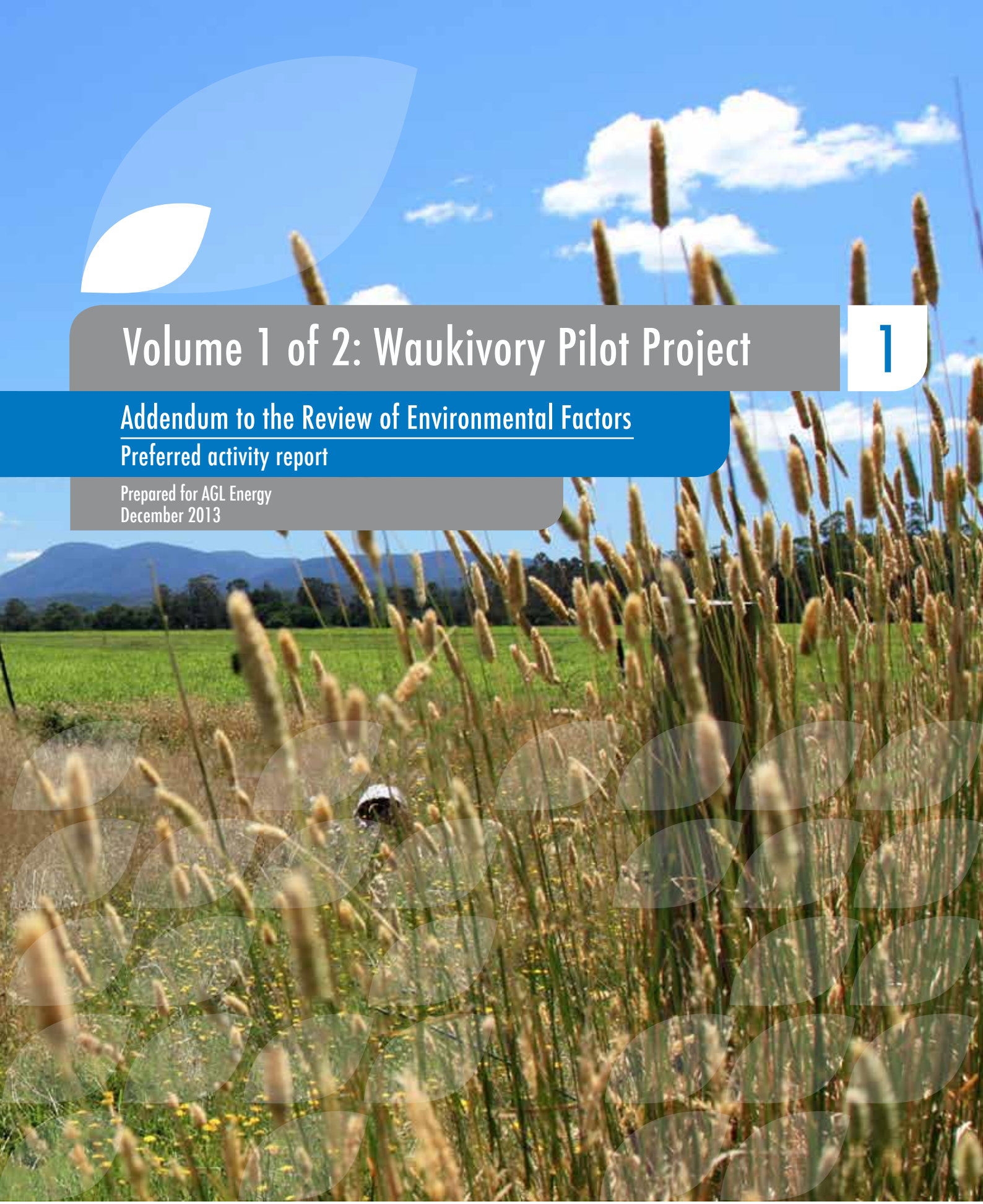

Volume 1 of 2: Waukivory Pilot Project

1

Addendum to the Review of Environmental Factors

Preferred activity report

Prepared for AGL Energy
December 2013

AGL Energy in action.

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Volume 1 of 2:
Waukivory Pilot Project – Addendum to the Review of Environmental Factors
PAR Chapters 1 to 12

Volume 2 of 2:
Waukivory Pilot Project – Addendum to the Review of Environmental Factors
PAR Appendix A to E

Addendum to Review of Environmental Factors

Preferred Activity Report | Waukivory Pilot Project

Prepared for AGL Upstream Investments Pty Ltd | 5 December 2013

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Addendum to Review of Environmental Factors

Final

Report J13005RP2 | Prepared for AGL Upstream Investments Pty Ltd | 5 December 2013

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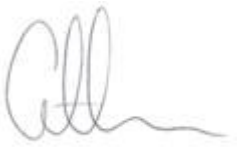
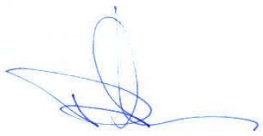
Signature			Signature	
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1 Introduction

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 is the fracture stimulation and pilot testing of four existing vertical exploration wells. The proposed activity is called '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. The activity will be temporary with the wells suspended and the surplus land rehabilitated to its pre-existing state at completion of the activity.

1.2 Activity application

An activity application supported by a review of environmental factors (REF) for the Waukivory Pilot was submitted to the Department of Trade and Investment, Regional Infrastructure and Services – Office of Coal Seam Gas (OCSG) on 30 September 2013 under Part 5 of the *Environmental Planning and Assessment Act 1979* (E&A Act). The REF was prepared in accordance with *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. The OCSG will be responsible for administering the activity approval under the EP&A Act, should it be granted.

The REF assessed different options for the location of ancillary infrastructure for the proposed activity, depending upon operational needs at the time of construction. This preferred activity report (PAR) presents the preferred option, called the 'preferred activity' and is an addendum to the REF.

The potential environmental impacts of the preferred activity were assessed in the REF, including measures to minimise potential impacts. The PAR presents information from the REF relevant to the preferred activity only, including a description of preferred activity, its methods and environmental assessment. Additional information requested by OCSG, Environment Protection Authority (EPA), Office of Environment and Heritage (OEH) and NSW Office of Water (NOW) about the preferred activity is also included.

The broader Gloucester Gas Project (GGP) is approved under Part 3A of the EP&A Act and 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 preferred activity is not part of those approvals.

1.3 Agency requests for information

Following lodgement of the activity application and supporting REF, OCSG received submissions from the EPA, OEH and NOW and requested that the PAR address particular matters raised. Table 1.1 summarises the information request and provides a section reference for where they are addressed.

Table 1.1 Agency requests for information

Agency	Request summary	Section of this PAR
OCSG	The REF refers to a number of options for consideration. OCSG is unable to assess options [sic] and requires that the proponent commits to a specified preferred activity and that specific assessment information is provided for this activity.	Addressed throughout the PAR
	The Waukivory Pilot relies on Tiedmans Irrigation Trial project for re-use of produced water. OCSG requests information on what is intended to occur with produced water once Tiedmans Irrigation Trial approval expires or if the continuation of the Tiedmans Irrigation Trial proves unfeasible.	Section 2.7
	Additional project details should be supported by maps and diagrams where appropriate to more clearly illustrate and explain the project.	Addressed throughout the PAR
	Standards, methods, procedures, environmental risks and mitigation measures proposed are required for the preferred activity.	Section 2.9
	Traffic management plan for trucking flow back water to a licensed facility.	Section 2.7.2 and Section 2.9
	Additional information relating to the risk of floodplain obstruction and flood contingency management at WK12 and WK 14 and associated impacts.	Section 2.9 and Section 4.4
OEH	Revise assessment and mitigation measures to prevent the mixing of produced water and flood waters across the sites should flooding occur.	Section 2.9 and Section 4.4
	Revise the risk assessment in the REF given the issues and information provided in OEH's letter.	Section 2.9 and Section 4.4
	Commit to adaptive management to prevent environmental harm should there be any groundwater drawdown.	Section 2.7.4 and Section 4.3
NOW	Invest in broader spatial data collection that reflects the likely distribution of the depressurisation impacts. This would include investigating the steeply dipping coal strata to the east of bores WK12 and WK14 and within the same seams that will be subject to fracture stimulation and flow testing. This shall include monitoring of pressure and groundwater quality effects in shallower strata and close to land [sic] the surface.	Section 2.7.4
	Revisit options and commit to the collection of water quality data throughout the flow testing period such as time series loggers for salinity, temperature, pH etc.	Section 2.7.4
	Further monitoring to understand the variance in water quality parameters may be required prior to the activity commencing.	
	Define the final return water flow flowback volume at 100 % of the fracture simulation fluid used at each well.	Section 2.7.4
EPA	Provide information on what will occur with produced water once the Tiedmans Irrigation Trial approval ceases in July 2014.	Sections 2.2 and 2.7.3
	Outcropping of coal seams and potential for fugitive emissions - what, if any, risks may result at the outcropping from the dewatering of the seam.	Section 4.6
	Surface management of hydraulic fracturing fluids and flowback water - provide clarification to address the following points: • additive toxicity risks to surface waters due to potential combinations of undiluted chemicals related to handling, storage and mixing methods;	Section 4.5

Table 1.1 Agency requests for information

Agency	Request summary	Section of this PAR
	• assistive/antagonistic effects in made-up fracture fluid, taking into account the quality of source water, in particular if sourced from existing dams containing CSG exploration water; and • an overview of mixing methods of chemicals to clarify potential risks and mitigation options.	
	Provide comparative assessment of the requirements of the NSW Road Noise Policy vs the Environmental Criteria for Road Traffic Noise as they apply to the Waukivory Pilot's impacts.	Section 4.7

2 Description of preferred activity

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

2.1 Overview

The REF assessed different options for the location of ancillary infrastructure for the Waukivory Pilot. The preferred activity (being the preference of the options presented in the REF) includes:

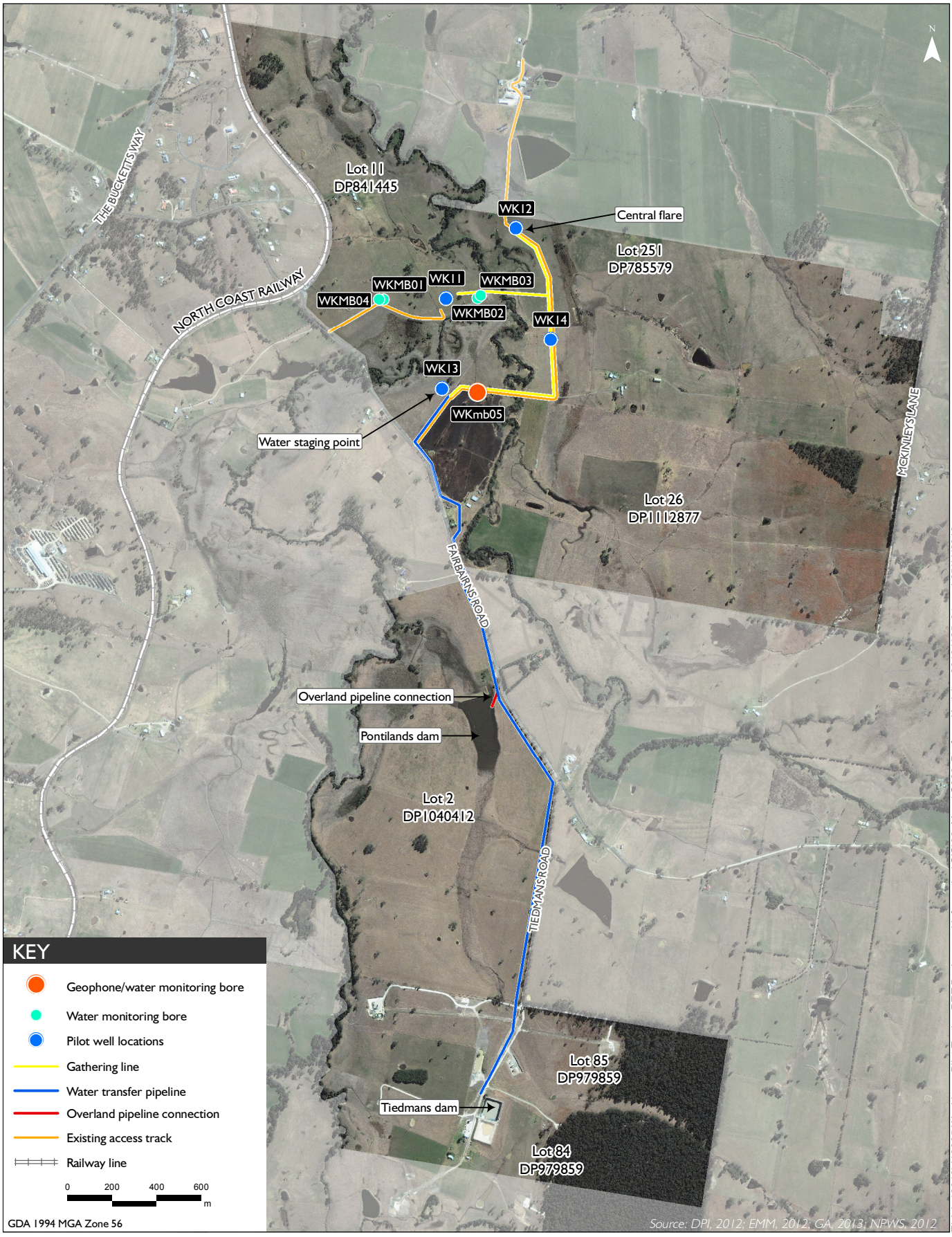
- conversion of four existing exploration wells (WK11, WK12, WK13 and WK14) to pilot wells using perforation and fracture stimulation techniques;
- pilot testing of the four wells;
- construction of a water storage area at WK13 for flowback and produced water, called the 'water staging point';
- construction of a buried water pipeline and water and gas gathering lines;
- construction of an enclosed central gas flare at WK12;
- delivery of equipment (and water) to undertake the activity;
- lawful disposal of flowback water;
- lawful re-use or 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.

Each of the elements of the preferred activity listed above were described and assessed in the REF.

The location of infrastructure, including pilot wells, water and gas gathering lines, water pipeline and central flare for the preferred activity is shown on Figure 2.1.

A central flare will be constructed at WK12 (which was assessed in the REF). Gas gathering lines will connect the flare with each of the pilot wells (see Figure 2.2). The central flare at WK12 would be used 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.

A water pipeline will be required to transport water from two nearby dams, Tiedmans dam and Pontilands dam (on land owned by AGL) to WK13 for use as source water for fracture stimulation activities. Produced water from the water staging point at WK13 will be transferred via the same pipeline to the Tiedmans dam for beneficial re-use.



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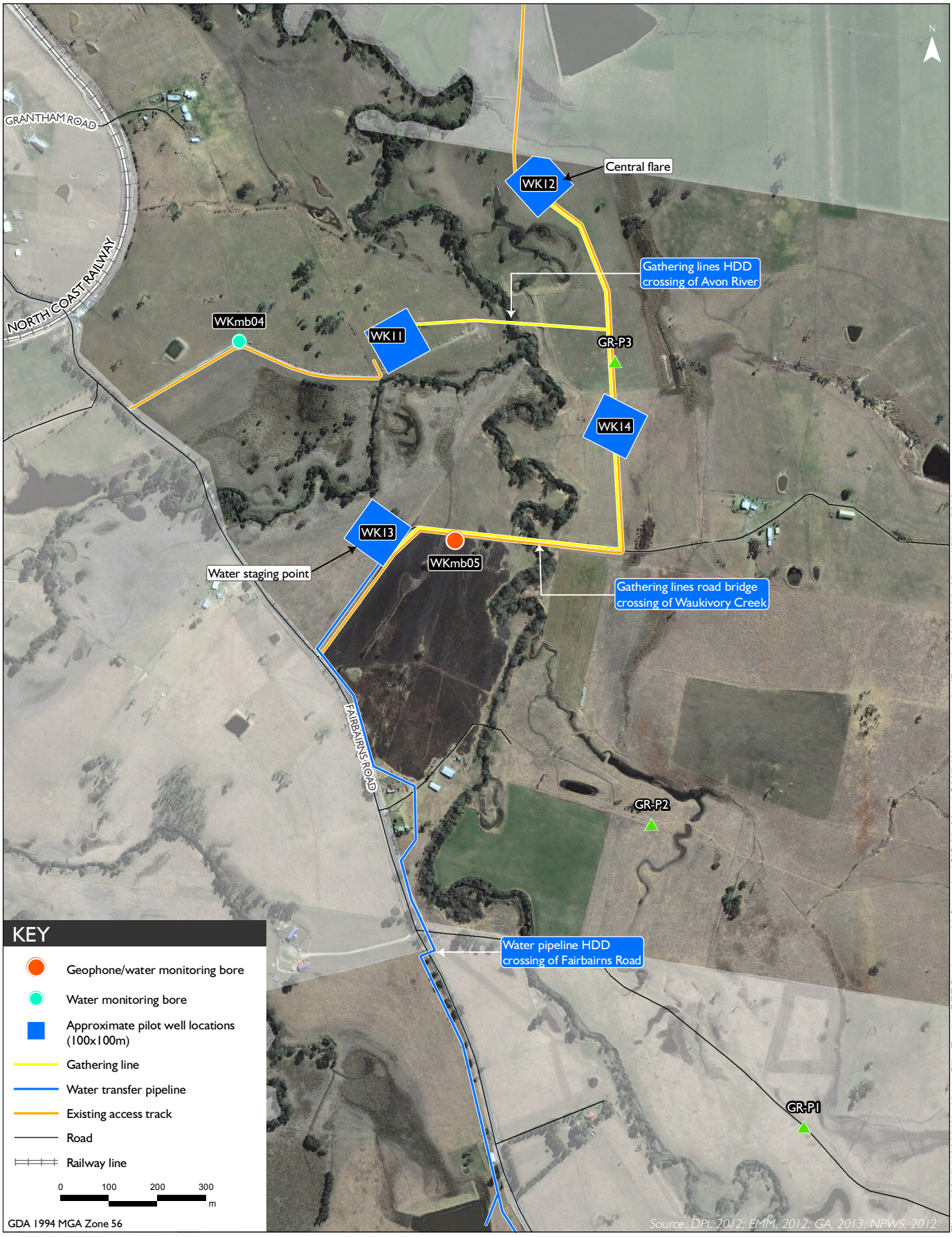
Proposed layout for preferred activity

Addendum to the Review of Environmental Factors
Waukivory Pilot Project

Figure 2.1



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Location of watercourse and road crossings

Addendum to the Review of Environmental Factors
Waukivory Pilot Project

Figure 2.2

Underboring of the Avon River will be required for gathering lines (water and gas) to connect WK11 with the water staging point at WK13, and WK11 with 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.

2.2 Activity footprint

As described in Section 2.8.2 of the REF, the footprint of the preferred activity includes:

- an area of 100 x 100 m (footprint previously assessed by EMM (2011)) surrounding each of the four pilot wells (see Figures 2.3, 2.4 and 2.5);
- a water staging point comprising a double-lined, dual compartment turkeys nest dam constructed at WK13 with a footprint of 30 x 40 m within the overall 100 x 100 m pilot well footprint (see Figure 2.3);
- water gathering lines connecting WK11, WK12, WK13 and WK14 to the water staging point at WK13, for the transfer of flowback and produced water from wells to the water staging point (see Figure 2.2);
- a water pipeline from the water staging point at WK13 to Tiedmans dam buried to a depth of between 450 mm to 1,000 mm for a distance of approximately 3.5 km (see Figure 2.1). The pipeline will traverse the Waukivory Pilot site and other AGL-owned properties, and include an underbored crossing of Fairbairns Road (see Figure 2.2), and an overland connection approximately 70 m long to Pontilands dam (for source water); and
- gas gathering lines (co-located with water gathering lines) connecting WK11, WK12, WK13 and WK14 (see Figure 2.2) to the central flare at WK12. The central flare at WK12 will have a footprint of 10 x 10 m within the overall 100 x 100 m area (see Figure 2.4), and be connected to the four pilot wells by gas gathering lines.

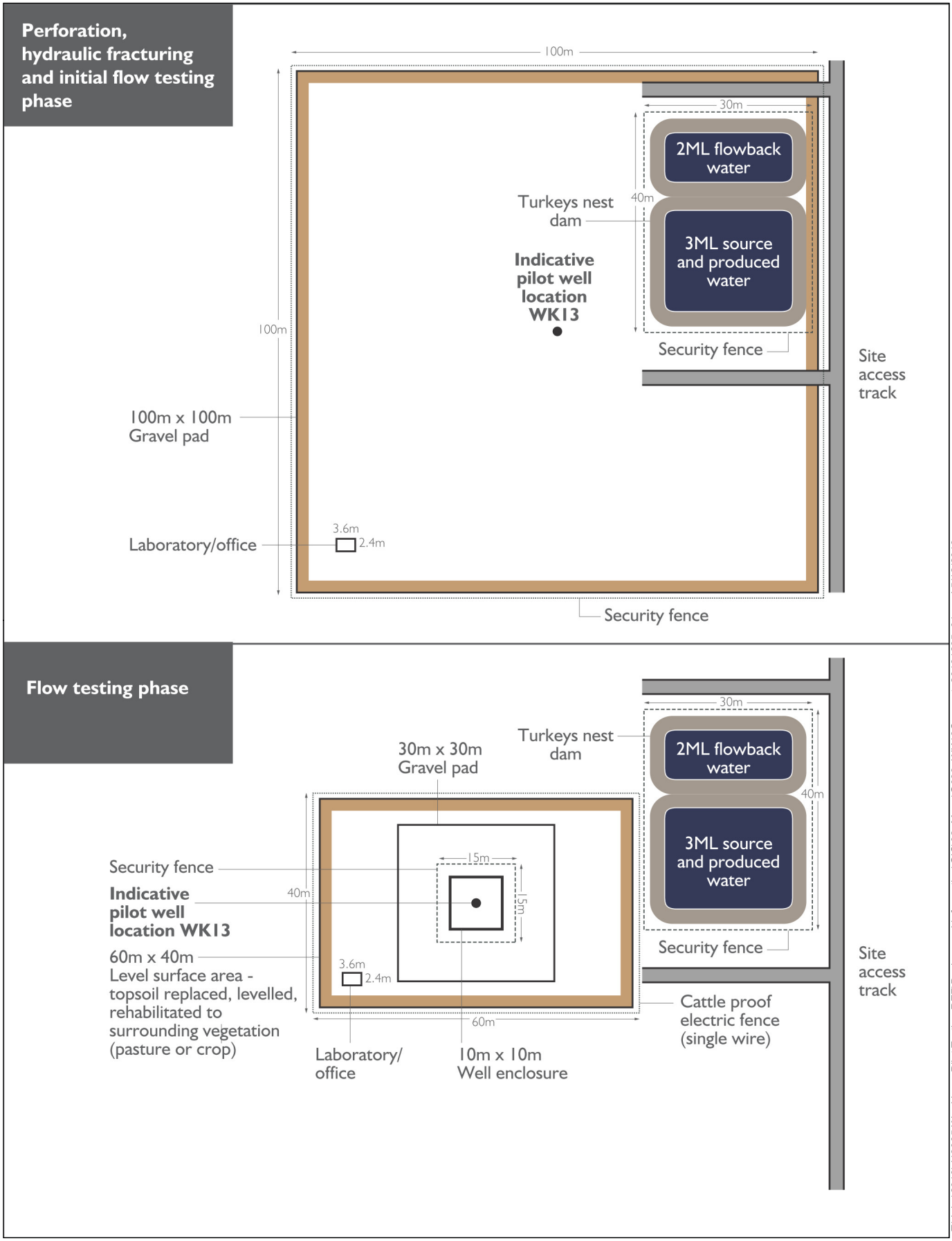
The dam at the water staging point will receive flowback and produced water (stored in separate compartments) from each of the four wells via the water gathering lines (see Figure 2.3).

Flowback water will be collected by truck from the water staging point for lawful disposal at an appropriate facility. Truck movements will be scheduled to ensure minimal disruptions to the local road network. The impact of these truck movements on traffic and local roadways are assessed in Section 6.1.

Produced water stored at the water staging point will eventually be transported by water pipeline from the water staging point to the Tiedmans dam. The proposed water pipeline between the water staging point at WK13 and the Tiedmans property is illustrated in Figure 2.1. A total of 6 megalitres (ML) of source water will be sourced from the Pontilands dam and Tiedmans dam and be transferred to the water staging point via the water pipeline.

Some minor levelling activities will occur on the pad in the vicinity of the wells to ensure stability of equipment and plant as described in Section 2.8.2 of the REF.

Once the produced water from the wells has reduced in volume, the lined pit will be removed and rehabilitated and replaced by an onsite storage tank.



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WK13 conceptual site layout
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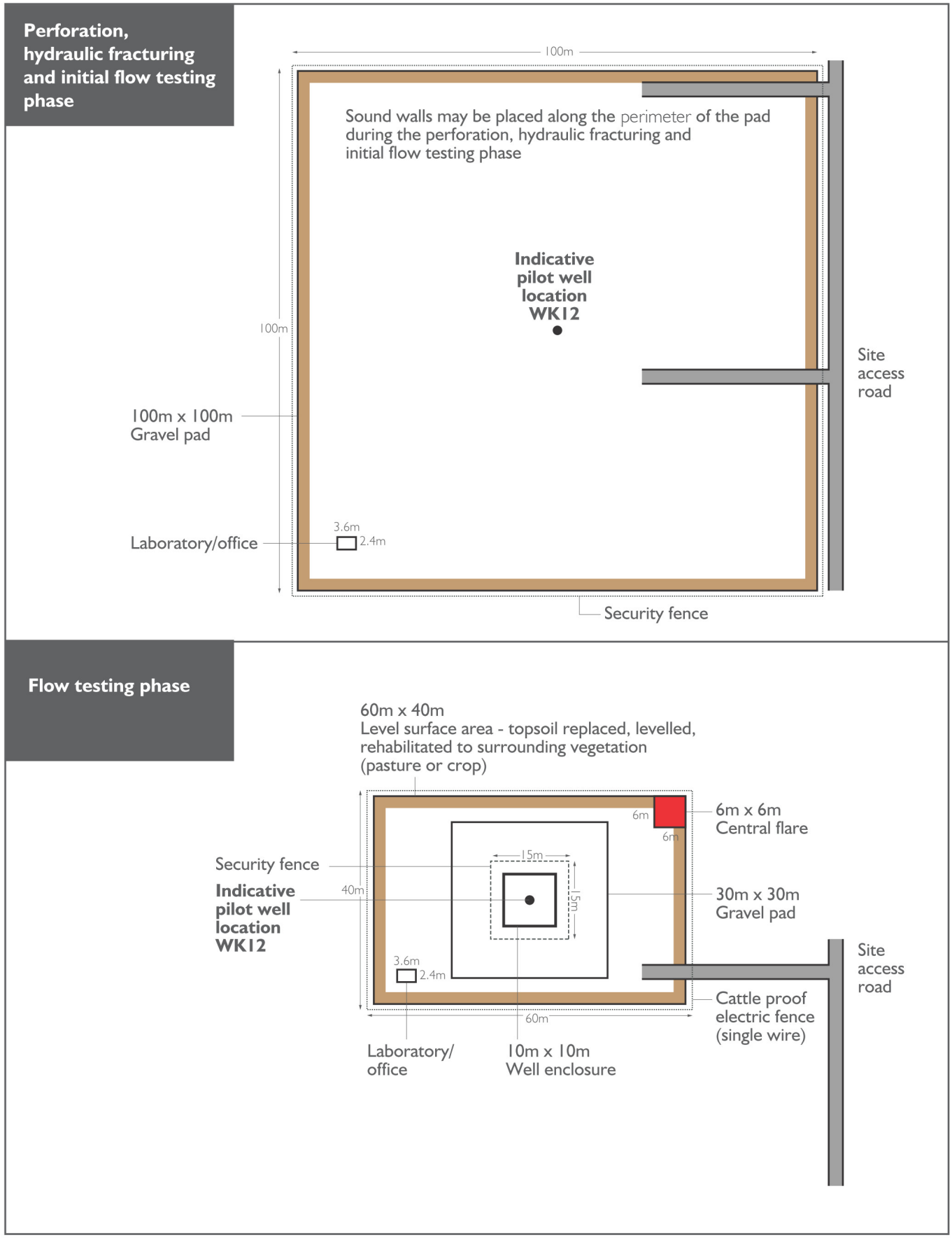
Waukivory Pilot Project
Figure 2.3



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WK12 conceptual site layout

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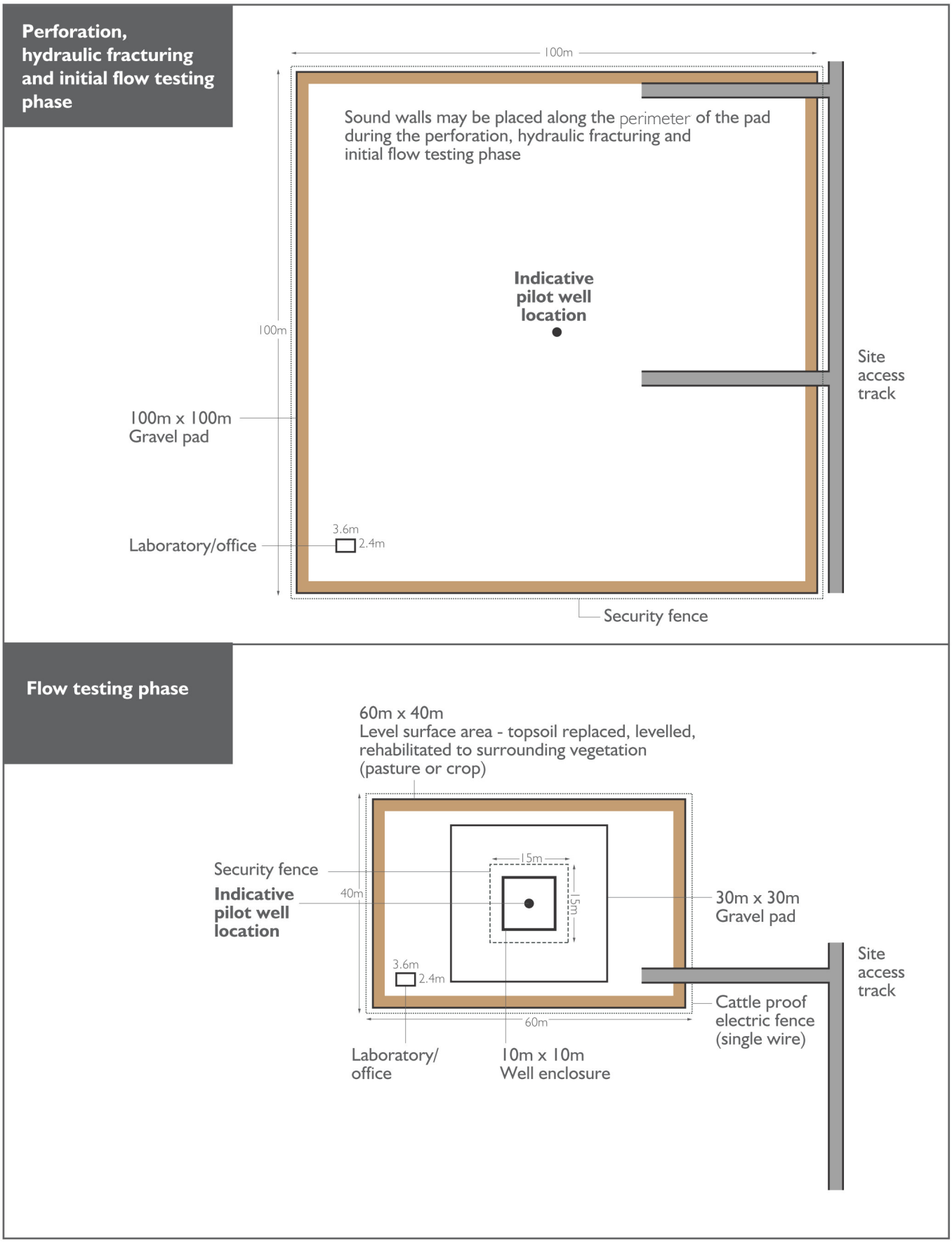
Waukivory Pilot Project

Figure 2.4



WK11 and WK14 conceptual site layout

Addendum to the Review of Environmental Factors
Waukivory Pilot Project

Figure 2.5

AGL proposes to re-use a portion of the produced water for irrigation of crops at the Tiedmans property (owned by AGL), provided the irrigation water achieves prescribed water quality criteria as outlined in the approved Water Management Plan for the Tiedmans Irrigation Trial (DTIRIS-Division of Resources and Energy (DRE) in 2012). The transportation of produced water from the water staging point at WK13 by pipeline to the Tiedmans property has been assessed as part of the REF. The on-site use of that produced water on the Tiedmans property, its storage, blending and irrigation activities (described below) will be subject to the conditions of the existing, separate Part 5 approval (already granted to July 2014) for the Tiedmans Irrigation Trial. On 5 November 2013, AGL lodged an application with the OCSG requesting an extension of the approval granted for the Tiedmans Irrigation Trial for another 24 months from July 2014.

Fencing would be installed for security of each of the compounds and the turkeys nest dam at the water staging point.

2.3 Works timetable, scheduling and milestones

The works timetable, schedule and milestones are as described in Section 2.8.3 of the REF.

2.4 Hours of operation and employees

The hours of operation are as described in Section 2.8.4 of the REF.

2.5 Security

Security is as described in Section 2.8.5 of the REF.

2.6 Construction phase: site establishment

2.6.1 Water storage

The preferred activity will require the construction of a water staging point at WK13, which will minimise truck movements onsite and on the local road network. Water storage is required for flowback water, which is expected to occur immediately after the fracture stimulation program (and may flow back for several weeks or months), and produced water, which is natural groundwater generated from coal seams during flow testing and production dewatering.

The maximum volume of flowback water and produced water to be pumped for the four gas wells is 20 ML, comprising up to 6 ML of flowback water and 14 ML of produced water.

The dimensions of the turkeys nest dam at the water staging point will be approximately 30 x 40 m, with an excavated depth of up to 2 m. The height of the sides of the dam will be a minimum of 500 mm above the 1 in 100 year annual exceedance probability (AEP) flood level (see Figure 2.3).

During the perforation and hydraulic fracture stimulation phase, the dam will be within the 100 x 100 m footprint of WK13. During the flow testing phase, the dam will be within the reduced rehabilitated pad, which will be approximately 60 x 40 m level (see Figure 2.3).

The standard approach adopted by AGL to plan and design water storage dams is to approach a construction contractor such as the NSW Government owned Soil Conservation Service to undertake a design and construction plan for the dam.

The turkeys nest dam will be designed to have 500 mm freeboard above the 1 in 100 year AEP flood level. It will be double-lined with a geo-membrane liner separated by a high density polyethylene (HDPE) geonet membrane sheet for leak detection and collection. The double lining will cover the outside of the dam which will provide erosion protection in a flood event.

The construction process of the dam will generally involve:

- site survey and establishment of sediment and erosion control structures, including the installation of diversion channels upslope of the disturbance area to divert clean water around the works;
- remove and stockpile topsoil onsite (for later use in rehabilitation);
- undertake civil works involving excavators, bulldozers and dump trucks to excavate sub-soil from 'cut' area to 'fill' area;
- bulk earthworks to form dam structure and addition of any required soil ameliorants to achieve structural stability of the dam walls;
- compaction of bund walls and soils to achieve desired permeability;
- installation of liners (geo-membrane liner separated by a HDPE geonet membrane sheet);
- re-spreading of topsoil on 'cut' areas and dam wall;
- installation of security fencing around perimeter of the dam; and
- rehabilitation of disturbed areas surrounding the dam including replacement of topsoil and seeding with grasses as soon as practicable following construction to form a stabilised surface.

Sediment control measures will be monitored during the construction process to ensure their effectiveness. Soil disturbance will be minimised as far as practicable.

Once constructed, the dam will have a total capacity of approximately 5 megalitres (ML) (or 5,000 m^3) comprising:

- a 2 ML compartment for flowback water from the pilot test wells; and
- a 3 ML compartment for produced water from the pilot test wells during the flow testing period.

An operational freeboard of approximately 500 mm will be maintained in the turkeys nest dam at all times to allow for unexpected heavy rainfall. Should this freeboard level be reached, pumping of water to the dam will cease to prevent overtopping. The freeboard will be monitored through the AGL 'daily environment checklist' procedure.

Well heads will be fully enclosed and water gathering lines will be buried and not exposed to flood risk.

The average exploration well in the Gloucester Basin can produce between 5 and 30 kilolitres (kL) of water per day, and the proposed dam sizing provides ample capacity for this range.

2.6.2 Water gathering lines and underbore of Avon River

As described in Section 2.8.2 of the REF, the water staging point will require the construction of water gathering lines, connecting WK11, WK12 and WK14 to the water staging point at 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 layout of the gathering lines is shown in Figures 2.1 and 2.2.

The gathering lines will be buried, except across Waukivory Creek (between WK13 and WK14), where they will cross the existing road bridge above-ground. At that point, the HDPE gathering lines will be fully encased in steel to provide extra support and protection.

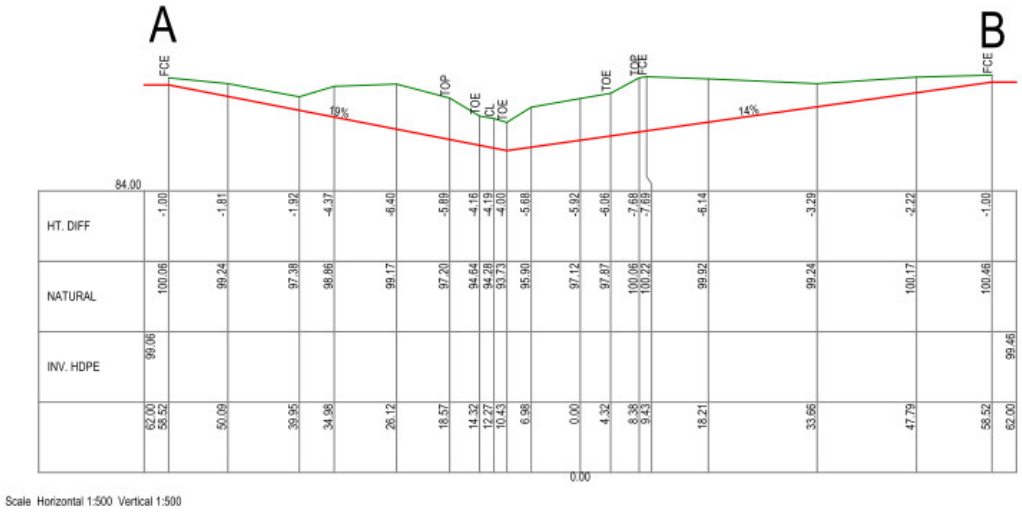
The section of gathering line connecting to WK11 will require an approximate 80 m underbored crossing of the Avon River using horizontal directional drilling (HDD) techniques. The depth of underboring will be more than 4 m below the bed of the Avon River as shown on Figure 2.6. This method involves drilling a hole at a shallow angle beneath the surface, then pulling the welded pipe string pipe through the drill hole. The construction of the crossing of the Avon River will involve minor earthworks for the levelling and establishment of construction pads at the drill entry and exit points, drilling using HDD techniques and insertion of pipeline. A cross section of the proposed underbore location at the Avon River is shown on Figure 2.6.

Site establishment for the HDD crossing will include establishment of controls at the construction pads including (but not limited to) sediment control, site fencing, drill entry and receive pits, and controls to prevent water entering the site. The location of the drill entry and receiving pits will not require vegetation removal. Topsoil will need to be removed and stockpiled to level the areas.

The HDD method involves using a specific drill rig to drill a hole at a shallow angle beneath the watercourse, followed by pulling a welded pipe string pipe through the drill hole. The HDD process for the Avon River crossing will include:

- establishment of drilling rig layout at the drill entry and exit points on either side of the watercourse. The construction pad for the rig at the entry point will be up to 40 x 40 m, and 20 x 20 m at the exit site;
- establishment of sediment and erosion control structures at the HDD entry and exit points, including bunding to prevent the release of drilling fluids or spills entering the surrounding environment;
- mixing of drilling fluid (also called drilling mud) – mixing will be undertaken in a mixing tank. Mixed fluid is then transferred to an active tank, from where it is pumped to the drilling rig, through the drill pipe, into the borehole and onto the cutting face;
- commencement of drilling – the HDD bore hole will follow a shallow curve. Initially, a pilot hole will be drilled. During drilling, the drilling fluid suspends the cuttings and travels out of the borehole and into the borehole returns collection. The borehole drilling fluid returns is positioned directly behind the hole entry point. From returns collection the mud is pumped to the sucker truck tank or recirculated; and
- reaming out of hole to enable insertion of pipe – the pilot hole will then be reamed out to approximately 1.25 times the diameter of the pipeline. A length of pipeline at least the length of the bore hole will be fabricated on a projection of the HDD alignment before it is pulled through the completed bore hole from the exit point to the entry point by the drill rig. Drilling fluid will then be pumped into the bore hole to secure the pipeline in place.

A typical arrangement for the underbore of the Avon River using HDD is shown in Figure 2.7.



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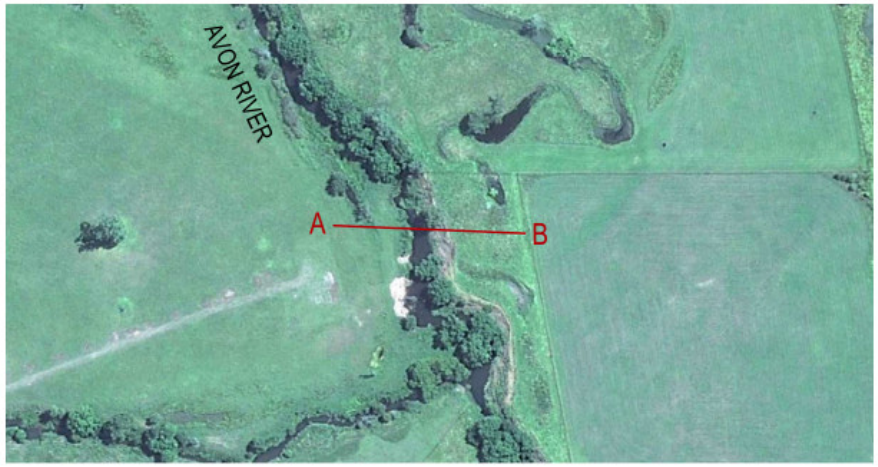

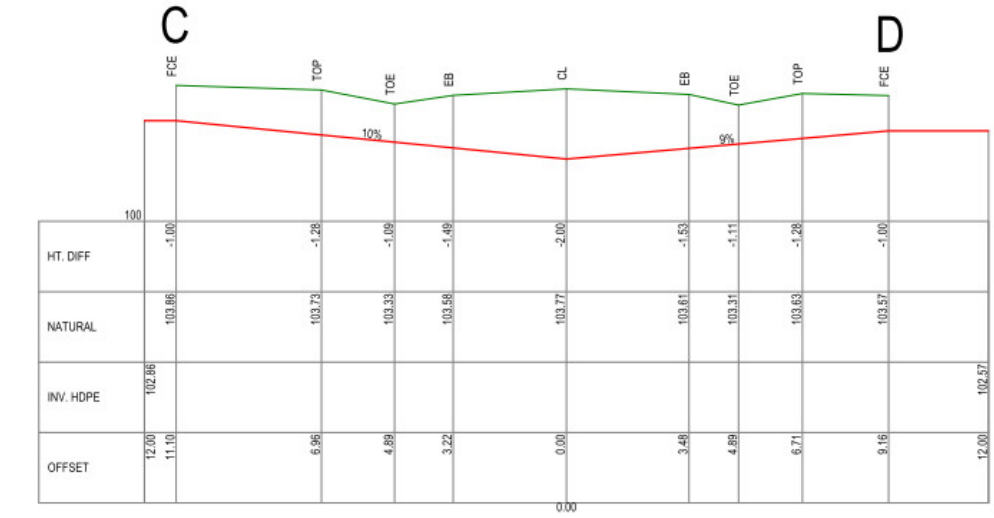

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Source: CalCo Surveyors, 2013

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Cross section of proposed underbore locations (Avon River and Fairbairns Road)

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Waukivory Pilot Project
Figure 2.6

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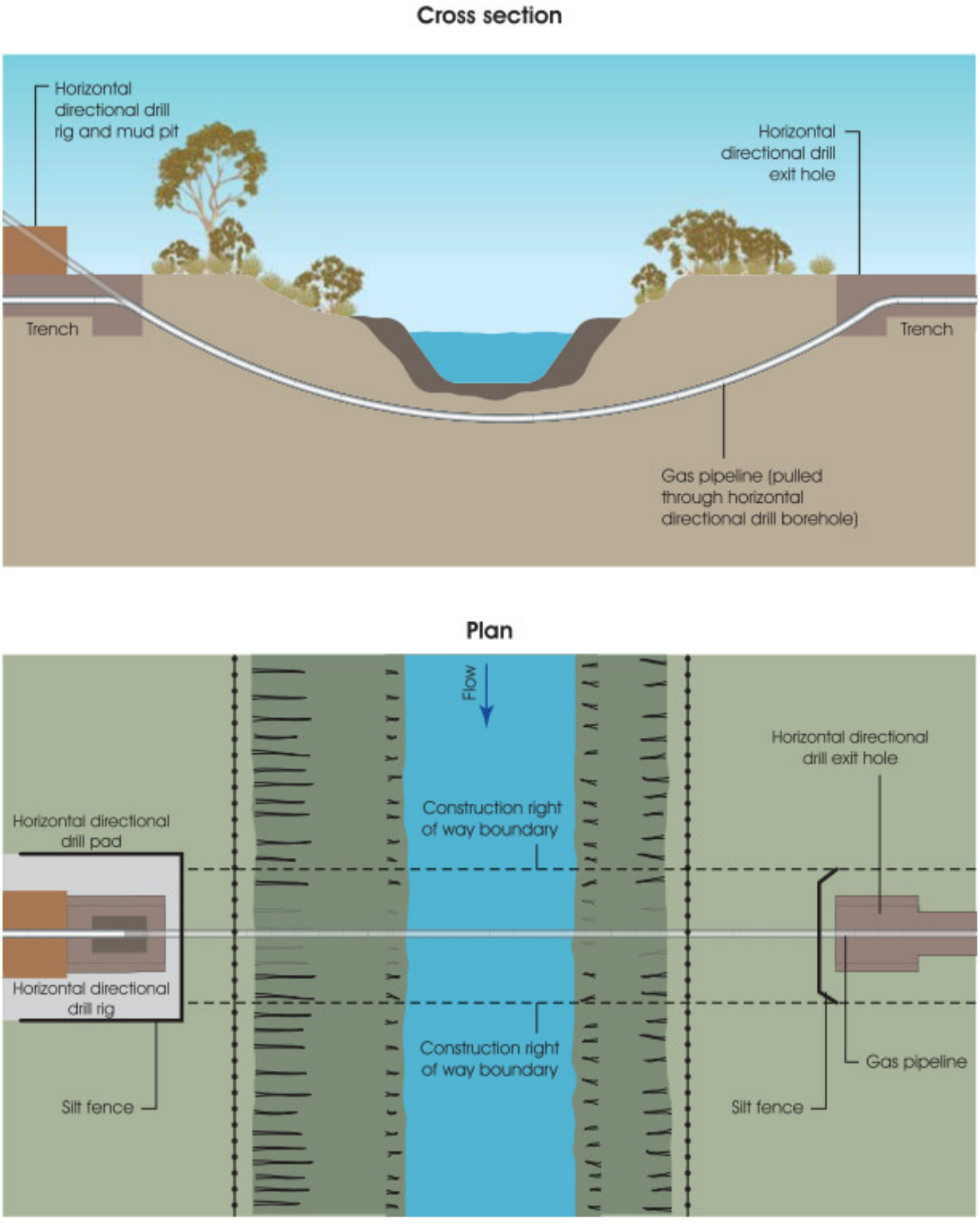

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Source: Coffey, 2013

Typical arrangement for HDD of the Avon River

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Figure 2.7

HDD requires the use of drilling fluid to drive down hole motors, drill bits and reamers, to remove the cuttings from the bottom of the hole and carry them to the entry point, to cool and lubricate the drill string and drill bit and to line, support and protect the walls of the hole.

For HDD, low viscosity and high gel strength are required to ensure the cuttings are effectively suspended in the slurry and returned to the entry point. The drilling fluid will include bentonite, Ez-mud Gold and Bore-gel to achieve a low viscosity, high gel strength and sufficient bentonite content. The material safety data sheets (MSDS) for these products will be kept on site.

The bentonite content of the drilling fluid is critical for drilling boreholes through rock. The fine particles of bentonite form a thin, low-permeability filter cake around the walls of the borehole. This filter cake seals the pores and other openings in rock preventing the escape of drilling fluid through the rock and the inflow of formation fluids. Soda ash is sometimes used in small quantities to treat out calcium hardness and/or raise pH, it reduces the amount of mud material required after water treatment.

To manage environmental risks during the HDD process, the HDD - Fluid Management Plan (see Appendix A) identifies:

- safeguards to minimise the chance of drilling fluid being lost to the environment;
- inspection procedures to ensure the safeguards are adequately maintained;
- a drilling fluid volume tracking procedure to ensure that drilling fluid volumes are being checked;
- a drilling fluid loss incident management procedure as a contingency if drilling fluid loss is detected; and
- management measures to prevent surface water and ground water ingress to the borehole.

The same process will be implemented for the underbore crossing of Fairbairns Road for the water pipeline to the Tiedmans property.

2.6.3 Upgrade of access roads and other ancillary works

Upgrades of access roads and other ancillary works will be as described in Section 2.8.6 of the REF.

2.6.4 Receipt, storage and onsite management of construction materials

Receipt, storage and onsite management of construction materials will be as described in Section 2.8.6 of the REF.

2.6.5 Drilling and associated activities

No drilling of new exploration holes is required as part of the activity as pilot testing will occur using existing exploration wells (WK11, WK12, WK13 and WK14), as described in Section 2.8.6 of the REF.

2.6.6 Water pipeline to the Tiedmans property

The construction of the water pipeline from WK13 to the Tiedmans property will be as described in Section 2.8.6 of the REF. The water pipeline from the water staging point at WK13 to Tiedmans and Pontilands dams traverses the Waukivory Pilot site and other AGL-owned properties.

The water pipeline will have two functions: to transfer produced water from the water staging point to the Tiedmans dam, and to transport source water from the Tiedmans dam and Pontilands dam to the water staging point for use in fracture stimulation.

The water pipeline will be a single pipeline and include an above-ground section of pipeline connecting to Pontilands dam approximately 70 m in length (see Figure 2.1). This overland section of pipeline will connect into a tee-section in the main pipeline between Tiedmans dam and WK13 (see Figure 2.1). The pipeline to Pontilands dam will be able to be disconnected when not in use, which will prevent flowback and produced water from inadvertently being pumped into the dam.

The transportation of produced water and source water by the water pipeline to the existing AGL dams has been assessed as part of this PAR, but the storage, blending and irrigation works at the Tiedmans property have previously been assessed as part of the irrigation trial activity, and are subject to an existing, separate approval under Part 5 of the EP&A Act (see Section 2.8.7 of the REF). An application is currently pending with the OCSG for a modification of the Tiedmans Irrigation Trial approval to extend the period for undertaking the works in that approval by another 24 months from 12 July 2014.

2.7 Operational phase: pilot testing and maintenance

As described in Section 2.8.7 of the REF, the main activities during 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.

Hydraulic fracture stimulation and pilot testing will be as described in Section 2.8.7 of the REF. The flaring method proposed for pilot testing is described in Section 2.8.7 of the REF. The central flare will be at WK12 for the preferred activity (see Figure 2.1).

Additional information on source water used for hydraulic fracture stimulation and water management is provided in the following sections.

2.7.1 Water source for hydraulic fracture stimulation

It is expected that the total volume of source water required for the fracture stimulation program for the four wells will be 6 ML.

Source water for hydraulic fracture stimulation will be sourced from either Pontilands dam or Tiedmans dam, on Fairbairns Road and Tiedmans Road respectively (both dams are owned by AGL). Water will be transported to the water staging point at WK13 by the water pipeline. The overland pipeline connection to Pontilands dam (Figure 2.1) will enable water to be pumped from Pontilands dam to the water staging point.

AGL has applied to the NOW to licence Pontilands dam and to take water for ‘stock, irrigation and industrial’ purposes. Pontilands dam contains about 50 ML of water and the Tiedmans dam contains about 20 ML; therefore there will be sufficient source water available for the preferred activity.

As previously stated in the REF and this PAR, source water will be supplied to the pilot wells by buried gathering lines from the water staging point.

2.7.2 Management of produced water and flowback water

As described in Section 2.8.7 of the REF, the maximum volume of flowback water and produced water likely to be pumped from the four wells is 20 ML. Of this, 6 ML is expected to comprise flowback water. The balance of 14 ML will comprise produced water. The proposed water management strategy (as described and assessed in the REF) for flowback and produced water involves:

- capture and pumping of all the flowback and produced water at the wells through water gathering lines to the dam at WK13;
- storing flowback and produced water in the turkeys nest dam at WK13 and monitoring volume and salinity levels;
- transportation of flowback water by truck for lawful disposal at an appropriate facility;
- monitoring the salinity of the produced water– water quality is unlikely to exceed 15,000 µS/cm and more likely to be around 7,000 µS/cm; and
- transfer of produced water via the water pipeline (see Figure 2.1) to the Tiedmans dam.

The preferred activity will require transport of flowback water by truck from the water staging point to a licensed disposal facility. Transport of flowback water will involve up to 240 truck movements over a period of up to 16 weeks, being an average of three water trucks per day departing from WK13. Trucks will access the water staging point from the existing property access off Fairbairns Road (via The Bucketts Way) and use the existing internal access track to WK13.

Water trucks will operate Monday to Friday, 7.00 am to 6.00 pm, and Saturday, 8.00 am to 1.00 pm. The contractor's traffic management plan will ensure transportation during school bus times, 8.00 am to 8.30 am and 3.30 pm to 4.00 pm, during school days will be avoided and transportation during periods when tourist groups are visiting the local herb farm on Fairbairns Road, to minimise disturbance of this local business.

A Traffic Management Plan (TMP) has been prepared for the transportation of flowback water from the Waukivory Pilot and is provided in Appendix B. The TMP has used the existing management framework within the overarching Traffic and Access Management Sub Plan (TAMSP) as part of the Environmental Management Plan (EMP) for exploration activities. The TAMSP requires TMPs for traffic generating activities that may have an effect on the local road network. Measures outlined in the TMP will be implemented to mitigate impacts on local roads. The TMP addresses the following matters:

- selection of suitable size water trucks, ie 25,000 litre (L) maximum volume in semi-trailer or truck and dog configuration, for use on Fairbairns Road in the locality of Forbesdale;
- scheduling of haulage vehicle movements to minimise disruptions to other vehicles, including school bus operations 8.00 am to 8.30 am and 3.30 pm to 4.00 pm on school days;
- residents along Fairbairns Road will be notified of the intended dates of commencement and completion of the trucking operation by an appropriate means prior to the commencement of trucking;
- provision of AGL's project telephone number, website and email address to enable members of the community to comment on and identify any specific concerns relating to the haulage operation; and

- measures and procedures to be implemented to monitor and ensure compliance of the haulage operation with the traffic management plan.

2.7.3 Produced water re-use options

As described and assessed in the REF, beneficial re-use of produced water is the preferred option. The full range of produced water re-use options considered for the preferred activity is described in Section 2.8.7 of the REF.

Given the relatively small volumes of produced water expected from the preferred activity, the only viable options are:

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

The Waukivory Pilot will utilise the water management plan on the Tiedmans property which was approved by DTIRIS-DRE in 2012. An application for the extension of the Tiedmans Irrigation Trial approval is currently pending with the OCSG to extend the period within which works under this approval may be undertaken. This strategy involves blending the produced water generated from flow testing programs with fresh water sources and irrigating. The results from the current pilot irrigation at the Tiedmans property (the Tiedmans Irrigation Trial) demonstrate that produced water from pilot wells can be beneficially re-used for the irrigation of crops.

If produced water is unable to be irrigated as part of the Tiedmans Irrigation Trial then it will be stored in the third produced water holding dam on the Tiedmans property, which was originally assessed in the REF submitted in 2011 and subsequently constructed to store produced water from this trial. A maximum of 14 ML of produced water is expected to be generated; the dam has a capacity of 20 ML. Therefore, there will be sufficient space to capture and store all the produced water in the event that water cannot be irrigated as part of the Tiedmans Irrigation Trial. In this case the stored water would be re-used when Stage 1 of the GGP is commissioned in accordance with an approved extracted water management strategy and the Stage 1 Environment Protection Licence.

In the highly unlikely event that there is insufficient capacity in these produced water storage dams on the Tiedmans property to store the produced water from the Waukivory Pilot then the excess water would be transported off-site to an appropriate facility for lawful disposal. The transportation of this water, should it be required, would be subject to the existing TASMP in the EMP (EMM 2013).

2.7.4 Water monitoring

One of the objectives of the Waukivory Pilot is to assess water production volumes and groundwater connectivity. Groundwater monitoring and monitoring of flowback and produced water is described in the REF, and will be managed and controlled by the Surface and Groundwater Management Plan (SWGMP) (see Appendix D of the REF).

In addition to the monitoring described in Section 2.8.7 of the REF, monitoring measures have been refined and are detailed in following sections.

i Groundwater monitoring network

There is a substantial groundwater monitoring network across the Gloucester Basin with 45 AGL groundwater monitoring bores installed for baseline and ongoing monitoring of the GGP (Figure 2.8). The monitoring network is continuing to expand and will be more than 50 sites early in 2014. There are four in the immediate vicinity of the Waukivory Pilot and this will increase to about eight with the conversion of WKmb05 to vibrating wire piezometers (VWP's). In addition, AGL understands that the NOW has plans to install several groundwater monitoring bores in the Gloucester Basin as part of their state-wide observation bore network in early 2014. NOW may want to site one of these locations in the eastern recharge areas to provide additional regional coverage of water levels.

The bores within the Waukivory Pilot area are presented on the map in Figure 2.9, and on the schematic diagram in Figure 2.10 which shows indicative bore completion for bores within 1.5 km of the activity. It can be seen that there is good spatial and hydrogeologic unit coverage within close proximity of the Waukivory Pilot. The geophone well (WKmb05) will be converted to multiple VWP's before the start of the Waukivory Pilot (flow testing program) and will monitor both shallow and deep target coal seams and intervening aquitards.

In addition to the local AGL monitoring bores, Gloucester Resources Limited (GRL) which has a coal exploration lease nearby, also undertake groundwater monitoring. Three nearby GRL bores are screened in the alluvium immediately east of the Waukivory Pilot site. Negotiations are currently occurring between AGL and GRL to provide data and access to these bores during the activity.

The (regional) spatial distribution of bores that AGL monitor can be seen on Figure 2.8. Monitoring extends well beyond the Waukivory Pilot site, to the north and to the south. Figure 2.8 also illustrates the spatial spread across different hydrogeological units with monitoring bores into alluvium, shallow fractured rock, interburden, shallow target coal, and deeper target coal.

Dataloggers are installed in each of the AGL groundwater monitoring bores and log groundwater levels every six hours. These are downloaded every three months, and manual groundwater level measurements are also recorded. The alluvial bores owned by GRL are equipped with dataloggers and regularly downloaded.

Groundwater level and water quality data in the broader monitoring network have been collected since January 2011, representing 35 months of baseline data. Baseline water quality sampling has been collected in two comprehensive sampling events, the first taking place between 4 April and 11 May 2011, and the second between 17 June and 3 July 2013. At the Waukivory Pilot site, groundwater level and water quality data has been collected since January 2012. The analytical suite included physio-chemical parameters, major ions, dissolved metals and minor/trace elements, nutrients, dissolved gases, hydrocarbons, environmental isotopes (oxygen-18 and deuterium), isotopes of methane and radioisotopes (carbon-14 and tritium).

Monitoring bores at the Waukivory Pilot site have been sampled twice for AGL's comprehensive analytical suite. The first sampling event was undertaken from June to August 2012, and the second event was undertaken in June 2013. The first sampling event also included analysis of environmental isotopes (oxygen-18 and deuterium), isotopes of methane and radioisotopes (carbon-14 and tritium).

An additional round of sampling of the Waukivory Pilot site monitoring bores immediately prior to the activity is proposed in early 2014.

The gas wells themselves cannot be sampled as they are not yet perforated and are therefore isolated with no exposure to any groundwater. Perforation of the holes will occur immediately prior to fracture stimulation and flow testing.

ii Surface water monitoring network

Surface water will be monitored at three stream locations which are shown on Figure 2.9. The surface water monitoring locations include one upstream on Waukivory Creek, one upstream on Avon River, and one downstream on Avon River.

The surface water monitoring locations will have water level, temperature and salinity loggers installed so that there is continuous data collection. Water samples will also be taken periodically for laboratory analysis. Water samples will be taken quarterly. A comprehensive baseline sample from each location will be obtained prior to any site activities. The SWGMP will be updated to reflect the surface water sampling locations, analytical suite and frequency of sampling.

iii Monitoring of fracture fluids

Water for hydraulic fracture stimulation is planned to be sourced from the nearby Pontilands dam. AGL has a chemical analysis of water from the dam and will collect another sample prior to the program commencing.

A human health and ecological risk assessment (HHERA) for hydraulic stimulation activities has been completed by Enrisks (2013) and provided in the REF in Appendix M. The risk assessment complies with AS/NZS ISO 31000:2009 Risk management – principles and guidelines, and identifies risks associated with the fracture stimulation activity, the likelihood of each risk, the consequence of each risk and appropriate management controls. Risks associated with chemical use, impact on water resources and waste management (eg flowback water) are addressed in this risk assessment.

The HHERA assesses individual chemicals in the fracture fluid. Synergistic or antagonistic effects of mixtures of chemicals in hydraulic fracture stimulation have not been assessed as such an assessment is extremely complex as not only the chemicals included in the mix need to be taken into account, but also chemical and physical interactions with substances present in the geologic strata where the fluids are applied.

An overview of chemical handling and storage methods, and potential risks and mitigation options are provided in the Dangerous Goods and Hazardous Materials Sub Plan and the Soil and Water Management Sub Plan of the EMP (EMM 2013) (Appendix E of the REF).

The electrical conductivity (EC) of the fracture stimulation fluids will be monitored prior to injection, and this is known to be lower than the natural EC of the groundwater in the coal seams, which is expected to be approximately 5,000 – 7,000 µS/cm. Following fracture stimulation, gas wells will be pumped to remove flowback water, and then produced water to depressurise coal seams to stimulate gas flow.

AGL concurs with the NOW's statement that flowback water is defined when 100% of the volume of fracture fluid is recovered but maintains that a salinity trigger of 5,000 µS/cm should be used for the return waters. The salinity trigger is important as in rare instances (in very low permeability formations) not all fracture stimulation water is recovered (ie the total volumes pumped are slightly less than the injected volumes).

The flowback water will be taken off-site by truck to an appropriate facility for lawful disposal (refer to Section 2.7.2). Pumping of the gas wells will continue during the pilot testing program and produced water will be piped to the Tiedmans property for use in the irrigation trial. Section 2.7.3 sets out how AGL will manage the produced water if AGL is unable to use the water at the Tiedmans property in accordance with the Tiedmans Irrigation Trial approval.

iv Groundwater monitoring during the flow test

AGL will install salinity and temperature dataloggers at each gas well and these will be downloaded regularly during the flow testing period. The salinity/temperature loggers will be installed into the water line after the gas separating chamber at each gas well. The logging interval will be 6 hourly for both salinity and temperature.

The salinity and temperature logging will be downloaded on a monthly basis and data analysed for trends or changes. Water quality parameters (EC, temperature, pH, dissolved oxygen and oxidation/reduction potential Eh) will be measured in the field weekly.

The NOW suggested that diffuse samplers be used to collect water quality data (including hydrocarbons) at specific periods throughout the Waukivory Pilot. However, at Waukivory, passive diffusion bag (PDB) samplers are not considered an appropriate method for sampling the gas well. PDB samplers cannot be installed or removed from gas wells once the headworks are installed. PDB samplers are also not appropriate for sampling in the groundwater monitoring bores for the following reasons:

- The primary assessment method to detect if there is any connectivity or pressure response between shallow aquifers and deep water bearing zones is water level monitoring. Taking water samples during the flow testing program would compromise the water level data set.
- The AGL comprehensive analytical suite includes inorganic ions, metals, nutrients, hydrocarbons and dissolved gases. PDB samplers are not suitable for collecting inorganic ions.
- The goal of the AGL water quality monitoring is to collect a representative sample at a point of time. PDB samplers integrate concentrations over time and do not provide representative water quality results at specific points in time.
- The monitoring bores in the shallow fractured rock and thrust fault have low permeabilities. PDB samplers are not suitable for low permeability formations (hydraulic conductivity $<8.64 \times 10^{-4}$ m/day).
- AGL require representative samples taken at specific points in time (pre and post stimulation). Sample collection must be done in the shortest amount of time possible to capture a representative sample. PDB samplers need to be deployed for at least two weeks to ensure that deionised water in the diffusion bag has time to equilibrate with the surrounding groundwater (which will not provide a result applicable to a discrete time period).

It is inappropriate to link sampling events (using PDB samplers) to predefined triggers such as a change in water level or salinity. The salinity of water coming out of the gas wells will change during the hydraulic stimulation process and subsequent pumping by several thousand microsiemens (µS/cm) (as the water contributions from each of the individual coal seams vary).

2.8 Maintenance activities, future expansions or additions

Maintenance activities, future expansions or additions will be as described in Section 2.8.8 of the REF.

2.9 Mitigation strategy

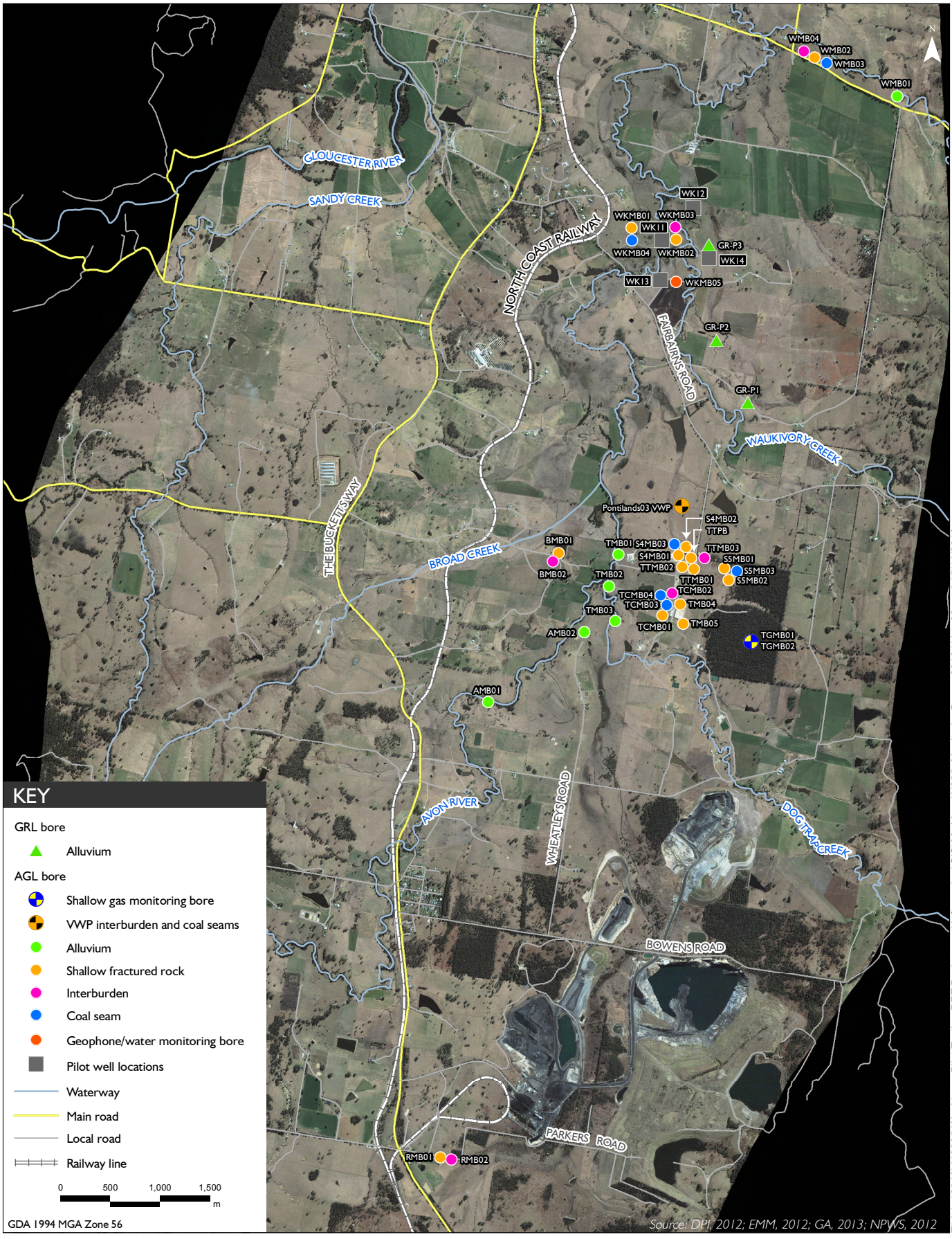
The mitigation strategy which represents AGL's statement of commitments for the preferred activity was described in Section 2.11 of the REF. Measures to avoid potential environmental impacts from the preferred activity were summarised in Table 2.9 of the REF. The table below presents additional mitigation measures for certain environmental aspects. These additional mitigation measures include utilising the existing groundwater monitoring network (see Figure 2.8). Whilst these monitoring bores are not part of the activity application, data gathered prior to and during the Waukivory Pilot will be gathered and analysed as part of the SWGMP.

Table 2.1 Additional impact avoidance and mitigation measures

Aspect	Proposed measures
Groundwater	
Irrigation of produced water	AGL has lodged an application to vary the Tiedmans Irrigation Trial approval to extend the time period so that it is consistent with the Waukivory Pilot should it be approved. If produced water is unable to be irrigated as part of the Tiedmans Irrigation Trial then it will be stored in the third produced water holding dam at the Tiedmans property which was constructed to store produced water from the trial. A maximum of 14 ML of produced water is expected to be pumped during the Waukivory Pilot and the dam has a capacity of 20 ML so there will be sufficient space to capture and store all the produced water. Stored water would then be reused when the Stage 1 project is commences.
Spatial coverage of the groundwater monitoring network	The monitoring network is continuing to expand and will be more than 50 sites early in 2014.
	The geophone well will be converted to a multiple VWP prior to the start of the Waukivory Pilot and monitoring both shallow and deep target coal seams.
	Negotiations are currently occurring between AGL and GRL to provide data and access to GRL alluvial monitoring bores during the pilot testing.
	Dataloggers set to record data at 6-hourly intervals are installed in all groundwater monitoring bores. These are downloaded every three months.
Groundwater quality information	An additional round of water chemistry sampling for the Waukivory monitoring bores immediately prior to the activity.
	AGL will install salinity and temperature dataloggers at each gas well and these will be downloaded monthly during the flow testing period. The salinity/temperature loggers will be installed into the water line after the gas separating chamber at each gas well. The logging interval will be 6 hourly for both salinity and temperature.
	Water quality parameters (EC, temperature, pH, dissolved oxygen and Eh) will be measured in the field weekly.
Monitoring of fracture fluids	The EC of the fracture stimulation fluids will be monitored prior to injection.
Monitoring of outcrop areas	Two shallow gas monitoring wells (TGMB01 and TGMB02) are installed in the outcrop of the Roseville Coal Seam at the eastern boundary of the Tiedmans property and will be monitored during the Waukivory Pilot.
Protection of groundwater from HDD	HDD will follow the HDD - Fluid Management Plan at Appendix A.

Table 2.1 Additional impact avoidance and mitigation measures

Aspect	Proposed measures
Traffic	
Transport of flowback water	A TMP has been prepared for the transportation of flowback water (refer to Appendix B) which will address the following matters: • selection of suitable trucks, ie size and weight, for use on Fairbairns Road in the locality of Forbesdale; • scheduling of haulage vehicle movements to minimise disruptions to other vehicles, including school bus operations 8.00 to 8.30 am and 3.30 to 4.00 pm; • notification of residents along Fairbairns Road of the intended dates of commencement and completion of trucking operation by mailout or other appropriate means; • provision of AGL's project telephone number, website and email address to enable members of the community to comment on and identify any specific concerns relating to the haulage operation; and • measures and procedures to be implemented to monitor and ensure compliance of the haulage operation with the traffic management plan.
Surface water	
Surface water quality monitoring	Baseline surface water quality monitoring is required. Two upstream locations (Waukivory Creek and Avon River) and one downstream location (Avon River) will be monitored. A round of water chemistry sampling for these sites will occur immediately prior to the activity. AGL will install water level, salinity and temperature data loggers at surface water monitoring sites on the Avon River and Waukivory Creek and these will be downloaded quarterly during the flow testing period. The logging interval will be 6 hourly for levels, salinity and temperature. Water quality parameters including salinity, temperature, acidity, dissolved oxygen and redox potential will be measured in the field as part of each water sampling event.
Protection of surface water from HDD	HDD will follow the HDD - Fluid Management Plan at Appendix A.
	Downstream surface water quality will be monitored. AGL will install a salinity and temperature data logger at the downstream location. The logging interval will be 6-hourly for both salinity and temperature.
Pontilands dam	The overland pipe connection from Pontilands dam to the pipeline from Tiedmans dam will be disconnected from the hydrant when not in use.
Flood	
Protection of flood plain	The turkeys nest dam will be designed to have 500 mm freeboard above the 1 in 100 year AEP flood level to prevent overtopping during a flood event. This will prevent the mixing of flowback water and produced water with flood waters.
	The operating procedure for the turkeys nest dam will include maintaining 500 mm freeboard in the dam at all times. The level of freeboard in the dam will be monitored through the AGL 'daily environment checklist' procedure.
	Weather will be monitored, and in the event of a flood pumping will cease and any flowback water levels will be decreased through transportation to appropriate facilities.
	Measures in the AGL procedure DCS_GLO_DC_PR_010 Exploration Drilling Flood Management relevant to the pilot program will be implemented.
	Noise barriers will only be installed on site for the duration of fracturing (ie 14 days).
	If enough time is allowed prior to a flood, noise barriers will either be dropped flat or opened to allow water flow through the area.
Air quality	
Fugitive emissions	TGMB01 and TGMB02 will be monitored during the Waukivory Pilot.



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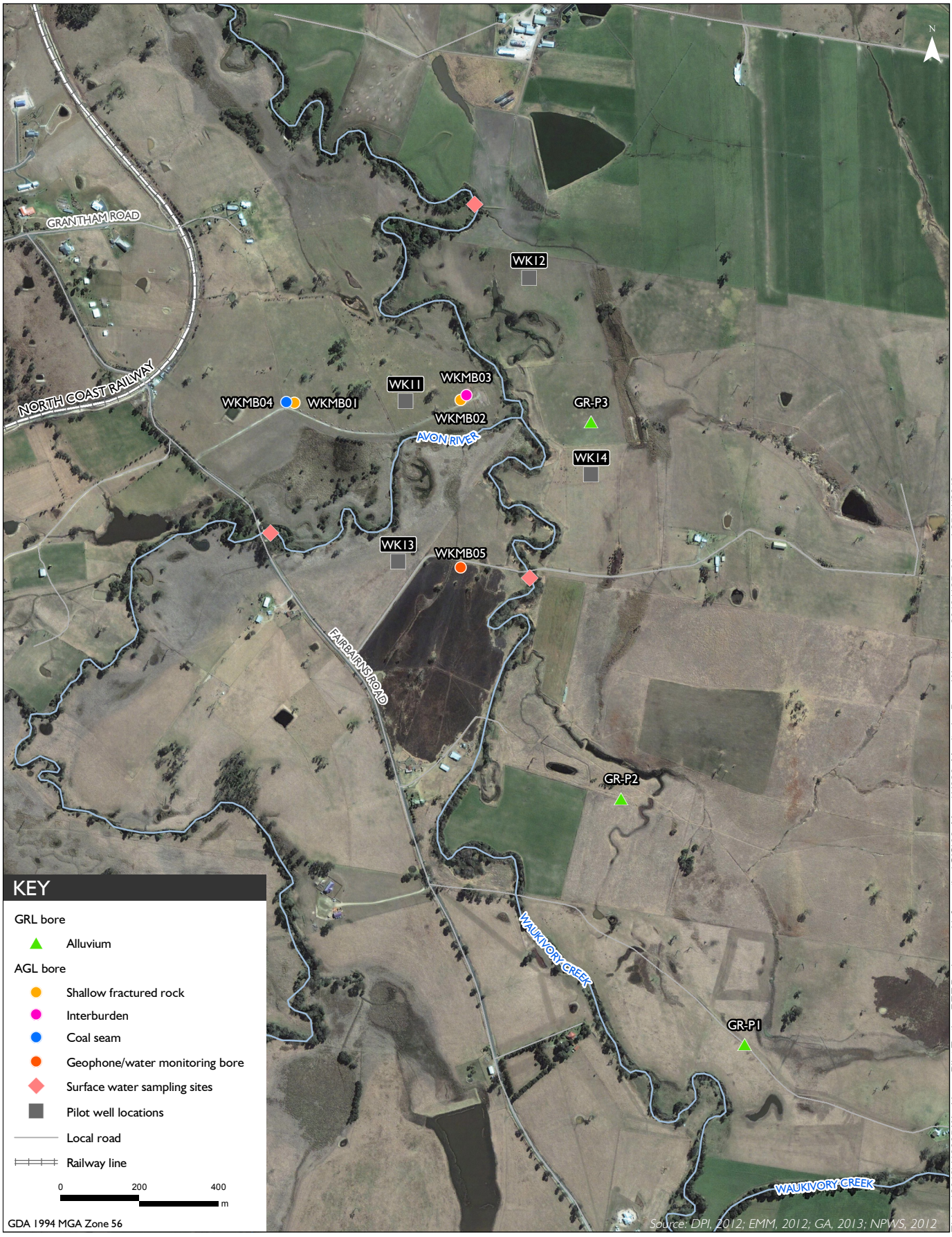
Note: monitoring bore locations offset for clarity

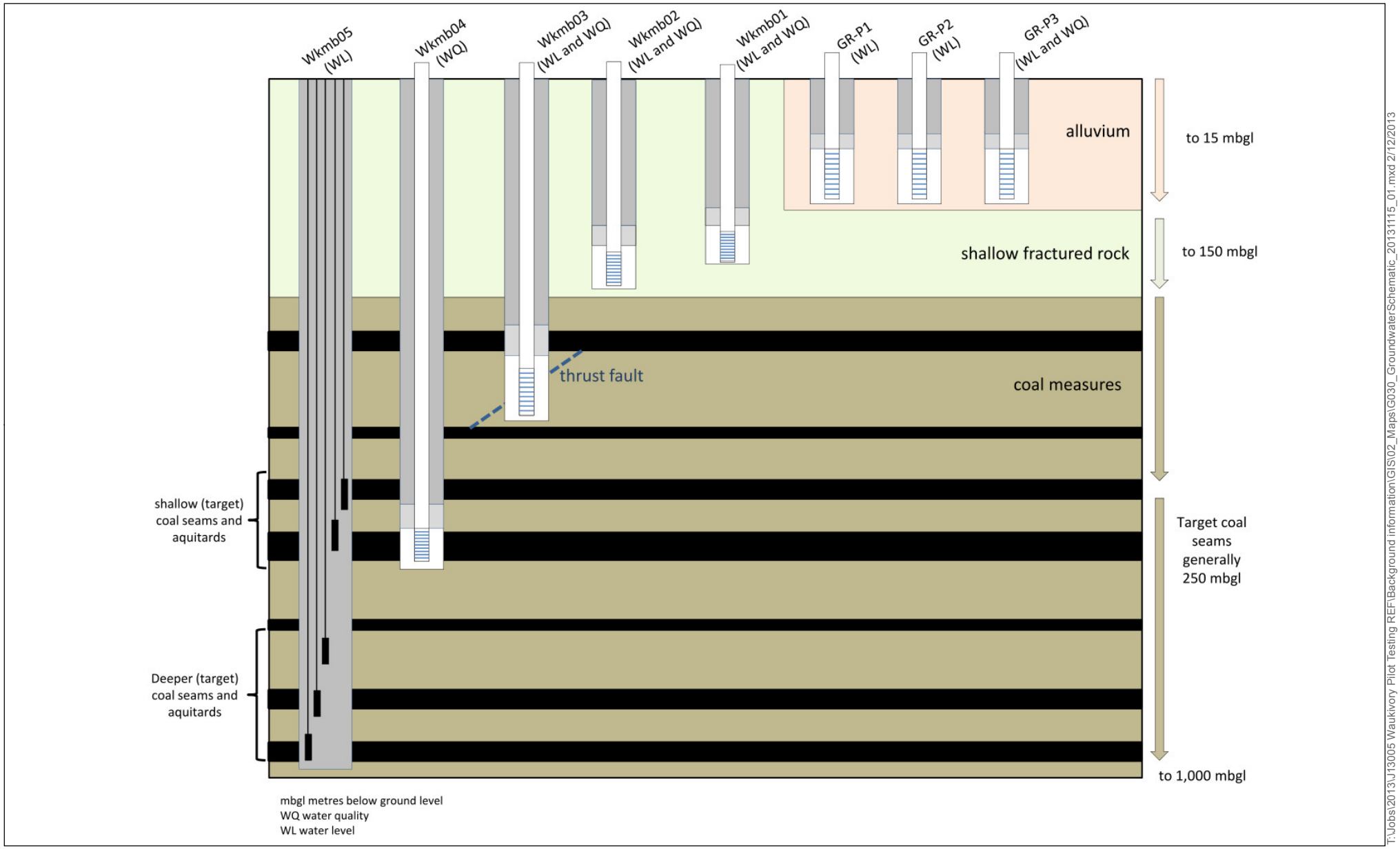
EMM
EMGA Mitchell McLennan

Groundwater monitoring bores for the Gloucester Gas Project
Addendum to the Review of Environmental Factors
Waukivory Pilot Project
Figure 2.8



EMM
EMGA Mitchell McLennan

Groundwater monitoring bores for the Gloucester Gas Project at Waukivory
Addendum to the Review of Environmental Factors
Waukivory Pilot Project
Figure 2.9



Schematic of groundwater monitoring bores within 1.5km of the Waukivory pilot testing site

Addendum to the Review of Environmental Factors
Waukivory Pilot Project
Figure 2.10

3 Impact assessment

Chapters 6 to 12 of the REF include an analysis of the environmental impacts of the preferred activity in accordance with section 111 of the EP&A Act, clause 228 of the *Environmental Planning and Assessment Regulation 2000* (EP&A Regulation) and the ESG2 guidelines and the draft supplement. The extent, size, scope, intensity and duration of each impact was assessed in the REF so that the responsible determining authority, in this case the 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.

This PAR has been prepared for the purposes of responding to requests for further information from the OCSG, the EPA, NOW and the OEH. This PAR also includes an assessment of environmental impacts of the preferred activity. Groundwater modelling was undertaken to assess impacts to all hydrogeological units, and in particular to consider issues raised within respect to alluvial and shallow fractured rock groundwater units in the immediate area and the drawdown impacts at distance (particularly towards the eastern outcrop areas) (Appendix C).

4 Physical and chemical impacts

4.1 Soil quality and land stability

Effects on soil quality and land stability were assessed in Section 6.1 of the REF and aspects relevant to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

4.1.1 Impact assessment

i Well surface infrastructure location

The 100 m x 100 m area of each well has been previously assessed and approved with the drilling of the wells (EMM 2011). The water staging point at WK13 will be approximately 30 m x 40 m. A site layout plan of WK13 including the dam is shown on Figure 2.3. The total area of disturbance remains within the 100 m x 100 m footprint previously assessed in the original REF (EMM 2011).

Civil works for construction of the dam will involve the use of excavators, bulldozers and dump trucks, as described in the REF.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to soil quality and land stability.

ii Water and gas gathering lines

There will be a small area of soil disturbance between WK11 and the gathering line between WK12 and WK14 as a result of construction of the gathering lines, including the underbore of the Avon River. Overall, soil disturbance would be minimised by implementing using HDD techniques to cross the Avon River compared to a method such as open trenching.

To enable the underbore to occur, construction pads at the HDD entry and exit points will be established on each side of the Avon River. Site establishment for the HDD crossing will include establishment of controls at the construction pads including (but not limited to) sediment control, site fencing, drill entry and receive pits, and controls to prevent water entering the site.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to soil quality and land stability.

iii Water pipeline to the Tiedmans property

Construction of the proposed water pipeline will involve trenching and installation of approximately 3.5 km of pipeline from the Tiedmans property, along Fairbairns Road. An underbore of Fairbairns Road using HDD techniques will also be required. The water pipeline trenches would be shallow (ie a depth of up to 1 m) and are unlikely to encounter sensitive soils based on the site assessment. To enable the underbore to occur, construction pads at the HDD entry and exit points will be established on each side of Fairbairns Road.

The water pipeline will include an overland section of pipeline connecting to Pontilands dam approximately 70 m in length (see Figure 2.1). This overland section of pipeline will connect into a tee-section in the water pipeline between Tiedmans dam and WK13 (see Figure 2.1). The pipeline to Pontilands dam will be able to be disconnected when not in use, which will prevent produced water from inadvertently being pumped into the dam.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to soil quality and land stability.

4.1.2 Summary

Impacts to soil quality and land stability from the preferred activity are considered to be negligible. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

4.2 Surface water

Effects on surface water have been considered in Section 6.2 of the REF. Relevant aspects to the preferred activity were assessed in the REF are summarised in this section. For further detailed information, please refer to the REF.

4.2.1 Impact assessment

i Well surface infrastructure location

The proposed water management strategy at the Waukivory Pilot is to capture flowback and produced water in a turkeys nest dam at WK13.

The dimensions of the turkeys nest dam will be approximately 30 x 40 m, with a freeboard of at least 500 mm above the 1 in 100 year AEP flood level.

As described in Section 2.6.1, the standard approach adopted by AGL to plan and design water storage dams is to approach a construction contractor such as the NSW Government owned Soil Conservation Service to undertake a design and construction plan for the dam. The turkeys nest dam will be designed by a civil engineer based upon site constraints such as geotechnical characteristics, location, topography and flood flows. It will be designed to have 500 mm freeboard above the 1 in 100 year AEP flood level. The operating procedures for the turkeys nest dam will include the maintenance of approximately 500 mm freeboard in the dam at all times to allow for unexpected heavy rainfall. It will be double-lined with a geo-membrane liner separated by a HDPE geonet membrane sheet for leak detection and collection. The double lining will cover the outside of the dam which will provide erosion protection in a flood event.

There is potential for construction activities to impact on surface water quality. Potential impacts could result from spills and surface water runoff from disturbed areas. Management measures for these potential impacts are outlined in AGL's EMP for exploration activities (Appendix E in the REF).

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to surface water.

ii Water and gas gathering lines

The installation of the water and gas gathering lines between WK12, WK13 and WK are described in Section 2.8.2 of the REF.

Installation of the water and gas gathering lines from WK11 to connect to the lines between WK12 and WK14 will involve underboring the Avon River east of WK11 by HDD.

The drill will start at the entry point and drill about 80 m under the Avon River to the exit point on the other side of the river. Pipe lengths are prefabricated and then pulled through the completed bore hole. The depth of underboring will be more than 4 m below the bed of the Avon River as shown on Figure 2.6. There will be no disturbance of the bed or banks of the Avon River or the natural movement of water in the watercourse.

The underboring entry and exit points will be securely bunded to prevent the release of drilling fluid from excavated material or spills entering the surrounding environment.

In the unlikely event that the underbore intersects with a natural fracture in the bed of the watercourse, a potential release of drilling fluid could occur. This would have the potential to impact the watercourse (ie turbidity and contamination) until the drilling fluid is contained and the leak is sealed. The risk of such an event occurring is unlikely, and will be managed through implementation of the HDD - Fluid Management Plan (see Appendix A). The HDD method is, itself, a mitigation to avoid impacts to sensitive watercourse and riparian vegetation.

The HDD - Fluid Management Plan (refer to Appendix A) has been developed for the underbore which outlines safeguards to prevent drilling fluids being lost to the environment, inspection procedures and volumetric drilling fluid tracking procedures. It also includes the requirement for site-specific geotechnical investigations to be undertaken prior to underboring to identify the geology, potential issues and to select appropriate underboring equipment. With the underbore, the pipe is a sufficient depth beneath the watercourse to minimise the risk of contamination associated with natural faults in the riverbed.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) and Section 2.9 of this PAR including the HDD - Fluid Management Plan (refer to Appendix A) is considered appropriate to manage and minimise impacts to water bodies, watercourses, wetlands and natural drainage systems.

iii Water pipeline to the Tiedmans property

There is potential for construction activities to impact on surface water quality. Potential impacts could result from spills and surface water runoff from disturbed areas. Management measures for these potential impacts are outlined in the EMP in Appendix E the REF (EMM 2013).

The overland pipe from Pontilands dam to the pipeline from Tiedmans dam will be disconnected from the hydrant when not in use. This will prevent produced water from the pilot wells and source water from Tiedmans dam inadvertently entering Pontilands dam.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to surface water.

4.2.2 Summary

Impacts to surface water from the preferred activity are considered to be low adverse. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

4.3 Groundwater

Effects on groundwater levels and quality have been assessed in Section 6.2 of the REF and relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

4.3.1 Impact assessment

i Groundwater numerical modelling

A numerical cross-sectional model has been prepared to assess the impacts of the Waukivory Pilot on the local and regional groundwater systems (Appendix C). The model was constructed using the most recent data from groundwater investigations at the Waukivory Pilot site. Groundwater modelling of the Waukivory Pilot was simulated over 24 months and assessed drawdown impacts from the activities.

The results of the modelling indicated:

- pressure drawdown due to gas flow testing would form a steep and very localised cone of depression immediately around the gas well;
- there would be no groundwater drawdown predicted for systems shallower than 70 metres below ground level (mBGL);
- the water table aquifer (ie alluvial and shallow fractured rock units) would not be impacted;
- changes in groundwater pressures in shallow target coal seams would extend 200 m laterally, and in deeper seams approximately 50 m laterally; and
- changes in groundwater pressures would not extend to the steeply dipping strata area to the east, where the Rocky Hill Coal Mine is proposed.

The predicted drawdowns would be localised to and confined to the immediate area (200 m) surrounding the Waukivory Pilot. Impacts do not extend to outcrop areas, which are approximately 2 to 3 km to the east. The location of the monitoring bores at the Waukivory Pilot site range from 100 m through to several hundred metres from each of the gas wells. This spacing interval is appropriate for the monitoring of predicted impacts.

Should there be an unexpected drawdown in shallow aquifers then an adaptive management approach will be used to prevent environmental harm. Groundwater levels will be monitored closely to assess trends and to ensure that there is no change to shallow aquifers and impact base flows. It is highly unlikely that surface water receptors will be influenced given the produced water volume will not exceed 0.05 ML/day and 14 ML in total. If there is a significant reduction in stream flow as a direct result of flow testing then one or more of the gas wells will be shut-in to ensure stream flows recover.

ii Groundwater dependent ecosystems

AGL's shallow monitoring network provides more accurate data that is also ground-truthed. The groundwater monitoring data was used in numerical modelling, producing groundwater table maps which, in turn, were used to consider potential groundwater dependent ecosystems (GDEs) in the area.

The GDE Atlas (Bureau of Meteorology 2012) identifies some vegetation ecosystems that rely on the subsurface presence of groundwater within the Stage 1 gas field development area (GFDA) and the broader Gloucester Basin. The area identified within the Stage 1 GDFA is on the Tiedmans property and relates to natural vegetation cover. There is no known regional groundwater dependence for this residual vegetation cover as water levels are more than 10 mBGL in the bedrock.

The Hunter Catchment Management Authority (CMA) vegetation map (unpublished dataset obtained by EMM) identifies Weeping Lilly Pilly/Water Gum riparian warm temperate rainforest along the alluvial banks of the Avon River and Waukivory Creek. EMM ecologists have confirmed that Weeping Lilly Pilly occurs in the area.

The potential risk to the Weeping Lilly Pilly is low because the connection between the shallow and deep groundwater systems will be limited by the permeability of the rock strata which is known to be very low (Parsons Brinckerhoff 2013).

Isotopic and hydrograph data also indicate limited vertical connection between shallow and deep groundwater systems. Isotopic dating indicates that groundwater in the shallow coal seams is greater than 10,000 years old, on average, while groundwater within the alluvium and shallow rock domains is mostly modern (less than 200 years). Monitoring bore hydrographs show rapid groundwater responses to rainfall events in shallow bores and alluvium, but negligible, delayed or subdued responses in deeper bores. These data do not preclude connection between the shallow and deep systems, but imply that recharge to the deeper hydrogeological units via vertical or lateral seepage is very slow (Parsons Brinckerhoff 2012) and is in the order of tens of thousands of years.

The groundwater modelling indicates that there will be no impact to groundwater in alluvial or shallow rock aquifers during the flow testing. The modelling indicates that groundwater pressures will not impact strata shallower than 70 m. The alluvial aquifers in the Waukivory Pilot area are approximately 15 mBGL and the root zone for vegetation is less than this. Impacts to groundwater dependent vegetation will not occur as a result of the Waukivory Pilot.

iii Well surface infrastructure location

The preferred well surface infrastructure location will have no additional impact to the shallow beneficial aquifers to those already assessed in the REF (EMM 2013).

A shallow excavation up to 2 m deep will be required for the turkeys nest dam at WK13. The excavation is not expected to reach the water table in the shallow (alluvial) aquifer.

The turkeys nest dam will be designed to minimise the risk of leaching and potential contamination of the alluvial aquifer. It will be double-lined with a dual geo-membrane liner separated by a HDPE geonet membrane sheet for leak detection and collection.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to shallow beneficial aquifers.

iv Water and gas gathering lines

Potential impacts on the shallow alluvial aquifer could include groundwater mixing with drilling fluid and fuel, oil and grease as a result of the underbore of the Avon River. These impacts could result from groundwater ingress to the drilling annulus or encountering underlying cracks or fissures in the underlying geological formation.

A HDD - Fluid Management Plan (refer to Appendix A) has been developed for the underbore which outlines safeguards to prevent drilling fluids being lost to the environment, inspection procedures and volumetric drilling fluid tracking procedures. It also includes the requirement for site-specific geotechnical investigations to be undertaken prior to underboring to identify the geology, potential issues and to select appropriate underboring equipment.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) and the HDD - Fluid Management Plan (refer to Appendix A) are considered appropriate to manage and minimise impacts to shallow beneficial aquifers.

v Water pipeline to the Tiedmans property

Potential impacts to shallow alluvial aquifers from the underbore of Fairbairns Road will be managed in the same manner as the underbore of the Avon River which is described in the section above.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) and the HDD - Fluid Management Plan (refer to Appendix A) are considered appropriate to manage and minimise impacts to shallow alluvial aquifers.

4.3.2 Summary

Impacts to groundwater from the preferred activity are considered to be low adverse. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

4.4 Flooding

A qualitative assessment of flooding was presented in Section 6.4 of the REF. For further detailed information, please refer to the REF.

A quantitative assessment of floodplain obstruction and contingency management of the preferred activity has been completed by WRM and is provided in Appendix D. The results are summarised in this section.

4.4.1 Impact assessment

i Well surface infrastructure location

The flood assessment confirms that well surface infrastructure at WK11 will not be affected by a 1 in 100 year AEP flood level. Well surface infrastructure at WK12, WK13 and WK14 is within the 1 in 100 year AEP flood level.

Well surface infrastructure including the turkeys nest dam at WK13 is relatively small and is considered to be insignificant from a flood impact point of view. However, the temporary noise barriers which will be installed at WK12, WK13 and WK14 for approximately 14 days during fracturing have potential to cause floodplain impacts.

Floodplain impacts resulting mainly from the noise barriers include impacts to flood levels and flood velocities.

Flood modelling of a 1 in 100 year AEP flood level was done with the temporary noise barriers in place to simulate a worst case scenario. The modelling of this scenario showed that there would be very small (1 cm to 5 cm) increase in flood level over a large area upstream of WK12 with the greatest flood level increase (15 cm to 30 cm) in the area of the WK12 compound where the floodplain narrows. It also showed there would be increases to water velocities which, except for a small area at WK12 (where the flood velocity is already high), would not present a high scour risk or impact on channel geometry of waterways.

Potential impacts will only result if a large flood coincides with the short period the noise barriers will be onsite (ie 14 days). As detailed in Table 2.1 of the PAR, should flood warnings allow, the noise barriers will be dropped or opened prior to inundation so that flow is not obstructed.

The REF (EMM 2013) includes appropriate procedures to ensure the safety of personnel in a flood event.

The risk of significant flood impacts occurring as a result of well surface infrastructure is very small. The implementation of the mitigation strategy outlined in the REF (EMM 2013) and Table 2.1 is considered appropriate to manage and minimise impacts of floodplain obstruction.

The risk of a significant flood event resulting in the mixing of flowback water or produced water with flood waters is also very small. The well heads are fully enclosed and water gathering lines buried. The turkeys nest dam will be constructed to have 500 mm freeboard above the 1 in 100 year AEP flood level and an operating freeboard of 500 mm will be maintained in the dam at all times to allow for heavy unexpected rainfall. The maintenance of an operating freeboard will be monitored through the AGL 'daily environmental checklist' procedure. The dam will be constructed with a double lining which will provide erosion protection to the outside of the dam in a flood event.

Measures in the AGL procedure DCS_GLO_DC_PR_010 Exploration Drilling Flood Management relevant to the Waukivory Pilot will be implemented. The principal objective of this procedure is to detail steps that will be taken by operational teams to reduce the risk to surface water from flooding. The relevant measures and responses include:

- equipment and materials stored on the site will be limited to as low as reasonably possible;
- all non essential, hydrocarbons and chemicals will be stored off-site at an approved AGL facility;
- all oils and chemicals required onsite will be stored in a securely bunded area or self-bunded container and removed from site once a severe weather warning (which could lead to a flood event) is received;
- stormwater holding ponds emptied; and
- well head is checked and secured.

Weather forecasts/ flood levels will be monitored each morning and response steps taken if inclement weather/floods are forecast.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) and this PAR is considered appropriate to manage flood impacts.

ii Water and gas gathering lines

The water and gas gathering lines will be buried and flood impacts are expected to be negligible.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage flood impacts.

iii Water pipeline to the Tiedmans property

The water pipeline to the Tiedmans property will be buried and flood impacts are expected to be negligible.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage flood impacts.

4.4.2 Summary

Impacts from flood obstruction resulting from the preferred activity are considered to be negligible. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

4.5 Hydraulic fracture chemicals and flowback water

Hazardous materials and chemical use have been assessed in Section 6.5 of the REF. Disposal of flowback water was assessed in Section 6.6.1 of the REF. Relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

4.5.1 Potential impacts

An assessment of risk with regard to hydraulic fracture fluid additives is provided in the in the Fracture Stimulation Management Plan (FSMP) and HHERA in the REF (EMM 2013).

The risk of hydraulic fracturing chemicals to human health and the environment is evaluated in HHERA. The risk assessment complies with AS/NZS ISO 31000:2009 *Risk management – principles and guidelines*, and identifies risks associated with the fracture stimulation activity, the likelihood of each risk, the consequence of each risk and appropriate management controls. Risks associated with chemical use, impact on water resources and waste management (eg flowback water) are addressed in this risk assessment.

The HHERA concluded the toxicity risk of hydraulic fracture chemicals to human health and the environment is negligible or low. This means potential impacts can be effectively managed through implementation of appropriate management measures, such as those outlined in the FSMP.

Water for hydraulic fracture stimulation will be sourced from Pontilands dam and Tiedmans dam. AGL has undertaken chemical analysis of water from these dams and will collect another sample prior to the activity commencing. Fluid rheology and compatibility tests will be conducted on source water with fracture stimulation additives at the laboratory and then again immediately prior to the fracture stimulation activity.

The HHERA provides a risk assessment of individual chemicals in the fracture fluid. The source water will be taken from a fresh water dam, the chemical composition of which is within limits for make-up water for fracture stimulation fluids according to the fracture stimulation service provider and the laboratory results confirming no incompatibility between make up water and fluid additives. As such, no antagonistic effects will be encountered between source water and fracture stimulation chemicals. Fluid compatibility and breaker compatibility between formation water and fracture fluid additives will also be assessed. Fracture stimulation fluids will therefore not act adversely in the formation, except for the possibility of clay in the formation being sensitive to the freshwater used as source for fracture stimulation fluid. Core samples taken from the Pontilands 3 corehole drilled earlier this year (nearby to the Waukivory Pilot) are currently being laboratory-tested to assess the presence of sensitive clays. If it is deemed necessary, a clay stabiliser (choline chloride) will be added to the fracture stimulation fluid. This additive has already been assessed in the HHERA and presented in the REF (EMM 2013).

An overview of chemical handling and storage methods, and potential risks and mitigation options are provided in the REF (EMM 2013). Batch mixing of fracture stimulation fluids will not be required. The fracture stimulation service provider will mix fluids in a small volume hydrating unit as they are required. This negates the need for excess make-up of fracture stimulation fluid, and excess disposal requirements. Less handling and mixing of chemicals will result in a lower exposure to safety risks and greatly reduced risk of spillage of made-up fracture stimulation fluid. The risk to the environment from raw fracture stimulation fluids spilling is mitigated by the small volume containers of each chemical. The highest risk fluid is the bactericide Tolcide. This is a short kill bactericide and degrades rapidly in the environment. The original containers will be decanted into small volume containers prior to leaving the provider's base, reducing any environmental impact in the unlikely event that a spill was to occur.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to human health and ecology.

4.5.2 Summary

In consideration of the above, impacts to the environment from hydraulic fracture chemicals is considered to be low adverse.

4.6 Emissions

Emissions were assessed in Section 6.7 of the REF and relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

4.6.1 Impact assessment

i Well surface infrastructure location

Gas from WK11, WK 12, WK 13 and WK 14 will be directed to a central flare at WK12 (see Figure 2.4). An additional contingency flare may be installed at WK12 should the telemetry identify higher than expected gas flows.

The air quality assessment in the REF (EMM 2013) predicted that low emissions are expected with a minor amount of pollutants escaping to the atmosphere. It also predicted that potential air quality emission concentrations at receivers from the flare at WK12 would not approach EPA air quality criteria, particularly given the distance of the flare at WK12 to identified sensitive receivers (greater than 500 m).

ii Fugitive emissions

The risk associated with fugitive gas emissions from shallow beneficial aquifers and in areas of outcropping targeted coal seams has been considered in this assessment and discussed below.

Dissolved methane occurs naturally in the shallow rock, interburden and shallow coal seams of the Leloma, Jilleon, and Wenham formations, as well as the target coal seams ranging from depths 300 m to 1,000 m.

During flow testing of gas well Stratford 4 in September to October 2012, dissolved methane concentrations were measured in monitoring bores to the east of the gas well (S5 monitoring site). These monitoring bores are screened in the Jilleon Formation, with the deepest monitoring bore screened in the Roseville Coal Seam. There were no statistically significant changes in dissolved methane concentrations in the monitoring bores indicating no methane migration from deeper to shallow coal seams or fractured bedrock during depressurisation of target seams. The S5 monitoring site is close to the outcrop area of coal seams (less than 3 km). These results indicate minimal risk of gas migration to outcrop areas from depressurisation of deep coal seams during the Waukivory pilot test.

Two shallow gas monitoring wells (TGMB01 and TGMB02) are installed in the outcrop of the Roseville Coal Seam at the eastern boundary of the Tiedmans property. These gas wells are installed above the water table and are dry. The gas monitoring wells were sampled as part of the Phase 2 Groundwater Investigations (Parsons Brinckerhoff 2012). Concentrations of oxygen, argon and nitrogen were typical of air, while carbon dioxide concentrations were marginally above air concentrations. Background methane concentrations were close to the laboratory limit of reporting (16 µg/L and 138 µg/L). The levels of methane at the outcrop area pose no risk to the environment or the community and the risk of increased methane emissions is considered negligible.

Given the results of the groundwater modelling, fugitive gas emissions are not expected to occur, but the two gas monitoring bores will be monitored during the Waukivory Pilot.

4.6.2 Summary

In consideration of the above, impacts to the environment from emissions is considered to be negligible.

4.7 Noise and vibration

Noise and vibration have been considered in Section 6.8 of the REF and relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

4.7.1 Impact assessment

i Well surface infrastructure location

An environmental noise assessment is presented in Section 6.8 of the REF.

The noise assessment in the REF adopted the Environmental Criteria for Road Traffic Noise (ECRTN) (EPA 1999) as the relevant policy for assessing project related road noise impacts. The policy was adopted for consistency with previous noise assessments completed prior to June 2011.

An assessment in accordance with the Road Noise Policy (RNP) (DECCW 2011) has been undertaken for comparative purposes.

a. RNP road noise criteria

The RNP provides guidance on assessing project-related road traffic noise. The preferred activity will potentially generate additional traffic on existing sub-arterial roads (The Bucketts Way) and local roads. Table 4.1 presents the road noise assessment criteria, reproduced from Table 3 of the RNP.

Table 4.1 Road traffic noise assessment criteria for residential land uses

Road category	Type of project/development	Assessment criteria, dB(A)	
		Day (07.00 am to 10.00 pm)	**Night (10.00 pm to 07.00 am)**
Freeway/arterial/sub-arterial roads	Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{eq(15\text{-}hr)}$ 60 (external)	$L_{eq(9\text{-}hr)}$ 55 (external)
Local roads	Existing residences affected by additional traffic on existing local roads generated by land use developments	$L_{eq(1\text{-}hr)}$ 55(external)	$L_{eq(1\text{-}hr)}$ 50 (external)

The RNP states where existing road traffic noise criteria are already exceeded, any additional increase in total traffic noise level should be limited to 2 dB.

In addition to meeting the assessment criteria, any significant increase in total traffic noise at receptors must be considered. Receptors experiencing increases in total traffic noise levels above those presented in Table 4.2 should be considered for mitigation. The relative increase criterion is not applicable to local roads.

Table 4.2 Relative increase criteria for residential land uses

Road Category	Type of project/development	Total traffic noise level increase - dB(A)	
		Day (07.00 am to 10.00 pm)	**Night (10.00 pm to 07.00 am)**
Freeway/arterial/sub-arterial roads and transitways	New road corridor/redevelopment of existing road/land use development with the potential to generate additional traffic on existing road.	Existing traffic $L_{eq(15\text{-}hr)}$+12 dB (external)	Existing traffic $L_{eq(9\text{-}hr)}$+ 12 dB (external)

b. Results

The Calculation of Road Traffic Noise (CORTN) (UK Department of Transport) method was used to predict the L_{eq} noise from traffic associated with the project. CORTN, which was developed by the UK Department of Transport, considers traffic flow volume, average speed, percentage of heavy vehicles and road gradient to establish noise source strength, and includes attenuation due to distance, ground, atmospheric absorption and screening from buildings or barriers.

The expected traffic generation for the project is five light vehicle movements per hour. 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 4.3.

Table 4.3 Predicted traffic noise levels

Set Back Distance (m)	Bucketts Way				Local roads			
	Day $L_{eq\ (15\text{-}hr)}$, dB(A)		Night $L_{eq(9\text{-}hr)}$, dB(A)		Day $L_{eq(1\text{-}hr)}$, dB(A)		Night $L_{eq(1\text{-}hr)}$, 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
Criteria	**60**	**60**	**55**	**55**	**55**	**55**	**50**	**50**

CoRTN calculations show that traffic noise at sensitive receivers would satisfy the RNP criteria for all periods for both road types. Project related traffic would also satisfy the relative increase criterion.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise noise and vibration impacts from the preferred activity.

ii Water and gas gathering lines

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 including underboring activities are considered to be low adverse.

iii Water pipeline to the Tiedmans property

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 identified residential assessment locations.

The results show that predicted daytime trenching noise would not meet criteria at all assessment as works pass the near point of residences. However, given the anticipated trenching duration of 14 days, each receiver would be exposed to noise above the criteria for approximately four days in total. With the implementation of recommended mitigation measures outlined in the REF 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 Section 2.11 of the REF.

5 Biological impacts

5.1 Impact assessment

Biological impacts were assessed in Section 7 of the REF and relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

5.1.1 Well surface infrastructure location

The 100 m x 100 m area of each well has been previously assessed and approved with the drilling of the wells (EMM 2011). The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to biological values.

5.1.2 Water and gas gathering lines

The proposed area of disturbance, inclusive of the HDD entry and exit locations, 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.

No impacts in addition to those assessed in the REF (EMM 2013) are predicted. Therefore, the implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to biological resources.

5.1.3 Water pipeline to the Tiedmans property

The pipeline connecting Pontilands dam to a tee-section hydrant on the pipeline from the Tiedmans property will be laid out overland and connected when required (see Figure 2.1). It will not result in any surface disturbance, and therefore will not result in biological impacts.

The trenching areas for the water pipeline between the Tiedmans property and WK13 occur in highly disturbed vegetation and the preferred activity is not considered to meet the description of clearing of native vegetation. Native plant communities were previously replaced with introduced pasture species used for the grazing of stock. No impacts other than those addressed in the REF are considered likely to occur as result of the construction of the pipeline between WK13 and the Tiedmans property.

Measures in the EMP will be implemented to prevent new weed species being introduced and minimise the spread of existing noxious weed species.

5.2 Impact assessment summary

Impacts to biological resources from the preferred activity are considered to be negligible. The mitigation strategy in the REF (EMM 2013) has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

6 Community impacts

6.1 Impact assessment

Community impacts were assessed in Section 8 of the REF. Relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

6.1.1 Well surface infrastructure location

The 100 m x 100 m area of each well has been previously assessed and approved for the drilling of the wells (EMM 2011).

The potential visual and scenic impacts for the preferred option of a central flare at WK12 are discussed in Section 6.7 of the REF. As a second flare at WK11, described in the REF, no longer forms part of the preferred activity, the visual and scenic impacts discussed in the REF are conservative and irrelevant now.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate given the nearest receiver is over 500 m away, the activity is temporary and the impact is negligible.

6.1.2 Water and gas gathering lines

Potential impacts on community safety for the underbore of the Avon River are assessed in Section 8.5 of the REF and are negligible.

Potential 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 installed if this was not practical.

Therefore, the implementation of the mitigation strategy outlined in the REF is considered appropriate to manage and minimise impacts to visual and scenic impacts, traffic impacts, impacts to community services and infrastructure, access to community sites, economic impacts and community safety and fire risk are as assessed in the REF.

6.1.3 Water pipeline to the Tiedmans property

The pipeline connecting Pontilands dam to a hydrant on the pipeline from the Tiedmans property will be laid out overland and connected when required. It will not result in any surface disturbance, and will be on land owned by AGL.

Potential impacts on traffic and local roads from the preferred option of a water pipeline between WK13 and Tiedmans has been assessed in Section 8.3 of the REF.

The construction of the proposed buried water pipeline to the Tiedmans property is short in duration (less than three weeks) and not expected to result in adverse visual impacts.

The implementation of the mitigation strategy outlined in the REF is considered appropriate to manage and minimise impacts to visual and scenic impacts, traffic impacts, impacts to community services and infrastructure, access to community sites, economic impacts and community safety and fire risk are as assessed in the REF.

6.1.4 Transportation of flowback water

The preferred activity will require transportation of flowback water by truck from the water staging point to a licensed facility for lawful disposal. Transportation of flowback water will involve up to a total of 240 truck movements over a period of up to 16 weeks, with an a average of three water trucks per day departing from WK13. Trucks will access the water staging point from an existing property access on Fairbairns Road (via The Bucketts Way) and use existing internal access track to WK13.

Water trucks will operate Monday to Friday, 7.00 am to 6.00 pm and Saturday, 8.00 am to 1.00 pm. Transportation during school bus times, 8.00 am to 8.30 am and 3.30 pm to 4.00 pm, during school days and peak tourist times for the Herb Farm on Fairbairns Road will be avoided.

There is an existing level crossing on the access route to the well sites area via Fairbairns Road. However this level crossing has a relatively good level of safety control with flashing lights installed so there should not be any additional safety issues with the anticipated level of additional truck traffic using the road for the flowback water transportation.

The measures in the TMP at Appendix B will be implemented to mitigate traffic impacts on local roads. The TMP has been prepared in accordance with the requirements of the TAMSP in the EMP (AGL 2013).

6.2 Impact assessment summary

Impacts to community resources including visual and scenic impacts, traffic impacts, impacts to community services and infrastructure, access to community sites, economic impacts and community safety and fire risk from the preferred activity are considered to be negligible. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

7 Natural resource impacts

7.1 Impact assessment

Natural resources impacts were assessed in Section 9 of the REF. Relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

7.1.1 Well surface infrastructure location

The 100 m x 100 m area of each well has been previously assessed and approved for the drilling of the wells (EMM 2011).

Soil would be disturbed for the construction of the double-lined dual compartment turkeys nest dam and the levelling of ground for other infrastructure. Areas of soil disturbance will be stabilised once construction is complete. Therefore, the preferred activity is expected to have a low adverse impact on land and soil following implementation of measures in the EMP included with the REF.

The implementation of the mitigation strategy outlined in the REF is considered appropriate to manage and minimise impacts to natural resources.

7.1.2 Water and gas gathering lines

Soil would be disturbed for the installation of the water and gas gathering lines, including the underbore of the Avon River. Areas of soil disturbance will be stabilised once construction is complete.

Site establishment for the HDD crossing will include establishment of controls at the construction pads including (but not limited to) sediment control, site fencing, drill entry and receive pits, and controls to prevent water entering the site.

The preferred activity is expected to have a low adverse impact on land and soil following implementation of measures in the EMP included with the REF.

7.1.3 Water pipeline to the Tiedmans property

The overland pipe connecting Pontilands dam to a hydrant on the water pipeline will not result in surface disturbance, whilst the water pipeline trenches would be shallow (ie a depth of up to 1 m) and unlikely to impact natural resources.

The preferred activity presents minimal risk to agriculture as the site has not been mapped as strategic agricultural land (SAL) and is deemed to not be within a critical industry cluster. Furthermore, the 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. Impacts to agricultural resources are considered to be low adverse.

The land disturbed from the preferred activity will be rehabilitated to its pre-existing state at completion of the activity. Subject to the results of the Waukivory Pilot, this land is likely to be available for agricultural activities. Furthermore, the sourcing of water from Tiedmans dam and Pontilands dam by water pipeline and transfer of produced water to the Tiedmans property via the pipeline, compared to transporting by truck, will reduce the usage of the local road network by trucks.

7.2 Impact assessment summary

Natural resource impacts from the preferred activity are considered to be negligible. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

8 Aboriginal and cultural heritage impacts

8.1 Impact assessment

Aboriginal and cultural heritage impacts were assessed in Section 10 of the REF and relevant aspects to the preferred activity are summarised in this section. For further detailed information, please refer to the REF.

An additional due diligence assessment was done for the preferred activity in accordance with the NSW Minerals Council's 2010 code of practice: *NSW Minerals Industry Due Diligence Code of Practice for the Protection of Aboriginal Objects.* The Aboriginal heritage assessment report is provided at Appendix E.

8.1.1 Well surface infrastructure location

The 100 m x 100 m area of each well has been previously assessed and approved with the drilling of the wells (EMM 2011).

A search of the NSW Heritage database and the Gloucester Local Environment Plan (LEP) revealed no items of state or local heritage significance within the vicinity of the preferred activity.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise impacts to Aboriginal and cultural heritage values.

8.1.2 Water and gas gathering lines

There will be a small area of disturbance between WK11 and the water and gas gathering lines between WK12 and WK14 as a result of the construction of the gathering lines and underbore. The depth of boring will be more than 4 m below the natural surface level of the Avon River and the construction pads at the HDD entry and exit points will be about 40 m from the Avon River.

The proposed area of disturbance 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. The local landscape features are not considered to be conducive to past Aboriginal occupation (EMM 2013). As such, the potential for Aboriginal objects to occur on the ground surface or as subsurface deposits is considered to be negligible.

A potential archaeological deposit (PAD) was previously identified on the eastern end of the low spur, with 20 m of elevated flat area behind the spur being defined as archaeologically sensitive (EMM 2013). The water and gas gathering lines are at least 50 m north of the PAD and will occur on sloping land and on not elevated flat areas associated with the PAD.

An isolated artefact (WK-IF-1) was previously identified within the PAD on a rehabilitated access track (EMM 2011). It was noted that the artefact may have been imported from introduced gravels. Nevertheless, this isolated artefact will not be impacted by the water and gas gathering lines.

A potential scarred tree has also been recorded near the Waukivory Pilot (EMM 2011). However, the potential scarred tree is more than 100 m south of the water and gas gathering and will not be impacted.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise potential impacts to Aboriginal and cultural heritage values.

8.1.3 Water pipeline to the Tiedmans property

The water pipeline trenches would be shallow (ie a depth of up to 1 m) and are unlikely to encounter sensitive soils. To enable the underbore to occur, construction pads at the HDD entry and exit points will be established on each side of Fairbairns Road.

The water pipeline will include an overland section of pipeline connecting to Pontilands dam approximately 70 m in length (see Figure 2.1). It will not result in surface disturbance.

The proposed area of disturbance 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. The local landscape features within the preferred activity area is not considered to be conducive to past Aboriginal occupation (EMM 2013). As such, the potential for Aboriginal objects to occur on the ground surface or as subsurface deposits is considered to be negligible.

The implementation of the mitigation strategy outlined in the REF (EMM 2013) is considered appropriate to manage and minimise potential impacts to aboriginal and cultural heritage values.

8.2 Impact assessment summary

Impacts to Aboriginal and cultural heritage values from the preferred activity have been assessed (Appendix E) and are considered to be negligible. The mitigation strategy has been designed to manage and minimise impacts from the activity. These measures are considered appropriate and sufficient for the nature and duration of the activity.

9 Matters of national environmental significance

Matters of national environmental significance were assessed in Section 11.1 of the REF. No MNES were found to be significantly impacted by the preferred activity. As the preferred activity requires minimal land disturbance and based on the assessment undertaken in the REF, the preferred activity will not have a significant impact on any MNES.

AGL has assessed the Waukivory Pilot against the Commonwealth Department of Environment (DoE) (formerly the Department of Sustainability, Environment, Water, Population and Communities) *Draft significant impact guidelines: Coal seam gas and large coal mining developments – impacts on water resources* and determined the project would not have a significant impact on water resources.

Therefore, the Waukivory Pilot will not be referred under the EPBC Act water trigger. The self assessment report has been provided to DoE and can be supplied to OCSG if required.

10 Cumulative impacts

The cumulative environmental impacts of the preferred activity were assessed in Section 12.1 of the REF. A number of environmental investigations were completed as part of the REF and consideration has been given to the wider area within the environmental assessments prepared as part of the REF and in the environmental investigations prepared as part of the wider PEL 285 area.

It is considered that if the recommendations of the REF report and appropriate controls are in place during the works, the preferred activity is unlikely to have any cumulative environmental impact.

11 Summary of impacts

The PAR documents the assessment of the potential environmental impacts of the preferred activity and responds to the information requests raised by the OCSG (refer to Table 1.1).

Table 11.1 summarises the impacts of the preferred activity and the extent of such impacts. The assessment did not identify any increase in the impact levels identified in the REF. The REF provides a complete summary of environmental impacts of the activity.

Table 11.1 Summary of impacts

Impacts	Level of impact REF (EMM 2013)	Level of impact PAR
Physical and chemical	Negligible to low adverse	Negligible to low adverse
Biological	Negligible	Negligible
Community	Low adverse	Low adverse
Natural resource	Negligible to low adverse	Negligible to low adverse
Aboriginal heritage	Negligible	Negligible
Historic cultural heritage	Low adverse	Low adverse
Cumulative	Negligible	Negligible

12 Conclusion

The PAR presents information from the REF (EMM 2013) relevant to the preferred activity only, including a description of preferred activity, its methods and environmental assessment. Additional information requested by OCSG about the preferred activity has also been included.

Additional management measures for potential impacts identified in the PAR have been included in Section 2.9 - Mitigation strategy.

Following the implementation of the mitigation strategy in the REF (EMM 2013) and the mitigation measures in the PAR, all impacts for the preferred activity are expected to remain negligible to low adverse.

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