groundwater contamination risk is considered to be low;
- natural resource impacts – the proposed activity will not affect any reserved conservation areas. The proposed activity involves the use of groundwater, but not from beneficial aquifers used by the community. Soil will be disturbed for installation of activity infrastructure, however these impacts are considered temporary;
- Aboriginal and cultural heritage impacts – no culturally modified trees, Aboriginal objects or places, landscape features will be disturbed for the proposed activities. The land is not subject to any native title claims or agreements;
- historical cultural heritage impacts – no European heritage sites will be impacted by the proposed activity; and
- MNES – none will be impacted by the proposed activity.

The proposed activity is not expected to result in any long-term adverse impacts upon the local environment or community. Both project specific and cumulative impacts will have a negligible to low adverse environmental impact. Significant impacts to the environment are not expected, and as such an EIS is not required. The proposed activity is considered unlikely to significantly impact threatened species, populations or critical habitat and as such a species impact statement is not required.



## References

---

AGL 2012, *Type B Appliance Approval in New South Wales*, prepared for AGL customers by AGL Energy Services

Australian Bureau of Agricultural and Resource Economics (ABARE) 2004, *Production systems, productivity and profit in the Australian dairy industry*, Prepared for Dairy Australia, Report No. 04.1

Australian Energy Regulator 2010, *State of the Energy Market 2010 Chapter 3: Natural Gas*, Australian Competition and Consumer Commission, Melbourne

AGL 2013, *Surface Water and Groundwater Management Plan for the Waukivory Pilot Testing Program – Gloucester Gas Project*, 15 April 2013

Australian and New Zealand Environment and Conservation Council (ANZECC) and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) 2000, *Australian and New Zealand Guidelines for Fresh and Marine Water Quality*, Australian Water Association, Artarmon

Bureau of Meteorology 2013, *Atlas of Groundwater Dependent Ecosystems*, [www.bom.gov.au/water/groundwater/gde](http://www.bom.gov.au/water/groundwater/gde), viewed 15 February 2013

Commonwealth of Australia 2001, *2000-2002 National Land and Water Resources Audit*, <http://www.anra.gov.au/topics/salinity/overview/nsw.html>, viewed 30 April 2013

Department of Environment and Climate Change and Water (DECCW) 1999, *Environmental criteria for road traffic noise*, Department of Environment and Climate Change and Water NSW, Sydney

Department of Environment and Climate Change and Water (DECCW) 2000, *NSW Industrial Noise Policy*, Department of Environment and Climate Change and Water NSW, Sydney

Department of Environment and Climate Change and Water (DECCW) 2009, *Interim Construction Noise Guideline*, Department of Environment and Climate Change and Water NSW, Sydney

Department of Environment, Climate Change and Water (DECCW) NSW 2010, *Due Diligence Code of Practice for the Protection of Aboriginal Objects in New South Wales*, Department of Environment, Climate Change and Water, Sydney

Department of Lands and Water Conservation (DLWC) 2002, *The NSW State Groundwater Dependent Ecosystem Policy: A Component Policy of the NSW Groundwater Policy Framework Document*, Department of Land and Water Conservation, Sydney

Department of Sustainability Environment Water Population and Communities (DSEWPoC) 2012, *EPBC Act Protected Matters Report*, created on 21 January 2013

Department of Trade and Investment Resources and Energy (DTIRE) 2012. *ESG2: Environmental Impact Guidelines: For exploration, mining and petroleum production activities subject to Part 5 of the Environmental Planning and Assessment Act 1979: Including content requirements for a Review of Environmental Factors (REF)*, Department of Trade and Investment Resources and Energy, March 2012, Sydney

Department of Trade and Investment Resources and Energy (TIRE) 2012, *Additional Part 5 REF requirements for petroleum prospecting: A supplement to ESG2: Environmental Impact Assessment Guidelines*, Department of Trade and Investment Resources and Energy, Sydney

Department of Energy and Resources (DRE) 2012, *Guideline for Agricultural Impact Statements at the Exploration Stage*, 2012

Department of Planning and Industries (DP&I) 2012, *Strategic Regional Land Use Policy*, NSW Department of Planning and Infrastructure, Sydney

Ecologically Sustainable Development (ESD) Steering Committee 1992, *National Strategy for Ecologically Sustainable Development*, Commonwealth Government, Canberra

EMGA Mitchell McLennan (EMM) 2011, *Proposed Exploration Well: Waukivory Review of Environmental Factors - Gloucester Shire*, prepared for AGL Upstream Investments Pty Ltd

EMGA Mitchell McLennan (EMM) 2013, *Hunter Gas Pilot Testing Project: Windermere, Review of Environmental Factors*, prepared for AGL Upstream Investments Pty Ltd

Environmental Risk Sciences (ERS) 2012, *Human Health and Ecological Risk Assessment – Hydraulic Fracturing Activities*, report to AGL Energy Limited

Gloucester Bushfire Management Committee (GBFMC) 2010, *Bush Fire Risk Management Plan*, Gloucester Bush Fire Management Committee

NSW Government 2012a, *Upper Hunter Strategic Regional Land Use Plan*, NSW Department of Planning and Infrastructure, Sydney

NSW Government 2012b, *Draft Code of Practice for Coal Seam Gas Extraction*, NSW Department of Planning and Infrastructure, Sydney

Parsons Brinckerhoff (PB) 2012, *Stage 1 Gas Field Development Area Gloucester Gas Project: Phase 2 Groundwater Investigations*, prepared for AGL Upstream Investments Pty Ltd

## Definitions, abbreviations and units of measure

---

### Definitions

Definition	Description
Alluvial aquifer	Permeable zones that store and produce groundwater from unconsolidated sediments. Shallow alluvial aquifers are generally unconfined aquifers.
Alluvium	Unconsolidated sediments (clays, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on river beds, floodplains and alluvial fans.
Anticline	A geological fold that has been uplifted such that its oldest beds are at its core.
Aquifer	Rock or sediment formation, group of formations or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water.
Aquitard	A low permeability unit that can store groundwater and also transmit it slowly from one aquifer to another. Aquitards retard but do not prevent the movement of water to or from an adjacent aquifer.
Australian height datum	The reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.
Beneficial aquifer	An aquifer that contains groundwater of sufficient quantity and quality to be used for a variety of consumptive uses.
Bore	A structure drilled below the surface to obtain water from an aquifer or series of aquifers.
Cation exchange capacity.	The measure of a soil's ability to exchange and retain cations.
Central flare	Facility where gas will be tested to an enclosed flare.
Coal measures	The coal-bearing part of the rock strata.
Coal seam	A layer of coal within a sedimentary rock sequence.
Coal seam gas	A form of natural gas (predominantly methane) that is extracted from coal seams.
Dangerous goods	Solids, liquids or gases that can harm people, other living organisms and the environment.
Dewatering	The process of removing formation water from a targeted coal seam so that gas flow is enhanced.
Drawdown	A lowering of the water table in an unconfined aquifer or the pressure surface of a confined aquifer caused by pumping of groundwater from bores and wells.
Endangered ecological community	Ecological community listed under the TSC and/or EPBC Acts.
Electrical conductivity or EC	A measure of a fluid's ability to conduct an electrical current and is an estimation of the total ions dissolved, expressed in microseimens per cm ( $\mu\text{S}/\text{cm}$ ) or EC Units.
Exploration well	Wells previously drilled and suspended at the Waukivory Pilot.
Flaring	The gas testing process.
Floodplain	The flat land adjacent to a stream or river that stretches from the banks of its channel to the base of the enclosing valley walls and experiences flooding during periods of high discharge.
Flowback	The process of allowing fluids to flow from a gas well following a treatment, either in preparation for a subsequent phase of treatment, or in preparation for cleanup and returning to well to production.
Flowback water	The water injected into the coal seam during hydraulic fracture stimulation that is recovered during dewatering.
Fractured rock aquifer	These occur in sedimentary, igneous and metamorphosed rocks which have been subject to disturbance, deformation or weathering, and which allow water to move through joints, bedding planes, fractures and faults. Although fractured rock aquifers are found over a wide area, they generally contain much less groundwater than alluvial and porous sedimentary aquifers.
Gigajoule	A gigajoule (GJ) is equal to one billion joules. Joules are a unit of energy.

## Definitions

Definition	Description
Groundwater	The water contained in interconnected pores below the water table in an unconfined aquifer or at depth in a confined aquifer.
Hydraulic fracture stimulation	A fracture stimulation technique that increases a gas well's productivity by creating a pathway into the targeted coal seam. This is done by injecting fluids and sand through the perforated interval, directly into the coal seam under high pressure.
Irrigability	A measure of the ability of soil to accept applied water.
Migratory species	Species listed as migratory under the EPBC Act.
Monitoring bore	A non-pumping bore used to measure the elevation of the water table and/or water quality. Monitoring bores generally have a short well screen against a single aquifer through which water can enter.
Monocline	A step-like fold in a rock stratum.
Petajoules	A petajoule (PJ) is equal to $10^{15}$ joules, which are a unit of energy.
pH	Potential of Hydrogen. It provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where seven is neutral, greater than seven is alkaline and less than seven is acidic).
Proppant	Natural sand or synthetic high strength particles used in hydraulic fracture stimulation to fill the fracture space and hold the fracture open during pilot testing.
Pilot test well	The exploration wells that will be fracture stimulated and then pilot tested.
Pilot testing	A program to identify the viability of coal seam gas reserves in an area.
Produced water	Natural groundwater generated from coal seams during pilot testing.
Recharge	The process which replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table or by river water reaching the water table. The addition of water to an aquifer.
Rehabilitation	Returning the land to pre-activity conditions.
Review of Environmental Factors	Environmental assessment prepared under Part 5 of the EP&A Act.
Salinity	The concentration of dissolved salts in water or salt content in soils, usually expressed in EC units.
Sediment	A naturally occurring material that is broken down by weathering and erosion, and is transported by wind or water.
Sodicity	A measure of the exchangeable sodium percentage in soil.
Stratigraphic hole	A borehole drilled to obtain a detailed record of the character and composition of the target rock formation.
Supervisory control and data acquisition system	AGL's remote monitoring and control system for the pilot wells.
Suspended well	A well in which drilling operations has temporarily discontinued with the intention to return at a later date. This occurs due to operations constraints on the surface location.
Threatened ecological community	An ecological community listed as vulnerable or endangered under the TSC Act and/or EPBC Act.
Threatened population	A population of a species listed under the TSC Act
Threatened species	A species listed as vulnerable or endangered, or critically endangered under the TSC Act and/or EPBC Act.
Total suspended solids	A measure of the suspended solids in water.
Water bearing zone	Geological strata that are saturated with groundwater, but not of sufficient permeability to be called an aquifer.
Water table	The top of an unconfined aquifer. It is at atmospheric pressure and indicates that level below which soil and rock are saturated with water.

## Definitions

Definition	Description
Water quality	A term used to describe the chemical, physical and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Well	A pilot test well or gas production well.
Wellbore	A hole that is drilled to aid in the exploration and recovery of natural resources including oil, gas or water. A wellbore is the actual hole that forms the well, and can be encased by materials such as steel and cement.
Wellhead	The component at the surface of the pilot test well that provides a structural and pressure-containing interface for the testing equipment.
Zonal isolation	Isolating an interval or unit of rock from surrounding rock types on the basis of its lithology or other features such as faults or fractures.

## Abbreviations

Abbreviation	Expansion
AHIMS	Aboriginal Heritage Information Management System
APZ	Asset protection zone
AHD	Australian Height Datum
AGL	AGL Upstream Investments Pty Ltd
AIP	<i>NSW Aquifer Interference Policy</i>
asl	Above sea level
ASS	Acid Sulfate Soil
AWS	Automatic Weather Station
CBL	Cement Bond Logs
CEC	Cation exchange capacity
CIC	Critical industry Cluster
CMA	Catchment Management Authority
CoP - fracture stimulation activities	NSW Code of Practice - fracture stimulation activities
CoP – well integrity	NSW Code of Practice - well integrity
CSG	Coal seam gas
DCCEE	Commonwealth Department of Climate Change and Energy Efficiency
DTIRIS – DRE	NSW Department of Trade and Investment, Regional Infrastructure and Services – Division of Resources and Energy
DSEWPaC	Department of Sustainability Environment Water Population and Communities
ECRTN	Environmental Criteria for Road Traffic Noise
EEC	Endangered ecological community
EIS	Environmental impact Statement
EMM	EMGA Mitchell McLennan
EMP	Environmental Management Plan
EPA	Environment Protection Agency
EP&A Act	<i>NSW Environmental Planning and Assessment Act 1979</i>
EP&A Regulation	<i>NSW Environmental Planning and Assessment Act Regulation 2000</i>
EPBC Act	<i>Commonwealth Environment Protection and Biodiversity Conservation Act 1999</i>

## Abbreviations

Abbreviation	Expansion
ERP	Emergency Response Plan
ERS	Environmental Risk Sciences
ESD	Ecologically sustainable development
ESG2 guidelines	ESG2: Environmental Impact Assessment Guidelines for exploration, mining, and petroleum production activities subject to Part 5 of the EP&A Act
FSMP	Fracture Stimulation Management Plan
GDE	Groundwater Dependent Ecosystems
GHG	Greenhouse gas
GGP	Gloucester Gas Project
HDPE	High density polyethylene
HHERA	Human health and Ecological Risk Assessment
HSE	Health Safety and Environment
ILUA	Indigenous Land Use Agreements
LEP	Local Environmental Plan
LMZ	Land Management Zone
MNES	Matter of national environmental significance
MSDS	Material safety data sheets
NPW Act	<i>NSW National Parks and Wildlife Act 1974</i>
NOW	NSW Office of Water
OC	Organic carbon
OCSG	NSW Office of Coal Seam Gas
OEH	Office of the Environment and Heritage
ORP	Oxygen Reduction Potential (tendency of a subsidence to acquire electrons and therefore be reduced, expressed in milli-volts (mV))
PEL	Petroleum exploration licence
PO Act	<i>Petroleum (Onshore) Act 1991</i>
POEA Act	<i>NSW Protection of the Environment Administration Act 1991</i>
POEO Act	<i>NSW Protection of the Environment Operations Act 1997</i>
RBL	Rating Background Level
REF	Review of Environmental Factors
RMS	NSW Roads and Maritime Services
RO	Reverse osmosis
SAL	Strategic Agricultural Land
SCADA	Supervisory control and data acquisition system
SDV	Shut down valve
SWGMP	Surface Water and Groundwater Management Plan
SRLUP	Strategic Regional Land use Plan
TEC	Threatened ecological communities
TDS	Total dissolved solids
TSC Act	<i>NSW Threatened Species Conservation Act 1995</i>
TSS	Total suspended solids
VOC	Volatile Organic Compounds
VWP	Vibrating wire piezometer
WMA	<i>NSW Water Management Act 2000</i>



## Units of measurement

Unit	Description
° C	Degrees Celsius
µPa	Micropascal
µS/cm	Microsiemens per centimetre
dBA	Decibel A filter
EC	Electrical conductivity units
KL	Kilolitres
L	Litre
L/s	Litres per second
LA1	The level exceeded for 1% of the time
LA10	The level exceeded for 10% of the time
LA90	Background noise level
LAeq	The notional steady sound level
LAmx	Weighted sound pressure level over a specific time period
m	Metres
mBGL	Metres below ground level
mg/L	Milligrams per litre
ML	Megalitres
mm	Millimetres
mm/hr	Millimetres per hour







[www.emgamm.com](http://www.emgamm.com)

**SYDNEY**  
Ground Floor, Suite 1, 20 Chandos Street  
St Leonards NSW 2065  
T 02 9493 9500 F 02 9493 9599

**NEWCASTLE**  
Level 1, 6 Bolton Street  
Newcastle NSW 2300  
T 02 4927 0506 F 02 4926 1312

**BRISBANE**  
Suite 1, Level 4, 87 Wickham Terrace  
Spring Hill Queensland 4000  
T 07 3839 1800 F 07 3839 1866