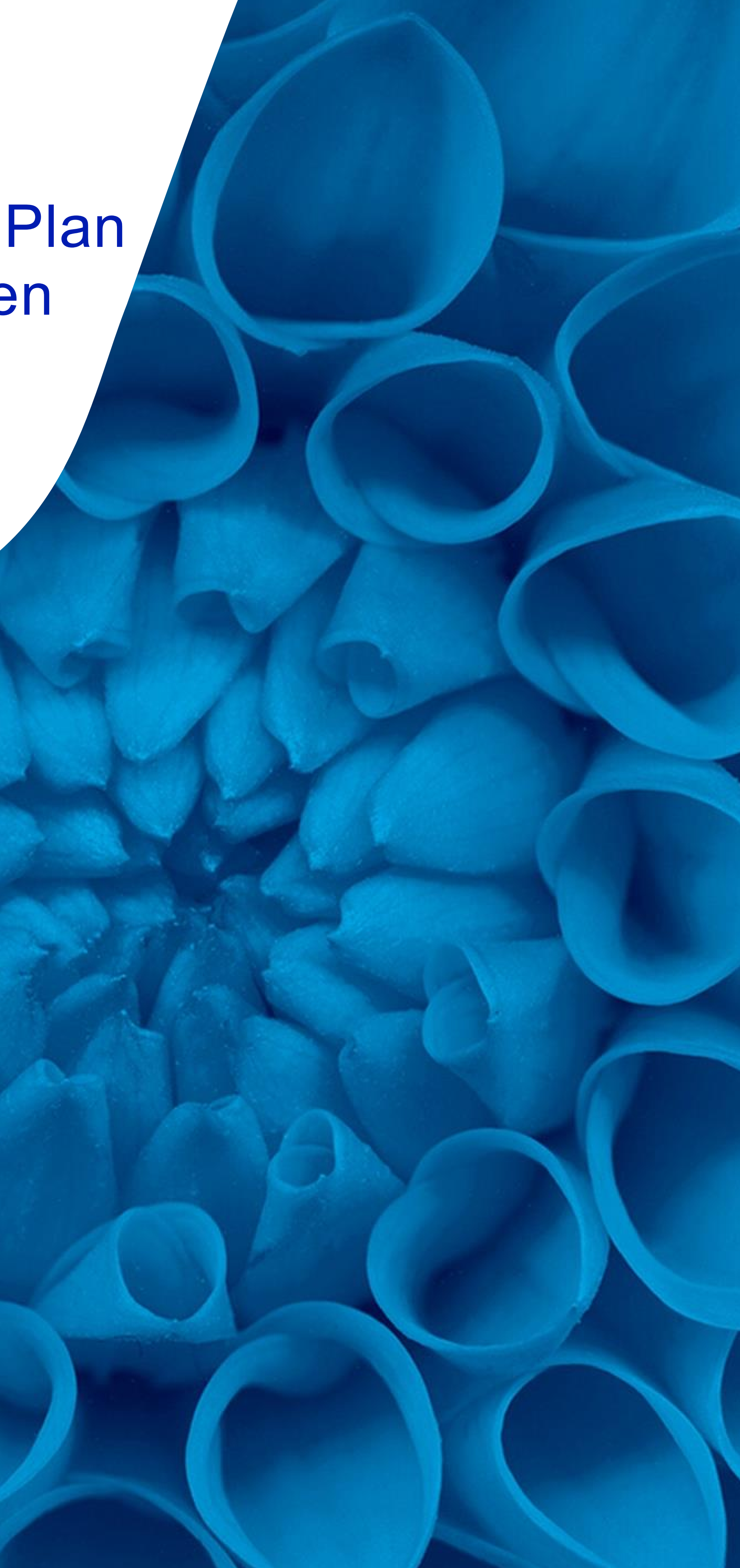
Groundwater Management Plan for the Camden Gas Project



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Document revision history

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25/10/2011	V1.1	J. Ross	Initial Draft for Internal Review
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Glossary	
Alluvium	Unconsolidated sediments (clays, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on river beds, floodplains, and alluvial fans.
Alluvial aquifer	Permeable zones that store and produce groundwater from unconsolidated alluvial sediments. Shallow alluvial aquifers are generally unconfined aquifers.
Anthropogenic	Occurring because of, or influenced by, human activity.
Aquiclude	A very low permeability unit that forms either the upper or lower boundary of a groundwater flow system and does not transmit water or allow water to migrate from upper and lower horizons.
Aquifer	Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water.
Aquifer properties	The characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquifer, confined	An aquifer that is overlain by low permeability strata. The hydraulic conductivity of the confining bed is significantly lower than that of the aquifer.
Aquifer, semi-confined	An aquifer overlain by a low-permeability layer that permits water to slowly flow through it. During pumping, recharge to the aquifer can occur across the confining layer – also known as a leaky artesian or leaky confined aquifer.
Aquifer, unconfined	Also known as a water table aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of an unconfined aquifer.
Aquitard	A low-permeability unit that can store groundwater and also transmit it slowly from one formation to another. Aquitards retard but do not prevent the movement of water to or from adjacent aquifers.
Australian Height Datum (AHD)	The reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.
Bore	A structure drilled below the surface to obtain water from an aquifer or series of aquifers.
Claystone	A non-fissile rock of sedimentary origin composed primarily of clay-sized particles (less than 0.004 mm).
Coal	A sedimentary rock derived from the compaction and consolidation of vegetation or swamp deposits to form a fossilised carbonaceous rock.
Coal seam	A layer of coal within a sedimentary rock sequence.
Coal seam gas (CSG)	Coal seam gas is a form of natural gas (predominantly methane) that is extracted from coal seams.

Confining bed	Low permeability strata that may be saturated but will not allow water to move through it under ordinary hydraulic gradients.
Contamination	The presence in, on or under the land of a substance at a concentration above the concentration at which the substance is normally present in, on or under (respectively) land in the same locality, being a presence that presents risk of harm to human health or any other aspect of the environment.
Control Sites	Dedicated monitoring bore sites distant from any well pad so as to avoid severe areas of depressurisation.
Dewatering	The process of removing formation water from a targeted coal seam. Dewatering is required to reduce pressure in the coal so gas can desorb and produce.
Discharge	The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.
Drawdown	A lowering of the water table in an unconfined aquifer or the pressure surface of a confined aquifer caused by pumping of groundwater from bores and wells.
Electrical conductivity (EC)	A measure of a fluid's ability to conduct an electrical current and is an estimation of the total ions dissolved. It is often used as a measure of water salinity.
Flowback	The process of allowing fluids to flow from a gas well following a treatment (such as fracture stimulation), either in preparation for a subsequent phase of treatment or in preparation for clean-up and returning the well to production.
Formation water	Natural groundwater occurring within the pores of rock.
Fracture stimulation	See hydraulic fracturing.
Fractured rock aquifer	Aquifers that occur in sedimentary, igneous and metamorphosed rocks which have been subjected to disturbance, deformation, or weathering, and which allow water to move through joints, bedding planes, fractures and faults. Although fractured rock aquifers are found over a wide area, they generally contain much less groundwater than alluvial and porous sedimentary aquifers.
FY	Financial year. FY2018, for example, refers to the 12 month period from July 1 2017 to June 30 2018. Note, the water year coincides with the financial year.
Groundwater	The water contained in interconnected pores or fractures located below the water table in the saturated zone.
GMP	Groundwater Management Plan
GMWSP	Greater Metropolitan Region Water Sharing Plan
Groundwater system	A system that is hydrogeologically more similar than different in regard to geological province, hydraulic characteristics and water quality, and may consist of one or more geological formations.

Hydraulic conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium (notionally equivalent to the permeability of an aquifer to fresh water).
Hydraulic fracturing	A fracture stimulation technique that increases a gas well's productivity by creating a pathway into the targeted coal seam by injecting sand and fluids through the perforated interval directly into the coal seam under high pressure.
Key Indicator Sites	Dedicated monitoring bore sites within 400m of a well pad location to assess connectivity and drainage from shallow aquifers as this will be the area of greatest depressurisation.
microSiemens per centimetre (μS/cm)	A measure of water salinity commonly referred to as EC (see also Electrical Conductivity). Most commonly measured in the field with calibrated field meters.
Monitoring bore	A non-pumping bore generally of small diameter that is used to measure the elevation of the water table and/or water quality. Bores generally have a short well screen against a single aquifer through which water can enter.
NOW	New South Wales Office of Water; since early 2017 was renamed as DoI Water (formally DPI Water) and since late 2017 was renamed as NRAR
NRAR	National Resources Access Regulator
pH	Potential of Hydrogen; the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per litre; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral, greater than 7 is alkaline and less than 7 is acidic).
Piezometer	See monitoring bore or vibrating wire piezometer (as appropriate).
Piezometric surface	The potential level to which water will rise above the water level in an aquifer in a bore that penetrates a confined aquifer; if the potential level is higher than the land surface, the bore will overflow and is referred to as artesian.
Produced water	Groundwater generated from coal seams during flow testing and production dewatering.
Proppant	Sand or synthetic high strength particles used during fracture stimulation to fill the fracture space and hold the fracture open during the production life of a well.
Recharge	The process which replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table and by river water reaching the water table or exposed aquifers. The addition of water to an aquifer.
Sandstone	Sandstone is a sedimentary rock composed mainly of sand-sized minerals or rock grains (predominantly quartz).
Sandstone aquifer	Permeable sandstone that allows percolation of water and other fluids, and is porous enough to store large quantities.

Sedimentary rock aquifer	These occur in consolidated sediments such as porous sandstones and conglomerates, in which water is stored in the intergranular pores, and limestone, in which water is stored in solution cavities and joints. These aquifers are generally located in sedimentary basins that are continuous over large areas and may be tens or hundreds of metres thick. In terms of quantity, they contain the largest volumes of groundwater.
Screen	A type of bore lining or casing of special construction, with apertures designed to permit the flow of water into a bore while preventing the entry of aquifer or filter pack material.
Shale	A laminated sediment in which the constituent particles are predominantly of clay size.
Siltstone	A fine-grained rock of sedimentary origin composed mainly of silt-sized particles (0.004 to 0.06 mm).
Standing water level (SWL)	The height to which groundwater rises in a bore after it is drilled and completed, and after a period of pumping when levels return to natural atmospheric or confined pressure levels.
Stratigraphy	The depositional order of sedimentary rocks in layers.
Vibrating wire piezometer	A vibrating wire piezometer measures pore pressure and consists of a vibrating wire pressure transducer and signal cable. It can be installed in a borehole, embedded in fill or suspended in a standpipe.
Water bearing zone	Geological strata that are saturated with groundwater but not of sufficient permeability to be called an aquifer.
Water quality	Term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water table	The top of an unconfined aquifer. It is at atmospheric pressure and indicates the level below which soil and rock are saturated with water.
Well	Pertaining to a gas exploration well or gas production well.
Zonal isolation	Isolating an interval or unit of rock from surrounding rock types on the basis of its lithology or other features, such as faults or fractures.

1. Introduction

This Groundwater Management Plan (GMP) has been prepared as a condition of licence attaching to the combined works and use approvals issued for the Camden Gas Project (CGP) by National Resources Access (formerly NSW Department of Industry Water (DoI Water), DPI Water and NSW Office of Water (NOW)). This GMP also satisfies condition PRP 2 of Environment Protection Licence (EPL) 12003 issued by the Environment Protection Authority (EPA), which requires a GMP for the CGP.

The GMP Version 1.4 was independently peer reviewed by Liz Webb (Senior Hydrogeologist) at Parsons Brinckerhoff (PB) (PB, 2012).

The CGP ceased gas production on 28 August 2023. All remaining gas wells have been shut in and are progressively being decommissioned and rehabilitated. Produced water is no longer generated from the remaining gas wells. Details on construction and production operations have been retained in this version of the GMP to provide full context of AGL's activities.

1.1. Objectives

The purpose of the GMP is to provide a framework which describes how AGL will assess changes in the different groundwater systems located beneath the CGP area, particularly the shallow beneficial aquifers, due to dewatering of the deep coal seams and other coal seam gas (CSG) activities. The primary risks to groundwater to be assessed are:

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

The objectives of this GMP are therefore to:

- Describe the water level and water quality monitoring network across the different groundwater systems located beneath the CGP area;
- Identify water level and water quality trends that may suggest connectivity or contamination of aquifers due to CSG activities;
- Provide a monitoring (and an action response) framework for the groundwater monitoring program at Camden;
- Provide water triggers for an action plan should there be unexpected water level or water quality impacts; and
- Outline the reporting and review requirements for the monitoring program.

1.2. Responsibilities

AGL is responsible for compliance with this GMP.

AGL is responsible for compiling the annual technical reports required by NRAR in accordance with the licence conditions associated with the combined works and use approvals and this GMP.

Response triggers were developed in consultation with DPI Water (now NRAR). A summary of the individual roles and responsibilities are provided in Table 1.

Table 1: Groundwater Management Roles and Responsibilities

Role	Responsibility	Frequency
Preparation and review of GMP	AGL – Environment Business Partner	Annually, commencing in June each year
Compliance matters		
Annual (NRAR) Bore Licence Compliance Report	AGL – Environment Business Partner	Annual report by 30 September each year
Response triggers and actions (including assessment, clean-up or remediation of contaminated groundwater)	AGL – Environment Business Partner External Consultant	As required

1.3. Reporting requirements

As part of the EPL 12003, AGL was required to prepare and submit to the EPA by 31 July 2012 a Draft GMP for the premises and proposed expansion areas. Version 2.3 of this GMP was submitted for their review.

This GMP has also been prepared as a condition of licence attaching to all the original industrial bore licences (which have since transitioned to the Water Access Licences and associated works and use approvals) issued for the CGP by NRAR. The reporting requirements as defined within the conditions associated with the works and use approvals are addressed in Section 4.

2. Background

The current wellfield layout for the Camden Gas Project (CGP) is shown in Table 2.

Background details relating to geology, hydrogeology and the wellfield are provided in the initial desktop study for the CGP (CM Jewell, 2001), the Hydrogeological Summary (AGL, 2013a), the Phase 1 groundwater investigation report for the northern expansion area (PB, 2011), and the bore licensing compliance reports (e.g. EMM, 2017).

2.1. Geological and hydrogeological setting

2.1.1. Regional and local geology

The CGP is located within the Southern Coalfield of the Sydney Geological Basin. The Sydney Basin is sedimentary in origin and the deposition of sediments occurred from the early Carboniferous (290 million years ago) through to the latter part of the Triassic (200 million years ago). The Sydney Basin on-laps the Lachlan Fold Belt to the west and south, with basin depth increasing to the north and east.

The geological strata of the Sydney Basin (from youngest to oldest) can be summarised as:

- Unconsolidated alluvial deposits along the major rivers and dune/beach deposits along the coast (Tertiary and Quaternary in age).
- Fractured volcanic intrusive and flows (and associate dyke swarms and occasional sills) within the Sydney Basin (Jurassic and Tertiary in age).
- Sedimentary rocks (including substantial coal measures at depth) of the Sydney Basin (Permian and Triassic age).
- Fractured basement rocks below the Sydney Basin (Palaeozoic age).

Locally the stratigraphy of the CGP area (from youngest to oldest) can be summarised as:

- Alluvial sediments (sand, gravel, silt and clay) overlie the Wianamatta Shales and Hawkesbury Sandstone along the major rivers and creeks. These sediments are rarely more than 20 m thick.
- Wianamatta Group: where alluvial deposits are not present, the Triassic Wianamatta Group comprises the surficial geology over most of the CGP area. It can be very thin to more than 100 m thick in some of the more elevated areas. The Wianamatta Group primarily comprises shales, with occasional calcareous claystone, laminate and coal. Ashfield Shale is the most widespread rock type, at surface, across the area.
- Mittagong Formation: separates the Ashfield Shale from the underlying Hawkesbury Sandstone. It is a thin layer (generally less than 10 m thick) comprising dark grey to grey alternating beds of shale laminate, siltstone and quartzose sandstone.
- Hawkesbury Sandstone: alluvial in origin, with a thickness of approximately 200 m in the Camden area. Sandstone thicknesses increase to the north. The Triassic Hawkesbury Sandstone is generally medium to coarse grained quartz sandstone, with interbedded siltstone, finer grained sandstone and shale lenses. Shale lenses are common within this formation.
- Narrabeen Group: the total thickness of these Triassic rocks is approximately 450 m across the CGP area.
  - Gosford Sub-group (Triassic): Newport Formation is medium grained, light to dark grey, quartzose sandstone interbedded with siltstone. Garie Formation is a thin, cream kaolinite claystone, which grades upwards to grey.

- Clifton Sub-group (Triassic): Bald Hill Claystone is grey to red/brown claystones and mudstones, occasional siderite nodules and generally softer than the overlying Garie Formation. Bulgo Sandstone is white to grey coarse grained sandstone, fining upwards to coarse pebbly sandstone, with interbedded siltstone. Stanwell Park Claystone comprises alternating light grey/green to brown sandstone and claystone intervals, with minor conglomerate. Scarborough Sandstone is fine to very coarse grained, white to grey sandstone, with occasional siltstone and conglomerate laminae. Wombarra Claystone consists of light grey/green to dark grey claystone, siltstone, mudstone with minor quartz lithic sandstone and conglomerate.

- Illawarra Coal Measures: the sedimentary thickness is approximately 300 m in the central area of the Southern Coalfield. The upper sections of the Permian Illawarra Coal Measures (Sydney Sub-group) contain the major coal seams: Bulli, Balgownie, Wongawilli, Tongarra and Woonona. The underlying Cumberland Sub-group generally contains thin coal seam development.
- Shoalhaven Group: The Permian Budgong Sandstone is shallow marine to littoral, typically comprising fine and course grained sandstone.
- Basement geology: The Southern Sydney Basin Permian and Triassic rocks have been deposited upon early to middle Palaeozoic basement rocks. These rocks consist of intensely folded and faulted slates, phyllites, quartzite sandstones and minor limestones of Ordovician to Silurian age.

2.1.2. Regional and local hydrogeology

Thin Tertiary and Quaternary alluvial deposits occur in valleys, creeks and river beds across the region. The unconfined aquifers within the alluvium are responsive to rainfall and stream flow, and are a useful aquifer across the region for stock and small scale irrigation purposes.

The Wianamatta Group shales are characterised by saline groundwater due to marine deposition, and are generally not considered beneficial aquifers. The shales are generally low permeability, occasionally have minor aquifers and perched water tables but mostly behave as aquitards. The underlying Mittagong Formation is low permeability and is not considered an aquifer.

The Hawkesbury Sandstone is a dual porosity regional aquifer system that occurs across the whole of the Sydney Basin. Groundwater flow is variable throughout the Hawkesbury Sandstone, and is generally dominated by secondary porosity and fracture flow when associated with structures such as faults and fracture zones. The primary porosity of the rock matrix is low, and a water bore that does not intercept major fractures or fissures is likely to yield less than 2 litres per second (L/s). Where Hawkesbury Sandstone outcrops at surface there is rainfall recharge and there is fresher water in the sandstone aquifers. There is a wide range of water quality from these aquifers across the region from fresh-brackish to moderately saline. In areas where the sandstone is not exposed, the water quality within the upper sections of the Hawkesbury Sandstone is often poorer than the lower sections due to leakage of salt from the overlying shale formations. The Hawkesbury Sandstone is the major (semi-confined) aquifer across the region.

The sandstone formations within the Narrabeen Group (predominantly the Bulgo Sandstone and the Scarborough Sandstone) are considered minor (confined) aquifers. These formations are generally considered to be much lower yielding and of poorer water quality then the overlying Hawkesbury Sandstone. They are not used for water supply purposes.

Coal seams, such as those present in the Permian Illawarra Coal Measures, generally form minor water bearing zones. Groundwater associated with coal seams is generally poor in quality, with moderate to high salinities. These zones are not used for water supply.

Locally the greatest thickness of Quaternary alluvium is along the floodplain of the Nepean River, although there are minor occurrences along tributaries, and other sediments associated with residual Tertiary terraces. The alluvial deposits are generally shallow, discontinuous (except along the Nepean River) and relatively permeable. The unconfined aquifers within the alluvium are a useful aquifer across the local area.

The aquifers within the Hawkesbury Sandstone are mostly primary permeability aquifers in the local area because of the lack of major fracturing and fault systems. Yields are highest and salinities are freshest south of the Nepean River because of the proximity to recharge areas, however north of the Nepean River, the salinities increase and become moderately saline in all aquifers within the sandstone. Beneficial uses are generally stock and limited domestic/irrigation use south of the Nepean River and generally limited stock use north of the Nepean River.

Locally the groundwater conditions in the deeper Narrabeen Group and Illawarra Coal Measures are the same as occur in the wider region.

To conclude, the only beneficial aquifers (used for water supply) across the CGP area are the shallow alluvial aquifers (where present) and the porous and fractured rock aquifers within the Hawkesbury Sandstone. There is no surface expression of the deeper groundwater systems and consequently there are no groundwater dependent ecosystems associated with the sedimentary rock groundwater systems.

It should be noted the Cumberland Shale Hills/Plains Woodland, which is identified as a highly probable groundwater dependant ecosystem is present within the vicinity of the project area (Serov et al., 2012); however it appears it is dependent on very shallow, localised perched groundwater in soils (derived from Wianamatta Shale) and local colluvium/alluvium rather than the deeper, regional groundwater systems.

2.2. Phase 2 site groundwater investigations

Investigations have been completed within the CGP and the former northern control area to characterise the shallow groundwater systems which has included the installation of dedicated monitoring bores so as to monitor and protect shallow beneficial aquifers. Nested monitoring bore locations (into the Wianamatta Shale and Hawkesbury Sandstone) were installed at three locations, two within the CGP and one, as a background site, within the northern control area (see Section 5.2). Permeability, water level and water chemistry information was obtained from each site. Monitoring ceased in the northern control area in October 2016. Monitoring ceased in the CGP in 2024.

The nested monitoring bores within the CGP were located in areas reasonably close to wells (approximately 40 m away) in both undisturbed strata and in areas with minor faulting systems. A background nested monitoring bore location was located approximately 12 km to the north east of the CGP (northern control area) until the bores were decommissioned in October 2016. The data collected from the nested monitoring bores enabled assessment of connectivity and drainage from shallow aquifers, as a direct result of CSG dewatering operations. The nested monitoring bore located near a zone of minor faulting within the coal seams assisted in the assessment of potential pathways between shallow and deep aquifers/water bearing zones as a result of the fault systems.

2.3. Production wellfield

2.3.1. Current status, decommissioning and rehabilitation schedule

The CGP is owned and operated by AGL, and is located in the Macarthur region 60 km southwest of Sydney, in the Wollondilly, Camden, and Campbelltown Local Government Areas. The CGP has been producing gas for the Sydney region since 2001 and consisted of a total of 144 gas wells, low-pressure underground gas gathering pipes and a gas plant facility. Most wells are approved under the *Water Management Act (2000)* (with relevant Water Access Licences (WALs) and Works and Use Approvals (WUAs) applying) or are suspended and planned to be plugged and abandoned.

AGL announced in February 2016 that at Camden, it will extract gas from its existing wells enabling closure of the facility in 2023. The CGP ceased gas production on 28 August 2023. All remaining gas wells are now being progressively decommissioned and rehabilitated.

AGL currently holds three Petroleum Production Leases (PPLs 1, 4, and 5) in the area under the *Petroleum (Onshore) Act 1991 (POA)* enabling the production, gathering and sale of coal seam methane gas (CSG). PPL 2 and PPL 6 have been relinquished.

The well surface locations (or well sites) are scattered throughout the PPLs and were determined following extensive geological exploration and analysis. Locations are mostly in areas of undisturbed (essentially flat lying) strata and away from fault systems, in order to maximise gas flow.

Once the preferred geological target areas were identified, the well site selection process considered the environmental and social constraints of the area. These included land use (existing and future), topography, subsurface geology, flora and fauna, archaeology and noise. This detailed design information become part of the environmental assessment and approvals process for new gas fields and facilities.

Wells were named and numbered according to a two letter abbreviation of the well field so that each well, even if it is co-located with a number of other wells, has its own unique name, for example EM17 or MP30.

A gas well generally has four main stages in its life cycle which are outlined below:

i) Drilling (construction and fracture stimulation (where required), includes associated civil construction);

ii) Commissioning (flowback, includes initial rehabilitation of the surplus construction area);

iii) Production (dewatering, operation and maintenance); and

iv) Well closure, abandonment and final rehabilitation.

2.3.2. Well construction

The production wells within the fields comprise a mixture of vertical, deviated and horizontal wells. The most recent drilling programs were entirely horizontal wells with multiple wellheads on single pads so as to minimise the land use impacts. The two well types are:

- Vertical and Deviated Drilling: Vertical and deviated wells (all of which have been fracture stimulated) are the primary gas well type in the CGP area. Wells are drilled vertically or at a deviation to a maximum of 45° (for deviated wells) to intercept the Bulli and Balgownie Coal Seams. Wells have multiple casings with a conductor casing near surface (6 - 30 m, depending on the shallow sedimentary environment) to support surface formations and avoid cave ins near surface during drilling operations, a surface casing to around 120 – 140 m (depending on the location) to exclude shallow aquifers and a production casing to full depth. All casings are pressure cemented in place.
- Horizontal Drilling: Horizontal wells are used to increase the drainage area of a reservoir and provide a means of stimulating the reservoir through the drilling process. Like vertical wells, horizontal wells also have steel conductor and surface casing which is pressure cemented in place to exclude shallow aquifers. The well is drilled vertically from the surface and gradually builds angle so as to intersect the seam near parallel with the seam dip angle. Once intersected, this portion of the well bore is cased, cemented and a smaller hole is subsequently drilled through the seam anywhere from about 1300 to 2500 m. This allows a significant reduction in the number of surface locations along with the ability to access previously sterilised gas reserves.

Shallow beneficial aquifers (which in this area are mostly less than 150 m from surface in the alluvium and shallow sandstone but occasionally up to 300 m from surface in the Hawkesbury Sandstone) are protected by up to four barriers within the well construction: two steel and two cement barriers. The well construction design incorporates numerous contingencies to ensure zonal isolation between coal seams and other formations, including the shallow aquifers. Aside from the important environmental considerations, zonal isolation is important for gas production, as water migration from other sources will hinder gas production, so all precautions are taken during well construction to ensure no communication between other formations can exist with respect to the well shaft.

Gas production is maximised when the hydrostatic pressure of the coal seam is reduced (dewatered) and there is minimal ongoing water contributions from the coal seam and adjacent formations.

2.3.3. Production

During the production/operational phase of a production well, the well is initially dewatered in order to initiate and maintain gas flow from the target coal seam. To maximise gas production from production wells, the water level in the wellbore must be kept depressed. Because coal seams are usually relatively shallow, low pressure formations compared to conventional gas reservoirs, it aids gas production to pump water from coal seam gas wells continuously or intermittently to minimise and maintain the lowest bottom-hole pressure and allow gas to flow into the wellbore.

In summary the producing seams are generally flowing at very low pressure and the water levels are just above or within the perforated interval. The produced water is collected onsite in 10,000 L plastic tanks, and is collected (at regular intervals) and trucked to the RPGP for filtration, prior to being transported to a licenced offsite water recycling plan. Once gas is flowing freely, there is little work required to maintain production other than monitoring, routine maintenance and removal of produced water.

2.4. Future plans for the CGP

The CGP has ceased gas production. All remaining wells are currently shut in and will be progressively decommissioned and rehabilitated throughout FY25.

3. Water management framework

In NSW, drilling activities that intersect groundwater systems and abstractions from different groundwater sources are managed by NRAR. Activities that affect the quality of the receiving waters (in this case deep groundwater systems) are managed by the Environment Protection Authority (EPA). There are numerous groundwater policies and licensing systems that apply to different areas and different projects. Only those policies and plans that are relevant to the CGP are discussed in this GMP.

The access, taking and use of groundwater in NSW is currently managed and implemented by NRAR under two primary legal instruments — the *Water Management Act 2000* and the *Water Act 1912*. Activities that could potentially impact the quality of a groundwater system are managed under the *POEO Act 1997*.

All (sedimentary rock) groundwater in the CGP area is located within two groundwater sources – the Sydney Basin Nepean Groundwater Source (south of the Nepean River) and the Sydney Basin Central Groundwater Source (north of the Nepean River). These are two of 13 groundwater sources gazetted under the Greater Metropolitan Region Groundwater Sharing Plan (GMWSP).

Groundwater within these water sources was managed under the *Water Act 1912* up until 30 June 2011 but is now managed under the *Water Management Act 2000* as the GMWSP for the area encompassing the CGP commenced on the 1st July 2011.

3.1. Groundwater Policies

There are several overarching policies that apply to the development and management of groundwater systems across NSW. These include:

- The **NSW State Groundwater Policy Framework** (Department of Land and Water Conservation (DLWC), 1997). The NSW State Groundwater Policy Framework introduces three policy documents:
  - NSW Groundwater Quality Protection Policy (DLWC, 1998)
  - NSW Groundwater Quantity Management Policy (draft) (DLWC, 2001)
  - NSW Groundwater Dependent Ecosystem Policy (DLWC, 2002).

The NSW State Groundwater Policy Framework aims to slow, halt or reverse degradation in groundwater resources, ensure long-term sustainability of the biophysical characteristics of the groundwater system, maintain the full range of beneficial uses of these resources and maximise the economic benefit to the region and state.

Other policies of interest include:

- Buried Groundwater Sources Policy (NOW, 2011).
- Aquifer Interference Policy (NOW, 2012).

The **Buried Groundwater Sources Policy** has been developed to set out a framework for how access to water will be managed in groundwater sources that are fully buried or partly buried (such as deep sedimentary basins).

Water sharing plans made under the *Water Management Act 2000* set limits on the availability of water by specifying a limit on the total volume of water available for extraction from water sources within the plan area. This limit is termed the long-term average annual extraction limit (LTAAEL). Where this water is now fully allocated under a WSP, this policy allows additional water to be allocated from groundwater storage.

Fully buried or partly buried groundwater sources have little or no surface expression (outcrop), and therefore have very little or no water available for extraction based on rainfall recharge. Fractured rock groundwater systems generally have relatively small volumes of water in storage, whereas porous rock groundwater systems can be capable of storing large volumes of water. Consequently, this policy allows the release of a very small percentage of the volume of water in storage in porous rock groundwater systems (0.002% of storage).

This policy has no application in the CGP area at this time.

The **Aquifer Interference Policy** defines aquifer interference activities and describes how these will be managed under the licensing and approvals regime in the *Water Management Act 2000*. Under this policy, a water access licence is required when taking water from an aquifer and adjacent water sources that may be impacted by the aquifer interference activity. The volume taken must be in excess of three megalitres (ML) per annum. The policy focuses on high risk activities such as mining, coal seam gas, sand and gravel extraction, construction dewatering, aquifer injection activities, and other activities that have the potential to contaminate groundwater or result in unacceptable loss of storage or other structural damage to an aquifer.

3.2. Legislation

3.2.1. Water Act (1912)

The *Water Act 1912* came into force at the turn of the last century and since 2003 has been progressively phased out (repealed) and replaced by the *Water Management Act 2000* as new Water Sharing Plans are gazetted.

All of AGL's bore licences for the CGP were originally issued under the *Water Act 1912*. In FY2013, all the production bore licences transitioned to WALs and WUAs under the *Water Management Act 2000*.

AGL held 137 industrial bore licences (and an allocation of 30 ML per year) for its existing CGP and associated dewatering activities from the deep coal seams and two industrial bore licences for shallow bores (and allocations of 5 and 2.4 ML per year) for its drilling and water make-up operations. These have been transitioned to four Water Access Licences, works and use approvals. This GMP only relates to the CGP wellfield, dewatering activities, monitoring activities and associated compliance activities.

Application for groundwater monitoring bores remains licensable under the *Water Act 1912* at this time.

3.2.2. Water Management Act (2000)

The *Water Management Act 2000* is gradually being introduced across NSW. Once a water sharing plan commences, the *Water Act 1912* is repealed for that water source and existing licences are converted to new consents under the *Water Management Act 2000*. The groundwater sources in the southern Sydney Basin were included in a new GMWSP in July 2011; hence groundwater licences issued under the *Water Act 1912* have now been converted to water access licences.

3.2.3. Protection of the Environment Operations Act (1997)

The EPA has amended AGL's environment protection licence (EPL) 12003 for the CGP to require further detail in relation to groundwater management, produced water management, and best management practices relating to drilling, hydraulic fracturing, well workovers and periodic chemical treatments.

The primary intent of the new licence conditions is to ensure that groundwater systems (as receiving waters) are protected. An unusual aspect is that the targeted coal seams are not aquifers (these are poor water bearing zones) and the native water quality is slightly to moderately saline (electrical conductivity that is typically in the range of 7,000 – 15,000 μS/cm).

The conditions under the Pollution Studies and Reductions Programs section of the licence were included in EPL 12003 on 22 December 2011. They are generally consistent with the intent of the bore licence conditions that authorise well construction, development and dewatering under the *Water Act*.

Additional amendments to the EPL relating to groundwater monitoring were made in February 2016. The EPL included requirements for monitoring of specific pollutants at two specified monitoring points (CSG wells) at six-monthly intervals. It was also a requirement of the EPL that the monitoring results be published on AGL's website. This condition has now been removed from EPL 12003 but previous results are still available on this webpage: https://www.agl.com.au/about-agl/how-we-source-energy/camden-gas-project/documents

3.3. Greater Metropolitan Groundwater Sharing Plan

The Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources (GMWSP) commenced on the 1 July 2011 (NSW Government, 2011).

The GMWSP covers 13 groundwater sources. The Greater Metropolitan Region groundwater sources are located on the east coast of NSW, covering an area of approximately 32,500 km^2. The region spans from Broken Bay in the north, to Shoalhaven Heads in the south, and Lithgow and Goulburn to the west.

Most of the current CGP wellfield area is located within the Sydney Basin Nepean Groundwater Source. The former northern control area of the CGP is located in the Sydney Basin Central Groundwater Source area. The Nepean River is the divide between the two groundwater sources, although hydrogeologically there is flow from (approximately) south to north across this boundary.

The Sydney Basin Nepean Groundwater Source is bounded by the Nepean River to the north and the Woronora and Illawarra escarpments to the east and south. The area comprises mostly water supply catchments and the Metropolitan Dams network plus Warragamba Dam and its protected catchment. There are also agricultural and rural residential lands around the towns of Mittagong, Bowral, Moss Vale and Robertson. There are a substantial number of bores into the Hawkesbury Sandstone aquifer across this area. The total area of the Sydney Basin Nepean Groundwater Source is approximately 3,860 km^2.

The Sydney Basin Central Groundwater Source is bounded by the Hawkesbury River to the north and by the Nepean River to the west and south. A large proportion of Sydney's population resides within this groundwater source area and relatively few water bores are distributed across the area. The total area of the Sydney Basin Central Groundwater Source is approximately 3,760 km^2.

Both the Sydney Basin Nepean Groundwater Source and the Sydney Basin Central Groundwater Source do not specifically recognise the deeper groundwater contained in the Permian Coal Measures as a separate water source. However under the GMWSP, all groundwater extracted from the sedimentary rocks, irrespective of the horizon from which groundwater is pumped, is authorised as part of the long-term average annual extraction limits (LTAAEL) for these two water sources.

AGL's 30 ML per year entitlement is a miniscule component of the LTAAEL that is available for allocation to consumptive users across the Nepean Groundwater Source (99,568 ML per year) and the Central Groundwater Source (45,915 ML per year). The allocation is currently assigned to the Nepean Groundwater Source.

4. Compliance Requirements

This section describes the bore licensing requirements and the specific conditions relating to each of the construction, operation, monitoring and abandonment activities. These conditions are now associated with the combined work and use approvals for the Camden Gas Project.

4.1. Water Access Licences, Works and Use Approvals and bore licences

AGL held 137 bore licences for the CGP gas production wells, which have now been transitioned to two Water Access Licences (24856 and 24736) and Works and Use Approvals (10WA112288 and 10WA112294) or have otherwise expired. Existing production gas wells have a combined allocation of 30 ML per year, with 15 ML allocated to the Sydney Basin Central Groundwater Source and 15 ML allocated to the Sydney Basin Nepean Groundwater Source, and are licensed for industrial purposes. The WAL and WUA conditions and a compliance assessment are included in Appendix A.

Operational gas production wells, or those that are potentially operational, are licensed. Older suspended wells never likely to produce again and plugged and abandoned wells are not licensed. The current list of remaining wells across the CGP (licence, approval, well number) is provided in Table 2.

Table 2: Licensed Gas Production Wells in the Camden Gas Project Wellfield

Licence No.	WAL	Field	Well name	Licence No.	WAL	Field	Well name
10WA112294	24736	EMAI	EM02	10WA112294	24736	Mahon	MH01
10WA112294	24736	EMAI	EM03	10WA112288	24856	Menangle Park	MP01
10WA112294	24736	EMAI	EM04	10WA112288	24856	Menangle Park	MP02*
10WA112294	24736	EMAI	EM05	10WA112288	24856	Menangle Park	MP03*
10WA112294	24736	EMAI	EM06	10WA112288	24856	Menangle Park	MP05
10WA112294	24736	EMAI	EM07	10WA112288	24856	Menangle Park	MP05A
10WA112294	24736	EMAI	EM08	10WA112288	24856	Menangle Park	MP07
10WA112294	24736	EMAI	EM09	10WA112288	24856	Menangle Park	MP08
10WA112294	24736	EMAI	EM10	10WA112288	24856	Menangle Park	MP09
10WA112294	24736	EMAI	EM11	10WA112288	24856	Menangle Park	MP10
10WA112294	24736	EMAI	EM12	10WA112288	24856	Menangle Park	MP11
10WA112294	24736	EMAI	EM13	10WA112288	24856	Menangle Park	MP12
10WA112294	24736	EMAI	EM14	10WA112288	24856	Menangle Park	MP13
10WA112294	24736	EMAI	EM15	10WA112288	24856	Menangle Park	MP14
10WA112294	24736	EMAI	EM16	10WA112288	24856	Menangle Park	MP15
10WA112294	24736	EMAI	EM17	10WA112288	24856	Menangle Park	MP16
10WA112294	24736	EMAI	EM18	10WA112288	24856	Menangle Park	MP17
10WA112294	24736	EMAI	EM19	10WA112288	24856	Menangle Park	MP22
10WA112294	24736	EMAI	EM20	10WA112288	24856	Menangle Park	MP23
10WA112294	24736	EMAI	EM21	10WA112288	24856	Menangle Park	MP25
10WA112294	24736	EMAI	EM22	10WA112288	24856	Menangle Park	MP30
10WA112294	24736	EMAI	EM23	10WA112294	24736	Mt Taurus	MT01
10WA112294	24736	EMAI	EM24	10WA112294	24736	Mt Taurus	MT02
10WA112294	24736	EMAI	EM25	10WA112294	24736	Mt Taurus	MT03
10WA112294	24736	EMAI	EM27	10WA112294	24736	Mt Taurus	MT04
10WA112294	24736	EMAI	EM28	10WA112294	24736	Mt Taurus	MT05
10WA112294	24736	EMAI	EM30	10WA112294	24736	Mt Taurus	MT06
10WA112294	24736	EMAI	EM31	10WA112294	24736	Mt Taurus	MT07
10WA112294	24736	EMAI	EM32	10WA112294	24736	Mt Taurus	MT08
10WA112294	24736	EMAI	EM33	10WA112294	24736	Mt Taurus	MT09
10WA112294	24736	EMAI	EM34	10WA112294	24736	Mt Taurus	MT10
10WA112294	24736	EMAI	EM37	10WA112294	24736	Razorback	RB05
10WA112294	24736	EMAI	EM38	10WA112294	24736	Razorback	RB06
10WA112294	24736	EMAI	EM39	10WA112294	24736	Razorback	RB07
10WA112294	24736	EMAI	EM40	10WA112294	24736	Razorback	RB08
10WA112288	24856	Glenlee	GL02	10WA112294	24736	Razorback	RB10
10WA112288	24856	Glenlee	GL04	10WA112294	24736	Razorback	RB11
10WA112288	24856	Glenlee	GL05	10WA112294	24736	Razorback	RB12
10WA112288	24856	Glenlee	GL06	10WA112288	24856	Rosalind Park	RP02

Licence No.	WAL	Field	Well name	Licence No.	WAL	Field	Well name
10WA112288	24856	Glenlee	GL07	10WA112288	24856	Rosalind Park	RP03
10WA112288	24856	Glenlee	GL08	10WA112288	24856	Rosalind Park	RP04
10WA112288	24856	Glenlee	GL09	10WA112288	24856	Rosalind Park	RP05
10WA112288	24856	Glenlee	GL10	10WA112288	24856	Rosalind Park	RP06
10WA112288	24856	Glenlee	GL11	10WA112288	24856	Rosalind Park	RP07
10WA112288	24856	Glenlee	GL12	10WA112288	24856	Rosalind Park	RP08
10WA112288	24856	Glenlee	GL13	10WA112288	24856	Rosalind Park	RP09
10WA112288	24856	Glenlee	GL14	10WA112288	24856	Rosalind Park	RP10
10WA112288	24856	Glenlee	GL15	10WA112288	24856	Rosalind Park	RP11
10WA112288	24856	Glenlee	GL16	10WA112288	24856	Rosalind Park	RP12
10WA112288	24856	Glenlee	GL17	10WA112288	24856	Spring Farm	SF01*
10WA112294	24736	Johndilo	JD01	10WA112288	24856	Spring Farm	SF02
10WA112294	24736	Johndilo	JD04	10WA112288	24856	Spring Farm	SF03*
10WA112294	24736	Johndilo	JD05	10WA112288	24856	Spring Farm	SF05
10WA112294	24736	Johndilo	JD06	10WA112288	24856	Spring Farm	SF07
10WA112294	24736	Johndilo	JD07A	10WA112288	24856	Spring Farm	SF08
10WA112294	24736	Johndilo	JD11	10WA112288	24856	Spring Farm	SF09
10WA112294	24736	Joe Stanley	JS01	10WA112288	24856	Spring Farm	SF17#
10WA112294	24736	Joe Stanley	JS03	10WA112288	24856	Sugarloaf	SL02
10WA112294	24736	Joe Stanley	JS04	10WA112288	24856	Sugarloaf	SL03
10WA112294	24736	Kay Park	KP01	10WA112288	24856	Sugarloaf	SL09
10WA112294	24736	Kay Park	KP02	10WA112294	24736	Wandinong	WG01
10WA112294	24736	Kay Park	KP03	10WA112294	24736	Wandinong	WG02
10WA112294	24736	Kay Park	KP05	10WA112294	24736	Wandinong	WG03
10WA112294	24736	Kay Park	KP06	10WA112294	24736	Wandinong	WG04
10WA112294	24736	Logan Brae	LB05	10WA112294	24736	Wandinong	WG05
10WA112294	24736	Logan Brae	LB06	10WA112294	24736	Wandinong	WG06
10WA112294	24736	Logan Brae	LB07				
10WA112294	24736	Logan Brae	LB09				
10WA112294	24736	Logan Brae	LB10				
10WA112294	24736	Logan Brae	LB11				

Notes:

(shaded)	Plugged and abandoned well * well decommissioning in progress
#	Pad location only

There are three monitoring bore licences that relate to the dedicated monitoring bores constructed for the CGP (Table 3). These monitoring bores have been decommissioned.

Table 3: Monitoring bore licences

Licence	Field	Monitoring bore ID	Installation date
10BL605366	Menangle Park	MPMB01, MPMB02, MPMB03, MPMB04	June 2013
10BL605472	Glenlee	GLMB01, GLMB02, GLMB03	February 2014
10BL605581	Rosalind Park	RPsMB01, RPsMB02, RPsMB03, RPsMB04, RPsMB05, RPsMB06	July 2014

5. Groundwater monitoring plan, response triggers and reporting

Government (through the NOW (now named NRAR)) in February 2011 placed a number of monitoring program conditions on AGL's water bore licences, which have now transitioned to the conditions associated with the combined works and use approvals. These generally relate to:

- A formal groundwater management plan
- More precise monitoring of pumped volumes
- Installation of dedicated monitoring bores when directed
- Collection of periodic water level and water quality data
- Annual reporting of data and trends

The objective of a dedicated groundwater network and associated monitoring program is to protect the shallowest aquifers used for water supply across the area. These are the Quaternary and Tertiary alluvial aquifers and the Triassic sandstone aquifers (predominantly the Hawkesbury Sandstone) and (where present) the water table aquifer in the Wianamatta Shale.

The monitoring program for the CGP is designed to give reasonable spatial representation to allow for characterisation of the groundwater systems within the area (spatially distributed, both in terms of vertical and lateral distribution), in order to identify trends within each system and potentially identify whether there is a relationship between systems. The groundwater systems that are monitored (where possible) are: perched groundwater, alluvial aquifer, Wianamatta Group, Hawkesbury Sandstone, and Illawarra Coal Measures water bearing zones. Monitoring will occur at dedicated monitoring locations, CSG wells, and other receptors (water supply bores and perched water bearing zone area/s supplying Cumberland Shale Plains/Hill Woodland ecosystem). (Note: there are no ecosystems identified to be dependent on the deeper groundwater systems within the area (Biosis, 2012)).

Within the groundwater monitoring program, both water levels and quality will be monitored in all groundwater systems (where possible). Monitoring of water levels for each groundwater system is important to identify whether there is a change over time (impact) with respect to the CSG operations that could indicate connectivity between aquifers/water bearing zones. Monitoring for water quality is also important to diagnose connectivity or relationship between aquifers as well as for identifying impacts (changes in water quality) from other anthropogenic activities (not just CSG).

Historic licence conditions required development of the Groundwater Monitoring Plan within 12 months and the dedicated monitoring bores within 3 years of the issue of the bore licences (i.e. by February 2012 and February 2014 respectively). Earlier versions of this GMP were compliant with these conditions. This document is the updated GMP for 2025.

5.1. Historical management and monitoring

AGL has had a number of programs in place to protect shallow groundwater resources across the CGP. These have mostly been voluntary programs and have not required any specific compliance reporting except for some elements in the Annual Environmental Performance Report (AGL, 2011c). The extent of groundwater monitoring is consistent with the low risk to groundwater identified in the initial desktop report (CM Jewell, 2001). AGL's programs to monitor and protect groundwater include:

- Designing and constructing gas wells with multiple casings, pressure cemented to ensure long life and to exclude shallow groundwater.

- Monitoring the integrity of gas wells constructed throughout the field to ensure that steel casings are cemented to full depth and that the pressure cementing of casing strings is to surface so as to isolate all aquifers.
- Containment of all drilling/fracturing fluids in lined pits and tanks, tankering of fluids away for disposal at licensed wastewater facilities thereby minimising the potential for impacts to surface water or groundwater.
- Monitoring and recording of produced water flows from gas wells.
- Water sampling of selected gas wells to characterise the deep groundwater quality.
- Tracking the performance of selected water supply bores (into the Hawkesbury sandstone aquifer).

This information is presented in numerous well completion reports, environmental compliance reports, annual reports and sustainability reports.

There have been no surveys of private water supply bores across the CGP area. There are a reasonable number of bores into shallow aquifers in the CGP area (particularly south of the Nepean River) (73 water supply bores based on NOW Pinneena database (NOW, 2010)) (PB, 2011). In most cases these bores are not suitable for inclusion in a dedicated monitoring network because they are pumped bores where water levels are varying continuously. Also the bore completions generally involve suspended casing and/or non-cemented sections of the borehole so that water quality results may not be representative of individual aquifers. Regardless, two licenced water supply bores within the CGP area have been monitored for water quality as part of the groundwater monitoring program.

5.2. Monitoring network

AGL established a groundwater monitoring network at three sites between November 2011 and February 2014. All groundwater monitoring bores were constructed in accordance with the *Minimum Construction Requirements for Water Bores in Australia* (NUDLC 2012). Details of the bore construction are provided in the relevant drilling and completion reports (PB 2014) and summarised below.

5.2.1. Northern control area

Given the withdrawal of plans for expansion into the northern expansion area, background (control) monitoring at dedicated nested monitoring bores (shallow aquifers) ceased with the decommissioning of monitoring bores in October 2016.

One nested monitoring site was installed (RMB at Denham Court – operational from November 2011 to October 2016).

The purpose of this monitoring location was to collect background data for the shallower aquifer systems remote from the operating CGP for comparison with data collected from similar shallower aquifer zones within the operating wellfield.

At this location (RMB), there were three monitoring bores installed targeting shallower aquifer systems, one within the Ashfield Shale (Wianamatta Group) and two within the Hawkesbury Sandstone (one installed towards top and one towards the bottom). The benefit of having multiple monitoring bores in the one location installed at different depths allowed for vertical characterisation of the groundwater systems and assessment for interaction and/or connectivity.

In addition, AGL installed a very shallow dedicated monitoring bore at the Denham Court site to monitor the potential perched groundwater that may support the Cumberland Shale Plains/Hills Woodland ecosystem (which is identified as a "highly probable" groundwater dependent ecosystem, existing on soils derived from Wianamatta Shale and well drained Holocene Alluvium (Serov et al., 2012)). This bore was installed in June

2013 and decommissioned in October 2016. It is noted this bore remained dry for the duration of the monitoring program.

This monitoring network was installed as part of the Phase 2 groundwater investigation study, undertaken by Parsons Brinckerhoff. The study involved establishing dedicated monitoring bores at three sites within the existing CGP and a background location within the northern expansion area of the Camden Gas Project, detailed geological analysis of the sites, field work program (including permeability tests, datalogger installation and groundwater quality/isotope analysis), ongoing baseline monitoring, and a comprehensive technical report after all three locations were installed and fully operational (PB, 2014).

5.2.2. Stage 1 and 2 - CGP Area

AGL installed two dedicated nested monitoring bore sites within the existing CGP area (June 2013 and February 2014). Details of both sites are shown in Table 44. These sites were positioned within 40 – 100 m of operating gas wells and either in close proximity to the Nepean River (MPMB) or a subsurface faulted zone (GLMB), allowing for impact assessment with respect to such features. These monitoring bores were decommissioned in 2024 following the decommissioning of nearby gas wells.

No dedicated monitoring bores have been installed within deeper strata of the CGP wellfield. The operational gas wells themselves were used for groundwater management and operational monitoring purposes (as described above in Section 5.1).

Table 4: Dedicated monitoring sites for the CGP

Location	Type	Field	Comments	Purpose
MPMB	Nested monitoring bores	Menangle Park	MPMB01 – Alluvium Depth – 18 m Screened Interval – 10–16 m MPMB02 – Hawkesbury Sandstone Depth – 42.4 m Screened Interval – 27-39 m MPMB03 – Hawkesbury Sandstone Depth – 108.5 m Screened Interval – 97–106 m MPMB04 – Hawkesbury Sandstone/Newport Formation Depth – 192.6 m Screened Interval – 191.6 – 182.6 m	To monitor conditions of the shallower aquifer systems present in the area (Alluvium and Hawkesbury Sandstone) within the central part of the operating CGP wellfield.
GLMB	Nested monitoring bores / vibrating wire piezometers (VWP)	Glenlee	GLMB01 (VWP) – Hawkesbury Sandstone Depth – 102 m Monitored zone – 87-99 m GLMB02 (VWP) – Hawkesbury Sandstone Depth – 190.3 m Monitored zone – 168-180 m GLMB03 – Hawkesbury Sandstone Depth – 228.3 m Screened Interval – 212-224 m	To monitor conditions of the shallower aquifer systems present in the area (Hawkesbury Sandstone) within the northern part of the operating CGP wellfield and to investigate the conditions within proximity to a faulted zone to assess the influence of faults on groundwater flow within the area.

Deeper baseline monitoring of groundwater systems below the Bald Hill Claystone is not considered warranted at the present time because:

- It is most unlikely there will be beneficial groundwater resources below 300m depth.
- There is no historical use of groundwater from depths greater than 300m.
- The groundwater at this depth is unlikely to be linked to ecosystems.
- Groundwater in the Narrabeen Group sandstones will most likely be moving laterally rather than being recharged by shallow groundwater resources through the Bald Hill Claystone aquitard.
- There are two additional aquitards/aquicludes below the Bald Hill Claystone (Stanwell Park Claystone and the Wombarra Claystone) that will inhibit vertical leakage.
- If the Bald Hill Claystone is leaky, the basal monitoring bore in the Hawkesbury Sandstone will also react to depressurisation and provide early warning of aquifer drainage as a result of CSG activities.

If there was a water level decline in the Hawkesbury Sandstone attributable to the dewatering of coal seams at depth then a monitoring bore into the deeper strata below the Bald Hill Claystone would be installed to confirm trends. Overall the risk of a water level/water quality impact to the primary aquifers in the Hawkesbury Sandstone are considered low because the likelihood of an event is considered rare and the consequence of drainage (of a relatively small volume) is also low on AGL's risk assessment scale (it is assessed as a Level 2 on a 1 to 5 scale).

5.2.3. Water levels

There were four nested monitoring bores in the former northern control area (RMB). This monitoring program commenced in late 2011 (with dedicated continuous dataloggers in the three deeper bores; the shallowest (RMB04) has never had sufficient water present) and ceased in October 2016. This monitoring site provided baseline data for the northern (downgradient) area and control data for comparison with data collected within the operating CGP wellfield.

There were four nested monitoring bores in the Menangle Park area (MPMB) in the central part of operating CGP wellfield. This monitoring program commenced in June 2013 (with dedicated continuous dataloggers) and ceased in 2024. This monitoring site was located in close proximity to MP16 and MP25 wells and the Nepean River.

There were three nested monitoring bores in the Glenlee area (GLMB), within the northern part of the operating CGP wellfield, one conventional monitoring bore (GLMB03) and two vibrating wire piezometers (VWPs) (GLMB01 and GLMB02). GLMB01 and GLMB02, originally installed as conventional monitoring bores, were converted to VWPs in March 2015. This monitoring program commenced in February 2014 (with dedicated continuous data loggers) and ceased in 2024. This monitoring site was located in close proximity to operating gas wells and a subsurface faulted zone.

These three sites were selected based on their geographical spread and alignment with the regional groundwater flow direction as well as being in close proximity to significant features (gas wells, faulted zones, the Nepean River and a control site, away from significant development).

Water levels are rarely monitored in gas production wells because of the nature of the internal tubing, pumping equipment, and API wellhead configuration.

Coal is a natural water bearing zone and as such in its dormant state holds water. In order to initiate and maintain gas flow from coal, this water must continuously drain from the coal seam. Initial water can be significant but the rate will decrease over a six to 12 month period to as little as zero in some cases. To maximise gas production from coal seam gas wells, the water level in the wellbore must be kept below the lowest producing coal seam. Because coal seams are usually relatively shallow compared to conventional gas reservoirs, and are low pressure formations, it aids gas production to pump water from coal seam gas wells continuously or intermittently to minimise and maintain the lowest bottom-hole pressure and allow gas to flow into the wellbore. In summary the producing seams are generally flowing at very low pressure and the water levels are maintained just above or within the perforated interval.

5.2.4. Water quality

Background water quality monitoring data was recorded at the nested monitoring bores at the former northern control area (RMB) until April 2016. Water quality monitoring data was recorded at the nested bores within the CGP area (MPMB and GLMB) until 2024. Water quality data was unable to be collected from GLMB01 and GLMB02 after the bores were converted to VWPs in March 2015.

Some 15 gas wells across the existing CGP area were water sampled in FY2011 and continued in FY2012 to determine the most appropriate network to assess deep groundwater quality. The network was modified for FY2013 and FY2014 comprising an appropriate selection of wells based on geographical spread and water production. A network of 10 (gas well) sites was selected for monitoring in FY2015. The sites were chosen predominantly on the basis of their geographic spread, water production volumes, and the fact that they typically produce deep formation water when depressurised. Monitoring groundwater from the gas wells ceased in 2023 when the remaining gas wells were shut in for decommissioning and rehabilitation.

5.3. Monitoring frequency

Historically, the primary proof that shallow aquifers were protected was the integrity of gas production well construction and the diminishing produced water volumes.

Water levels are now an additional primary proof of shallow groundwater impacts associated with CSG dewatering in new areas; dataloggers are installed within the dedicated monitoring bores to continuously (at 6 hourly intervals) collect water level/pressure data.

5.3.1. Water levels

Water levels are rarely monitored in gas production wells because of the nature of the internal tubing, pumping equipment, and API wellhead configuration. Occasional water levels are obtained during production and workovers (using sonologs) but ongoing water level data is not available routinely from gas production wells (see also Section 5.2.3 for explanation).

Continuous water level monitoring (at 6 hourly intervals) was in place at all dedicated monitoring bores. This monitoring program commenced in November 2011 until the monitoring bores were decommissioned in 2024.

5.3.2. Water Quality

Comprehensive water quality monitoring for the nested monitoring bores occurred quarterly between May 2013 and June 2015 as part of the enhanced groundwater monitoring program; 6 monthly comprehensive sampling has occurred since FY2016. The preferred months for water sampling are November and May. For the first sampling event (when the monitoring bores are first installed) an isotope sampling program was also included. Prior to May 2013, only one water quality sample had been collected from the Denham Court monitoring bore site.

For the CGP gas wells, since February 2016, a water sample was analysed every six months and in accordance with the monitoring requirements outlined in EPL 12003. EPL 12003 previously required one comprehensive sample to be collected annually and basic samples collected for the remaining six-monthly sampling events.

In addition, if a well within the network has undergone maintenance and town water has been used during the maintenance, the well will temporarily be removed from the monitoring network until it can be sure that formation water is being produced and reliable water samples can be obtained again.

5.4. Produced Water volumes

Volumes of produced water were monitored at each well pad via manual measurement of the volume removed from each site. Produced water was removed from the well pad's holding tank via truck when the tank approached full capacity. The tanks' capacity was monitored via remote high level alarm and/or by regular manual monitoring to ensure no overflow occurs. Monitoring the amount of produced water from each site provided information on the rate of water production over time for each monitored well. Many wells produced very little water, if any.

5.5. Response triggers

Several triggers are proposed, including a change in the beneficial use of an aquifer (note that "aquifer" in this GMP refers only to the alluvial and Hawkesbury Sandstone aquifers as deeper zones are deemed to be water bearing zones and are non-aquifers). The other response triggers relate to water level and water quality trends (for all analytes) where those trends are clearly related to CSG dewatering activities. The primary proofs of aquifer connectivity and potential aquifer contamination (or the lack thereof) are water level drawdowns and water quality changes.

5.5.1. Beneficial use

A generalised beneficial use matrix has been designed (in accordance with both yield and water quality characteristics) (Table 5). Each aquifer/water bearing zone can be assigned one or more beneficial use categories (based on cells within the matrix). Beneficial use category varies spatially for each aquifer. The scale or volume of water required for individual uses may influence the beneficial use; for example, a small scale farming operation may be able to make use of a water supply bore that has a yield of <1.5 L/s, whereas for a large scale farming operation this may not be sufficient. The aquifers in the CGP area rarely yield water at a rate >5 L/s. Recycling, as a beneficial use category, has been added and mainly applies to produced water, which is a by-product of coal mining and CSG operations.

The following beneficial use categories can be assigned to each aquifer/water bearing zone (in accordance with Table 5):

- Alluvial aquifers – A1, A2, A3, B2, B3, and C2
- Hawkesbury Sandstone aquifer – A2, A3, B2, B3, and C2
- Narrabeen Group aquifers – C3
- Illawarra coal water bearing zones – C3, D3

Note that some of the (high yield) beneficial use categories do not occur in the CGP area.

Table 5: Generalised beneficial use matrix, based on salinity (electrical conductivity) and yield (adapted from EPA Vic, 1997).

		Yield (L/s)			
		>5	1.5-5	<1.5	
Electrical conductivity (µS/cm)	0-800	D+I+S+In	D+I+S	D+S	A
	801-1600	D+I+S+In	D+I+S	D+S	B
	1601-6000	I+S+In	I+S	S+R	C
	6001-25000	S+In	S	R	D
	>25000	In			E
		1	2	3	

Key: D – domestic; I – irrigation; S – stock; In – industry, R - recycling

5.5.2. Drawdowns

There are very large drawdowns in the coal seam water bearing zones during wellfield operation that are normal for the operation of a CSG wellfield. The key connectivity issue is if there are water level declines in shallow aquifers as a consequence of this depressurisation. Whilst AGL continues to build an understanding of the historical/seasonal variability in the water level drawdowns across the different field areas, if such an event was to occur, AGL would work closely with NRAR to gather all possible water level data from the broader area to best understand the geographical extent, possible causes and to decide practical solutions.

Response triggers for shallow aquifers will be reviewed after monitoring data has been collected and natural characteristics and trends identified. They will be further developed with NRAR as historical/seasonal variability in the existing wellfield areas becomes more precisely known.

Given the lack of baseline water level data from shallow aquifers within the CGP area, indicators for significant water level changes within the existing CGP wellfield area are yet to be determined. Declines outside of the agreed range would be sufficient to justify an investigation and management response involving:

- A check of nearby water bore use
- A check of nearby and recent (water bore and gas) drilling activities
- A check of the climatic conditions and expected trends
- A check of the integrity of the monitoring bore and datalogger

If it was suspected that the water level decline was due to CSG dewatering activities at depth, then the decline would be reported to NRAR and a more detailed action plan would be implemented involving:

- A check of produced water volumes from nearby gas wells
- A check of the integrity of local water bores (if any) and gas wells
- Other recommendations as discussed and agreed with DPI Water

If the decline was reported at a private water bore location, then the apparent water level decline investigation would involve:

- Referral to NRAR in the first instance to assess the validity of the claim and to recommend a course of action.

5.5.3. Water quality

Significant water quality variations could also be an indication of connectivity. Changed water quality could also be an indication of impacts from different anthropogenic activities. Whilst AGL continues to build an understanding of the historical/seasonal variability in the water quality across the different field areas, if such an event was to occur, AGL would work closely with NRAR to gather all possible water quality data from the broader area to best understand the geographical extent, and possible causes.

If water quality, with respect to salinity, at all monitoring sites (including the monitored gas wells) over time changes to a different beneficial use category (Table 5) or if water quality, with respect to all other analytes (including heavy metals, salts, hydrocarbons), deviates significantly from the typically observed trend, and if the change is attributable to CSG activities, then this would be sufficient variability to justify an investigation and management response involving:

- A check of nearby water bore use or land use changes.
- A check of nearby and recent activities.
- A check of the integrity of the monitoring bore or gas well.

Again, it should be noted that a significant change in salinity indicating a potential impact can only be applied to high water volume producing wells (defined as >50 KL per annum). Wells that produce low volumes of water typically produce water that is physically altered via evaporation and condensation processes within the well bore and/or coal seam; this water is not representative of formation water (PB, 2013). It is not uncommon to observe a high water volume producing well taper to a low volume producing well and to also observe the salinity of the produced water decrease over time. Such an event as this would not trigger a response as it is not representing a change in formation water quality.

If it was suspected that the change in water quality of beneficial aquifers was due to CSG dewatering activities at depth, then the change in salinity would be reported to NRAR/EPA and a more detailed action plan would be implemented involving:

- A check of the integrity of local water bores (if any) and gas wells.
- Other recommendations as discussed and agreed with NRAR/EPA.

If the change in water quality was reported at a private water bore location, then the management response would involve:

- Referral to NRAR/EPA in the first instance to assess the validity of the claim and to recommend a course of action.

5.6. Management responses

Changes in groundwater levels and water quality may not be the result of the CSG activities. It is important that identified trends, or impacts notified to either AGL or to NRAR/EPA, be thoroughly investigated in the first instance and a conclusion drawn that the impact is (or possibly is) or is not the result of the CSG activities.

This section details the management responses if a trend or an impact is (or is possibly) associated with the CGP activities. The assessment of whether an impact is or is not CSG related, and a more detailed protocol that describes AGL's water management responses if there is a water level or water quality impact is provided in Appendix B.

5.6.1. Water levels

If water levels change at dedicated monitoring sites by more than the response trigger (i.e. greater than 5 m outside of the normal range for consolidated rock aquifers) or if the yield of a water supply bore changes to another beneficial use category (Table 5) over time, and if the change is attributable to CSG activities, then the following would be considered:

- Suspension of dewatering from proximate gas well(s) to assess whether recovery can be achieved and/or;
- Suspension of dewatering if private water supply bores occur within 2km's and water level changes (outside of the normal range) are proven and/or;
- Other management responses as may be agreed/directed by NRAR.

5.6.2. Water quality

If water quality, with respect to salinity, at dedicated monitoring sites over time changes to a different beneficial use category (Table 5) or if water quality, with respect to other analytes, deviates significantly from the typical observed trend, and if the change is attributable to CSG activities, then the following would be considered:

- › Suspension of dewatering if private water supply bores occur within 2km's and water quality changes (outside of the normal range) are proven and/or;
- › Other management responses as may be agreed/directed by NRAR (or EPA).

If assessed as attributable to AGL's CSG activities, contaminated groundwater would be remediated following a program designed and implemented by suitably qualified and experienced groundwater professionals.

5.7. Annual reporting

In line with the previous bore licence conditions, a technical compliance report is submitted to NRAR annually for each water year commencing 1 July. The compliance report will include details on:

- Activities during the period (decommissioning of abandoned wells);
- Volumes of produced water during the period;
- Impacts of the wellfield operation on monitored groundwater systems;
- Predictions of produced water volumes, and potential adverse impacts for the next operating period; and
- Changes to the monitoring network for the upcoming water year

AGL's commitment is to lodge these reports by 30 September each year for the preceding water year (July to June).

6. Seepage monitoring plan, response triggers, and reporting

6.1. Monitoring network

Six shallow seepage detection bores were installed in July 2014 to monitor seepage around in-ground tanks at the RPGP. These in-ground tanks and the associated seepage detection bores were decommissioned in 2024 as part of the RPGP decommissioning works. All monitoring has now ceased.

The seepage monitoring bores were installed to shallow depths (maximum 10 meters below ground level) for the purpose of monitoring perched groundwater that may be present as well as seepage from adjacent in-ground tanks that stored waste water.

7. Review of the GMP

It is planned to review and update the GMP every two years.

The plan is not static but will evolve over time, and is interpreted as a “living” document. The plan will only be formally resubmitted to NRAR and EPA if there are major changes to the monitoring network, water quality monitoring suite, or the proposed monitoring frequency; however, the agencies will be involved in the review process where appropriate.

8. Supporting Documents

Some additional documents have been prepared by AGL that complement the detail in this GMP. The Camden Gas Project (CGP) Environmental Management Plan is a condition of approval, while the water sampling protocol (AGL, 2011b) has been written to assist field staff to collect accurate water level data and representative water quality samples.

8.1. Environmental Management Plan

This Environmental Management Plan (EMP) for the CGP describes AGL's system to manage potential environmental issues associated with the project.

The CGP activities can be summarised as the construction, operation, maintenance and rehabilitation of well sites and the gas gathering systems, RPGP, and the sales gas pipeline.

The objective of the EMP is to describe the overall environmental management framework for the CGP, setting out what AGL is required to do, how AGL will do it and the monitoring AGL use to ensure compliance and improve operations.

It identifies the petroleum titles, development consents, Environment Protection Licence, water licences and relevant legislation. The EMP describes activities, contains specific environmental management plans (Sub Plans) for key aspects of our operations, and sets out the processes for implementation, monitoring and review. Detailed site specific information is provided in site specific plans which are referenced in the Sub Plans as applicable. This GMP is a Sub Plan of the EMP.

9. Consultation

This document has been developed in consultation with NRAR (formerly NOW). Feedback received has been and will continue to be considered by AGL and incorporated into the subsequent version(s).

As mentioned in Section 1.3, as part of the EPL 12003, AGL was required to prepare and submit to the EPA a Draft GMP for the premises and proposed expansion areas. Version 2.3 of this GMP was submitted for their review. Feedback received during the consultation process was considered by AGL and incorporated into the subsequent version.

As mentioned in Section 1, Version 1.4 of this document was independently peer reviewed by Liz Webb (Senior Hydrogeologist) at Parsons Brinckerhoff (PB) (PB, 2012). Feedback received as a result of the peer review process was considered by AGL and incorporated into the subsequent version.

10. References

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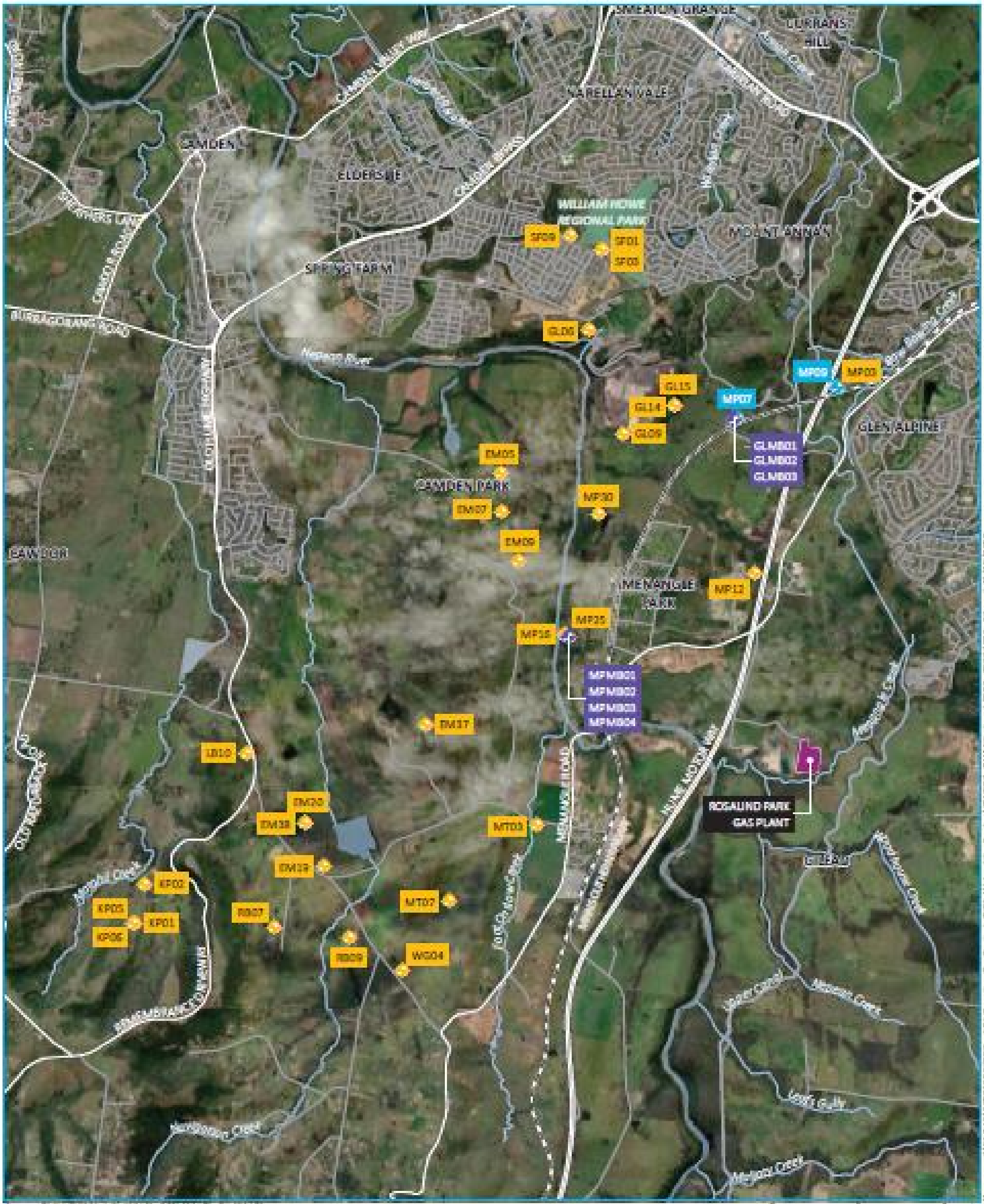
11. Figures

Figure 1 – Groundwater Monitoring Network



KEY

- Rosalind Park Gas Plant
- EPL GW monitoring point
- Groundwater monitoring bore
- Gas well (operating or temporarily shut-in, excluding suspended wells)

Existing environment

- Rail line
- Major road
- Minor road
- Named watercourse
- Waterbody
- NPWS reserve

EPL monitoring network prior to September 2023

Camden Gas Project
Annual Groundwater Report
Figure 1.1

A Appendix

Conditions on Water Access Licences and Works Approvals

Table 6: Works Approval conditions for both 10WA112288 and 10WA112294

Condition	Details	Compliance assessment
Take of water		
MW0655-00001	Any water supply work authorised by this approval must take water in compliance with the conditions of the access licence under which water is being taken.	Noted.
Water management works		
MW0097-00001	If contaminated water is found above the production aquifer during the construction of the water supply work authorised by this approval, the licensed driller must: a. notify DPI Water in writing within 48 hours of becoming aware of the contaminated water; and b. adhere to the Minimum Construction Requirements for Water Bores in Australia (2012), as amended or replaced from time to time.	Noted.
MW0487-00001	The water supply work authorised by this approval must be constructed within three (3) years from the date this approval is granted.	Noted. No new works are planned.
MW0044-00001	A. When a water supply work authorised by this approval is to be abandoned or replaced, the approval holder must contact DPI Water in writing to verify whether the work must be decommissioned	Noted.
	B. The work is to be decommissioned, unless the approval holder receives notice from the Minister not to do so.	Noted.
	C. When decommissioning the work the approval holder must: i. comply with the minimum requirements for decommissioning bores prescribed in the Minimum Construction Requirements for Water Bores in Australia (2012), as amended or replaced from time to time; and ii. notify DPI Water in writing within sixty (60) days of decommissioning that the work has been decommissioned.	Noted. NRAR is notified annually of all works decommissioned during the previous financial year.
Monitoring and recording		

Condition	Details	Compliance assessment
MW0484-00001	Before water is taken through the water supply work authorised by this approval, confirmation must be recorded in the logbook that cease to take conditions do not apply and water may be taken. The method of confirming that water may be taken, such as visual inspection, internet search, must also be recorded in the logbook. If water may be taken, the: A. date, and B. time of the confirmation, and C. flow rate or water level at the reference point in the water source must be recorded in the logbook.	Produced water volumes are tracked by compilation of trucked volumes from each well. This data is provided to NRAR's reference annually.
MW2338-00001	The completed logbook must be retained for five (5) years from the last date recorded in the logbook.	The logbook is maintained digitally and is archived for at least 5 years.
MW2336-00001	The purpose or purposes for which water is taken, as well as details of the type of crop, area cropped, and dates of planting and harvesting, must be recorded in the logbook each time water is taken.	Water associated with this approval has only been taken for the purpose of coal seam gas production.
MW2337-00001	The following information must be recorded in the logbook for each period of time that water is taken: A. date, volume of water, start and end time when water was taken as well as the pump capacity per unit of time, and B. the access licence number under which the water is taken, and C. the approval number under which the water is taken, and D. the volume of water taken for domestic consumption and/or stock watering.	Noted. Produced water volumes are tracked by compilation of trucked volumes from each well.
MW0482-00001	Where a water meter is installed on a water supply work authorised by this approval, the meter reading must be recorded in the logbook before taking water. This reading must be recorded every time water is to be taken.	Not applicable.
MW2339-00001	A logbook must be kept, unless the work is metered and fitted with a data logger. The logbook must be produced for inspection when requested by the relevant licensor.	Produced water volumes are tracked by compilation of trucked volumes from each well. AGL provides this data for NRAR's reference annually.
Reporting		
MW0051-00001	Once the approval holder becomes aware of a breach of any condition on this approval, the approval holder must notify	Noted.

Condition	Details	Compliance assessment
	the Minister as soon as practicable. The Minister must be notified by: a. email: water.enquiries@dpi.nsw.gov.au or b. telephone: 1800 353 104. Any notification by telephone must also be confirmed in writing within seven (7) business days of the telephone call.	
Other conditions – Water management works		
DK1363-00001 (10WA112288 only)	The approval holder must not construct or install works used for the purpose of conveying, distributing or storing water from the works authorised by this approval, that obstruct the reasonable passage of floodwaters flowing in, to, or from a river or lake.	Noted.

Table 3: Water Access Licence conditions for both WAL 24856 and 24736

Condition	Details	Compliance assessment
Take of water		
MW0929-00001	From 1 July 2018, if the water supply work nominated on this access licence is located at or less than 40 m from the top of the high bank of a river then: a. water must not be taken in this groundwater source when flows are in the Very Low Flow Class for an unregulated river access licence in that river; b. this restriction will only apply when the system that confirms when water can be taken is available on DPI Water website. c. DPI Water will inform the licence holder in writing of the applicable restrictions and how to access the information on its website when the system becomes operative.	Not applicable.
MW00919-00001	A maximum water allocation of 0.1 ML/unit share may be carried over in the account for this access licence from one water year to the next water year if a water meter is installed on each water supply work nominated on this licence and each meter is maintained in working order.	Noted. It is noted the annually take of water is typically significantly less than the allocation.
MW0605-00001	Water must be taken in compliance with the conditions of the approval for the nominated work on this access licence through which water is to be taken.	Noted. Refer to Table 10.

Condition	Details	Compliance assessment
MW0547-00001	The total volume of water taken under this licence in any water year must not exceed a volume equal to: a. the sum of water in the account from the available water determination for the current year, plus; b. the water carried over in the account from the previous water year, plus c. the net amount of water assigned to or from the account under a water allocation assignment, plus d. any water re-credited by the Minister to the account.	Noted. It is noted the annually take of water is typically significantly less than the allocation.
Monitoring and recording		
MW2338-00001	The completed logbook must be retained for five (5) years from the last date recorded in the logbook.	The logbook is maintained digitally and is archived for at least 5 years.
MW0606-00001	The volume of water taken in the water year must be recorded in the logbook at the end of each water year. The maximum volume of water permitted to be taken in that water year must also be recorded in the logbook.	Produced water volumes are tracked by compilation of trucked volumes from each well. This data is provided for NRAR's reference annually.
MW2336-00001	The purpose or purposes for which water is taken, as well as details of the type of crop, area cropped, and dates of planting and harvesting, must be recorded in the logbook each time water is taken.	Water associated with this approval has only been taken for the purpose of coal seam gas production.
MW2337-00001	The following information must be recorded in the logbook for each period of time that water is taken: a. date, volume of water, start and end time when water was taken as well as the pump capacity under which the water is taken, and b. the access licence number under which the water is taken, and c. the approval number under which water is taken, and d. the volume of water taken for domestic consumption and/or stock watering	Noted. Produced water volumes are tracked by compilation of trucked volumes from each well.
MW2339-00001	A logbook must be kept, unless the work is metered and fitted with a data logger. The logbook must be produced for inspection when requested by DPI Water.	Produced water volumes are tracked by compilation of trucked volumes from each well. AGL provides this data for NRAR's reference annually.
Reporting		

Condition	Details	Compliance assessment
MW0051-00002	Once the approval holder becomes aware of a breach of any condition on this approval, the approval holder must notify the Minister as soon as practicable. The Minister must be notified by: a. email: water.enquiries@dpi.nsw.gov.au, or b. telephone: 1800 353 104. Any notification by telephone must also be confirmed in writing within seven (7) business days of the telephone call.	Noted.

B Appendix

Management response protocol

The following management response protocol applied for confirmed or possible changes in water resource trend or impact arising from the operation of the CGP. Although the CGP has ceased gas production operations, the management response protocol has been retained for context.

i) Situations that trigger management response – shallow aquifers

In this context, shallow aquifer/s refers to alluvial aquifers, Hawkesbury Sandstone aquifers, and Narrabeen Group sandstone aquifers.

A situation that triggers a management response would be if water levels change at dedicated shallow aquifer monitoring sites by more than the response trigger (i.e. greater than 5 m outside of the normal range for consolidated rock aquifers) or if the yield of a water supply bore changes to another beneficial use category (Table 5) over time, and if the change is attributable to CSG activities.

A situation that triggers a management response would be if water quality, with respect to salinity, at dedicated shallow aquifer monitoring sites over time changes to a different beneficial use category (Table 5) or if water quality, with respect to other analytes, deviates significantly from the typical observed trend, and if the change is attributable to CSG activities.

To assess whether a water level or water quality impact is attributable to a CSG activity, the following process will be implemented by AGL and each case reviewed/endorsed by NRAR and EPA:

- Review the data set or incident/complaint (if from a private landowner) to identify possible causes
- Implement additional sampling and monitoring as appropriate
- Inspect the bore site and interview the landowner (if it is a private water supply impact)
- Assess the trend or impact in terms of local CGP operations issues (such as dewatering volumes, performance of individual wells, workovers, timing of events etc)
- Conclude whether the trend or impact is or is not attributable to a CSG activity
- Advise NRAR/EPA and recommend a course of action if the trend is or is possibly attributable to a CSG activity

The two responses below are based on a trend or impact that is proven or is likely to be attributable to CSG operations.

(a) Management response for a situation observed at shallow aquifer monitoring site

If a situation that triggers a management response is identified at one of the shallow aquifer monitoring sites, the following procedure would be employed, until the situation is rectified.

- Develop a remedial action plan (RAP) for NRAR/EPA to endorse. Actions could include:
    - Perform maintenance on relevant gas well(s) if appropriate, in order to attempt to rectify situation;
    - Suspend dewatering from proximate gas well(s) to assess whether remediation/recovery in water quality/levels can be achieved;

(b) Management response for a situation observed at private water supply bore

If a situation that triggers a management response is identified at a shallow aquifer (private water supply) site, the following procedure would be employed, until the situation is rectified.

- Develop a remedial action plan (RAP) for NRAR/EPA to endorse. Actions could include:
  - Perform maintenance on relevant gas well(s) if appropriate, in order to attempt to rectify situation;
  - Suspend dewatering from gas well(s) within 2 km's to assess whether remediation/recovery in water quality/levels can be achieved;
- Determine appropriate alternative water supply arrangement with bore owner if situation cannot be rectified.

ii) Situations that trigger management response – coal seam monitoring site

In those instances where a change is identified at an Illawarra Coal Measure monitoring site (which is not recognised as a beneficial aquifer) then there is a lesser requirement for a water management response.

A situation that triggers a management response would be if water quality, with respect to salinity, at high water volume producing coal seam monitoring sites over time changes to a different beneficial use category (Table 5) or if water quality, with respect to other analytes, deviates significantly from the typically observed trend, and if the change is attributable to CSG activities, or if volumes of produced water from a CSG well significantly increases over time. Note there are no water level triggers defined, only water quality triggers that are salinity related . Nonetheless the following response will be adopted by AGL.

a) Management response for a situation observed at coal seam monitoring site

If a situation is identified at a deep coal seam monitoring site, the following procedure would be employed.

1. Desktop analysis of situation in order to attempt to identify possible causes and history;
2. Inspect the monitoring or production site and implement additional sampling and monitoring as appropriate;
3. Assess the water quality trend in terms of local CGP operations issues (such as dewatering volumes, performance of individual wells, workovers, timing of events etc);
4. Conclude whether the trend is or is not attributable to a CSG activity
5. Advise NRAR/EPA where necessary