Appendix K

Hydrogeochemical Assessment

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Hume Coal Project

Hydrogeochemical Assessment

Prepared for

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LIST OF ACRONYMS AND ABBREVIATIONS

ADWG	Australian Drinking Water Guidelines
AI Policy	Aquifer Interference Policy
ANZECC	Australian and New Zealand Environment and Conservation Council
ARMCANZ	Agriculture and Resource Management Council of Australia and New Zealand
BOD	biological oxygen demand
BTEX	benzene, toluene, ethylbenzene and xylenes
CPP	coal processing plant
DO	dissolved oxygen
DPI	Department of Primary Industries
DRE	Department of Resources and Energy
EC	electrical conductivity
Eh	measure of the oxidation or reduction state of a solution, relative to the standard hydrogen electrode
EMM	EMM Consulting Pty Limited
GDE	groundwater dependent ecosystem
Geosyntec	Geosyntec Consultants Pty Limited
ha	hectare
HAW	Hawkesbury Sandstone
Hume Coal	Hume Coal Pty Limited
ICM	Illawarra Coal Measures
IESC	Independent Expert Scientific Committee
K	hydraulic conductivity
kg	kilogram
kg/L	kilograms per litre
KLC	kinetic leach column
km	kilometre
L	litre
LGA	local government area
LOR	limit of reporting
m	metre
m/day	metres per day
m/yr	metres per year
mbgl	metres below ground level
meq/L	milliequivalents per litre
µg/L	micrograms per litre
mg/L	milligrams per litre
ML	megalitre
ML/day	megalitres per day

mm	millimetres
µS/cm	microsiemens per centimetre; a measure of fluid electrical conductivity
Mt	million tonnes
Mtpa	million tonnes per annum
NHMRC	National Health and Medical Research Council
OCP	organochlorine pesticides
OEH	Office of Environment and Heritage
OPP	organophosphorus pesticides
ORP	oxidation-reduction potential (see also: Eh)
PAH	polycyclic aromatic hydrocarbons
PB	Parsons Brinckerhoff
pH	measure of acidity or alkalinity of a solution, expressed as -log[H^+]
PWD	Primary Water Dam
ROM	run of mine
SEARs	Secretary's Environmental Assessment Requirements
TDS	total dissolved solids
TRH	total recoverable hydrocarbons
WG	Wianamatta Group Shales
WMA	Water Management Act 2000
WSP	water sharing plan
WWS	Wongawilli Seam

EXECUTIVE SUMMARY

Geosyntec Consultants Pty Limited (Geosyntec) was commissioned by Hume Coal Pty Limited (Hume Coal) to undertake a hydrogeochemical assessment of groundwater and surface water resources within and in the vicinity of the Hume Coal Project (herein the "project"). The purpose of the assessment was:

- To document baseline groundwater quality conditions from monitoring data collected prior to the commencement of mining activities;
- To perform predictive assessment of potential changes to hydrogeochemical conditions arising from project activities;
- To propose mitigating actions for project activities with the potential to impact groundwater quality; and
- To propose ongoing monitoring to verify the performance of the project activities and mitigation actions with respect to baseline groundwater quality.

The following Project related influences to groundwater quality were evaluated as the focus of this assessment:

- Changes to groundwater quality resulting from enhanced vertical flux of groundwater from saline shale formations to underlying sandstone formations;
- Water quality resulting from rainfall infiltration into surface stockpiles of mine reject material, and potential for leachate infiltration into shallow groundwater resources;
- Changes to groundwater quality resulting from groundwater flow through mine reject materials backfilled into the underground mine voids, and transport of derived solutes downgradient from the backfilled workings; and
- Changes to groundwater quality resulting from co-disposal of dam water from multiple sources via injection into sealed underground mine voids.

The outcomes of the assessment of these project activities are summarised below:

- The magnitude of mining-induced leakage from the Wianamatta Group Shales into the underlying Hawkesbury Sandstone was modelled to be small. A maximum increase of 9% above the baseline leakage rate was modelled (from 11.1 to 12.1 ML/day), most of which was predicted to occur between years 10 and 19 of the mine operation. Likewise, the salt flux (calculated from the average total dissolved solids [TDS] in shale groundwater) increased proportionally with groundwater leakage from 6,887,550 kg/year to 7,497,790 kg/yr, or 9% above baseline conditions. Over the full 74-year period during which the model results indicated an incremental increase in groundwater flux over baseline conditions (including the post-mining recovery period), the net increase in salt flux from the Wianamatta Group

Shales into the underlying Hawkesbury Sandstone is 1.3% above baseline conditions. The area of increased vertical leakage is likely to be limited to the immediate footprint of the underground operations. The incremental influence on the quality of the underlying Hawkesbury Sandstone groundwater resource was determined to be insufficient to impact on the beneficial uses of the resource (given that the baseline leakage rate has resulted in only a limited influence on the groundwater quality of the Hawkesbury Sandstone).

- During the initial 12-18 months of mine operation, mine reject material will be stored in a surface stockpile, until there is sufficient void space in the underground workings to commence underground emplacement of the reject material. Results from kinetic leach column (KLC) tests indicated the potential for acid generation and enhanced metals solubility when reject material is exposed to oxygen and oxygen-enriched water. The stockpile will be managed to minimise the potential for water ingress (including stormwater controls to prevent run on from adjacent land), such that water interaction with the stockpiled reject material should be limited to rainfall directly onto the stockpile. The potential for rainfall to infiltrate into the stockpile will be limited by contouring of the stockpile to promote surface runoff (to be captured and contained in the mine water management system), and through vegetation of the stockpile surface to promote evapotranspiration, the magnitude of which, on average, exceeds rainfall during eight months of the year. A further contingency will include addition of a limestone amendment to the reject material prior to stockpiling to buffer potential acid generation, which KLC tests have demonstrated to be an effective method for preventing the development of acidic and metalliferous drainage from the reject material. Close to the end of the mine life, the reject stockpile will be reprocessed through the coal processing plant (CPP) and pumped into underground mine voids for disposal.
- Once sufficient mine void space is available, mine reject material will be pumped directly from the CPP into the underground mine voids for final emplacement, avoiding the requirement for long-term surface storage or disposal of reject material. The reject material will be pumped into completed mine panels, which will be sealed with bulkheads and allowed to backfill with natural groundwater. Results from KLC tests indicated the potential for acid generation and enhanced metals solubility when reject material interacts with natural groundwater. The results of limestone amended KLC tests indicated a sufficient buffering capacity to mitigate the acid generation and associated metals solubility under fully saturated conditions (as will be the case in the underground void). The water quality results from the fully saturated, limestone amended KLC test were equivalent or superior to the average baseline groundwater quality in the Wongawilli Seam and Hawkesbury Sandstone. Accordingly, limestone

amendment of the reject material prior to underground emplacement is considered to be adequate to protect the beneficial uses of the receiving groundwater resources.

- The mine water management plan will include a portion of the water in the Primary Water Dam (PWD) being pumped into the sealed underground mine voids. The water balance for the site indicates that the average annual input to the PWD will comprise approximately 70% extracted groundwater, 20% rainfall, and 10% process water from the CPP and dust suppression returns. The water quality resulting from the proportional mixing of these end member waters was simulated using a mixing model, with KLC tests results, geochemical modelling and published rainfall quality data used to represent the end member water types. The mixed PWD water quality is predicted to exceed several beneficial use criteria for dissolved metals; however, comparison to the average WWS baseline groundwater quality (the "receiving environment" for water injected into the sealed panels) indicates similar exceedances of dissolved metals criteria, and a similar overall beneficial use profile. Two metals (nickel and copper) marginally exceeded the average WWS groundwater quality concentrations; however, these estimated concentrations are conservative for the following reasons:
    - the quality of the CPP process water that would report to the PWD (which was the driver for the elevated nickel and copper concentrations) was simulated by adopting "first flush" results from concentrated KLC leachate testing. The larger water-to-solids ratio in the CPP would be expected to produce a more dilute water quality than the KLC first flush results;
    - some of the dissolved metals load would be expected to adsorb onto precipitating iron oxide colloids in the PWD, which was not accounted for in the geochemical modelling; and
    - further dilution would occur when the PWD water mixes with natural groundwater in the sealed panel following injection;
    - In consideration of the bullet points above, there was considered to be a low risk of the injected PWD water impacting the beneficial use status of the WWS groundwater resource beyond the point of injection.

It is proposed that the mitigation measures discussed in the previous bullet points are supplemented by the continuation of the baseline groundwater monitoring program to verify the efficacy of the measures, and the ongoing suitability of the groundwater resources for their current beneficial uses. Robust environmental management systems should also be implemented to reduce the potential for incidental releases of hazardous substances used during mine operations (for example, fuels, oils or solvents used for operation or mechanical repair of plant), and to define a procedure to rapidly respond to incidental releases to minimise impact to the environment.

Following a detailed review of the potential groundwater quality influences of the proposed mining activities, the beneficial uses of the groundwater resources are expected to be maintained through a combination of:

- mine site environmental management measures to prevent releases of contaminating materials;
- specific mitigation measures to buffer the development of acid generation and enhanced metals solubility in reject material, and
- monitoring to verify the efficacy of the environmental management systems and mitigation measures.

1. INTRODUCTION

Geosyntec Consultants Pty Limited (Geosyntec) was commissioned by Hume Coal Pty Limited (Hume Coal) to undertake a hydrogeochemical assessment of groundwater and surface water resources within and in the vicinity of the Hume Coal Project (herein the "project"). The purpose of the assessment was to document baseline water quality conditions from monitoring data collected prior to the commencement of mining activities, and to perform predictive assessment of potential changes to hydrogeochemical conditions arising from project activities.

1.1 Project Description

The project area is approximately 100 km south-west of Sydney and 4.5 km west of Moss Vale town centre in the Wingecarribee LGA (refer to **Figure 1.1** and **Figure 1.2**). The project involves developing and operating an underground coal mine and associated infrastructure over a total estimated project life of 23 years. Indicative mine and surface infrastructure plans are provided in **Figure 1.3** and **Figure 1.4**. A full description of the project, as assessed in this report, is provided in Chapter 2 of the main EIS (EMM 2016a).

- In summary it involves:
- Ongoing resource definition activities, along with geotechnical and engineering testing and other low impact fieldwork to facilitate detailed design.
- Establishment of a temporary construction accommodation village.
- Development and operation of an underground coal mine, comprising of approximately two years of construction and 19 years of mining, followed by a closure and rehabilitation phase of up to two years, leading to a total project life of 23 years. Some coal extraction will commence during the second year of construction during installation of the drifts, and hence there will be some overlap between the construction and operational phases.
- Extraction of approximately 50 million tonnes (Mt) of run-of-mine (ROM) coal from the Wongawilli Seam, at a rate of up to 3.5 million tonnes per annum (Mtpa). Low impact mining methods will be used, which will have negligible subsidence impacts.
- Following processing of ROM coal in the coal preparation plant (CPP), production of up to 3 Mtpa of metallurgical and thermal coal for sale to international and domestic markets.
- Construction and operation of associated mine infrastructure, mostly on cleared land, including:
    - one personnel and materials drift access and one conveyor drift access from the surface to the coal seam;

- ventilation shafts, comprising one upcast ventilation shaft and fans, and up to two downcast shafts installed over the life of the mine, depending on ventilation requirements as the mine progresses;
- a surface infrastructure area, including administration, bathhouse, washdown and workshop facilities, fuel and lubrication storage, warehouses, laydown areas, and other facilities. The surface infrastructure area will also comprise the CPP and ROM coal, product coal and emergency reject stockpiles;
- surface and groundwater management and treatment facilities, including storages, pipelines, pumps and associated infrastructure;
- overland conveyors;
- rail load-out facilities;
- explosives magazine;
- ancillary facilities, including fences, access roads, car parking areas, helipad and communications infrastructure; and
- environmental management and monitoring equipment.

- Establishment of site access from Mereworth Road, and minor internal road modifications and relocation of some existing utilities.
- Coal reject emplacement underground, in the mined-out voids.
- Peak workforces of approximately 414 full-time equivalent employees during construction and approximately 300 full-time equivalent employees during operations.
- Decommissioning of mine infrastructure and rehabilitating the area once mining is complete, so that it can support land uses similar to current land uses.

The project area, shown in **Figure 1.2**, is approximately 5,051 hectares (ha). Surface disturbance will mainly be restricted to the surface infrastructure areas shown indicatively on **Figure 1.4**, though will include some other areas above the underground mine, such as drill pads and access tracks. The project area generally comprises direct surface disturbance areas of up to approximately 117 ha, and an underground mining area of approximately 3,472 ha, where negligible subsidence impacts are anticipated.

A construction buffer zone will be provided around the direct disturbance areas. The buffer zone will provide an area for construction vehicle and equipment movements, minor stockpiling and equipment laydown, as well as allowing for minor realignments of surface infrastructure. Ground disturbance will generally be minor and associated with temporary vehicle tracks and sediment controls as well as minor works such as backfilled trenches associated with realignment of existing services. Notwithstanding, environmental features identified in the relevant technical assessments will be marked as avoidance zones so that activities in this area do not have an environmental impact.

Product coal will be transported by rail, primarily to Port Kembla terminal for the international market, and possibly to the domestic market depending on market demand. Rail works and use are the subject of a separate EIS and State significant development application for the Berrima Rail Project.

1.2 Project Area and Study Area

The project area defined in the previous section includes the above ground and underground footprint of the activities associated with the development of the mine. The study area for the hydrogeochemical assessment includes the project area, as well as areas down hydraulic gradient from the project area (i.e. areas with the potential to receive groundwater originating from the project area, the quality of which may be influenced by the project activities).

Given that the focus of the hydrogeochemical assessment is the potential influence of project activities on groundwater quality, the study area largely comprises the underground project area, and portions of the aquifers down hydraulic gradient from the underground workings.

1.3 Objectives of Hydrogeochemical Assessment

The overarching objective of the hydrogeochemical assessment was to assess the potential for changes to groundwater quality, and associated potential impacts to environmental values, arising from the Project activities. The following Project related influences to groundwater quality were evaluated as the focus of this assessment:

- Changes to groundwater quality resulting from enhanced vertical flux of groundwater from saline shale formations to underlying sandstone formations;
- Water quality resulting from rainfall infiltration into surface stockpiles of mine reject material, and potential for leachate infiltration into shallow groundwater resources;
- Changes to groundwater quality resulting from groundwater flow through mine reject materials backfilled into the underground mine voids, and transport of derived solutes downgradient from the backfilled workings; and
- Changes to groundwater quality resulting from co-disposal of dam water from multiple sources via injection into sealed underground mine voids.

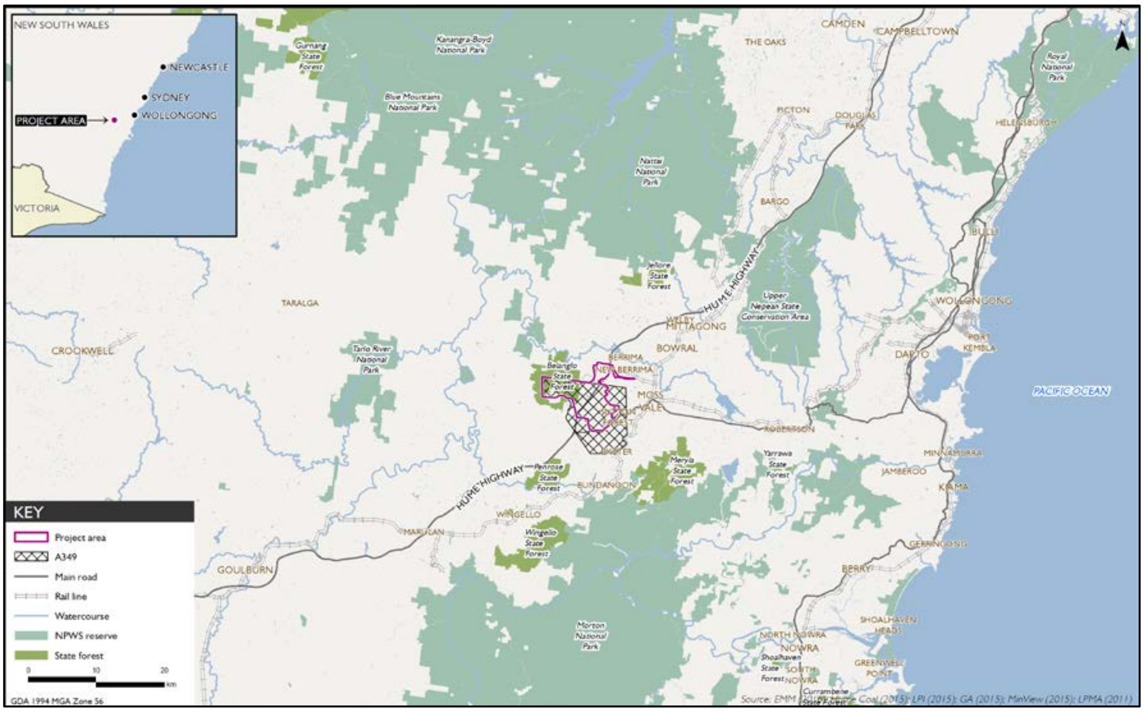

Figure 1.1. Regional context (from EMM, 2016b)

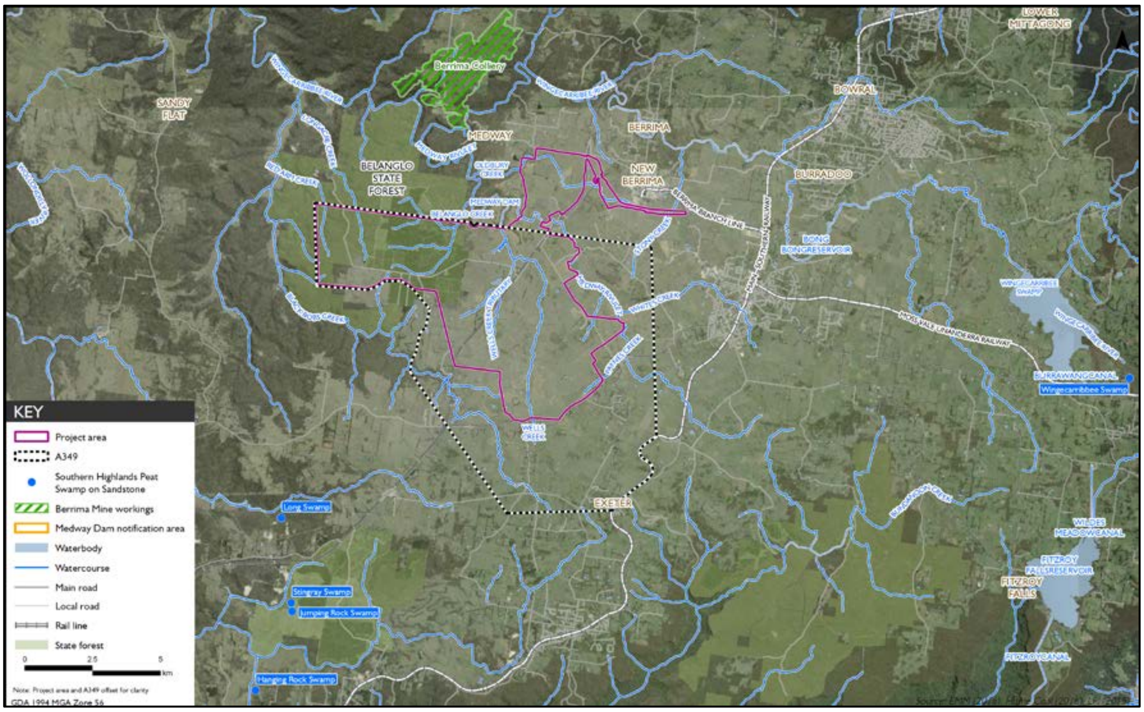

Figure 1.2. Local context (from EMM, 2016b)

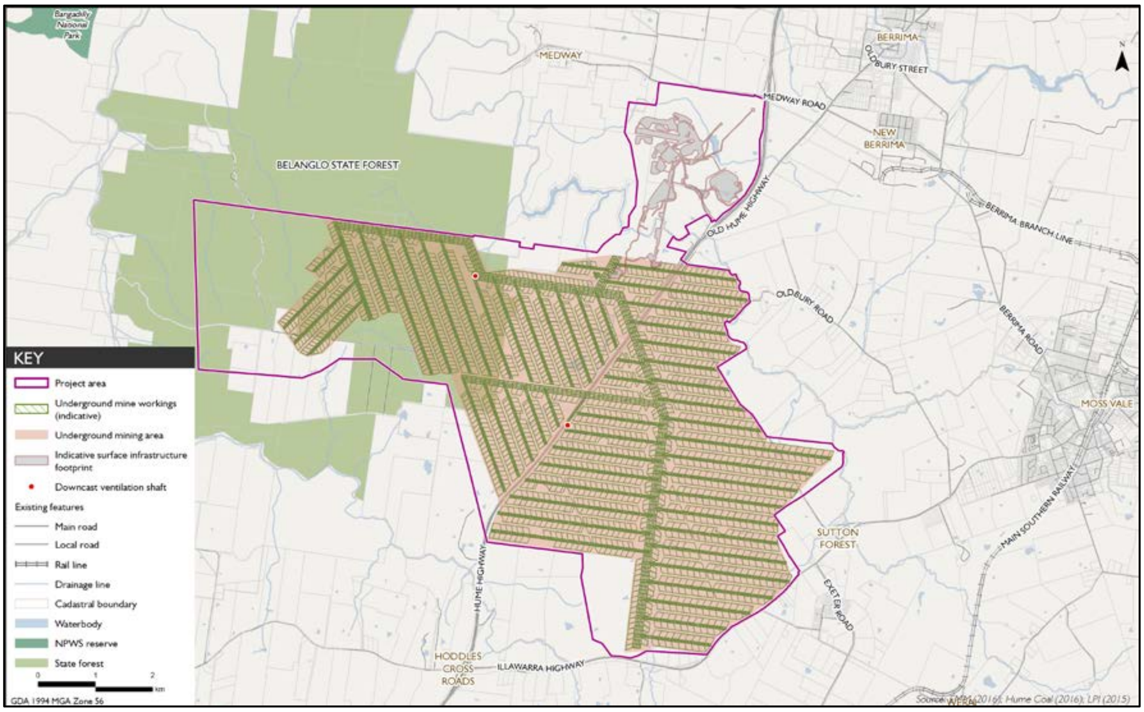

Figure 1.3. Indicative Mine Infrastructure Plan (from EMM, 2016b)

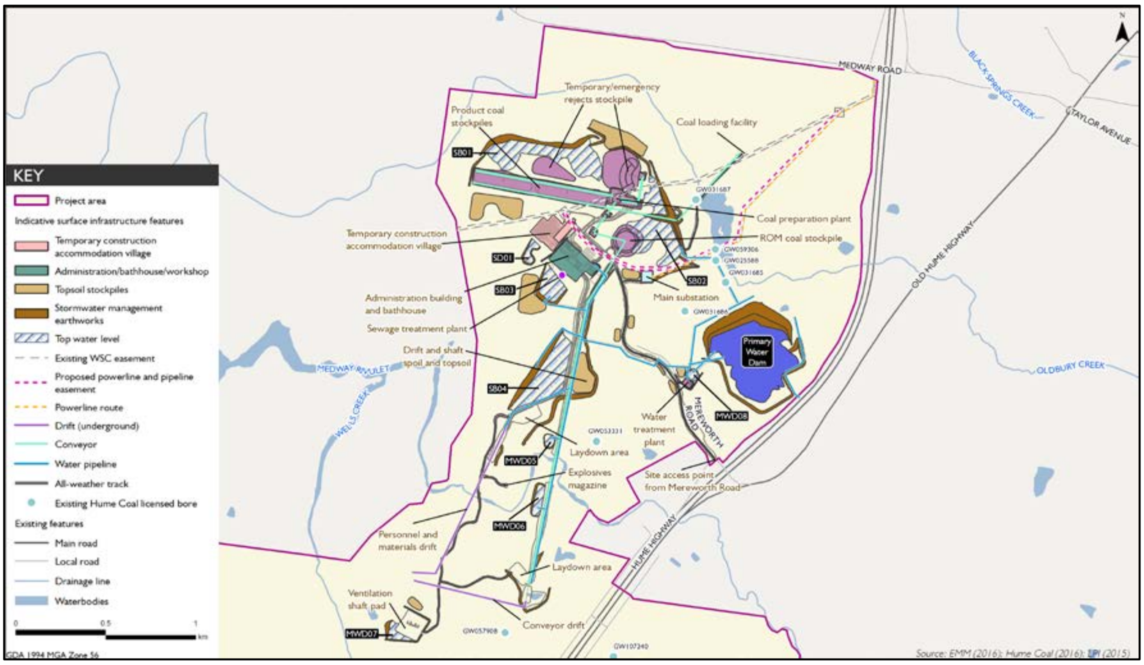

Figure 1.4. Indicative Surface Infrastructure Plan (from EMM, 2016b)

1.4 Scope of Services

The completion of the hydrogeochemical assessment comprised the following tasks:

- Literature review of available reports and monitoring data regarding groundwater quality within the Project area, as supplied by Hume Coal. The groundwater flow model report for the Project was also reviewed for context, and to assist with design of simulations to assess groundwater quality influences of Project activities;
- Review, organisation and hydrogeochemical analysis of existing water quality data to document baseline, pre-development conditions;
- Geochemical modelling to predict water quality evolution in the subsurface and in aboveground storage ponds in response to Project activities;
- Risk-based evaluation of the changes to water quality resulting from Project activities, in the context of the prevailing water quality regulatory legislation, policies and guidelines and with specific regard to relevant receptors; and
- Recommendations for monitoring and mitigation measures to reduce or manage potential adverse changes to groundwater quality resulting from Project activities.

1.5 Project Team

The key members of the hydrogeochemical assessment team and their qualifications are summarised as follows:

- **Dr Lange Jorstad**, Senior Hydrogeologist, Geosyntec – Dr Jorstad holds a BSc in geology from the University of California, Santa Barbara, and PhD in hydrogeochemistry from the University of New South Wales. He has 19 years' experience as a consulting hydrogeologist, is a NSW EPA accredited site auditor, a Registered Professional Geoscientist (hydrogeology) with the Australian Institute of Geoscientists, and is Vice President of the Australian Chapter of the International Association of Hydrogeologists.

- **Dr Bruce Sass**, Principal Geochemist, Geosyntec – Dr Sass holds a BS in geology from the State University of New York, an MSc in geochemistry from Washington State University, and a PhD in physical chemistry from the University of Pennsylvania. He has more than 25 years as a consulting environmental geochemist, with particular expertise in the analysis and modelling of the geochemical processes affecting leaching, fate, transport and sequestration of hazardous constituents from mine wastes and other waste materials.

1.6 Report Structure

The hydrogeochemical assessment provides a critical review of the baseline water quality conditions within and in the vicinity of the Project area, and predictive analysis of potential changes to groundwater quality arising from Project activities. The hydrogeochemical assessment report is structured as follows:

- **Section 2** provides a summary the environmental setting of the Project area, with a focus on the geology, hydrogeology and groundwater resource development, surface water features, and potential groundwater dependent ecosystems (GDEs);
- **Section 3** provides a summary of legislation, policies, guidelines, approval requirements and assessment criteria relevant to water quality within the study area;
- **Section 4** provides a description of the methodologies used to perform this hydrogeochemical assessment, including identification of the data sources used in this assessment;
- **Section 5** provides a baseline hydrogeochemical characterisation of groundwater associated with different geological units based on data provided from the baseline monitoring program;
- **Section 6** provides the details of the predicted influence of project activities on groundwater and surface water quality, and assessment of the potential for unacceptable impacts to the beneficial uses of the groundwater resource;
- **Section 7** provides a summary of the key conclusions from the hydrogeochemical assessment, including suggestions to mitigate or reduce potential unacceptable impacts associated with the Project activities;
- **Section 8** provides a list of references; and
- **Section 9** provides the limitations that apply to the assessment.

1.7 Key Assessment Outcomes

The hydrogeochemical assessment identified the following key outcomes with regard to the potential influence of Project activities on groundwater quality:

- The baseline quality of the groundwater resources of the Hawkesbury Sandstone and the Illawarra Coal Measures is broadly characterised by low TDS groundwater that is suitable to support most beneficial uses. Within each formation, a number of groundwater quality parameters and analytes exceed or are outside the range of one or more beneficial use assessment criteria (for example, the pH of groundwater within the Hawkesbury Sandstone is generally below the trigger value range for protection of freshwater species in upland rivers in South-east Australia). However, the baseline water quality criteria exceedances are generally limited in number and only marginally exceed the relevant criteria, and are not considered to limit the beneficial uses of the resource as a whole. Within the study area, these two formations are accessed by approximately 90% of the water supply bores (for which screened interval data are available).

- Dewatering of underground mine voids during active mine operations will result in partial depressurisation[1] of some of the overlying water bearing formations. The downward vertical hydraulic gradients induced by depressurisation are predicted to result in a temporary increase in the flux of groundwater from the Wianamatta Group shales (where present) to the upper portion of the Hawkesbury Sandstone. Given the higher TDS of the shale groundwater, this phenomenon has the potential to temporarily raise the TDS of the upper Hawkesbury Sandstone groundwater. The numerical flow model for the study area (Coffey, 2016b) was used to estimate the magnitude of increased flux attributable to Hume Coal mining activities, which indicated a peak increase of 1 megalitre [ML] per day (ML/day) (9% increase from baseline), with the maximum effect occurring within a short duration during mining. Likewise, a proportional maximum increase in salt flux (as groundwater TDS) of 9% was also predicted to occur. A net salt flux increase of 1.3% over baseline conditions was calculated for the 74-year period during which modelling predicted an incremental increase in groundwater leakage (including active mining operations and post-mining recovery). The current influence of baseline groundwater flux from the shales to the underlying sandstone was reviewed for multi-level monitoring wells installed through the shale, which generally indicated a minor TDS difference relative to wells installed in sandstone outcrop areas. A mixing model was used to assess the water quality resulting from relative mixing proportions of the shale and sandstone groundwater, which indicated that an unrealistically large proportion (> 40%) of shale groundwater would be required to reduce the beneficial use status of the underlying Hawkesbury Sandstone groundwater resource.

- The results of kinetic leach column (KLC) testing were used to assess the potential change to groundwater quality resulting from groundwater

[1] Depressurisation refers to a decrease in hydrostatic pressure in a geological formation due to a release of groundwater storage; in this case due to drainage of groundwater from stratigraphically adjacent formations into the mine workings, which are dewatered for safety purposes.

interaction with mining reject material emplaced in the underground mine voids. The results of column leaching tests were selected from columns considered to best represent the expected subsurface conditions: simulated mine reject material generated from cores recovered from the Project area, leached with groundwater obtained from the Wongawilli Seam, as would occur in within the backfilled mine void. The "wet" KLC tests referenced in this assessment were maintained under a 100-mm water cover, and were not subjected to alternate wet/dry cycles or heating (as per the leachate generation assessment approach for surface storage of mine reject material). However, the oxygen saturation of the groundwater used as the leaching agent may have been higher (due to atmospheric exposure) than would be expected at depth in the subsurface, resulting in a conservative estimate of sulphide mineral oxidation. Data from two columns were considered; one with mine reject material amended with limestone as an additional alkalinity source, and the other unamended. The results were compared to baseline water quality for the Hawkesbury Sandstone and Wongawilli Seam to assess whether leaching from mine reject material would potentially result in degradation of the beneficial use status of the groundwater resources. The results of the unamended KLC test indicated leachate water quality exceeded one or more of the beneficial use criteria that were generally also exceeded in the baseline groundwater quality, although the magnitude of the exceedance was larger (by approximately an order of magnitude) for certain metals in the leachate results. The final leachate pH of the unamended column was relatively low, indicating a potential for acid generation. It should be noted that the potential for higher oxygen saturation in the groundwater sample used as the leaching agent, relative to the expected *in-situ* conditions in the subsurface, would introduce conservatism to the KLC test results with respect to sulphide mineral oxidation and hence acid generation. The leachate quality from the limestone amended reject material was very favourable, with approximately neutral pH values throughout the test, and with leachate analyte concentrations that were below most of beneficial use criteria, including many that were exceeded in the baseline groundwater quality. Accordingly, the assessment indicated that limestone amendment of the mine reject material prior to emplacement in the mine void is likely to produce leachate that is indistinguishable from native groundwater quality, and is considered unlikely to change the beneficial use status of the surrounding groundwater resources.

- During the initial 12-18 months as the project is developed, the coal reject generated from mining of the initial panels will be stored in a temporary coal reject stockpile adjacent to the CPP until sufficient void space is available underground, and the plant is commissioned to commence production of the reject in a semi-liquid mixture (slurry) suitable for pumping for underground emplacement. In addition, if the slurry operation is interrupted, for example during maintenance, reject will be temporarily diverted to an emergency surface stockpile for later reprocessing. The fines managed on the surface in this manner will be dewatered via belt press filters (avoiding the need for a tailings dam) prior to being combined with the course reject. This combined reject will be placed for co-disposal on the temporary coal reject stockpile, which will be progressively constructed, contoured and when full, top dressed and revegetated. Once mining is completed, rejects stored at the surface will be removed, reprocessed and pumped underground to remaining voids. Surface emplacements will then be rehabilitated. The coal reject stockpile will be managed such that it does not receive run off from the surrounding mine site, however will still be exposed to rainfall that falls directly on the stockpile. To reduce the potential for acid generation and mobilisation of metals arising from oxidation of reject minerals in the stockpile, the reject will be amended with limestone prior to emplacement in the stockpile to buffer acid generation.

- The mine water management plan will include a portion of the water in the Primary Water Dam (PWD) being pumped into the sealed underground panels. The water balance for the site indicates that the average annual input to the PWD will comprise approximately 70% extracted groundwater, 20% rainfall, and 10% process water from the CPP and dust suppression returns. The water quality resulting from the proportional mixing of these end member waters was simulated using a mixing model, with data from KLC tests, geochemical modelling and published rainfall quality data used to represent the end member water types. The mixed PWD water quality exceeds a number of beneficial use criteria for dissolved metals; however comparison to the average WWS baseline groundwater quality (the "receiving environment" for water injected into the sealed panels) indicates similar exceedances of dissolved metals criteria, and a similar overall beneficial use profile. Two metals (nickel and copper) marginally exceeded the average WWS groundwater quality concentrations; however, these estimated concentrations are conservative for the following reasons:
    - the quality of the CPP process water that would report to the PWD (which was the driver for the elevated nickel and copper concentrations) was simulated by adopting "first flush" results from concentrated KLC leachate testing. The larger water-to-solids ratio in the CPP would be expected to produce a more dilute water quality than the KLC first flush results;

- some of the dissolved metals load would be expected to adsorb onto precipitating iron oxide colloids in the PWD, which was not accounted for in the geochemical modelling; and
- further dilution would occur when the PWD water mixes with natural groundwater in the sealed panel following injection.

2. PROJECT AREA DESCRIPTION AND ENVIRONMENTAL SETTING

2.1 General Site Description

The project area is approximately 100 km south-west of Sydney and 4.5 km west of Moss Vale town centre in the Wingecarribee LGA (refer to **Figure 1.1** and **Figure 1.2**). The nearest area of surface disturbance will be associated with the surface infrastructure area, which will be 7.2 km north-west of Moss Vale town centre. It is in the Southern Highlands region of NSW and the Sydney Basin Biogeographic Region.

The project area is in a semi-rural setting, with the wider region characterised by grazing properties, small-scale farm businesses, natural areas, forestry, scattered rural residences, villages and towns, industrial activities such as the Berrima Cement Work and Berrima Feed Mill, and some extractive industry and major transport infrastructure such as the Hume Highway.

Surface infrastructure is proposed to be developed on predominately cleared land owned by Hume Coal or affiliated entities, or for which there are appropriate access agreements in place with the landowner. Over half of the remainder of the project area (principally land above the underground mining area) comprises cleared land that is, and will continue to be, used for livestock grazing and small-scale farm businesses. Belanglo State Forest covers the north-western portion of the project area and contains introduced pine forest plantations, areas of native vegetation and several creeks that flow through deep sandstone gorges. Native vegetation within the project area is largely restricted to parts of Belanglo State Forest and riparian corridors along some watercourses. With some minor portions of forest in elevated positions such as Mt Gingenbullen.

The project area is traversed by several drainage lines including Oldbury Creek, Medway Rivulet, Wells Creek, Wells Creek Tributary, Belanglo Creek and Longacre Creek, all of which ultimately discharge to the Wingecarribee River, at least 5 km downstream of the project area (Figure 1.2). The Wingecarribee River's catchment forms part of the broader Warragamba Dam and Hawkesbury-Nepean catchments. Medway Dam is also adjacent to the northern portion of the project area (Figure 1.2).

Most of the central and eastern parts of the project area have very low rolling hills with occasional elevated ridge lines. However, there are steeper slopes and deep gorges in the west in Belanglo State Forest.

Existing built features across the project area include scattered rural residences and farm improvements such as outbuildings, dams, access tracks, fences, yards and gardens, as well as infrastructure and utilities including roads, electricity lines, communications cables and water and gas pipelines. Key roads that traverse the project area are the Hume Highway and Golden Vale Road. The Illawarra Highway borders the south-east section of the project area.

Industrial and manufacturing facilities adjacent to the project area include the Berrima Cement Works and Berrima Feed Mill on the fringe of New Berrima. Berrima Colliery's mining lease (CCL 748) also adjoins the project area's northern boundary. Berrima Colliery is currently not operating with production having ceased in 2013 after almost 100 years of operation. The mine is currently undergoing closure.

2.2 Geology

The study area is located in the south-western portion of the Sydney Basin, a regionally extensive sedimentary basin. The geology of the study area consists predominantly of a thick sedimentary sequence of the Sydney Basin, with more recent volcanic intrusions also present within the study area. The geology relevant to the study area is described in the following sections, in descending stratigraphic order.

2.2.1 Robertson Basalt

Volcanic activity during the late-Triassic to early-Jurassic periods resulted in basaltic intrusions (necks, sills, dykes and basalt surface flows) through the sedimentary geology of the Sydney Basin. The volcanic activity was particularly concentrated in the Southern Highlands, with basalt flows defining the surface geology along the southern portion of the exploration lease, and in other discrete areas within and around the study area.

2.2.2 Wianamatta Group Shales

The Wianamatta Group (WG) represents a late-Triassic marine depositional regime broadly consisting of two shale formations (Ashfield and Bringelly Shales) separated by the Minchinbury Sandstone. The shale formations are described as black to dark grey shale, claystone and laminite, while the intermediate Minchinbury Sandstone is described as a fine to medium grained lithic sandstone.

The WG shales are present in the eastern half of the study area, and have been eroded away in the west of the study area, exposing the underlying Hawkesbury Sandstone.

2.2.3 Hawkesbury Sandstone

The Hawkesbury Sandstone (HAW) was deposited during the Middle Triassic in a fluvatile (non-marine) depositional environment. The HAW is up to 250 m thick in the central Sydney Basin, and is approximately 100 m thick in the study area. It consists primarily of quartz, feldspar and mica in a kaolinitic clay matrix and is cemented by secondary quartz and siderite (Standard, 1969). The sandstone beds exhibit both sheet facies, characterised by cross-bedding, and massive facies that lack internal sedimentary structure, reflecting variable depositional processes. Minor clayey sandstone, siltstone and shale lenses may be present in the profile.

2.2.4 Narrabeen Group

The late-Permian to early-Triassic Narrabeen Group consists of a variable depositional sequence comprising interbedded sandstones, siltstones, claystones and conglomerates. The Narrabeen Group formations are mostly absent within the study area, with a maximum thickness of 6 m in the northern portion of the study area. Outside the study area the Narrabeen Group exceeds 300 m in thickness. Where the Narrabeen Group is absent, the HAW unconformably overlies the Illawarra Coal Measures.

2.2.5 Illawarra Coal Measures

The late-Permian Illawarra Coal Measures (ICM) are approximately 50 m thick in the study area, and consist of interbedded layers of sandstone, conglomerate, shale and coal. The ICM host the Wongawilli Seam, which is the mining target for the Hume Coal Project. The Wongawilli Seam occurs in the upper portion of the ICM, and is overlain unconformably by the HAW. At the top of the WWS there are, across most of the mine lease, carbonaceous to tuffaceous claystone layers.

The ICM overlies the Shoalhaven Group, consisting of marine sandstone interbedded with latite flows, which in turn overlies Palaeozoic basement formations.

2.3 Hydrogeology

A detailed review of the hydrogeology of the study area is available in the Coffey (2016) Groundwater Assessment report, including a review of baseline hydrogeological conditions (Vol.1), and predictive modelling of the influence of the mining activities on the local groundwater resources (Vol.2). The hydrogeology of the study area is summarised in this section based largely on hydrogeological conceptual model described in Coffey (2016).

The most important groundwater resource from a water supply perspective is associated with the HAW, which is accessed by approximately 90% of the private water supply bores in the study area. With the exception of the southern basalt intrusion, it is the shallowest fresh water supply, and the yields are sufficient to support most beneficial uses. The southern basalt intrusion is also a highly developed groundwater supply, with fresh groundwater quality and airlift yields in the rage of 10 to 20 L/sec.

2.3.1 Hydraulic Conductivity

The regional hydrogeology of the study area is characterised by fractured rock aquifer systems, with groundwater flow predominantly controlled by defects in the rock mass, including fractures, joints and bedding plane partings. The hydraulic conductivity of the rock mass is generally a function of defect spacing/frequency and aperture thickness, both of which decrease with depth. Hydraulic conductivity values in the study area generally range between 0.01 and 10 m/day, and are higher than elsewhere in the Southern Coalfields where a large proportion of measured K values fall between 0.0001 and 0.01 m/day. The increased hydraulic conductivity in the vicinity of the study area is believed to be associated with tectonic disturbance of the rock mass during the period of intensive igneous intrusions, and may also have been influenced by the erosion of gorges to the north, west and south of the project area.

2.3.2 Groundwater Recharge and Discharge

Recharge to the local aquifers occurs primarily via rainfall infiltration. With respect to the HAW, the outcrop areas occur along the western portion of the study area, and are capped by the lower permeability WG shale formations in the eastern half of the study area. HAW also outcrops in the gorges to the south-east of the project area. Leakage from the Wingecarribee Reservoir some 15km to the east of the study area is also considered to contribute a reasonable component of groundwater recharge within the study area.

Groundwater discharge from the regional aquifer systems occurs as baseflow contribution to local watercourses, evapotranspiration of groundwater seepage (particularly at escarpment seepage faces), groundwater extraction for water supply and ongoing discharge to the mine voids of the Berrima and Loch Catherine mines, which still have strong inward hydraulic gradients associated with them.

2.3.3 Hydraulic Head Distribution

The hydraulic head[2] distribution in the study area is strongly influenced by the local topography and surface geology. Hydraulic head values are elevated in the outcropping sandstone along the western portion of the study area and around the Wingecarribee Reservoir in the southeast, with decreasing head values towards discharge points in the south (e.g. the deeply incised Bundanoon Creek valley) and the north (Medway Rivulet and the Berrima and Loch Catherine mine voids).

A detailed discussion of the interpreted head distribution was presented in Coffey (2016a). The general pattern consists of negligible vertical gradients[3] in the portion of the HAW beneath the WG shales, with downward vertical gradients developing close to escarpment discharge areas and above the Berrima Mine void, where a strong inward hydraulic gradient developed due to the propagation of depressurisation into the overlying HAW formation. In contrast to the HAW, a downward vertical gradient was inferred in the southern basalt intrusion and WG shale formations.

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[2] Hydraulic head is a water level measurement in a well corrected to a common elevation reference (in this case, the Australian Height Datum). Groundwater generally flows from areas of higher hydraulic head to areas of lower hydraulic head.

[3] A hydraulic gradient is the groundwater equivalent of a topographic slope: it is the change in hydraulic head over a given distance. Hydraulic gradients are commonly expressed in terms of horizontal gradients (i.e. planar to ground surface), and vertical gradients (perpendicular to ground surface).

2.3.4 Groundwater Use

A total of 430 registered water supply bores were identified within the study area (i.e. within the boundary of the numerical flow model domain). The majority of these were registered for stock, domestic and/or irrigation use, with the balance comprising unspecified "industrial" use, mineral water extraction, and monitoring bores. Of these bores, 117 contained enough information to identify the formations in which they were screened. Approximately 90% of the bores were screened in the Hawkesbury Sandstone (HAW) and/or the Illawarra Coal Measures (ICM), with the balance screened in the Wianamatta Group shales or the basalt.

2.4 Sensitive Receptors

From a review of the environmental setting of the study area, the following receptors were identified:

- Coffey (2016a,b) reported the presence of several hundred registered private bores within and surrounding the project area. The depths of the majority of private bores within the A349 mine lease indicate that they are installed within the HAW, beneath a reasonable thickness of WG shales. The notable exception is a cluster of shallow bores installed within the basalt in the south-eastern portion of A349. Within the domain of the groundwater model (Coffey, 2016b), Coffey identified 83 private bores with water access licences for irrigation or industrial uses, with a combined allocation of 14.5 ML/day, and a further 299 unlicensed bores for stock and/or domestic use (landholder rights) with an assumed combined extraction rate of approximately 2.4 ML/day. As discussed in further detail later in this report, the water quality and yields from the HAW are sufficient to support most beneficial uses. The integrity of the groundwater resources within the study area, and the water supply bores that access them are considered to be the primary receptors of concern for any changes to groundwater quality resulting from mining activities;

- A number of rivers and creeks within the study area receive baseflow from groundwater, including the Wingecarribee River, Medway Rivulet, Lower Wollondilly River, and various creeks within these catchments. Accordingly, a change to groundwater quality from mining activities would have the potential to also affect baseflow quality and hence the aquatic ecology of the receiving water bodies; and

- Several other potential groundwater dependent ecosystems (GDEs) were identified within and surrounding the Hume Coal project area, generally comprising swamps and wetlands to the southwest of the project area (approximately 15 km from the boundary of A349), and Southern Highlands shale forest and woodland, portions of which are located within the project area, but the majority is located to the west and southwest of the project area. It is understood that the potential GDEs are associated with areas of shallow groundwater, accordingly the groundwater quality accessed by the GDEs would be strongly influenced by recently recharged groundwater, rather than groundwater associated with the deeper strata in which the mine workings are proposed.

The assessment of potential changes to groundwater quality associated with mining activities considered the potential impacts to the receptors identified above.

3. ASSESSSMENT REQUIREMENTS

This assessment has been prepared in accordance with the relevant governmental assessment requirements, guidelines and policies, and in consultation with the relevant government agencies. The legislation, guidelines and policies relevant to the hydrogeochemical assessment are discussed in Section 3.1, followed by a summary of the Secretary's Environmental Assessment Requirements (SEARs), and those of referral authorities, specific to the project.

3.1 Legislation, Policies and Guidelines

3.1.1 Water Act 1912 and Water Management Act 2000

Surface water and groundwater resources in NSW are administered under the Water Act 1912 and the Water Management Act 2000 (WMA). The former jurisdiction of the Water Act 1912 has progressively been superseded by the WMA through the development of Water Sharing Plans (WSPs), which are regulatory instruments that set out the rules for managing the various water sources throughout NSW. WSPs for groundwater sources describe the nature and extent of the resource, the estimated volume in storage available for allocation as water supply, the portion of storage required for maintenance of environmental values (and therefore unavailable for licenced water supply), and the administrative process for licencing and managing allocation of the groundwater resource for water supply.

The study area is within the area covered by the WSP for the Greater Metropolitan Region Groundwater Sources 2011, issued under the WMA, which commenced on 1 July 2011. The jurisdiction of the WSP is divided into a number of groundwater source areas, of which the study area falls within the Sydney Basin Nepean Groundwater Source (Nepean Management Zone 1).

3.1.2 Aquifer Interference Policy

The Aquifer Interference (AI) Policy is the NSW Government policy for the licensing and assessment of aquifer interference activities. The AI Policy defines "aquifer interference" activities as those activities that involve:

- Penetration of an aquifer
- Interference with water in an aquifer
- Obstruction of groundwater flow
- Taking of water from an aquifer
- Disposal of taken groundwater

While the AI Policy applies to all aquifer interference activities, it was developed with particular regard to mining and extractive activities. Examples of activities assessed under the policy include dewatering, water injection into aquifers and activities with the potential to impact groundwater quality or result in structural damage to an aquifer (e.g. compaction).

The AI Policy sets out a framework for assessing the impacts of aquifer interference activities on water resources as follows:

- Assessment of impacts to groundwater resources and related environmental values arising from the proposed activity;
- Quantification of the contribution of all water sources affected by the aquifer interference activity, and demonstrated ability to obtain the necessary licenses to account for the take of water from all affected water sources;
- Ability to demonstrate design to prevent the take of water where licensed allocations are not available;
- Ability to demonstrate that minimal impact considerations can be met; and
- Proposed remediation actions for impacts greater than those predicted as part of the relevant approval.

One of the key objectives of the AI Policy is to assess the potential impacts of projects relative to minimal impact considerations for the affected water sources. These considerations include:

- Threshold values with respect to changes to water tables (in unconfined aquifers), changes to water pressure (in confined aquifers) and changes to water quality arising from proposed aquifer interference activities;
- Two standards of minimal impact considerations developed for highly productive or less productive groundwater sources:
- Highly productive groundwater sources are defined as having total dissolved solids values less than 1,500 mg/L and are capable of yielding groundwater at a rate greater than 5 L/s. Within this category, minimal harm considerations have been developed for alluvial, coastal sand, porous and fractured rock water sources.
- Less productive groundwater sources are those that do not meet the above criteria, with separate considerations developed for alluvial and porous/fractured rock water sources.

- Minimal harm considerations which afford protection to specific environmental values of groundwater under the AI Policy, including groundwater sources, connected surface water sources, GDEs, groundwater dependent culturally significant sites and water users. The values are protected through the application of the previously mentioned threshold values, and vertical and horizontal buffers for certain activities (e.g. underground mining).

With minor exceptions, groundwater quality within the project area that will be subject to aquifer interference activities is characterised by TDS values less than 1500 mg/L, and includes water supply bores with yields greater than 5 L/sec, which classifies the groundwater sources as "highly productive" within the minimal impact assessment framework.

With regard to the assessment of project influences on groundwater quality, the following minimal impact considerations apply to highly productive porous and fractured rock groundwater sources under the AI Policy:

1. Any change in the groundwater quality should not lower the beneficial use category of the groundwater source beyond 40 m from the activity.
2. If condition 1 is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply works.

3.1.3 Summary of Assessment Criteria

Ecological Water Quality Criteria

The methodology and criteria for ecological water quality assessment in Australia are presented in the Australian and New Zealand Environment and Conservation Council (ANZECC) and Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ) Australian and New Zealand Guidelines for Fresh and Marine Water Quality (herein ANZECC 2000).

The ANZECC 2000 guidelines present assessment criteria (referred to as "trigger values") for a range of organic and inorganic chemicals, which are applicable to both protection of aquatic ecology, and suitability for primary industries. While the guidelines are not specifically "groundwater criteria", they apply at the point of use or exposure and are therefore relevant where an aquatic ecosystem is partially or wholly dependent on groundwater, or where groundwater supply supports primary industry.

The relevant ANZECC 2000 water quality criteria for protection of aquatic ecosystems and suitability for primary industries are included in the baseline groundwater quality monitoring summary tables attached to this assessment.

Health-based Water Quality Criteria ADWG 2011

The methodology and criteria for health-based assessment of drinking water quality in Australia are presented in the National Health and Medical Research Council (NHMRC) and Natural Resource Management Ministerial Council (NRMMC) Australian Drinking Water Guidelines (ADWG, 2011). The ADWG (2011) lists health-based and aesthetic criteria for various organic and inorganic chemicals. Because aquifers within the study area are accessed for potable water supply, both the health-based and aesthetic criteria have been considered in this assessment.

3.2 SEARs and Referral Authority Requirements

The SEARs for the project were issued by the Secretary of the DPE in a letter dated 20 August 2015. The SEARs that are specific to the hydrogeochemical assessment are summarised in **Table 3.1**. These broad SEARs are addressed progressively throughout this report, and in particular **Section 6** with regard to impact assessment.

Table 3.1 Secretary's environmental assessment requirements

Requirement
An assessment of the likely impacts of the development on the quantity and quality of the region's surface and groundwater resources having regard to the EPA's, DPI's and Water NSW's requirements and recommendations.
An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure, and other water users.

To inform preparation of the SEARs, DP&E invited other government agencies to recommend matters for address in the EIS. These matters were then taken into account by the Secretary for DP&E when preparing the SEARs. Copies of the government agencies' advice to DP&E was attached to the SEARs.

Four agencies, including the Department of Resources and Energy (DRE), Fisheries NSW, the NSW Office of Water under the Department of Primary Industries (DPI Water) and the Office of Environment and Heritage (OEH), raised matters relevant to the hydrogeochemical assessment. These were mainly their standard requirements for projects of this nature, though included some project-specific requirements. These matters are listed in Table 3.2 and Table 3.3, respectively, and have been taken into account in preparing this hydrogeochemical assessment, as indicated in the tables.

Table 3.2 Referral authority environmental assessment requirements

Requirement	**Section addressed**
DRE	
An assessment and life of mine management strategy of the potential for geochemical constraints to rehabilitation, particularly associated with the management of overburden/interburden and reject material. Based on this, the EIS should document the processes that will be implemented throughout the mine life to identify and appropriately manage geochemical risks that may affect the ability to achieve sustainable rehabilitation outcomes.	Section 6.2
A life of mine tailings management strategy which details measures to be implemented to avoid the exposure of potentially environmentally sensitive tailings material as well as promote geotechnical stability of the rehabilitated landform.	Section 6.2
DPI Water	
A detailed assessment against the NSW Aquifer Interference Policy (2012) using DPI Water's assessment framework.	Section 6
Assessment of impacts on surface and ground water sources (both quality and quantity), related infrastructure, adjacent licensed water users, basic landholder rights, watercourses, riparian land, wetlands, and groundwater dependent ecosystems, and measures proposed to reduce and mitigate these impacts.	Section 6 (groundwater only, surface water quality addressed in a separate report).
Proposed surface and groundwater monitoring activities and methodologies.	Section 7.4
Proposed management and disposal of produced or incidental water.	Section 6.3
Assessment of any potential cumulative impacts on water resources, and any proposed options to manage the cumulative impacts.	Sections 6 and 7
Sufficient baseline monitoring for groundwater quantity and quality for all aquifers and GDEs to establish a baseline incorporating typical temporal and spatial variations.	Section 5
The existing groundwater users within the area (including the environment), any potential impacts on these users and safeguard measures to mitigate impacts.	Sections 6 and 7

Requirement	Section addressed
An assessment of groundwater quality, its beneficial use classification and prediction of any impacts on groundwater quality.	Sections 5, 6 and 7, and Appendix A
An assessment of the potential for groundwater contamination (considering both the impacts of the proposal on groundwater contamination and the impacts of contamination on the proposal).	Sections 6 and 7
Measures proposed to protect groundwater quality, both in the short and long term.	Sections 6 and 7
Measures for preventing groundwater pollution so that remediation is not required.	Sections 6 and 7
Protective measures for any groundwater dependent ecosystems (GDEs).	Section 7.2
The results of any models or predictive tools used.	Sections 6 and 7
Where potential impact/s are identified the assessment will need to identify limits to the level of impact and contingency measures that would remediate, reduce or manage potential impacts to the existing groundwater resource and any dependent groundwater environment or water users, including information on: - Any proposed monitoring programs, including water levels and quality data. - Reporting procedures for any monitoring program including mechanism for transfer of information. - An assessment of any groundwater source/aquifer that may be sterilised from future use as a water supply as a consequence of the proposal. - Identification of any nominal thresholds as to the level of impact beyond which remedial measures or contingency plans would be initiated (this may entail water level triggers or a beneficial use category). - Description of the remedial measures or contingency plans proposed. - Any funding assurances covering the anticipated post development maintenance cost, for example on-going groundwater monitoring for the nominated period.	Sections 6 and 7

Requirement	Section addressed
OEH	
The EIS must describe background conditions for any water resource likely to be affected by the development, including: a. Existing surface and groundwater. b. Hydrology, including volume, frequency and quality of discharges at proposed intake and discharge locations. c. Water Quality Objectives (as endorsed by the NSW Government http://www.environment.nsw.gov.au/ieo/index.htm) including groundwater as appropriate that represent the community's uses and values for the receiving waters. d. Indicators and trigger values/criteria for the environmental values identified at (c) in accordance with the ANZECC (2000) Guidelines for Fresh and Marine Water Quality and/or local objectives, criteria or targets endorsed by the NSW Government.	Sections 5 and 6, and Appendix A
The EIS must assess the impacts of the development on water quality, including: a. The nature and degree of impact on receiving waters for both surface and groundwater, demonstrating how the development protects the Water Quality Objectives where they are currently being achieved, and contributes towards achievement of the Water Quality Objectives over time where they are currently not being achieved. This should include an assessment of the mitigating effects of proposed stormwater and wastewater management during and after construction. b. Identification of proposed monitoring of water quality.	Sections 6 and 7

4. ASSESSMENT METHODOLOGY

4.1 Literature Review

Information available for review as part of this assessment included hydrogeological and geochemical specialist reports prepared for the EIS, previous technical reports addressing groundwater quality in the study area, and tabulated baseline groundwater monitoring results. The information reviewed is detailed in the reference list in Section 8, and is discussed in further detail in the relevant portions of this assessment.

4.2 Data Sources

The primary data sources used for this study included the baseline groundwater monitoring data collected by Parsons Brinckerhoff (PB) and provided in electronic format by EMM, an environmental isotope study performed by PB (2012), and KLC test results from the RGS (2016) geochemical assessment.

Output was also provided from the Coffey (2016b) numerical model, indicating the extent of vertical hydraulic connectivity between the WG shale formations and the underlying HAW formations, as well as the predicted vertical groundwater flux (in megalitres [ML] per day for six-monthly time steps) between the WG and HAW, expressed both as a total flux and as the incremental increase attributable to mining activities.

4.3 Data Analysis and Interpretation

The available groundwater monitoring data are summarised in Tables A1 to A6 attached to this report. The data were grouped by representative formations, statistically assessed for variability across the monitoring period and for inter-formation comparison purposes, and compared to relevant published water quality guidelines to assess the baseline suitability of the groundwater resources for various beneficial uses.

Data from the RGS (2016) KLC test results were used for comparison to the baseline groundwater monitoring results, to evaluate the potential for changes to groundwater quality resulting from the emplacement of mine reject material in the underground voids.

The vertical flux data between the WG and HAW provided by Coffey (2016b) from their numerical flow model was compared to the natural aquifer recharge estimates for the study area, with proportional mixing calculations used to assess the potential change in water quality in the HAW that may occur because of the temporary increased flux of more saline groundwater from the WG to the HAW.

Finally, the predicted evolution of groundwater quality held in storage in a surface pond was modelled using PHREEQC (v. 3.3.8), which assumed an open-system gas exchange and equilibration (oxygen and carbon dioxide) with the atmosphere, and calculation of the resulting change to water quality. This modelling was completed to support decisions for water reuse and disposal, in the event that surplus water was generated at any stage of the mining operation.

5. BASELINE HYDROGEOCHEMICAL CHARACTERISATION

Baseline groundwater monitoring was carried out between October 2011 and September 2015, using a network of monitoring wells installed in representative locations across the study area and screened within the relevant geological formations. The baseline groundwater monitoring network comprised 46 monitoring wells targeting the following formations:

- Robertson Basalt (2)
- Wianamatta Group shales (1)
- Hawkesbury Sandstone (23)
- Illawarra Coal Measures (3)
- Wongawilli Seam (15)
- Tongarra Seam (2)

Figure 5.1 presents the locations of the monitoring wells in the Study Area. Summary tables of the baseline groundwater monitoring results (by formation type) are attached (Tables A1 to A6, Appendix A). A tabulated summary of the well construction details, sourced from the Coffey (2016a) report, is also attached in Table A7 for reference.

The groundwater samples collected as part of the baseline monitoring program were analysed for most or all of the following analytes:

- Field water quality parameters:
    - Temperature, pH, electrical conductivity (EC), dissolved oxygen (DO), oxidation-reduction potential (ORP)
- Major cations and anions:
    - Calcium, magnesium, sodium, potassium, chloride, sulphate, alkalinity (primarily bicarbonate), silica
- Dissolved metals and metalloids:
    - Aluminium, antimony, arsenic, beryllium, barium, boron, cadmium, chromium, cobalt, copper, iron (total and ferrous), lead, lithium, manganese, mercury, molybdenum, nickel, selenium, strontium, tin, uranium, vanadium and zinc
- Nutrients:
    - Ammonia, nitrite, nitrate, phosphorous (total and reactive)
- Other inorganics:
    - fluoride, cyanide, bromine, iodine

- Organic analytes:
    - Total recoverable hydrocarbons (TRH)
    - Benzene, toluene, ethylbenzene, xylenes (BTEX)
    - Polycyclic aromatic hydrocarbons (PAHs)
    - Phenolic compounds
    - Organochlorine (OC) and organophosphorus (OP) pesticides

5.1 Robertson Basalt

5.1.1 Summary of Monitoring Points

There are two piezometers installed within the Robertson Basalt (each in a separate occurrence of the basalt, located approximately 10 km apart). H56XC was sampled five times between December 2012 and February 2015. H136C was sampled four times between August 2014 and September 2015.

5.1.2 Field Water Quality Parameters

Water quality parameters are relatively consistent among the nine total measurements. The pH can be described as approximately neutral as values ranged from 6.07 to 7.74, with an average value of 6.75. Electrical conductivity (EC) ranged from 446 to 797 µS/cm, with the average being 653 µS/cm. Total dissolved solids (TDS) ranged from 261 to 518 mg/L, with an average of 421 mg/L. Dissolved oxygen (DO) ranged from 21 to 84 % saturated, with an average of 56 % sat. Redox potential ranged from -117 to +179 mV, with an average of 58 mV. Groundwater temperature ranged from 15.6 to 18.6 °C, with an average temperature of 17.2 °C.

The groundwater quality of the Robertson Basalt can be described as approximately neutral and having relatively low dissolved solids content. Despite the unsaturated DO measurements, the redox data portray the water as relatively oxidizing, a conclusion that is supported by low dissolved iron, which is described below. As shown by the Pourbaix diagram in **Figure 5.2** only two basalt groundwater samples plot near the phase boundary between ferrihydrite (amorphous ferric hydroxide) and a solution phase consisting mainly of ferrous [Fe(+2)] species. The majority of points plot in the ferrihydrite region indicating that dissolved iron primarily consists of ferric [Fe(+3)] species. Redox measurements were converted from an electrode (Ag/AgCl) reference to that of the standard hydrogen electrode.

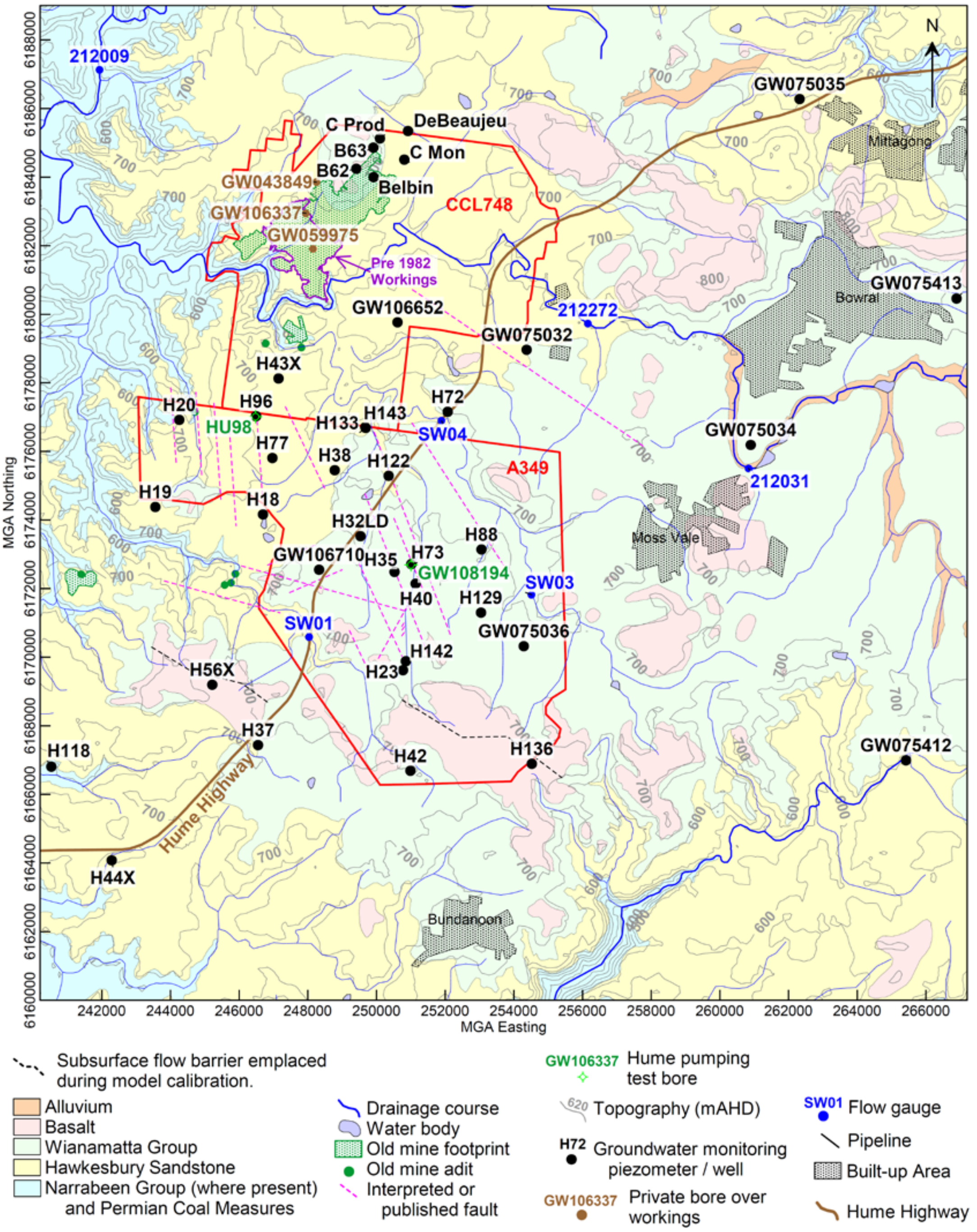

Figure 5.1. Groundwater monitoring network for the Study Area (from Coffey, 2016a).

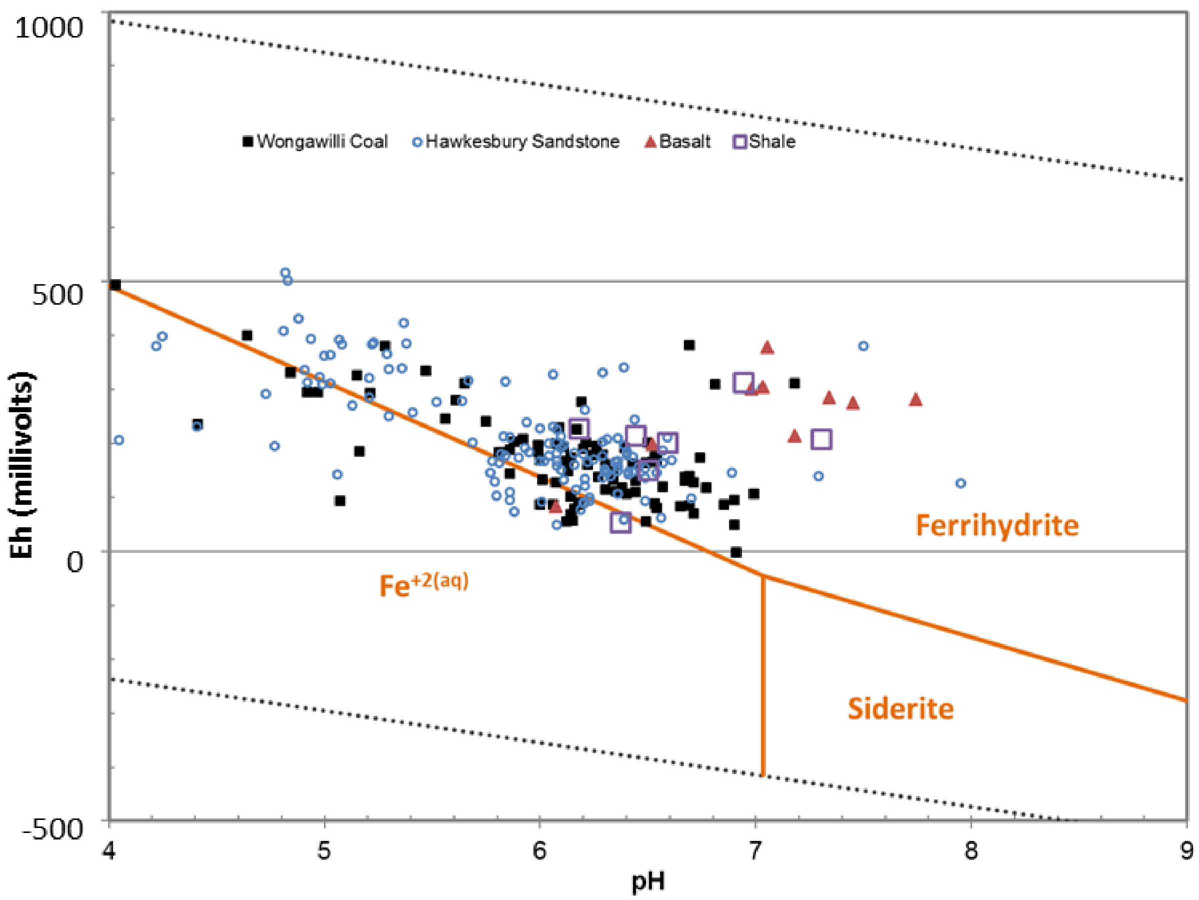

Figure 5.2. Pourbaix diagram for major groundwater types in Hume Coal study area.

5.1.3 Major and Minor Ions

The relatively low TDS of this groundwater is reflected in the low concentrations of primary groundwater constituents. Alkaline earth metals calcium and magnesium range from 30 to 61 mg/L and 25 to 57 mg/L, respectively. Alkali metal cations sodium and potassium range from 20 to 69 mg/L and 2 to 4 mg/L, respectively. Bicarbonate is the dominant anion, which is reflected in total alkalinity values ranging from 236 to 350 mg/L as $CaCO_3$. Chloride and sulphate range from 27 to 60 mg/L and 7 to 86 mg/L, respectively. Anions such as fluoride, cyanide and thiocyanate were not detected in these groundwater samples.

The dominant hydrochemical water type in the basalt was Mg-Ca-HCO_3-Cl, indicating that the water represents a mixture of rainfall recharge that has been influenced by mineral dissolution within the basalt matrix.

5.1.4 Metals and Metalloids

The dissolved metals content of the basalt tends to be quite low, with concentrations frequently below their respective laboratory limits of reporting (LOR). Although aluminium was above its detection limit of 0.01 mg/L in a few instances, the solubility of aluminium at approximately neutral pH is several orders of magnitude below the reported concentrations, which suggests that the lab results may not represent true dissolved phase aluminium. Copper and nickel are reported slightly above their LOR of 0.001 mg/L in a few instances, but concentrations were below detection in other sampling periods. On the contrary, zinc was detected well above its LOR of 0.005 mg/L in five out of six sampling events.

Iron and manganese are useful indicators of redox conditions in groundwater. Both elements can have concentrations above 1 mg/L when the groundwater is anoxic (anaerobic), but concentrations are often very low under oxidizing conditions, which appears to be the situation throughout most of the sampling events in the basalt. Reduced (ferrous) iron was measured directly in one sampling event (23/9/2015), and found to be undetectable (<0.05 mg/L).

Other trace metals, antimony, arsenic, cadmium, chromium, cobalt, lead, molybdenum, and selenium, as well as boron, were below detection in all but a few instances. No groundwater data are available for the following elements: beryllium, barium, lithium, strontium, tin, uranium, vanadium, bromine, iodine, and mercury.

5.1.5 Nutrients

Analysis results for nutrients were not performed on the basalt groundwater.

5.1.6 Organic Compounds

Analysis results for organic compounds were not performed on the basalt groundwater.

5.1.7 Beneficial Uses

The groundwater quality of the basalt intrusions is characterised by relatively low TDS and approximately neutral pH, with very few exceedances of the water quality assessment criteria. Where exceedances occurred, they were generally associated with metals concentrations that were marginally above the ANZECC (2000) ecological criteria. Accordingly, groundwater associated with the basalt intrusions in the study area is likely to be suitable for a broad range of beneficial uses, from a water quality perspective.

5.2 Wianamatta Group Shales

5.2.1 Summary of Monitoring Points

There is one piezometer installed in the shale, H35B, which was sampled on seven occasions between December 2013 and September 2015. The water quality is similar to WG shale groundwater encountered in other portions of the Sydney Basin.

5.2.2 Field Water Quality Parameters

Water quality parameters are relatively consistent among the nine total measurements. The pH can be described as approximately neutral as values ranged from 6.18 to 7.30 with the most probable value being 6.8 (**Figure 5.3**).

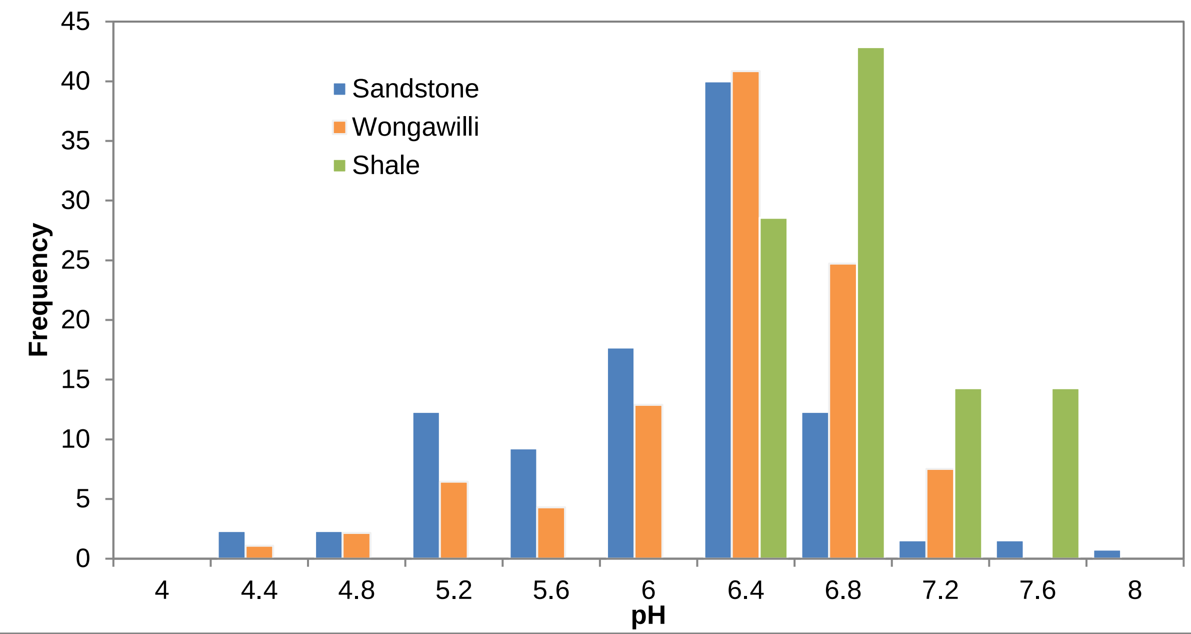

Figure 5.3. Histogram showing pH distribution in the HAW, the WWS, and WG Shale formations (all formations normalised to 100)

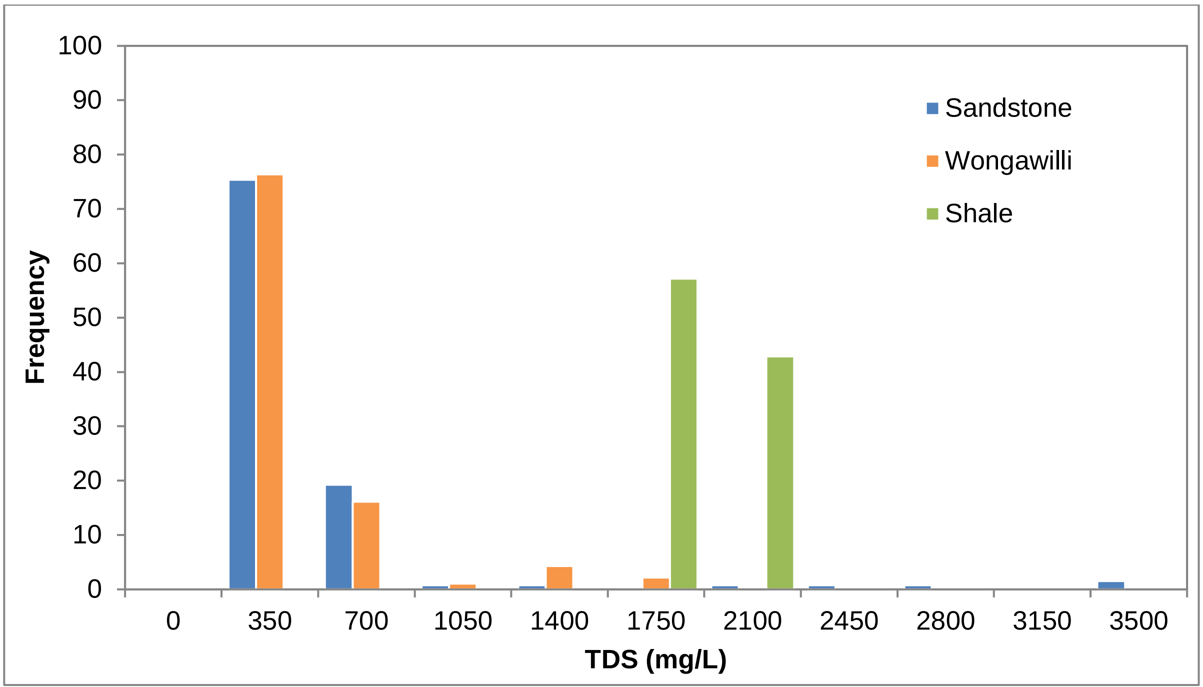

Figure 5.4. Histogram showing TDS distribution in the HAW, the WWS, and WG Shale formations (all formations normalised to 100)

EC ranged from 2364 to 2885 µS/cm, with the average being 2617 µS/cm. TDS ranged from 1,537 to 1,875 mg/L, with an average value of 1700 mg/L (**Figure 5.4**). DO ranged from 13 to 90% saturated, with an average of 50 % sat. Redox potential ranged from -147 to +113 mV, with an average of -4 mV. Groundwater temperature ranged from 13.4 to 18.4 °C.

Like the Robertson Basalt, the pH range of the Wianamatta Group shales can be described as approximately neutral. However, unlike the basalt, the shales have significantly higher TDS load, which is characteristic of the marine origin of the basal shale formations. The Pourbaix diagram (**Figure 5.2**) shows that some of the shale groundwater is near the stability boundary between ferrihydrite [amorphous $Fe(OH)_3$] and a reducing groundwater that contains predominantly ferrous [Fe(+2)] iron.

5.2.3 Major and Minor Ions

Laboratory analysis was performed on six groundwater samples between December 2013 and September 2015. The moderately high TDS in the shale groundwater is reflected in the chloride content, which ranges from 528 to 707 mg/L and cations calcium, magnesium and sodium, which range from approximately 110 to 200 mg/L. Total alkalinity is also moderately high (258 to 380 mg/L) and suggests the presence of calcium carbonate in the shale. Sulphate is relatively low at 32 to 86 mg/L and potassium is minor (between 8 and 12 mg/L). Fluoride detections are coincident with the LOR (0.1 mg/L) and cyanide and thiocyanate were not analysed.

The predominant hydrochemical water type in the WG shale formation was Mg-Ca-Na-Cl-HCO_3. The strong chloride signal in the shale is likely to be associated with connate salts from its original marine deposition.

5.2.4 Metals and Metalloids

The dissolved metals content of the shale formations tends to be quite low, with many concentrations being below their respective detection limits. As noted above, the solubility of aluminium at approximately neutral pH is much lower than the detection limit of 0.01 mg/L. The fact that aluminium was not detected in all but one sampling event is consistent with aluminium chemistry. Therefore, the measurement on 12/13/2013, when the concentration of aluminium was 0.77 mg/L, is considered an outlier.

Molybdenum and copper are reported slightly above their LOR of 0.001 mg/L in a few instances, but were below detection in other sampling periods. The concentrations of cobalt and nickel were low but consistently above the LOR, where the average values were 0.024 and 0.037 mg/L, respectively. Iron and manganese concentrations range from 0.45 to 4.2 mg/L and 0.53 and 0.93 mg/L, respectively. Iron concentrations exceeded 1 mg/L only in the first two sampling events, and were less than 1 mg/L in subsequent events. Speciation analysis in two samples collected in 2015 showed ferrous iron content to be 0.19 and 0.48 mg/L.

Several metals are consistently above the LORs, including barium, strontium, zinc and lithium. Barium is frequently affected by the solubility of the mineral barite

($BaSO_4$) and strontium readily substitutes for calcium in calcite. Lithium and zinc can be present at trace levels in many types of minerals.

Other trace metals, antimony, arsenic, beryllium, cadmium, chromium, lead, and selenium, as well as boron, were below detection in all but a few instances.

5.2.5 Nutrients

Ammonium concentrations were 0.22 and 0.24 mg/L at the 2013 and 2015 sampling events. Ammonium contains a reduced form of nitrogen [N(-3)] and its presence is consistent with the absence of nitrate, which contains oxidized nitrogen [N(+5)]. Phosphorous was not detected in any of the three sampling events where it was analysed.

5.2.6 Organic Compounds

No organic compounds were detected above their respective LORs in shale groundwater.

5.2.7 Beneficial Uses

Groundwater associated with the WG shales is typically too saline, and the yield is to low, to support a broad range of beneficial uses. Although the TDS is relatively moderate with respect to shale groundwater in other parts of the Sydney Basin, it is still above the typical taste threshold for potable supply, and is generally considered to have limited potential as a groundwater resource.

5.3 Hawkesbury Sandstone

5.3.1 Summary of Monitoring Points

There are 23 monitoring wells screened in the HAW, as follows:

H18B	H37B	H56XB	H96C	H142B
H19B	H38C	H72B	H118A	H142C
H23B	H42C	H72C	H129B	H143C
H23C	H43B	H73C	H133C	
H32LDB	H44XB	H88B	H136B	

5.3.2 Field Water Quality Parameters

Water quality parameters were measured 130 times at 23 piezometers in HAW during several rounds of sampling between October 2011 and September 2015.

- The pH values among all samples ranged from 4.05 to 7.95, with the most probable value being 6.4 (**Figure 5.3**). The histogram shows that the pH range of the sandstone extends much lower than that of the shale. A slightly acid pH is characteristic of HAW groundwater in other parts of the Sydney Basin; the lower pH values generally correlate to the western portions of the project area were the HAW is not overlain by the WG Shales or basalt bodies. The higher pH values in HAW wells installed below WG Shales or basalt bodies are similar to the pH values in the overlying formations, suggesting that acidic rainfall recharge is buffered in the WG Shales and basalt before infiltrating deeper into the underlying HAW formations.

- EC ranged from 41 to 4882 µS/cm, with an average value of 478 µS/cm, which represents a spread of over two orders of magnitude. TDS ranged from 27 to 3,172 mg/L, with a most probable value of 350 mg/L (**Figure 5.4**). The high end of the EC and TDS data range is very unusual for HAW groundwater, and all the unusually high values are associated with monitoring wells H142B and H142C, which were installed to replace wells H23B and H23C, respectively. A plot of EC and TDS values in these wells (**Figure 5.5**) clearly indicates a spike in the solute load when the replacement wells were installed, which raises the possibility that the elevated EC and TDS values are either an artefact of the well installation process. An alternative explanation is that the slight change in installation locations (approximately 250 m from the original H23B/C locations) encountered significantly different water quality conditions, which is difficult to reconcile with the otherwise consistent groundwater quality within the HAW. Assuming that the EC/TDS values from H142B and H142C are not representative of natural HAW aquifer groundwater quality, the average and maximum EC values would decrease to 307 µS/cm and 970 µS/cm, respectively, and average and maximum TDS values would decrease to 200 mg/L and 630 mg/L, respectively.
- DO ranged from 1.5 to 118.1 % sat, with an average of 31.1 % sat.
- Redox potential ranged from -151.9 to 315.3 mV, with an average of 14.6 mV.
- Groundwater temperature ranged from 12.4 to 33.1 °C, with the average being 18 °C. Four temperature measurements exceeded 25 °C, which upon evaluation are considered outliers (i.e. are likely to reflect conditions during sampling rather than conditions in-situ).

The HAW is a quartzose sandstone with major quartz and minor feldspar, clay, and iron compounds such as siderite. It follows that dissolved silica (SiO_2) would reflect equilibrium with respect to quartz and other silicate phases. The average concentration of SiO_2 is 10 mg/L in all the HAW groundwater samples. The total mass of dissolved ions is generally quite low, suggesting that soluble mineral phases are not especially prevalent in the permeable zones of the sandstone aquifer.

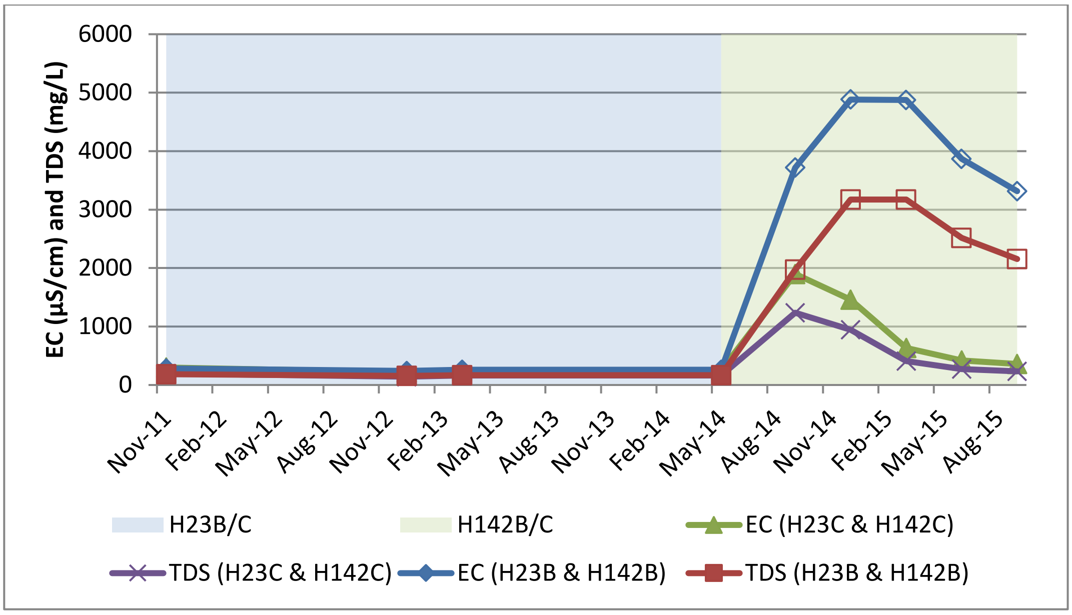

Figure 5.5. EC and TDS trends for original and replacement wells H23B/C (Nov 2011 to May 2014) and H142B/C (Sept 2014 to Sept 2015), demonstrating a spike is solute load following installation of the replacement wells.

5.3.3 Major and Minor Ions

It is evident that chloride is the predominant ion in the HAW. The negative charge due to chloride is approximately balanced by the combined equivalent concentrations of magnesium and sodium. Most of the alkalinity measurements are below 180 mg/L, whereas sulphate tends to be less than 50 mg/L. Calcium and magnesium may be as high as 200 mg/L, while sodium was reported to be as high as 600 mg/L. All of the major ions were non-detectable at some sampling events.

Figure 5.6 shows a Piper plot for the most recent sampling event in all HAW monitoring wells. The two trilinear (triangle) diagrams express the concentrations of major cations (calcium, magnesium and sodium + potassium) and anions (chloride, sulphate and bicarbonate + carbonate). The area shaped like a diamond is a projection of cation and anion concentrations: sulphate + chloride and calcium + magnesium increase toward the top of the diamond; and sodium + potassium and bicarbonate + carbonate increase toward the bottom of the diamond. Piper plots are useful for detecting and characterising mixing of two or more types of groundwater, assuming that such mixing occurs in the hydrogeological regime being investigated. The cation trilinear diagram shows a continuous range from magnesium-rich to sodium-rich groundwater, but none which are rich in calcium. The anion trilinear diagram shows two distinct distributions of groundwater types. One type consists of bicarbonate and chloride with very low sulphate (base of triangle) and the other consists of sulphate and bicarbonate without chloride (left side of triangle).

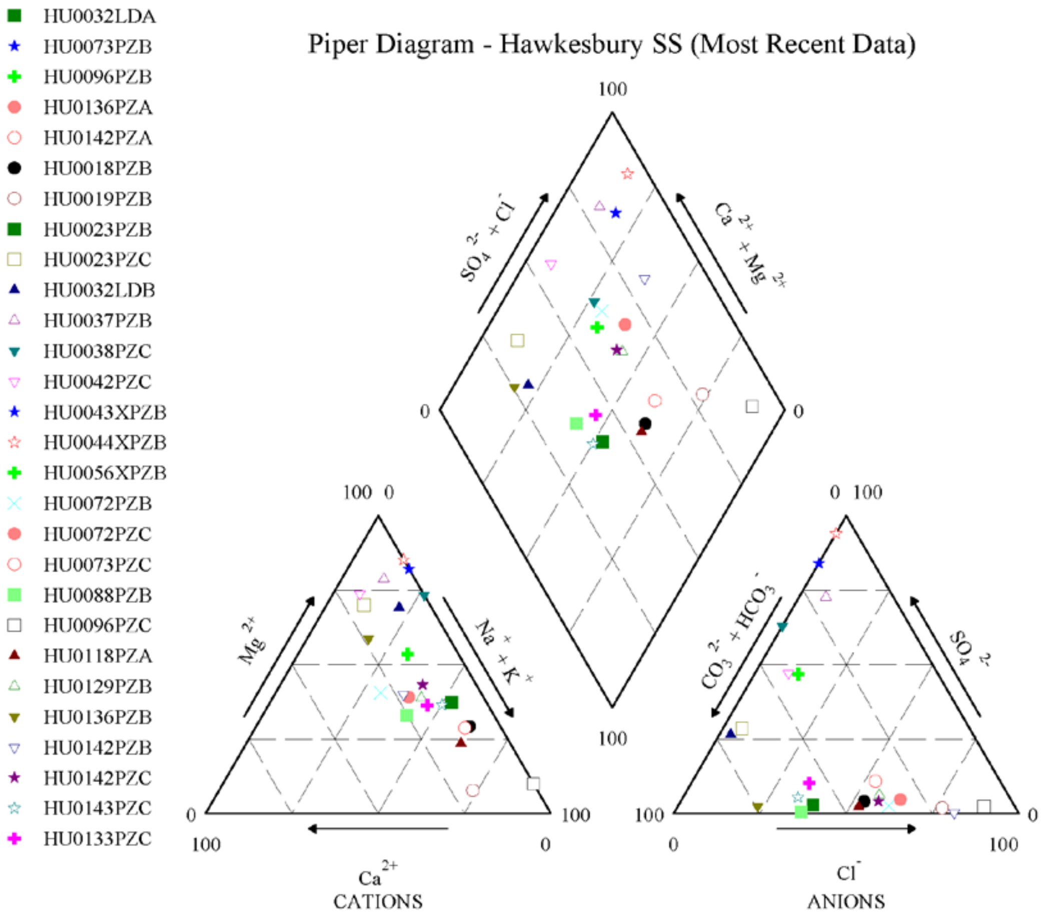

Figure 5.6. Piper plot of major ion data from most recent monitoring event for the HAW monitoring wells.

Projections of the cations and anions onto the diamond fill the upper half, which implies that the water sample range among three types: Mg–HCO_3, Na–Cl, and Mg–SO_4. A review of the locations of the various wells did not indicate clear distinctions based on the depth of the screened interval within the HAW, or the location within the study area, with the following exception: wells located on the outcropping sandstone recharge beds[4] tended to have a more dominant Na-Cl signature, whereas wells installed through outcropping shale tended to have a more dominant Mg-CO_3 signature.

The wells with sulfate-dominant anions were mixed between sandstone and shale surface geology, with no clear distinction about the source of the additional sulfate within the sandstone formations. However, these wells were generally also characterised by low EC values, low pH values, and generally low chloride and bicarbonate concentrations, suggesting that the sulfate-dominant waters may be associated with areas subject to efficient rainfall recharge.

[4] Recharge beds are surface outcrops of permeable geological formations that facilitate the efficient infiltration of surface water into the subsurface as groundwater recharge.

5.3.4 Metals and Metalloids

Concentrations of most dissolved metals are low, as is characteristic for groundwater with approximately neutral pH. Most aluminium measurements are below the LOR (0.01 mg/L), although a maximum of 0.41 mg/L was recorded in one instance. Aluminium concentrations above 0.01 mg/L are not representative of dissolved species and are believed to be outliers. Antimony is at or below 0.002 mg/L in all instances. Arsenic was not detectable in most cases (<0.001 mg/L), but averages 0.008 mg/L in samples that were above the LOR; the maximum concentration of arsenic was 0.044 mg/L. Selenium was below detection (<0.01 mg/L) in most cases, but reached a maximum of 0.16 mg/L in one instance. The average concentration of barium is 0.14 mg/L and was 0.83 mg/L in one instance. Cadmium, chromium, lead, molybdenum, tin, uranium, and mercury were typically below 0.001 mg/L.

Iron and manganese are redox-sensitive metals and tend to be quite soluble under reducing conditions. Iron concentrations range from non-detectable to 21.9 mg/L, with an average concentration of 7.2 mg/L. Similarly, manganese concentrations range from below the LOR to 1.73 mg/L, with an average concentration of 0.46 mg/L. The relatively elevated dissolved iron and manganese concentrations in groundwater suggest a reducing environment.

Other metals and metalloids associated with coal include cobalt and copper, which have maximum concentrations of 0.27 and 0.26 mg/L, respectively and nickel which has a maximum concentration of 0.63 mg/L. Boron was below the LOR in all samples. Strontium, which substitutes for calcium in many minerals phases, was elevated (1.5 mg/L) in one instance, and much lower in others. The highest concentrations of strontium (1.49 mg/L, vs the average value of 0.16 mg/L) and barium (0.83 mg/L, vs the average value of 0.14 mg/L) were both in well H142B, which exhibited the anomalously high EC and TDS values (**Figure 5.5**).

5.3.5 Nutrients

As the groundwater system is reducing, ammonia tended to dominate over nitrate and nitrite. However, the maximum values of ammonia and nitrate were between 0.77 to 0.78 mg/L. Total phosphorus ranged from <0.01 mg/L to 0.19 mg/L and the biochemical oxygen demand (BOD) was <2 mg/L.

5.3.6 Organic Compounds

All organic analytes were below the laboratory LORs with the following minor exceptions:

- One detection of 3- & 4-methylphenol in H38C (4.7 µg/L);
- Four detections of toluene (6 to 20 µg/L) in four different wells; and

- One detection of total recoverable hydrocarbons (TRH) in the F1 carbon range (C_6-C_{10} minus BTEX) of 20 µg/L, which is the same sample in which toluene was detected at 20 µg/L.

Organic compounds such as these have been reported to naturally occur within Permian coal measures in NSW (Volk et al, 2011); however, are unusual within the HAW in the absence of an anthropogenic (contamination) source. Another possibility, given the rare detections and low concentrations reported, is the potential for laboratory contamination, which occasionally occurs due to carry over on analytical instruments and glassware. Repeatability (or lack thereof) in future monitoring is likely to be the best indicator of whether these reported detections represent an actual presence in the HAW, or an artefact of the laboratory analyses.

5.3.7 Beneficial Uses

Groundwater in the HAW is an important local water supply resource, and according to the available bore registration and water access licence details is developed to support domestic, stock and irrigation supply. It is characterised by a low solute load and, in combination with relatively good yields, makes it suitable to support most beneficial uses.

5.4 Wongawilli Seam

5.4.1 Summary of Monitoring Points

Groundwater monitoring data were available from the following 15 monitoring wells:

H18A	H38A	H44XA	H88A	H136A
H23A	H42A	H72A	H96B	H142A
H32LDA	H43XA	H73B	H129A	H143B

5.4.2 Field Water Quality Parameters

Water quality parameters were measured a total of 130 times across the 15 monitoring wells in the Wongawilli Seam between October 2011 and September 2015. The pH values among all samples ranged from 4.03 to 7.18, with an average value of 5.5 (**Figure 5.3**). EC ranged from 40.8 to 2383 µS/cm, with the average being 469 µS/cm. TDS ranged from 46 to 1550 mg/L, while the average is 310 mg/L. As with the HAW monitoring wells, anomalously high ED and TDS values were reported for well H142A, which was installed as a replacement for H23A. The elevated EC and TDS values correlate to elevated barium and strontium concentrations, which may suggest a drilling fluid source.

DO ranged from 0.7 to 113% sat, with an average of 23% sat. Redox potential ranged from -202 to 294 mV, with an average of -30 mV. Temperature ranged from 11.5 to 25.2 °C, with an average value of 18.1 °C. As discussed for the HAW, the reported temperatures are considered likely to reflect the ambient temperature during sample collection.

Dissolved silica (SiO_2) ranged from 7.4 to 34 mg/L with an average concentration of 11 mg/L. The concentration of dissolved ions is generally quite low, suggesting that minerals other than quartz are not especially prevalent in the permeable zones.

5.4.3 Major and Minor Ions

Laboratory analysis was performed on 93 groundwater samples between October 2011 and September 2015. Chloride is the dominant anion in the Wongawilli Seam, similar to the HAW. In the former, chloride concentrations ranged from 10 to over 500 mg/L. Total alkalinity ranges from non-detectable to 315 mg/L as $CaCO_3$. In one instance the alkalinity of a sample collected from H18A on 25/03/2015 was reported to be 1090 mg/L and appears to be an outlier. No specific interpretation has been attempted for this elevated alkalinity result, however the data point was not excluded from the set as it did not disproportionately influence the statistical assessment of the WWS groundwater data. Calcium and magnesium ranged from non-detectable to approximately 100 mg/L, whereas sodium was the dominant cation reaching concentrations of over 500 mg/L.

5.4.4 Metals and Metalloids

The dissolved metals content of the Wongawilli Seam tends to be quite low, with many concentrations being below their respective LORs. Most of the aluminium measurements were below the LOR of 0.01 mg/L, save a few that probably are not representative of the dissolved phase.

The concentrations of arsenic, cobalt, copper and molybdenum, were low but occasionally above the LORs. Iron and manganese concentrations were occasionally quite elevated: concentration maxima were as high as 4 and 20 mg/L, respectively. Speciation analysis in 12 samples showed ferrous iron content to be between 1.85 and 15 mg/L. The presence of ferrous iron and relatively high concentration of total iron and manganese suggest a reducing groundwater environment.

Several metals are consistently above LORs, including barium, strontium, zinc, and lithium. Barium is frequently affected by the solubility of the mineral barite ($BaSO_4$) and strontium readily substitutes for calcium in calcite. Lithium and zinc can be present at trace levels in many types of minerals. As previously mentioned, elevated barium and strontium concentrations in well H142A could potentially be attributable to drilling fluid use during well installation.

Antimony, cadmium, chromium, lead and uranium were below the LORs in all but a few instances. No detections above the LORs were reported for the following elements: beryllium, tin, vanadium and mercury.

5.4.5 Nutrients

Both ammonia and nitrate were reported above the respective LORs in 14 and 16 samples, respectively. None of the concentrations exceeded the assessment criteria. Total and reactive phosphorous were also detected above the LORs in nine and two samples, respectively. BOD was below the LOR in the three samples analysed.

5.4.6 Organic Compounds

All organic analytes were below the laboratory LORs with the following minor exceptions:

- One detection of phenol in H42A (1.3 µg/L);
- Four detections of toluene (2 to 62 µg/L) in four different wells;
- Two detections of TRH C_6-C_{10} (40 to 100 µg/L); and
- One detection of TRH F1 (40 µg/L).

As discussed in Section 5.3.6, organic compounds such as these have been reported to naturally occur within Permian coal measures in NSW (Volk et al, 2011). The majority of organic compound detections occurred during the same sampling events (December 2013 and February 2015), and involved wells that would have been sampled close to the same time (e.g. H42A and H42C; H88A and H88B), which raises the question of potential laboratory contamination. Repeatability (or lack thereof) in future monitoring is likely to be the best indicator of whether these reported detections represent an actual presence in groundwater, or an artefact of the laboratory analyses.

5.5 Illawarra Coal Measures

5.5.1 Summary of Monitoring Points

There were three monitoring wells installed in the ICM:

- H73A
- H143A
- H133A

5.5.2 Field Water Quality Parameters

Water quality parameters among the ICM are relatively consistent among the 14 total measurements. The pH can be described as approximately neutral as values ranged from 6.10 to 7.13. EC ranged from 243 to 1190 µS/cm, with the average being about 600 µS/cm. TDS ranged from 158 to 774 mg/L, with an average of 405 mg/L. DO ranged from 3 to 80% saturated, with an average of 24% sat. Redox potential ranged from -180 to +30 mV, with an average of -75 mV. Temperature of the groundwater ranged from 15.5 to 21.1 °C, with an average of 19 °C.

5.5.3 Major and Minor Ions

The dominant anion in the ICM groundwater is bicarbonate, as represented by total alkalinities ranging from 70 to 330 mg/L in 14 groundwater samples. Chloride (21 to 261 mg/L) and sulphate (4 to 119 mg/L) tended to be lower in concentration. Fluoride was detected in 7 rounds of sampling and ranged from 0.2 to 0.7 mg/L. Calcium (13 to 117 mg/L) and sodium (17 to 50 mg/L) were the dominant cations, while magnesium ranged from 8 to 47 mg/L and potassium was between 2 and 9 mg/L.

5.5.4 Metals and Metalloids

The dissolved metals concentrations in the ICM groundwater were relatively low, with many concentrations being below their respective LORs. The exceptions were iron (0.65 to 8.9 mg/L) and manganese (0.076 to 0.74 mg/L) which were somewhat elevated. Speciation analysis in four samples showed ferrous iron content to be between 0.88 to 6.4 mg/L. The presence of ferrous iron and relatively high concentration of total iron and manganese suggest a reducing groundwater environment.

Several metals are consistently above laboratory LORs, including barium (0.11 to 2.6 mg/L), strontium (0.12 to 0.60 mg/L), zinc (0.012 to 0.52 mg/L), and lithium (0.038 and 0.18 mg/L). Barium is frequently affected by the solubility of the mineral barite ($BaSO_4$) and strontium readily substitutes for calcium in calcite. Lithium and zinc can be present at trace levels in many types of minerals.

Cadmium, lead and uranium were below LORs in all instances. No groundwater data are available for the following elements: antimony chromium beryllium, tin, vanadium and mercury.

5.5.5 Nutrients

Ammonia was analysed in four samples and the concentrations ranged from 0.08 to 0.26 mg/L. Nitrate was analysed in one sample, but was not detected. Total phosphorus was measure in two samples and the concentrations were 0.06 and 0.13 mg/L.

5.5.6 Organic Compounds

All organic analytes were below the LOR in the ICM groundwater.

5.6 Spatial and Temporal Variability in Baseline Monitoring Data

As discussed in Section 5.3.3, the major ion data were reviewed with respect to the location of the wells across the study area. In particular, the data were evaluated to see if there was a difference in water types between wells installed in areas of HAW outcrop where substantial recharge occurs, and in areas of shale outcrop where less direct recharge influence is expected. The review indicated that, as expected, wells installed within the sandstone outcrop areas had a dominant Na-Cl signature, which is typical of rainfall recharge close to the coast. Wells installed where shale overlays the sandstone had a dominant Mg-CO_3 signature, which is characteristic of older groundwater that reflects a greater degree of water-rock interaction in the aquifer.

Groundwater in the shale has a higher solute load than groundwater in the other formations, which is typical of the WG shales in Sydney basin. However, the salinity of the groundwater in the one monitoring well screened in the shale is only moderately higher than groundwater in the other formations; it would not be unusual for groundwater in thicker occurrences of the WG shales to have ED/TDS values an order of magnitude higher than those reported for the study area.

Groundwater quality in the HAW and the WWS are surprisingly similar. While it is common for groundwater in the HAW to have a low solute load, coal seam groundwater would typically be expected to be more distinct (greater solute load, greater variability in geochemical signature). There was no significant distinction noted between groundwater in the HAW, the WWS, the ICM and the basalt. This suggests a limited degree of soluble mineral phases in these formations, such that the groundwater retains a relatively similar geochemical signature. It is also possible that historical extraction from the deeper formations (WWS, ICM) resulted in induced infiltration from the overlying HAW, hence the geochemical similarity of the water types in these two formations.

Isotopic analysis of the groundwater in the HAW and WWS (PB, 2012) indicated that both water types retained an isotopic signature that was similar to the meteoric water line, indicating a rainfall origin with limited isotopic fractionation processes (evaporation, mixing) following recharge. Isotopic age dating of the HAW and WWS water samples indicated an increasing age with depth (approximately 4500 years before present [BP] in the HAW, and 6000 year BP in the WWS), with the water ages in both formations representing relatively modern water compared to the depositional age of the formations.

With minor exceptions, the groundwater quality appeared to remain relatively stable across the monitoring period. **Figures 5.7** and **5.8** demonstrate the consistency in major ion chemistry (expressed as milliequivalents per litre [meq/L]) over the monitoring period for two monitoring wells.

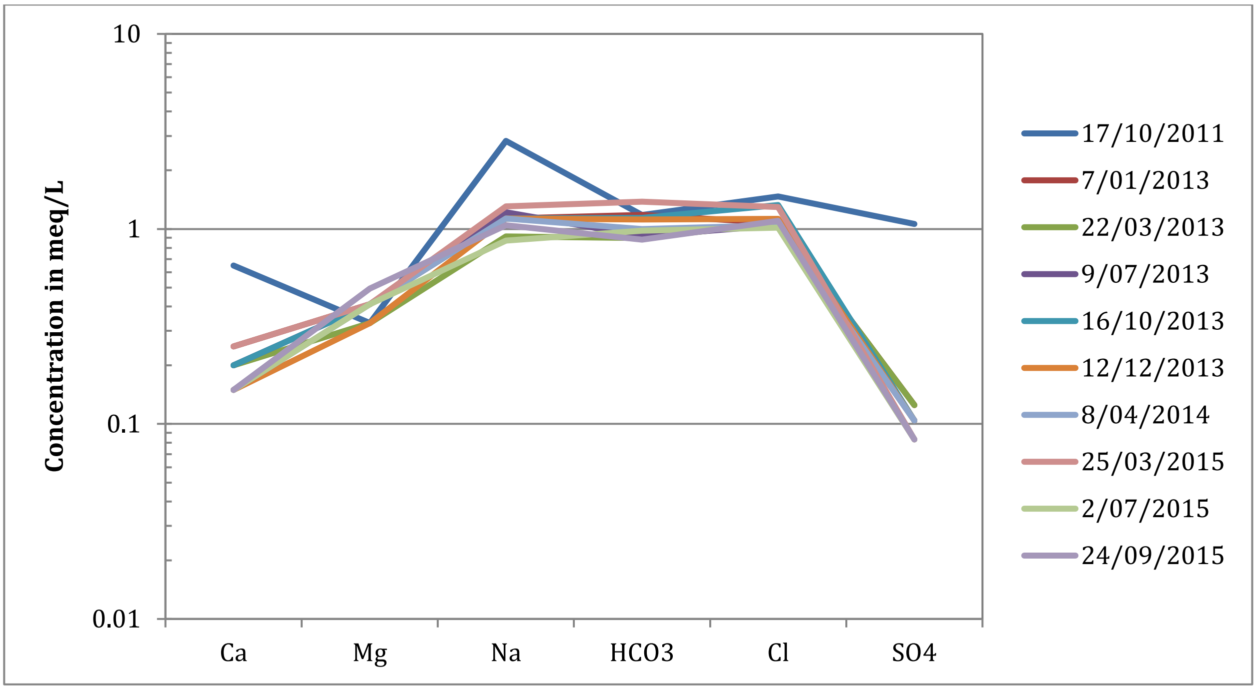

Figure 5.7. Temporal plot of major ion monitoring results for H18B.

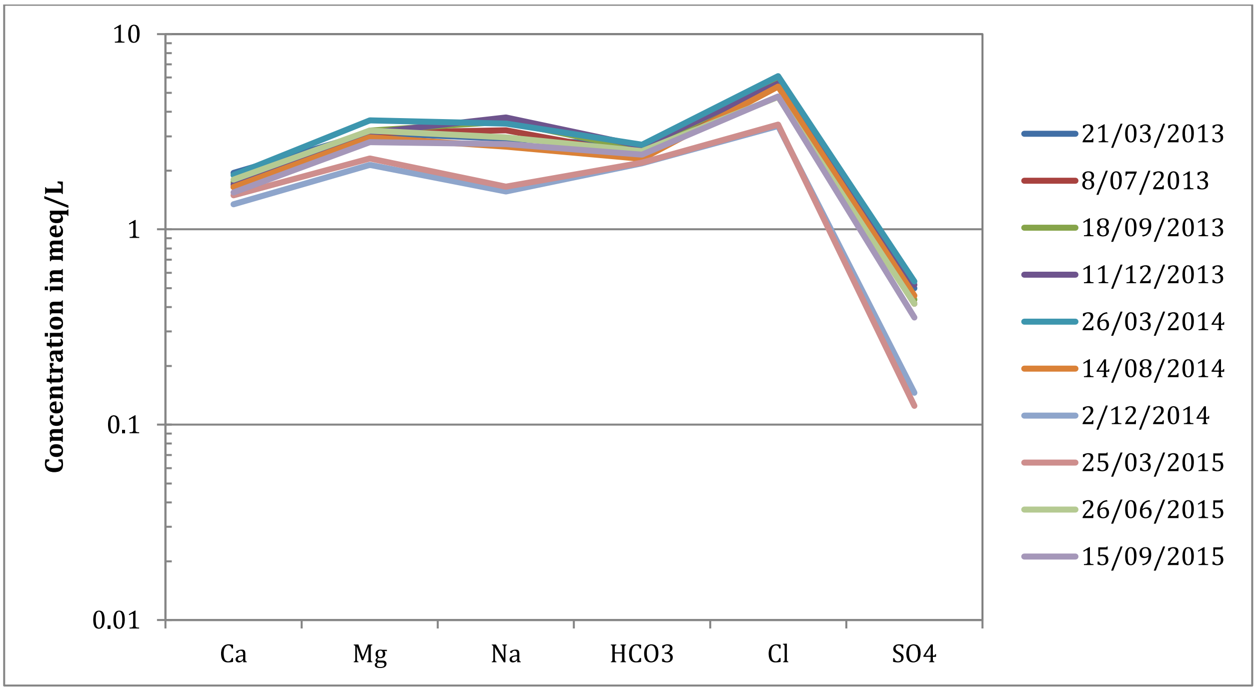

Figure 5.8. Temporal plot of major ion monitoring results for H72C.

6. PREDICTED INFLUENCE OF PROJECT ACTIVITIES

6.1 Water Quality Change from Induced Inter-Aquifer Transfer

6.1.1 Assessment Methodology and Assumptions

Dewatering of the underground mine voids during mining will result in temporary partial depressurisation of some of the overlying formations, which is predicted to temporarily increase the vertical (downward) hydraulic gradients in the water bearing formations above the mine footprint. The partial depressurisation effects in the HAW will result in a temporary increase in the vertical gradient between the WG shale formations and the HAW, with a resultant increase in the flux of groundwater from the shale formations downward into the upper portion of the HAW. This phenomenon is expected to be most pronounced during mining years 10 to 19, and will abate as mined panels are sealed and the panels are allowed to hydraulically re-equilibrate to background conditions.

To assess the magnitude of inter-aquifer transfer of higher TDS water from the WG shales into the upper HAW, time-integrated flux data was obtained from the numerical model for both the base case (i.e. no mining influence) and the in response to mining case, such that the incremental increase in inter-aquifer transfer attributable to mining activities could be evaluated. A mixing model was used to assess the groundwater quality that would result from mixing different proportions of groundwater from the WG shales and the HAW to assess the potential for the estimated flux increase to cause a decrease in the beneficial use category of the upper HAW groundwater resource.

This assessment conservatively assumes that there is a direct hydraulic connection between the base of the WG shale formation, and the underlying upper formations of the HAW. This is the assumption that was adopted in the numerical model conceptualisation, although it has also been interpreted from vertical head distributions that the two formations could be separated by a desaturated zone in some areas, in which case leakage from the shale into the underlying sandstone would be expected to already be occurring at its maximum flux rate.

6.1.2 Modelling Results

The Coffey (2016b) numerical flow model was used to quantify the simulated flux of groundwater between the WG shale formations and the upper HAW formation. Simulations were run for a 100-year period, both with and without the influence of the Hume Coal mining activities, to provide a baseline groundwater flux in the absence of Hume Coal mining influences, and a mining influenced flux, the difference of which represents the incremental induced flux from the mining activities. The area within the model domain inferred to have a direct hydraulic connection between the WG shales and the upper HAW formation is presented in **Figure 6.1**.

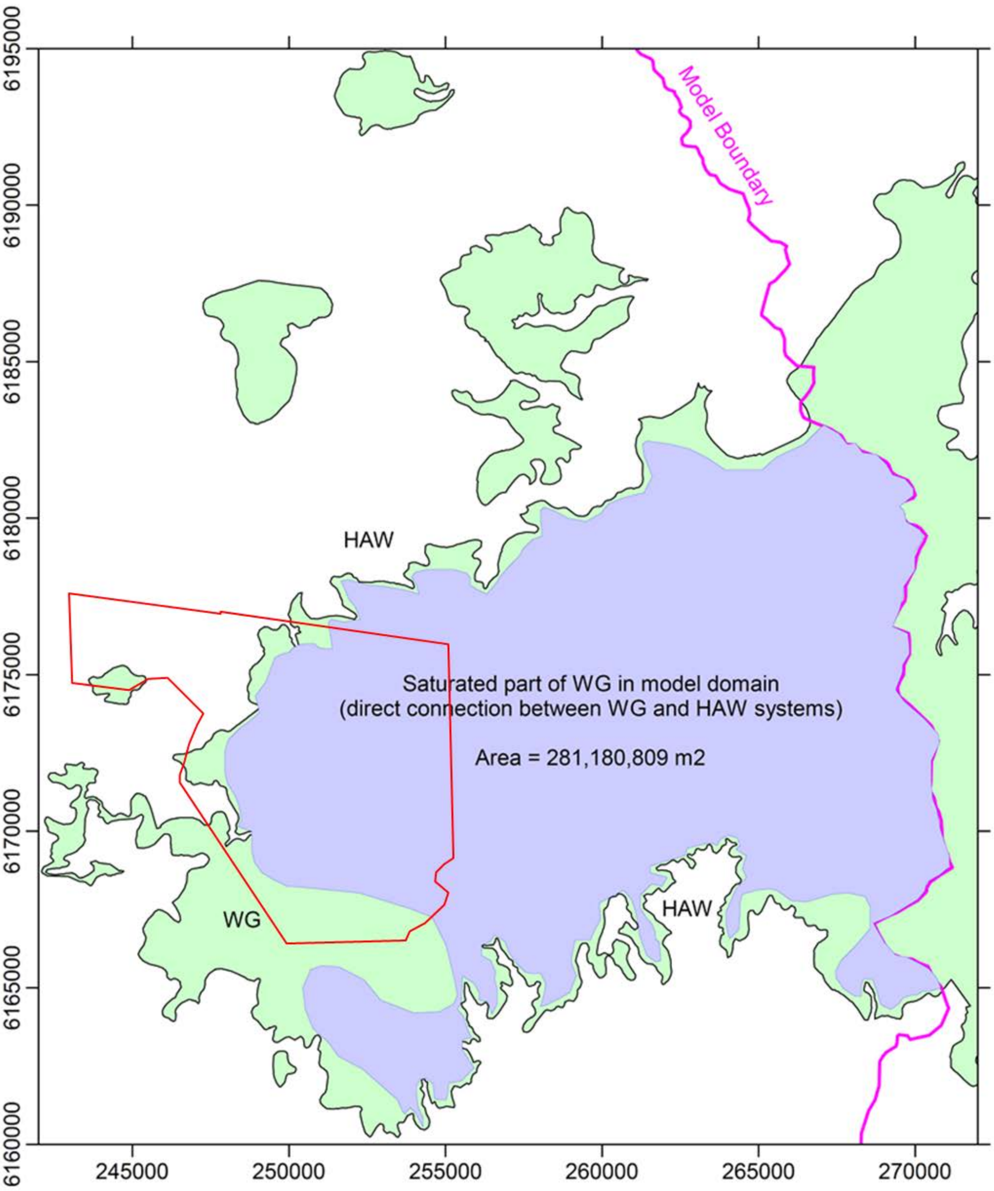

Figure 6.1. Extent of numerical model domain where a hydraulic connection exists between the WG shale and the underlying HAW.

In the absence of Hume Coal mining influences within the model domain, the baseline inter-aquifer transfer from the WG shales to the upper HAW was consistently around 11.1 ML/day for the entire simulation period. With the Hume Coal mining schedule activated, an incremental increase in the vertical flux was predicted between Years 1 and 74, peaking in the Year 14.5 time step at 12.1 ML/day, or a 1 ML (9%) increase over the baseline conditions. The incremental flux over the simulation period is presented in **Figure 6.2**.

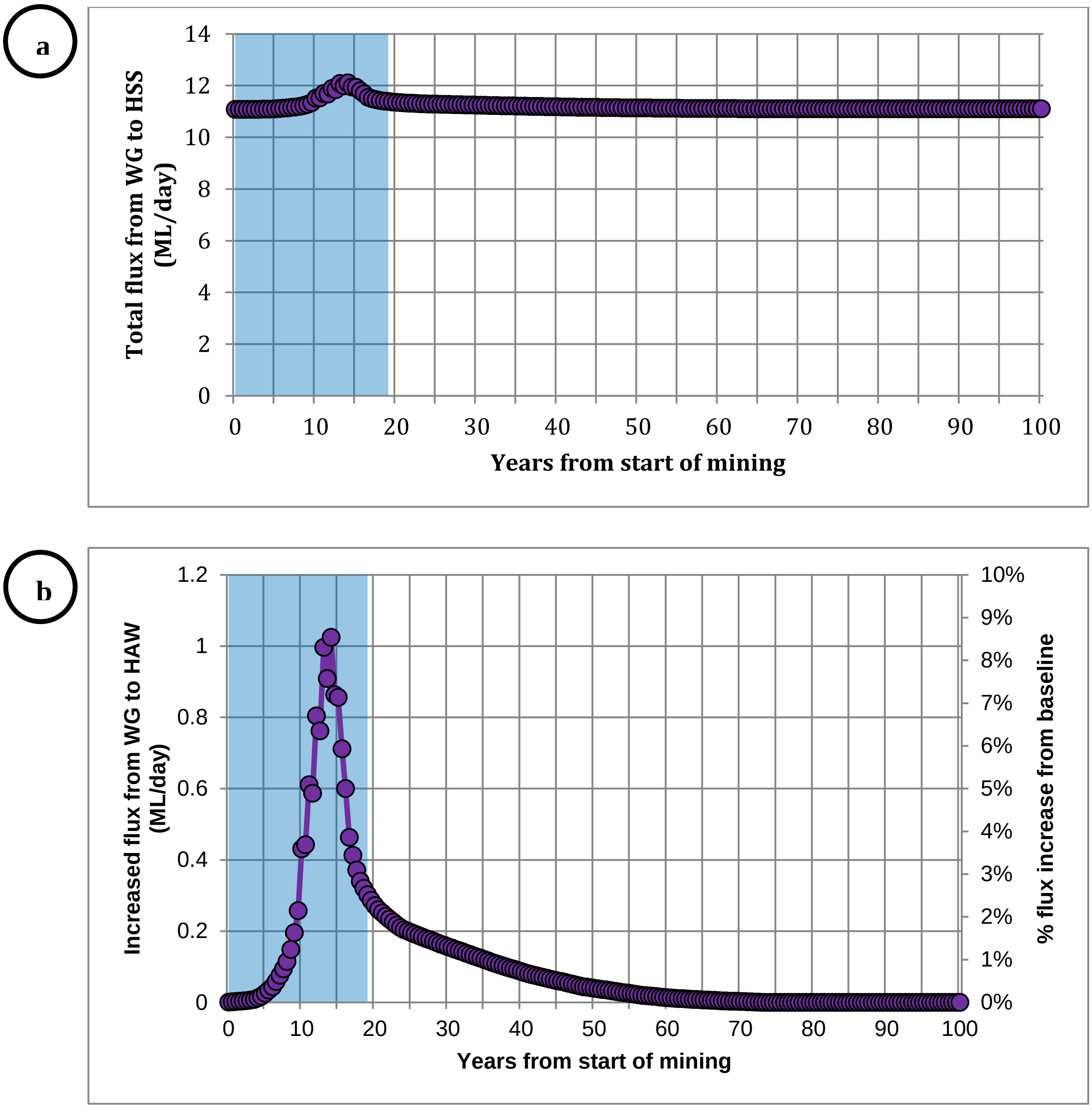

Figure 6.2. Predicted (a) total flux and (b) incremental increase in groundwater flux from WG shale to upper HAW attributable to Hume Coal mining activities (active mining period in blue).

In order to address the Independent Expert Scientific Committee (IESC) guidelines with regard to changes in the salt balance attributable to project activities, the groundwater flux model results were also used to estimate the salt load transferred from the WG shale formations to the underlying shallow HAW:

- Under baseline conditions, the groundwater flux from the WG shales to the HAW was 11.1 ML/day, with an average TDS of 1,700 mg/L. Hence the baseline salt transfer under pre-mining conditions equates to 18,870 kg/day, or 6,887,550 kg/year;

- Under mining influenced conditions, the increase in salt flux is proportional to the increase in groundwater flux, peaking at 7,497,790 kg/yr at the Year 14.5 time step (or 9% above baseline conditions). Over the full 74-year period during which the model results indicated an incremental increase in groundwater flux from mining influences (including the post-mining recovery period), the net increase in salt flux from the WG shale to the HAW is 1.3% above baseline conditions.

The groundwater quality implications of the increased vertical groundwater flux from the WG shales to the HAW attributable to mining activities is discussed in **Section 6.1.3** below.

6.1.3 Potential Impacts

The temporary increase in groundwater flux from the WG shale to the upper HAW would result in an increased solute load in the upper water bearing formations within the affected portion of the HAW.

The potential influence of the temporary increase in WG groundwater flux should be considered in the context of the baseline conditions. There is currently an 11.1 ML/day flux of groundwater between these two formations due to existing downward vertical hydraulic gradients. The downward gradients are attributable to the effects of mounding in recharge areas (e.g. elevated hydraulic head values due to surface water infiltration) and depressurisation from discharge as baseflow or from escarpment faces, as well as the ongoing depressurisation/ dewatering effects of the Berrima and Loch Catherine mine voids to the north.

Water quality from the multi-level monitoring wells installed in areas of shale surface geology was reviewed to assess whether the current baseline condition had resulted in an increased salinity signal in the underlying HAW. In all cases, the water quality in HAW wells installed beneath areas of shale outcrop were characterised by low TDS conditions suitable for most beneficial uses. Wells installed in areas of sandstone outcrop generally exhibited slightly lower TDS values, but all were within the range of very low to low EC with respect to the ANZECC (2000) irrigation criteria, and consistent with "good quality" drinking water according to the TDS criteria in the ADWG (2011). In addition, TDS concentrations were generally either stable or increasing with depth at each monitoring location, whereas the opposite distribution would be expected if the downward flux of shale groundwater were imparting a significant water quality effect on the underlying HAW.

A mixing model was used to assess solute concentrations that would result from mixing different proportions of WG and HAW groundwater, considering average groundwater quality from the two formations. With respect to the potential to diminish the beneficial uses of the HAW groundwater resource, EC and TDS were the most sensitive parameters, as the other analytes were generally substantially below the relevant beneficial use criteria even when a high proportion of shale groundwater was considered in a mixing scenario. The mixing analysis indicated that a ratio consisting of >40% WG shale groundwater would be required to produce a mixed TDS value that exceeds 900 mg/L (the threshold at which groundwater is considered “poor quality” from a drinking water perspective). The same ratio would result in groundwater considered to be suitable for irrigation of “moderately tolerant crops”, from an EC perspective.

Given that the predicted increase in groundwater flux between the WG shale and underlying HAW is a maximum of 9% with a short duration peak, and the current baseline flux has not significantly affected the underlying HAW water quality, it is considered unlikely that a material change to HAW groundwater quality with the potential to reduce the beneficial uses of the groundwater resource would occur as a result of the additional mining induced flux.

6.1.4 Mitigation Measures

The principal mitigation measure with respect to the temporary increase in groundwater flux from the WG shale to the upper HAW is the non-caving underground mining approach, which will minimise the deformation to the mine overburden, and also minimise the stress period over which the maximum depressurisation effects occur. The area of maximum drawdown from mining activities was also predicted to be limited to a relatively tight radius around the underground mining footprint (Coffey, 2016b), such that a relatively small portion of the study area is likely to be subject to a temporary increase in groundwater flux from the WG shale. No additional mitigation measure is considered to be warranted in light of the relatively low risk to the groundwater resource.

6.2 Water Quality Effects of Reject Slurry Emplacement in Underground Mine Voids

6.2.1 Process Description for the Management and Disposal of CPP Reject Material

The process of preparing the ROM coal for market involves a series of crushing, screening and “washing” processes in the CPP to separate the coal from the waste rock (reject) material. The coal preparation process generally consists of initial crushing of the ROM coal to limit the maximum size of the coal, followed by physical screening of the crushed ROM coal material into different particle size fractions, followed by a predominantly density-driven separation processes (washing) to separate the less dense coal from the denser waste rock in each grade. The reject material resulting from the washing process will include particle size fractions ranging from silt/clay ultrafines to coarse aggregate (8-16 mm topsize). The different reject grades will be mixed, amended with limestone ultrafines as a precautionary measure to buffer potential acid produced by prolonged exposure of sulphide minerals to oxygen, and pumped into completed underground mine panels for disposal.

Following emplacement of the waste in the underground panels, the panels will be sealed by bulkheads, dewatering of the sealed panel will be terminated, and the backfilled panels will naturally recharge with native groundwater. Until the backfilled panels are sealed, there will be an inward hydraulic gradient into the panels as a result of dewatering of the underground workings. Once the panels are sealed, hydraulic pressures will recover and natural groundwater flow conditions are expected to be re-established within the coal seam.

Once the backfilled and sealed panels have re-saturated with natural groundwater, it is expected that the groundwater will interact with the emplaced reject material, and any potentially dissolved species leached from the reject material will be transported with the natural flow of groundwater into the down hydraulic gradient portions of the coal seam. Accordingly, the anticipated change to groundwater quality arising from this process has been assessed through consideration of the geochemical testing results (specifically, KLC testing) reported by RGS (2016) using representative samples of reject material and groundwater for leaching.

For avoidance of doubt, with regard to the DRE environmental assessment requirement referencing overburden and interburden, the Hume Coal project is an underground mining operation that will not generate waste overburden/interburden. The only mining waste product will be the reject material, which is addressed in this assessment.

6.2.2 Assessment Methodology and Assumptions

The results of KLC testing were used as a conservative indication of the groundwater quality that would arise from interaction with the reject material emplaced in the underground voids. Data were selected from the leach columns that were considered to provide the closest representation to the expected conditions in the subsurface. Namely, columns were selected that used fine reject material (for conservatism), leached with groundwater obtained from the WWS, in fully saturated columns (i.e. as opposed to intermittently wet and dry columns, which was not considered to be a realistic occurrence in the subsurface). Data from two columns with these specifications were assessed: one column that was amended with limestone (KLC 24; as proposed for the reject material prior to emplacement), and one column without limestone amendment (KLC 22). The use of limestone is intended to increase the acid buffering capacity of the reject material, to prevent excessive generation of acidity and mobilisation of metals in groundwater if sulphide minerals in the rejects are subject to oxidation.

A detailed methodology for the KLC tests is provided in RGS (2016). As a general overview, the columns were prepared with representative samples of reject material generated from drill core recovered from the study area. The columns were then continuously saturated with groundwater sampled from the coal seam, and leachate samples were collected at the commencement of the test and then on a monthly basis for a period of six months. Samples were submitted to ALS Environmental, a NATA accredited analytical laboratory, for analysis of pH, EC, major ions, speciated alkalinity, acidity and metals.

The results of the KLC tests were compared to groundwater quality in the WWS and the HAW from the baseline monitoring program, to assess whether the leachate from the KLC tests had the potential to degrade the natural groundwater quality and potentially reduce its beneficial uses. An important assumption is that under post-mining conditions, once hydraulic pressures are re-established, the groundwater that comes in contact with the emplaced mine rejects in the underground voids is likely to be groundwater flowing laterally through the WWS, and that will continue to flow through the WWS following contact with the reject materials. Hence, the receiving environment is considered to be the groundwater resources within the WWS, down hydraulic gradient from the emplaced reject materials. However, for conservatism, the KLC results were also compared to baseline HAW water quality as this is the primary groundwater resource accessed in the study area.

6.2.3 Assessment Results

The results of the assessment are summarised in Table 6.1. This table includes the water quality criteria for the foreseeable beneficial uses of groundwater in the study area, the results of the KLC tests for the limestone-amended and the unamended columns, and the average groundwater qualities for the HAW and WWS, calculated from the baseline monitoring data.

The periodic sampling of the KLCs generally indicated a slight “first flush” effect of more elevated solute concentrations in leachate, which stabilised after one or two sampling events. It is reasonable to assume that this phenomenon could occur in the subsurface following emplacement of the reject material. Accordingly, the average and final water qualities for the two KLC tests are included in Table 6.1 for comparison.

The results in Table 6.1 have been highlighted based on the highest concentration assessment criterion exceeded. The key observations are as follows:

- The baseline WWS and HAW groundwater quality exceeds assessment criteria for a number of metals. Most of the exceedances are of ANZECC (2000) criteria, which apply where groundwater discharges to an aquatic ecosystem. This occurs naturally in incised water courses and at the edge of the escarpment, where groundwater either seeps from the escarpment face or discharges as baseflow to the local water courses. The baseline groundwater quality also exceeds certain irrigation and drinking water criteria, although the exceedances are marginal and in some cases very rarely detected above the laboratory limit of reporting (LOR) (e.g. selenium);
- The average water quality results are generally higher than the final equilibrated water quality results for the two columns. This stands to reason as the average values take the first flush into consideration;

- In both cases, the EC values from the KLC tests are very close to the EC values of natural groundwater. The results suggest that leachate from both column scenarios would have a negligible influence on natural groundwater quality.
- The results for KLC 22, the unamended column, indicate that acid is generated through flushing of the unamended reject material by natural groundwater. The final pH value is 3.9, which is lower than even the slightly acidic pH values of the natural WWS and HAW groundwater. The reduced pH has evidently also resulted in mobilisation of certain metals in the leachate. Table 6.1 indicates exceedances of primarily ANZECC (2000) criteria for half of the metals analysed, including an exceedance of the drinking water guideline for nickel.
- The results for KLC 24, with limestone amendment, indicate that the buffering capacity of the limestone was sufficient to manage the acid generated though water-reject contact. The pH values remained close to neutral throughout the test, and the column leachate analytical results are actually substantially more favourable than the natural groundwater quality, with respect to water quality criteria exceedances. In fact, the final sample from KLC 24 only exceeded the selenium criterion because the LOR was higher than the criterion. All other analytes are below the various assessment criteria.

The results of the limestone-amended KLC test indicate that the expected leachate quality arising from groundwater interaction with the reject material presents a negligible risk to groundwater quality. In fact, even the unamended leachate results only differ marginally from the natural groundwater quality in terms of the particular metals exceeding the respective criteria (however certain metals such as manganese, nickel and zinc are approximately an order of magnitude higher than the average values in baseline groundwater).

6.2.4 Mitigation Measures

The KLC tests have clearly demonstrated the value of amending the reject material with limestone prior to emplacement in the subsurface, to provide the alkalinity required for acid buffering and to prevent increased metals solubility. It is recommended that this proposed approach be adopted during mining activities as a conservative safeguard for the quality of the local groundwater resource.

Table 6.1: Underground reject storage - comparison of KLC 22 and 24 results with HAW and WWS groundwater quality

	ANZECC (2000)				KLC 22		KLC 24		WWS	HAW
Analytes	Aquatic	Irrigation	Livestock	ADWG (2011)	Avg	Final	Avg	Final	Avg	Avg
EC	-	-	-	-	475	473	575	462	469	478
pH	-	-	-	-	4.3	3.9	7.4	7.6	5.5	5.3
Calcium	-	-	1000	-	16	15	66	48	24	22
Magnesium	-	-	-	-	13	14	10	7	15	23
Sodium	-	460	-	-	32	41	29	34	46	48
Potassium	-	-	-	-	2	2	2	2	4	5.3
Bicarbonate	-	-	-	-	9	<1	108	108	109	73
Chloride	-	700	-	-	84	73	78	66	78	105
Sulfate	-	-	1000	500	91	98	67	33	17	15
Aluminium	0.055	20	5	ID	0.178	0.140	<0.01	<0.01	0.103	0.053
Antimony	-	-	-	0.003	<0.001	<0.001	<0.001	<0.001	0.0025	0.002
Arsenic	0.013	2	0.5	0.01	<0.001	<0.001	0.005	0.006	0.012	0.008
Boron	0.37	5	5	4	<0.05	<0.05	<0.05	<0.05	0.33	--
Cadmium	0.0002	0.05	0.01	0.002	0.0021	0.0013	<0.0001	<0.0001	0.0037	0.0003
Chromium	0.001	1	1	0.05	<0.001	<0.001	<0.001	<0.001	0.002	0.003
Cobalt	-	0.1	1	-	0.149	0.118	0.024	0.002	0.010	0.015
Lead	0.0034	5	0.1	0.01	0.003	0.002	<0.001	<0.001	0.016	0.002
Copper	0.0014	5	1	2	0.019	0.003	<0.001	<0.001	0.008	0.015
Manganese	1.9	10	-	0.5	2.9	4.2	0.362	0.136	0.690	0.463
Molybdenum	-	0.05	0.15	0.05	<0.001	<0.001	0.017	0.022	0.014	0.004
Nickel	0.011	2	1	0.02	0.370	0.257	0.072	0.003	0.017	0.023
Selenium	0.005	0.05	0.02	0.01	<0.01	<0.01	<0.01	<0.01	0.06	0.14
Zinc	0.008	5	20	ID	0.993	0.620	0.093	<0.005	0.080	0.056
Fluoride	-	2	2	1.5	0.2	<0.1	0.4	0.4	0.16	0.1
Iron	-	10	-	-	9.99	4.55	<0.05	<0.05	7.67	8.8

6.3 Water Quality Management for Surface Storage of CPP Reject Material

6.3.1 Description of Temporary Surface Storage of CPP Reject Material

During the initial 12-18 months as the project is developed, the coal reject will be stored in a temporary coal reject stockpile adjacent to the CPP until sufficient void space is available underground, and the plant is commissioned to commence underground emplacement. During this initial period, the fines will be dewatered via belt press filters (avoiding the need for a tailings dam) prior to being combined with the course reject. This combined reject will be placed for co-disposal on the temporary coal reject stockpile, which will be progressively constructed, contoured and when full, top dressed and revegetated. At the end of the operational phase of the project the reject on the temporary coal reject stockpile will be put back through the reject plant and pumped underground prior to sealing the surface entries to the underground mine.

In addition, if the slurry operation is interrupted, for example during maintenance, reject will be temporarily diverted to an emergency surface stockpile for later reprocessing. This will allow coal washing to continue throughout any interruption. The belt press filters will be used for dewatering during these periods.

Stormwater controls will be implemented for the surface operations of the mine, including the coal reject stockpile location, to prevent the stockpile management area from receiving stormwater runoff from the surrounding areas. However the stockpile(s) will still be exposed to rainfall, a portion of which will have the potential to infiltrate into the stockpile, contribute to the oxidation of sulphide minerals present in the reject, and potentially mobilise acid and solutes generated from the water-reject interaction.

6.3.2 Assessment Methodology and Assumptions

As with the assessment of underground emplacement of coal reject material discussed in Section 6.2, the results of KLC testing were used as a conservative indication of the water quality that would result from the interaction of rainfall with the stockpiled reject material. Data were selected from the leach columns that were considered to provide the closest representation of intermittent rainfall on a reject stockpile. Namely, columns were selected that used fine reject material (for conservatism), leached with deionised water as a proxy for rain water, in intermittently wet and dry columns that approximate the conditions of periodic rainfall on the reject stockpile with drying cycles between storms. Data from three columns with these specifications were assessed:

- One column containing only the composite reject material (KLC 10);
- One column that was amended with 1% limestone (KLC 16); and
- One column that was amended with 2% limestone (KLC 18).

The use of limestone is intended to increase the acid buffering capacity of the reject material, to prevent excessive generation of acidity and mobilisation of metals in infiltrating rain water if sulphide minerals in the reject are subject to oxidation.

A detailed methodology for the KLC tests is provided in RGS (2016). As a general overview, the columns were prepared with representative samples of reject material generated from drill core recovered from the study area. The columns were then flushed on a monthly basis, for a period of six months, with approximately 1 L of deionised water. The water that passed through the columns was sampled and submitted to ALS Environmental, a NATA accredited analytical laboratory, for analysis of pH, EC, major ions, speciated alkalinity, acidity and metals. Between monthly flushing cycles, heat lamps were used to dry the columns to minimise moisture retention and promote maximum exposure to atmospheric oxygen (conservatively enhancing the potential for sulphide mineral oxidation between flushing cycles).

The results of the KLC tests were assessed relative to the appropriate water quality criteria for drinking water, primary industries and aquatic ecosystems. The results were also compared to groundwater quality in the HAW from the baseline monitoring program, to assess whether the leachate from the KLC tests had the potential to degrade the natural groundwater quality and potentially reduce its beneficial uses if water from the reject stockpile drained into the underlying formation.

It is important to note that the assumption of monthly rainfall infiltration into the reject stockpile, particularly once it is top dressed and re-vegetated, is inherently conservative for the following reasons:

- Review of average rainfall and evaporation patterns in the study area presented in Coffey (2016a) indicated that a soil moisture deficit is likely to occur for eight months of an average year (from September to April), when pan evaporation exceeds the average monthly rainfall;
- The re-vegetation of the stockpile will also introduce transpiration as an added impediment to deep drainage of rainfall into the reject stockpile; and
- The stockpile will be contoured to promote efficient surface runoff of rainfall falling on the stockpile, further reducing the potential for rainfall infiltration into the reject stockpile.

6.3.3 Assessment Results

The results of the assessment are summarised in **Table 6.2**. This table includes the water quality criteria for the foreseeable beneficial uses of groundwater in the study area, the results of the KLC tests for the limestone-amended and the unamended columns, and the average groundwater quality for the HAW, calculated from the baseline monitoring data.

The periodic sampling of the KLCs generally indicated a slight "first flush" effect of more elevated solute concentrations in leachate, which stabilised after the first sampling event. Accordingly, the average and final water qualities for the KLC tests are included in **Table 6.2** for comparison.

The results in **Table 6.2** have been highlighted based on the highest concentration assessment criterion exceeded. The key observations are as follows:

- The baseline HAW groundwater quality exceeds assessment criteria for a number of metals. Most of the exceedances are of ANZECC (2000) criteria, which apply where groundwater discharges to an aquatic ecosystem. This occurs naturally in incised water courses and at the edge of the escarpment, where groundwater either seeps from the escarpment face or discharges as baseflow to the local water courses. The baseline groundwater quality also exceeds certain irrigation and drinking water criteria, although the exceedances are marginal and in some cases very rarely detected above the LOR (e.g. selenium);
- The average water quality results are generally higher than the final equilibrated water quality results for the three columns. This stands to reason as the average values take the first flush into consideration. It is noted that non-detect results were not factored into the "average" concentration calculations, and a number of analytes were only detected in one or two sampling events over the course of the six month trial;
- In all cases, the final EC values from the KLC tests were below the average baseline EC values of HAW groundwater. The higher average EC values for the limestone amended columns reflected the influence of enhanced limestone dissolution during the initial flushing events, which subsequently stabilised at EC values similar to HAW groundwater. The results suggest that leachate from the three column scenarios would have a negligible influence on natural groundwater quality.
- The results for KLC 10, the unamended column, indicated that acid is generated through exposure to atmospheric oxygen and flushing with oxidised water. The final pH value of 4.7, was slightly lower than even the slightly acidic pH value of the natural HAW groundwater (pH avg = 5.3). The lower pH evidently also resulted in mobilisation of certain metals in the leachate. **Table 6.2** indicates that approximately half of the metals analysed exceeded one or more of the beneficial use assessment criteria.
- The results for KLC 16 and 18, with 1% and 2% limestone amendment respectively, indicated that the buffering capacity of the limestone was sufficient to manage the acid generated though water-reject contact. The pH values remained close to neutral throughout the test, and the column leachate analytical results were similar to or more favourable than the natural

groundwater quality, with respect to water quality criteria exceedances. The final sample from KLC 16 presented an equivalent beneficial use status to the HAW groundwater. The final sample from KLC 18 only exceeded the selenium criterion because the LOR was higher than the criterion; all other analytes are below the various assessment criteria.

The results of the limestone-amended KLC tests indicated that the expected water quality resulting from rainfall infiltration into the reject stockpile presents a negligible risk to the baseline beneficial uses of HAW groundwater resource.

6.3.4 Mitigation Measures

The KLC tests have clearly demonstrated the value of amending the reject material with limestone prior to emplacement in a stockpile, to provide the alkalinity required for acid buffering and to prevent increased metals solubility. Given the increased potential for oxidation of sulphide minerals in a surface stockpile (relative to the fully saturated conditions for underground emplacement), the KLC with 2% limestone amendment outperformed the KLC with 1% limestone amendment in terms of final water quality; however the final water quality from the 1% limestone amendment resulted in the same beneficial use status as the baseline quality of the HAW groundwater. Accordingly, although there are multiple management measures proposed to reduce the potential for water infiltration into the reject stockpile, it is recommended that limestone amendment be adopted as a contingency measure to reduce the potential for drainage from the reject stockpile posing an unacceptable risk to the surrounding surface and groundwater resources.

Table 6.2: Surface reject storage - comparison of KLC 10, 16 and 18 results with HAW groundwater quality

Analytes	ANZECC (2000)			ADWG (2011)	KLC 10		KLC 16		KLC 18		HAW
	Aquatic	Irrigation	Livestock		Average	Final	Average	Final	Average	Final	Avg
EC					239	120	873	325	844	300	478
pH	-	-	-	-	4.6	4.7	7.3	7.8	7.5	7.9	5.3
Calcium	-	-	1000	-	14	6	132	46	120	25	22
Magnesium	-	-	-	-	12	6	18	3	17	2	23
Sodium	-	460	-	-	8	<1	11	2	10	1	48
Potassium	-	-	-	-	7	<1	3	2	3	<1	5.3
Bicarbonate	-	-	-	-	4	4	63	45	84	62	73
Chloride	-	700	-	-	56	24	146	21	143	19	105
Sulfate	-	-	1000	500	44	22	274	82	252	71	15
Aluminium	0.055	20	5	ID	0.369	0.059	0.161	0.161	<0.01	<0.01	0.053
Antimony	ID	-	-	0.003	<0.001	<0.001	0.001	0.001	0.001	<0.001	0.002
Arsenic	0.013	2	0.5	0.01	0.017	<0.001	0.006	0.004	0.006	0.002	0.008
Boron	0.37	5	5	4	0.058	<0.05	<0.05	<0.05	<0.05	<0.05	--
Cadmium	0.0002	0.05	0.01	0.002	0.0062	0.0032	0.0010	0.0004	0.0012	<0.0001	0.0003
Chromium	0.001	1	1	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003
Cobalt	ID	0.1	1	-	0.197	0.090	0.069	0.002	0.104	<0.001	0.015
Copper	0.0014	5	1	2	0.069	0.029	0.020	0.056	0.001	0.001	0.015
Lead	0.0034	5	0.1	0.01	0.009	0.003	<0.001	<0.001	<0.001	<0.001	0.002
Manganese	1.9	10	-	0.5	1.7	1.3	0.55	0.03	0.59	0.01	0.46
Molybdenum	ID	0.05	0.15	0.05	<0.001	<0.001	0.036	0.051	0.043	0.034	0.004
Nickel	0.011	2	1	0.02	0.559	0.266	0.117	0.003	0.157	<0.001	0.023
Selenium	0.005	0.05	0.02	0.01	0.02	<0.01	0.03	<0.01	0.045	<0.01	0.14
Zinc	0.008	5	20	ID	1.63	0.939	0.152	0.006	0.132	<0.001	0.056
Fluoride	-	2	2	1.5	0.4	<0.1	0.7	0.8	0.7	0.8	0.1
Iron	ID	10	ID	ID	1.31	0.21	0.06	0.06	<0.05	<0.05	8.8

6.4 PWD Water Quality Assessment for Subsurface Disposal

6.4.1 Assessment Methodology and Assumptions

The water balance for the site indicates that the average annual input to the PWD will comprise approximately 70% extracted groundwater, 20% rainfall, and 10% process water from the CPP and dust suppression returns. The preferred disposal method for this water is injection into the underground workings (in sealed panels). Accordingly, Geosyntec was asked to consider a likely PWD water quality resulting from the mixture of the different end member water types, and the implications for injection into sealed panels.

The PWC water quality was estimated through simple mixing of end member waters based on the ratios indicated in the water balance. The quality of the end member water types was estimated as follows:

- Groundwater quality was estimated using geochemical modelling to simulate the effects of open-system equilibration with the atmosphere (described in further detail below);
- The CPP process water quality was estimated by averaging the "first flush" water quality results from two KLC tests (10, 20 and 22) that consisted of mine reject composite material without limestone amendment. This was considered to be a conservative approximation, as the small volume of water flushed through the columns during the KLC test resulted in a concentrated leachate, whereas the CPP processes should result in a more dilute solute load due to the greater water to rock ratio; and
- Rainfall quality was estimated from a CSIRO publication that included analytical results for 38 rainwater samples collected in Sydney between 2007 and 2011 (CSIRO, 2012).

The resulting PWD water quality resulting from the mixture of these water types was compared to average WWS water quality, to assess whether injection of the water into sealed underground panels would present a risk to the beneficial uses of the WWS groundwater resource.

6.4.1.1 Groundwater Quality Evolution in Contact with Atmosphere

The evolution of groundwater quality stored in a dam was assessed through geochemical modelling using PHREEQC (v. 3.3.8), based on typical groundwater quality from the WWS (baseline data from H18A was adopted for the modelling). The following assumptions were made with respect to the geochemical modelling approach:

- extracted groundwater would be stored in a dam allowing for "open system" interaction with the atmosphere;
- The groundwater would be stored long enough for gas exchange with the atmosphere to reach equilibrium;

- Precipitation of solids as a result of water chemistry changes in the pond would occur rapidly and would settle out as a sludge on the base on the pond (i.e. ongoing reaction with the pond water chemistry would be negligible);
- Mixing with other water types while in storage was not considered (e.g. rainfall or stormwater). However, this assumption is considered to be conservative, as mixing with rainfall or stormwater runoff would be expected to have a dilution effect with respect to groundwater quality; and
- Evaporation and recharge of pond water assumed to maintain constant volume (i.e. no evaporative concentration or dilution influences on the pond water quality).

Interaction between pond water and the atmosphere was simulated in two steps:

- Step 1: CO_2(g) exchange with atmosphere.
- Step 2: O_2(g) exchange with atmosphere.

After each step, minerals that were above saturation were allowed to precipitate (these become the sludge layer in the conceptual model). The simulations were performed in small, quasi-equilibrium increments: '–' signifies desorption of CO_2 and '+' signifies absorption of O_2.

6.4.2 Assessment Results

Selected outputs from the pond water equilibration modelling are presented in **Figures 6.3 to 6.6**. **Table 6.3** presents a summary of the end member water qualities reporting to the PWD, the resulting "mixed" water quality according to the average ratios in the site water balance, and the average WWS groundwater quality to represent the "receiving environment".

As the groundwater equilibrates with the atmospheric concentrations of CO_2 (400 ppmv) and O_2 (20% vol), **Figure 6.3** demonstrates how excess CO_2 from groundwater is vented to the atmosphere (Step 1), followed by diffusion of atmospheric oxygen into the pond water (Step 2).

The loss of CO_2 in Step 1 results in an increase in pH of the pond water and a decrease in the Eh, however the Eh spikes again in response to the O_2 influx during Step 2 (**Figure 6.4**). In response to the change in pH and Eh, siderite ($FeCO_3$) precipitates from solution, followed by ferrihydrite (FeOOH) precipitation in response to the oxygen influx oxidised Fe^{2+} to Fe^{3+}. During the final stages of pond water equilibration with the atmosphere, calcite ($CaCO_3$) may precipitate (**Figure 6.5**). The mineral precipitation causes the pond water to become depleted in dissolved calcium, iron and manganese (**Figure 6.6**). Many of the trace metals in the pond water will be similarly affected by the mineral precipitation reactions.

The major water quality changes resulting from equilibration of pond water with the atmosphere are an increased pH and Eh, and depletion of dissolved iron (due to iron mineral precipitation). It is similarly expected that a minor decrease in TDS would occur due to mineral precipitation; however with the exception of groundwater associated with the WG shale formations, groundwater TDS in the study area is relatively low to begin with. The geochemical modelling has assumed equilibrium reactions occurring within a relatively short timeframe, however the reaction kinetics may be such that only a quasi-equilibrium would be achieved for certain reactions. In particular, the extent to which iron mineral phases will precipitate and drop out of suspension is unclear – it is possible that precipitating iron minerals could form colloids that could remain in suspension in the water column, despite not being in a dissolved phase.

The proportional mixing of end member waters resulted in an estimated average PWD water quality, as presented in **Table 6.3**. The mixed PWD water quality exceeds several beneficial use criteria for dissolved metals; however, a comparison to the average WWS baseline groundwater quality indicates similar exceedances of dissolved metals criteria, and a similar overall beneficial use profile.

Two metals (nickel and copper) marginally exceeded the average WWS groundwater quality concentrations; however, these estimated concentrations are conservative for the following reasons:

- the quality of the CPP process water that would report to the PWD (which was the driver for the elevated nickel and copper concentrations) was simulated by adopting “first flush” results from concentrated KLC leachate testing. The larger water-to-solids ratio in the CPP would be expected to produce a more dilute water quality than the KLC first flush results;
- some of the dissolved metals load would be expected to adsorb onto precipitating iron oxide colloids in the PWD, which was not accounted for in the geochemical modelling; and
- further dilution would occur when the PWD water mixes with natural groundwater in the sealed panel following injection.

In consideration of the bullet points above, there was considered to be a low risk of the injected PWD water impacting the beneficial use status of the WWS groundwater resource beyond the point of injection.

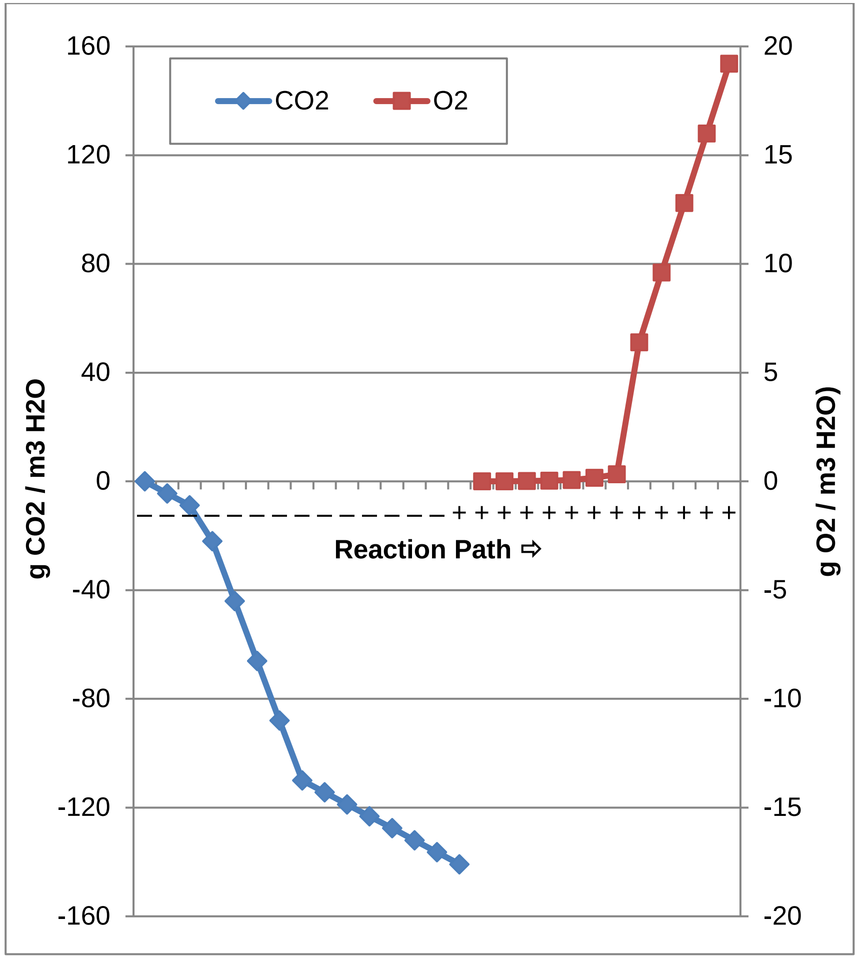

Figure 6.3. Pond water equilibration with atmospheric CO_2 and O_2.

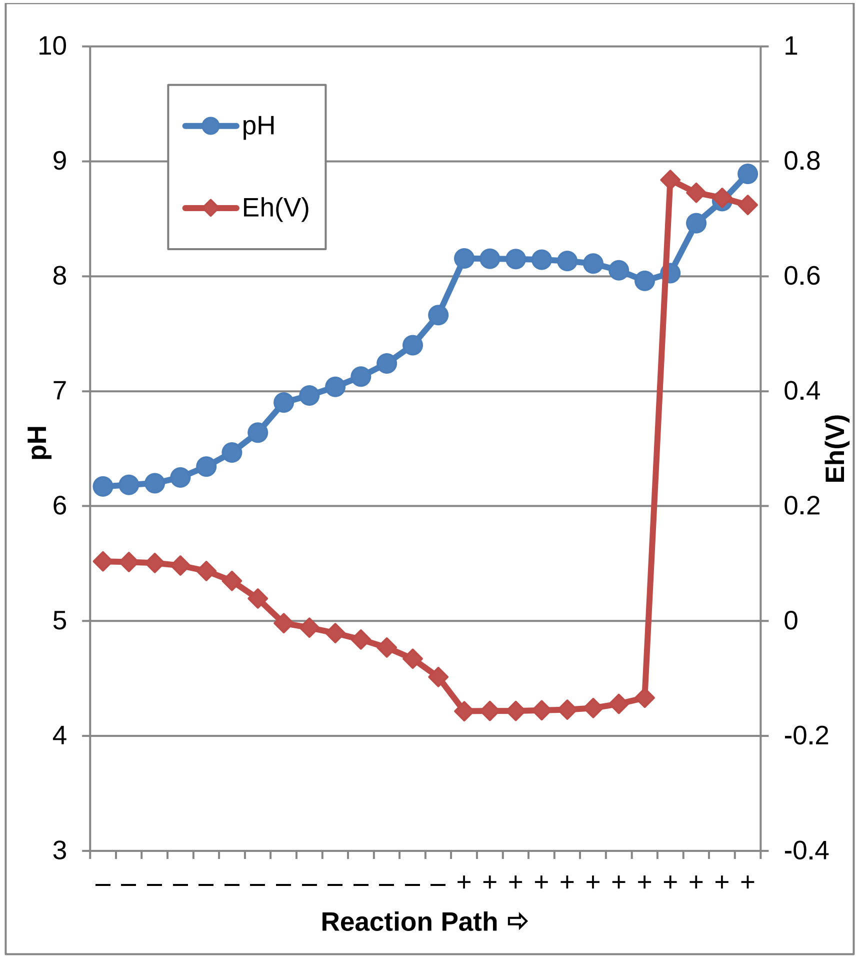

Figure 6.4. Pond water pH and Eh evolution during equilibration with atmospheric gases.

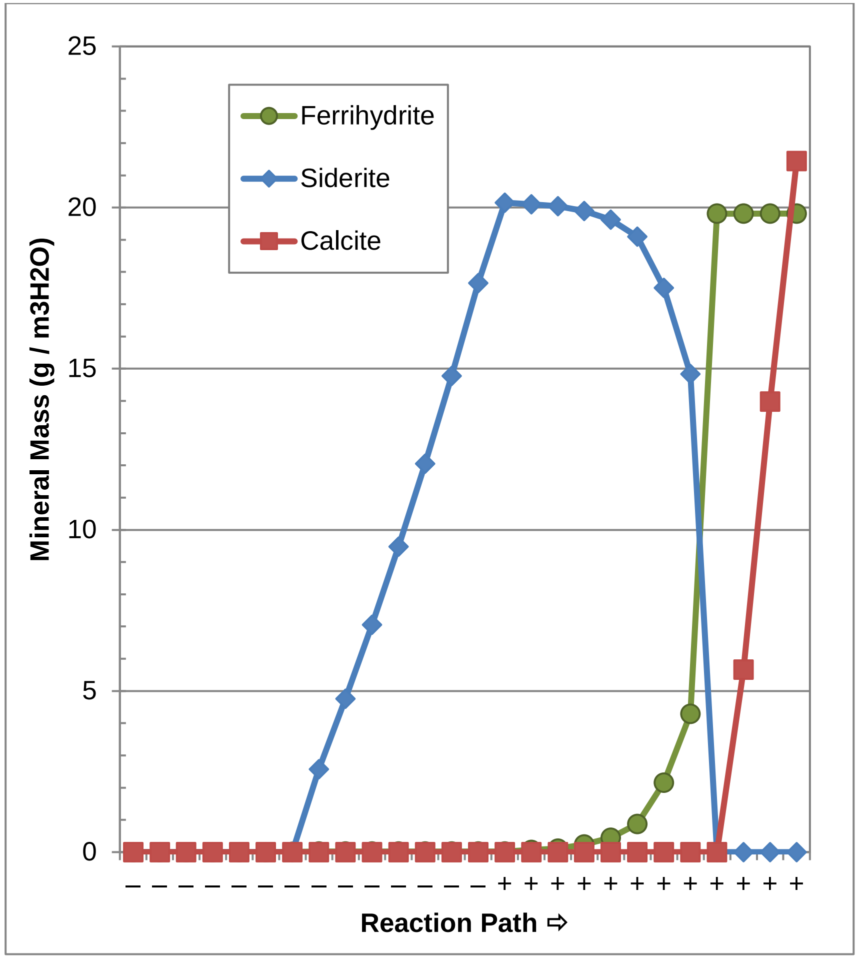

Figure 6.5. Major mineral phase precipitation during pond water equilibration with atmospheric gases.

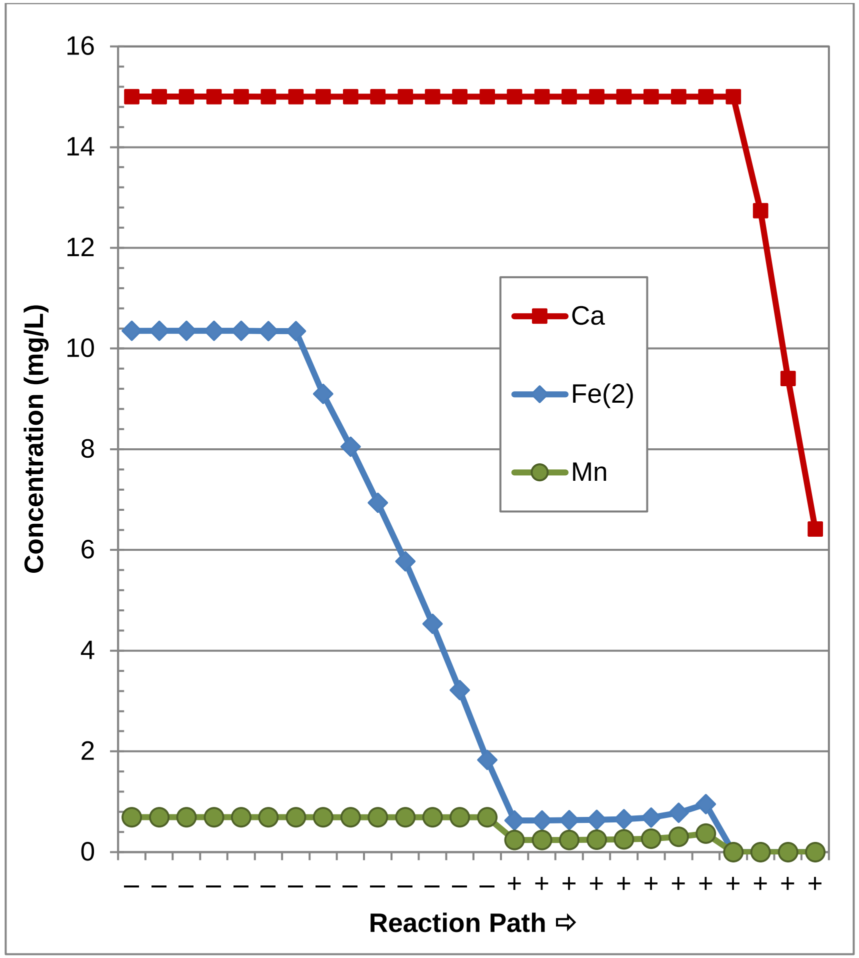

Figure 6.6. Depletion of Ca, Fe(2) and Mn in response to mineral precipitation in pond water.

Table 6.3: Estimated PWD water quality based on average annual inputs, and comparison to WWS water quality

Analytes	ANZECC (2000) Aquatic	ANZECC (2000) Irrigation	ANZECC (2000) Livestock	ADWG (2011)	CPP (10%)	GW (70%)	Rain (20%)	PWD mix	WWS (avg)
pH	6.5-8.0	-	-	-	5.1	8.0	5.3	5.8	5.5
EC	-	-	-	-	565	227	97	235	469
Calcium	-	-	1000	-	28	15	2	14	24
Magnesium	-	-	-	-	22	NR	2	3	15
Sodium	-	460	-	-	21	48	12	38	46
Potassium	-	-	-	-	5	2	0.5	2	4
Bicarbonate	-	-	-	-	15	79	0.1	57	109
Chloride	-	700	-	-	128	39	23	45	78
Sulfate	-	-	1000	500	83	18	6	22	17
Aluminium	0.055	20	5	ID	0.76	NR	NR	0.076	0.103
Antimony	ID	-	-	0.003	<0.001	NR	<0.05	NA	0.003
Arsenic	0.013	2	0.5	0.01	0.008	0.009	<0.05	0.007	0.012
Boron	0.37	5	5	4	<0.05	NR	<0.1	NA	0.33
Cadmium	0.0002	0.05	0.01	0.002	0.0185	<0.0001	<0.05	0.0019	0.0037
Chromium	0.001	1	1	0.05	<0.001	0.0001	<0.05	0.0001	0.002
Cobalt	ID	0.1	1	-	0.323	0.008	<0.05	0.038	0.010
Copper	0.0014	5	1	2	0.154	0.007	0.051	0.031	0.008
Lead	0.0034	5	0.1	0.01	0.017	<0.001	<0.05	0.002	0.016
Manganese	1.9	10	-	0.5	1.78	0.06	0.06	0.229	0.69
Molybdenum	ID	0.05	0.15	0.05	<0.001	0.009	<0.05	0.006	0.014
Nickel	0.011	2	1	0.02	0.89	0.012	0.083	0.114	0.017
Selenium	0.005	0.05	0.02	0.01	0.01	NR	<0.05	0.001	0.06
Zinc	0.008	5	20	ID	2.132	0.024	0.215	0.273	0.080
Fluoride	-	2	2	1.5	0.3	0.16	0.164	0.2	0.16
Iron	ID	10	-	ID	2.2	0.0001	<0.1	0.2	7.67

7. CONCLUSIONS

7.1 Summary of Baseline Groundwater Quality Monitoring

- The baseline monitoring program for the project was considered to include adequate spatial (lateral and vertical) resolution across the project area, and to have covered a sufficient timeframe with adequate monitoring frequency to provide an acceptable baseline assessment of spatial and temporal variability in groundwater quality;

- The baseline quality of the groundwater resources of the HAW and the ICM is broadly characterised by low TDS groundwater that is suitable to support most beneficial uses. Within each formation, several groundwater quality parameters and analytes exceeded or were outside the range of one or more beneficial use assessment criteria (for example, the pH of groundwater within the HAW is generally below the trigger value range for protection of freshwater species in upland rivers in South-east Australia). However, the baseline water quality criteria exceedances are generally limited in number and only marginally exceed the relevant criteria, and are not considered to limit the beneficial uses of the resource (although may warrant localised treatment requirements for potable use). Within the study area, these two formations are accessed by approximately 90% of the registered water supply bores (for which screened interval data are available);

- The baseline groundwater quality of the WG shales is saline, and considered to be unsuitable for potable use and for irrigation of many crops. The typical low yields associated with the WG shales also limits the beneficial uses of the groundwater resource; and

- The groundwater quality associated with the shallow basalt groundwater resources, despite slightly higher TDS values than the HAW and ICM, was generally considered to be suitable to support most beneficial uses. This is supported by a cluster of shallow water supply bores installed within the basalt body on the south-eastern boundary of A349 (Figure 9.1 of Coffey, 2016a).

7.2 Summary of Potential Impacts from Project Activities

The following conclusions are made with regard to the potential influence of Project activities on groundwater quality:

- Dewatering of underground mine voids during active mine operations will result in partial depressurisation of some of the overlying water bearing formations. Modelling results indicated that the downward vertical hydraulic gradients induced by depressurisation is expected to result in a temporary increase in the flux of groundwater from the WG shales (where present) to the upper portion of the HAW. Given the higher TDS of the shale groundwater, this phenomenon has the potential to temporarily raise the TDS of the upper HAW groundwater. The numerical flow model for the study area (Coffey, 2016b) was used to estimate the magnitude of increased flux attributable to Hume Coal mining activities, which indicated a peak increase of 1 ML/day (9% increase from baseline), with the maximum effect occurring within a short duration during mining. Likewise, a proportional maximum increase in salt flux (as groundwater TDS) of 9% was also predicted to occur. A net salt flux increase of 1.3% over baseline conditions was calculated for the 74-year period during which modelling predicted an incremental increase in groundwater leakage (including active mining operations and post-mining recovery). The current influence of baseline groundwater flux from the shales to the underlying sandstone was reviewed for multi-level monitoring wells installed through the shale, which generally indicated a minor TDS difference relative to wells installed in sandstone outcrop areas. A mixing model was used to assess the water quality resulting from relative mixing proportions of the shale and sandstone groundwater, which indicated that an unrealistically large proportion (> 40%) of shale groundwater would be required to reduce the beneficial use status of the underlying HAW groundwater resource.

- The results of KLC testing were used to assess the potential change to groundwater quality resulting from groundwater interaction with mining reject material emplaced in the underground mine voids. The results of column leaching tests were selected from columns considered to best represent the expected subsurface conditions: simulated mine reject material generated from cores recovered from the Project area, leached with groundwater obtained from the WWS, as would occur within the backfilled mine void. Data from two columns were considered; one with mine reject material amended with limestone as an additional alkalinity source, and the other unamended. The results were compared to baseline water quality for the Hawkesbury Sandstone and Wongawilli Seam to assess whether leaching from mine reject material would potentially result in degradation of the beneficial use status of the groundwater resources. The results of the unamended column leaching test indicated leachate water quality exceeded one or more of the beneficial use criteria that were generally also exceeded in the baseline groundwater quality, although the magnitude of the exceedance was substantially larger for certain metals in the leachate results. The final leachate pH of the unamended column was relatively low, indicating that acid generation was a potential concern. The leachate quality from the limestone amended reject material was very favourable, with approximately neutral pH values throughout the test, and with leachate analyte concentrations that were below most of the beneficial use criteria, including many that were exceeded in the baseline groundwater quality. Accordingly, the assessment indicated that limestone amendment of the mine reject material prior to emplacement in the mine void is likely to produce leachate that is indistinguishable from natural groundwater quality, and is considered unlikely to change the beneficial use status of the groundwater resources.

- During the initial 12-18 months as the project is developed, the coal reject generated from mining of the initial panels will be stored in a temporary coal reject stockpile adjacent to the CPP until sufficient void space is available underground, and the plant is commissioned to commence underground emplacement. In addition, if the slurry operation is interrupted, for example during maintenance, reject will be temporarily diverted to an emergency surface stockpile for later reprocessing. The fines managed on the surface in this manner will be dewatered via belt press filters (avoiding the need for a tailings dam) prior to being combined with the course reject. This combined reject will be placed on the temporary coal reject stockpile, which will be progressively constructed, contoured and when full, top dressed and revegetated. Once mining is completed, rejects stored at the surface will be removed, reprocessed and pumped underground to remaining voids. Surface emplacements will then be rehabilitated. The coal reject stockpile will be managed such that it does not receive run off from the surrounding mine site, however will still be exposed to rainfall that falls directly on the stockpile. To reduce the potential for acid generation and mobilisation of metals arising from oxidation of reject minerals in the stockpile, the reject will be amended with limestone prior to emplacement in the stockpile to buffer acid generation.

- The mine water management plan will include a portion of the water in the PWD being pumped into the sealed underground panels. The water balance for the site indicates that the average annual input to the PWD will comprise approximately 70% extracted groundwater, 20% rainfall, and 10% process water from the CPP and dust suppression returns. The water quality resulting from the proportional mixing of these end member waters was simulated using a mixing model, with data from KLC tests, geochemical modelling and published rainfall quality data used to represent the end member water types. The mixed PWD water quality exceeds several beneficial use criteria for dissolved metals; however, comparison to the average WWS baseline groundwater quality (the "receiving environment" for water injected into the sealed panels) indicates similar exceedances of dissolved metals criteria, and a similar overall beneficial use profile. Two metals (nickel and copper) marginally exceeded the average WWS groundwater quality concentrations. Considering the conservatism in estimating the quality of the CPP process water that would report to the dam (which was the driver for the elevated nickel and copper concentrations), the fact that some of the metals load would be expected to adsorb onto precipitating iron oxide colloids in the dam (which was not accounted for in the geochemical modelling) and the further dilution that would occur when the PWD water mixes with natural groundwater in the sealed panel following injection, there is considered to be a low risk of the injected PWD water causing a degradation of the beneficial use status of the WWS groundwater resource beyond the point of injection.

Regarding the requirements of the AI Policy in relation to groundwater quality, it is not anticipated that the project activities will result in a lowering of the beneficial use category of the groundwater source beyond 40 m from the activity, assuming the mitigation measures discussed in the following section are implemented. It follows from this conclusion that unacceptable cumulative impacts to groundwater quality are also not anticipated as a result of mining activities.

In addition, the (partial) groundwater dependency of GDEs identified in the study area is understood to be associated with shallow groundwater (i.e. <10 mbgl), whereas the subsurface project activities are associated with deeper strata. The project activities are not expected to produce a change to groundwater quality in the immediate footprint of the mining activities that could impact the biodiversity or biological function of a GDE at the point of groundwater discharge several kilometres away. Accordingly, GDEs in the study area are not considered to be at risk of harm from mining activities, from a groundwater quality perspective.

7.3 Summary of Mitigation Measures

Based on the evaluation of potential groundwater quality impacts resulting from Project activities, the Hume Coal project is considered to present a low risk to the groundwater resources of the mine lease and surrounding areas.

No specific mitigation measures are recommended regarding the temporary increase in groundwater flux from the WG shales to the HAW, as the magnitude and duration of the estimated additional flux are considered unlikely to result in a change to the beneficial use status of the underlying HAW groundwater resource.

Regarding emplacement of mine reject material in the underground mine voids, the results of KLC tests indicated the leachate quality benefit of amending the mine reject material with limestone prior to emplacement as a surplus alkalinity source. The resulting leachate quality retained a neutral pH throughout the test, and dissolved analyte concentrations in the leachate were generally lower than in the baseline water quality from the HAW and the WWS. Accordingly, it is recommended that the limestone amendment of reject material is adopted as a precautionary measure, to provide confidence in safeguarding the quality of the groundwater resources of the lower HAW and WWS following emplacement of the mine reject material.

Regarding the prevention of groundwater contamination to preclude the need for remediation (DPI Water environmental assessment condition), the KLC test results suggest that limestone amendment should suffice to buffer acid generation and prevent solubilisation and mobilisation of metals at concentrations that would impact the beneficial uses of the groundwater resource. The storage and use of hazardous materials at the site (e.g. fuels, maintenance chemicals, etc), represents another potential source of groundwater contamination. Accordingly, environmental management systems should be implemented for the active mine operation for the transport, storage, handling and disposal of hazardous substances to prevent release to the environment. The relevant measures are discussed in further detail in the Hazard and Risk Assessment Report (EMM, 2016c).

7.4 Recommended Monitoring Program

It is recommended that the baseline groundwater monitoring program should continue during the operation of the mine, and for sufficient time during the post-closure period to confirm the efficacy of the limestone amendment in mitigating acid and metals mobilisation from the emplaced reject material.

It is recommended that the full monitoring network continues to be used, acknowledging that some of the wells may be destroyed during the course of mining. As discussed in the Water Assessment Report (EMM, 2016b), expansion of the monitoring network should be considered upon commencement of construction to provide compliance monitoring coverage close to potential sources of groundwater impact (for example, the mine reject temporary stockpile location).

It is recommended that monitoring continues on a quarterly basis until there is sufficient data to verify that mining activities are not resulting in unacceptable changes to groundwater quality.

The current analytical suite is considered to be sufficient for the purposes of assessing groundwater quality changes attributable to mining activities. Based on the baseline water quality results, it is considered that a reduced analytical suite would be adequate to assess the primary water quality risk of acid, salinity and metals mobilisation on a quarterly basis, and that organic analytes, and certain inorganic analytes, could be included in a “full” analytical suite annually. A summary is presented below:

- Quarterly field measurement of water quality parameters during purging and sampling (temperature, pH, EC, DO, ORP);

- Quarterly laboratory analysis for:
    - Major cations and anions
    - Dissolved metals and metalloids
- Annual laboratory analysis for:
    - TRH
    - BTEX
    - PAHs
    - Phenolic compounds
    - OCPs and OPPs
    - N and P based nutrients, fluoride and cyanide

It is considered unlikely that the project activities would present an increased risk of microbiological contamination (e.g. coliforms), which are typically associated with leaks from shallow septic tank systems or sewerage drains. Accordingly, there is limited value in continuing with the microbiological analyses.

It is good industry practice to review the monitoring program framework and results in detail on an annual basis, to assess whether the program should continue in its current form or if there is justification to modify the program. Any proposal to modify the program should be supported by a thorough analysis of the monitoring results in the context of the risks to water quality. The annual review should consider justification for increasing, maintaining or reducing monitoring locations, frequency and analytical suite in response to water quality trends, and potentially in response to loss of monitoring infrastructure.

It is recommended that there be a separate procedure for responding to and assessing specific incidents of potential environmental concern (e.g. spills or unintentional releases of hazardous substances, loss of containment of poor quality water, etc), which then triggers additional consideration of the ongoing groundwater quality monitoring program if warranted by the nature of the release. Additional monitoring requirements in response to incidents should be assessed and implemented as soon as possible following the incident, rather than postponing until the next annual review.

Geosyntec consultants

8. REFERENCES

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9. LIMITATIONS

The opinions provided in this report were based on review and analysis of data and specialist studies performed by third parties, and provided to Geosyntec by Hume Coal. Geosyntec has relied on the factual information provided as being a true and accurate representation of the conditions encountered at the site, and cannot be held liable for errors or omissions in third party information supplied as part of this study.

The necessity to rely on third party information results in an inherent level of uncertainty that exists despite Geosyntec's compliance with appropriate professional standards of care. In addition, the documents supplied to Geosyntec for review as part of these services may contain limitations statements. Accordingly, the advice developed on the basis of those documents is, by extension, subject to those same limitations.

The statement of limitations is not intended to reduce the confidence in the work product or the professional standard of care with which it was prepared. Rather it provides realistic expectations for those using the results of this study regarding the potential sources of uncertainty inherent in its preparation.

APPENDIX A

Tables

Table A1: Baseline Groundwater Monitoring Results - Basalt

Location			Water Quality Criteria				HU0056XPZC					HU0136PZC											
Date			ANZECC (2000)			ADWG (2011)	19/12/2012	19/12/2013	25/09/2014	13/11/2014	5/02/2015	29/08/2014	1/12/2014	4/02/2015	23/09/2015								
Analyte	**Units**	**LOR**	**Aquatic**	**Irrigation**	**Livestock**											**n**	**Detects**	**Exc**	**Min**	**Max**	**Avg**	**Geomean**	**Std Dev**
General field parameters																							
pH	pH units		6.5-7.5				6.52	7.74	7.45	7.34	7.18	7.05	7.03	6.98	6.07	9	9	2	6.07	7.74	6.75	7.04	0.50
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			757	738	797	446	643	620	619	623	631	9	9	9	446	797	653	645	103
Conductivity (lab)	µS/cm	1	30-350												612	1	1	1	612	612	612	612	
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	491	480	518	261	418	403	402	405	410	9	9		261	518	421	414.13	74.55
Total Dissolved Solids (lab)	mg/L	10													374	1	1		374	374	374	374	
Dissolved oxygen	% sat		90-110				38.6	21.3	51.8	57.7	67.8	58.6	66.4	84.3	61.6	9	9		21.3	84.3	56.5	53	18
Redox	mV						-1.5	82.0	76.1	85	14.8	178.6	105.7	101.5	-116.8	9	9		-116.8	178.6	58.4		84
Temperature	ºC						18.52	18.46	18.62	17.1	16.67	15.65	17.17	16.07	16.08	9	9		15.7	18.6	17.1	17	1
Suspended Solids	mg/L	5													<5	1	0						
Turbididty	NTU	0.1	2-25													0	0						
Major Ions																							
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1		<1	<1	<1	<1	<1	<1	8	0						
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	8	<1		<1	<1	<1	<1	<1	<1	8	1						
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	281	245		350	311	253	256	254	236	8	8		236	350	273	271	39
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	289	245		350	311	253	256	254	236	8	8		236	350	274	272	39
Acidity as $CaCO_3$	mg/L	1	-	-	-	-										0	0						
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	83	45		10	7	8	8	7	8	8	8	0	7	83	22.0	13	28
Chloride	mg/L	1	-	700	-	ID	54	60		27	33	50	57	57	50	8	8	0	27	60	48.5	47	12
Calcium	mg/L	1	-	-	1000	-	61	44		52	39	33	31	30	34	8	8	0	30	61	40.5	39	11
Magnesium	mg/L	1	-	-	ID	-	38	25		48	40	56	47	51	57	8	8		25	57	45.3	44	11
Sodium	mg/L	1	-	460	-	-	68	69		41	44	25	20	23	24	8	8	0	20	69	39.3	35	20
Potassium	mg/L	1	-	-	-	-	4	3		2	2	2	2	2	2	8	8		2	4	2.38	2	1
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	24.2			35.8	37.2	52.2	44	43.8	42	7	7		24.2	52.2	39.9	39	9
Total Anions	meq/L	0.01	-	-	-	-	9.03	7.52		7.96	7.29	7.27	6.89	6.83	6.29								
Total Cations	meq/L	0.01	-	-	-	-	9.23	7.33		8.38	7.2	7.39	6.34	6.75	7.48								
Ionic Balance	%	0.01	-	-	-	-	1.12	1.32		2.53	0.62	0.84	4.2	0.62	8.63								
Other Inorganics																							
Flouride	mg/L	0.1	-	2	2	1.5										0	0						
Free cyanide	mg/L	0.004	0.007	-	-	0.08										0	0						
Total cyanide	mg/L	0.004	-	-	-	-										0	0						
Thiocyanate	mg/L	0.1	-	-	-	-										0	0						
Dissolved metals																							
Aluminium	mg/L	0.01	0.055	20	5	ID				0.04	0.01	0.04	<0.01	0.02	<0.01	6	4	0	0.01	0.04	0.03	0.02	0.02
Antimony	mg/L	0.001	ID	-	-	0.003				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6	0						
Arsenic	mg/L	0.001	0.013	2	0.5	0.01				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6	0						
Beryllium	mg/L	0.001	ID	0.5	ID	0.06										0	0						
Barium	mg/L	0.001	-	-	-	2										0	0						
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002				<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	6	0						
Chromium	mg/L	0.001	0.001	1	1	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6	0						
Cobalt	mg/L	0.001	ID	0.1	1	-				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6	0						
Copper	mg/L	0.001	0.0014	5	1#	2				0.007	0.003	0.003	0.002	0.002	<0.001	6	5	5	0.002	0.007	0.003	0.003	0.002
Lead	mg/L	0.001	0.0034	5	0.1	0.01				0.002	<0.001	<0.001	<0.001	<0.001	<0.001	6	1	0	0.002	0.002	0.002	0.002	
Lithium	mg/L	0.001	-	2.5	-	-										0	0						
Manganese	mg/L	0.001	1.9	10	-	0.5	0.051	0.189		0.006	0.027	0.003	0.002	0.001	<0.001	8	7	0	0.001	0.189	0.040	0.01	0.07
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	6	0						
Nickel	mg/L	0.001	0.011	2	1	0.02				0.001	<0.001	0.002	<0.001	<0.001	<0.001	6	2	0	0.001	0.002	0.002	0.001	0.001
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	6	0						
Strontium	mg/L	0.001	-	-	-	-										0	0						
Tin	mg/L	0.001	ID	-	-	-										0	0						
Uranium	mg/L	0.001	ID	0.1	0.2	0.017										0	0						
Vanadium	mg/L	0.01	ID	0.5	ID	-										0	0						
Zinc	mg/L	0.005	0.008	5	20	ID				0.012	0.029	0.01	0.006	0.007	<0.005	6	5	3	0.006	0.029	0.013	0.011	0.009
Boron	mg/L	0.05	0.37	5	5	4				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	6	0						
Iron	mg/L	0.05	ID	10	ID	ID	0.49	0.08		0.08	<0.05	<0.05	<0.05	<0.05	<0.05	8	3	0	0.08	0.49	0.2	0.15	0.24
Ferrous iron	mg/L	0.05	-	-	-	-									<0.05	0	0						
Bromine	mg/L	0.1	-	-	-	-										0	0						
Iodine	mg/L	0.1	-	-	-	ID										0	0						
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001										0	0						
Total metals																							
Aluminium	mg/L	0.01	-	-	-	-										0	0						
Manganese	mg/L	0.001	-	-	-	-									<0.001	1	0						
Iron	mg/L	0.05	-	-	-	-									<0.05	1	0						
Nutrients																							
Ammonia as N	mg/L	0.01	2.57													0	0						
Nitrite as N	mg/L	0.01			9											0	0						
Nitrate as N	mg/L	0.01			90											0	0						
Total phosphorous	mg/L	0.01														0	0						
Reactive phosphorous	mg/L	0.01														0	0						

Table A2: Baseline Groundwater Monitoring Results - Wianamatta Group Shale

Location			Water Quality Criteria				HU0035PZB														
Date			ANZECC (2000)			ADWG (2011)	13/12/2013	25/03/2014	25/07/2014	5/12/2014	4/02/2015	1/07/2015	22/09/2015								
Analyte	Units	LOR	Aquatic	Irrigation	Livestock									n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
General field parameters																					
pH	pH units		6.5-7.5				6.44	6.50	6.94	6.59	7.30	6.18	6.37	7	7	3	6.18	7.3	6.50	6.62	0.38
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium)			2365	2588	2409	2734	2732	2608	2885	7	7	7	2365	2885	2617	2612	185
Conductivity (lab)	µS/cm	1	30-350	>2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)								2600		1	1	1	2600	2600	2600	2600	
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality)	1537	1673	1566	1778	1776	1696.5	1875	7	7		1537	1875	1700	1696.51	120.93
Total Dissolved Solids (lab)	mg/L	10				>900-1200 (poor quality) >1200 (unacceptable)						1480	1750	2	2		1480	1750	1615	1609	191
Dissolved oxygen	% sat		90-110				61.0	22.6	90.0	48.0	52.2	65.4	12.9	7	7		12.9	90	50.3	43	26
Redox	mV						15.3	-49	112.8	1.5	7.3	28.4	-146.7	7	7		-146.7	112.8	-4.3		79
Temperature	ºC						15.49	16.26	15.58	17.00	18.40	13.50	13.43	7	7		13.4	18.4	15.7	16	2
Suspended Solids	mg/L	5										1350	1220	2	2		1220	1350	1285.00	1283	92
Turbididty	NTU	0.1	2-25										1050	1	1	1	1050	1050	1050.00	1050	
Major ions																					
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1		<1	<1	<1	6	0						
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1		<1	<1	<1	6	0						
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	258	331	293		380	322	315	6	6		258	380	317	314	41
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	258	331	293		380	322	315	6	6		258	380	317	314	41
Acidity as $CaCO_3$	mg/L	1	-	-	-	-						79		1	1		79	79	79.00	79	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	73	86	76		63	44	32	6	6	0	32	86	62.3	59	21
Chloride	mg/L	1	-	700	-	ID	528	586	588		597	668	707	6	6	1	528	707	612.3	610	64
Calcium	mg/L	1	-	-	1000	-	141	166	167		177	180	170	6	6	0	141	180	166.8	166	14
Magnesium	mg/L	1	-	-	ID	-	127	144	141		152	159	149	6	6		127	159	145.3	145	11
Sodium	mg/L	1	-	460	-	-	108	127	136		157	160	257	6	6	0	108	257	157.5	151	52
Potassium	mg/L	1	-	-	-	-	8	8	11		8	8	12	6	6		8	12	9.17	9	2
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	9.91	11.1	8		10.2	8.6	9.35	6	6		8	11.1	9.5	9	1
Total Anions	meq/L	0.01	-	-	-	-	21.6	24.9	24		25.7	26.2	26.9								
Total Cations	meq/L	0.01	-	-	-	-	22.4	25.9	26.1		28.4	29.2	32.2								
Ionic Balance	%	0.01	-	-	-	-	1.88	1.84	4.22		4.87	5.5	9.02								
Other Inorganics																					
Flouride	mg/L	0.1	-	2	2	1.5	0.1	0.1				0.1	0.1	4	4	0	0.1	0.1	0.10	0.10	0.00
Free cyanide	mg/L	0.004	0.007	-	-	0.08	<0.004							1	0	0	0				
Total cyanide	mg/L	0.004	-	-	-	-	<0.004							1	0		0				
Thiocyanate	mg/L	0.1	-	-	-	-	<0.1							1	0		0				
Dissolved metals																					
Aluminium	mg/L	0.01	0.055	20	5	ID	0.77	<0.01	<0.01		<0.01	<0.01	0.03	6	2	1	0.03	0.77	0.40	0.15	0.52
Antimony	mg/L	0.001	ID	-	-	0.003	<0.001	<0.001	0.001		<0.001	<0.001	<0.001	6	1		0.001	0.001	0.001	0.00	
Arsenic	mg/L	0.001	0.013	2	0.5	0.01	0.004	0.002	<0.001		0.001	0.001	<0.001	6	4	0	0.001	0.004	0.002	0.00	0.00
Beryllium	mg/L	0.001	ID	0.5	ID	0.06	<0.001	<0.001					<0.001	3	0		0				
Barium	mg/L	0.001	-	-	-	2	0.424	0.268				0.358	0.413	4	4		0.268	0.424	0.366	0.36	0.07
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002	<0.0001	<0.0001	0.0002		<0.0001	<0.0001	<0.0001	6	1	0	0.0002	0.0002	0.000	0.00	
Chromium	mg/L	0.001	0.001	1	1	0.05	0.002	<0.001	0.001		<0.001	<0.001	<0.001	6	2	1	0.001	0.002	0.002	0.00	0.00
Cobalt	mg/L	0.001	ID	0.1	1	-	0.026	0.03	0.016		0.025	0.015	0.033	6	6		0.015	0.033	0.024	0.02	0.01
Copper	mg/L	0.001	0.0014	5	1	2	0.011	0.011	0.004		0.004	<0.001	0.015	6	5	5	0.004	0.015	0.009	0.008	0.005
Lead	mg/L	0.001	0.0034	5	0.1	0.01	0.004	<0.001	<0.001		<0.001	<0.001	0.005	6	2	2	0.004	0.005	0.005	0.004	0.00
Lithium	mg/L	0.001	-	2.5	-	-	0.146						0.194	2	2		0.146	0.194	0.170	0.17	0.03
Manganese	mg/L	0.001	1.9	10	-	0.5	0.653	0.692	0.532		0.666	0.611	0.926	6	6	0	0.532	0.926	0.680	0.67	0.13
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05	0.001	0.002	0.005		0.008	0.003	0.005	6	6		0.001	0.008	0.004	0.00	0.00
Nickel	mg/L	0.001	0.011	2	1	0.02	0.042	0.042	0.036		0.034	0.025	0.041	6	6	6	0.025	0.042	0.037	0.036	0.007
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01	<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	6	0		0				
Strontium	mg/L	0.001	-	-	-	-	0.309	0.325				0.343	0.323	4	4		0.309	0.343	0.325	0.32	0.01
Tin	mg/L	0.001	ID	-	-	-	<0.001						<0.001	2	0		0				
Uranium	mg/L	0.001	ID	0.1	0.2	0.017	0.002	0.001					<0.001	3	2	0	0.001	0.002	0.002	0.00	0.00
Vanadium	mg/L	0.01	ID	0.5	ID	-	<0.01	<0.01					<0.01	3	0	0	0				
Zinc	mg/L	0.005	0.008	5	20	ID	0.293	0.085	0.075		0.054	0.011	0.266	6	6	6	0.011	0.293	0.131	0.082	0.118
Boron	mg/L	0.05	0.37	5	5	4	0.06	0.07	0.06		0.06	<0.05	0.05	6	5	0	0.05	0.07	0.1	0.0596629	0.007071068
Iron	mg/L	0.05	ID	10	ID	ID	4.23	1.24	<0.05		0.56	0.5	0.45	6	5		0.45	4.23	1.4	0.92	1.62
Ferrous iron	mg/L	0.05	-	-	-	-						0.19	0.48	1	2		0.19	0.48	0.34	0.30	0.21
Bromine	mg/L	0.1	-	-	-	-	1.3	1.2					1	3	3		1	1.3	1.167	1.16	0.15
Iodine	mg/L	0.1	-	-	-	ID	0.5						0.1	2	2		0.1	0.5	0.3	0.22	0.28
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001	<0.0001							1	0	1					
Total metals																					
Aluminium	mg/L	0.01	-	-	-	-	4.02						1.14	1	2		1.14	4.02	2.58	2.14	2.04
Manganese	mg/L	0.001	-	-	-	-	1.19					1.56	1.44	1	3		1.19	1.56	1.397	1.39	0.19
Iron	mg/L	0.05	-	-	-	-	20.4					42.9	19.9	1	3		19.9	42.9	27.7	25.92	13.14
Nutrients																					
Ammonia as N	mg/L	0.01	2.57				0.22						0.24	1	2	0	0.22	0.24	0.23	0.23	0.01
Nitrite as N	mg/L	0.01			9		<0.01	<0.01					0.01	1	1	0	0.01	0.01	0.01	0.01	
Nitrate as N	mg/L	0.01			90		0.03	0.02					0.01	1	3	0	0.01	0.03	0.02	0.02	0.01
Total phosphorous	mg/L	0.01					0.49							1	1		0.49	0.49	0.49	0.49	
Reactive phosphorous	mg/L	0.01					<0.01	<0.01					<0.01	1	0						

Table A2: Baseline Groundwater Monitoring Results - Wianamatta Group Shale

Location			Water Quality Criteria				HU0035PZB						
Date			ANZECC (2000)			ADWG (2011)	13/12/2013	25/03/2014	25/07/2014	5/12/2014	4/02/2015	1/07/2015	22/09/2015
Analyte	Units	LOR	Aquatic	Irrigation	Livestock								
Organochloride pesticides													
alpha-BHC	µg/L	0.5					<0.5						<0.5
Hexachlorobenzene (HCB)	µg/L	0.5					<0.5						<0.5
beta-BHC	µg/L	0.5					<0.5						<0.5
gamma-BHC	µg/L	0.5					<0.5						<0.5
delta-BHC	µg/L	0.5					<0.5						<0.5
Heptachlor	µg/L	0.5					<0.5						<0.5
Aldrin	µg/L	0.5					<0.5						<0.5
Heptachlor epoxide	µg/L	0.5					<0.5						<0.5
trans-Chlordane	µg/L	0.5					<0.5						<0.5
alpha-Endosulfan	µg/L	0.5					<0.5						<0.5
cis-Chlordane	µg/L	0.5					<0.5						<0.5
Dieldrin	µg/L	0.5					<0.5						<0.5
4.4`-DDE	µg/L	0.5					<0.5						<0.5
Endrin	µg/L	0.5					<0.5						<0.5
beta-Endosulfan	µg/L	0.5					<0.5						<0.5
4.4`-DDD	µg/L	0.5					<0.5						<0.5
Endrin aldehyde	µg/L	0.5					<0.5						<0.5
Endosulfan sulfate	µg/L	0.5					<0.5						<0.5
4.4`-DDT	µg/L	2					<2.0						<2.0
Endrin ketone	µg/L	0.5					<0.5						<0.5
Methoxychlor	µg/L	2					<2.0						<2.0
Total Chlordane (sum)	µg/L	0.5					<0.5						<0.5
Sum of DDD + DDE + DDT	µg/L	0.5					<0.5						<0.5
Sum of Aldrin + Dieldrin	µg/L	0.5					<0.5						<0.5
Organophosphorous pesticides													
Dichlorvos	µg/L	0.5					<0.5						<0.5
Demeton-S-methyl	µg/L	0.5					<0.5						<0.5
Monocrotophos	µg/L	2					<2.0						<2.0
Dimethoate	µg/L	0.5					<0.5						<0.5
Diazinon	µg/L	0.5					<0.5						<0.5
Chlorpyrifos-methyl	µg/L	0.5					<0.5						<0.5
Parathion-methyl	µg/L	2					<2.0						<2.0
Malathion	µg/L	0.5					<0.5						<0.5
Fenthion	µg/L	0.5					<0.5						<0.5
Chlorpyrifos	µg/L	0.5					<0.5						<0.5
Parathion	µg/L	2					<2.0						<2.0
Pirimphos-ethyl	µg/L	0.5					<0.5						<0.5
Chlorfenvinphos	µg/L	0.5					<0.5						<0.5
Bromophos-ethyl	µg/L	0.5					<0.5						<0.5
Fenamiphos	µg/L	0.5					<0.5						<0.5
Prothiofos	µg/L	0.5					<0.5						<0.5
Ethion	µg/L	0.5					<0.5						<0.5
Carbophenothion	µg/L	0.5					<0.5						<0.5
Azinphos Methyl	µg/L	0.5					<0.5						<0.5
Phenolic compounds													
Phenol	µg/L	1					<1.0						<1.0
2-Chlorophenol	µg/L	1					<1.0						<1.0
2-Methylphenol	µg/L	1					<1.0						<1.0
3- & 4-Methylphenol	µg/L	1					<2.0						<2.0
2-Nitrophenol	µg/L	2					<1.0						<1.0
2.4-Dimethylphenol	µg/L	1					<1.0						<1.0
2.4-Dichlorophenol	µg/L	1					<1.0						<1.0
2.6-Dichlorophenol	µg/L	1					<1.0						<1.0
4-Chloro-3-methylphenol	µg/L	1					<1.0						<1.0
2.4.6-Trichlorophenol	µg/L	1					<1.0						<1.0
2.4.5-Trichlorophenol	µg/L	1					<1.0						<1.0
Pentachlorophenol	µg/L	1					<2.0						<2.0
Polynuclear aromatic hydrocarbons													
Naphthalene	µg/L	1					<1.0						<1.0
Acenaphthylene	µg/L	1					<1.0						<1.0
Acenaphthene	µg/L	1					<1.0						<1.0
Fluorene	µg/L	1					<1.0						<1.0
Phenanthrene	µg/L	1					<1.0						<1.0
Anthracene	µg/L	1					<1.0						<1.0
Fluoranthene	µg/L	1					<1.0						<1.0
Pyrene	µg/L	1					<1.0						<1.0
Benz(a)anthracene	µg/L	1					<1.0						<1.0
Chrysene	µg/L	1					<1.0						<1.0
Benzo(b)fluoranthene	µg/L	1					<1.0						<1.0
Benzo(k)fluoranthene	µg/L	1					<1.0						<1.0
Benzo(a)pyrene	µg/L	0.5					<0.5						<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1					<1.0						<1.0
Dibenz(a.h)anthracene	µg/L	1					<1.0						<1.0
Benzo(g.h.i)perylene	µg/L	1					<1.0						<1.0
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5					<0.5						<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5					<0.5						<0.5
BTEX													
Benzene	µg/L	1					<1						<1
Toluene	µg/L	2	ID			800	<2						<2
Ethylbenzene	µg/L	2					<2						<2
meta- & para-Xylene	µg/L	2					<2						<2

Table A2: Baseline Groundwater Monitoring Results - Wianamatta Group Shale

Location			Water Quality Criteria				HU0035PZB						
Date			ANZECC (2000)			ADWG (2011)	13/12/2013	25/03/2014	25/07/2014	5/12/2014	4/02/2015	1/07/2015	22/09/2015
Analyte	**Units**	**LOR**	**Aquatic**	**Irrigation**	**Livestock**								
ortho-Xylene	µg/L	2					<2						<2
Total Xylenes	µg/L	2					<2						<2
Sum of BTEX	µg/L	1					<1						<1
Naphthalene	µg/L	5					<5						<5
Total petroleum hydrocarbons													
C6 - C9 Fraction	µg/L	20					<20						<20
C10 - C14 Fraction	µg/L	50					<50						<50
C15 - C28 Fraction	µg/L	100					<100						<100
C29 - C36 Fraction	µg/L	50					<50						<50
C10 - C36 Fraction (sum)	µg/L	50					<50						<50
Total Recoverable Hydrocarbons													
C6 - C10 Fraction	µg/L	20					<20						<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20					<20						<20
>C10 - C16 Fraction	µg/L	100					<100						<100
>C16 - C34 Fraction	µg/L	100					<100						<100
>C34 - C40 Fraction	µg/L	100					<100						<100
>C10 - C40 Fraction (sum)	µg/L	100					<100						<100
>C10 - C16 Fraction minus Naphthalene	µg/L	100					<100						<100
Microbiology													
Faecal coliforms	CFU/100 m	1					<2						<2
E coli	CFU/100 m	1					<2						<2
Total coliforms	CFU/100 m	1					~<2						<2

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0018PZB										HU0019PZB						HU0023PZB				HU0023PZC			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	17/10/2011	7/01/2013	22/03/2013	9/07/2013	16/10/2013	12/12/2013	8/04/2014	25/03/2015	2/07/2015	24/09/2015	18/10/2011	29/08/2012	4/01/2013	17/12/2013	9/04/2014	4/02/2015	16/11/2011	18/12/2012	25/03/2013	21/05/2014	15/11/2011	18/12/2012	25/03/2013	21/05/2014
General field parameters																														
pH	pH units		6.5-7.5				6.04	5.79	5.84	5.86	5.93	6.08	5.78	6.08	5.82	5.86	6.89	6.23	7.29	6.59	5.29	6.29	6.2	6.21	6.04	6.33	6.1	5.77	5.9	6.08
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium)			333	254		251	261	245	237	221	228.5	230	390	490	287	364	227	254	281	241	259	260	302	219	246	248
Conductivity (lab)	µS/cm	1	30-350	>2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)											224															
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality)	260	165	174	163	169	159	154	171	148.2	149	254	305	188	236	148	165	183	156.000	168.000	169.000	196	142.000	160.000	161.000
Total Dissolved Solids (lab)	mg/L	10				>900-1200 (poor quality) >1200 (unacceptable)									114	137														
Dissolved oxygen	% sat		90-110				18.3	3	5.3	9.8	14.4	27.2	8.8	10.5	16.4	10.4	118.1	18.3	25	34.4	57.4	61.7	16.7	15.2	13.1	81.8	23.9	13.2	20.6	29.1
Redox	mV						-0.9	-70.9	-23.2	10	-9.7	-18.3	-33	-42.1	-21.4	-106.2	-55.6	-107.9	-62.3	10.9	165	130.8	-110.9	-67.3	-23.1	-61.5	-9.2	-54.5	-27.2	-151.9
Temperature	ºC						19.6	18.1	18.75	16.6	17.58	17.9	17.6	16.7	14	14.07	19.76	13.94	19.86	18.22	15.40	17.30	15.48	22.45	20.87	18.61	26.07	29.64	20.29	19.25
Suspended Solids (lab)	mg/L	5													<5	24														
Turbidity	NTU	0.1	2-25													8.3														
Major ions																														
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	59	59	45	46	57	56	50	69	49	44	95	28	30	78	10	24	70	71	69	63	60	60	66	67
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	59	59	45	46	57	56	50	69	49	44	95	28	30	78	10	24	70	71	69	63	60	60	66	67
Acidity as $CaCO_3$	mg/L	1	-	-	-	-									103												3	4	4	2
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	51	6	6	5	5	5	5	4	4	4	32	7	1	2	2	2	11	5	5	3	38	22	28	28
Chloride	mg/L	1	-	700	-	ID	52	38	38	37	47	40	37	46	36	39	58	57	53	59	56	61	28	25	30	30	6	5	5	4
Calcium	mg/L	1	-	-	1000	-	13	5	4	4	4	3	3	5	3	3	27	10	9	20	6	8	11	8	6	4	11	10	10	9
Magnesium	mg/L	1	-	-	ID	-	4	5	4	5	5	4	5	5	5	6	2	2	2	3	2	2	11	12	11	9	25	18	16	20
Sodium	mg/L	1	-	460	-	-	65	26	21	28	26	26	26	30	20	24	63	34	35	41	33	36	24	22	17	24	1	<1	<1	<1
Potassium	mg/L	1	-	-	-	-	2	1	1	2	1	1	1	<1	<1	<1	1	2	2	1	1	<1	<1	1	<1	<1	9.7	9.4	8.9	9.5
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	10.6	10.0	10.2	11	11.7	10.7	11.6	9.5	10.2	9.8	11.3	9.2	9.1	9.21	8.8	8.2	10.1	10.0	9.0	9.4				<0.1
Total Anions	meq/L	0.01	-	-	-	-	3.71	2.38	2.10	2.07	2.57	2.35	2.46	2.76	2.08	2.06	4.2	2.31	2.12	3.26	1.82	2.24	2.42	2.23	2.33	2.17	2.33	1.90	2.19	2.17
Total Cations	meq/L	0.01	-	-	-	-	3.86	2.51	2.28	1.88	2.46	2.29	2.58	2.69	1.43	1.69	4.28	2.19	2.19	3.14	1.92	2.13	2.50	2.37	2.40	2.36	2.32	1.86	2.27	2.27
Ionic Balance	%	0.01	-	-	-	-	1.94										0.9	-	-	1.97			-	-	-		-	-	-	
Other Inorganics																														
Flouride	mg/L	0.1	-	2	2	1.5						<0.1			<0.1	<0.1				<0.1						<0.1				
Free cyanide	mg/L	0.004	0.007	-	-	0.08						<0.004								<0.004										
Total cyanide	mg/L	0.004	-	-	-	-						<0.004								<0.004										
Thiocyanate	mg/L	0.1	-	-	-	-						<0.1								<0.1										
Dissolved metals																														
Aluminium	mg/L	0.01	0.055	20	5	ID						0.06	0.07	0.34	<0.01	<0.01				0.23	<0.01	0.02				0.41				0.03
Antimony	mg/L	0.001	ID	-	-	0.003						<0.001	<0.001	<0.001	<0.001	<0.001				0.002	<0.001	<0.001				<0.001				<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01						0.006	0.006	0.008	0.004	0.005				0.001	<0.001	<0.001				0.001				<0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06						<0.001				<0.001				<0.001						<0.001				<0.001
Barium	mg/L	0.001	-	-	-	2						0.051			0.03	0.03				0.129						0.037				0.029
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002						<0.0001	<0.0001	0.0002	<0.0001	<0.0001				<0.0001	<0.0001	<0.0001				<0.0001				<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05						<0.001	<0.001	<0.001	<0.001	<0.001				0.008	<0.001	<0.001				<0.001				<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-						0.016	0.021	0.016	0.02	0.017				0.017	0.006	0.006				0.002				0.002
Copper	mg/L	0.001	0.0014	5	1#	2						<0.001	<0.001	<0.001	<0.001	<0.001				0.257	0.095	0.084				0.002				<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01						<0.001	<0.001	0.003	<0.001	<0.001				0.0033	0.006	0.002				0.001				<0.001
Lithium	mg/L	0.001	-	2.5	-	-						0.012				0.011				0.005						0.012				0.016
Manganese	mg/L	0.001	1.9	10	-	0.5	0.782	0.772	0.895	0.806	0.8	0.828	0.926	0.884	0.849	0.863	0.22	0.257	0.412	0.474	0.182	0.179	0.559	0.537	0.539	0.5	0.569	0.549	0.560	0.532
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05						0.009	0.005	0.003	0.003	0.004				0.001	<0.001	<0.001				0.011				0.001
Nickel	mg/L	0.001	0.011	2	1	0.02						0.026	0.032	0.026	0.03	0.025				0.023	0.02	0.01				0.014				0.011
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01						<0.01	<0.01	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01				<0.01				<0.01
Strontium	mg/L	0.001	-	-	-	-						0.055			0.036	0.036				0.192						0.055				0.046
Tin	mg/L	0.001	ID	-	-	-						<0.001				<0.001				0.001						<0.001				<0.001
Uranium	mg/L	0.001	ID	0.1	0.2	0.017						<0.001				<0.001				<0.001						<0.001				<0.001
Vanadium	mg/L	0.01	ID	0.5	ID	-						<0.01				<0.01				<0.01						<0.01				<0.01
Zinc	mg/L	0.005	0.008	5	20	ID						0.056	0.054	0.271	0.052	0.056				0.186	0.071	0.018				0.077				0.067
Boron	mg/L	0.05	0.37	5	5	4						<0.05	<0.05	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05				<0.05				<0.05
Iron	mg/L	0.05	ID	10	ID	ID	6.92	12.8	13.70	15.2	12.8	12.2	15.9	13.3	13.7	13.2	0.15	<0.05	0.87	0.44	0.12	<0.05	7.78	8.92	8.54	7.4	9.67	9.48	9.37	8.12
Ferrous iron	mg/L	0.05	-	-	-	ID									15	14.2														
Bromine	mg/L	0.1	-	-	-	-						0.2				<0.1				0.1						0.1				<0.1
Iodine	mg/L	0.1	-	-	-	ID						<0.1				<0.1				<0.1						<0.1				<0.1
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001						<0.0001								<0.0001										
Total metals																														
Aluminium	mg/L	0.01	-	-	-	-						0.29				0.25				0.85										
Manganese	mg/L	0.001	-	-	-	-						0.957			0.882	0.895				0.508										
Iron	mg/L	0.05	-	-	-	-						13.5			14.3	14.5				0.58										
Nutrients																														
Ammonia as N	mg/L	0.01	2.57									0.01				0.01				0.09										
Nitrite as N	mg/L	0.01			9							<0.01				<0.01				<0.01										
Nitrate as N	mg/L	0.01			90							0.02				<0.01				0.04										
Nitrite + Nitrate as N	mg/L	0.01																												
Total phosphorous	mg/L	0.01										0.03								0.15										
Reactive phosphorous	mg/L	0.01										<0.01				<0.01				<0.01										
Biochemical oxygen demand	mg/L	2														<2														
Isotopes																														
Oxygen-18	‰	0.01					-7.05										-6.53						-5.99				-6.41			
Deuterium	‰	0.1					-42.7										-43.4						-38.6				-39.1			
Carbon-13	‰	0.1					-16.6										-16.5						-12.3				-11.6			
Radiocarbon	pMC	0.1					44.18±0.14										66.0±0.17						30.55±0.11				33.26±0.11			
Radiocarbon Age (uncorrected)	yrs BP	1					6503±25										3279±20						9465±30				8783±25			
Tritium	TU	0.01					0.02±0.02^										0.14±0.03^						0.06±0.03^				0.01±0.03^			

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0032LDB				HU0037PZB			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	12/12/2013	3/04/2014	26/03/2015	24/09/2015	29/08/2012	20/12/2012	18/12/2013	3/02/2015
General field parameters														
pH	pH units		6.5-7.5				5.95	5.69	5.80	5.86	5.21	4.05	5.38	5.23
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			112	113	110	115	124	108	115	125
Conductivity (lab)	µS/cm	1	30-350					113		91				
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	72	73	71	74	81	70.000	74.000	81.000
Total Dissolved Solids (lab)	mg/L	10						60		46				
Dissolved oxygen	% sat		90-110				24.5	8.3	29.8	14.5	41.3	49.3	72.2	63.7
Redox	mV						-18.0	0.8	-97.1	-91.8	85.1	5.3	183.8	186.7
Temperature	ºC						18.01	18.6	16.7	14.55	15.16	33.10	17.09	21.48
Suspended Solids (lab)	mg/L	5												
Turbidity	NTU	0.1	2-25											
Major ions														
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	31	23	27	30	9	7	8	11
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	31	23	27	30	9	7	8	11
Acidity as $CaCO_3$	mg/L	1	-	-	-	-	5	4	4	4	<1	<1	1	<1
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	11	10	24	11	25	27	30	38
Chloride	mg/L	1	-	700	-	ID	1	1	2	1	4	2	1	3
Calcium	mg/L	1	-	-	1000	-	2	2	2	2	3	3	2	3
Magnesium	mg/L	1	-	-	ID	-	8	10	9	9	13	14	16	16
Sodium	mg/L	1	-	460	-	-	<1	<1	<1	<1	<1	<1	<1	<1
Potassium	mg/L	1	-	-	-	-	9.14	8.9	8.3	8.6	9.4	8.9	8.46	8
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	<0.1	<0.1					<0.1	
Total Anions	meq/L	0.01	-	-	-	-	1.03	0.82	1.3	0.99	0.89	0.90	1.03	1.29
Total Cations	meq/L	0.01	-	-	-	-	1.09	0.65	1.16	0.6	1.01	0.96	0.91	1.09
Ionic Balance	%	0.01	-	-	-	-					6.32	3.23	6.19	
Other Inorganics														
Flouride	mg/L	0.1	-	2	2	1.5	<0.004						<0.004	
Free cyanide	mg/L	0.004	0.007	-	-	0.08	<0.004						<0.004	
Total cyanide	mg/L	0.004	-	-	-	-	<0.1						<0.1	
Thiocyanate	mg/L	0.1	-	-	-	-								
Dissolved metals														
Aluminium	mg/L	0.01	0.055	20	5	ID	0.05	<0.01	0.08	<0.01			0.03	0.01
Antimony	mg/L	0.001	ID	-	-	0.003	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06	<0.001						<0.001	
Barium	mg/L	0.001	-	-	-	2	0.046						0.015	
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002	<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-	0.009	0.01	0.01	0.009			<0.001	<0.001
Copper	mg/L	0.001	0.0014	5	1#	2	<0.001	<0.001	<0.001	<0.001			0.002	0.005
Lead	mg/L	0.001	0.0034	5	0.1	0.01	<0.001	<0.001	0.002	<0.001			<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-	0.004						0.003	
Manganese	mg/L	0.001	1.9	10	-	0.5	0.634	0.647	0.526	0.563	0.032	0.019	0.015	0.017
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02	0.009	0.01	0.014	0.01			0.022	0.022
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01	<0.01	<0.01	<0.01	<0.01			<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-	0.018						0.028	
Tin	mg/L	0.001	ID	-	-	-	<0.001						<0.001	
Uranium	mg/L	0.001	ID	0.1	0.2	0.017	<0.001						<0.001	
Vanadium	mg/L	0.01	ID	0.5	ID	-	<0.01						<0.01	
Zinc	mg/L	0.005	0.008	5	20	ID	0.205	0.03	0.074	0.027			0.162	0.224
Boron	mg/L	0.05	0.37	5	5	4	<0.05	<0.05	<0.05	<0.05			<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	9.83	11.2	9.36	10.5	<0.05	0.14	0.05	<0.05
Ferrous iron	mg/L	0.05	-	-	-	ID				11.0				
Bromine	mg/L	0.1	-	-	-	-	0.3						<0.1	
Iodine	mg/L	0.1	-	-	-	ID	<0.1						<0.1	
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001	<0.0001						<0.0001	
Total metals														
Aluminium	mg/L	0.01	-	-	-	-	0.28						0.22	
Manganese	mg/L	0.001	-	-	-	-	0.665			0.574			0.016	
Iron	mg/L	0.05	-	-	-	-	11.7			11.5			0.14	
Nutrients														
Ammonia as N	mg/L	0.01	2.57				<0.01						0.78	
Nitrite as N	mg/L	0.01			9		<0.01	<0.01					<0.01	
Nitrate as N	mg/L	0.01			90		0.01	0.02					0.25	
Nitrite + Nitrate as N	mg/L	0.01												
Total phosphorous	mg/L	0.01					0.03						0.02	
Reactive phosphorous	mg/L	0.01					<0.01	<0.01					<0.01	
Biochemical oxygen demand	mg/L	2												
Isotopes														
Oxygen-18	‰	0.01					-7.32							
Deuterium	‰	0.1					-43.38							
Carbon-13	‰	0.1												
Radiocarbon	pMC	0.1												
Radiocarbon Age (uncorrected)	yrs BP	1												
Tritium	TU	0.01					<0.05±0.08							

	HU0038PZC								HU0042PZC					HU0043PZB			
Analyte	24/07/2012	14/12/2012	11/12/2013	2/04/2014	15/08/2014	2/12/2014	12/02/2015	15/09/2015	26/03/2013	3/07/2013	19/08/2013	17/12/2013	2/02/2015	31/08/2012	3/01/2013	18/12/2013	5/02/2015
General field parameters																	
pH	5.21	5.13	5.07	4.88		5.30	5.00	5.06	6.08	6.25	6.31	6.57	5.3	5.67	4.91	5.52	5.03
Conductivity (field)	44	46	43	42.8		51	41	45	575	503	481	471	401	64	66	79	63
Conductivity (lab)				42				36									
Total Dissolved Solids (field)	28.600	31.000	28.000	30.000		34	27	29	374	327	313	306	260	42	43	51	41
Total Dissolved Solids (lab)				24			30	32									
Dissolved oxygen	50.0	49.3	68.2	60.0		54.0	65.2	71.4	22.1	34	29.5	43.4	38.6	34.4	86.3	68.2	89.2
Redox	120.8	68.9	191.2	230.9		136.7	161.3	-58.3	25.1	-30.7	-54.4	-37.2	50.7	115	135.5	75.5	163.9
Temperature	16.00	19.37	17.33	18.40		22.15	18.50	19.87	18.06	13.3	16.04	19.02	17.32	12.37	32.54	24.54	22.62
Suspended Solids (lab)																	
Turbidity																	
Major ions																	
Hydroxide Alkalinity as $CaCO_3$	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	18	5	4	4	4	7	6	5	126	96	91	81	75	4	2	10	5
Total Alkalinity as $CaCO_3$	18	5	4	4	4	7	6	5	126	96	91	81	75	4	2	10	5
Acidity as $CaCO_3$	<1	1	1	<1	<1	1	<1	<1	24	16	13	12	6	2	2	2	2
Sulfate as SO_4^{2-}	5	7	6	6	8	20	6	8	79	82	87	81	79	14	14	13	25
Chloride	1	<1	<1	<1	<1	1	<1	<1	18	19	13	11	12	<1	<1	3	<1
Calcium	<1	<1	<1	<1	<1	1	<1	<1	18	18	18	15	14	<1	<1	<1	<1
Magnesium	7	6	5	6	6	6	6	6	44	2	50	41	34	8	9	10	10
Sodium	<1	<1	<1	<1	<1	<1	<1	<1	28	43	2	<1	2	<1	<1	<1	<1
Potassium	8.4	7.4	7.76	7.8	8.3	7.6	7.67	7	9.1	9.3	9.5	9.7	8.4	7.7	7.7	-	6.7
Silica/Silicon as SiO_2/Reactive silica			<0.1	<0.1			<0.1					<0.1					
Total Anions	0.5	0.32	0.27	0.25	0.31	0.72	0.29	0.32	5.25		4.54	4.15	3.85	0.52	0.48	0.61	0.85
Total Cations	0.35	0.26	0.22	0.26	0.26	0.39	0.26	0.26	5.13		4.59	4.09	3.58	0.35	0.39	0.58	0.43
Ionic Balance	17.65	10.34	10.20	1.96					1.13		0.52	0.75	3.72	-	-	-	
Other Inorganics																	
Flouride			<0.004				<0.004					<0.004					
Free cyanide			<0.004				<0.004					<0.004					
Total cyanide			<0.1				<0.1					<0.1					
Thiocyanate																	
Dissolved metals																	
Aluminium			0.02	0.02	<0.01	0.03	<0.01	<0.01				<0.01	<0.01				0.01
Antimony			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001				<0.001
Arsenic			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001				<0.001
Beryllium			<0.001				<0.001					<0.001					
Barium			0.016				0.003					0.073					
Cadmium			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				<0.0001	<0.0001				<0.0001
Chromium			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001				<0.001
Cobalt			<0.001	<0.001	<0.001	0.001	<0.001	<0.001				<0.001	<0.001				<0.001
Copper			0.008	0.026	0.007	0.02	0.01	<0.001				0.002	<0.001				0.011
Lead			0.002	0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001				<0.001
Lithium			0.001	-			<0.001					0.018					
Manganese	0.080	0.076	0.037	0.036	0.028	0.062	0.041	0.029	0.740	0.654	0.689	0.647	0.436	0.075	0.056	0.030	0.034
Molybdenum			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001				<0.001
Nickel			0.001	0.001	0.002	0.002	0.001	0.001				0.005	0.007				0.004
Selenium			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01				<0.01	<0.01				<0.01
Strontium			0.012				0.004					0.195					
Tin			<0.001				<0.001					<0.001					
Uranium			<0.001				<0.001					<0.001					
Vanadium			<0.01				<0.01					<0.01					
Zinc			0.071	0.014	0.022	0.012	0.011	<0.005				0.144	0.079				0.226
Boron			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				<0.05	<0.05				<0.05
Iron	0.06	0.08	<0.05	<0.05	<0.05	0.07	<0.05	<0.05	2.25	8.50	12.20	9.79	5.51	0.40	0.34	0.08	0.1
Ferrous iron																	
Bromine			<0.1				<0.1					0.2					
Iodine			<0.1				<0.1					<0.1					
Mercury			<0.0001				<0.0001					<0.0001					
Total metals																	
Aluminium			0.01				<0.01					0.02					
Manganese			0.043				0.042	0.027				0.717					
Iron			<0.05				<0.05	<0.05				11.6					
Nutrients																	
Ammonia as N			0.03				0.1					<0.01					
Nitrite as N			<0.01	<0.01			<0.01					<0.01					
Nitrate as N			0.08	0.08			0.08					0.02					
Nitrite + Nitrate as N																	
Total phosphorous			<0.01	-			<0.01					<0.01					
Reactive phosphorous			<0.01	<0.01			<0.01					<0.01					
Biochemical oxygen demand																	
Isotopes																	
Oxygen-18																	
Deuterium																	
Carbon-13																	
Radiocarbon																	
Radiocarbon Age (uncorrected)																	
Tritium																	

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0044XPZB									HU0056XPZB					HU0072PZB									
Analyte	Units	LOR	ANZECC (2000) Aquatic	ANZECC (2000) Irrigation	ANZECC (2000) Livestock	ADWG (2011)	23/08/2012	14/12/2012	26/03/2013	2/07/2013	18/09/2013	10/12/2013	25/03/2014	24/07/2014	3/02/2015	19/12/2012	19/12/2013	25/09/2014	13/11/2014	5/02/2015	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	17/09/2015
General field parameters																														
pH	pH units		6.5-7.5				4.22	4.41	4.73	4.99	5.36	5.08	5.22	4.94	5.37	5.94	6.06	5.64	5.41	7.95	6.23	6.29	6.49	6.7	6.3	6.39	6.35	6.41	6.41	6.36
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			83	81	72	55.9	79	66	61	63	60	114	128	118	131.9	161	510	628	635	626	630	634	652	650	626	637
Conductivity (lab)	µS/cm	1	30-350										59												632				650	614
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	54	53	46	30	52	43	39	41	39	74	83	76	71	105	425	409	413	407	410	412	424	422	410	414
Total Dissolved Solids (lab)	mg/L	10											46												364				357	312
Dissolved oxygen	% sat		90-110				31.5	3.16	32.8	-	68.2	76.4	52.7	63.7	72.5	10.6	34.6	26.7	17.5	33.5	1.5	18.0	10.7	29.3	8.3	14.0	18.4	13.8	10.7	5.7
Redox	mV						180.3	30.1	91.3	109	138.6	182.9	183.2	192.3	221.8	37.8	126.5	77.8	56	-74.9	-100.8	-64.8	-107.9	-101.9	-48	-4.9	-36.1	-54.0	-58.2	-95.0
Temperature	ºC						12.77	17.6	18.35	13.80	15.02	17.47	19.25	13.34	19.72	20.64	19.54	16.96	24.5	16.48	19.15	16.8	16.28	17.14	17.59	16.88	24.43	17.3	15.6	14.84
Suspended Solids (lab)	mg/L	5																											<5	<5
Turbidity	NTU	0.1	2-25																											
Major ions																														
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	3.0	2	2	4	8	2	3	2	2	24	32	21	21	27	110	104	103	104	108	100	114	114	107	106
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	3.0	2	2	4	8	2	3	2	2	24	32	21	21	27	110	104	103	104	108	100	114	114	107	106
Acidity as $CaCO_3$	mg/L	1	-	-	-	-	3	2	<1	<1	<1	<1	<1	<1	<1	9	8	8	7	6									36	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	18	14	14	21	21	13	10	13	25	18	20	16	17	30	12	5	5	7	5	7	6	6	6	7
Chloride	mg/L	1	-	700	-	ID	1	<1	<1	1	3	<1	<1	<1	<1	4	3	2	3	6	125	133	135	126	131	132	127	133	127	126
Calcium	mg/L	1	-	-	1000	-	2	<1	<1	<1	<1	<1	<1	<1	<1	4	2	3	4	5	37	30	30	29	25	29	32	33	33	33
Magnesium	mg/L	1	-	-	ID	-	11	12	11	<1	11	8	8	10	9	11	14	10	17	11	27	28	28	26	28	28	27	29	30	28
Sodium	mg/L	1	-	460	-	-	<1	<1	<1	8	<1	<1	<1	<1	<1	1	5	2	2	4	33	44	44	39	42	39	37	42	43	38
Potassium	mg/L	1	-	-	-	-	5.8	5.7	6.0	5.5	5.7		6.40	5.7	5.4	11.0		9.8	9.2	14.2	3	4	4	3	3	3	3	3	3	3
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-							<0.1				<0.1				8.5	8.9	8.4	8.5	8.6	9.4	8.3	8	8.4	8.2
Total Anions	meq/L	0.01	-	-	-	-	0.63	0.48	0.43		0.75	0.41	0.34	0.41	0.75	1.17	1.37	1.04	1.04	1.51	5.97	5.93	5.97	5.78	5.96	5.870	5.990	6.15	5.84	5.82
Total Cations	meq/L	0.01	-	-	-	-	0.69	0.52	0.48		0.63	0.35	0.35	0.43	0.39	1.03	1.05	0.83	1.27	1.29	5.89	5.82	5.82	5.56	5.71	5.800	5.760	6.19	6.06	5.68
Ionic Balance	%	0.01	-	-	-	-															0.75	0.98	1.29	1.94	2.15	0.560	1.950	0.26	1.83	1.19
Other Inorganics																														
Flouride	mg/L	0.1	-	2	2	1.5																		0.1	0.1				0.1	
Free cyanide	mg/L	0.004	0.007	-	-	0.08																		<0.004						
Total cyanide	mg/L	0.004	-	-	-	-																		<0.004						
Thiocyanate	mg/L	0.1	-	-	-	-																		<0.1						
Dissolved metals																														
Aluminium	mg/L	0.01	0.055	20	5	ID							0.02	0.02	0.02			<0.01	0.06	0.08				<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003							<0.001	<0.001	<0.001			<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01							<0.001	<0.001	<0.001			<0.001	<0.001	0.002				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06							<0.001											<0.001	<0.001					
Barium	mg/L	0.001	-	-	-	2							0.013											0.215	0.177				0.18	
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002							<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001				<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05							<0.001	<0.001	<0.001			<0.001	<0.001	0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-							<0.001	<0.001	<0.001			0.002	0.001	0.002				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	0.0014	5	1#	2							0.012	0.004	0.006			0.005	0.001	0.013				<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01							0.002	<0.001	0.001			<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-																		0.042						
Manganese	mg/L	0.001	1.9	10	-	0.5	0.027	0.020	0.009	0.006	0.009	0.080	0.026	0.013	0.009	0.152	0.042	0.201	0.175	0.168	0.318	0.287	0.273	0.323	0.27	0.278	0.294	0.242	0.262	0.253
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05							<0.001	<0.001	<0.001			<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02							<0.001	0.014	<0.001			0.004	0.004	0.006				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01							<0.01	<0.01	<0.01			<0.01	<0.01	<0.01				<0.01	<0.01	0.110	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-							0.004											0.169	0.144				0.132	
Tin	mg/L	0.001	ID	-	-	-																		<0.001						
Uranium	mg/L	0.001	ID	0.1	0.2	0.017							<0.001											<0.001	<0.001					
Vanadium	mg/L	0.01	ID	0.5	ID	-							<0.01											<0.01	<0.01					
Zinc	mg/L	0.005	0.008	5	20	ID							0.096	0.143	0.019			0.012	0.014	0.02				0.008	0.041	<0.005	0.010	0.064	<0.005	<0.005
Boron	mg/L	0.05	0.37	5	5	4							<0.05	<0.05	<0.05			<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	<0.05	0.06	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	0.56	<0.05	1.36	1.94	5.17	5.72	5.6	5.18	4.2	4.71	5.180	4.730	4.89	4.94	4.94
Ferrous iron	mg/L	0.05	-	-	-	ID																							5.59	5.35
Bromine	mg/L	0.1	-	-	-	-							<0.1											0.4	0.4					
Iodine	mg/L	0.1	-	-	-	ID																		<0.1						
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001																		<0.0001						
Total metals																														
Aluminium	mg/L	0.01	-	-	-	-																		0.02						
Manganese	mg/L	0.001	-	-	-	-																		0.309					0.275	0.269
Iron	mg/L	0.05	-	-	-	-																		6.71					5.48	5.45
Nutrients																														
Ammonia as N	mg/L	0.01	2.57																					0.1						
Nitrite as N	mg/L	0.01			9								<0.01											<0.01	<0.01					
Nitrate as N	mg/L	0.01			90								0.77											0.02	0.05					
Nitrite + Nitrate as N	mg/L	0.01																												
Total phosphorous	mg/L	0.01																						0.02						
Reactive phosphorous	mg/L	0.01											<0.01											<0.01	<0.01					
Biochemical oxygen demand	mg/L	2																												
Isotopes																														
Oxygen-18	‰	0.01																												
Deuterium	‰	0.1																												
Carbon-13	‰	0.1																												
Radiocarbon	pMC	0.1																												
Radiocarbon Age (uncorrected)	yrs BP	1																												
Tritium	TU	0.01																												

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0072PZC										HU0073PZC									HU0088PZB				
Analyte	**Units**	**LOR**	**ANZECC (2000) Aquatic**	**ANZECC (2000) Irrigation**	**ANZECC (2000) Livestock**	**ADWG (2011)**	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	15/09/2015	27/03/2013	7/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	10/12/2013	2/04/2014	26/09/2014	3/12/2014	11/02/2015
General field parameters																														
pH	pH units		6.5-7.5				6.17	6.16	6.36	6.4	6.08	6.29	6.36	6.29	6.31	6.39	5.81	6.06	6.22	6.00	6.10	6.36	6.19	6.11	6.01	6.40	6.40	6.46	6.49	6.43
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium)			923	877	910	944	970	851	613	602	843	831	252	207	231	221	218	211	214.2	210.6	209	424	418	416	380	402
Conductivity (lab)	µS/cm	1	30-350	>2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)							981				880	814					203			198			440			
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality)	600	572	592	614	630	553	398	390	546	540	163	118	150	142	143	137	139	137	136	275	268	270	247	231
Total Dissolved Solids (lab)	mg/L	10				>900-1200 (poor quality) >1200 (unacceptable)					598				498	492					111		112	101	113		169			172
Dissolved oxygen	% sat		90-110				5.5	14.4	8.5	11	9.1	7.1	14.50	25.4	7.2	20.6	3.3	24.6	22.3	27	11.7	15.5	12.3	17	11.6	17.0	14.1	21.2	14.2	23.7
Redox	mV						-85.9	-41.0	8.1	-16.0	-33.5	2.1	-33.4	-24.4	7.3	-142.4	-36.3	30	-35.8	-34.1	-50	-44.2	-124.6	-68.5	-109.2	-22.3	-17.2	-43.7	-47.0	-25.8
Temperature	ºC						17.72	16.5	15.62	16.38	16.81	16.05	21.54	17.6	14.9	13.33	19.2	20.2	18.21	18.52	18.7	19.26	18.5	15.5	16.9	19.32	19.00	19.07	21.82	23.50
Suspended Solids (lab)	mg/L	5													<5	<5								<5	<5					
Turbidity	NTU	0.1	2-25																											
Major ions																														
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	134	120	128	133	136	115	109	110	126	121	46	68	62	52	41	57	54	58	28	130	110	136	119	125
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	134	120	128	133	136	115	109	110	126	121	46	68	62	52	41	57	54	58	28	130	110	136	119	125
Acidity as $CaCO_3$	mg/L	1	-	-	-	-									46									64						
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	24	20	21	25	26	22	7	6	20	17	8	6	4	6	6	8	5	5	8	4	2	<1	2	1
Chloride	mg/L	1	-	700	-	ID	198	192	203	198	216	191	120	122	169	170	41	33	36	28	32	24	36	26	29	51	53	54	44	52
Calcium	mg/L	1	-	-	1000	-	39	33	35	34	38	33	27	30	36	31	6	4	4	4	4	4	7	4	3	19	19	20	21	19
Magnesium	mg/L	1	-	-	ID	-	38	38	39	38	44	36	26	28	39	34	6	5	5	5	4	5	5	5	5	15	16	17	14	15
Sodium	mg/L	1	-	460	-	-	67	74	82	86	80	61	36	38	68	63	18	19	18	19	23	20	19	17	20	35	37	37	25	32
Potassium	mg/L	1	-	-	-	-	4	4	4	4	4	3	3	3	3	3	<1	<1	<1	<1	<1	<1	<1	<1	<1	4	5	6	10	7
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	9.0	8.6	8.5	8.6	8.8	9.1	8.2	7.6	8.4	8.7	8.4	9.1	10.4	9.6	9.3	8.7	9.52	9.3	9.18	7.2	8.2	8.3	8.1	8.35
Total Anions	meq/L	0.01	-	-	-	-	8.76	8.23	8.72	8.76	9.35	8.14	5.71	5.76	7.70	7.57	2.24	2.41	2.34	1.95	1.85	1.98	2.2	2		4.12	3.95	4.24	3.66	3.99
Total Cations	meq/L	0.01	-	-	-	-	8.52	8.1	8.63	9.03	9.10	7.74	5.43	5.85	8.04	7.16	2.31	2.52	2.37	1.96	1.53	1.48	2.37	1.35		3.98	4.00	4.16	3.54	3.88
Ionic Balance	%	0.01	-	-	-	-	1.40	0.83	0.55	1.5	1.37	2.49	2.53	0.70	2.16	2.75	-	-	-	-			-	-		1.78	0.61	0.97	1.63	1.35
Other Inorganics																														
Flouride	mg/L	0.1	-	2	2	1.5				<0.1	0.1				0.1					<0.1	<0.1		<0.1	0.1	<0.1	0.1	0.1			<0.1
Free cyanide	mg/L	0.004	0.007	-	-	0.08				<0.004										<0.004			<0.004			<0.004				<0.004
Total cyanide	mg/L	0.004	-	-	-	-				<0.004										<0.004			<0.004			0.004				<0.004
Thiocyanate	mg/L	0.1	-	-	-	-				<0.1										<0.1			<0.1			<0.1				<0.1
Dissolved metals																														
Aluminium	mg/L	0.01	0.055	20	5	ID				0.02	0.02	<0.01	<0.01	<0.01	<0.01	<0.01				<0.01	<0.01	0.01	0.01	<0.01	<0.01	0.02	<0.01	0.02	0.05	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				0.002	0.002	0.001	0.002	0.002	0.001	0.009	0.026	0.04	0.02	0.029
Beryllium	mg/L	0.001	ID	0.5	ID	0.06				<0.001	<0.001									<0.001			<0.001		<0.001	<0.001				<0.001
Barium	mg/L	0.001	-	-	-	2				0.297	0.311				0.255					0.028			0.042	0.021	0.02	0.336				0.261
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002				<0.0001	<0.0001	<0.0001	<0.0001	0.0004	<0.0001	<0.0001				<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	0.00	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-				0.004	0.003	0.00	<0.001	<0.001	0.002	<0.001				0.008	0.005	0.003	0.002	0.004	0.005	0.179	0.066	0.03	0.02	0.01
Copper	mg/L	0.001	0.0014	5	1#	2				0.002	0.001	<0.001	0.00	0.002	<0.001	0.007				0.001	<0.001	0.005	<0.001	<0.001	<0.001	0.002	<0.001	0.00	0.01	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01				<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-				0.049										0.012			0.011		0.012	0.052				0.042
Manganese	mg/L	0.001	1.9	10	-	0.5	0.646	0.464	0.53	0.604	0.646	0.44	0.29	0.244	0.49	0.274	1.150	0.780	0.718	0.912	0.793	0.616	0.823	0.644	0.627	0.65	0.228	0.15	0.15	0.103
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001				0.004	0.004	<0.001	<0.001	0.002	0.001	<0.001	<0.001	0.00	0.00	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02				0.006	0.007	0.004	<0.001	<0.001	0.005	0.015				0.009	0.007	0.006	0.005	0.005	0.006	0.217	0.083	0.03	0.02	0.013
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01				<0.01	<0.01	0.16	<0.01	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-				0.213	0.193				0.153					0.034			0.037	0.02	0.024	0.197				0.145
Tin	mg/L	0.001	ID	-	-	-				<0.001										<0.001			<0.001		<0.001	<0.001				<0.001
Uranium	mg/L	0.001	ID	0.1	0.2	0.017				<0.001	<0.001									<0.001			<0.001		<0.001	<0.001				<0.001
Vanadium	mg/L	0.01	ID	0.5	ID	-				<0.01	<0.01									<0.01			<0.01		<0.01	<0.01				<0.01
Zinc	mg/L	0.005	0.008	5	20	ID				0.017	0.117	<0.005	0.01	0.04	<0.005	0.041				0.021	0.017	0.012	0.013	0.006	0.006	0.214	0.072	0.08	0.03	0.019
Boron	mg/L	0.05	0.37	5	5	4				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	8.08	6.64	6.6	5.88	6.15	6.22	5.57	5.89	5.79	0.98	13.60	15.50	18.10	21.9	15.9	16.4	14.5	15.8	13.5	2.41	3.11	2.98	1.74	2.38
Ferrous iron	mg/L	0.05	-	-	-	ID									6.59	3.97									16.1					
Bromine	mg/L	0.1	-	-	-	-				0.3	0.6									0.4			<0.1		<0.1	0.3				0.1
Iodine	mg/L	0.1	-	-	-	ID				<0.1										<0.1			<0.1		<0.1	<0.1				<0.1
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001				<0.0001										<0.0001			<0.0001			<0.0001				<0.0001
Total metals																														
Aluminium	mg/L	0.01	-	-	-	-				<0.01										<0.01			0.12	0.647	<0.01	<0.01				0.87
Manganese	mg/L	0.001	-	-	-	-				0.6					0.507	0.451				0.898			0.809	15.9	0.684	0.659				0.128
Iron	mg/L	0.05	-	-	-	-				6.83					6.56	6.07				22			16.4	17.1	16.2	2.6				6.77
Nutrients																														
Ammonia as N	mg/L	0.01	2.57							0.13										<0.01			<0.1		0.02	0.16				0.14
Nitrite as N	mg/L	0.01			9					<0.01	<0.01									<0.01	<0.01		<0.1		<0.01	<0.01	<0.01			<0.01
Nitrate as N	mg/L	0.01			90					0.02	<0.01									0.02	0.01		0.02		<0.01	0.02	<0.01			0.02
Nitrite + Nitrate as N	mg/L	0.01																												
Total phosphorous	mg/L	0.01								0.04										<0.01			0.04			<0.01				0.04
Reactive phosphorous	mg/L	0.01								<0.01	<0.01									<0.01	<0.01		<0.01		<0.01	<0.01	<0.01			<0.01
Biochemical oxygen demand	mg/L	2																												
Isotopes																														
Oxygen-18	‰	0.01																												
Deuterium	‰	0.1																												
Carbon-13	‰	0.1																												
Radiocarbon	pMC	0.1																												
Radiocarbon Age (uncorrected)	yrs BP	1																												
Tritium	TU	0.01																												

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0096PZC								HU0118PZA				HU0129PZB				HU0133PZC	HU0136PZB			HU0142PZB				
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	20/03/2014	25/08/2014	1/12/2014	6/02/2015	22/05/2014	10/02/2015	24/06/2015	16/09/2015	23/05/2014	29/08/2014	1/12/2014	4/02/2015	24/09/2014	1/12/2014	26/03/2015	30/06/2015	17/09/2015
General field parameters																															
pH	pH units		6.5-7.5				5.03	4.92	4.81	4.25	4.98	4.83	4.82	4.77	6.44	5.84	6.02	5.83	6.16	6.20	6.21	6.21	5.95	7.50	6.39	7.03	6.49	6.61	6.57	6.54	6.56
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			84	120	110	111.5	115	116	116	118	192	186	182	177	520	513	485	518	189	591	589	566	3717	4882	4875	3866	3313
Conductivity (lab)	µS/cm	1	30-350							118			112								486	460								3870	
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	48	78	71	72	75	75	75	77	125	121	118	115	338	333	315	336	123	384	383	368	1970	3172	3172	2516	2154
Total Dissolved Solids (lab)	mg/L	10								70		100	52	53							194	284	92						2430	2090	2070
Dissolved oxygen	% sat		90-110				56.6	51.9	66.7	50.2	56.3	57.4	82	70.6	36	11.8	48.4	24.0	13.5	25.6	8.9	18.9	31.9	96.3	77.0	92.6	12.4	21.2	19.8	13.9	14.0
Redox	mV						110	111.7	208.2	197.9	122.5	301.6	315.3	-5.2	43.8	113.3	-33.4	11.8	-18.9	-20.6	-79.8	-111.6	-10.2	179.6	140.2	100.4	-64.3	-32.9	-13.3	-54.5	-138.7
Temperature	ºC						18.7	17.29	18.22	17.8	22.14	13.9	13.8	14.25	19	15.16	13.82	14.35	19.35	17.33	14.9	17.9	18.12	18.24	22.35	17.54	20.41	23.43	20.60	16.10	16.38
Suspended Solids (lab)	mg/L	5											<5	19							<5	<5								<5	<5
Turbidity	NTU	0.1	2-25											8.8																	13.2
Major ions																															
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	6	4	3	4	3	<1	2	4	31	28	29	43	100	83	68	81	57	316	238	232	339	446	377	362	299
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	6	4	3	4	3	<1	2	4	31	28	29	43	100	83	68	81	57	316	238	232	339	446	377	362	299
Acidity as $CaCO_3$	mg/L	1	-	-	-	-							53								47										
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	2	1	1	1	<1	<1	1	1	3	1	1	2	10	10	10	13	10	159	8	7	8	11	6	6	4
Chloride	mg/L	1	-	700	-	ID	28	36	29	32	23	35	27	29	31	29	37	35	96	97	92	87	25	40	47	51	1020	1150	1300	1030	925
Calcium	mg/L	1	-	-	1000	-	1	<1	<1	<1	<1	<1	<1	<1	7	2	3	3	15	15	17	17	4	34	34	29	145	198	182	168	148
Magnesium	mg/L	1	-	-	ID	-	<1	<1	<1	<1	1	1	1	1	3	2	3	3	19	20	20	22	5	42	40	44	188	229	236	201	158
Sodium	mg/L	1	-	460	-	-	17	16	18	22	19	17	16	17	19	15	13	15	45	46	42	45	12	29	20	24	326	406	391	322	275
Potassium	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	2	<1	<1	<1	1	2	2	2	<1	2	2	2	9	9	11	8	6
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	7.8	8.2	7.5	7.5	7.6	8.01	7.4	7.46	8.7	9.4	8.6	7.9	13.8	13.0	13.3	13.0	8.42	14.3	48.3	49.4	9.2	8.9	9.64	10	9.68
Total Anions	meq/L	0.01	-	-	-	-	0.95	1.12	0.90	1.00	0.71	0.99	0.82	0.92	1.56	1.4	1.64	1.89	4.91	4.6	4.16	4.34	2.05	10.8	6.25	6.22	35.7	41.6	44.3	36.4	32.2
Total Cations	meq/L	0.01	-	-	-	-	0.83	0.85	0.78	0.96	0.91	0.82	0.78	0.82	1.47	1.2	1.88	1.99	4.77	4.45	4.37	4.67	2.02	6.47	5.91	6.16	37.1	46.6	45.8	39.1	32.5
Ionic Balance	%	0.01	-	-	-	-	-	-	-										1.54	1.74	2.46	3.59		24.9	2.79	0.47	1.93	5.71	1.63	2.18	0.55
Other Inorganics																															
Flouride	mg/L	0.1	-	2	2	1.5			<0.1	<0.1		<0.1	<0.1	<0.1					0.1	<0.1	<0.1		<0.1						<0.1	<0.1	<0.1
Free cyanide	mg/L	0.004	0.007	-	-	0.08			<0.004			<0.004											<0.004						<0.004		
Total cyanide	mg/L	0.004	-	-	-	-			<0.004			<0.004											<0.004						<0.004		
Thiocyanate	mg/L	0.1	-	-	-	-			<0.1			1.2											<0.1						<0.1		
Dissolved metals																															
Aluminium	mg/L	0.01	0.055	20	5	ID			0.02	0.04	0.07	0.05	0.02	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	<0.01	0.02	0.07	<0.01	<0.01	<0.01	0.02	<0.01	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01			<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.02	0.015	0.016	0.016	0.002	0.003	<0.001	<0.001	0.002	<0.001	<0.001	0.001	0.002
Beryllium	mg/L	0.001	ID	0.5	ID	0.06			<0.001			<0.001		<0.001					<0.001	<0.001			<0.001						<0.001		<0.001
Barium	mg/L	0.001	-	-	-	2			0.012			0.019	0.012	0.011					0.153	0.112	0.108		0.04						0.825	0.654	0.532
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002			<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0008	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05			<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-			0.002	0.002	0.003	0.002	0.002	0.003	0.001	<0.001	<0.001	<0.001	0.036	0.005	0.005	0.005	0.015	0.274	0.002	<0.001	0.009	0.005	0.005	0.006	0.005
Copper	mg/L	0.001	0.0014	5	1#	2			0.004	0.005	0.009	0.002	<0.001	0.002	0.003	0.002	<0.001	<0.001	<0.001	<0.001	0.003	<0.001	<0.001	0.014	<0.001	<0.001	<0.001	0.003	0.007	<0.001	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01			<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-			0.001			0.001		<0.001					0.021	0.023			0.009						0.147		0.101
Manganese	mg/L	0.001	1.9	10	-	0.5	0.053	0.039	0.043	0.04	0.073	0.043	0.039	0.078	0.405	0.41	0.427	0.452	0.656	0.54	0.571	0.565	1.24	0.278	0.02	0.001	1.25	1.21	1.19	1.27	1.48
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.006	0.004	0.005	0.004	<0.001	0.004	<0.001	<0.001	0.001	0.002	<0.001	0.001	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02			0.002	0.002	0.004	0.001	0.001	0.003	0.008	0.003	<0.001	<0.001	0.043	0.01	0.013	0.011	0.02	0.627	0.009	<0.001	0.02	0.011	0.009	0.01	0.011
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-			0.008			0.007	0.005	0.006					0.105	0.096	0.085		0.037						1.49	1.11	0.959
Tin	mg/L	0.001	ID	-	-	-			<0.001			<0.001		<0.001					<0.001	<0.001			<0.001						<0.001		<0.001
Uranium	mg/L	0.001	ID	0.1	0.2	0.017			<0.001			<0.001		<0.001					<0.001	<0.001			<0.001						0.001		<0.001
Vanadium	mg/L	0.01	ID	0.5	ID	-			<0.01			<0.01		<0.01					<0.01	<0.01			<0.01						<0.01		<0.01
Zinc	mg/L	0.005	0.008	5	20	ID			0.045	0.063	0.028	0.028	0.008	0.019	0.226	0.019	0.02	0.016	0.023	0.013	0.023	0.015	0.053	0.318	0.026	<0.005	0.024	0.021	0.021	0.011	0.007
Boron	mg/L	0.05	0.37	5	5	4			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	0.07	<0.05	<0.05	<0.05	0.14	<0.05	<0.05	<0.05	0.8	16.4	17.1	17.3	8.14	9.41	10.4	11.1	15.1	<0.05	0.16	<0.05	4.35	0.86	0.93	1.98	3.16
Ferrous iron	mg/L	0.05	-	-	-	ID							<0.05	<0.05							11.4	10.9								2.57	3.37
Bromine	mg/L	0.1	-	-	-	-			0.1			<0.01		<0.1					0.3	0.2			<0.1						3.2		2.3
Iodine	mg/L	0.1	-	-	-	ID			<0.1			<0.01		<0.1					<0.1	<0.1			<0.1						<0.1		<0.1
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001			<0.0001			<0.0001											<0.0001						<0.0001		
Total metals																															
Aluminium	mg/L	0.01	-	-	-	-			0.41			1.90		0.20									<0.01						0.99		0.02
Manganese	mg/L	0.001	-	-	-	-			0.05			0.06	0.043	0.08							0.576	0.549	1.24						1.38	1.28	1.34
Iron	mg/L	0.05	-	-	-	-			0.21			1.03	0.12	0.09							11.2	10.7	15.6						7.1	2.18	3.01
Nutrients																															
Ammonia as N	mg/L	0.01	2.57						0.04			<0.01		<0.01									<0.01						0.21		0.11
Nitrite as N	mg/L	0.01			9				<0.01	<0.01		<0.01		0.02									<0.01						<0.01		<0.01
Nitrate as N	mg/L	0.01			90				0.15	0.19		0.15		0.11									0.02						<0.01		0.01
Nitrite + Nitrate as N	mg/L	0.01																													0.01
Total phosphorous	mg/L	0.01							0.06			0.19											<0.01						0.08		
Reactive phosphorous	mg/L	0.01							<0.01	<0.01		<0.01		<0.01									<0.01						<0.01		<0.01
Biochemical oxygen demand	mg/L	2												<2																	<2
Isotopes																															
Oxygen-18	‰	0.01																													
Deuterium	‰	0.1																													
Carbon-13	‰	0.1																													
Radiocarbon	pMC	0.1																													
Radiocarbon Age (uncorrected)	yrs BP	1																													
Tritium	TU	0.01																													

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

Analyte	Units	LOR	Water Quality Criteria ANZECC (2000) Aquatic	Water Quality Criteria ANZECC (2000) Irrigation	Water Quality Criteria ANZECC (2000) Livestock	Water Quality Criteria ADWG (2011)	HU0142PZC 24/09/2014	HU0142PZC 3/12/2014	HU0142PZC 26/03/2015	HU0142PZC 30/06/2015	HU0142PZC 17/09/2015	HU0143PZC 4/12/2014	HU0143PZC 25/03/2015	HU0143PZC 25/06/2015	HU0143PZC 23/09/2015
General field parameters															
pH	pH units		6.5-7.5				6.36	6.43	6.30	6.11	6.08	6.1	6.21	6.00	5.88
Conductivity (field)	μS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium)			1900	1458	634	420.1	357	214	202.8	177.5	174
Conductivity (lab)	μS/cm	1	30-350	>2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)						416				165	140
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality)	1236	947	409	273	232	139	132	115	113
Total Dissolved Solids (lab)	mg/L	10				>900-1200 (poor quality) >1200 (unacceptable)			339	220	170			69	84
Dissolved oxygen	% sat		90-110				7.3	23.9	10.6	25.1	15.1	2.50	19.9	7.4	10.5
Redox	mV						-52.1	-52.9	-53.6	-4.7		12.8	61.3	26.3	-127.6
Temperature	ºC						19.97	22.77	18.5	15.8	16.39	21.51	19.2	15.6	15.45
Suspended Solids (lab)	mg/L	5								<5	<5			14	25
Turbidity	NTU	0.1	2-25								3.5				
Major ions															
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	185	170	98	83	59	50	48	41	47
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	185	170	98	83	59	50	48	41	47
Acidity as $CaCO_3$	mg/L	1	-	-	-	-				74				54	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	6	19	6	4	6	7	4	5	4
Chloride	mg/L	1	-	700	-	ID	514	339	129	69	62	21	32	19	18
Calcium	mg/L	1	-	-	1000	-	68	54	23	12	10	12	13	4	3
Magnesium	mg/L	1	-	-	ID	-	92	58	28	20	17	5	4	5	5
Sodium	mg/L	1	-	460	-	-	165	114	49	29	30	14	13	12	13
Potassium	mg/L	1	-	-	-	-	4	4	2	1	1	<1	<1	<1	<1
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	9.8	10	9.2	9.6	9.04	8	7.1	8	7.8
Total Anions	meq/L	0.01	-	-	-	-	18.3	13.4	5.72	3.69	3.05	1.74	1.95	1.46	1.53
Total Cations	meq/L	0.01	-	-	-	-	18.2	12.5	5.63	3.53	3.23	1.62	1.66	1.13	1.13
Ionic Balance	%	0.01	-	-	-	-	0.21	3.19	0.77	2.18	2.79				
Other Inorganics															
Flouride	mg/L	0.1	-	2	2	1.5			<0.1	<0.1	<0.1			<0.1	
Free cyanide	mg/L	0.004	0.007	-	-	0.08			<0.004						
Total cyanide	mg/L	0.004	-	-	-	-			<0.004						
Thiocyanate	mg/L	0.1	-	-	-	-			<0.1						
Dissolved metals															
Aluminium	mg/L	0.01	0.055	20	5	ID	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01	0.001	0.001	0.001	0.001	<0.001	0.001	<0.001	<0.001	<0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06			<0.001		<0.001				
Barium	mg/L	0.001	-	-	-	2			0.079	0.055	0.046			0.024	
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-	0.008	0.005	0.004	0.006	0.006	0.005	0.003	0.004	0.005
Copper	mg/L	0.001	0.0014	5	1#	2	<0.001	0.002	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-			0.02		0.013				
Manganese	mg/L	0.001	1.9	10	-	0.5	1.63	1.73	1.14	1.3	1.34	0.932	0.784	1	1.02
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02	0.015	0.016	0.008	0.009	0.01	0.009	0.006	0.009	0.008
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-			0.154	0.088	0.074			0.026	
Tin	mg/L	0.001	ID	-	-	-			<0.001		<0.001				
Uranium	mg/L	0.001	ID	0.1	0.2	0.017			<0.001		<0.001				
Vanadium	mg/L	0.01	ID	0.5	ID	-			<0.01		<0.01				
Zinc	mg/L	0.005	0.008	5	20	ID	0.026	0.012	0.01	0.017	0.012	0.028	0.025	0.013	0.012
Boron	mg/L	0.05	0.37	5	5	4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	7.74	8.5	5.88	7.56	8.32	11.5	2.17	14.4	14.2
Ferrous iron	mg/L	0.05	-	-	-	ID				8.87	8.39			15.6	15.4
Bromine	mg/L	0.1	-	-	-	-			0.3		0.2				
Iodine	mg/L	0.1	-	-	-	ID			<0.1		<0.1				
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001			<0.0001						
Total metals															
Aluminium	mg/L	0.01	-	-	-	-			1.86		0.02				
Manganese	mg/L	0.001	-	-	-	-			1.35	1.35	1.29			1.06	1.07
Iron	mg/L	0.05	-	-	-	-			9.32	8.02	8.26			16.9	17.1
Nutrients															
Ammonia as N	mg/L	0.01	2.57						0.01		0.02				
Nitrite as N	mg/L	0.01			9				<0.01		<0.01				
Nitrate as N	mg/L	0.01			90				<0.01		0.01				
Nitrite + Nitrate as N	mg/L	0.01									0.01				
Total phosphorous	mg/L	0.01							0.18						
Reactive phosphorous	mg/L	0.01							<0.01		<0.01				
Biochemical oxygen demand	mg/L	2									<2				
Isotopes															
Oxygen-18	‰	0.01													
Deuterium	‰	0.1													
Carbon-13	‰	0.1													
Radiocarbon	pMC	0.1													
Radiocarbon Age (uncorrected)	yrs BP	1													
Tritium	TU	0.01													

Analyte	n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
pH	130	130	119	4.05	7.95	5.34	5.91	0.66
Conductivity (field)	129	129	50	41	4882	480	259	801
Conductivity (lab)	23	23	11	36	3870	511	268	787
Total Dissolved Solids (field)	130	130		27	3172	308	168.11	506.45
Total Dissolved Solids (lab)	35	35		24	2430	349	158	594
Dissolved oxygen	130	129		1.5	118.1	31.1	22	25
Redox	129	129		-151.9	315.3	14.6		100
Temperature	130	130		12.4	33.1	18.2	18	3
Suspended Solids (lab)	18	4		14	25	20.50	20	5
Turbidity	4	4	0	3.5	13.2	8.45	8	4
Major ions								
Hydroxide Alkalinity as $CaCO_3$	131	0						
Carbonate Alkalinity as $CaCO_3$	131	0						
Bicarbonate Alkalinity as $CaCO_3$	131	130		2	446	73	36	80
Total Alkalinity as $CaCO_3$	131	130		2	446	73	36	80
Acidity as $CaCO_3$	51	36		1	103	17.58	7	25
Sulfate as SO_4^{2-}	131	128	0	1	159	14.9	8	21
Chloride	131	116	5	1	1300	104.7	33	223
Calcium	131	105	0	1	198	22.1	11	36
Magnesium	131	126		1	236	23.1	11	40
Sodium	131	99	0	1	406	47.9	27	74
Potassium	129	96		1	14.2	5.35	4	3
Silica/Silicon as SiO_2/Reactive silica	98	88		7.1	49.4	10.1	9	6
Total Anions								
Total Cations								
Ionic Balance								
Other Inorganics								
Flouride	40	9	0	0.1	0.1	0.10	0.10	0.00
Free cyanide	18	0	0					
Total cyanide	18	1		0.004	0.004	0.00	0.004	
Thiocyanate	13	1		1.2	1.2	1.20	1.2	
Dissolved metals								
Aluminium	88	41	10	0.01	0.41	0.05	0.03	0.08
Antimony	88	2	0	0.002	0.002	0.002	0.00	0.00
Arsenic	88	34	8	0.001	0.044	0.008	0.00	0.01
Beryllium	30	0						
Barium	39	39	0	0.003	0.825	0.136	0.06	0.19
Cadmium	88	9	4	0.0001	0.0008	0.000	0.00	0.00
Chromium	88	5	3	0.001	0.008	0.003	0.00	0.00
Cobalt	88	61	2	0.001	0.274	0.015	0.01	0.04
Copper	88	43	39	0.001	0.257	0.015	0.005	0.042
Lead	88	12	1	0.001	0.006	0.002	0.002	0.00
Lithium	28	25	0	0.001	0.147	0.026	0.01	0.03
Manganese	131	131	0	0.001	1.73	0.463	0.24	0.40
Molybdenum	88	22	0	0.001	0.011	0.004	0.00	0.00
Nickel	88	74	25	0.001	0.627	0.023	0.009	0.076
Selenium	88	2	2	0.11	0.16	0.135	0.13	0.04
Strontium	39	39		0.004	1.49	0.164	0.06	0.31
Tin	27	1		0.001	0.001	0.001	0.001	
Uranium	30	1	0	0.001	0.001	0.001	0.00	
Vanadium	30	0						
Zinc	88	81	75	0.006	0.318	0.056	0.032	0.069
Boron	88	0	0					
Iron	131	105	30	0.05	21.9	7.2	3.56	5.49
Ferrous iron	18	16	8	2.57	16.1	9.64	8.36	4.72
Bromine	30	19		0.1	3.2	0.526	0.30	0.81
Iodine	27	0						
Mercury	18	0	0					
Total metals								
Aluminium	24	18		0.01	1.9	0.50	0.19	0.59
Manganese	38	38		0.016	15.9	1.040	0.42	2.52
Iron	38	35		0.09	22	8.8	4.88	6.06
Nutrients								
Ammonia as N	23	16	0	0.01	0.78	0.12	0.06	0.19
Nitrite as N	31	1	0	0.02	0.02	0.02	0.02	
Nitrate as N	31	25	0	0.01	0.77	0.09	0.04	0.16
Nitrite + Nitrate as N	2	2		0.01	0.01	0.01	0.01	0.00
Total phosphorous	19	12		0.02	0.19	0.07	0.05	0.06
Reactive phosphorous	31	0						
Biochemical oxygen demand	4	0						
Isotopes								
Oxygen-18								
Deuterium								
Carbon-13								
Radiocarbon								
Radiocarbon Age (uncorrected)								
Tritium								

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0018PZB										HU0019PZB						HU0023PZB				HU0023PZC			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	17/10/2011	7/01/2013	22/03/2013	9/07/2013	16/10/2013	12/12/2013	8/04/2014	25/03/2015	2/07/2015	24/09/2015	18/10/2011	29/08/2012	4/01/2013	17/12/2013	9/04/2014	4/02/2015	16/11/2011	18/12/2012	25/03/2013	21/05/2014	15/11/2011	18/12/2012	25/03/2013	21/05/2014
Organochloride pesticides																														
alpha-BHC	µg/L	0.5										<0.5				<0.5				<0.5										
Hexachlorobenzene (HCB)	µg/L	0.5										<0.5				<0.5				<0.5										
beta-BHC	µg/L	0.5										<0.5				<0.5				<0.5										
gamma-BHC	µg/L	0.5										<0.5				<0.5				<0.5										
delta-BHC	µg/L	0.5										<0.5				<0.5				<0.5										
Heptachlor	µg/L	0.5										<0.5				<0.5				<0.5										
Aldrin	µg/L	0.5										<0.5				<0.5				<0.5										
Heptachlor epoxide	µg/L	0.5										<0.5				<0.5				<0.5										
trans-Chlordane	µg/L	0.5										<0.5				<0.5				<0.5										
alpha-Endosulfan	µg/L	0.5										<0.5				<0.5				<0.5										
cis-Chlordane	µg/L	0.5										<0.5				<0.5				<0.5										
Dieldrin	µg/L	0.5										<0.5				<0.5				<0.5										
4.4`-DDE	µg/L	0.5										<0.5				<0.5				<0.5										
Endrin	µg/L	0.5										<0.5				<0.5				<0.5										
beta-Endosulfan	µg/L	0.5										<0.5				<0.5				<0.5										
4.4`-DDD	µg/L	0.5										<0.5				<0.5				<0.5										
Endrin aldehyde	µg/L	0.5										<0.5				<0.5				<0.5										
Endosulfan sulfate	µg/L	0.5										<0.5				<0.5				<0.5										
4.4`-DDT	µg/L	2										<2.0				<2.0				<2.0										
Endrin ketone	µg/L	0.5										<0.5				<0.5				<0.5										
Methoxychlor	µg/L	2										<2.0				<2.0				<2.0										
Total Chlordane (sum)	µg/L	0.5										<0.5				<0.5				<0.5										
Sum of DDD + DDE + DDT	µg/L	0.5										<0.5				<0.5				<0.5										
Sum of Aldrin + Dieldrin	µg/L	0.5										<0.5				<0.5				<0.5										
Organophosphorous pesticides																														
Dichlorvos	µg/L	0.5										<0.5				<0.5				<0.5										
Demeton-S-methyl	µg/L	0.5										<0.5				<0.5				<0.5										
Monocrotophos	µg/L	2										<2.0				<2.0				<2.0										
Dimethoate	µg/L	0.5										<0.5				<0.5				<0.5										
Diazinon	µg/L	0.5										<0.5				<0.5				<0.5										
Chlorpyrifos-methyl	µg/L	0.5										<0.5				<0.5				<0.5										
Parathion-methyl	µg/L	2										<2.0				<2.0				<2.0										
Malathion	µg/L	0.5										<0.5				<0.5				<0.5										
Fenthion	µg/L	0.5										<0.5				<0.5				<0.5										
Chlorpyrifos	µg/L	0.5										<0.5				<0.5				<0.5										
Parathion	µg/L	2										<2.0				<2.0				<2.0										
Pirimphos-ethyl	µg/L	0.5										<0.5				<0.5				<0.5										
Chlorfenvinphos	µg/L	0.5										<0.5				<0.5				<0.5										
Bromophos-ethyl	µg/L	0.5										<0.5				<0.5				<0.5										
Fenamiphos	µg/L	0.5										<0.5				<0.5				<0.5										
Prothiofos	µg/L	0.5										<0.5				<0.5				<0.5										
Ethion	µg/L	0.5										<0.5				<0.5				<0.5										
Carbophenothion	µg/L	0.5										<0.5				<0.5				<0.5										
Azinphos Methyl	µg/L	0.5										<0.5				<0.5				<0.5										
Phenolic compounds																														
Phenol	µg/L	1										<1.0				<1.0				<1.0										
2-Chlorophenol	µg/L	1										<1.0				<1.0				<1.0										
2-Methylphenol	µg/L	1										<1.0				<1.0				<1.0										
3- & 4-Methylphenol	µg/L	1										<2.0				<2.0				<2.0										
2-Nitrophenol	µg/L	2										<1.0				<1.0				<1.0										
2.4-Dimethylphenol	µg/L	1										<1.0				<1.0				<1.0										
2.4-Dichlorophenol	µg/L	1										<1.0				<1.0				<1.0										
2.6-Dichlorophenol	µg/L	1										<1.0				<1.0				<1.0										
4-Chloro-3-methylphenol	µg/L	1										<1.0				<1.0				<1.0										
2.4.6-Trichlorophenol	µg/L	1										<1.0				<1.0				<1.0										
2.4.5-Trichlorophenol	µg/L	1										<1.0				<1.0				<1.0										
Pentachlorophenol	µg/L	1										<2.0				<2.0				<2.0										
Polynuclear aromatic hydrocarbons																														
Naphthalene	µg/L	1										<1.0				<1.0				<1.0										
Acenaphthylene	µg/L	1										<1.0				<1.0				<1.0										
Acenaphthene	µg/L	1										<1.0				<1.0				<1.0										
Fluorene	µg/L	1										<1.0				<1.0				<1.0										
Phenanthrene	µg/L	1										<1.0				<1.0				<1.0										
Anthracene	µg/L	1										<1.0				<1.0				<1.0										
Fluoranthene	µg/L	1										<1.0				<1.0				<1.0										
Pyrene	µg/L	1										<1.0				<1.0				<1.0										
Benz(a)anthracene	µg/L	1										<1.0				<1.0				<1.0										
Chrysene	µg/L	1										<1.0				<1.0				<1.0										
Benzo(b)fluoranthene	µg/L	1										<1.0				<1.0				<1.0										
Benzo(k)fluoranthene	µg/L	1										<1.0				<1.0				<1.0										
Benzo(a)pyrene	µg/L	0.5										<0.5				<0.5				<0.5										
Indeno(1.2.3.cd)pyrene	µg/L	1										<1.0				<1.0				<1.0										
Dibenz(a.h)anthracene	µg/L	1										<1.0				<1.0				<1.0										
Benzo(g.h.i)perylene	µg/L	1										<1.0				<1.0				<1.0										
Sum of polycyclic aromatic hydrocarbor	µg/L	0.5										<0.5				<0.5				<0.5										
Benzo(a)pyrene TEQ (zero)	µg/L	0.5										<0.5				<0.5				<0.5										

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0032LDB				HU0037PZB				HU0038PZC								HU0042PZC					HU0043PZB			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	12/12/2013	3/04/2014	26/03/2015	24/09/2015	29/08/2012	20/12/2012	18/12/2013	3/02/2015	24/07/2012	14/12/2012	11/12/2013	2/04/2014	15/08/2014	2/12/2014	12/02/2015	15/09/2015	26/03/2013	3/07/2013	19/08/2013	17/12/2013	2/02/2015	31/08/2012	3/01/2013	18/12/2013	5/02/2015
Organochloride pesticides																															
alpha-BHC	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Hexachlorobenzene (HCB)	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
beta-BHC	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
gamma-BHC	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
delta-BHC	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Heptachlor	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Aldrin	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Heptachlor epoxide	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
trans-Chlordane	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
alpha-Endosulfan	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
cis-Chlordane	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Dieldrin	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
4.4`-DDE	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Endrin	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
beta-Endosulfan	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
4.4`-DDD	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Endrin aldehyde	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Endosulfan sulfate	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
4.4`-DDT	µg/L	2					<2.0						<2.0				<2.0				<2.0					<2.0					
Endrin ketone	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Methoxychlor	µg/L	2					<2.0						<2.0				<2.0				<2.0					<2.0					
Total Chlordane (sum)	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Sum of DDD + DDE + DDT	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Sum of Aldrin + Dieldrin	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Organophosphorous pesticides																															
Dichlorvos	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Demeton-S-methyl	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Monocrotophos	µg/L	2					<2.0						<2.0				<2.0				<2.0					<2.0					
Dimethoate	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Diazinon	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Chlorpyrifos-methyl	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Parathion-methyl	µg/L	2					<2.0						<2.0				<2.0				<2.0					<2.0					
Malathion	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Fenthion	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Chlorpyrifos	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Parathion	µg/L	2					<2.0						<2.0				<2.0				<2.0					<2.0					
Pirimphos-ethyl	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Chlorfenvinphos	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Bromophos-ethyl	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Fenamiphos	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Prothiofos	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Ethion	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Carbophenothion	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Azinphos Methyl	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Phenolic compounds																															
Phenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
2-Chlorophenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
2-Methylphenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
3- & 4-Methylphenol	µg/L	1					<2.0						<2.0				<2.0				4.7					<2.0					
2-Nitrophenol	µg/L	2					<1.0						<1.0				<1.0				<1.0					<1.0					
2.4-Dimethylphenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
2.4-Dichlorophenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
2.6-Dichlorophenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
4-Chloro-3-methylphenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
2.4.6-Trichlorophenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
2.4.5-Trichlorophenol	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Pentachlorophenol	µg/L	1					<2.0						<2.0				<2.0				<2.0					<2.0					
Polynuclear aromatic hydrocarbons																															
Naphthalene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Acenaphthylene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Acenaphthene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Fluorene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Phenanthrene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Anthracene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Fluoranthene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Pyrene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Benz(a)anthracene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Chrysene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Benzo(b)fluoranthene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Benzo(k)fluoranthene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Benzo(a)pyrene	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Indeno(1.2.3.cd)pyrene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Dibenz(a.h)anthracene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Benzo(g.h.i)perylene	µg/L	1					<1.0						<1.0				<1.0				<1.0					<1.0					
Sum of polycyclic aromatic hydrocarbor	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					
Benzo(a)pyrene TEQ (zero)	µg/L	0.5					<0.5						<0.5				<0.5				<0.5					<0.5					

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0044XPZB									HU0056XPZB					HU0072PZB									
Analyte	**Units**	**LOR**	**Aquatic**	**ANZECC (2000) Irrigation**	**Livestock**	**ADWG (2011)**	23/08/2012	14/12/2012	26/03/2013	2/07/2013	18/09/2013	10/12/2013	25/03/2014	24/07/2014	3/02/2015	19/12/2012	19/12/2013	25/09/2014	13/11/2014	5/02/2015	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	17/09/2015
Organochloride pesticides																														
alpha-BHC	µg/L	0.5																						<0.5						
Hexachlorobenzene (HCB)	µg/L	0.5																						<0.5						
beta-BHC	µg/L	0.5																						<0.5						
gamma-BHC	µg/L	0.5																						<0.5						
delta-BHC	µg/L	0.5																						<0.5						
Heptachlor	µg/L	0.5																						<0.5						
Aldrin	µg/L	0.5																						<0.5						
Heptachlor epoxide	µg/L	0.5																						<0.5						
trans-Chlordane	µg/L	0.5																						<0.5						
alpha-Endosulfan	µg/L	0.5																						<0.5						
cis-Chlordane	µg/L	0.5																						<0.5						
Dieldrin	µg/L	0.5																						<0.5						
4.4`-DDE	µg/L	0.5																						<0.5						
Endrin	µg/L	0.5																						<0.5						
beta-Endosulfan	µg/L	0.5																						<0.5						
4.4`-DDD	µg/L	0.5																						<0.5						
Endrin aldehyde	µg/L	0.5																						<0.5						
Endosulfan sulfate	µg/L	0.5																						<0.5						
4.4`-DDT	µg/L	2																						<2.0						
Endrin ketone	µg/L	0.5																						<0.5						
Methoxychlor	µg/L	2																						<2.0						
Total Chlordane (sum)	µg/L	0.5																						<0.5						
Sum of DDD + DDE + DDT	µg/L	0.5																						<0.5						
Sum of Aldrin + Dieldrin	µg/L	0.5																						<0.5						
Organophosphorous pesticides																														
Dichlorvos	µg/L	0.5																						<0.5						
Demeton-S-methyl	µg/L	0.5																						<0.5						
Monocrotophos	µg/L	2																						<2.0						
Dimethoate	µg/L	0.5																						<0.5						
Diazinon	µg/L	0.5																						<0.5						
Chlorpyrifos-methyl	µg/L	0.5																						<0.5						
Parathion-methyl	µg/L	2																						<2.0						
Malathion	µg/L	0.5																						<0.5						
Fenthion	µg/L	0.5																						<0.5						
Chlorpyrifos	µg/L	0.5																						<0.5						
Parathion	µg/L	2																						<2.0						
Pirimphos-ethyl	µg/L	0.5																						<0.5						
Chlorfenvinphos	µg/L	0.5																						<0.5						
Bromophos-ethyl	µg/L	0.5																						<0.5						
Fenamiphos	µg/L	0.5																						<0.5						
Prothiofos	µg/L	0.5																						<0.5						
Ethion	µg/L	0.5																						<0.5						
Carbophenothion	µg/L	0.5																						<0.5						
Azinphos Methyl	µg/L	0.5																						<0.5						
Phenolic compounds																														
Phenol	µg/L	1																						<1.0						
2-Chlorophenol	µg/L	1																						<1.0						
2-Methylphenol	µg/L	1																						<1.0						
3- & 4-Methylphenol	µg/L	1																						<2.0						
2-Nitrophenol	µg/L	2																						<1.0						
2.4-Dimethylphenol	µg/L	1																						<1.0						
2.4-Dichlorophenol	µg/L	1																						<1.0						
2.6-Dichlorophenol	µg/L	1																						<1.0						
4-Chloro-3-methylphenol	µg/L	1																						<1.0						
2.4.6-Trichlorophenol	µg/L	1																						<1.0						
2.4.5-Trichlorophenol	µg/L	1																						<1.0						
Pentachlorophenol	µg/L	1																						<2.0						
Polynuclear aromatic hydrocarbons																														
Naphthalene	µg/L	1																						<1.0						
Acenaphthylene	µg/L	1																						<1.0						
Acenaphthene	µg/L	1																						<1.0						
Fluorene	µg/L	1																						<1.0						
Phenanthrene	µg/L	1																						<1.0						
Anthracene	µg/L	1																						<1.0						
Fluoranthene	µg/L	1																						<1.0						
Pyrene	µg/L	1																						<1.0						
Benz(a)anthracene	µg/L	1																						<1.0						
Chrysene	µg/L	1																						<1.0						
Benzo(b)fluoranthene	µg/L	1																						<1.0						
Benzo(k)fluoranthene	µg/L	1																						<1.0						
Benzo(a)pyrene	µg/L	0.5																						<0.5						
Indeno(1.2.3.cd)pyrene	µg/L	1																						<1.0						
Dibenz(a.h)anthracene	µg/L	1																						<1.0						
Benzo(g.h.i)perylene	µg/L	1																						<1.0						
Sum of polycyclic aromatic hydrocarbor	µg/L	0.5																						<0.5						
Benzo(a)pyrene TEQ (zero)	µg/L	0.5																						<0.5						

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0072PZC										HU0073PZC									HU0088PZB				
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	15/09/2015	27/03/2013	7/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	10/12/2013	2/04/2014	26/09/2014	3/12/2014	11/02/2015
Organochloride pesticides																														
alpha-BHC	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Hexachlorobenzene (HCB)	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
beta-BHC	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
gamma-BHC	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
delta-BHC	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Heptachlor	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Aldrin	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Heptachlor epoxide	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
trans-Chlordane	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
alpha-Endosulfan	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
cis-Chlordane	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Dieldrin	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
4.4`-DDE	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Endrin	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
beta-Endosulfan	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
4.4`-DDD	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Endrin aldehyde	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Endosulfan sulfate	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
4.4`-DDT	µg/L	2								<2.0										<2.0			<2.0		<2.0					<2.0
Endrin ketone	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Methoxychlor	µg/L	2								<2.0										<2.0			<2.0		<2.0					<2.0
Total Chlordane (sum)	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Sum of DDD + DDE + DDT	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Sum of Aldrin + Dieldrin	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Organophosphorous pesticides																														
Dichlorvos	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Demeton-S-methyl	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Monocrotophos	µg/L	2								<2.0										<2.0			<2.0		<2.0					<2.0
Dimethoate	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Diazinon	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Chlorpyrifos-methyl	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Parathion-methyl	µg/L	2								<2.0										<2.0			<2.0		<2.0					<2.0
Malathion	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Fenthion	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Chlorpyrifos	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Parathion	µg/L	2								<2.0										<2.0			<2.0		<2.0					<2.0
Pirimphos-ethyl	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Chlorfenvinphos	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Bromophos-ethyl	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Fenamiphos	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Prothiofos	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Ethion	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Carbophenothion	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Azinphos Methyl	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Phenolic compounds																														
Phenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
2-Chlorophenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
2-Methylphenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
3- & 4-Methylphenol	µg/L	1								<2.0										<2.0			<2.0		<2.0					<2.0
2-Nitrophenol	µg/L	2								<1.0										<1.0			<1.0		<1.0					<1.0
2.4-Dimethylphenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
2.4-Dichlorophenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
2.6-Dichlorophenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
4-Chloro-3-methylphenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
2.4.6-Trichlorophenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
2.4.5-Trichlorophenol	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Pentachlorophenol	µg/L	1								<2.0										<2.0			<2.0		<2.0					<2.0
Polynuclear aromatic hydrocarbons																														
Naphthalene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Acenaphthylene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Acenaphthene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Fluorene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Phenanthrene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Anthracene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Fluoranthene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Pyrene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Benz(a)anthracene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Chrysene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Benzo(b)fluoranthene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Benzo(k)fluoranthene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Benzo(a)pyrene	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Dibenz(a.h)anthracene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Benzo(g.h.i)perylene	µg/L	1								<1.0										<1.0			<1.0		<1.0					<1.0
Sum of polycyclic aromatic hydrocarbon	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5								<0.5										<0.5			<0.5		<0.5					<0.5

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0096PZC								HU0118PZA				HU0129PZB				HU0133PZC	HU0136PZB			HU0142PZB				
Analyte	Units	LOR	ANZECC (2000) Aquatic	Irrigation	Livestock	ADWG (2011)	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	20/03/2014	25/08/2014	1/12/2014	6/02/2015	22/05/2014	10/02/2015	24/06/2015	16/09/2015	23/05/2014	29/08/2014	1/12/2014	4/02/2015	24/09/2014	1/12/2014	26/03/2015	30/06/2015	17/09/2015
Organochloride pesticides																															
alpha-BHC	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Hexachlorobenzene (HCB)	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
beta-BHC	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
gamma-BHC	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
delta-BHC	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Heptachlor	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Aldrin	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Heptachlor epoxide	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
trans-Chlordane	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
alpha-Endosulfan	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
cis-Chlordane	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Dieldrin	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
4.4`-DDE	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Endrin	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
beta-Endosulfan	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
4.4`-DDD	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Endrin aldehyde	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Endosulfan sulfate	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
4.4`-DDT	µg/L	2							<2.0			<2.0		<2.0															<2.0		<2.0
Endrin ketone	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Methoxychlor	µg/L	2							<2.0			<2.0		<2.0															<2.0		<2.0
Total Chlordane (sum)	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Sum of DDD + DDE + DDT	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Sum of Aldrin + Dieldrin	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Organophosphorous pesticides																															
Dichlorvos	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Demeton-S-methyl	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Monocrotophos	µg/L	2							<2.0			<2.0		<2.0															<2.0		<2.0
Dimethoate	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Diazinon	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Chlorpyrifos-methyl	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Parathion-methyl	µg/L	2							<2.0			<2.0		<2.0															<2.0		<2.0
Malathion	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Fenthion	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Chlorpyrifos	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Parathion	µg/L	2							<2.0			<2.0		<2.0															<2.0		<2.0
Pirimphos-ethyl	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Chlorfenvinphos	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Bromophos-ethyl	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Fenamiphos	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Prothiofos	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Ethion	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Carbophenothion	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Azinphos Methyl	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Phenolic compounds																															
Phenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
2-Chlorophenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
2-Methylphenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
3- & 4-Methylphenol	µg/L	1							<2.0			<2.0		<2.0															<2.0		<2.0
2-Nitrophenol	µg/L	2							<1.0			<1.0		<1.0															<1.0		<1.0
2.4-Dimethylphenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
2.4-Dichlorophenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
2.6-Dichlorophenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
4-Chloro-3-methylphenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
2.4.6-Trichlorophenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
2.4.5-Trichlorophenol	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Pentachlorophenol	µg/L	1							<2.0			<2.0		<2.0															<2.0		<2.0
Polynuclear aromatic hydrocarbons																															
Naphthalene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Acenaphthylene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Acenaphthene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Fluorene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Phenanthrene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Anthracene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Fluoranthene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Pyrene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Benz(a)anthracene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Chrysene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Benzo(b)fluoranthene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Benzo(k)fluoranthene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Benzo(a)pyrene	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Dibenz(a.h)anthracene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Benzo(g.h.i)perylene	µg/L	1							<1.0			<1.0		<1.0															<1.0		<1.0
Sum of polycyclic aromatic hydrocarbon	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5
Benzo(a)pyrene TEQ (zero)	µg/L	0.5							<0.5			<0.5		<0.5															<0.5		<0.5

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0142PZC					HU0143PZC			
Analyte	Units	LOR	ANZECC (2000) Aquatic	ANZECC (2000) Irrigation	ANZECC (2000) Livestock	ADWG (2011)	24/09/2014	3/12/2014	26/03/2015	30/06/2015	17/09/2015	4/12/2014	25/03/2015	25/06/2015	23/09/2015
Organochloride pesticides															
alpha-BHC	µg/L	0.5							<0.5		<0.5				
Hexachlorobenzene (HCB)	µg/L	0.5							<0.5		<0.5				
beta-BHC	µg/L	0.5							<0.5		<0.5				
gamma-BHC	µg/L	0.5							<0.5		<0.5				
delta-BHC	µg/L	0.5							<0.5		<0.5				
Heptachlor	µg/L	0.5							<0.5		<0.5				
Aldrin	µg/L	0.5							<0.5		<0.5				
Heptachlor epoxide	µg/L	0.5							<0.5		<0.5				
trans-Chlordane	µg/L	0.5							<0.5		<0.5				
alpha-Endosulfan	µg/L	0.5							<0.5		<0.5				
cis-Chlordane	µg/L	0.5							<0.5		<0.5				
Dieldrin	µg/L	0.5							<0.5		<0.5				
4.4`-DDE	µg/L	0.5							<0.5		<0.5				
Endrin	µg/L	0.5							<0.5		<0.5				
beta-Endosulfan	µg/L	0.5							<0.5		<0.5				
4.4`-DDD	µg/L	0.5							<0.5		<0.5				
Endrin aldehyde	µg/L	0.5							<0.5		<0.5				
Endosulfan sulfate	µg/L	0.5							<0.5		<0.5				
4.4`-DDT	µg/L	2							<2.0		<2.0				
Endrin ketone	µg/L	0.5							<0.5		<0.5				
Methoxychlor	µg/L	2							<2.0		<2.0				
Total Chlordane (sum)	µg/L	0.5							<0.5		<0.5				
Sum of DDD + DDE + DDT	µg/L	0.5							<0.5		<0.5				
Sum of Aldrin + Dieldrin	µg/L	0.5							<0.5		<0.5				
Organophosphorous pesticides															
Dichlorvos	µg/L	0.5							<0.5		<0.5				
Demeton-S-methyl	µg/L	0.5							<0.5		<0.5				
Monocrotophos	µg/L	2							<2.0		<2.0				
Dimethoate	µg/L	0.5							<0.5		<0.5				
Diazinon	µg/L	0.5							<0.5		<0.5				
Chlorpyrifos-methyl	µg/L	0.5							<0.5		<0.5				
Parathion-methyl	µg/L	2							<2.0		<2.0				
Malathion	µg/L	0.5							<0.5		<0.5				
Fenthion	µg/L	0.5							<0.5		<0.5				
Chlorpyrifos	µg/L	0.5							<0.5		<0.5				
Parathion	µg/L	2							<2.0		<2.0				
Pirimphos-ethyl	µg/L	0.5							<0.5		<0.5				
Chlorfenvinphos	µg/L	0.5							<0.5		<0.5				
Bromophos-ethyl	µg/L	0.5							<0.5		<0.5				
Fenamiphos	µg/L	0.5							<0.5		<0.5				
Prothiofos	µg/L	0.5							<0.5		<0.5				
Ethion	µg/L	0.5							<0.5		<0.5				
Carbophenothion	µg/L	0.5							<0.5		<0.5				
Azinphos Methyl	µg/L	0.5							<0.5		<0.5				
Phenolic compounds															
Phenol	µg/L	1							<1.0		<1.0				
2-Chlorophenol	µg/L	1							<1.0		<1.0				
2-Methylphenol	µg/L	1							<1.0		<1.0				
3- & 4-Methylphenol	µg/L	1							<2.0		<2.0				
2-Nitrophenol	µg/L	2							<1.0		<1.0				
2.4-Dimethylphenol	µg/L	1							<1.0		<1.0				
2.4-Dichlorophenol	µg/L	1							<1.0		<1.0				
2.6-Dichlorophenol	µg/L	1							<1.0		<1.0				
4-Chloro-3-methylphenol	µg/L	1							<1.0		<1.0				
2.4.6-Trichlorophenol	µg/L	1							<1.0		<1.0				
2.4.5-Trichlorophenol	µg/L	1							<1.0		<1.0				
Pentachlorophenol	µg/L	1							<2.0		<2.0				
Polynuclear aromatic hydrocarbons															
Naphthalene	µg/L	1							<1.0		<1.0				
Acenaphthylene	µg/L	1							<1.0		<1.0				
Acenaphthene	µg/L	1							<1.0		<1.0				
Fluorene	µg/L	1							<1.0		<1.0				
Phenanthrene	µg/L	1							<1.0		<1.0				
Anthracene	µg/L	1							<1.0		<1.0				
Fluoranthene	µg/L	1							<1.0		<1.0				
Pyrene	µg/L	1							<1.0		<1.0				
Benz(a)anthracene	µg/L	1							<1.0		<1.0				
Chrysene	µg/L	1							<1.0		<1.0				
Benzo(b)fluoranthene	µg/L	1							<1.0		<1.0				
Benzo(k)fluoranthene	µg/L	1							<1.0		<1.0				
Benzo(a)pyrene	µg/L	0.5							<0.5		<0.5				
Indeno(1.2.3.cd)pyrene	µg/L	1							<1.0		<1.0				
Dibenz(a.h)anthracene	µg/L	1							<1.0		<1.0				
Benzo(g.h.i)perylene	µg/L	1							<1.0		<1.0				
Sum of polycyclic aromatic hydrocarbor	µg/L	0.5							<0.5		<0.5				
Benzo(a)pyrene TEQ (zero)	µg/L	0.5							<0.5		<0.5				

Analyte	n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
Organochloride pesticides								
alpha-BHC	21	0						
Hexachlorobenzene (HCB)	21	0						
beta-BHC	21	0						
gamma-BHC	21	0						
delta-BHC	21	0						
Heptachlor	21	0						
Aldrin	21	0						
Heptachlor epoxide	21	0						
trans-Chlordane	21	0						
alpha-Endosulfan	21	0						
cis-Chlordane	21	0						
Dieldrin	21	0						
4.4`-DDE	21	0						
Endrin	21	0						
beta-Endosulfan	21	0						
4.4`-DDD	21	0						
Endrin aldehyde	21	0						
Endosulfan sulfate	21	0						
4.4`-DDT	21	0						
Endrin ketone	21	0						
Methoxychlor	21	0						
Total Chlordane (sum)	21	0						
Sum of DDD + DDE + DDT	21	0						
Sum of Aldrin + Dieldrin	21	0						
Organophosphorous pesticides								
Dichlorvos	21	0						
Demeton-S-methyl	21	0						
Monocrotophos	21	0						
Dimethoate	21	0						
Diazinon	21	0						
Chlorpyrifos-methyl	21	0						
Parathion-methyl	21	0						
Malathion	21	0						
Fenthion	21	0						
Chlorpyrifos	21	0						
Parathion	21	0						
Pirimphos-ethyl	21	0						
Chlorfenvinphos	21	0						
Bromophos-ethyl	21	0						
Fenamiphos	21	0						
Prothiofos	21	0						
Ethion	21	0						
Carbophenothion	21	0						
Azinphos Methyl	21	0						
Phenolic compounds								
Phenol	21	0						
2-Chlorophenol	21	0						
2-Methylphenol	21	0						
3- & 4-Methylphenol	21	1		4.7	4.7	4.7		
2-Nitrophenol	21	0						
2.4-Dimethylphenol	21	0						
2.4-Dichlorophenol	21	0						
2.6-Dichlorophenol	21	0						
4-Chloro-3-methylphenol	21	0						
2.4.6-Trichlorophenol	21	0						
2.4.5-Trichlorophenol	21	0						
Pentachlorophenol	21	0						
Polynuclear aromatic hydrocarbons								
Naphthalene	21	0						
Acenaphthylene	21	0						
Acenaphthene	21	0						
Fluorene	21	0						
Phenanthrene	21	0						
Anthracene	21	0						
Fluoranthene	21	0						
Pyrene	21	0						
Benz(a)anthracene	21	0						
Chrysene	21	0						
Benzo(b)fluoranthene	21	0						
Benzo(k)fluoranthene	21	0						
Benzo(a)pyrene	21	0						
Indeno(1.2.3.cd)pyrene	21	0						
Dibenz(a.h)anthracene	21	0						
Benzo(g.h.i)perylene	21	0						
Sum of polycyclic aromatic hydrocarbor	21	0						
Benzo(a)pyrene TEQ (zero)	21	0						

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0018PZB										HU0019PZB						HU0023PZB				HU0023PZC			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	17/10/2011	7/01/2013	22/03/2013	9/07/2013	16/10/2013	12/12/2013	8/04/2014	25/03/2015	2/07/2015	24/09/2015	18/10/2011	29/08/2012	4/01/2013	17/12/2013	9/04/2014	4/02/2015	16/11/2011	18/12/2012	25/03/2013	21/05/2014	15/11/2011	18/12/2012	25/03/2013	21/05/2014
BTEX																														
Benzene	µg/L	1										<1				<1				<1										
Toluene	µg/L	2	ID			800						<2				<2				<2										
Ethylbenzene	µg/L	2										<2				<2				<2										
meta- & para-Xylene	µg/L	2										<2				<2				<2										
ortho-Xylene	µg/L	2										<2				<2				<2										
Total Xylenes	µg/L	2										<2				<2				<2										
Sum of BTEX	µg/L	1										<1				<1				<1										
Naphthalene	µg/L	5										<5				<5				<5										
Total petroleum hydrocarbons																														
C6 - C9 Fraction	µg/L	20										<20				<20				<20										
C10 - C14 Fraction	µg/L	50										<50				<50				<50										
C15 - C28 Fraction	µg/L	100										<100				<100				<100										
C29 - C36 Fraction	µg/L	50										<50				<50				<50										
C10 - C36 Fraction (sum)	µg/L	50										<50				<50				<50										
Total Recoverable Hydrocarbons																														
C6 - C10 Fraction	µg/L	20										<20				<20				<20										
C6 - C10 Fraction minus BTEX (F1)	µg/L	20										<20				<20				<20										
>C10 - C16 Fraction	µg/L	100										<100				<100				<100										
>C16 - C34 Fraction	µg/L	100										<100				<100				<100										
>C34 - C40 Fraction	µg/L	100										<100				<100				<100										
>C10 - C40 Fraction (sum)	µg/L	100										<100				<100				<100										
>C10 - C16 Fraction minus Naphthalen	µg/L	100										<100				<100				<100										
Microbiology																														
Faecal coliforms	CFU/100 mL	1										<1				<1				<1										
E coli	CFU/100 mL	1										<1				<1				<1										
Total coliforms	CFU/100 mL	1										<1				<1				<1										

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0032LDB				HU0037PZB				HU0038PZC								HU0042PZC					HU0043PZB			
Analyte	**Units**	**LOR**	**Aquatic**	**ANZECC (2000) Irrigation**	**Livestock**	**ADWG (2011)**	12/12/2013	3/04/2014	26/03/2015	24/09/2015	29/08/2012	20/12/2012	18/12/2013	3/02/2015	24/07/2012	14/12/2012	11/12/2013	2/04/2014	15/08/2014	2/12/2014	12/02/2015	15/09/2015	26/03/2013	3/07/2013	19/08/2013	17/12/2013	2/02/2015	31/08/2012	3/01/2013	18/12/2013	5/02/2015
BTEX																															
Benzene	µg/L	1					<1						<1				<1				<1					<1					
Toluene	µg/L	2	ID			800	<2						7				<2				<2					20					
Ethylbenzene	µg/L	2					<2						<2				<2				<2					<2					
meta- & para-Xylene	µg/L	2					<2						<2				<2				<2					<2					
ortho-Xylene	µg/L	2					<2						<2				<2				<2					<2					
Total Xylenes	µg/L	2					<2						<2				<2				<2					<2					
Sum of BTEX	µg/L	1					<1						7				<1				<1					20					
Naphthalene	µg/L	5					<5						<5				<5				<5					<5					
Total petroleum hydrocarbons																															
C6 - C9 Fraction	µg/L	20					<20						<20				<20				<20					40					
C10 - C14 Fraction	µg/L	50					<50						<50				<50				<50					<50					
C15 - C28 Fraction	µg/L	100					<100						<100				<100				<100					<100					
C29 - C36 Fraction	µg/L	50					<50						<50				<50				<50					<50					
C10 - C36 Fraction (sum)	µg/L	50					<50						<50				<50				<50					<50					
Total Recoverable Hydrocarbons																															
C6 - C10 Fraction	µg/L	20					<20						<20				<20				<20					40					
C6 - C10 Fraction minus BTEX (F1)	µg/L	20					<20						<20				<20				<20					20					
>C10 - C16 Fraction	µg/L	100					<100						<100				<100				<100					<100					
>C16 - C34 Fraction	µg/L	100					<100						<100				<100				<100					<100					
>C34 - C40 Fraction	µg/L	100					<100						<100				<100				<100					<100					
>C10 - C40 Fraction (sum)	µg/L	100					<100						<100				<100				<100					<100					
>C10 - C16 Fraction minus Naphthalen	µg/L	100					<100						<100				<100				<100					<100					
Microbiology																															
Faecal coliforms	CFU/100 mL	1					<1						<1				<1				<1					<1					
E coli	CFU/100 mL	1					<1						<1				<1				<1					<1					
Total coliforms	CFU/100 mL	1					<1						~1				10				11					<1					

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0044XPZB									HU0056XPZB					HU0072PZB									
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	23/08/2012	14/12/2012	26/03/2013	2/07/2013	18/09/2013	10/12/2013	25/03/2014	24/07/2014	3/02/2015	19/12/2012	19/12/2013	25/09/2014	13/11/2014	5/02/2015	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	17/09/2015
BTEX																														
Benzene	µg/L	1																						<1						
Toluene	µg/L	2	ID			800																		<2						
Ethylbenzene	µg/L	2																						<2						
meta- & para-Xylene	µg/L	2																						<2						
ortho-Xylene	µg/L	2																						<2						
Total Xylenes	µg/L	2																						<2						
Sum of BTEX	µg/L	1																						<1						
Naphthalene	µg/L	5																						<5						
Total petroleum hydrocarbons																														
C6 - C9 Fraction	µg/L	20																						<20						
C10 - C14 Fraction	µg/L	50																						<50						
C15 - C28 Fraction	µg/L	100																						<100						
C29 - C36 Fraction	µg/L	50																						<50						
C10 - C36 Fraction (sum)	µg/L	50																						<50						
Total Recoverable Hydrocarbons																														
C6 - C10 Fraction	µg/L	20																						<20						
C6 - C10 Fraction minus BTEX (F1)	µg/L	20																						<20						
>C10 - C16 Fraction	µg/L	100																						<100						
>C16 - C34 Fraction	µg/L	100																						<100						
>C34 - C40 Fraction	µg/L	100																						<100						
>C10 - C40 Fraction (sum)	µg/L	100																						<100						
>C10 - C16 Fraction minus Naphthalene	µg/L	100																						<100						
Microbiology																														
Faecal coliforms	CFU/100 mL	1																						<1						
E coli	CFU/100 mL	1																						<1						
Total coliforms	CFU/100 mL	1																						<1						

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0072PZC										HU0073PZC									HU0088PZB				
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	15/09/2015	27/03/2013	7/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	10/12/2013	2/04/2014	26/09/2014	3/12/2014	11/02/2015
BTEX																														
Benzene	µg/L	1								<1										<1			<1		<1					<1
Toluene	µg/L	2	ID			800				<2										<2			<2		<2					6
Ethylbenzene	µg/L	2								<2										<2			<2		<2					<2
meta- & para-Xylene	µg/L	2								<2										<2			<2		<2					<2
ortho-Xylene	µg/L	2								<2										<2			<2		<2					<2
Total Xylenes	µg/L	2								<2										<2			<2		<2					<2
Sum of BTEX	µg/L	1								<1										<1			<1		<1					6
Naphthalene	µg/L	5								<5										<5			<5		<5					<5
Total petroleum hydrocarbons																														
C6 - C9 Fraction	µg/L	20								<20										<20			<20		<20					<20
C10 - C14 Fraction	µg/L	50								<50										<50			<50		<50					<50
C15 - C28 Fraction	µg/L	100								<100										<100			<100		<100					<100
C29 - C36 Fraction	µg/L	50								<50										<50			<50		<50					<50
C10 - C36 Fraction (sum)	µg/L	50								<50										<50			<50		<50					<50
Total Recoverable Hydrocarbons																														
C6 - C10 Fraction	µg/L	20								<20										<20			<20		<20					<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20								<20										<20			<20		<20					<20
>C10 - C16 Fraction	µg/L	100								<100										<100			<100		<100					<100
>C16 - C34 Fraction	µg/L	100								<100										<100			<100		<100					<100
>C34 - C40 Fraction	µg/L	100								<100										<100			<100		<100					<100
>C10 - C40 Fraction (sum)	µg/L	100								<100										<100			<100		<100					<100
>C10 - C16 Fraction minus Naphthalene	µg/L	100								<100										<100			<100		<100					<100
Microbiology																														
Faecal coliforms	CFU/100 mL	1								<1										<1			<1		<1					<1
E coli	CFU/100 mL	1								<1										<1			<1		<1					<1
Total coliforms	CFU/100 mL	1								<1										<1			<1		<1					~1

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0096PZC								HU0118PZA				HU0129PZB				HU0133PZC	HU0136PZB			HU0142PZB				
			ANZECC (2000)																												
Analyte	Units	LOR	Aquatic	Irrigation	Livestock	ADWG (2011)	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	20/03/2014	25/08/2014	1/12/2014	6/02/2015	22/05/2014	10/02/2015	24/06/2015	16/09/2015	23/05/2014	29/08/2014	1/12/2014	4/02/2015	24/09/2014	1/12/2014	26/03/2015	30/06/2015	17/09/2015
BTEX																															
Benzene	µg/L	1							<1			<1		<1															<1		<1
Toluene	µg/L	2	ID			800			<2			<2		8															<2		<2
Ethylbenzene	µg/L	2							<2			<2		<2															<2		<2
meta- & para-Xylene	µg/L	2							<2			<2		<2															<2		<2
ortho-Xylene	µg/L	2							<2			<2		<2															<2		<2
Total Xylenes	µg/L	2							<2			<2		<2															<2		<2
Sum of BTEX	µg/L	1							<1			<1		8															<1		<1
Naphthalene	µg/L	5							<5			<5		<5															<5		<5
Total petroleum hydrocarbons																															
C6 - C9 Fraction	µg/L	20							<20			<20		<20															<20		<20
C10 - C14 Fraction	µg/L	50							<50			<50		<50															<50		<50
C15 - C28 Fraction	µg/L	100							<100			<100		<100															<100		<100
C29 - C36 Fraction	µg/L	50							<50			<50		<50															<50		<50
C10 - C36 Fraction (sum)	µg/L	50							<50			<50		<50															<50		<50
Total Recoverable Hydrocarbons																															
C6 - C10 Fraction	µg/L	20							<20			<20		<20															<20		<20
C6 - C10 Fraction minus BTEX (F1)	µg/L	20							<20			<20		<20															<20		<20
>C10 - C16 Fraction	µg/L	100							<100			<100		<100															<100		<100
>C16 - C34 Fraction	µg/L	100							<100			<100		<100															<100		<100
>C34 - C40 Fraction	µg/L	100							<100			<100		<100															<100		<100
>C10 - C40 Fraction (sum)	µg/L	100							<100			<100		<100															<100		<100
>C10 - C16 Fraction minus Naphthalene	µg/L	100							<100			<100		<100															<100		<100
Microbiology																															
Faecal coliforms	CFU/100 mL	1							<1			<2		<1															<2		<1
E coli	CFU/100 mL	1							<1			<2		<1															<2		<1
Total coliforms	CFU/100 mL	1							~<1			<2		<1															54		~1

Table A3: Baseline Groundwater Monitoring Results - Hawkesbury Sandstone

			Water Quality Criteria				HU0142PZC					HU0143PZC			
Analyte	Units	LOR	ANZECC (2000) Aquatic	Irrigation	Livestock	ADWG (2011)	24/09/2014	3/12/2014	26/03/2015	30/06/2015	17/09/2015	4/12/2014	25/03/2015	25/06/2015	23/09/2015
BTEX															
Benzene	µg/L	1							<1		<1				
Toluene	µg/L	2	ID			800			<2		<2				
Ethylbenzene	µg/L	2							<2		<2				
meta- & para-Xylene	µg/L	2							<2		<2				
ortho-Xylene	µg/L	2							<2		<2				
Total Xylenes	µg/L	2							<2		<2				
Sum of BTEX	µg/L	1							<1		<1				
Naphthalene	µg/L	5							<5		<5				
Total petroleum hydrocarbons															
C6 - C9 Fraction	µg/L	20							<20		<20				
C10 - C14 Fraction	µg/L	50							<50		<50				
C15 - C28 Fraction	µg/L	100							<100		<100				
C29 - C36 Fraction	µg/L	50							<50		<50				
C10 - C36 Fraction (sum)	µg/L	50							<50		<50				
Total Recoverable Hydrocarbons															
C6 - C10 Fraction	µg/L	20							<20		<20				
C6 - C10 Fraction minus BTEX (F1)	µg/L	20							<20		<20				
>C10 - C16 Fraction	µg/L	100							<100		<100				
>C16 - C34 Fraction	µg/L	100							<100		<100				
>C34 - C40 Fraction	µg/L	100							<100		<100				
>C10 - C40 Fraction (sum)	µg/L	100							<100		<100				
>C10 - C16 Fraction minus Naphthalen	µg/L	100							<100		<100				
Microbiology															
Faecal coliforms	CFU/100 mL	1							<2		<1				
E coli	CFU/100 mL	1							<2		<1				
Total coliforms	CFU/100 mL	1							<2		<1				

21	0						
21	4		6	20	10.25		
21	0						
21	0						
21	0						
21	0						
21	4		6	20	10.25		
21	0						
21	1		40	40	40		
21	0						
21	0						
21	0						
21	0						
21	1		40	40	40		
21	1		20	20	20		
21	0						
21	0						
21	0						
21	0						
21	0						
21	0						
21	0						
21	3		10	54	25		

Table A4: Baseline Groundwater Monitoring Results - Illawarra Coal Measures

Location			Water Quality Criteria				HU0073PZA									HU0143PZA				HU0133PZA								
Date			ANZECC (2000)			ADWG (2011)	27/03/2013	6/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	4/12/2014	25/03/2015	25/06/2015	23/09/2015	23/05/2014								
Analyte	Units	LOR	Aquatic	Irrigation	Livestock																n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
General field parameters																												
pH	pH units		6.5-7.5				6.93	7.01	7.13	6.99	7	7.12	6.67	6.97	7.09	6.10	6.45	6.66	6.50	6.35	14	14	3	6.1	7.13	6.65	6.78	0.33
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			770	652	740	703	670	811	1190	600	607	243	640	397.5	324	255	14	14	11	243	1190	614	562	251
Conductivity (lab)	µS/cm	1	30-350								713			607				384	290		4	4	3	290	713	499	469	195
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	501	401	481	456	442	527	773.5	390	345	158	416	397	211	166	14	14		158	774	405	372	159
Total Dissolved Solids (lab)	mg/L	10									355		909	308	346			164	156	141	7	7		141	909	340	277	268
Dissolved oxygen	% sat		90-110				3.3	8.5	17.2	14.6	12.1	21.2	16.3	15.7	10.3	62.4	12.8	80.6	12.0	44.5	14	14		3.3	80.6	23.7	17	23
Redox	mV						-128	11	-71.5	-79.4	-102.5	-81.8	1.45	-130.1	-179.5	29.5	-99.2	-47	-139	-36.3	14	14		-179.5	29.5	-75.2		61
Temperature	ºC						20.82	20.4	19.82	21.1	20	19.4	18.8	16.7	17.96	19.47	18.4	15.5	16.14	21.1	14	14		15.5	21.1	19.0	19	2
Suspended Solids	mg/L	5												<5	<5			<5	21		4	1		21	21	21.0	21	
Turbididty	NTU	0.1	2-25				2-25														1	0						
Major Ions																												
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	14	0						
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	14	0						
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	275	336	314	282	272	293	273	302	275	71	174	109	115	84	14	14		71	336	227	202	94
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	275	336	314	282	272	293	273	302	275	71	174	109	115	84	14	14		71	336	227	202	94
Acidity as $CaCO_3$	mg/L	1	-	-	-	-								23				18			2	2		18	23	21	20	4
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	42	16	15	12	9	22	7	10	8	28	119	36	16	4	14	14	0	4	119	24.6	16	29
Chloride	mg/L	1	-	700	-	ID	63	46	51	47	44	78	261	25	26	27	39	33	21	30	14	14	0	21	261	56.5	44	61
Calcium	mg/L	1	-	-	1000	-	85	79	76	74	74	70	117	71	66	18	44	24	22	13	14	14	0	13	117	59.5	39	31
Magnesium	mg/L	1	-	-	ID	-	31	30	28	26	27	33	47	24	25	8	26	14	14	8	14	14		8	47	24.4	22	11
Sodium	mg/L	1	-	460	-	-	23	25	28	24	28	46	50	22	26	18	40	34	26	17	14	14	0	17	50	29.1	28	10
Potassium	mg/L	1	-	-	-	-	7	8	8	6	9	6	8	7	7	2	4	3	3	3	14	14		2	9	5.79	5	2
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	6.7	8.4	9.4	8.7	9.3	10.6	11.8	9.2	9.52	9.3	13.7	9.9	9.4	9.95	14	14		6.7	13.7	9.7	10	2
Total Anions	meq/L	0.01	-	-	-	-	8.15	8.34	8.02	7.21	7.11	8.51	13	6.95		2.76	7.05	3.86	3.22	2.61								
Total Cations	meq/L	0.01	-	-	-	-	7.97	8.02	7.72	7.03	7.36	8.36	12.1	6.65		2.39	6.66	3.9	3.46	2.42								
Ionic Balance	%	0.01	-	-	-	-	1.06	2.01	1.96	1.25	1.77	0.88	3.47	2.15			2.93	0.6	3.5									
Other Inorganics																												
Flouride	mg/L	0.1	-	2	2	1.5				0.6	0.6		0.4	0.6	0.7			0.2		0.3	7	7		0.2	0.7	0.5	0.4	0.2
Free cyanide	mg/L	0.004	0.007	-	-	0.08				<0.004			<0.004							<0.004	3	0						
Total cyanide	mg/L	0.004	-	-	-	-				<0.004			<0.004							<0.004	3	0						
Thiocyanate	mg/L	0.1	-	-	-	-				<0.1			<0.1							<0.1	3	0						
Dissolved metals																												
Aluminium	mg/L	0.01	0.055	20	5	ID				<0.01	0.06	<0.01	0.04	<0.01	<0.01	0.02	0.01	<0.01	<0.01	0.02	11	5	1	0.01	0.06	0.03	0.02	0.02
Antimony	mg/L	0.001	ID	-	-	0.003				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	11	0						
Arsenic	mg/L	0.001	0.013	2	0.5	0.01				0.016	0.013	0.004	0.001	0.011	0.012	0.002	0.022	0.027	0.013	0.001	11	11		0.001	0.027	0.01	0.01	0.01
Beryllium	mg/L	0.001	ID	0.5	ID	0.06				<0.001			<0.001		<0.001					<0.001	4	0						
Barium	mg/L	0.001	-	-	-	2				1.05			2.59	0.939	0.978			0.131		0.106	6	6		0.106	2.59	0.97	0.57	0.90
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002				<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	11	1		0.0002	0.0002	0.00	0.00	#DIV/0!
Chromium	mg/L	0.001	0.001	1	1	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	11	0						
Cobalt	mg/L	0.001	ID	0.1	1	-				0.003	0.002	0.001	0.002	<0.001	<0.001	0.009	0.016	0.006	0.004	0.003	11	9		0.001	0.016	0.005	0.004	0.005
Copper	mg/L	0.001	0.0014	5	1#	2				0.002	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.002	<0.001	<0.001	<0.001	11	3	3	0.002	0.002	0.002	0.002	0.0
Lead	mg/L	0.001	0.0034	5	0.1	0.01				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	11	1	0	0.001	0.001	0.001	0.001	
Lithium	mg/L	0.001	-	2.5	-	-				0.18			0.143		0.181					0.038	4	4		0.038	0.181	0.136	0.115	0.067
Manganese	mg/L	0.001	1.9	10	-	0.5	0.330	0.162	0.143	0.165	0.113	0.377	0.586	0.104	0.076	0.563	0.744	0.365	0.3	0.406	14	14	0	0.076	0.744	0.317	0.254	0.206
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05				0.004	0.003	0.002	<0.001	0.004	0.005	<0.001	0.002	<0.001	<0.001	0.002	11	7		0.002	0.005	0.003	0.003	0.001
Nickel	mg/L	0.001	0.011	2	1	0.02				0.003	0.002	0.004	0.004	<0.001	<0.001	0.038	0.029	0.012	0.008	0.006	11	9	3	0.002	0.038	0.012	0.007	0.013
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01				<0.01	<0.01	<0.01	<0.1	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	11	0						
Strontium	mg/L	0.001	-	-	-	-				0.433			0.602	0.33	0.357			0.158		0.116	6	6		0.116	0.602	0.333	0.287	0.179
Tin	mg/L	0.001	ID	-	-	-				<0.001			<0.001		<0.001					<0.001	4	0						
Uranium	mg/L	0.001	ID	0.1	0.2	0.017				0.002			<0.001		<0.001					<0.001	4	1		0.002	0.002	0.002	0.002	
Vanadium	mg/L	0.01	ID	0.5	ID	-				<0.01			<0.1		<0.01					<0.01	4	0						
Zinc	mg/L	0.005	0.008	5	20	ID				0.012	0.013	<0.005	0.019	<0.005	<0.005	0.517	0.04	0.012	0.026	0.012	11	8	8	0.012	0.517	0.081	0.034	0.176
Boron	mg/L	0.05	0.37	5	5	4				0.07	<0.05	<0.05	<0.05	<0.05	0.08	<0.05	<0.05	<0.05	<0.05	<0.05	11	2		0.07	0.08	0.075	0.075	0.007
Iron	mg/L	0.05	ID	10	ID	ID	1.59	1.03	0.84	1.16	1	2.16	5.28	0.86	0.65	0.84	8.9	5.48	4.75	4.23	14	14	0	0.65	8.9	2.8	2.59	2.53
Ferrous iron	mg/L	0.05	-	-	-	ID								1.17	0.88			6.4	5.16		4	4		0.88	6.4	3.40	2.41	2.79
Bromine	mg/L	0.1	-	-	-	-				0.5			0.6		0.2					0.1	4	4		0.1	0.6	0.4	0.3	0.2
Iodine	mg/L	0.1	-	-	-	ID				<0.1			<0.1		<0.1					<0.1	4	0						
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001				<0.0001			<0.0001							<0.0001	3	0						
Total metals																												
Aluminium	mg/L	0.01	-	-	-	-				0.02			0.36		<0.01					0.03	4	3		0.02	0.36	0.14	0.06	0.19
Manganese	mg/L	0.001	-	-	-	-				0.166			0.588	0.103	0.094			0.366	0.316	0.398	7	7		0.094	0.588	0.290	0.238	0.181
Iron	mg/L	0.05	-	-	-	-				1.06			7.23	1.11	0.97			6.19	5.79	4.65	7	7		0.97	7.23	3.86	2.81	2.74
Nutrients																												
Ammonia as N	mg/L	0.01	2.57							0.25			0.26		0.23					0.08	4	4		0.08	0.26	0.21	0.19	0.08
Nitrite as N	mg/L	0.01			9					<0.01	<0.01		<0.1		<0.01					<0.01	5	0						
Nitrate as N	mg/L	0.01			90					0.03	<0.01		<0.01		<0.01					<0.01	5	1		0.03	0.03	0.03	0.03	
Total phosphorous	mg/L	0.01								0.06			0.13							<0.01	3	2		0.06	0.13	0.10	0.09	0.05
Reactive phosphorous	mg/L	0.01								<0.01	<0.01		<0.01		<0.01					<0.01	5	0						

Table A4: Baseline Groundwater Monitoring Results - Illawarra Coal Measures

Location			Water Quality Criteria				HU0073PZA									HU0143PZA				HU0133PZA
Date			ANZECC (2000)			ADWG (2011)	27/03/2013	6/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	4/12/2014	25/03/2015	25/06/2015	23/09/2015	23/05/2014
Analyte	Units	LOR	Aquatic	Irrigation	Livestock															
Organochloride pesticides																				
alpha-BHC	µg/L	0.5								<0.5			<0.5		<0.5					
Hexachlorobenzene (HCB)	µg/L	0.5								<0.5			<0.5		<0.5					
beta-BHC	µg/L	0.5								<0.5			<0.5		<0.5					
gamma-BHC	µg/L	0.5								<0.5			<0.5		<0.5					
delta-BHC	µg/L	0.5								<0.5			<0.5		<0.5					
Heptachlor	µg/L	0.5								<0.5			<0.5		<0.5					
Aldrin	µg/L	0.5								<0.5			<0.5		<0.5					
Heptachlor epoxide	µg/L	0.5								<0.5			<0.5		<0.5					
trans-Chlordane	µg/L	0.5								<0.5			<0.5		<0.5					
alpha-Endosulfan	µg/L	0.5								<0.5			<0.5		<0.5					
cis-Chlordane	µg/L	0.5								<0.5			<0.5		<0.5					
Dieldrin	µg/L	0.5								<0.5			<0.5		<0.5					
4.4`-DDE	µg/L	0.5								<0.5			<0.5		<0.5					
Endrin	µg/L	0.5								<0.5			<0.5		<0.5					
beta-Endosulfan	µg/L	0.5								<0.5			<0.5		<0.5					
4.4`-DDD	µg/L	0.5								<0.5			<0.5		<0.5					
Endrin aldehyde	µg/L	0.5								<0.5			<0.5		<0.5					
Endosulfan sulfate	µg/L	0.5								<0.5			<0.5		<0.5					
4.4`-DDT	µg/L	2								<2.0			<2.0		<2.0					
Endrin ketone	µg/L	0.5								<0.5			<0.5		<0.5					
Methoxychlor	µg/L	2								<2.0			<2.0		<2.0					
Total Chlordane (sum)	µg/L	0.5								<0.5			<0.5		<0.5					
Sum of DDD + DDE + DDT	µg/L	0.5								<0.5			<0.5		<0.5					
Sum of Aldrin + Dieldrin	µg/L	0.5								<0.5			<0.5		<0.5					
Organophosphorous pesticides																				
Dichlorvos	µg/L	0.5								<0.5			<0.5		<0.5					
Demeton-S-methyl	µg/L	0.5								<0.5			<0.5		<0.5					
Monocrotophos	µg/L	2								<2.0			<2.0		<2.0					
Dimethoate	µg/L	0.5								<0.5			<0.5		<0.5					
Diazinon	µg/L	0.5								<0.5			<0.5		<0.5					
Chlorpyrifos-methyl	µg/L	0.5								<0.5			<0.5		<0.5					
Parathion-methyl	µg/L	2								<2.0			<2.0		<2.0					
Malathion	µg/L	0.5								<0.5			<0.5		<0.5					
Fenthion	µg/L	0.5								<0.5			<0.5		<0.5					
Chlorpyrifos	µg/L	0.5								<0.5			<0.5		<0.5					
Parathion	µg/L	2								<2.0			<2.0		<2.0					
Pirimphos-ethyl	µg/L	0.5								<0.5			<0.5		<0.5					
Chlorfenvinphos	µg/L	0.5								<0.5			<0.5		<0.5					
Bromophos-ethyl	µg/L	0.5								<0.5			<0.5		<0.5					
Fenamiphos	µg/L	0.5								<0.5			<0.5		<0.5					
Prothiofos	µg/L	0.5								<0.5			<0.5		<0.5					
Ethion	µg/L	0.5								<0.5			<0.5		<0.5					
Carbophenothion	µg/L	0.5								<0.5			<0.5		<0.5					
Azinphos Methyl	µg/L	0.5								<0.5			<0.5		<0.5					
Phenolic compounds																				
Phenol	µg/L	1								<1.0			<1.0		<1.0					
2-Chlorophenol	µg/L	1								<1.0			<1.0		<1.0					
2-Methylphenol	µg/L	1								<1.0			<1.0		<1.0					
3- & 4-Methylphenol	µg/L	1								<2.0			<2.0		<2.0					
2-Nitrophenol	µg/L	2								<1.0			<1.0		<1.0					
2.4-Dimethylphenol	µg/L	1								<1.0			<1.0		<1.0					
2.4-Dichlorophenol	µg/L	1								<1.0			<1.0		<1.0					
2.6-Dichlorophenol	µg/L	1								<1.0			<1.0		<1.0					
4-Chloro-3-methylphenol	µg/L	1								<1.0			<1.0		<1.0					
2.4.6-Trichlorophenol	µg/L	1								<1.0			<1.0		<1.0					
2.4.5-Trichlorophenol	µg/L	1								<1.0			<1.0		<1.0					
Pentachlorophenol	µg/L	1								<2.0			<2.0		<2.0					
Polynuclear aromatic hydrocarbons																				
Naphthalene	µg/L	1								<1.0			<1.0		<1.0					
Acenaphthylene	µg/L	1								<1.0			<1.0		<1.0					
Acenaphthene	µg/L	1								<1.0			<1.0		<1.0					
Fluorene	µg/L	1								<1.0			<1.0		<1.0					
Phenanthrene	µg/L	1								<1.0			<1.0		<1.0					
Anthracene	µg/L	1								<1.0			<1.0		<1.0					
Fluoranthene	µg/L	1								<1.0			<1.0		<1.0					
Pyrene	µg/L	1								<1.0			<1.0		<1.0					
Benz(a)anthracene	µg/L	1								<1.0			<1.0		<1.0					
Chrysene	µg/L	1								<1.0			<1.0		<1.0					
Benzo(b)fluoranthene	µg/L	1								<1.0			<1.0		<1.0					
Benzo(k)fluoranthene	µg/L	1								<1.0			<1.0		<1.0					
Benzo(a)pyrene	µg/L	0.5								<0.5			<0.5		<0.5					
Indeno(1.2.3.cd)pyrene	µg/L	1								<1.0			<1.0		<1.0					
Dibenz(a.h)anthracene	µg/L	1								<1.0			<1.0		<1.0					
Benzo(g.h.i)perylene	µg/L	1								<1.0			<1.0		<1.0					
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5								<0.5			<0.5		<0.5					
Benzo(a)pyrene TEQ (zero)	µg/L	0.5								<0.5			<0.5		<0.5					

Table A4: Baseline Groundwater Monitoring Results - Illawarra Coal Measures

Location			Water Quality Criteria				HU0073PZA									HU0143PZA				HU0133PZA
Date			ANZECC (2000)			ADWG (2011)	27/03/2013	6/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	4/12/2014	25/03/2015	25/06/2015	23/09/2015	23/05/2014
Analyte	Units	LOR	Aquatic	Irrigation	Livestock															
BTEX																				
Benzene	µg/L	1								<1			<1		<1					
Toluene	µg/L	2	ID			800				<2			<2		<2					
Ethylbenzene	µg/L	2								<2			<2		<2					
meta- & para-Xylene	µg/L	2								<2			<2		<2					
ortho-Xylene	µg/L	2								<2			<2		<2					
Total Xylenes	µg/L	2								<2			<2		<2					
Sum of BTEX	µg/L	1								<1			<1		<1					
Naphthalene	µg/L	5								<5			<5		<5					
Total petroleum hydrocarbons																				
C6 - C9 Fraction	µg/L	20								<20			<20		<20					
C10 - C14 Fraction	µg/L	50								<50			<50		<50					
C15 - C28 Fraction	µg/L	100								<100			<100		<100					
C29 - C36 Fraction	µg/L	50								<50			<50		<50					
C10 - C36 Fraction (sum)	µg/L	50								<50			<50		<50					
Total Recoverable Hydrocarbons																				
C6 - C10 Fraction	µg/L	20								<20			<20		<20					
C6 - C10 Fraction minus BTEX (F1)	µg/L	20								<20			<20		<20					
>C10 - C16 Fraction	µg/L	100								<100			<100		<100					
>C16 - C34 Fraction	µg/L	100								<100			<100		<100					
>C34 - C40 Fraction	µg/L	100								<100			<100		<100					
>C10 - C40 Fraction (sum)	µg/L	100								<100			<100		<100					
>C10 - C16 Fraction minus Naphthalene (F	µg/L	100								<100			<100		<100					
Microbiology																				
Faecal coliforms	CFU/100 m	1								<1			<2		<1					
E coli	CFU/100 m	1								<1			<2		<1					
Total coliforms	CFU/100 m	1								<1			~<2		~<1					

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0018PZA										HU0023PZA				HU0032LDA				HU0038PZA							
Analyte	**Units**	**LOR**	**Aquatic**	**ANZECC (2000) Irrigation**	**Livestock**	**ADWG (2011)**	17/10/2011	7/01/2013	22/03/2013	9/07/2013	17/10/2013	12/12/2013	8/04/2014	25/03/2015	2/07/2015	24/09/2015	16/11/2011	17/12/2012	25/03/2013	21/05/2014	12/12/2013	3/04/2014	26/03/2015	24/09/2015	24/07/2012	14/12/2012	11/12/2013	2/04/2014	15/08/2014	2/12/2014	12/02/2015	15/09/2015
General field parameters																																
pH	pH units		6.5-7.5				6.41	6.28	6.18	6.44	6.34	6.24	6.01	6.91	6.07	6.00	6.9	6.43	6.34	6.53	6.20	5.81	5.86	6.16	6.18	6.27	6.12	6.00	6.11	5.92	5.99	6.12
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			509	425	419	504	437	329	260	1090	265	255	1706	540	356	406	158	159	160.4	162	208	210	201	197	187	260	222	191
Conductivity (lab)	µS/cm	1	30-350												256							152		125				207				152
Total Dissolved Solids (field)	g/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	330	276	272	327	284	214	169	1047	172	166	1109	351	231	264	103	105	104	105	136	137	131	127	121	189	144	124
Total Dissolved Solids (lab)	mg/L	10										195			135	104						88		93							110	98
Dissolved oxygen	% sat		90-110				19.1	3.5	7.7	20.5	19.6	10.4	16	5.3	30.9	10.3	11.4	16.2	16	29.1	21.6	18.8	26.9	10.5	3.5	12.8	17.4	16.8	6.5	24.6	27.5	11.0
Redox	mV						-16	-191.6	-98.7	-89.7	-52.3	-93.5	-66.9	-201.6	-72.3	-114.0	-150.5	-37.6	-67.6	-25.1	-10.6	-16.5	-56.7	-121.2	-110.5	-61.9	-33.0	-31.7	-6.7	7.7	-15.5	-144.7
Temperature	ºC						14.76	22.4	18.59	16.6	20.02	21.64	18.2	16.1	13.4	14.08	17.17	15.03	21.38	15.87	18.51	19.1	16.3	16.88	17.30	19.65	19.90	19.70	19.13	20.58	18.00	19.10
Suspended Solids	mg/L	5										36			60	52																
Turbidity	NTU	0.1	2-25													17.9																
Major Ions																																
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	7	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	114	131	101	147	120	95	64	1090	71	57	208	125	93	130	36	29	40	40	39	47	43	35	41	62	44	44
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	114	131	101	147	120	95	64	1090	71	57	208	132	93	130	36	29	40	40	39	47	43	35	41	62	44	44
Acidity as $CaCO_3$	mg/L	1	-	-	-	-									99																	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	130	34	31	29	18	14	6	<1	6	6	58	4	6	2	9	8	7	7	6	7	7	7	4	6	4	3
Chloride	mg/L	1	-	700	-	ID	49	40	38	39	48	42	34	100	35	37	376	106	42	47	24	24	28	16	27	25	31	29	24	34	31	28
Calcium	mg/L	1	-	-	1000	-	32	22	21	19	15	7	9	28	11	8	57	30	19	25	1	2	2	1	10	7	6	6	5	16	12	6
Magnesium	mg/L	1	-	-	ID	-	2	4	3	4	3	2	3	3	4	4	50	20	11	11	2	2	2	3	3	2	2	3	2	4	3	3
Sodium	mg/L	1	-	460	-	-	105	57	55	80	64	49	29	555	23	28	213	56	23	34	11	14	17	12	18	18	19	19	15	23	26	15
Potassium	mg/L	1	-	-	-	-	2	4	1	3	<1	<1	1	2	<1	<1	8	2	2	2	<1	<1	<1	<1	1	<1	<1	1	<1	1	<1	<1
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	11.4	11.4	10.6	11.8	11.9	10.9	11.2	30.3	10.5	9.8	10.5	10.0	10.3	10.5	8.72	8.3	8.2	8.3	10.2	8.9	9.09	8.7	10	9.3	9.49	9
Total Anions	meq/L	0.01	-	-	-	-	6.37	4.45	7.66	4.64	4.13	3.38	2.65	24.6	2.53	2.31	16	5.71	3.17	3.96	1.58	1.65	1.73	1.4	1.67	1.79	1.88	1.66	1.58	2.32	1.84	1.73
Total Cations	meq/L	0.01	-	-	-	-	6.38	4.58	7.50	4.83	4.06	3.31	2.68	25.9	1.88	1.95	16.4	5.63	3.28	3.84	1.58	1.91	1.92	0.82	1.55	1.75	2.02	1.4	1.71	2.15	1.98	1.95
Ionic Balance	%	0.01	-	-	-	-	0.08	1.44	1.06	2	0.88	0.97	-	2.51			1.41	0.72	1.77	1.58	-		-		3.73	1.13	3.59	8.50				
Other Inorganics																																
Flouride	mg/L	0.1	-	2	2	1.5						<0.1			<0.1	<0.1				<0.1	<0.1	<0.1					<0.1	0.2			0.2	
Free cyanide	mg/L	0.004	0.007	-	-	0.08						<0.004									<0.004						<0.004				<0.004	
Total cyanide	mg/L	0.004	-	-	-	-						<0.004									<0.004						<0.004				<0.004	
Thiocyanate	mg/L	0.1	-	-	-	-						<0.1									<0.1						<0.1				<0.1	
Dissolved metals																																
Aluminium	mg/L	0.01	0.055	20	5	ID						0.06	0.06	0.18	<0.01	<0.01				0.01	0.01	<0.01	0.08	<0.01			0.01	0.03	<0.01	0.02	<0.01	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003						<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01						0.012	0.01	0.002	0.007	0.006				0.002	<0.001	0.001	0.002	0.002			<0.001	0.001	<0.001	0.001	<0.001	<0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06						<0.001				<0.001				<0.001	<0.001						<0.001				<0.001	
Barium	mg/L	0.001	-	-	-	2						0.118			0.105	0.079				0.063	0.084						0.085				0.116	
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002						<0.0001	<0.0001	<0.0001	<0.0001	<0.0001				<0.0001	<0.0001	<0.0001	<0.0001	<0.0001			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05						0.002	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-						0.008	0.008	<0.001	0.008	0.009				<0.001	0.004	0.005	0.006	0.005			<0.001	0.001	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	0.0014	5	1#	2						<0.001	0.007	<0.001	<0.001	<0.001				<0.001	<0.001	0.002	0.001	<0.001			0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01						<0.001	<0.001	<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-						0.013				0.01				0.018	0.012						0.019				0.014	
Manganese	mg/L	0.001	1.9	10	-	0.5	0.506	0.653	0.573	0.623	0.621	0.732	0.800	0.215	0.754	0.798	0.786	0.531	0.478	0.342	0.929	1	0.915	0.932	0.674	0.660	0.624	0.654	0.578	0.768	0.693	0.606
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05						0.013	0.008	<0.001	0.008	0.007				0.008	0.003	0.002	0.004	0.002			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02						0.014	0.01	<0.001	0.011	0.012				0.002	0.006	0.007	0.009	0.007			0.002	0.002	<0.001	<0.001	<0.001	<0.001
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01						<0.01	<0.01	<0.01	<0.01	<0.01				<0.01	<0.01	<0.01	<0.01	<0.01			<0.01	<0.01	0.02	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-						0.125			0.092	0.069				0.112	0.035						0.09				0.109	
Tin	mg/L	0.001	ID	-	-	-						<0.001				<0.001				<0.001	<0.001						<0.001				<0.001	
Uranium	mg/L	0.001	ID	0.1	0.2	0.017						<0.001				<0.001				<0.001	<0.001						<0.001				<0.001	
Vanadium	mg/L	0.01	ID	0.5	ID	-						<0.01				<0.01				<0.01	<0.01						<0.01				<0.01	
Zinc	mg/L	0.005	0.008	5	20	ID						0.014	0.033	0.005	0.014	0.033				0.031	0.213	0.018	0.015	<0.005			0.01	0.022	0.006	0.008	0.007	<0.005
Boron	mg/L	0.05	0.37	5	5	4						<0.05	<0.05	0.33	<0.05	<0.05				<0.05	<0.05	<0.05	<0.05	<0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	2.44	10.6	5.08	9.62	5.17	11.9	13.1	0.95	13	14.3	6.03	6.54	7.06	2.94	16.5	20.5	17	17.9	14.4	14.00	12	13.6	12.8	15.4	13.8	14
Ferrous iron	mg/L	0.05	-	-	-	ID									14.6	15.0								19.0								
Bromine	mg/L	0.1	-	-	-	-						0.1				0.1				0.2	0.6						0.1				<0.1	
Iodine	mg/L	0.1	-	-	-	ID						0.4				<0.1				<0.1	0.2						<0.1				<0.1	
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001						<0.0001									<0.0001						<0.0001				<0.0001	
Total metals																																
Aluminium	mg/L	0.01	-	-	-	-						0.46				0.94					0.06						0.03				0.45	
Manganese	mg/L	0.001	-	-	-	-						0.83			0.777	0.794					0.99			0.945			0.663				0.6	0.645
Iron	mg/L	0.05	-	-	-	-						14.1			14.6	14.9					19.6			19.1			13.6				13.7	14.2
Nutrients																																
Ammonia as N	mg/L	0.01	2.57									<0.01				0.02					<0.01						0.02				0.04	
Nitrite as N	mg/L	0.01			9							<0.01				<0.01					<0.01	<0.01					<0.01	<0.01			<0.01	
Nitrate as N	mg/L	0.01			90							0.02				0.06					0.02	0.01					0.02	<0.01			0.02	
Nitrite + Nitrate as N	mg/L	0.01																														
Total phosphorous	mg/L	0.01										0.04									0.02						<0.01	-			0.02	
Reactive phosphorous	mg/L	0.01										<0.01				0.02					<0.01	<0.01					<0.01	<0.01			<0.01	
Biochemical oxygen demand	mg/L	2														<2																
Isotopes																																
Oxygen-18	‰	0.01					-6.94										-6.47				-7.26											
Deuterium	‰	0.1					-42.6										-39.3				-42.67											
Carbon-13	‰	0.1					-14.9										-11.5															
Radiocarbon	pMC	0.1					30.74±0.11										44.31±0.13															
Radiocarbon Age (uncorrected)	yrs BP	1					9416±30										6478±28															
Tritium	TU	0.01					0.04±0.03^										0.05±0.03^				0.14±0.08											

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0042PZA						HU0043XPZA				HU0044XPZA								HU0072PZA									
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	23/08/2012	19/12/2012	3/07/2013	19/08/2013	17/12/2013	2/02/2015	30/08/2012	3/01/2013	17/12/2013	5/02/2015	24/08/2012	14/12/2012	2/07/2013	18/09/2013	10/12/2013	20/03/2014	28/07/2014	18/02/2015	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	15/09/2015
General field parameters																																		
pH	pH units		6.5-7.5				6.5	6.25	6.3	6.67	6.99	6.09	6.52	6.17	6.26	5.88	5.65	4.41	5.61	4.64	4.84	4.03	5.16	5.75	6.38	6.44	6.69	6.85	6.35	6.19	6.49	6.14	6.54	6.49
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			496	344	444	479	467	453	224	129	115	112	202	246	218	350	332	355	379	371	618	640	634	621	594	597	636	615	585	592
Conductivity (lab)	µS/cm	1	30-350																										588				603	566
Total Dissolved Solids (field)	g/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	324	224	289	311	303	295	145	83	75	73	131	160	121	228	216	231	247	241	402	416	412	404	384	388	409	397	380.2	385
Total Dissolved Solids (lab)	mg/L	10																											384				336	332
Dissolved oxygen	% sat		90-110				8.6	44.3	24	28.4	40.7	20.3	22.3	17.3	28.9	51.5	33.7	38.4	-	31.5	41.2	26.7	25.1	113.2	1.7	7.3	19.7	26.8	3.9	27.2	17.8	16.0	7.3	47.4
Redox	mV						1.2	-22.2	-85.3	-62.9	-93.1	29.0	-34.7	25.6	-4.3	3.8	112.1	36.5	81	200.1	130.7	293.6	-15.5	41.7	-81.8	-68.5	-114.8	-112.6	-88.3	77	-35.4	-98.1	-120	-144.6
Temperature	°C						18.05	19.23	14.4	13.91	16.44	16.39	15.27	20.21	20.97	22.53	11.47	17.04	15.1	15.96	16.02	19.3	15.87	16.49	19.82	18.4	16.85	18.37	17.10	17.61	21.82	18.5	16.2	16.19
Suspended Solids	mg/L	5																															10	<5
Turbidity	NTU	0.1	2-25																															
Major Ions																																		
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1				<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	133	103	104	142	130	130	55	30	12	24	28	5				<1	<1	<1	135	124	133	136	118	111	138	130	116	114
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	133	103	104	142	130	130	55	30	12	24	28	5				<1	<1	<1	135	124	133	136	118	111	138	130	116	114
Acidity as $CaCO_3$	mg/L	1	-	-	-	-																											30	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	40	7	15	4	6	6	23	5	3	2	22	49				136	149	131	9	17	11	7	4	6	5	5	4	3
Chloride	mg/L	1	-	700	-	ID	54	45	56	60	55	64	18	12	11	23	24	15				10	15	10	100	113	114	108	110	111	110	115	100	106
Calcium	mg/L	1	-	-	1000	-	32	18	19	36	28	28	16	6	4	3	10	6				10	8	9	35	33	33	31	32	31	37	34	34	33
Magnesium	mg/L	1	-	-	ID	-	18	16	16	15	13	17	2	2	2	2	3	6				19	17	20	23	24	24	22	25	24	23	28	27	26
Sodium	mg/L	1	-	460	-	-	39	28	4	29	28	32	23	10	10	9	15	13				14	16	19	36	54	54	50	37	38	37	44	40	38
Potassium	mg/L	1	-	-	-	-	3	3	41	4	5	4	<1	<1	<1	4	9	3				3	3	2	6	6	6	5	4	4	4	4	4	4
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	11.0	9.5	8.9	10.1	9.7	8.7	10.1	9.1	-	7.4	14.0	17.0				13.5	14.0	18.6	9.1	9.5	9.3	9.3	9.2	9.8	9	8.6	8.9	8.7
Total Anions	meq/L	0.01	-	-	-	-	5.01	3.47		4.61	4.27	4.53	2.09	1.04	0.61	1.17	1.69	1.54				3.11	3.53	3.01	5.71	6.02	6.10	5.91	5.54	5.470	5.960	5.95	5.22	5.33
Total Cations	meq/L	0.01	-	-	-	-	4.85	3.51		4.45	4.11	4.46	1.96	0.09	0.8	1.17	1.63	1.44				3.09	2.57	2.97	5.55	6.12	6.12	5.83	5.37	5.280	5.650	6.8	5.76	5.54
Ionic Balance	%	0.01	-	-	-	-	1.65	0.51		1.79	2.01	0.77										0.30			1.37	0.87	0.18	0.68	1.62	1.820	2.720	6.84	4.91	1.95
Other Inorganics																																		
Flouride	mg/L	0.1	-	2	2	1.5					<0.1																	0.2	0.1				0.1	
Free cyanide	mg/L	0.004	0.007	-	-	0.08					<0.004																	<0.004						
Total cyanide	mg/L	0.004	-	-	-	-					<0.004																	<0.004						
Thiocyanate	mg/L	0.1	-	-	-	-					<0.1																	<0.1						
Dissolved metals																																		
Aluminium	mg/L	0.01	0.055	20	5	ID					0.02	<0.01				<0.01						0.12	0.14	0.07				0.03	0.01	<0.01	0.100	0.04	<0.01	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003					<0.001	<0.001				<0.001						<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01					<0.001	0.002				<0.001						<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06					<0.001																	<0.001	<0.001					
Barium	mg/L	0.001	-	-	-	2					0.411																	0.274	0.227				0.234	
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002					<0.0001	<0.0001				<0.0001						0.0007	0.00	<0.0001				<0.0001	<0.0001	<0.0001	<0.0001	0.0305	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05					<0.001	<0.001				<0.001						<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-					<0.001	0.002				<0.001						0.033	0.03	0.029				<0.001	<0.001	<0.001	<0.001	0.005	<0.001	<0.001
Copper	mg/L	0.001	0.0014	5	1#	2					0.002	<0.001				0.005						0.004	0.01	0.013				0.002	<0.001	0.001	<0.001	0.061	<0.001	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01					<0.001	<0.001				<0.001						0.017	0.05	0.004				<0.001	<0.001	<0.001	<0.001	0.041	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-					0.072																	0.054						
Manganese	mg/L	0.001	1.9	10	-	0.5	0.594	0.399	0.407	0.419	0.331	0.279	0.252	0.404	0.590	0.538	0.547	2.37				3.79	4.25	4.22	0.216	0.167	0.186	0.191	0.203	0.209	0.252	0.265	0.199	0.189
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05					<0.001	0.001				<0.001						<0.001	<0.001	<0.001				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Nickel	mg/L	0.001	0.011	2	1	0.02					0.002	0.011				0.01						0.056	0.06	0.05				0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01					<0.01	<0.01				<0.01						<0.01	<0.01	<0.01				<0.01	<0.01	0.100	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-					0.374																	0.274	0.171				0.155	
Tin	mg/L	0.001	ID	-	-	-					<0.001																	<0.001						
Uranium	mg/L	0.001	ID	0.1	0.2	0.017					<0.001																	<0.001	<0.001					
Vanadium	mg/L	0.01	ID	0.5	ID	-					<0.01																	<0.01	<0.01					
Zinc	mg/L	0.005	0.008	5	20	ID					0.014	0.01				0.111						0.534		0.198				0.473	0.036	0.014	0.010	1.57	<0.005	0.008
Boron	mg/L	0.05	0.37	5	5	4					<0.05	<0.05				<0.05						<0.05		<0.05				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	5.11	6.23	6.46	6.86	5.3	3.17	1.79	6.79	10.60	6.76	4.50	19.30				1.4		0.29	3.63	2.75	3.18	3.03	3.34	3.620	3.740	3.68	3.55	3.62
Ferrous iron	mg/L	0.05	-	-	-	ID																											4.05	3.82
Bromine	mg/L	0.1	-	-	-	-					0.1																	0.4	0.3					
Iodine	mg/L	0.1	-	-	-	ID					<0.1																	<0.1						
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001					<0.0001																	<0.0001						
Total metals																																		
Aluminium	mg/L	0.01	-	-	-	-					0.11																	0.02						
Manganese	mg/L	0.001	-	-	-	-					0.381																	0.191					0.207	0.211
Iron	mg/L	0.05	-	-	-	-					6.24																	3.2					4.03	3.71
Nutrients																																		
Ammonia as N	mg/L	0.01	2.57								0.11																	0.17						
Nitrite as N	mg/L	0.01			9						<0.01																	<0.01	<0.01					
Nitrate as N	mg/L	0.01			90						0.01																	0.02	0.2					
Nitrite + Nitrate as N	mg/L	0.01																																
Total phosphorous	mg/L	0.01									<0.01																	0.02						
Reactive phosphorous	mg/L	0.01									<0.01																	<0.01	<0.01					
Biochemical oxygen demand	mg/L	2																																
Isotopes																																		
Oxygen-18	‰	0.01																																
Deuterium	‰	0.1																																
Carbon-13	‰	0.1																																
Radiocarbon	pMC	0.1																																
Radiocarbon Age (uncorrected)	yrs BP	1																																
Tritium	TU	0.01																																

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0073PZB									HU0088PZA					HU0096PZB								HU0129PZA			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	27/03/2013	7/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	11/12/2013	2/04/2014	26/09/2014	3/12/2014	11/02/2015	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	22/05/2014	10/02/2015	24/06/2015	16/09/2015
General field parameters																																
pH	pH units		6.5-7.5				5.86	5.99	6.22	6.13	6.13	6.30	6.40	6.14	6.06	6.69	6.67	6.71	6.74	6.54	4.92	5.21	5.15	4.97	5.56	5.47	5.28	5.07	6.34	6.29	6.18	6.15
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			457	195	223	210	219	237	233	209.6	209	486	520	481	40.8	519	84	142	131	130	146	155.2	132.6	130	595	493	466.8	468
Conductivity (lab)	µS/cm	1	30-350								197			187			550							139			129				469	432
Total Dissolved Solids (field)	g/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	298	111	145	136	143	154	152	136.5	136	315	338	312	265	337	46	92	85	83.5	95	100.8	86.4	84	387	320	303.6	304
Total Dissolved Solids (lab)	mg/L	10									102		104	94	90		224			246				69		115	65	60			203	258
Dissolved oxygen	% sat		90-110				0.7	23.6	16.4	15.9	11.4	16	13.9	108.8	12.6	29.8	21.0	26.1	25.6	35.4	9.6	13.5	17.6	10.8	12.4	23.2	32	14.4	16.1	21.3	27	10.3
Redox	mV						-11.6	-4	-39.6	-43.4	-51	-39.1	-93.7	-25.6	-112.7	-61.0	-69.3	-72.2	-25.6	-31.2	95	93.6	126.1	95.7	45.2	134.6	181.1	-107.6	-63.5	-20.9	-114.0	-143.0
Temperature	ºC						20.97	21.5	19.98	19.88	20.4	19.28	18.0	15.3	19.38	19.6	19.5	19.0	19.4	24.97	19.8	18.29	18.73	18.2	18.32	14.9	14.1	15.27	20.34	16.82	15.5	16.32
Suspended Solids	mg/L	5												10	<5												<5	<5			<5	<5
Turbidity	NTU	0.1	2-25																									2.3				
Major Ions																																
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	41	65	55	41	34	66	64	51	30	165	157	171	165	168	7	9	8	6	15	16	8	8	154	91	80	80
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	41	65	55	41	34	66	64	51	30	165	157	171	165	168	7	9	8	6	15	16	8	8	154	91	80	80
Acidity as $CaCO_3$	mg/L	1	-	-	-	-								45													55				51	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	26	7	8	10	10	4	6	9	9	1	2	2	<1	2	2	2	2	1	<1	2	2	1	18	13	11	10
Chloride	mg/L	1	-	700	-	ID	80	28	33	27	30	21	34	25	28	54	60	54	43	57	32	40	33	35	27	39	30	31	87	87	86	78
Calcium	mg/L	1	-	-	1000	-	13	6	6	5	5	12	10	6	6	33	38	33	28	30	<1	<1	<1	<1	4	2	<1	<1	33	18	16	16
Magnesium	mg/L	1	-	-	ID	-	12	4	5	4	4	7	7	5	5	16	20	17	11	15	2	2	2	1	2	2	2	2	24	19	19	18
Sodium	mg/L	1	-	460	-	-	32	17	16	16	20	14	15	14	16	33	36	41	31	41	18	18	19	22	23	21	17	18	40	48	45	39
Potassium	mg/L	1	-	-	-	-	1	1	1	<1	1	2	2	1	1	6	6	6	7	6	<1	<1	<1	<1	<1	<1	<1	<1	2	2	1	2
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	8.9	8.6	9.9	9.2	8.7	9.6	8.73	9	9.09	9.8	10	9.2	9.4	9.7	8.7	9.1	8.4	8.4	8.7	9.1	8.1	8.32	14.8	13.9	13	12.5
Total Anions	meq/L	0.01	-	-	-	-	3.62	2.23	2.20	1.79	1.73	1.99	2.36	1.91		4.84	5.14	4.98	4.51	5.01	1.08	1.35	1.13	1.13	1.06	1.46	1.05	1.06	5.91	4.54	4.25	4.01
Total Cations	meq/L	0.01	-	-	-	-	3.63	2.25	2.22	1.68	1.47	1.84	2.43	1.34		4.70	5.26	4.98	3.95	4.73	1.02	1.07	0.99	1.04	1.36	1.28	0.9	0.95	5.66	4.6	4.34	4.03
Ionic Balance	%	0.01	-	-	-	-	0.22									1.49	1.19	<0.01	6.7	2.85	-	-	-			-	-		2.19	0.62	1.06	0.25
Other Inorganics																																
Flouride	mg/L	0.1	-	2	2	1.5				<0.1	<0.1		<0.1	0.1	<0.1	0.3	0.3			0.2			<0.1	<0.1		<0.1	<0.1	<0.1	0.1	<0.1	0.1	
Free cyanide	mg/L	0.004	0.007	-	-	0.08				<0.004			<0.004			<0.004				<0.004			<0.004			<0.004						
Total cyanide	mg/L	0.004	-	-	-	-				<0.004			<0.004			<0.004				<0.004			<0.004			<0.004						
Thiocyanate	mg/L	0.1	-	-	-	-				<0.1			<0.1			<0.1				<0.1			<0.1			<0.1						
Dissolved metals																																
Aluminium	mg/L	0.01	0.055	20	5	ID				<0.01	0.03	0.03	0.02	<0.01	<0.01	0.04	<0.01	0.01	0.01	<0.01			0.02	0.02	0.05	0.02	0.02	0.02	<0.01	<0.01	<0.01	<0.01
Antimony	mg/L	0.001	ID	-	-	0.003				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.003			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001
Arsenic	mg/L	0.001	0.013	2	0.5	0.01				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.014	0.008	0.011	0.004	0.004			0.01	<0.001	0.002	<0.001	<0.001	<0.001	0.057	0.047	0.041	0.038
Beryllium	mg/L	0.001	ID	0.5	ID	0.06				<0.001			<0.001		<0.001	<0.001				<0.001			<0.001			<0.001		<0.001	<0.001	<0.001		
Barium	mg/L	0.001	-	-	-	2				0.098			0.194	0.115	0.106	0.357				0.401			0.026			0.036	0.02	0.016	0.296	0.15	0.124	
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002				<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	0.0002	<0.0001	<0.0001			<0.0001	<0.0001	0.0003	0.0002	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Chromium	mg/L	0.001	0.001	1	1	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Cobalt	mg/L	0.001	ID	0.1	1	-				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.004	0.005	0.003	0.001	0.001			0.004	0.003	0.004	0.003	0.004	0.003	0.046	0.024	0.015	0.013
Copper	mg/L	0.001	0.0014	5	1#	2				0.001	<0.001	<0.001	0.001	<0.001	<0.001	0.003	<0.001	0.001	<0.001	<0.001			<0.001	0.001	0.03	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lead	mg/L	0.001	0.0034	5	0.1	0.01				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001			<0.001	<0.001	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
Lithium	mg/L	0.001	-	2.5	-	-				0.022			0.03		0.024	0.095				0.114			0.006			0.004		<0.001	0.019	0.021		
Manganese	mg/L	0.001	1.9	10	-	0.5	1.240	0.562	0.556	0.636	0.619	0.527	0.519	0.553	0.576	0.259	0.179	0.251	0.134	0.159	0.140	0.146	0.179	0.124	0.187	0.144	0.113	0.124	0.514	0.649	0.603	0.53
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05				<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.089	0.016	0.014	0.012
Nickel	mg/L	0.001	0.011	2	1	0.02				0.001	0.002	0.003	0.013	0.001	0.002	0.008	0.007	0.006	0.006	0.008			0.005	0.004	0.009	0.004	0.003	0.003	0.108	0.044	0.03	0.026
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01				<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	-	-	-				0.045			0.064	0.04	0.042	0.227				0.14			0.014			0.021	0.01	0.006	0.174	0.114	0.096	
Tin	mg/L	0.001	ID	-	-	-				<0.001			<0.001		<0.001	<0.001				<0.001			<0.001			<0.001		<0.001	<0.001	<0.001		
Uranium	mg/L	0.001	ID	0.1	0.2	0.017				<0.001			<0.001		<0.001	<0.001				<0.001			<0.001			<0.001		<0.001	0.001	<0.001		
Vanadium	mg/L	0.01	ID	0.5	ID	-				<0.01			<0.01		<0.01	<0.01				<0.01			<0.01			<0.01		<0.01	<0.01	<0.01		
Zinc	mg/L	0.005	0.008	5	20	ID				0.015	0.017	0.01	0.053	<0.005	<0.005	0.085	0.005	0.026	0.006	0.067			0.056	0.054	0.118	0.073	0.026	0.023	0.01	0.008	0.006	0.039
Boron	mg/L	0.05	0.37	5	5	4				<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05
Iron	mg/L	0.05	ID	10	ID	ID	10.80	14.50	14.60	20.8	14.1	14	12.2	13.6	12.8	2.57	2.01	1.71	2.17	1.18	1.52	2.20	2.37	2.13	1.74	1.88	1.61	1.76	3.83	8.06	9.5	8.93
Ferrous iron	mg/L	0.05	-	-	-	ID								14.8	15.2												2.02	1.85			10.5	9.89
Bromine	mg/L	0.1	-	-	-	-				0.8			0.1		0.1	0.4				0.1			0.2			<0.1		<0.1	0.3	0.2		
Iodine	mg/L	0.1	-	-	-	ID				<0.1			<0.1		<0.1	<0.1				<0.1			<0.1			<0.1		<0.1	<0.1	<0.1		
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001				<0.0001			<0.0001			<0.0001				<0.0001			<0.0001			<0.0001						
Total metals																																
Aluminium	mg/L	0.01	-	-	-	-				0.59			0.53		0.04	0.04				0.44			0.04			0.33		0.02				
Manganese	mg/L	0.001	-	-	-	-				0.733			0.522	0.557	0.602	0.234				0.178			0.184			0.151	0.116	0.124			0.634	0.567
Iron	mg/L	0.05	-	-	-	-				21.4			14.4	14.2	15.1	2.79				4.08			2.66			5.28	1.89	1.84			10.4	9.62
Nutrients																																
Ammonia as N	mg/L	0.01	2.57							0.01			0.02		0.05	0.18				0.13			0.01			0.01		<0.01				
Nitrite as N	mg/L	0.01			9					<0.01	<0.01		<0.01		<0.01	<0.01	<0.01			<0.01			<0.01	<0.01		<0.01		0.01				
Nitrate as N	mg/L	0.01			90					0.02	0.01		<0.01		0.01	0.01	<0.01			<0.01			0.01	0.05		<0.01		<0.01				
Nitrite + Nitrate as N	mg/L	0.01																														
Total phosphorous	mg/L	0.01								0.01			0.03			<0.01				0.03			<0.01			0.04						
Reactive phosphorous	mg/L	0.01								<0.01	<0.01		<0.01		<0.10	<0.01	<0.01			<0.01			<0.01	<0.01		<0.01		<0.01				
Biochemical oxygen demand	mg/L	2																										<2				
Isotopes																																
Oxygen-18	‰	0.01																														
Deuterium	‰	0.1																														
Carbon-13	‰	0.1																														
Radiocarbon	pMC	0.1																														
Radiocarbon Age (uncorrected)	yrs BP	1																														
Tritium	TU	0.01																														

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0136PZA				HU0142PZA					HU0143PZB											
Analyte	Units	LOR	ANZECC (2000) Aquatic	ANZECC (2000) Irrigation	ANZECC (2000) Livestock	ADWG (2011)	29/08/2014	1/12/2014	4/02/2015	23/09/2015	24/09/2014	1/12/2014	26/03/2015	30/06/2015	17/09/2015	4/12/2014	18/02/2015	25/06/2015	23/09/2015	n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
General field parameters																											
pH	pH units		6.5-7.5				6.69	7.18	6.81	6.90	6.71	6.77	6.65	6.53	6.57	6.07	6.21	6.39	6.14	93	93	69	4.03	7.18	5.52	6.14	0.58
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			574	557	556	538	2311	2383	2075	2139	1928	317	255	277.1	258	93	93	45	40.8	2383	464	341	470
Conductivity (lab)	µS/cm	1	30-350							521				2120				267	227	19	19	8	125	2120	415.11	304	449
Total Dissolved Solids (field)	g/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	373	362	362	350	1502	1550	1352	1391	1253	206	166	180	168	93	93		46	1550	307	228	311
Total Dissolved Solids (lab)	mg/L	10								267			1180	1200	1140			119	143	28	28		60	1200	270	175	331
Dissolved oxygen	% sat		90-110				45.7	27.7	61.3	42.1	9.0	21..2	21.5	20.4	25.1	46	14.4	15.8	9.5	93	91		0.7	113.2	23.0	18	18
Redox	mV						182.2	112.3	110.4	-105.2	-130.5	-81.6	-116.0	-111.7	-80.4	0.7	1.34	-8.8	-130.9	93	93		-201.6	293.6	-29.5		91
Temperature	ºC						16.67	22.57	17.71	16.26	23.57	25.2	19.0	15.9	16.9	20.20	19.20	13.60	16.49	93	93		11.47	25.2	18.08	18	3
Suspended Solids	mg/L	5												16	78			<5	6	15	8		6	78	33.50	23	27
Turbidity	NTU	0.1	2-25												71.5					3	3	0	2.3	71.5	30.57	14	36
Major Ions																											
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	90	0						
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	<1	90	1		7	7	7.00	7	
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	237	234	236	205	292	315	266	280	187	83	74	72	69	90	87		5	1090	109.22	71	128
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	237	234	236	205	292	315	266	280	187	83	74	72	69	90	87		5	1090	109.30	71	128
Acidity as $CaCO_3$	mg/L	1	-	-	-	-								60				34		7	7		30	99	53.43	50	23
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	10	12	10	10	92	43	32	10	11	3	4	8	4	90	87	0	1	149	17.21	8	30
Chloride	mg/L	1	-	700	-	ID	44	47	48	40	542	521	476	548	495	42	35	36	32	90	90	0	10	548	77.76	48	116
Calcium	mg/L	1	-	-	1000	-	35	35	32	32	92	122	106	127	105	30	14	18	15	90	84	0	1	127	24.12	15	25
Magnesium	mg/L	1	-	-	ID	-	43	38	42	41	80	74	83	86	67	6	8	7	8	90	90		1	86	15.32	8	19
Sodium	mg/L	1	-	460	-	-	22	19	22	20	272	237	187	176	160	18	18	18	20	90	90	1	4	555	46.16	29	73
Potassium	mg/L	1	-	-	-	-	2	2	2	2	7	5	5	4	4	<1	2	1	2	90	64		1	41	3.86	3	5
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	32.2	29.8	33.9	31	11.2	12.2	10.8	10.3	8.6	8.8	9.4	9.2	8.6	90	89		7.4	33.9	11.25	11	5
Total Anions	meq/L	0.01	-	-	-	-	6.18	6.25	6.28	5.43	23	21.9	19.4	21.3	17.9	2.91	2.55	2.62	2.36								
Total Cations	meq/L	0.01	-	-	-	-	6.29	5.75	6.06	5.89	23.2	22.6	20.4	21.2	17.8	2.77	2.19	2.28	2.33								
Ionic Balance	%	0.01	-	-	-	-	0.86	4.17	1.76	4.05	0.31	1.64	2.45	0.2	0.3												
Other Inorganics																											
Flouride	mg/L	0.1	-	2	2	1.5							0.1	0.2	0.1			0.1		33	15	0	0.1	0.3	0.16	0.15	0.07
Free cyanide	mg/L	0.004	0.007	-	-	0.08							<0.004							13	0	0					
Total cyanide	mg/L	0.004	-	-	-	-							<0.004							13	0						
Thiocyanate	mg/L	0.1	-	-	-	-							<0.1							13	0						
Dissolved metals																											
Aluminium	mg/L	0.01	0.055	20	5	ID	2.04	0.02	<0.01	<0.01	<0.01	<0.01	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	0.04	63	33	9	0.01	2.04	0.10	0.03	0.35
Antimony	mg/L	0.001	ID	-	-	0.003	0.003	0.003	0.003	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	63	6		0.001	0.003	0.003	0.00	0.00
Arsenic	mg/L	0.001	0.013	2	0.5	0.01	0.01	0.012	0.011	0.006	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	63	28	5	0.001	0.057	0.012	0.01	0.02
Beryllium	mg/L	0.001	ID	0.5	ID	0.06							<0.001		<0.001					21	0						
Barium	mg/L	0.001	-	-	-	2							0.455	0.664	0.651			0.104		28	28	0	0.016	0.664	0.200	0.13	0.18
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.0001	<0.0001	<0.0001	<0.0001	63	9	4	0.0001	0.0305	0.004	0.00	0.01
Chromium	mg/L	0.001	0.001	1	1	0.05	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	63	3	2	0.001	0.002	0.002	0.00	0.00
Cobalt	mg/L	0.001	ID	0.1	1	-	0.028	0.034	0.029	0.012	0.001	0.002	0.001	<0.001	<0.001	0.012	0.001	0.002	0.002	63	40	0	0.001	0.046	0.010	0.01	0.01
Copper	mg/L	0.001	0.0014	5	1#	2	0.003	0.012	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	0.001	<0.001	<0.001	<0.001	63	22	14	0.001	0.061	0.008	0.00	0.01
Lead	mg/L	0.001	0.0034	5	0.1	0.01	0.002	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	63	7	4	0.002	0.045	0.016	0.01	0.02
Lithium	mg/L	0.001	-	2.5	-	-							0.054		0.038					20	19	0	0.004	0.114	0.034	0.02	0.03
Manganese	mg/L	0.001	1.9	10	-	0.5	0.026	0.004	0.002	0.001	1.26	2.35	1.92	2.22	2.33	1.03	0.614	0.66	0.582	90	90	8	0.001	4.25	0.690	0.40	0.80
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05	0.023	0.037	0.02	0.017	0.002	0.003	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	63	21	1	0.001	0.089	0.014	0.01	0.02
Nickel	mg/L	0.001	0.011	2	1	0.02	0.085	0.102	0.072	0.045	0.009	0.004	0.01	0.009	0.002	0.01	0.003	0.002	0.003	63	53	14	0.001	0.108	0.017	0.01	0.03
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	63	2	2	0.02	0.1	0.060	0.04	0.06
Strontium	mg/L	0.001	-	-	-	-							1.53	2.01	1.91			0.1		28	28		0.006	2.01	0.291	0.10	0.55
Tin	mg/L	0.001	ID	-	-	-							<0.001		<0.001					20	0						
Uranium	mg/L	0.001	ID	0.1	0.2	0.017							0.002		<0.001					21	2	0	0.001	0.002	0.002	0.00	0.00
Vanadium	mg/L	0.01	ID	0.5	ID	-							<0.01		<0.01					21	0						
Zinc	mg/L	0.005	0.008	5	20	ID	0.038	0.033	0.045	0.087	0.008	0.01	0.015	<0.005	0.007	0.11	0.011	0.011	0.017	62	56	45	0.005	1.57	0.080	0.03	0.23
Boron	mg/L	0.05	0.37	5	5	4	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	62	1	0					
Iron	mg/L	0.05	ID	10	ID	ID	0.42	<0.05	<0.05	<0.05	4.58	7.16	5.82	8.44	13.8	0.13	9.88	9.16	8.69	89	86	29	0.13	20.8	7.7	5.36	5.47
Ferrous iron	mg/L	0.05	-	-	-	ID				<0.05				9.85	14.5			10.6	9.12	16	15	8	1.85	19	10.32	8.43	5.35
Bromine	mg/L	0.1	-	-	-	-							1.2		1.2					21	18		0.1	1.2	0.361	0.24	0.36
Iodine	mg/L	0.1	-	-	-	ID							<0.1		<0.1					20	2		0.2	0.4	0.3	0.28	0.14
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001							<0.0001							13	0						
Total metals																											
Aluminium	mg/L	0.01	-	-	-	-							17.2		0.76					17	17		0.02	17.2	1.30	0.19	4.11
Manganese	mg/L	0.001	-	-	-	-				0.059			2.43	2.32	2.2			0.671	0.606	30	30		0.059	2.43	0.671	0.46	0.62
Iron	mg/L	0.05	-	-	-	-				0.64			15.6	8.91	13.4			10	9.57	30	30		0.64	21.4	10.1	7.69	5.98
Nutrients																											
Ammonia as N	mg/L	0.01	2.57										0.04		0.06					17	14	0	0.01	0.18	0.06	0.04	0.06
Nitrite as N	mg/L	0.01			9								<0.01		<0.01					23	1	0	0.01	0.01	0.01	0.01	
Nitrate as N	mg/L	0.01			90								<0.01		0.03					23	16	0	0.01	0.2	0.03	0.02	0.05
Nitrite + Nitrate as N	mg/L	0.01													0.03					1	1		0.03	0.03	0.03	0.03	
Total phosphorous	mg/L	0.01											0.12							14	9		0.01	0.12	0.04	0.03	0.03
Reactive phosphorous	mg/L	0.01											0.1		<0.01					23	2		0.02	0.1	0.06	0.04	0.06
Biochemical oxygen demand	mg/L	2													<2					3	0						
Isotopes																											
Oxygen-18	‰	0.01																		3	3						
Deuterium	‰	0.1																		3	3						
Carbon-13	‰	0.1																		2	2						
Radiocarbon	pMC	0.1																		2	0						
Radiocarbon Age (uncorrected)	yrs BP	1																		2	0						
Tritium	TU	0.01																		3	0						

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0018PZA										HU0023PZA				HU0032LDA				HU0038PZA							
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	17/10/2011	7/01/2013	22/03/2013	9/07/2013	17/10/2013	12/12/2013	8/04/2014	25/03/2015	2/07/2015	24/09/2015	16/11/2011	17/12/2012	25/03/2013	21/05/2014	12/12/2013	3/04/2014	26/03/2015	24/09/2015	24/07/2012	14/12/2012	11/12/2013	2/04/2014	15/08/2014	2/12/2014	12/02/2015	15/09/2015
Organochloride pesticides																																
alpha-BHC	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Hexachlorobenzene (HCB)	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
beta-BHC	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
gamma-BHC	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
delta-BHC	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Heptachlor	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Aldrin	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Heptachlor epoxide	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
trans-Chlordane	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
alpha-Endosulfan	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
cis-Chlordane	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Dieldrin	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
4.4`-DDE	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Endrin	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
beta-Endosulfan	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
4.4`-DDD	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Endrin aldehyde	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Endosulfan sulfate	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
4.4`-DDT	µg/L	2										<2.0				<2.0					<2.0						<2.0				<2.0	
Endrin ketone	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Methoxychlor	µg/L	2										<2.0				<2.0					<2.0						<2.0				<2.0	
Total Chlordane (sum)	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Sum of DDD + DDE + DDT	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Sum of Aldrin + Dieldrin	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Organophosphorous pesticides																																
Dichlorvos	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Demeton-S-methyl	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Monocrotophos	µg/L	2										<2.0				<2.0					<2.0						<2.0				<2.0	
Dimethoate	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Diazinon	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Chlorpyrifos-methyl	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Parathion-methyl	µg/L	2										<2.0				<2.0					<2.0						<2.0				<2.0	
Malathion	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Fenthion	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Chlorpyrifos	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Parathion	µg/L	2										<2.0				<2.0					<2.0						<2.0				<2.0	
Pirimphos-ethyl	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Chlorfenvinphos	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Bromophos-ethyl	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Fenamiphos	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Prothiofos	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Ethion	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Carbophenothion	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Azinphos Methyl	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Phenolic compounds																																
Phenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
2-Chlorophenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
2-Methylphenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
3- & 4-Methylphenol	µg/L	1										<2.0				<2.0					<2.0						<2.0				<2.0	
2-Nitrophenol	µg/L	2										<1.0				<1.0					<1.0						<1.0				<1.0	
2.4-Dimethylphenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
2.4-Dichlorophenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
2.6-Dichlorophenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
4-Chloro-3-methylphenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
2.4.6-Trichlorophenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
2.4.5-Trichlorophenol	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Pentachlorophenol	µg/L	1										<2.0				<2.0					<2.0						<2.0				<2.0	
Polynuclear aromatic hydrocarbons																																
Naphthalene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Acenaphthylene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Acenaphthene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Fluorene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Phenanthrene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Anthracene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Fluoranthene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Pyrene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Benz(a)anthracene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Chrysene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Benzo(b)fluoranthene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Benzo(k)fluoranthene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Benzo(a)pyrene	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Indeno(1.2.3.cd)pyrene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Dibenz(a.h)anthracene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Benzo(g.h.i)perylene	µg/L	1										<1.0				<1.0					<1.0						<1.0				<1.0	
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	
Benzo(a)pyrene TEQ (zero)	µg/L	0.5										<0.5				<0.5					<0.5						<0.5				<0.5	

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0042PZA						HU0043XPZA				HU0044XPZA								HU0072PZA									
Analyte	Units	LOR	ANZECC (2000) Aquatic	ANZECC (2000) Irrigation	ANZECC (2000) Livestock	ADWG (2011)	23/08/2012	19/12/2012	3/07/2013	19/08/2013	17/12/2013	2/02/2015	30/08/2012	3/01/2013	17/12/2013	5/02/2015	24/08/2012	14/12/2012	2/07/2013	18/09/2013	10/12/2013	20/03/2014	28/07/2014	18/02/2015	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	15/09/2015
Organochloride pesticides																																		
alpha-BHC	µg/L	0.5									<0.5																	<0.5						
Hexachlorobenzene (HCB)	µg/L	0.5									<0.5																	<0.5						
beta-BHC	µg/L	0.5									<0.5																	<0.5						
gamma-BHC	µg/L	0.5									<0.5																	<0.5						
delta-BHC	µg/L	0.5									<0.5																	<0.5						
Heptachlor	µg/L	0.5									<0.5																	<0.5						
Aldrin	µg/L	0.5									<0.5																	<0.5						
Heptachlor epoxide	µg/L	0.5									<0.5																	<0.5						
trans-Chlordane	µg/L	0.5									<0.5																	<0.5						
alpha-Endosulfan	µg/L	0.5									<0.5																	<0.5						
cis-Chlordane	µg/L	0.5									<0.5																	<0.5						
Dieldrin	µg/L	0.5									<0.5																	<0.5						
4.4`-DDE	µg/L	0.5									<0.5																	<0.5						
Endrin	µg/L	0.5									<0.5																	<0.5						
beta-Endosulfan	µg/L	0.5									<0.5																	<0.5						
4.4`-DDD	µg/L	0.5									<0.5																	<0.5						
Endrin aldehyde	µg/L	0.5									<0.5																	<0.5						
Endosulfan sulfate	µg/L	0.5									<0.5																	<0.5						
4.4`-DDT	µg/L	2									<2.0																	<2.0						
Endrin ketone	µg/L	0.5									<0.5																	<0.5						
Methoxychlor	µg/L	2									<2.0																	<2.0						
Total Chlordane (sum)	µg/L	0.5									<0.5																	<0.5						
Sum of DDD + DDE + DDT	µg/L	0.5									<0.5																	<0.5						
Sum of Aldrin + Dieldrin	µg/L	0.5									<0.5																	<0.5						
Organophosphorous pesticides																																		
Dichlorvos	µg/L	0.5									<0.5																	<0.5						
Demeton-S-methyl	µg/L	0.5									<0.5																	<0.5						
Monocrotophos	µg/L	2									<2.0																	<2.0						
Dimethoate	µg/L	0.5									<0.5																	<0.5						
Diazinon	µg/L	0.5									<0.5																	<0.5						
Chlorpyrifos-methyl	µg/L	0.5									<0.5																	<0.5						
Parathion-methyl	µg/L	2									<2.0																	<2.0						
Malathion	µg/L	0.5									<0.5																	<0.5						
Fenthion	µg/L	0.5									<0.5																	<0.5						
Chlorpyrifos	µg/L	0.5									<0.5																	<0.5						
Parathion	µg/L	2									<2.0																	<2.0						
Pirimphos-ethyl	µg/L	0.5									<0.5																	<0.5						
Chlorfenvinphos	µg/L	0.5									<0.5																	<0.5						
Bromophos-ethyl	µg/L	0.5									<0.5																	<0.5						
Fenamiphos	µg/L	0.5									<0.5																	<0.5						
Prothiofos	µg/L	0.5									<0.5																	<0.5						
Ethion	µg/L	0.5									<0.5																	<0.5						
Carbophenothion	µg/L	0.5									<0.5																	<0.5						
Azinphos Methyl	µg/L	0.5									<0.5																	<0.5						
Phenolic compounds																																		
Phenol	µg/L	1									1.3																	<1.0						
2-Chlorophenol	µg/L	1									<1.0																	<1.0						
2-Methylphenol	µg/L	1									<1.0																	<1.0						
3- & 4-Methylphenol	µg/L	1									<2.0																	<2.0						
2-Nitrophenol	µg/L	2									<1.0																	<1.0						
2.4-Dimethylphenol	µg/L	1									<1.0																	<1.0						
2.4-Dichlorophenol	µg/L	1									<1.0																	<1.0						
2.6-Dichlorophenol	µg/L	1									<1.0																	<1.0						
4-Chloro-3-methylphenol	µg/L	1									<1.0																	<1.0						
2.4.6-Trichlorophenol	µg/L	1									<1.0																	<1.0						
2.4.5-Trichlorophenol	µg/L	1									<1.0																	<1.0						
Pentachlorophenol	µg/L	1									<2.0																	<2.0						
Polynuclear aromatic hydrocarbons																																		
Naphthalene	µg/L	1									<1.0																	<1.0						
Acenaphthylene	µg/L	1									<1.0																	<1.0						
Acenaphthene	µg/L	1									<1.0																	<1.0						
Fluorene	µg/L	1									<1.0																	<1.0						
Phenanthrene	µg/L	1									<1.0																	<1.0						
Anthracene	µg/L	1									<1.0																	<1.0						
Fluoranthene	µg/L	1									<1.0																	<1.0						
Pyrene	µg/L	1									<1.0																	<1.0						
Benz(a)anthracene	µg/L	1									<1.0																	<1.0						
Chrysene	µg/L	1									<1.0																	<1.0						
Benzo(b)fluoranthene	µg/L	1									<1.0																	<1.0						
Benzo(k)fluoranthene	µg/L	1									<1.0																	<1.0						
Benzo(a)pyrene	µg/L	0.5									<0.5																	<0.5						
Indeno(1.2.3.cd)pyrene	µg/L	1									<1.0																	<1.0						
Dibenz(a.h)anthracene	µg/L	1									<1.0																	<1.0						
Benzo(g.h.i)perylene	µg/L	1									<1.0																	<1.0						
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5									<0.5																	<0.5						
Benzo(a)pyrene TEQ (zero)	µg/L	0.5									<0.5																	<0.5						

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0073PZB									HU0088PZA					HU0096PZB								HU0129PZA			
			ANZECC (2000)																													
Analyte	Units	LOR	Aquatic	Irrigation	Livestock	ADWG (2011)	27/03/2013	7/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	11/12/2013	2/04/2014	26/09/2014	3/12/2014	11/02/2015	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	22/05/2014	10/02/2015	24/06/2015	16/09/2015
Organochloride pesticides																																
alpha-BHC	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Hexachlorobenzene (HCB)	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
beta-BHC	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
gamma-BHC	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
delta-BHC	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Heptachlor	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Aldrin	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Heptachlor epoxide	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
trans-Chlordane	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
alpha-Endosulfan	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
cis-Chlordane	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Dieldrin	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
4.4`-DDE	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Endrin	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
beta-Endosulfan	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
4.4`-DDD	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Endrin aldehyde	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Endosulfan sulfate	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
4.4`-DDT	µg/L	2								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
Endrin ketone	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Methoxychlor	µg/L	2								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
Total Chlordane (sum)	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Sum of DDD + DDE + DDT	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Sum of Aldrin + Dieldrin	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Organophosphorous pesticides																																
Dichlorvos	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Demeton-S-methyl	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Monocrotophos	µg/L	2								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
Dimethoate	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Diazinon	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Chlorpyrifos-methyl	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Parathion-methyl	µg/L	2								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
Malathion	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Fenthion	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Chlorpyrifos	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Parathion	µg/L	2								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
Pirimphos-ethyl	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Chlorfenvinphos	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Bromophos-ethyl	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Fenamiphos	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Prothiofos	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Ethion	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Carbophenothion	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Azinphos Methyl	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Phenolic compounds																																
Phenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2-Chlorophenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2-Methylphenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
3- & 4-Methylphenol	µg/L	1								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
2-Nitrophenol	µg/L	2								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2.4-Dimethylphenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2.4-Dichlorophenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2.6-Dichlorophenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
4-Chloro-3-methylphenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2.4.6-Trichlorophenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
2.4.5-Trichlorophenol	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Pentachlorophenol	µg/L	1								<2.0			<2.0		<2.0	<2.0				<2.0			<2.0			<2.0		<2.0				
Polynuclear aromatic hydrocarbons																																
Naphthalene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Acenaphthylene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Acenaphthene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Fluorene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Phenanthrene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Anthracene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Fluoranthene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Pyrene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Benz(a)anthracene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Chrysene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Benzo(b)fluoranthene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Benzo(k)fluoranthene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Benzo(a)pyrene	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Indeno(1.2.3.cd)pyrene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Dibenz(a.h)anthracene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Benzo(g.h.i)perylene	µg/L	1								<1.0			<1.0		<1.0	<1.0				<1.0			<1.0			<1.0		<1.0				
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				
Benzo(a)pyrene TEQ (zero)	µg/L	0.5								<0.5			<0.5		<0.5	<0.5				<0.5			<0.5			<0.5		<0.5				

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0136PZA				HU0142PZA					HU0143PZB											
Analyte	Units	LOR	ANZECC (2000) Aquatic	Irrigation	Livestock	ADWG (2011)	29/08/2014	1/12/2014	4/02/2015	23/09/2015	24/09/2014	1/12/2014	26/03/2015	30/06/2015	17/09/2015	4/12/2014	18/02/2015	25/06/2015	23/09/2015	n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
Organochloride pesticides																											
alpha-BHC	µg/L	0.5											<0.5		<0.5					17	0						
Hexachlorobenzene (HCB)	µg/L	0.5											<0.5		<0.5					17	0						
beta-BHC	µg/L	0.5											<0.5		<0.5					17	0						
gamma-BHC	µg/L	0.5											<0.5		<0.5					17	0						
delta-BHC	µg/L	0.5											<0.5		<0.5					17	0						
Heptachlor	µg/L	0.5											<0.5		<0.5					17	0						
Aldrin	µg/L	0.5											<0.5		<0.5					17	0						
Heptachlor epoxide	µg/L	0.5											<0.5		<0.5					17	0						
trans-Chlordane	µg/L	0.5											<0.5		<0.5					17	0						
alpha-Endosulfan	µg/L	0.5											<0.5		<0.5					17	0						
cis-Chlordane	µg/L	0.5											<0.5		<0.5					17	0						
Dieldrin	µg/L	0.5											<0.5		<0.5					17	0						
4.4`-DDE	µg/L	0.5											<0.5		<0.5					17	0						
Endrin	µg/L	0.5											<0.5		<0.5					17	0						
beta-Endosulfan	µg/L	0.5											<0.5		<0.5					17	0						
4.4`-DDD	µg/L	0.5											<0.5		<0.5					17	0						
Endrin aldehyde	µg/L	0.5											<0.5		<0.5					17	0						
Endosulfan sulfate	µg/L	0.5											<0.5		<0.5					17	0						
4.4`-DDT	µg/L	2											<2.0		<2.0					17	0						
Endrin ketone	µg/L	0.5											<0.5		<0.5					17	0						
Methoxychlor	µg/L	2											<2.0		<2.0					17	0						
Total Chlordane (sum)	µg/L	0.5											<0.5		<0.5					17	0						
Sum of DDD + DDE + DDT	µg/L	0.5											<0.5		<0.5					17	0						
Sum of Aldrin + Dieldrin	µg/L	0.5											<0.5		<0.5					17	0						
Organophosphorous pesticides																											
Dichlorvos	µg/L	0.5											<0.5		<0.5					17	0						
Demeton-S-methyl	µg/L	0.5											<0.5		<0.5					17	0						
Monocrotophos	µg/L	2											<2.0		<2.0					17	0						
Dimethoate	µg/L	0.5											<0.5		<0.5					17	0						
Diazinon	µg/L	0.5											<0.5		<0.5					17	0						
Chlorpyrifos-methyl	µg/L	0.5											<0.5		<0.5					17	0						
Parathion-methyl	µg/L	2											<2.0		<2.0					17	0						
Malathion	µg/L	0.5											<0.5		<0.5					17	0						
Fenthion	µg/L	0.5											<0.5		<0.5					17	0						
Chlorpyrifos	µg/L	0.5											<0.5		<0.5					17	0						
Parathion	µg/L	2											<2.0		<2.0					17	0						
Pirimphos-ethyl	µg/L	0.5											<0.5		<0.5					17	0						
Chlorfenvinphos	µg/L	0.5											<0.5		<0.5					17	0						
Bromophos-ethyl	µg/L	0.5											<0.5		<0.5					17	0						
Fenamiphos	µg/L	0.5											<0.5		<0.5					17	0						
Prothiofos	µg/L	0.5											<0.5		<0.5					17	0						
Ethion	µg/L	0.5											<0.5		<0.5					17	0						
Carbophenothion	µg/L	0.5											<0.5		<0.5					17	0						
Azinphos Methyl	µg/L	0.5											<0.5		<0.5					17	0						
Phenolic compounds																											
Phenol	µg/L	1											<1.0		<1.0					17	1		1.3	1.3	1.3		
2-Chlorophenol	µg/L	1											<1.0		<1.0					17	0						
2-Methylphenol	µg/L	1											<1.0		<1.0					17	0						
3- & 4-Methylphenol	µg/L	1											<2.0		<2.0					17	0						
2-Nitrophenol	µg/L	2											<1.0		<1.0					17	0						
2.4-Dimethylphenol	µg/L	1											<1.0		<1.0					17	0						
2.4-Dichlorophenol	µg/L	1											<1.0		<1.0					17	0						
2.6-Dichlorophenol	µg/L	1											<1.0		<1.0					17	0						
4-Chloro-3-methylphenol	µg/L	1											<1.0		<1.0					17	0						
2.4.6-Trichlorophenol	µg/L	1											<1.0		<1.0					17	0						
2.4.5-Trichlorophenol	µg/L	1											<1.0		<1.0					17	0						
Pentachlorophenol	µg/L	1											<2.0		<2.0					17	0						
Polynuclear aromatic hydrocarbons																											
Naphthalene	µg/L	1											<1.0		<1.0					17	0						
Acenaphthylene	µg/L	1											<1.0		<1.0					17	0						
Acenaphthene	µg/L	1											<1.0		<1.0					17	0						
Fluorene	µg/L	1											<1.0		<1.0					17	0						
Phenanthrene	µg/L	1											<1.0		<1.0					17	0						
Anthracene	µg/L	1											<1.0		<1.0					17	0						
Fluoranthene	µg/L	1											<1.0		<1.0					17	0						
Pyrene	µg/L	1											<1.0		<1.0					17	0						
Benz(a)anthracene	µg/L	1											<1.0		<1.0					17	0						
Chrysene	µg/L	1											<1.0		<1.0					17	0						
Benzo(b)fluoranthene	µg/L	1											<1.0		<1.0					17	0						
Benzo(k)fluoranthene	µg/L	1											<1.0		<1.0					17	0						
Benzo(a)pyrene	µg/L	0.5											<0.5		<0.5					17	0						
Indeno(1.2.3.cd)pyrene	µg/L	1											<1.0		<1.0					17	0						
Dibenz(a.h)anthracene	µg/L	1											<1.0		<1.0					17	0						
Benzo(g.h.i)perylene	µg/L	1											<1.0		<1.0					17	0						
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5											<0.5		<0.5					17	0						
Benzo(a)pyrene TEQ (zero)	µg/L	0.5											<0.5		<0.5					17	0						

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0018PZA										HU0023PZA				HU0032LDA				HU0038PZA							
Analyte	Units	LOR	ANZECC (2000) Aquatic	Irrigation	Livestock	ADWG (2011)	17/10/2011	7/01/2013	22/03/2013	9/07/2013	17/10/2013	12/12/2013	8/04/2014	25/03/2015	2/07/2015	24/09/2015	16/11/2011	17/12/2012	25/03/2013	21/05/2014	12/12/2013	3/04/2014	26/03/2015	24/09/2015	24/07/2012	14/12/2012	11/12/2013	2/04/2014	15/08/2014	2/12/2014	12/02/2015	15/09/2015
BTEX																																
Benzene	µg/L	1										<1				<1					<1						<1				<1	
Toluene	µg/L	2	ID			800						3				<2					<2						<2				2	
Ethylbenzene	µg/L	2										<2				<2					<2						<2				<2	
meta- & para-Xylene	µg/L	2										<2				<2					<2						<2				<2	
ortho-Xylene	µg/L	2										<2				<2					<2						<2				<2	
Total Xylenes	µg/L	2										<2				<2					<2						<2				<2	
Sum of BTEX	µg/L	1										3				<1					<1						<1				2	
Naphthalene	µg/L	5										<5				<5					<5						<5				<5	
Total petroleum hydrocarbons																																
C6 - C9 Fraction	µg/L	20										<20				<20					<20						<20				<20	
C10 - C14 Fraction	µg/L	50										<50				<50					<50						<50				<50	
C15 - C28 Fraction	µg/L	100										<100				<100					<100						<100				<100	
C29 - C36 Fraction	µg/L	50										<50				<50					<50						<50				<50	
C10 - C36 Fraction (sum)	µg/L	50										<50				<50					<50						<50				<50	
Total Recoverable Hydrocarbons																																
C6 - C10 Fraction	µg/L	20										<20				<20					<20						<20				<20	
C6 - C10 Fraction minus BTEX (F1)	µg/L	20										<20				<20					<20						<20				<20	
>C10 - C16 Fraction	µg/L	100										<100				<100					<100						<100				<100	
>C16 - C34 Fraction	µg/L	100										<100				<100					<100						<100				<100	
>C34 - C40 Fraction	µg/L	100										<100				<100					<100						<100				<100	
>C10 - C40 Fraction (sum)	µg/L	100										<100				<100					<100						<100				<100	
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100										<100				<100					<100						<100				<100	
Microbiology																																
Faecal coliforms	CFU/100 mL	1										<1				~<1					<1						<1				<2	
E coli	CFU/100 mL	1										<1				~<1					<1						<1				<2	
Total coliforms	CFU/100 mL	1										<1				<1					<1						<1				46	

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0042PZA						HU0043XPZA				HU0044XPZA								HU0072PZA									
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	23/08/2012	19/12/2012	3/07/2013	19/08/2013	17/12/2013	2/02/2015	30/08/2012	3/01/2013	17/12/2013	5/02/2015	24/08/2012	14/12/2012	2/07/2013	18/09/2013	10/12/2013	20/03/2014	28/07/2014	18/02/2015	21/03/2013	8/07/2013	18/09/2013	11/12/2013	26/03/2014	14/08/2014	2/12/2014	25/03/2015	26/06/2015	15/09/2015
BTEX																																		
Benzene	µg/L	1									<1																	<1						
Toluene	µg/L	2	ID			800					26																	<2						
Ethylbenzene	µg/L	2									<2																	<2						
meta- & para-Xylene	µg/L	2									<2																	<2						
ortho-Xylene	µg/L	2									<2																	<2						
Total Xylenes	µg/L	2									<2																	<2						
Sum of BTEX	µg/L	1									26																	<1						
Naphthalene	µg/L	5									<5																	<5						
Total petroleum hydrocarbons																																		
C6 - C9 Fraction	µg/L	20									40																	<20						
C10 - C14 Fraction	µg/L	50									<50																	<50						
C15 - C28 Fraction	µg/L	100									<100																	<100						
C29 - C36 Fraction	µg/L	50									<50																	<50						
C10 - C36 Fraction (sum)	µg/L	50									<50																	<50						
Total Recoverable Hydrocarbons																																		
C6 - C10 Fraction	µg/L	20									40																	<20						
C6 - C10 Fraction minus BTEX (F1)	µg/L	20									<20																	<20						
>C10 - C16 Fraction	µg/L	100									<100																	<100						
>C16 - C34 Fraction	µg/L	100									<100																	<100						
>C34 - C40 Fraction	µg/L	100									<100																	<100						
>C10 - C40 Fraction (sum)	µg/L	100									<100																	<100						
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100									<100																	<100						
Microbiology																																		
Faecal coliforms	CFU/100 mL	1									<1																	<1						
E coli	CFU/100 mL	1									<1																	<1						
Total coliforms	CFU/100 mL	1									<1																	<1						

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0073PZB									HU0088PZA					HU0096PZB								HU0129PZA			
Analyte	Units	LOR	Aquatic	ANZECC (2000) Irrigation	Livestock	ADWG (2011)	27/03/2013	7/08/2013	15/10/2013	10/12/2013	3/04/2014	5/12/2014	26/03/2015	29/06/2015	21/09/2015	11/12/2013	2/04/2014	26/09/2014	3/12/2014	11/02/2015	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	22/05/2014	10/02/2015	24/06/2015	16/09/2015
BTEX																																
Benzene	µg/L	1								<1			<1		<1	<1				<1			<1			<1		<1				
Toluene	µg/L	2	ID			800				<2			<2		<2	<2				62			<2			<2		<2				
Ethylbenzene	µg/L	2								<2			<2		<2	<2				<2			<2			<2		<2				
meta- & para-Xylene	µg/L	2								<2			<2		<2	<2				<2			<2			<2		<2				
ortho-Xylene	µg/L	2								<2			<2		<2	<2				<2			<2			<2		<2				
Total Xylenes	µg/L	2								<2			<2		<2	<2				<2			<2			<2		<2				
Sum of BTEX	µg/L	1								<1			<1		<1	<1				62			<1			<1		<1				
Naphthalene	µg/L	5								<5			<5		<5	<5				<5			<5			<5		<5				
Total petroleum hydrocarbons																																
C6 - C9 Fraction	µg/L	20								<20			<20		<20	<20				100			<20			<20		<20				
C10 - C14 Fraction	µg/L	50								<50			<50		<50	<50				<50			<50			<50		<50				
C15 - C28 Fraction	µg/L	100								<100			<100		<100	<100				<100			<100			<100		<100				
C29 - C36 Fraction	µg/L	50								<50			<50		<50	<50				<50			<50			<50		<50				
C10 - C36 Fraction (sum)	µg/L	50								<50			<50		<50	<50				<50			<50			<50		<50				
Total Recoverable Hydrocarbons																																
C6 - C10 Fraction	µg/L	20								<20			<20		<20	<20				100			<20			<20		<20				
C6 - C10 Fraction minus BTEX (F1)	µg/L	20								<20			<20		<20	<20				40			<20			<20		<20				
>C10 - C16 Fraction	µg/L	100								<100			<100		<100	<100				<100			<100			<100		<100				
>C16 - C34 Fraction	µg/L	100								<100			<100		<100	<100				<100			<100			<100		<100				
>C34 - C40 Fraction	µg/L	100								<100			<100		<100	<100				<100			<100			<100		<100				
>C10 - C40 Fraction (sum)	µg/L	100								<100			<100		<100	<100				<100			<100			<100		<100				
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100								<100			<100		<100	<100				<100			<100			<100		<100				
Microbiology																																
Faecal coliforms	CFU/100 mL	1								<1			<1		<1	<1				<1			<1			<2		<1				
E coli	CFU/100 mL	1								<1			<1		<1	<1				<1			<1			<2		<1				
Total coliforms	CFU/100 mL	1								<2			<1		~1	~1				140			<1			<2		<1				

Table A5: Baseline Groundwater Monitoring Results - Wongawilli Seam

Location			Water Quality Criteria				HU0136PZA				HU0142PZA					HU0143PZB			
Analyte	Units	LOR	ANZECC (2000) Aquatic	ANZECC (2000) Irrigation	ANZECC (2000) Livestock	ADWG (2011)	29/08/2014	1/12/2014	4/02/2015	23/09/2015	24/09/2014	1/12/2014	26/03/2015	30/06/2015	17/09/2015	4/12/2014	18/02/2015	25/06/2015	23/09/2015
BTEX																			
Benzene	µg/L	1											<1		<1				
Toluene	µg/L	2	ID			800							<2		<2				
Ethylbenzene	µg/L	2											<2		<2				
meta- & para-Xylene	µg/L	2											<2		<2				
ortho-Xylene	µg/L	2											<2		<2				
Total Xylenes	µg/L	2											<2		<2				
Sum of BTEX	µg/L	1											<1		<1				
Naphthalene	µg/L	5											<5		<5				
Total petroleum hydrocarbons																			
C6 - C9 Fraction	µg/L	20											<20		<20				
C10 - C14 Fraction	µg/L	50											<50		<50				
C15 - C28 Fraction	µg/L	100											<100		<100				
C29 - C36 Fraction	µg/L	50											<50		<50				
C10 - C36 Fraction (sum)	µg/L	50											<50		<50				
Total Recoverable Hydrocarbons																			
C6 - C10 Fraction	µg/L	20											<20		<20				
C6 - C10 Fraction minus BTEX (F1)	µg/L	20											<20		<20				
>C10 - C16 Fraction	µg/L	100											<100		<100				
>C16 - C34 Fraction	µg/L	100											<100		<100				
>C34 - C40 Fraction	µg/L	100											<100		<100				
>C10 - C40 Fraction (sum)	µg/L	100											<100		<100				
>C10 - C16 Fraction minus Naphthalene (F2)	µg/L	100											<100		<100				
Microbiology																			
Faecal coliforms	CFU/100 mL	1											<2		<2				
E coli	CFU/100 mL	1											<2		<2				
Total coliforms	CFU/100 mL	1											<2		<2				

17	0						
17	4		2	62	23.3		
17	0						
17	0						
17	0						
17	0						
17	4		2	62	23.3		
17	0						
17	2		40	100	70		
17	0						
17	0						
17	0						
17	0						
17	2		40	100	70		
17	1		40	40	40		
17	0						
17	0						
17	0						
17	0						
17	0						
17	0						
17	0						
17	2		46	140	93		

Table A6: Baseline Groundwater Monitoring Results - Tongarra Seam

Location			Water Quality Criteria				HU0096PZA								HU0133PZB								
Date			ANZECC (2000)			ADWG (2011)	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	23/05/2014								
Analyte	Units	LOR	Aquatic	Irrigation	Livestock											n	Detects	Exc	Min	Max	Avg	Geomean	Std Dev
General field parameters																							
pH	pH units		6.5-7.5				6.08	6.25	6.22	6.10	6.09	6.01	6.16	6.10	6.22	9	9	9	6.01	6.25	6.13	6.14	0.08
Conductivity (field)	µS/cm		30-350	0-650 (v. low) >650-1300 (low) >1300-2900 (medium) >2900-5200 (high) >5200-8100 (v. high) >8100 (extreme)			192	238	225	223	231	213.3	222.7	224	262	9	9	0	192	262	226	225	19
Conductivity (lab)	µS/cm	1	30-350							223			214			2	2	0	214	223	219	218	
Total Dissolved Solids (field)	mg/L					<600 (good quality) 600-900 (fair quality) >900-1200 (poor quality) >1200 (unacceptable)	0.110	0.155	0.147	0.145	0.150	0.139	0.145	0.145	0.170	9	9		0.11	0.17	0	0.14	0.02
Total Dissolved Solids (lab)	mg/L	10								113		107	103	108	116	5	5		103	116	109	109	
Dissolved oxygen	% sat		90-110				16.8	15.2	25.3	8.5	21.7	37.2	26.4	12.4	23.8	9	9		8.5	37.2	20.8	19	9
Redox	mV						27	8.8	-15	0.2	-3.2	19.3	-5	-133.5	-42.6	9	9		-133.5	27.0	-16.0		48
Temperature	ºC						20.00	19.90	20.36	19.30	19.00	14.2	14.6	15.44	20.32	9	9		14.2	20.4	18.1	18	3
Suspended Solids	mg/L	5											<5	<5		2	0						
Turbidity	NTU	0.1	2-25											3.3		1	1						
Major Ions																							
Hydroxide Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	9	0						
Carbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	<1	<1	<1	<1	<1	<1	<1	<1	<1	9	0						
Bicarbonate Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	69	64	53	46	63	53	64	58	87	9	9		46	87	62	61	12
Total Alkalinity as $CaCO_3$	mg/L	1	-	-	-	-	69	64	53	46	63	53	64	58	87	9	9		46	87	62	61	12
Acidity as $CaCO_3$	mg/L	1	-	-	-	-							65			1	1		65	65	65	65	
Sulfate as SO_4^{2-}	mg/L	1	-	-	1000	500	5	3	4	5	2	5	4	4	8	9	9	0	2	8	4.4	4	2
Chloride	mg/L	1	-	700	-	ID	30	37	34	34	25	40	28	30	30	9	9	0	25	40	32.0	32	5
Calcium	mg/L	1	-	-	1000	-	10	9	9	7	7	6	8	8	13	9	9	0	6	13	8.6	8	2
Magnesium	mg/L	1	-	-	ID	-	6	6	6	6	6	6	6	6	8	9	9		6	8	6.2	6	1
Sodium	mg/L	1	-	460	-	-	15	14	16	18	14	15	13	15	19	9	9	0	13	19	15.4	15	2
Potassium	mg/L	1	-	-	-	-	2	2	2	2	2	2	2	2	3	9	9		2	3	2.11	2	0
Silica/Silicon as SiO_2/Reactive silica	mg/L	0.1	-	-	-	-	9.0	9.6	8.2	8.8	9	9.42	8.9	8.79	9.62	9	9		8.21	9.62	9.0	9	0
Total Anions	meq/L	0.01	-	-	-	-	2.33	2.38	2.10	2.22	2.01	2.29	2.15	2.09	2.75								
Total Cations	meq/L	0.01	-	-	-	-	2.35	2.13	2.05	2.32	1.5	2.21	1.51	2.24	2.69								
Ionic Balance	%	0.01	-	-	-	-						1.8											
Other Inorganics																							
Flouride	mg/L	0.1	-	2	2	1.5			0.2	0.2		<0.1	0.1	0.2	0.1	6	5		0.1	0.2	0.2	0	0
Free cyanide	mg/L	0.004	0.007	-	-	0.08			<0.004			<0.004			<0.004	3	0						
Total cyanide	mg/L	0.004	-	-	-	-			<0.004			<0.004			<0.004	3	0						
Thiocyanate	mg/L	0.1	-	-	-	-			<0.1			<0.1			<0.1	3	0						
Dissolved metals																							
Aluminium	mg/L	0.01	0.055	20	5	ID			<0.01	<0.01	0.01	0.02	<0.01	<0.01	0.06	7	3	1	0.01	0.06	0.03	0.02	0.03
Antimony	mg/L	0.001	ID	-	-	0.003			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	7	0						
Arsenic	mg/L	0.001	0.013	2	0.5	0.01			<0.001	0.002	0.001	0.001	0.001	<0.001	<0.001	7	4		0.001	0.002	0.001	0.001	0.001
Beryllium	mg/L	0.001	ID	0.5	ID	0.06			<0.001			<0.001		<0.001	<0.001	4	0						
Barium	mg/L	0.001	-	-	-	2			0.099			0.057	0.07	0.067	0.116	5	5		0.057	0.116	0.082	0.079	0.025
Cadmium	mg/L	0.0001	0.0002	0.05	0.01	0.002			<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	7	0						
Chromium	mg/L	0.001	0.001	1	1	0.05			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	7	0						
Cobalt	mg/L	0.001	ID	0.1	1	-			0.003	0.002	0.001	<0.001	<0.001	<0.001	0.002	7	4		0.001	0.003	0.002	0.002	0.001
Copper	mg/L	0.001	0.0014	5	1#	2			<0.001	<0.001	0.01	0.003	<0.001	<0.001	<0.001	7	2	2	0.003	0.01	0.007	0.005	0.005
Lead	mg/L	0.001	0.0034	5	0.1	0.01			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	7	0						
Lithium	mg/L	0.001	-	2.5	-	-			0.058			0.035		0.042	0.039	4	4		0.035	0.058	0.044	0.043	0.010
Manganese	mg/L	0.001	1.9	10	-	0.5	0.493	0.527	0.708	0.565	0.651	0.734	0.561	0.558	0.482	9	9	0	0.482	0.734	0.587	0.58	0.09
Molybdenum	mg/L	0.001	ID	0.05	0.15	0.05			<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	7	0						
Nickel	mg/L	0.001	0.011	2	1	0.02			0.005	0.004	0.007	0.003	0.001	0.001	0.002	7	7	0	0.001	0.007	0.003	0.003	0.002
Selenium	mg/L	0.01	0.005	0.05	0.02	0.01			<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	<0.01	7	0						
Strontium	mg/L	0.001	-	-	-	-			0.056			0.034	0.035	0.036	0.104	5	5		0.034	0.104	0.053	0.048	0.030
Tin	mg/L	0.001	ID	-	-	-			<0.001			<0.001		<0.001	<0.001	4	0						
Uranium	mg/L	0.001	ID	0.1	0.2	0.017			<0.001			<0.001		<0.001	<0.001	4	0						
Vanadium	mg/L	0.01	ID	0.5	ID	-			<0.01			<0.01		<0.01	<0.01	4	0						
Zinc	mg/L	0.005	0.008	5	20	ID			0.043	0.042	0.054	0.02	0.006	<0.005	0.023	7	6	5	0.006	0.054	0.031	0.025	0.018
Boron	mg/L	0.05	0.37	5	5	4			<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	<0.05	7	0						
Iron	mg/L	0.05	ID	10	ID	ID	7.96	9.76	12.4	11.8	11.1	13.3	12.6	12.0	8.02	9	9	6	8.0	13.3	11.0	10.8	2.0
Ferrous iron	mg/L	0.05	-	-	-	ID							13.4	13.1		0	2		13.1	13.4	13.3	13.2	0.2
Bromine	mg/L	0.1	-	-	-	-			0.5			<0.1		<0.1	0.1	4	2		0.1	0.5	0.3	0.2	0.3
Iodine	mg/L	0.1	-	-	-	ID			<0.1			<0.1		<0.1	<0.1	4	0						
Mercury	mg/L	0.0001	0.00006	0.002	0.002	0.001			<0.0001			<0.0001			<0.0001	3	0						
Total metals																							
Aluminium	mg/L	0.01	-	-	-	-			<0.01			0.62		<0.01	0.08	4	2		0.1	0.6	0.4	0.2	0.4
Manganese	mg/L	0.001	-	-	-	-			0.697			0.724	0.575	0.584	0.48	5	5		0.5	0.7	0.6	0.6	0.1
Iron	mg/L	0.05	-	-	-	-			13.8			15.3	13	12.2	8.31	5	5		8.3	15.3	12.5	12.3	2.6
Nutrients																							
Ammonia as N	mg/L	0.01	2.57						0.03			<0.01		0.02	0.07	4	3		0.02	0.07	0.04	0.03	0.03
Nitrite as N	mg/L	0.01			9				<0.01	<0.01		<0.01		<0.01	<0.01	5	0						
Nitrate as N	mg/L	0.01			90				0.02	<0.01		<0.01		<0.01	0.01	5	2		0.01	0.02	0.02	0.01	0.01
Total phosphorous	mg/L	0.01							<0.01			0.06			<0.01	3	1		0.06	0.06	0.06	0.06	
Reactive phosphorous	mg/L	0.01							<0.01	<0.01		<0.01		<0.01	<0.01	5	0						
Biochemical oxygen demand	mg/L	2												<2									

Table A6: Baseline Groundwater Monitoring Results - Tongarra Seam

Location			Water Quality Criteria				HU0096PZA								HU0133PZB
Date			ANZECC (2000)			ADWG (2011)	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	23/05/2014
Analyte	Units	LOR	Aquatic	Irrigation	Livestock										
Organochloride pesticides															
alpha-BHC	µg/L	0.5							<0.5			<0.5		<0.5	
Hexachlorobenzene (HCB)	µg/L	0.5							<0.5			<0.5		<0.5	
beta-BHC	µg/L	0.5							<0.5			<0.5		<0.5	
gamma-BHC	µg/L	0.5							<0.5			<0.5		<0.5	
delta-BHC	µg/L	0.5							<0.5			<0.5		<0.5	
Heptachlor	µg/L	0.5							<0.5			<0.5		<0.5	
Aldrin	µg/L	0.5							<0.5			<0.5		<0.5	
Heptachlor epoxide	µg/L	0.5							<0.5			<0.5		<0.5	
trans-Chlordane	µg/L	0.5							<0.5			<0.5		<0.5	
alpha-Endosulfan	µg/L	0.5							<0.5			<0.5		<0.5	
cis-Chlordane	µg/L	0.5							<0.5			<0.5		<0.5	
Dieldrin	µg/L	0.5							<0.5			<0.5		<0.5	
4.4`-DDE	µg/L	0.5							<0.5			<0.5		<0.5	
Endrin	µg/L	0.5							<0.5			<0.5		<0.5	
beta-Endosulfan	µg/L	0.5							<0.5			<0.5		<0.5	
4.4`-DDD	µg/L	0.5							<0.5			<0.5		<0.5	
Endrin aldehyde	µg/L	0.5							<0.5			<0.5		<0.5	
Endosulfan sulfate	µg/L	0.5							<0.5			<0.5		<0.5	
4.4`-DDT	µg/L	2							<2.0			<2.0		<2.0	
Endrin ketone	µg/L	0.5							<0.5			<0.5		<0.5	
Methoxychlor	µg/L	2							<2.0			<2.0		<2.0	
Total Chlordane (sum)	µg/L	0.5							<0.5			<0.5		<0.5	
Sum of DDD + DDE + DDT	µg/L	0.5							<0.5			<0.5		<0.5	
Sum of Aldrin + Dieldrin	µg/L	0.5							<0.5			<0.5		<0.5	
Organophosphorous pesticides															
Dichlorvos	µg/L	0.5							<0.5			<0.5		<0.5	
Demeton-S-methyl	µg/L	0.5							<0.5			<0.5		<0.5	
Monocrotophos	µg/L	2							<2.0			<2.0		<2.0	
Dimethoate	µg/L	0.5							<0.5			<0.5		<0.5	
Diazinon	µg/L	0.5							<0.5			<0.5		<0.5	
Chlorpyrifos-methyl	µg/L	0.5							<0.5			<0.5		<0.5	
Parathion-methyl	µg/L	2							<2.0			<2.0		<2.0	
Malathion	µg/L	0.5							<0.5			<0.5		<0.5	
Fenthion	µg/L	0.5							<0.5			<0.5		<0.5	
Chlorpyrifos	µg/L	0.5							<0.5			<0.5		<0.5	
Parathion	µg/L	2							<2.0			<2.0		<2.0	
Pirimphos-ethyl	µg/L	0.5							<0.5			<0.5		<0.5	
Chlorfenvinphos	µg/L	0.5							<0.5			<0.5		<0.5	
Bromophos-ethyl	µg/L	0.5							<0.5			<0.5		<0.5	
Fenamiphos	µg/L	0.5							<0.5			<0.5		<0.5	
Prothiofos	µg/L	0.5							<0.5			<0.5		<0.5	
Ethion	µg/L	0.5							<0.5			<0.5		<0.5	
Carbophenothion	µg/L	0.5							<0.5			<0.5		<0.5	
Azinphos Methyl	µg/L	0.5							<0.5			<0.5		<0.5	
Phenolic compounds															
Phenol	µg/L	1							<1.0			<1.0		<1.0	
2-Chlorophenol	µg/L	1							<1.0			<1.0		<1.0	
2-Methylphenol	µg/L	1							<1.0			<1.0		<1.0	
3- & 4-Methylphenol	µg/L	1							<2.0			<2.0		<2.0	
2-Nitrophenol	µg/L	2							<1.0			<1.0		<1.0	
2.4-Dimethylphenol	µg/L	1							<1.0			<1.0		<1.0	
2.4-Dichlorophenol	µg/L	1							<1.0			<1.0		<1.0	
2.6-Dichlorophenol	µg/L	1							<1.0			<1.0		<1.0	
4-Chloro-3-methylphenol	µg/L	1							<1.0			<1.0		<1.0	
2.4.6-Trichlorophenol	µg/L	1							<1.0			<1.0		<1.0	
2.4.5-Trichlorophenol	µg/L	1							<1.0			<1.0		<1.0	
Pentachlorophenol	µg/L	1							<2.0			<2.0		<2.0	
Polynuclear aromatic hydrocarbons															
Naphthalene	µg/L	1							<1.0			<1.0		<1.0	
Acenaphthylene	µg/L	1							<1.0			<1.0		<1.0	
Acenaphthene	µg/L	1							<1.0			<1.0		<1.0	
Fluorene	µg/L	1							<1.0			<1.0		<1.0	
Phenanthrene	µg/L	1							<1.0			<1.0		<1.0	
Anthracene	µg/L	1							<1.0			<1.0		<1.0	
Fluoranthene	µg/L	1							<1.0			<1.0		<1.0	
Pyrene	µg/L	1							<1.0			<1.0		<1.0	
Benz(a)anthracene	µg/L	1							<1.0			<1.0		<1.0	
Chrysene	µg/L	1							<1.0			<1.0		<1.0	
Benzo(b)fluoranthene	µg/L	1							<1.0			<1.0		<1.0	
Benzo(k)fluoranthene	µg/L	1							<1.0			<1.0		<1.0	
Benzo(a)pyrene	µg/L	0.5							<0.5			<0.5		<0.5	
Indeno(1.2.3.cd)pyrene	µg/L	1							<1.0			<1.0		<1.0	
Dibenz(a.h)anthracene	µg/L	1							<1.0			<1.0		<1.0	
Benzo(g.h.i)perylene	µg/L	1							<1.0			<1.0		<1.0	
Sum of polycyclic aromatic hydrocarbons	µg/L	0.5							<0.5			<0.5		<0.5	
Benzo(a)pyrene TEQ (zero)	µg/L	0.5							<0.5			<0.5		<0.5	

Table A6: Baseline Groundwater Monitoring Results - Tongarra Seam

Location			Water Quality Criteria				HU0096PZA								HU0133PZB
Date			ANZECC (2000)			ADWG (2011)	8/08/2013	16/10/2013	9/12/2013	31/03/2014	5/12/2014	27/03/2015	7/07/2015	22/09/2015	23/05/2014
Analyte	Units	LOR	Aquatic	Irrigation	Livestock										
BTEX															
Benzene	µg/L	1							<1			<1		<1	
Toluene	µg/L	2	ID			800			<2			<2		<2	
Ethylbenzene	µg/L	2							<2			<2		<2	
meta- & para-Xylene	µg/L	2							<2			<2		<2	
ortho-Xylene	µg/L	2							<2			<2		<2	
Total Xylenes	µg/L	2							<2			<2		<2	
Sum of BTEX	µg/L	1							<1			<1		<1	
Naphthalene	µg/L	5							<5			<5		<5	
Total petroleum hydrocarbons															
C6 - C9 Fraction	µg/L	20							<20			<20		<20	
C10 - C14 Fraction	µg/L	50							<50			<50		<50	
C15 - C28 Fraction	µg/L	100							<100			<100		<100	
C29 - C36 Fraction	µg/L	50							<50			<50		<50	
C10 - C36 Fraction (sum)	µg/L	50							<50			<50		<50	
Total Recoverable Hydrocarbons															
C6 - C10 Fraction	µg/L	20							<20			<20		<20	
C6 - C10 Fraction minus BTEX (F1)	µg/L	20							<20			<20		<20	
>C10 - C16 Fraction	µg/L	100							<100			<100		<100	
>C16 - C34 Fraction	µg/L	100							<100			<100		<100	
>C34 - C40 Fraction	µg/L	100							<100			<100		<100	
>C10 - C40 Fraction (sum)	µg/L	100							<100			<100		<100	
>C10 - C16 Fraction minus Naphthalene	µg/L	100							<100			<100		<100	
Microbiology															
Faecal coliforms	CFU/100 m	1							<1			~10		<1	
E coli	CFU/100 m	1							<1			~10		<1	
Total coliforms	CFU/100 m	1							<1			34		<1	

Table A7: Monitoring Well Construction Details (from Coffey, 2016a)

Piezometer	Easting (MGA)	Northing (MGA)	RL Ground (mAHD)	RL Casing (mAHD)	Drilled Depth (mbgl)	Screen (mbgl)		Sandpack (mbgl)		Screened Stratum	L (m)	Comment
						From	To	From	To			
H18A	246696	6174166	691.74	691.67	108	96	99	95	99	WW	4	
H18B	246695	6174159	691.97	691.89	114	75	88	73	88	HAW	15	
H19A	243557	6174381	720.65	720.55	108	100	103	100	103	WW	3	
H19B	243562	6174379	720.46	720.36	88	70	81	69	81	HAW	12	
H20A	244258	6176920	703.25	703.18	80	71	77	71	77	HAW	6	Dry (SWL < 626 mAHD)
H20B	244255	6176930	703.67	703.59	114	80	86	78	86	WW	8	
H23A	250769	6169622	680.47	680.38	140	135	138	135	138	WW	3	
H23B	250763	6169620	680.63	680.55	132	118	130	116	130	HAW	14	Decommissioned. Replaced by H142A to H142C
H23C	250755	6169617	680.76	680.69	100	84	97	82	97	HAW	15	
H32LDA	249532	6173533	646.6	646.78	152	108	114	106	117	WW	11	A and B in same hole
H32LDB	249532	6173533	646.6	646.73	152	57	88	54	89	HAW	35	
H35A	250523	6172486	681.43	682.16	152	53	77	50	78	HAW	28	
H35B	250531	6172487	680.84	681.52	35	15	34	14	35	WG	21	
H37A	246551	6167440	703.79	703.7	111	101	105	101	107	ICM	6	WW absent
H37B	246546	6167438	703.77	703.69	90	72	87	70	90	HAW	20	
H38A	248783	6175453	658.53	657.67	117	105	108	103	110	WW	7	
H38B	248788	6175452	658.44	658.33	78	74	77	72	78	HAW	6	
H38C	248793	6175452	658.31	658.17	63	55	62	52	63	HAW	11	
H42A	250988	6166688	702.5	702.43	173	156	159	153	161	WW	8	
H42C	250985	6166678	702	701.92	150	142	150	135	150	HAW	15	
H43XA	247147	6178127	692.04	691.96	111	95	101	93	103	WW	10	
H43XB	247152	6178133	691.77	691.69	87	77	86	75	87	HAW	12	
H44XA	242285	6164084	641.94	641.92	12	8	11	7	12	WW	5	
H44XB	242281	6164077	647	646.96	5	4	5	3.5	5	HAW	2	
H56XB	245225	6169198	735.45		140	132	140	130	140	HAW	10	
H56XC	245234	6169198	735.51		26	19	25	17	26	Basalt	9	
H72A	252074	6177157	640.12	640.05	129	124	128	121	129	WW	8	
H72B	252083	6177169	640.43	640.36	99	92	98	88	98	HAW	10	
H72C	252091	6177180	640.85	640.77	46	39	45	35	46	HAW	11	
H73A	251015	6172718	656.46	657	172	151	169	149	172	ICM Lower	23	
H73B	251029	6172717	655.78	656.35	124	119	123	117	124	WW	7	
H73C	251035	6172717	655.5	656.13	86	79	85	77	86	HAW	9	
H88A	253059	6173144	655.44	655.37	156	143	146	141	148	WW	7	
H88B	253059	6173144	655.33	655.26	150	121	126	119	128	HAW	9	
H96A	246489	6177025	699.21	699.14	147	111	120	108	120	ICM Lower	12	
H96B	246491	6177029	699.1	699	101	92	98	91	101	WW	10	
H96C	246494	6177045	683	682.94	89	69	87	67	89	HAW	22	
H118A	240529	6166811	612.5		15.3	7	13	5	15.3	HAW	10	Near swamp (under peat)
H129A	253042	6171301	679.1	679.04	177	166	170	165	171	WW	6	
H129B	253044	6171306	679.2	679.11	177	146	153	146	153	HAW	7	
H133A	249685	6176683	648.15	647.98	141	119	126	115	127	ICM Lower	12	
H133B	249688	6176688	648.17	648.04	113	108	113	108	113	WW	5	Decommissioned. Replaced by H143A to H143C
H133C	249690	6176694	648.03	647.94	84	80	83	77	84	HAW	7	
H136A	254521	6166894	718.49	718.36	216	199	203	196	203	WW	7	
H136B	254517	6166890	718.52	718.4	168	157	168	155	168	HAW	13	
H136C	254513	6166887	718.51	718.4	60	52	59	50	60	Basalt	10	
H142A	250856	6169881	672.43		130.8	127	130	126	131	WW	5	Replacement for H23A
H142B	250855	6169886	672.32		119.8	112	118	110	120	HAW	10	Replacement for H23B
H142C	250855	6169892	672.23		86.8	81	84	79	86.8	HAW	8	Replacement for H23C
H143A	249671	6176708	649.55		125.8	115	125	116	126	ICM Lower	10	Replacement for H133A
H143B	249672	6176703	649.59		113	109	112	107	113	WW	6	Replacement for H133B
H143C	249673	6176697	649.45		95.9	92	95	88	95.9	HAW	8	Replacement for H133C
H40_1	251140	6172143	656.51	656.51	129	120	120	VWP	VWP	WW	Point	Packer testing. Core K.
H40_2	251140	6172143	656.51	656.51	129	107	107	VWP	VWP	HAW	Point	
H40_3	251140	6172143	656.51	656.51	129	81	81	VWP	VWP	HAW	Point	
H40_4	251140	6172143	656.51	656.51	129	39	39	VWP	VWP	HAW	Point	
H77_1	246966	6175811	689.74	689.74	98	87	87	VWP	VWP	WW	Point	Packer testing. Core K.
H77_2	246966	6175811	689.74	689.74	98	72	72	VWP	VWP	HAW	Point	
H77_3	246966	6175811	689.74	689.74	98	58	58	VWP	VWP	HAW	Point	
H122_1	250352	6175286	634.5	634.5	120	112	112	VWP	VWP	WW	Point	Packer testing. Core K.
H122_2	250352	6175286	634.5	634.5	120	86	86	VWP	VWP	HAW	Point	
H122_3	250352	6175286	634.5	634.5	120	45	45	VWP	VWP	HAW	Point	
H122_4	250352	6175286	634.5	634.5	120	15	15	VWP	VWP	HAW	Point	
GW106652	250614	6179763	652.32	652.85	120	25	120	Open hole		HAW	95	Intersects WW seam.
GW106710	248326	6172551	672.39	672.7	115	64	108	Open hole		HAW	44	