AGL Upstream Investments Pty Ltd

Drilling completion report: Waukivory groundwater monitoring bores

Gloucester Gas Project

30 July 2014

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Document information

Client: AGL Upstream Investments Pty Ltd
Title: Drilling completion report: Waukivory groundwater monitoring bores
Subtitle: Gloucester Gas Project
Document No: 2162406C-WAT-RPT-7761 RevB
Date: 30 July 2014

Rev	Date	Details
A	01/07/2014	Draft
B	30/07/2014	Final

Author, Reviewer and Approver details

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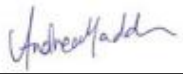
Approved by:	Andrea Madden	Date: 30/07/2014	Signature: 

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Glossary

Acidity	Base neutralising capacity.
Alkalinity	Acid neutralising capacity.
Alluvium	Unconsolidated sediments (clays, sands, gravels and other materials) deposited by flowing water. Deposits can be made by streams on river beds, floodplains, and alluvial fans.
Alluvial aquifer	Permeable zones that store and produce groundwater from unconsolidated alluvial sediments. Shallow alluvial aquifers are generally unconfined aquifers.
Ammonia	A compound of nitrogen and hydrogen (NH_3) that is a common by-product of animal waste and landfills but is also found naturally in reduced environments. Ammonia readily converts to nitrate in soils and streams.
Anion	An ion with a negative charge – usually non-metal ions when disassociated and dissolved in water.
Annulus	The void space between two strings of casing in a water bore or gas well.
Anthropogenic	Occurring because of, or influenced by, human activity.
Aquatic ecosystem	The stream channel, lake or estuary bed, water, and (or) biotic communities and the habitat features that occur therein.
Aquifer	Rock or sediment in a formation, group of formations, or part of a formation that is saturated and sufficiently permeable to transmit economic quantities of water.
Aquifer properties	The characteristics of an aquifer that determine its hydraulic behaviour and its response to abstraction.
Aquifer, confined	An aquifer that is overlain by low permeability strata. The hydraulic conductivity of the confining bed is significantly lower than that of the aquifer.
Aquifer, semi-confined	An aquifer overlain by a low-permeability layer that permits water to slowly flow through it. During pumping, recharge to the aquifer can occur across the leaky confining layer – also known as a leaky artesian or leaky confined aquifer.
Aquifer, unconfined	Also known as a water table aquifer. An aquifer in which there are no confining beds between the zone of saturation and the surface. The water table is the upper boundary of an unconfined aquifer.

Aquitard	A low permeability unit that can store groundwater and also transmit it slowly from one formation to another. Aquitards retard but do not prevent the movement of water to or from adjacent aquifers.
Artesian water	Groundwater that is under pressure when tapped by a bore and is able to rise above the level at which it is first encountered. It may or may not flow at ground level. The pressure in such an aquifer commonly is called artesian pressure, and the formation containing artesian water is a confined aquifer.
Australian Height Datum (AHD)	The reference point (very close to mean sea level) for all elevation measurements, and used for correlating depths of aquifers and water levels in bores.
Background concentration	A natural concentration of a substance in a particular environment that is indicative of minimal influence by human (anthropogenic) sources.
Baseline sampling	A period of regular water quality and water level measurements that are carried out over a period long enough to determine the natural variability in groundwater conditions.
Bedding plane	In sedimentary or stratified rocks, the division plane which separates the individual layers, beds or strata.
Blowout	The uncontrolled release of formation fluids and gases encountered during borehole drilling.
BoP	Blowout preventer, a large series of valves used to seal, control and monitor blowouts of formation fluids and gasses.
Bore	A structure drilled below the surface to obtain water from an aquifer or series of aquifers.
Boundary	A lateral discontinuity or change in the aquifer resulting in a significant change in hydraulic conductivity, storativity or recharge.
Carbon-13 (^{13}C)	A natural, stable isotope of carbon and one of the environmental isotopes. It makes up about 1.109% of all naturally occurring carbon on Earth.
Carbon-14 (^{14}C)	Or radiocarbon is a radioactive isotope of carbon. Its nucleus contains six (6) protons and eight (8) neutrons. Its presence in organic materials is used in radiocarbon dating. It occurs naturally and has a relative abundance up to one part per trillion (0.0000000001%) of all naturally-occurring carbon on Earth. Carbon-14 is one of the most important nuclides in groundwater studies because its half-life of 5,730 years covers a critical time scale of ~500 to 50,000 years, which is ideal for dating regional and intermediate flow systems.
Cation	An ion with a positive charge – usually metal ions when disassociated and dissolved in water.
Chlorine-36 (^{36}Cl)	A naturally occurring radioisotope of chlorine. It has a half-life of 301,000±2,000 years and is suitable for age dating groundwaters up to 1 million years old.

Claystone	A non-fissile rock of sedimentary origin composed primarily of clay-sized particles (less than 0.004 mm).
Coal	A sedimentary rock derived from the compaction and consolidation of vegetation or swamp deposits to form a fossilised carbonaceous rock.
Coal seam	A layer of coal within a sedimentary rock sequence.
Coal seam gas (CSG)	Coal seam gas is a form of natural gas (predominantly methane) that is extracted from coal seams.
Concentration	The amount or mass of a substance present in a given volume or mass of sample, usually expressed as microgram per litre (water sample) or micrograms per kilogram (sediment sample).
Conceptual model	A simplified and idealised representation (usually graphical) of the physical hydrogeologic setting and the hydrogeological understanding of the essential flow processes of the system. This includes the identification and description of the geologic and hydrologic framework, media type, hydraulic properties, sources and sinks, and important aquifer flow and surface-groundwater interaction processes.
Confining layer	Low permeability strata that may be saturated but will not allow water to move through it under natural hydraulic gradients.
Contamination	Contamination is the presence of a non-natural compound in soil or water, or unwanted compound in chemicals or other mixtures.
Datalogger	A digital recording instrument that is inserted in monitoring and pumping bores to record pressure measurements and water level variations.
Detection limit	The concentration below which a particular analytical method cannot determine, with a high degree of certainty, a concentration.
Deuterium (^{2}H)	Also called heavy hydrogen, a stable isotope of hydrogen with a natural abundance of one atom in 6,500 of hydrogen. The nucleus of deuterium, called a deuteron, contains one proton and one neutron, where a normal hydrogen nucleus has just one proton.
Dip	The inclination of a planar surface measured in the vertical plane perpendicular to its strike.
Dip - slip fault	A fault (either normal or reverse) where the relative movement (or slip) on the fault plane is vertical.
Discharge	The volume of water flowing in a stream or through an aquifer past a specific point in a given period of time.
Dissolution	Process of dissolving a substance into a liquid. If the saturation index is less than zero, the mineral is undersaturated with respect to the solution and the mineral might dissolve.
Dissolved organic carbon (DOC)	The combined total of all organic carbon species dissolved in solution. Where dissolved is defined as below 0.45 micrometres.

Electrical Conductivity (EC)	A measure of a fluid's ability to conduct an electrical current and is an estimation of the total ions dissolved. It is often used as a measure of water salinity.
Environmental isotopes	Also known as stable isotopes, they act as 'groundwater signatures' and can be used as natural groundwater tracers.
Equilibrium	A balance between the thermodynamic forces of precipitation and dissolution. A saturation index (SI) of zero indicates apparent equilibrium.
Falling head test	A hydraulic test on a monitoring bore or piezometer that involves a sudden rise in water level (i.e. a volume of water is quickly added to the water column and the rate of water level decline is measured). Also called a slug test or slug-in test.
Fault	A fracture in rock along which there has been an observable amount of displacement. Faults are rarely single planar units; normally they occur as parallel to sub-parallel sets of planes along which movement has taken place to a greater or lesser extent. Such sets are called fault or fracture zones.
Flow testing	A gas and water appraisal program (generally carried out over several months) to determine the dewatering profile required to flow gas from one or several test production wells completed for exploration purposes.
Fluvial	Pertaining to a river or stream.
Fluvial deposit	A sedimentary deposit consisting of material transported by suspension or laid down by a river or stream.
Formation water	See produced water.
Fracture	Breakage in a rock or mineral along a direction or directions that are not cleavage or fissility directions.
Fractured rock aquifer	These occur in sedimentary, igneous and metamorphosed rocks which have been subjected to disturbance, deformation, or weathering, and which allow water to move through joints, bedding planes, fractures and faults. Although fractured rock aquifers are found over a wide area, they generally contain much less groundwater than alluvial and porous sedimentary rock aquifers.
Fracture stimulation	See hydraulic fracturing.
Global Meteoric Water Line (GMWL)	A line that defines the relationship between oxygen-18 (^{18}O) and deuterium (^{2}H) in fresh surface waters and precipitation from a number of global reference sites.
Groundwater	The water contained in interconnected pores or fractures located below the water table in the saturated zone.
Groundwater age classification	Groundwater ages are commonly referred to as: Modern <100 years Sub-modern 100-1,000 years Old >1,000 years

Groundwater flow	The movement of water through openings in sediment and rock within the zone of saturation.
Groundwater system	A system that is hydrogeologically more similar than different in regard to geological province, hydraulic characteristics and water quality, and may consist of one or more geological formations.
Hydraulic conductivity	The rate at which water of a specified density and kinematic viscosity can move through a permeable medium (notionally equivalent to the permeability of an aquifer to fresh water).
Hydraulic fracturing	A fracture stimulation technique that increases a gas well's productivity by creating a pathway into the targeted coal seam by injecting sand and fluids through the perforated interval directly into the coal seam under high pressure.
Hydraulic gradient	The change in total hydraulic head with a change in distance in a given direction.
Hydraulic head	Is a specific measurement of water pressure above a datum. It is usually measured as a water surface elevation, expressed in units of length. In an aquifer, it can be calculated from the depth to water in a monitoring bore. The hydraulic head can be used to determine a hydraulic gradient between two or more points.
Hydrochemistry	Chemical characterisation of water (both surface water and groundwater).
Hydrogeology	The study of the interrelationships of geologic materials and processes with water, especially groundwater.
Hydrology	The study of the occurrence, distribution, and chemistry of all surface waters.
Igneous rocks	Rocks that have solidified from molten or partly molten material (magma).
Ion	An ion is an atom or molecule where the total number of electrons is not equal to the total number of protons, giving it a net positive or negative electrical charge.
Isotope	One of multiple forms of an element that has a different number of neutrons than other atoms of that element. Some elements have isotopes that are unstable or radioactive, while others have 'stable isotopes'.
Isotropic	Having hydraulic properties that are the same in all directions.
Lithology	The study of rocks and their depositional or formational environment on a large specimen or outcrop scale.
Local Meteoric Water Line (LMWL)	A line that defines the local relationship between oxygen-18 (18O) and deuterium (2H) in fresh surface waters and precipitation. In this report the LMWL used is for the Sydney region.
Major ions	Constituents commonly present in concentrations exceeding 10 milligram per litre. Dissolved cations generally are calcium, magnesium, sodium, and potassium; the major anions are sulphate, chloride, fluoride, nitrate, and those contributing to alkalinity, most generally assumed to be bicarbonate and carbonate.

Methane (CH_4)	An odourless, colourless, flammable gas, which is the major constituent of natural gas. It is used as a fuel and is an important source of hydrogen and a wide variety of organic compounds.
MicroSiemens per centimetre (µS/cm)	A measure of water salinity commonly referred to as EC (see also Electrical Conductivity). Most commonly measured in the field with calibrated field meters.
Monitoring bore	A non-pumping bore, is generally of small diameter that is used to measure the elevation of the water table and/or water quality. Bores generally have a short well screen against a single aquifer through which water can enter.
Normal faulting	Where the fault plane is vertical or dips towards the downthrow side of a fault.
Oxidising conditions	Conditions in which a species loses electrons and is present in oxidised form.
Oxygen-18 (^{18}O)	A natural, stable isotope of oxygen and one of the environmental isotopes. It makes up about 0.2 % of all naturally-occurring oxygen on Earth.
Percent modern carbon (pMC)	The activity of 14C is expressed as percent modern carbon (pMC) where 100 pMC corresponds to 95 % of the 14C concentration of NBS oxalic acid standard (close to the activity of wood grown in 1890).
Permeability	The property or capacity of a porous rock, sediment, clay or soil to transmit a fluid. It is a measure of the relative ease of fluid flow under unequal pressure. The hydraulic conductivity is the permeability of a material for water at the prevailing temperature.
Permeable material	Material that permits water to move through it at perceptible rates under the hydraulic gradients normally present.
Permian	The last period of the Palaeozoic era that finished approximately 230 million years before present.
pH	potential of Hydrogen; the logarithm of the reciprocal of hydrogen-ion concentration in gram atoms per litre; provides a measure on a scale from 0 to 14 of the acidity or alkalinity of a solution (where 7 is neutral, greater than 7 is alkaline and less than 7 is acidic).
Piezometer	See monitoring bore.
Porosity	The proportion of open space within an aquifer, comprised of intergranular space, pores, vesicles and fractures.
Porosity, primary	The porosity that represents the original pore openings when a rock or sediment formed.
Porosity, secondary	The porosity caused by fractures or weathering in a rock or sediment after it has been formed.
Porous rock	Consolidated sedimentary rock containing voids, pores or other openings (joints, cleats, fractures) which are interconnected in the rock mass and may be capable of storing and transmitting water.
Precipitation	(1) in meteorology and hydrology, rain, snow and other forms of water falling

	from the sky (2) the formation of a suspension of an insoluble compound by mixing two solutions. Positive values of saturation index (SI) indicate supersaturation and the tendency of the water to precipitate that mineral.
Produced water	Natural groundwater generated from coal seams during flow testing and production dewatering.
Pumping test	A test made by pumping a bore for a period of time and observing the change in hydraulic head in the aquifer. A pumping test may be used to determine the capacity of the bore and the hydraulic characteristics of the aquifer.
Quaternary	The most recent geological period extending from approximately 2.5 million years ago to the present day.
Quality assurance	Evaluation of quality-control data to allow quantitative determination of the quality of chemical data collected during a study. Techniques used to collect, process, and analyse water samples are evaluated.
Radioisotope	Radioisotopes undergo radioactive decay allowing for determination of residence times in aquifers and groundwater systems.
Recharge	The process which replenishes groundwater, usually by rainfall infiltrating from the ground surface to the water table and by river water reaching the water table or exposed aquifers. The addition of water to an aquifer.
Recharge area	A geographic area that directly receives infiltrated water from surface and in which there are downward components of hydraulic head in the aquifer. Recharge generally moves downward from the water table into the deeper parts of an aquifer then moves laterally and vertically to recharge other parts of the aquifer or deeper aquifer zones.
Recovery	The difference between the observed water level during the recovery period after cessation of pumping and the water level measured immediately before pumping stopped.
Recovery event	A monitoring event (in this case the download of dataloggers and the final water sampling program) completed after the pumping test.
Redox potential (ORP or Eh)	The redox potential is a measure (in volts) of the affinity of a substance for electrons – its electronegativity – compared with hydrogen (which is set at 0). Substances more strongly electronegative than (i.e. capable of oxidising) hydrogen have positive redox potentials. Substances less electronegative than (i.e. capable of reducing) hydrogen have negative redox potentials. Also known as oxidation-reduction potential and Eh.
Redox reaction	Redox reactions, or oxidation-reduction reactions, are a family of reactions that are concerned with the transfer of electrons between species, and are mediated by bacterial catalysis. Reduction and oxidation processes exert an important control on the distribution of species like O2, Fe2+, H2S and CH4 etc. in groundwater.
Reducing conditions	Conditions in which a species gains electrons and is present in reduced form.
Residence time	The time that groundwater spends in storage before moving to a different

	part of the hydrological cycle.
Reverse fault	A dip-slip fault in which the hangingwall (wall above the fault) moves upward relative to the footwall (wall beneath the fault).
Salinity	The concentration of dissolved salts in water, usually expressed in milligrams of total dissolved solids per litre (mg/L TDS) or units of electrical conductivity (EC).
Salinity classification	Fresh water quality – water with a salinity <800 µS/cm. Marginal water quality – water that is more saline than freshwater and generally waters between 800 and 1,600 µS/cm. Brackish quality – water that is more saline than freshwater and generally waters between 1,600 and 4,800 µS/cm. Slightly saline quality – water that is more saline than brackish water and generally waters with a salinity between 4,800 and 10,000 µS/cm. Moderately saline quality – water that is more saline than brackish water and generally waters between 10,000 and 20,000 µS/cm. Saline quality – water that is almost as saline as seawater and generally waters with a salinity greater than 20,000 µS/cm. Seawater quality – water that is generally around 55,000 µS/cm.
Sandstone	Sandstone is a sedimentary rock composed mainly of sand-sized minerals or rock grains (predominantly quartz).
Screen	A type of bore lining or casing of special construction, with apertures designed to permit the flow of water into a bore while preventing the entry of aquifer or filter pack material.
Sedimentary rock aquifer	These occur in consolidated sediments such as porous sandstones and conglomerates, in which water is stored in the intergranular pores, and limestone, in which water is stored in solution cavities and joints. These aquifers are generally located in sedimentary basins that are continuous over large areas and may be tens or hundreds of metres thick. In terms of quantity, they contain the largest volumes of groundwater.
Shale	A laminated sedimentary rock in which the constituent particles are predominantly of clay size.
Siltstone	A fine-grained rock of sedimentary origin composed mainly of silt-sized particles (0.004 to 0.06 mm).
Stable isotope	Stable isotopes are atoms of the same element that have different masses due to differences in the number of neutrons they contain. Stable isotopes are not subject to radioactive decay, meaning they do not breakdown over time.
Standing water level (SWL)	The height to which groundwater rises in a bore after it is drilled and completed, and after a period of pumping when levels return to natural atmospheric or confined pressure levels.
Stratigraphy	The depositional order of sedimentary rocks in layers.

Strike	The direction of a horizontal straight line constructed on an inclined planar surface, at the direction of 90^0 from the dip direction.
Strike-slip fault	A fault where the displacement (or slip) is horizontal / parallel to the strike of the displacement plane.
Surface water-groundwater interaction	This occurs in two ways: (1) streams gain water from groundwater through the streambed when the elevation of the water table adjacent to the streambed is greater than the water level in the stream; and (2) streams lose water to groundwater through streambeds when the elevation of the water table is lower than the water level in the stream.
Tertiary	Geologic time at the beginning of the Cainozoic era, 65 to 2.5 million years ago, after the Cretaceous and before the Quaternary.
Thrust fault	A reverse fault with a low angle of dip.
Total Dissolved Solids (TDS)	A measure of the salinity of water, usually expressed in milligrams per litre (mg/L). See also EC.
Tritium (^{3}H)	A short-lived isotope of hydrogen with a half-life of 12.43 years. It is commonly used to identify the presence of modern recharge. Tritium is produced naturally in small amounts owing to the interaction of cosmic radiation with atmospheric oxygen and nitrogen in the troposphere, and is also produced by thermonuclear explosions.
Tuff	Tuff is a type of volcanic rock consisting of consolidated explosive ash ejected from vents during a volcanic eruption.
Water quality	Term used to describe the chemical, physical, and biological characteristics of water, usually in respect to its suitability for a particular purpose.
Water quality data	Chemical, biological, and physical measurements or observations of the characteristics of surface and ground waters, atmospheric deposition, potable water, treated effluents, and waste water and of the immediate environment in which the water exists.
Water table	The top of an unconfined aquifer. It is at atmospheric pressure and indicates the level below which soil and rock are saturated with water.
Well	Pertaining to a gas exploration well or gas production well.
Workover	The process of performing major maintenance or remedial treatments on an oil or gas well. In many cases, workover implies the removal and replacement of the production tubing string after the well has been killed and a workover rig has been placed on location. Through-tubing workover operations, using coiled tubing, snubbing or slickline equipment, are routinely conducted to complete treatments or well service activities that avoid a full workover where the tubing is removed. This operation saves considerable time and expense.

Abbreviations

AGL	AGL Upstream Investments Pty Ltd
ANSTO	Australian Nuclear Science and Technology Organisation
BoM	Bureau of Meteorology
BTEX	Benzene, toluene, ethyl benzene and xylenes
CDFM	Cumulative deviation from mean
CSG	Coal seam gas
DIC	Dissolved organic carbon
DO	Dissolved oxygen
EC	Electrical Conductivity
JSA	Job Safety Analysis
HESP	Health, Environment and Safety Plan
GGP	Gloucester Gas Project
GMWL	Global Meteoric Water Line
GRL	Gloucester Resources Limited
LMWL	Local Meteoric Water Line
LOQ	Limit of quantitation
LOR	Limit of reporting
LTA	Long term average
ORP	Oxidation reduction potential
PAH	Polycyclic aromatic hydrocarbons
PEL	Petroleum Exploration Licence
PPE	Personal Protective Equipment
SMP	Safety Management Plan
SWL	Standing water level
SWMS	Safe Work Methods Statements
TD	Total depth
TDS	Total Dissolved Solids
TPH	Total recoverable hydrocarbons

Units

°C	degrees Celsius
L/s	litres per second
m	metres
mAHD	metres Australian Height Datum
mbgl	metres below ground level
m/day	metres per day
mL	millilitres
mm	millimetres
µS/cm	microSiemens per centimetre
mg/L	milligrams per litre
µg/L	micrograms per litre
mV	millivolt
‰	per mil
pCM	percent modern carbon
TU	tritium unit
VPDB	Vienna PeeDee Belemnite
VSMOW	Vienna Standard Mean Ocean Water
yrs BP	years before present

Executive summary

AGL Upstream Infrastructure Investments Pty Ltd (AGL) is proposing to build the Gloucester Gas Project (GGP) which will comprise several stages of development; however, only one stage, the Stage 1 Gas Field Development Area (GFDA) is currently approved. A comprehensive groundwater investigation (*Phase 2 Groundwater Investigations*) was completed in early 2012 to confirm the hydrogeological conceptual model across the stage 1 GDFA. Surface water and groundwater investigations are ongoing pending the commencement of the GGP.

This report relates to the completion of nested groundwater monitoring bores adjacent to AGL's proposed Waukivory Pilot flow test site. The bores were drilled between January and May 2012 and initial baseline monitoring data collected at the site to February 2014. With the upcoming Waukivory pilot there is an opportunity to collect additional groundwater data associated with the proposed flow testing trial where the deep coal seams will be fracture stimulated and dewatered.

The drilling program focussed on a fault zone where old rock layers are thrust over younger strata. The objective of the drilling program was to establish a monitoring network to assess the baseline groundwater conditions in the fractured rock aquifer in the upthrust fault block (close to the surface) and within the fault zone itself. The location of the monitoring bores was selected to be within the area of influence of the Waukivory Pilot gas well WK11 and potentially the other Waukivory Pilot gas wells (WK12, WK13, and WK14). Three groundwater monitoring bores (WKMB01, WKMB02 and WKMB04) were installed in the upthrust block (targeting the first major water cut in the shallow rock [Leloma Formation] and the Roseville Coal Seam) and one was installed within the fault zone (WKMB03). Although not detected during the drilling, gas was observed after installation in the bore screened in the Roseville Coal Seam (WKMB04). This bore was to be converted to a vibrating wire piezometer but the conversion was unsuccessful and it was subsequently plugged and abandoned by AGL.

Following the completion of the three remaining monitoring bores, screened in the Leloma Formation, in situ pressure transducers (dataloggers) were installed and hydraulic conductivity testing undertaken.

The hydraulic conductivity results were consistent with the values previously encountered within the Stage 1 GFDA of the GGP.

Initial monitoring indicates that groundwater levels and temporal trends in strata above and below the thrust fault are similar. Each of the three monitoring bores show a response to high rainfall events.

Initial groundwater quality monitoring suggests that:

- Groundwater quality is marginal to saline, with alkaline pH and strongly reducing to oxidizing conditions. Major ion chemistry is similar, although the relative concentrations vary between monitoring bores.
- Dissolved metal concentrations are typically low, however exceedances of the ANZECC (2000) guidelines for freshwater ecosystems were observed for aluminium, copper, lead, nickel and zinc in at least one monitoring bore. Ammonia, total phosphorus and reactive phosphorus were detected at concentrations above the ANZECC (2000) guidelines at all monitoring bores.
- TPH were detected at concentrations above the laboratory LOR at WKMB03 and WKMB04. PAHs and BTEX were below the laboratory LOR at all monitoring bores. Phenolic compounds were below the laboratory LOR at all monitoring bores, with the exception of phenol which was detected at WKMB03.
- Isotope data indicate that groundwater in all monitoring bores is of meteoric origin. Groundwater is several thousand years old in the shallow rock monitoring bores, several thousand years old in the fault zone at WKMB03 (14,500 yrs BP) and in the Roseville Coal Seam at WKMB04 (>40,000 yrs BP).

- Methane isotope data is below the LOQ and cannot be interpreted with a degree of confidence at WKMB01 and WKMB02; however values suggest a thermogenic origin. Methane isotope data indicates that methane is of early mature thermogenic origin at WKMB03 and WKMB04.

It is recommended that monitoring continues at the Waukivory monitoring bores in accordance with the existing program. It is also recommended that these monitoring bores are included in the groundwater monitoring plan for the Waukivory Pilot flow test due to commence in late-2014 (pending approvals) together with the installation of real-time telemetry recording groundwater level fluctuations, which would assist timely data collection and interrogation of groundwater levels during the proposed Waukivory Pilot flow test.

1. Introduction

This report is the drilling and completion report for the four groundwater monitoring bores constructed as part of the Waunkivory Pilot investigation and associated activities. The report includes baseline water levels and water quality information to February 2014.

1.1 Gloucester Gas Project

AGL Upstream Infrastructure Investments Pty Ltd (AGL) is proposing to build the Gloucester Gas Project (GGP) which comprises several stages of development facilitating the extraction of coal seam gas (CSG) from the Gloucester Basin. Concept Plan and Project Approval (Part 3A Approval) for the Stage 1 Gas Field Development Area (GFDA) was granted on 22 February 2011 under Part 3A of the *Environmental Planning and Assessment Act (1979) (EP&A Act)*. In addition the project received approval under the *Environment Protection and Biodiversity Conservation Act (1999) (EPBC Act)* (EPBC Approval) on 11 February 2013.

AGL also holds Petroleum Exploration Licence (PEL) 285, under the *Petroleum (Onshore) Act 1991*, covering the whole of the Gloucester Basin, approximately 100 km north of Newcastle, NSW. AGL has also applied for a Petroleum Production Lease (PPL) for the Stage 1 area subject of the planning approvals. The Stage 1 GFDA in relation to the PEL boundary is shown in Figure 1.1.

The GGP will involve the dewatering of deep groundwater and the extraction of gas from multiple coal seams within the Gloucester Coal Measures. Target coal seam depths will vary from site to site but are expected to range between 200 and 1,000 metres below ground level (mbgl). The current GGP includes the construction, operation and decommissioning of 110 coal seam gas wells and associated infrastructure, including gas and water gathering lines, within the Stage 1 GFDA.

1.2 Waukivory drilling program

Two nested sites of groundwater monitoring bores (four bores in total) were constructed on the Mitchell property, owned by Gloucester Resources Limited (GRL) in the vicinity of AGL's Waukivory Pilot flow test site, in Gloucester, from January to May 2012 as part of the *Phase 2 Groundwater Investigations* for the Stage 1 GFDA.

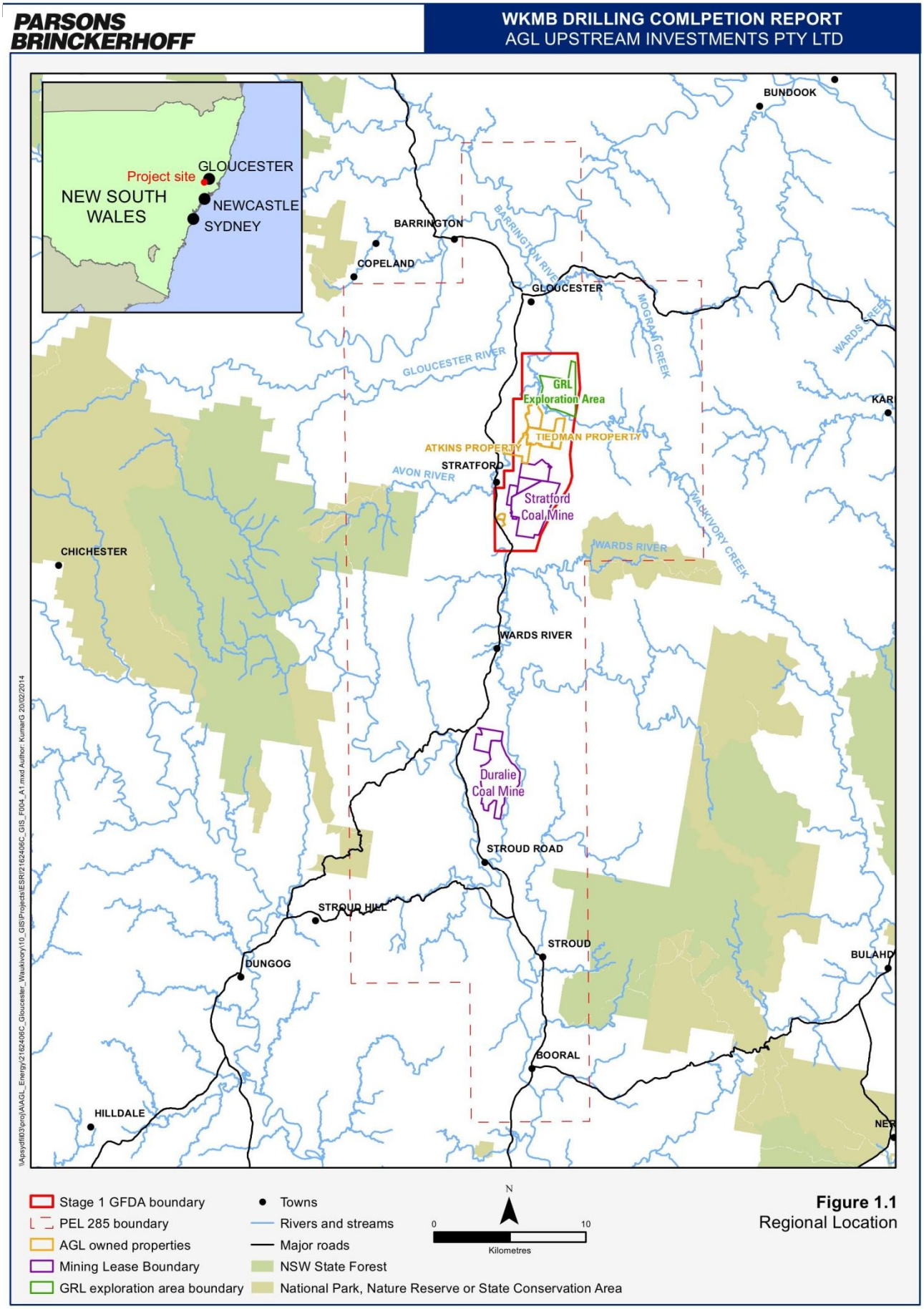
The addition of these four Waukivory bores to the existing monitoring network allows further characterisation of a local geological fault feature and facilitates the monitoring of local shallow groundwater during planned flow testing. In addition, the local geology and hydrogeology of the GGP can be further explored and greater characterisation of the groundwater systems determined.

The drilling program focussed on an identified fault zone where old rock layers are trust over younger strata. The objective of the drilling program was to establish a monitoring network to assess the baseline groundwater conditions in the fractured rock aquifer in the upthrust fault block (close to the surface) and within the fault zone itself. Three groundwater monitoring bores were installed in the upthrust block: two shallow rock monitoring bores were installed in the first major water cut in the Leloma Formation, and one monitoring bore was installed in the Roseville Coal Seam (Jilleon Formation). A further monitoring bore was installed in the fault zone in the Deards Coal Seam (Leloma Formation).

The Waukivory drilling program compromised:

- Installation of four groundwater monitoring bores (WKMB01, WKMB02, WKMB03 and WKMB04).
- Geophysical logging at the deepest groundwater monitoring bore (WKMB04).

- Installation of insitu pressure transducers (dataloggers) at all groundwater monitoring bores (except WKMB04).
- Hydraulic conductivity testing at all groundwater monitoring bores (except WKMB04).
- Baseline groundwater quality testing, including: field parameters, major cations and anions, dissolved metals, nutrients, dissolved methane, hydrocarbons and isotopic characteristics.


PARSONS BRINCKERHOFF
WKMB DRILLING COMLPETION REPORT
AGL UPSTREAM INVESTMENTS PTY LTD
Project site
GLOUCESTER
NEW SOUTH WALES
NEWCASTLE
SYDNEY
BUNDOOK
BARRINGTON
COPELAND
GLOUCESTER
BARRINGTON RIVER
MOGRAM CREEK
WARDS CREEK
GLOUCESTER RIVER
GRL Exploration Area
KAR
TIEDMAN PROPERTY
ATKINS PROPERTY
STRATFORD
AVON RIVER
Stratford Coal Mine
WAUKIVORY CREEK
WARDS RIVER
CHICHESTER
WARDS RIVER
Duralie Coal Mine
STROUD ROAD
STROUD HILL
STROUD
BULAHD
DUNGOG
BOORAL
HILLDALE
NEW
\\Apsydfil03\proj\AAGL_Energy\2162406C_Gloucester_Waukivory\10_GIS\Projects\ESRI\2162406C_GIS_F004_A1.mxd Author: KumarG 20/02/2014
Stage 1 GFDA boundary
PEL 285 boundary
AGL owned properties
Mining Lease Boundary
GRL exploration area boundary
Towns
Rivers and streams
Major roads
NSW State Forest
National Park, Nature Reserve or State Conservation Area
N
0
10
Kilometres
Figure 1.1
Regional Location

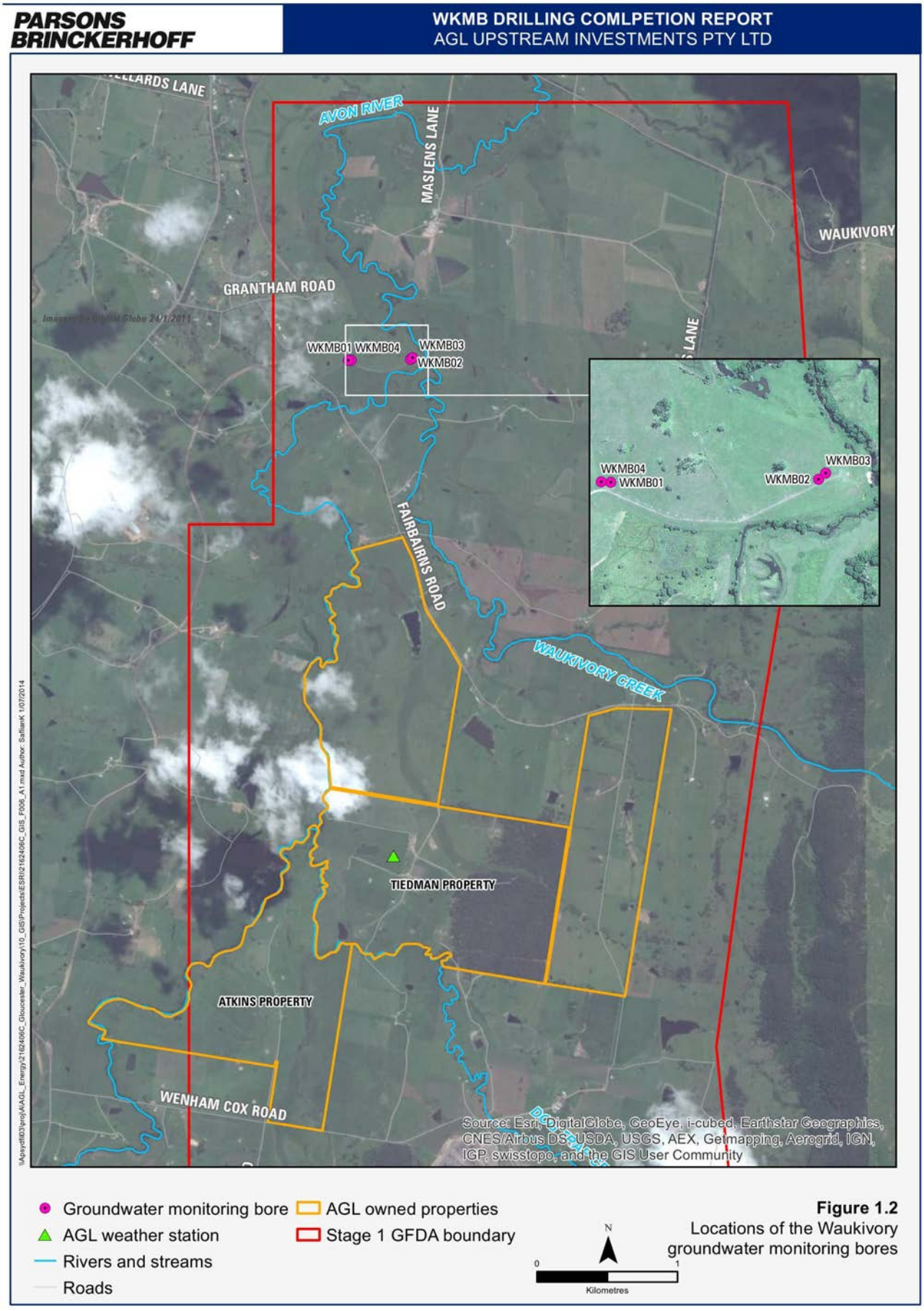


Figure 1.2
Locations of the Waukivory groundwater monitoring bores

2. Site characterisation

2.1 Site location

The Waukivory groundwater monitoring bore drill sites associated with the Waukivory Pilot are situated approximately 6 km south of Gloucester, NSW, on a GRL owned property, 176 Fairbairns Lane, Forbesdale. The site is bound to the east and south by the Avon River.

The Waukivory Pilot site is located in paddocks used for low intensity cattle grazing adjacent to the flood plain of the Avon River; the primary water course in the area.

2.2 Rainfall

There are three Bureau of Meteorology (BoM) weather stations within the Gloucester Basin in the vicinity of the Waukivory Pilot, and an additional AGL weather station on the Tiedman property at Stratford. Average rainfall and the period of monitoring for the BoM and AGL stations are presented in Table 2.1.

Table 2.1 BoM and AGL weather stations in the Gloucester Basin (BoM 2014)

Station ID	Name	Monitoring period	Long term average annual rainfall (mm)
BoM 60015	Gloucester Post Office	1888 to present	982.4
BoM 60112	Gloucester Hiawatha	1976 to present	1,023.2
BoM 60042	Craven (Longview)	1961 to present	1,061.6
AGL	Tiedman property	2011 to present	909.3

Long term annual rainfall averaged across all three BoM weather stations is approximately 1,022 mm.

Rainfall data collected by AGL since July 2011 are presented in Figure 2.1. Cumulative deviation from the mean monthly rainfall indicates that rainfall during 2011 was generally above average. Over the following two years since March 2012, rainfall conditions have been generally below average (with the exception of high rainfall in the first two months of 2013).

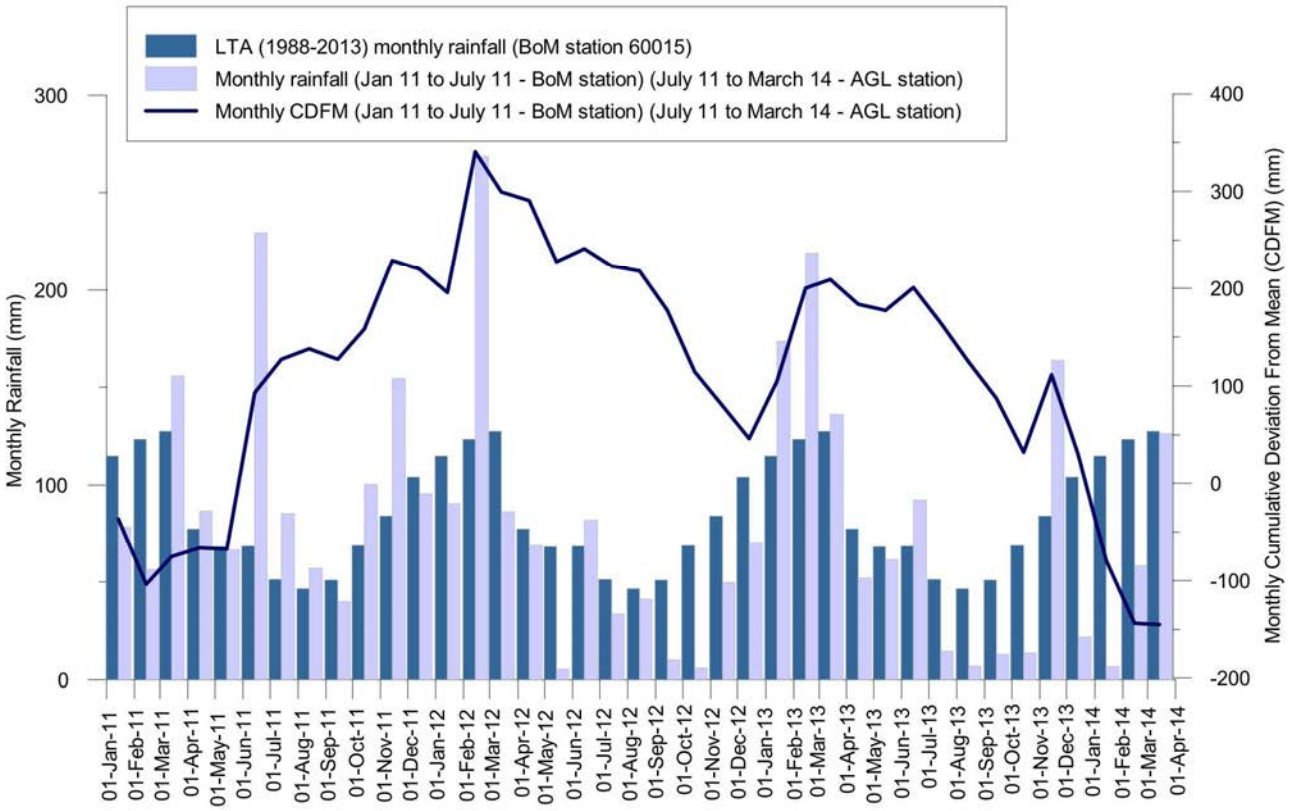


Figure 2.1 Monthly rainfall and cumulative deviation from the mean data from the AGL Gloucester Station (AGL 2014a)

2.3 Geological setting

2.3.1 Regional geology

The Gloucester Basin comprises a thick succession of Permian sedimentary rocks representing deposition in both terrestrial and marine environments during a complex period of subsidence, uplift and relative sea level change (marine transgression and regression).

The basin is a synclinal intermontane structure formed in part of the New England Fold Belt between a major Permian plate margin and the Sydney-Gunnedah Basin (Lennox 2009). The north – south trending synclinal nature of the Gloucester Basin resulted from the collision between the East Australian and Pacific Plates.

Following a period of extension during the Early Permian, the Gloucester Basin has undergone periods of normal and reverse faulting, with large scale tilting associated with late stage compressional movements towards the end of the Permian (Hughes 1984). Reverse faults dominate the present day structure.
A comparison with the contemporary horizontal stress field map (Hillis et al. 1998) indicates the basin is likely to be under compression in an east-west orientation.

The stratigraphy dips steeply (up to 90°) on the flanks of the basin, dipping towards the north-south trending synclinal basin axis and flattening toward the centre of the basin. Early-Permian and Carboniferous hard resistive volcanics form the ridgelines of the basin margins: the Mograni Range to the east; and the Gloucester and Barrington Tops to the west.

Overlying the Permian stratigraphy is a thin sequence of surficial Quaternary sediments. The Quaternary sediments are non-uniform in thickness, and comprise unconsolidated alluvial and colluvial sediments (sand,

gravel, silt and clay) along the drainage channels and across the River Avon floodplain, sourced from the surrounding outcropping Permian deposits.

2.3.2 Stratigraphy of the investigation area

The Gloucester Basin is divided into three major Permian stratigraphic units each representing a distinct depositional setting: the Gloucester Coal Measures, the Dewrang Group, and the Alum Mountain Volcanics. The generalised stratigraphy of the basin is summarised in Table 2.2. A geological map of the basin is shown in Figure 2.2.

The GGP within the Stage 1 GFDA will target the intermediate and deep coal seams in the Gloucester Coal Measures, generally below depths of 200 m to around 1000 m.

Table 2.2 Stratigraphy of the Gloucester Basin

Period	Group	Sub-group	Formation	Approx. thickness (m)	Coal seam	Depositional Environment	Tectonic Events
Upper Permian	Gloucester Coal Measures	Craven	Crowthers Road Conglomerate	350		Marine regression, progradation of alluvial fans	Uplift to west of Gloucester Basin
			Leloma	585	Linden		
					Jo Doth		
					Bindaboo		
					Deards		
			Jilleon	175	Cloverdale		
					Roseville		
					Tereel/Fairbairns		
			Wards River Conglomerate	Variable			
			Wenham	23.9	Bowens Road		
					Bowens Road Lower		
		Speldon Formation				Marine transgression but also some progradation of alluvial fans in the west related to uplift	Extension (normal fault development) and regional subsidence. Uplift to west of Basin
		Avon	Dog Trap Creek	126	Glenview		
			Waukivory Creek	326	Avon		
					Triple		
					Rombo		
					Glen Road		
					Valley View		
					Parkers Road		
	Dewrang	Mammy Johnsons		300	Mammy Johnsons	Marine transgression, regression and further marine transgression	Extension (normal fault development) and regional subsidence
		Weismantel		20	Weismantel		
		Duralie Road		250			
Lower Permian	Alum Mountain Volcanics				Clareval	Arc-related rift	
					Basal		

(1) Modified from AECOM (2009) and SRK (2005).

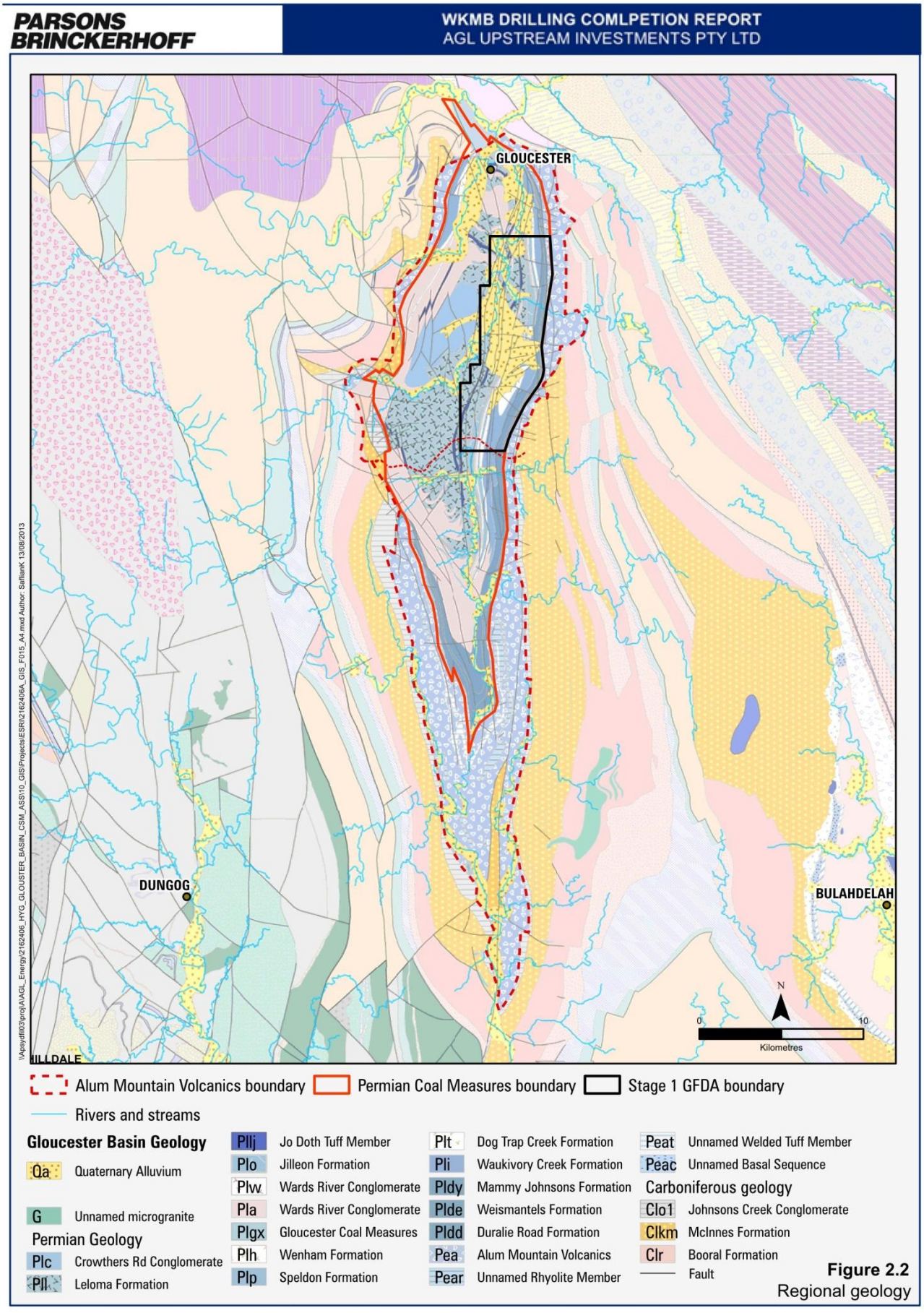


Figure 2.2
Regional geology

2.3.3 Structural geology of the investigation area

The tectonic development and structural setting of the Gloucester-Stroud Syncline is discussed by Roberts et al. (1991) based on regional geological mapping and seismic profile interpretation. Subsequent structural interpretations have been carried out by SRK (2005) and Lennox (2009). The following summary is based on those reports.

The Gloucester-Stroud Syncline is the largest structure in the surrounding region, being more than 55 km long and 24 km wide with steeply dipping limbs containing a stratigraphic section up to 8 km thick (Roberts et al. 1991). The syncline has a sinuous axial trace that trends in generally northerly direction (355°) but that swings eastwards (022°) between Stratford and Gloucester. The syncline is doubly plunging, closing at both ends forming a tight canoe-like structure. The axial plane is inclined slightly to the east; bedding in the limbs of the syncline tends to dip steeply toward the axis at more than 60°, with some bedding sub-vertical or slightly overturned.

The syncline is a fault bounded trough, active during the Permian. Roberts et al. (1991) identify up to six deformation events that were important in the depositional and structural development of the basin. SRK (2005) simplified the structural development into two main stages:

- Early – Middle Permian dextral tectonic margin, resulting in reactivation of NNW-striking faults as strike-slip dextral and formation of NE and EW striking normal faults, particularly around the margins of a circular basement feature (suspected deep intrusion) in the northern part of the basin. The majority of the coal measures were deposited during this complex phase.
- Late Permian shortening in a NE direction during the early stages of the Hunter Bowen Orogeny, resulting in reverse and thrust faulting on NNW faults and some NNE faults.

Combining structural domains with the known distribution of stratigraphy, SRK (2005) divides the basin into three structure/stratigraphic domains:

1. An eastern domain containing a number of coal seams in the Avon and Craven sub-groups.
2. A western domain where the surface mapping indicates sequences of Waukivory Formation and Wards River Conglomerate that mark periods of prograding fluvial systems that have significantly reduced the thickness of coal seams.
3. Major fault zones that separate the eastern and western domains.

2.3.3.1 Waukivory Fault

The fault zones identified in the Waukivory study area are mostly reverse faults where older rock strata are thrust over younger strata. Figure 2.3 shows the trace of the major faults identified in seismic section. The displacements of identified coal seams across the fault are mapped.

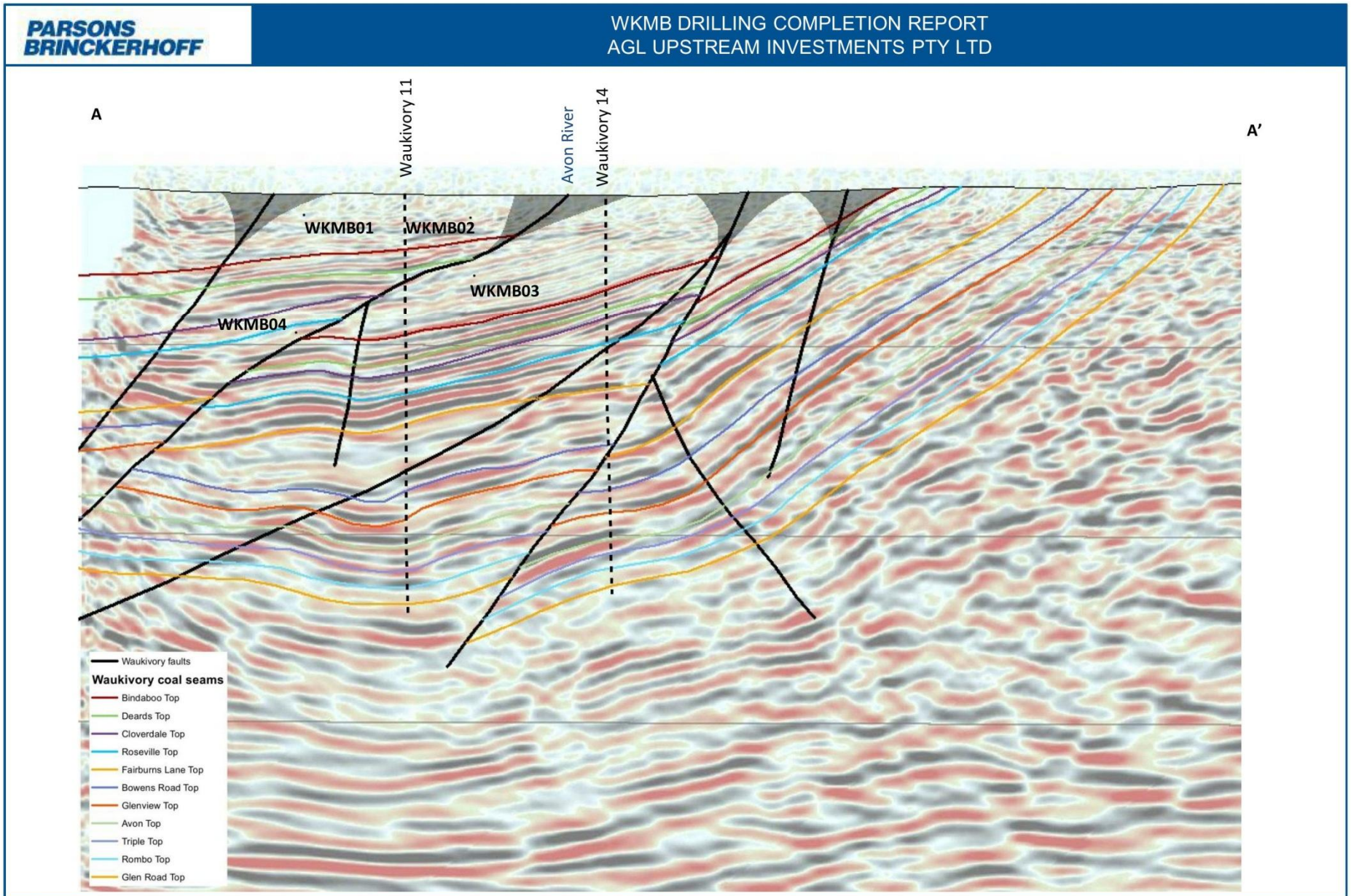


Figure 2.3 Waukivory interpreted seismic section (from Parsons Brinckerhoff (2014))

2.4 Hydrogeological setting

Four broad hydrogeological units have been identified within the Gloucester Basin (Table 2.3). The permeability and groundwater flow characteristics of rocks within the Gloucester Basin are controlled by several factors including lithology, depth and the degree of fracturing and faulting. In this sense hydrogeological units and flow systems do not always correspond with defined geological boundaries (Parsons Brinckerhoff 2014a).

Table 2.3 Main hydrogeological units of the Gloucester Basin

Unit	Aquifer type	Formation name	General lithology	Hydraulic characteristics
Alluvium	Semi-confined, clay capped, porous, granular	Quaternary alluvium	Clay/mixed gravels	Heterogeneous, highly variable permeability associated with varying lithology
Shallow Rock (<150m)	Semi-confined, fractured rock	Upper Permian Coal Measures, Alum Mountain Volcanics	Interbedded sandstone/siltstone with bedding plane fractures	Heterogeneous, high and low permeability domains associated with fault zones and fracturing
Interburden	Confined, fractured rock	Upper Permian Coal Measures	Interbedded indurated sandstone/siltstone and claystone	Low permeability associated with sparse fractures, permeability decreases with depth
Coal Seams	Confined, fractured rock	Upper Permian Coal Measures	Coal/shale	Low permeability associated with cleating and fractures in coal seams, permeability decreases with depth

The four hydrogeological units are summarised as follows (Parsons Brinckerhoff 2014a):

1. **Alluvial deposits** adjacent to major creeks and rivers comprising unconsolidated sand, gravel and clay. These systems are heterogeneous but generally permeable with rapid recharge, through-flow and discharge associated with interactions with streams, and to a lesser extent with the underlying less permeable shallow rock. Hydraulic conductivity measurements range from 0.3 to 300 metres per day (m/d), averaging around 10 m/d.
2. **Shallow rock** comprising variably weathered and fractured Permian rocks extending to approximately 150 m below the surface, across all sub-cropping Permian units. The shallow rock zone is highly heterogeneous with relatively impermeable domains separated by more permeable domains, but on the whole it is more permeable that the deeper coal measures. The higher permeability domains are due to a higher density of fracturing associated with an irregular weathering profile and the near-surface expression of faulting. Groundwater flow within this zone is more strongly controlled by weathering and fracturing than the attitude of geological strata. Hydraulic conductivity of the shallow rock ranges from 10 m/d to $1x10^{-6}$ m/d at a depth of 150 m, but is typically in the order of 10^{-3} to 10^{-4} m/d.
3. **Deep coal measures interburden**. Sandstone and siltstone units that form interburden to coal seams are indurated and typically of very low permeability, forming aquitards and confining layers. Permeability of the interburden decreases with depth such that, at the maximum depth of CSG production it is likely to be in the order of 10^{-5} to 10^{-7} m/d, or less.
4. **Coal seams** tend to be slightly more permeable than the interburden and commonly form weak water bearing zones. Permeability and storage are provided by small fractures and cleats in the coal. As with the interburden, drill-stem tests show that the permeability of coal seams generally decreases with depth. At the maximum depth of CSG production, the permeability of coal seams is very low (10^{-4} – 10^{-6} m/d), but may be an order of magnitude higher than the interburden.

3. Drilling program

Parsons Brinckerhoff was the principal contractor for the site investigation program, providing all project management services, including management of sub-contractors.

Parsons Brinckerhoff supplied all the required technical services including geological, geophysical, hydrogeological and surveying services using the following sub-contractors:

- Highland Drilling (all drilling and bore completions except the abandonment of WKMB04 which was carried out by AGL).
- Groundsearch Australia Pty (downhole geophysical logging).
- CalCo Surveyors Pty Ltd (surveying services).

3.1 Health, safety and environment

Onsite health, safety and environmental risks were managed through a health, environment and safety plan (HESP) (Parsons Brinckerhoff 2012a), construction and environment management plan (CEMP) (Parsons Brinckerhoff 2012b) and safety management plan (SMP) (Parsons Brinckerhoff 2011 and 2012c); these documents were prepared in advance of the drilling program and were reviewed and approved by AGL's safety team. Highland Drilling (nominated drilling contractors for the works) provided safe work method statements (SWMS) (Highland Drilling 2012a) and job safety analyses (JSA) (Highland Drilling 2012b) covering works relating to the drilling and construction of the boreholes, these documents were also reviewed and approved by AGL.

All Highland Drilling and Parsons Brinckerhoff staff and site visitors were required to undergo a drill site induction during which they were given an overview of the commitments included in the HESP, SMP and CEMP and how these applied to their specific duties.

3.1.1 Health, Environment and Safety Plan

Prior to the commencement of the field based phase of the project, Parsons Brinckerhoff developed a comprehensive site specific HESP for the supervision of drilling work and groundwater monitoring activities at the Gloucester sites: *Health, Environment and Safety Plan (HESP) AGL – Gloucester Gas Project, groundwater investigations* (Parsons Brinckerhoff 2012a). This plan details the planned field tasks and the associated risk, and introduced risk mitigation measures to manage the risks. Measures include: risk elimination, substitution and implementation of controls, training, and use of personal protective equipment (PPE).

3.1.2 Safety Management Plan

The installation of the monitoring bores was conducted in accordance with the SMP which was developed by Parsons Brinckerhoff in collaboration with Highland Drilling and approved by AGL (Parsons Brinckerhoff 2012c). The SMP should be read in conjunction with the following AGL and Highland Drilling documents which together cover the health, safety and environmental working procedures for AGL's GGP:

- Upstream Gas Golden Rules (AGL 2010).
- Gloucester Gas Operations Occupational Health and Safety Management Plan (OHSMP) (AGL 2012a).
- Gloucester Gas Operations Emergency Response Plan (AGL 2012b).
- Gloucester Gas Project Environmental Management Plan (EMP) (AGL 2013).

- Standard Work Method Statement – Gloucester drilling (Highland Drilling 2012a).
- Job Safety Analysis – Gloucester drilling (Highland Drilling 2012b).

All fieldwork undertaken at the Gloucester drill sites was covered by the aforementioned documents including subsequent testing, and groundwater monitoring and sampling. These documents aim to ensure that the health, safety and welfare of Parsons Brinckerhoff employees and subcontractors are upheld through systematically identifying and documenting hazards, and assessing and controlling the associated risks.

3.1.3 Construction and Environment Management Plan

All site operations were undertaken in accordance with the environmental management systems as detailed in a site specific CEMP.

A detailed water management plan was a critical part of the CEMP detailing the stringent measures implemented to ensure compliance to zero discharge of produced (drilling) waters to adjacent land and surface water receivers. To assist in managing the reuse of lower salinity groundwater and the disposal of higher salinity groundwater and drilling mud, the following water management plan was implemented:

- All water utilised during the drilling process was supplied and brought to site by AGL.
- All groundwater produced during the drilling operations was captured in above ground storage tanks. If the capacity of the tanks reached 80%, work on that bore ceased until excess water in the tanks could be emptied. All groundwater was trucked to the produced water storage dams on AGL's Tiedman property for disposal.
- Drilling muds (Halliburton EZ-mud) were disposed of to a licenced facility.
- All cuttings produced during drilling were also contained in above ground tanks and were dried and used for internal farm track maintenance on the Tiedman property.

Run-off waters from rainfall events were diverted from the drilling areas (where required) by the construction of diversion bunds on the up-gradient side of the site. Water from the drill pads and associated constructed access tracks was diverted away by sand bag bunds, silt fencing and other control structures so as to direct water onto adjacent grassed areas and avoid erosion of the drill pads, fire trail and track areas.

3.1.4 Wellsite Permit to Work System

The internationally recognised Wellsite Permit to Work System (www.wellsite.org.au) was used by Parsons Brinckerhoff for the GGP groundwater drilling program. The system provides the means to manage field safety aspects in a systematic, formalised and auditable manner. As a standardised work planning mechanism the Permit to Work System was used for all non-routine tasks where a health and safety plan did not exist (including hot works), thus forcing the individual to undertake a documented work plan and assessment of the risks.

3.2 Groundwater monitoring bore drilling and construction

Between January and May 2012, four groundwater monitoring bores were drilled and constructed on the Waukivory pilot site. AGL submitted a Category 1 notification together with the required Site Disturbance Notices to the Division of Resources and Energy (DRE) under the reconnaissance drilling program requirements of PEL 285. Test (monitoring bore) licences under the Water Act 1912 were obtained by AGL prior to the monitoring bore drilling program (Table 3.1).

The drilling and completion of the groundwater monitoring bores was carried out in accordance with the NSW Office of Water (NOW) bore licence conditions and followed a detailed design and specification compliant with the *National Uniform Drillers Licencing Committee (NUDLC) 2012, Minimum Construction Requirements for Water Bores in Australia, Edition 3*.

Table 3.1 Monitoring bore licences

NOW Licence No.	No. of locations	Local bore ID		Site location (property)	Lot	DP	Bore type
20BL173038	4 bores	WKMB01 WKMB02	WKMB03 WKMB04	Waukivory	11	841445	Groundwater monitoring

The drilling of all bores was undertaken by Highland Drilling, using a rotary drilling rig under the supervision of a Parsons Brinckerhoff hydrogeologist. The target depth of all boreholes was confirmed by the supervising hydrogeologist. Geological bore logs are included in Appendix A.

Table 3.2 and Figure 3.1 summarise the bore construction details.

Monitoring bores WKMB01 and WKMB04 were drilled between January and February 2012 and monitoring bores WKMB02 and WKMB03 were drilled between April and May 2012.

Table 3.2 Bore construction details

Monitoring bore	Borehole diameter (mm)	Predominant drill bit	BoP & muds	Depth of 6" casing (mbgl)	Total depth (mbgl)	Screened interval (mbgl)	Screened interval (mAHD)	Screened formation	Hydro-stratigraphic units	Construction details
WKMB01	127	Air hammer	N/A	18.0	54.0	47.0 – 53.0	51.2 – 48.2	Leloma (upthrust)	Siltstone / sandstone	50 mm uPVC casing and screen
WKMB02	127	Air hammer	BoP & muds	18.0	127.0	51.0 – 60.0	52.5 – 43.5	Leloma (upthrust)	Siltstone / sandstone	50 mm uPVC casing and screen
WKMB03	140	Air hammer	BoP & muds	36.0	210.0	200.0 – 209.0	-96.8 – -105.9	Leloma (fault zone)	Siltstone / sandstone	50 mm galvanised steel casing and screen
WKMB04	140	Air hammer	N/A	18.0	360.0	335.0 – 347.0	-234.0 – -246.0	Jilleon (upthrust)	Siltstone / sandstone / coal	50 mm galvanised steel casing and screen

(1) mbgl = metres below ground level; mAHD = metres Australian Height Datum.

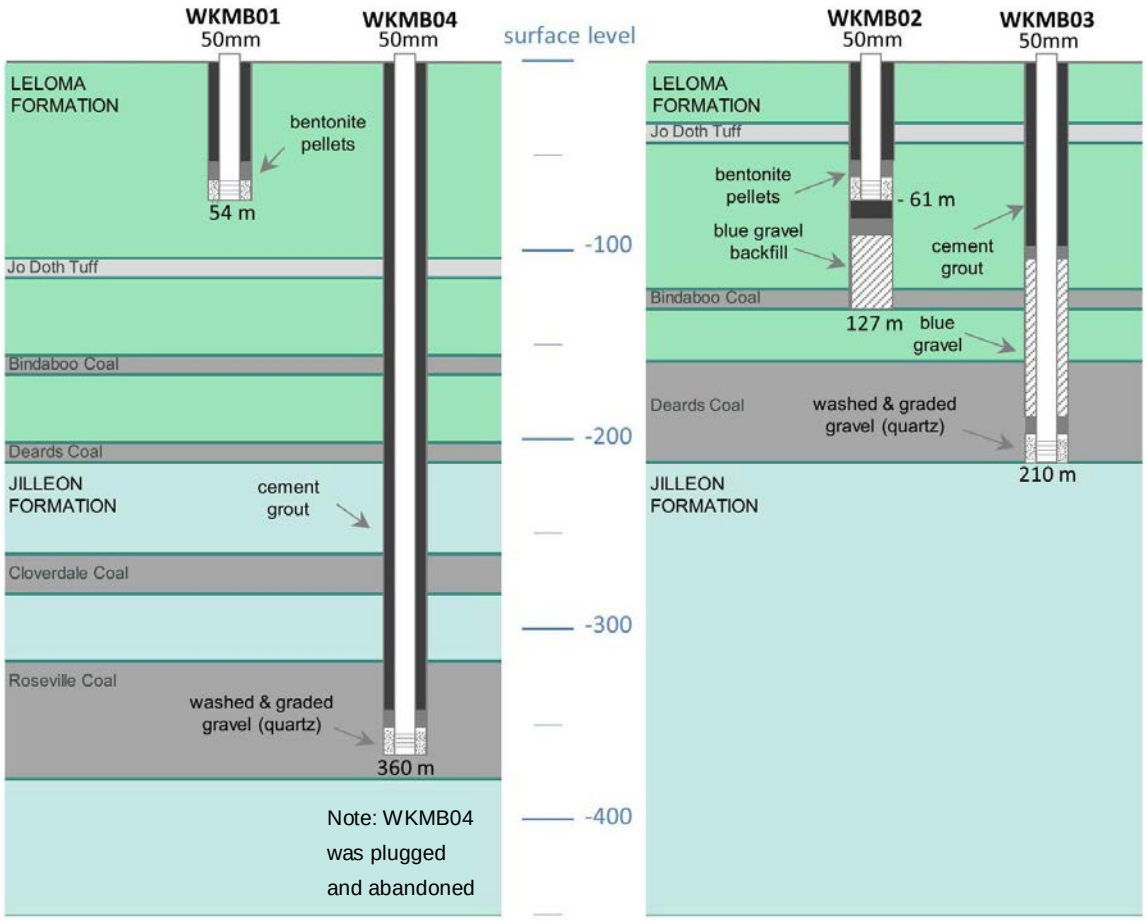


Figure 3.1 Nested groundwater monitoring bores at the Waukivory site

3.2.1 Drilling of monitoring bores

Drilling through the weathered horizon in the top 6 m was undertaken with a 200 mm (7.8") drag bit. This unstable section of the borehole was then lined with a 152 mm (6.0") internal diameter, welded steel surface casing of various lengths depending on the geology. Air rotary drilling through the solid rock was undertaken using a 140 mm (5.5") percussion hammer drill bit at all monitoring bores.

Although not encountered during the drilling, immediately following the drilling and completion of the deep monitoring bore, gas was observed in WKMB04, coming from the screened interval in the Roseville Coal Seam. Flows were controlled by installing a gas wellhead at this site to seal the bore.

Prior to the commencement of the second part of the field program, a desktop risk assessment for the drilling and construction of monitoring bores WKMB02 and WKMB03 was undertaken, as per the requirements of the updated SMP (Parsons Brinckerhoff, 2012c). Taking into consideration the borehole depth and the likely strata to be drilled through (i.e. faults and / or producing coal seams), monitoring bore WKMB02 was assessed to be low risk and WKMB03 was assessed to be high risk. The risk rating determines the construction method and level of well control required i.e. the practices used to prevent and/or manage the influx of formation fluids/gas in the borehole (blowouts) and this is often via the use of a Blowout Preventer (BoP) and drill muds.

As the deep monitoring bore WKMB03 was assessed to have the potential for gas, it was drilled using well control (utilising a 5.5" BoP). At a prescribed pressure threshold level the BoP is set to deploy and will clamp around the top of the drill rods or casing, killing potential gas surges released from coal seams.

The BoP requires an anchor into competent rock, typically around one third of the total drill depth. A 152 mm (6.0") internal diameter, screwed steel casing was installed to 36 mbgl and grouted in place at WKMB03. In addition to the 6.0" casing, a 203 mm (8.0") internal diameter, welded, steel riser was installed to support the upper, loosely consolidated profile to 6 mbgl. The drilling from 0 to 6 mbgl was undertaken with a 215 mm (8 ½") drag bit, while drilling from 6 to 210 mbgl (total depth) was undertaken with a 140 mm percussion hammer drill bit. As an additional well control measure, monitoring bore WKMB03 was drilled overbalanced. (i.e. using drilling muds (Halliburton EZ-mud)). When drilling overbalanced, formation fluids and gases are supressed by the weighting of the muds. The muds are pumped through the drill string, and are captured at the surface and recirculated.

Monitoring bore WKMB02 was originally planned to be WKMB03 and was drilled using a BoP. A number of collapses in the formation were encountered during drilling at this location, likely due to the narrow bore diameter and the low water inflow. To stabilize the bore, drilling foam was added and it was constructed to a shallower depth as WKMB02. The specifications of the backfill and collapses are presented in the geological log in Appendix A.

The Leloma Formation encountered at the Waukivory site is characterised by grey siltstone and fine grained (and minor very fine and fine to medium grained) grey sandstone, with minor carbonaceous staining. Some minor bands of Jo Doth Tuff and thin (less than 1 m), bright and dull coal seams were also observed. A few chips of chert and quartz were also identified. The Jilleon Formation was characterised by fine grained, grey sandstone and grey siltstone, and very thin (less than 1 m) sequences of bright coal). The intersection of the Jo Doth Tuff suggests that the formations dip towards the west.

The first water cuts were low (i.e. ~0.2 L/s) and were observed at between 20 mbgl (WKMB01) and 47 mbgl (WKMB04). The highest water cut (0.8 L/s) observed in the Leloma Formation was at 54 mbgl at WKMB01. Groundwater in the Leloma Formation was generally brackish to saline (712 µS/cm to 21,410 µS/cm) and alkaline (7.14 to 8.49 pH units). The maximum water cut observed in the Jilleon Formation was 0.3 L/s at 216 mbgl. Groundwater in the Jilleon Formation was brackish to moderately saline (2,688 µS/cm to 11,870 µS/cm) and alkaline (8.09 to 8.78 pH units).

3.2.2 Airlifting

Airlift development was continuous during drilling at the air rotary boreholes and they were further developed at termination until the discharge water was free of sediment and the water quality field parameters stabilised.

3.2.3 Logging

A detailed geological log of the lithology recorded at one metre intervals was produced, and instantaneous water flow recorded at the end of each drill rod (every 6 m) where applicable. Physio-chemical parameters (pH, electrical conductivity (EC), temperature, total dissolved solids (TDS), dissolved oxygen (DO) and oxidation reduction potential (ORP)) were measured (using a calibrated YSI water quality meter) at the end of each rod. These parameters are shown on the geological bore logs provided for each monitoring bore in Appendix A. Groundwater inflow and quality data could not be obtained for WKMB02 and WKMB03 as they were drilled with muds.

3.2.4 Borehole construction

Following the drilling of the bores to the target depth/formation, a Parsons Brinckerhoff hydrogeologist finalised the specifications and design of the groundwater monitoring bore installations.

The shallower monitoring bores WKMB01 and WKMB02 were installed with 50 mm internal diameter, Class 18 uPVC screwed casing and screen (0.5 mm aperture machine slotted) with a 1 m sump and end plug.

The deeper monitoring bores WKMB03 and WKMB04 were installed with 50 mm internal diameter, galvanised steel, screwed casing and stainless steel screen (1 mm aperture slots) with a 1 m galvanised steel sump and end cap at WKMB03, and a 13 m galvanised steel sump and end cap at WKMB04.

The screen length targeted the most productive water bearing zone. A washed and graded (3 - 5 mm) gravel filter pack was installed in the annulus around the screen and extended up to 13 m above the screened section.

Coated bentonite pellets were then installed above the gravel pack. A 4 to 6 m thick plug of bentonite was installed above the gravel pack at all monitoring bores. A cement grout mix was then tremmied in a controlled manner to the surface at all bores except WKMB03, which was backfilled with coarser blue gravel between 115 mbgl and 198 mbgl (adjacent to the initial proposed screened interval for WKMB02), and then grouted to the surface. The bentonite seal and cement grout ensure hydraulic isolation of the screened section preventing any flow of groundwater through the annulus of the bore column. Following the construction of each bore, the site was reinstated and a lockable steel monument welded over the bores and surrounded at its base by a concrete slab.

3.2.5 Downhole geophysics

WKMB04 was geophysically logged (gamma, density, resistivity, calliper and sonic) by Groundsearch Australia Pty under the supervision of Parsons Brinckerhoff hydrogeologists prior to the construction of the bore to accurately gauge changes in lithology. The geophysiscal logs are presented in Appendix B.

Geophysical logging was attempted at the original WKMB03 site (before it reverted to WKMB02) however there were too many collapses in the formation for the logging tools to reach total depth.

3.2.6 Survey

Registered surveyors CalCo Surveyors Pty Ltd surveyed the location and height of all the monitoring bores under the supervision of Parsons Brinckerhoff. All bores were surveyed to MGA, a grid coordinate system based on the Universal Transverse Mercator projection and the Geocentric Datum of Australia 1994. The bores were also surveyed for surface elevation to Australian Height Datum (AHD) (Table 3.3).

Table 3.3 Monitoring bore survey coordinates and elevations

Monitoring bore	Easting	Northing	Ground level elevation (mAHD)	Top of casing level elevation (mAHD)
WKMB01	402153.63	6452566.28	101.16	101.70
WKMB02	402575.54	6452572.49	103.49	104.08
WKMB03	402589.87	6452584.93	103.22	103.81
WKMB04	402133.69	6452567.49	100.98	102.38

3.2.7 WKMB04 workover

Safety concerns related to gas observed after construction at WKMB04 saw a gas wellhead immediately installed to shut in the gas flows. No groundwater level monitoring or water sampling was possible so a decision to convert the site to a vibrating wire piezometer was made in mid-2013. Prior to conversion it was possible to obtain one water sample from the deep screened interval by bailing the bore. Conversion to a fully grouted vibrating wire piezometer was scheduled for November 2013 however the conversion was abandoned after the cemented galvanised steel bore casing could not be successfully removed (AGL 2014b). The abandonment program was successfully carried out by Gas Field Services under the guidance of drilling engineers from AGL's Operations team.

4. Permeability testing

Falling and rising head ('slug') tests were conducted at monitoring bores WKMB01, WKMBO2 and WKMB03 to estimate the horizontal hydraulic conductivity of each screened water bearing zone. Hydraulic conductivity is the permeability of the formation with respect to the porous flow of water.

A falling head test is achieved by introducing a volume of water or solid 'slug' to displace the water column within the monitoring bore causing the water level to instantaneously rise and flow from the bore into the aquifer via the screen (Figure 4.1). A rising head test is the opposite, where a volume of water (or a solid slug) is instantaneously removed from the monitoring bore, causing the water level to fall, drawing water into the bore from the aquifer. The time it takes for the water level in the bore to recover to pre-test levels is related to the permeability of the host formation. Rising and falling head tests sometimes produce slightly different results and therefore each bore is tested three times (falling, rising, then falling again).

The slug consists of solid high-density plastic tube (1.6 m long). Details of the set-up for the falling and rising head tests are shown in Figure 4.1.

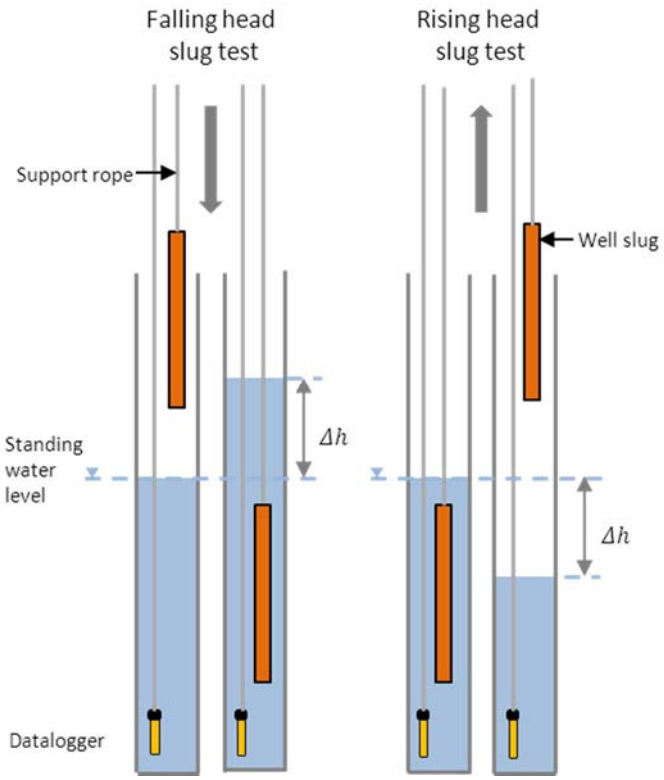


Figure 4.1 Rising and falling head (slug) testing (after Waterra 2011)

At the commencement of the testing, the standing water level (SWL) in the bore is measured from a fixed reference point at the top of casing and the datalogger programmed to record at 5 second intervals to measure rapid changes in water level within the bore.

Test data were processed and analysed using the appropriate Bouwer and Rice (Bouwer 1989), or Hvorslev (1951) method with AQTESOLV Version 4.5. Results are presented as estimates of hydraulic conductivity (as m/day) in Table 4.1. The AQTESOLV analyses are included in Appendix C.

The permeability values are consistent with hydraulic conductivity values previously encountered within the GGP (Parsons Brinckerhoff 2012d and 2014b).

Table 4.1 Hydraulic conductivity results from slug tests

Monitoring bore	Screened section (mbgl)	Lithology	Formation	Hydraulic conductivity range (m/day)^	Mean Hydraulic conductivity (m/day)
WKMB01	47.0 – 53.0	Siltstone / sandstone	Leloma	$2.71x10^{-4}$ – $3.31x10^{-4}$	2.94×10^{-4}
WKMB02	51.0 – 60.0	Siltstone / sandstone	Leloma	$6.35x10^{-4}$ – $1.35x10^{-3}$	7.4×10^{-4}
WKMB03	200.0 – 209.0	Siltstone / sandstone	Leloma	$1.68x10^{-4}$ - $2.68x10^{-4}$	2.1×10^{-4}
WKMB04	335.0 – 347.0	Siltstone / sandstone / coal	Jilleon	#	#

(1) # = no test undertaken, WKMB04 was plugged and abandoned.

(2) ^ All tests conducted with the Bower – Rice method.

5. Groundwater levels

This section presents the initial baseline groundwater level monitoring results for the Waukivory bores. Hydrographs showing groundwater levels and rainfall from the start of monitoring until March 2014 are presented in Figure 5.1. There is a strong correlation with large rainfall events. Individual hydrographs for each monitoring bore are included in Appendix D.

Following the completion of each monitoring bore (with the exception of the abandoned WKMB04), *in situ* pressure transducers (dataloggers) were suspended in the water column from a galvanised steel wire and programmed to record a groundwater level (or standing water level (SWL)) measurement every six hours. To verify the level recorded by the dataloggers, manual measurements are recorded quarterly using an electronic dip meter.

A barometric logger installed above the water table at monitoring bore S5MB01 on AGL's Tiedman property (part of the original Stage 1 groundwater monitoring network) is used to correct the raw pressure transducer data to allow for changes in atmospheric pressure. Initial manual groundwater level measurements following bore installation are presented in Table 5.1. Groundwater level monitoring is continuing and will be subject to more detailed assessment in the next Annual Groundwater Monitoring Status Report to be issued in September 2014 (for the water year 2013/14).

Table 5.1 Initial groundwater levels

Bore ID	Date	Screened formation	Ground elevation (mAHD)	SWL (mbgl)	SWL (mAHD)
WKMB01	29/02/2012	Leloma - shallow rock	101.16	5.42	96.28
WKMB02	04/06/2012	Leloma - shallow rock	103.49	7.49	96.60
WKMB03	13/08/2012	Leloma - interburden	103.22	4.42	99.39
WKMB04	N/A	Jilleon - interburden	100.98	N/A	N/A

(1) N/A = not applicable. WKMB04 was plugged and abandoned.

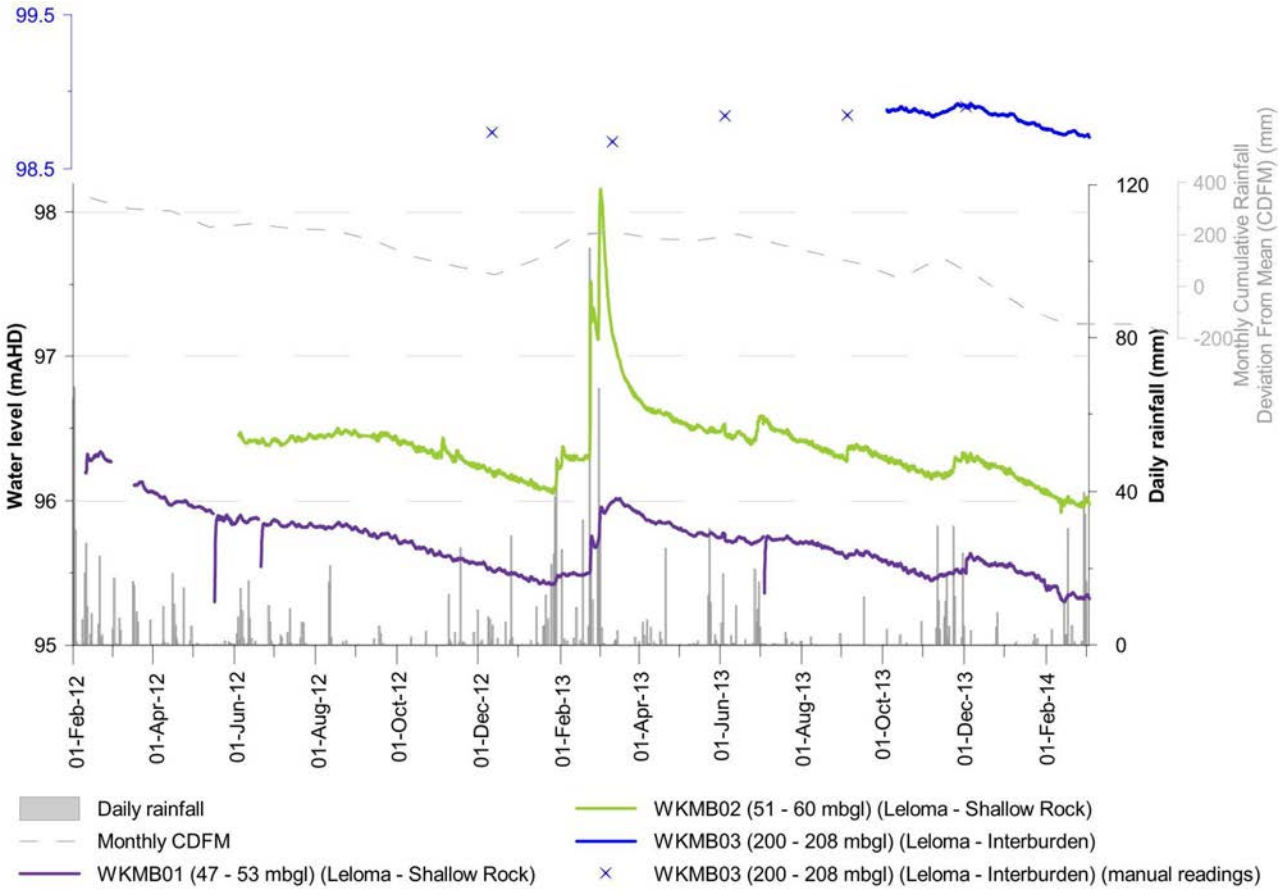


Figure 5.1 Groundwater levels at the Waukivory monitoring bores

5.1 Upthrust – shallow rock

The upthrust shallow rock monitoring bores WKMB01 and WKMB02 show similar strong responses to rainfall events (Figure 5.1). Groundwater levels in both bores respond rapidly, increasing up to ~0.5 m at WKMB01 and up to ~2.5 m at WKMB02 in response to the high rainfall events in January and February 2013.

5.2 Fault zone

The datalogger in interburden monitoring bore WKMB03 failed between September 2012 and September 2013, although manual readings are available for that period (Figure 5.1). Groundwater levels show a slight increase (~0.5 m) between September 2012 and September 2013. The data recorded shows a similar but possibly more subdued response to rainfall events compared to the shallow rock monitoring bores.

The water level at WKMB03 is higher than at the shallow rock monitoring bores, indicating the potential for upward flow at this location.

6. Groundwater quality

6.1 Groundwater quality monitoring

Groundwater sampling was undertaken between June and August 2013 at WKMB01, WKMB02 and WKMB03 and in October 2013 at WKMB04.

6.1.1 Sampling techniques

Two methods were used to obtain groundwater quality samples from the monitoring bores. The methods were selected based on the permeability of the screened formation of each bore which was determined during the drilling and subsequent hydraulic conductivity testing. All bores are relatively low yielding and a low flow sampling pump or double check bailer was used, in summary:

- A micro-purge™ low flow sampling pump was used at monitoring bores: WKMB01, WKMB02 and WKMB03.
- A double check bailer was used at monitoring bore WKMB04.

The micro-purge™ system allows groundwater to be drawn into the pump intake directly from the screened portion of the aquifer, eliminating the need to purge relatively large volumes of groundwater from these bores. Water quality parameters were monitored during the micro-purge™ pumping to ensure that a representative groundwater sample was collected.

The 45 mm diameter double check bailer has check valves (top and bottom), preventing water entry during retrieval and ensures that discrete specific samples are obtained.

Physio-chemical parameters (pH, EC, temperature, TDS, DO and ORP) were measured during and following purging using a calibrated YSI water quality meter.

6.1.2 Chemical analysis of water

Groundwater samples collected in the field were analysed for a broad chemical suite designed specifically to assess the chemical characteristics of the different water bearing zones at the monitoring sites. Table 6.1 details the groundwater analytical suite.

Table 6.1 Groundwater analytical suite

Category	Parameters	
Physical parameters (field)	Electrical conductivity (EC) Temperature Dissolved oxygen (DO)	pH Oxidation redox potential (ORP) Total dissolved solids (TDS)
Physical parameters (lab)	EC TDS	pH
Major ions	Calcium Magnesium Sodium Potassium	Chloride Bicarbonate Sulphate Fluoride Silica
Metals and minor/trace elements	Aluminium Arsenic Barium Beryllium Boron Bromine Cadmium Cobalt Copper Iron	Lead Manganese Mercury* Molybdenum Nickel Selenium Strontium Uranium Vanadium Zinc
Nutrients	Ammonia Phosphorus (total) Phosphorus (reactive)	Nitrite Nitrate Total organic carbon (TOC)
Hydrocarbons	Phenol compounds Polycyclic aromatic hydrocarbons (PAH)	Total petroleum hydrocarbons (TPH) Benzene, toluene, ethyl benzene and xylenes (BTEX) Oil and grease
Dissolved gases	Methane Ethene Ethane Propene	Propane Butene Butane
Isotopes	Oxygen-18 (^{18}O) Deuterium (^{2}H) Tritium (^{3}H) Chloride-36 (^{36}Cl)**	Radiocarbon (^{14}C) Carbon-13 dissolved organic carbon ($^{13}C_{DIC}$)* Carbon-13 methane ($^{13}C\text{-}CH_4$) and deuterium methane ($^{2}H\text{-}CH_4$)

(1) * Not analysed at WKMB04.

(2) ** Only analysed at WKMB04.

Groundwater samples for laboratory analysis were collected in the sample bottles specified by the laboratory, with appropriate preservation when required, as listed in Table 6.2. Samples undergoing dissolved metal analysis were filtered through 0.45 µm filters in the field prior to collection.

Table 6.2 Sample containers for chemical and isotopic analytes

Category	Sample container
Physical properties (turbidity) & major cations and anions	1 x 500 mL plastic, unpreserved
Dissolved metals	1 x 60 mL plastic, preserved with nitric acid, field filtered
Nutrients	1 x 125 mL plastic, preserved with sulphuric acid
Total organic carbon	1 x 40 mL amber glass, preserved with sulphuric acid
Phenols/PAH/TPH (C10-C36)	1 x 500 mL amber glass, unpreserved
TPH (C6-C9)/BTEX	2 x 40 mL amber glass, preserved with hydrochloric acid
Dissolved gases	2 x 40 mL amber glass, preserved with sulphuric acid
Oxygen-18 and deuterium	30 mL nalgene, unpreserved (no head space)
Radiocarbon	500 mL nalgene, unpreserved
Tritium, Chlorine-36	1 L nalgene, unpreserved
Isotopes of methane	2 x 40 mL amber vials, unpreserved

The samples were sent to the following laboratories under appropriate chain-of-custody protocols (documentation and laboratory results are provided in Appendices):

- Australian Laboratory Service (ALS) Environmental Pty Ltd, Smithfield, Sydney – Chemistry analysis. NATA certified laboratory (Appendix F).
- GNS Stable Isotope Laboratory, Lower Hutt, New Zealand – Oxygen-18 and deuterium analysis (Appendix G).
- Rafter Radiocarbon Laboratory, Lower Hutt, New Zealand – Carbon-14 analysis (Appendix H).
- Australian Nuclear Science and Technology Organisation (ANSTO), Lucas Heights – tritium (Appendix I).
- UC Davis Stable Isotope Facility, Davis, California, USA – carbon-13 ($^{13}C_{DIC}$) and methane isotope analysis ($^{13}C\text{-}CH_4$ and $^{2}H\text{-}CH_4$) (Appendix J).
- Australian National University (ANU) Department of Nuclear Physics, Canberra – Chlorinre-36 (Appendix K).

6.1.2.1 Field QA/QC

The field sampling procedures conformed to Parsons Brinckerhoff's Quality Assurance/Quality Control protocols to prevent cross-contamination and preserve sample integrity. The following QA/QC procedures were applied:

- Samples were collected in appropriate bottles with appropriate preservation solutions.
- Samples were kept chilled (<4°C) at all times.
- Samples were delivered to the laboratories within the specified holding times.
- Unstable parameters were analysed in the field (field parameters).

6.1.2.2 Laboratory QA/QC

The laboratories conduct their own internal QA/QC program to assess the repeatability of the analytical procedures and instrument accuracy. These programs include analysis of laboratory sample duplicates, spike samples, certified reference standards, surrogate standards/spikes and laboratory blanks.

6.2 Groundwater quality results

This chapter presents the baseline water quality monitoring results. The results have been compared against the ANZECC (2000) guidelines for freshwater ecosystems (south-east Australia – lowland rivers) because the rivers are the ultimate receiving waters for groundwater discharge. However these water guidelines are often naturally exceeded in catchments with rocks deposited in marine environments, hence they are only used here for comparative purposes rather than as strict water quality objectives or trigger values.

Full water quality results are presented in Appendix E.

Piper diagrams are a graphical representation of the chemistry of a water sample and can be used to graphically show the relative concentrations of major ions (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+}, Cl^{-}, HCO_3^{-} and SO_4^{2-}). The piper plot for all the Waukivory monitoring bores is presented in Figure 6.1.

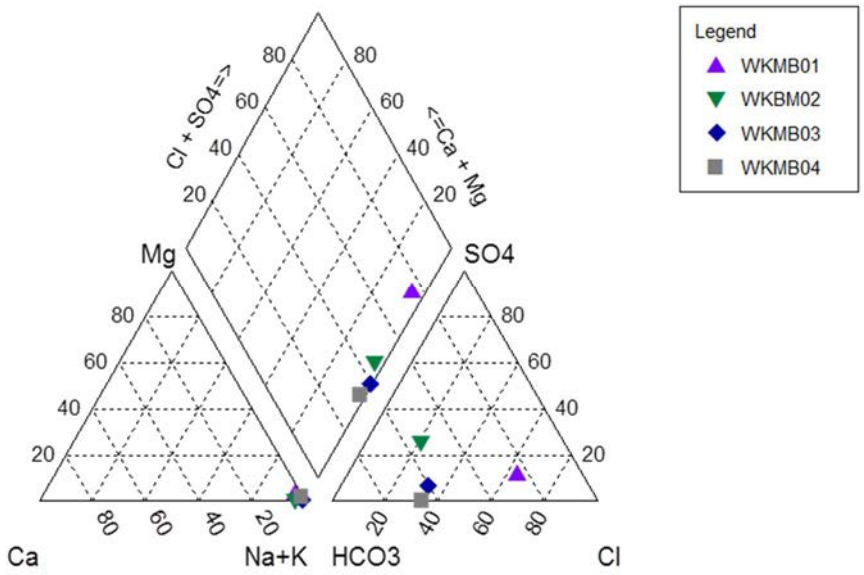


Figure 6.1 Piper diagram for the Waukivory monitoring bores

A summary of water quality results for the Waukivory monitoring bores is provided in Table 6.3. Full water quality results are presented in Appendix E.

Table 6.3 Water quality summary for the Waukivory monitoring bores

Parameters	Units	ANZECC (2000) guidelines[a]	WKMB01	WKMB02	WKMB03	WKMB04
General Parameters						
pH (field)	pH units	6.5 – 8.0[b]	7.87	**9.20**	**9.95**	**8.33**
pH (lab)			**8.270**	**9.07**	**10.00**	na
Conductivity (field)	µS/cm	125-2,200[b]	**5,436**	1,013	1,563	**16,420**
Conductivity (lab)			**6,100**	1,030	**3,050**	**16,500**
Temperature	^{o}C	-	17.76	17.26	18.02	29.00
Dissolved oxygen	% sat	85-110% [b]	**3.6**	**37.4**	**80.9**	**41.9**
TDS (field)	g/L	-	3.533	0.660	0.690	10.67
TDS (lab measured)			3.540	0.688	2.240	11.00
Redox potential	mV	-	-338.3	22.7	-19.6	34.8
Major ions						
Calcium	mg/L	-	23	7	5	10
Magnesium	mg/L	-	28	<1	<1	47
Sodium	mg/L	-	1,470	236	625	4,650
Potassium	mg/L	-	7	7	35	25
Chloride	mg/L	-	1,420	80	371	2,580
Sulphate	mg/L	-	349	129	94	<1
Total alkalinity as $CaCO_3$	mg/L	-	763	288	954	7,080
Dissolved metals						
Aluminium	mg/L	0.055 (pH>6.5)	**0.06**	**0.19**	**0.76**	0.02
Arsenic	mg/L	0.013 (AsV), 0.024 (AsIII)	0.002	0.002	0.003	0.002
Barium	mg/L	-	0.629	0.072	0.405	31.0
Beryllium	mg/L	ID	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	ID	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.0014	<0.001	0.001	**0.004**	<0.001
Lead	mg/L	0.0034	<0.001	<0.001	**0.049**	0.002
Manganese	mg/L	1.9	0.101	0.002	0.008	0.014
Mercury	mg/L	0.0006	na	na	na	<0.0001
Molybdenum	mg/L	ID	0.002	0.004	0.015	0.010
Nickel	mg/L	0.011	**0.014**	0.001	0.002	**0.012**
Selenium	mg/L	0.011 (total)	<0.01	<0.01	<0.01	<0.01

Parameters	Units	ANZECC (2000) guidelines[a]	WKMB01	WKMB02	WKMB03	WKMB04
Strontium	mg/L	-	3.75	0.463	0.758	28.000
Uranium	mg/L	ID	0.005	<0.001	<0.001	0.001
Vanadium	mg/L	ID	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.008	**0.018**	**0.018**	**1.220**	**1.530**
Boron	mg/L	0.37	<0.05	<0.05	0.10	0.11
Iron	mg/L	ID	0.96	<0.05	0.20	0.52
Bromine	mg/L	ID	3.7	0.2	0.8	5.6
Nutrients						
Ammonia as N	mg/L	0.02[a]	**0.75**	**0.44**	**13.50**	**3.70**
Nitrite as N	mg/L	0.02[a]	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.70	<0.01	<0.01	0.02	<0.01
Total phosphorus as P	mg/L	0.05[a]	**0.22**	**0.11**	**0.43**	**0.33**
Reactive phosphorus as P	mg/L	0.02[a]	**0.10**	**0.07**	**0.04**	**0.04**
Total organic carbon	mg/L	-	15	3	168	60
Dissolved gases						
Methane	µg/L	-	7,400	4,340	32,100	3,150
Phenolic compounds						
Phenol	µg/L	320	<1	<1	1.3	<1
PAH	µg/L	-	<LORs	<LORs	<LORs	<LORs
BTEX	µg/L	-	<LORs	<LORs	<LORs	<LORs
Total petroleum hydrocarbons						
C_{15}-C_{28}	µg/L	ID	<100	<100	270	14,700
C_{29}-C_{36}	µg/L	ID	<50	<50	140	7,820

(1) (a) ANZECC (2000) guidelines for the protection of freshwater aquatic ecosystems: 95% protection levels (trigger values).
(2) (b) ANZECC (2000) guidelines for the protection of freshwater aquatic ecosystems: trigger values for lowland rivers in south-east Australia.
(3) 'ID' indicates insufficient data for trigger value to be established.
(4) LOR – Laboratory limit of reporting.
(5) **BOLD** indicates a value outside of the ANZECC (2000) guideline trigger values.
(6) na – not analysed.

6.2.1 Field parameters

Groundwater salinity at WKMB01 was slightly saline (5,436 µS/cm) and exceeds the ANZECC (2000) guideline value (125 – 2,200 µS/cm). The pH conditions were moderately alkaline and above the ANZECC (2000) guideline (6.5-9.0). Redox conditions were strongly reducing.

Groundwater salinity at WKMB02 was marginal (1,013 µS/cm) and did not exceed the ANZECC (2000) guideline values (125 – 2,200 µS/cm). pH conditions were strongly alkaline and above the ANZECC (2000) guideline (6.5 – 8.0). Redox conditions were slightly oxidizing at WKMB02.

Groundwater salinity at WKMB03 was marginal (1,563 µS/cm) and EC values were within the ANZECC (2000) guideline values (125 – 2,200 µS/cm). pH conditions were strongly alkaline and above the ANZECC (2000) guideline (6.5 – 8.0). Redox conditions were slightly reducing.

Groundwater salinity WKMB04 was moderately saline (16,240 µS/cm) and exceeded the ANZECC (2000) guideline value (125 – 2,200 µS/cm). The pH conditions were moderately alkaline and redox conditions were slightly oxidising.

6.2.2 Major ion chemistry

Table 6.4 summarises the major ion chemistry of the Waukivory monitoring bores. Major ion chemistry is similar, although the relative concentrations vary between monitoring bores.

Table 6.4 Major ion chemistry

Bore	Water type
WKMB01	Na-Cl-HCO_3
WKMB02	Na-HCO_3-SO_4-Cl
WKMB03	Na-CO_3-Cl
WKMB04	Na-HCO_3-Cl

6.2.3 Dissolved metals

The major findings of dissolved metal analysis were as follows:

- Dissolved metal concentrations were typically low.
- Beryllium, cadmium, cobalt, selenium and vanadium were below the laboratory limit of reporting (LOR) at all monitoring bores. Mercury was analysed at WKMB04 only and was below the laboratory LOR.
- Arsenic and manganese were detected at all monitoring bores but did not exceed the ANZECC (2000) guideline values.
- Aluminium and zinc were detected at concentrations above the ANZECC (2000) guideline at all monitoring bores, except for aluminium at WKMB04. Copper and lead were detected at concentrations above the ANZECC (2000) guideline at WKMB03 and were below or just above the laboratory LOR at the other monitoring bores. Nickel was detected at concentrations above the ANZECC (2000) guideline at WKMB01 and WKMB04.
- Barium, molybdenum, strontium and bromine were detected at all monitoring bores. Uranium was detected at concentrations above the laboratory LOR at WKMB01 only. Boron was detected at WKMB03 and WKMB04. Iron was detected at all monitoring bores, except for WKMB02.

The dissolved metal concentrations are considered natural and not unusual for the Leloma and Jilleon formations.

6.2.4 Nutrients

Nitrite was below the limit of reporting at all monitoring bores. Nitrate was detected at concentrations below the ANZECC (2000) guideline at WKMB03 and was below the laboratory LOR at all other monitoring bores.

Ammonia, total phosphorus and reactive phosphorus were detected and exceeded the ANZECC (2000) guidelines at all monitoring bores. Total organic carbon ranged from 3 mg/L at WKMB02 to 168 mg/L at WKMB03.

6.2.5 Hydrocarbons

TPH (C_{15}-C_{28} and C_{29}-C_{36} fractions) were detected at concentrations above the laboratory LOR at WKMB03 and WKMB04. Hydrocarbons in these types of formations can be naturally occurring (Volk et al. 2011) and have been detected in sedimentary rocks in the Gloucester Basin during early exploration programs (Thornton1982; Hunt et al. 1983).

PAHs and BTEX were below the laboratory LOR at all monitoring bores.

Phenolic compounds were below the laboratory LOR at all monitoring bores, with the exception of phenol which was detected at WKMB03.

6.2.6 Dissolved gases

The dissolved methane concentration ranged from 3,150 µg/L at WKMB04 to 32,100 µg/L at WKMB03.

6.3 Isotopes

6.3.1 Stable isotopes of water

Stable isotope ($\delta^{18}O$ and $\delta^{2}H$) values are compared to the Global Meteoric Water Line (GMWL) ($\delta^{2}H = 8.13\ \delta^{18}O + 10.8$) (Rozanski et al. 1993) in Figure 6.2. The GMWL (as seen on Figure 6.2) provides an important key to the interpretation of oxygen-18 and deuterium data. It is a line that defines the relationship between oxygen-18 (^{18}O) and deuterium (^{2}H) in fresh surface waters and precipitation from a number of global reference sites. Water with an isotopic composition that lies on the meteoric water line is assumed to have originated from the atmosphere and to be unaffected by other isotopic processes. The isotopic values for the groundwater samples are also compared to the Local Meteoric Water Line ($\delta^{2}H = 8.3\ \delta^{18}O + 16.3$) (Crosbie et al. 2012). This line defines the relationship between ^{18}O and ^{2}H for rainfall in the Sydney region.

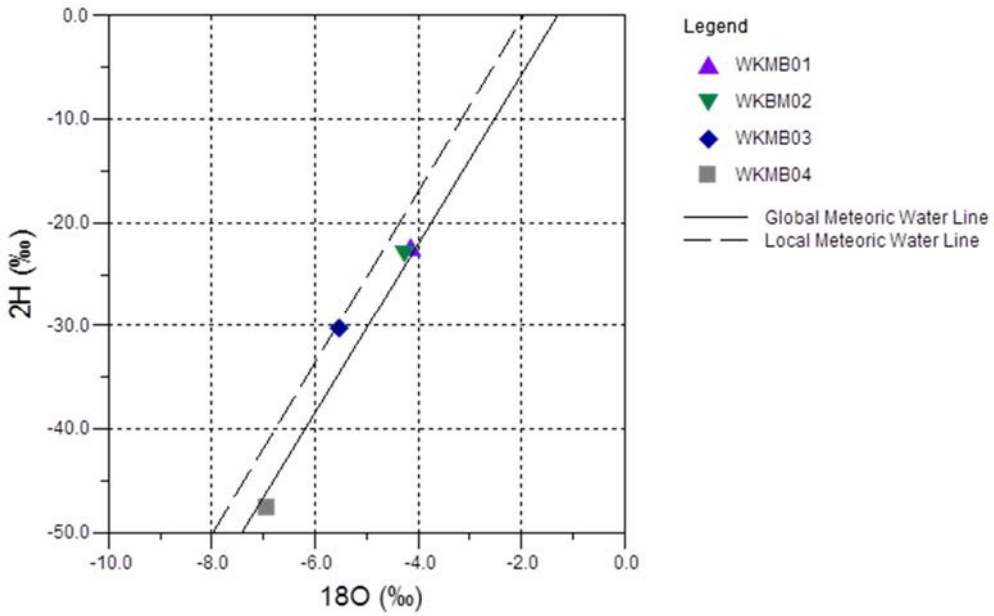


Figure 6.2 Deuterium versus oxygen-18 for Waukivory monitoring bores

Stable isotope results for all the Waukivory monitoring bores are presented in Table 6.5.

Table 6.5 Stable isotope results for the upthrust monitoring bores

Bore	Oxygen-18 (‰)	Deuterium (‰)
WKMB01	-4.13	-22.5
WKMB02	-4.27	-22.9
WKMB03	-5.53	-30.2
WKMB04	-6.94	-47.8

Stable isotope results indicate that WKMB01, WKMB02 and WKMB03 plot along the GMWL and LMWL, and WKMB04 near to the GMWL, indicating groundwater is of meteoric (rainfall) origin (Figure 6.2). These isotope results are consistent with previous monitoring rounds in the Gloucester Gas Project area in 2012 (Parsons Brinckerhoff 2012d) and 2013 (Parsons Brinckerhoff 2013a).

6.3.2 Radiogenic isotopes

Tritium and radiocarbon results are presented in Table 6.6. Carbon-13 of dissolved inorganic carbon (δ^{13}C-DIC) is also presented in Table 6.6.

Table 6.6 δ^{13}C-DIC, radiocarbon and tritium results for the upthrust monitoring bores

Bore	δ^{13}C (‰)	a^{14}C (pMC)	^{14}C age* (yrs BP)	^{14}C age# (yrs BP)	Tritium (TU)
WKMB01	-15.6	67.07±0.2	3,148±24	2,800	0.12^±0.03
WKMB02	-16.2	36.09±0.1	8,126±24	7,500	0.23±0.03
WKMB03	-1.8	11.90	17,041±48	14,500	0.33±0.03
WKMB04	33.05	0.43±0.07	43,634±1,324	>40,000	na

(1) * Uncorrected radiocarbon age.
(2) # Corrected radiocarbon age.
(3) ^ This result is below the Minimum Detectable Activity (MDA) and Limit of Quantification (Quant Limit) and therefore has an unacceptable level of uncertainty. Hence the data should only be used as an indicator of true concentration.
(4) na – not analysed.

The carbon-14 activity for WKMB01 was 67.07±0.2 pMC, corresponding to an uncorrected age of 3,148±24 yrs BP. Four correction methods are applied (Fontes-Garnier (1979); revised Fontes-Garnier; Tamers (1975) and Ingerson and Pearson (1964)) to apparent radiocarbon data to account for potential dilution of ^{14}C signature by incorporation of inactive carbon. The four models showed good agreement for corrected radiocarbon ages, and the average corrected radiocarbon age for WKMB01 was 2,800 yrs BP. Tritium was below the Limit of Quantification (LOQ). The LOQ is the lowest concentration or quantity of a target variable that can be reported with a specified degree of confidence.

The carbon-14 activity for WKMB02 was 36.09 ±0.1 pMC, corresponding to an uncorrected age of 8,124±24 yrs BP. The carbon-14 activity for WKMB03 was 11.90 pMC, corresponding to an uncorrected age of 17,041 yrs BP. Radiocarbon ages have been corrected to account for potential dilution by processes such as carbonate dissolution, sulphate reduction and methanogenesis (as defined in Clark and Fritz (1997)) and are 7,500 and 14,500 years for WKMB02 and WKMB03, respectively.

The carbon-14 activity was at the limit of the radiocarbon method for WKMB04, indicating that groundwater was >40,000 yrs BP.

The isotopically heavy δ^{13}C-DIC value for WKMB04 indicate residual biogenic CO_2 remaining after biogenic conversion of some of the CO_2 to CH_4. During biogenic methane production via CO_2 reduction, the CO_2 reducing bacteria utilise the lighter isotopes leaving the heavy isotopes in the residual CO_2. δ^{13}C values of CO_2 of up to +21‰ were detected in coal seams during AGL drilling exploration programs, and up to +23.7‰ during earlier exploration programs in 2000 (Weber and Smith 2001).

6.3.3 Carbon and hydrogen isotopes of methane (δ^{13}C-CH_4 and δ^{2}H-CH_4)

Compound specific isotopes of dissolved methane (carbon-13 (δ^{13}C-CH_4) and deuterium (δ^{2}H-CH_4)) were analysed in all groundwater monitoring bores. Dissolved methane concentrations and isotope results are presented in Table 6.7, and isotope results are compared to data collected by AGL from coal seams during exploration in the GGP area.

Table 6.7 Dissolved methane concentrations and isotope results for the upthrust monitoring bores

Bore	CH_4 (µg/L)	$\delta^{2}H_{CH4}$ (‰)	$\delta^{13}C_{CH4}$ (‰)
WKMB01	7,400	-135.6^	-45.6
WKMB02	4,340	-176.4^	-42.9^
WKMB03	32,100	-213.7	-22.5
WKMB04	3,150	-194.1	-32.38

Note: ^ Below LOQ.

The limit of quantitation (LOQ) is the lowest concentration or quantity of a target variable that can be reported with a specified degree of confidence; therefore sample WKMB01 and WKMB02 with δ^{2}H-CH_4 results below the LOQ cannot be interpreted with a degree of confidence; however values do suggest a thermogenic origin (Figure 6.3).

The results for WKMB03 and WKMB04 indicate the methane is early mature thermogenic methane.

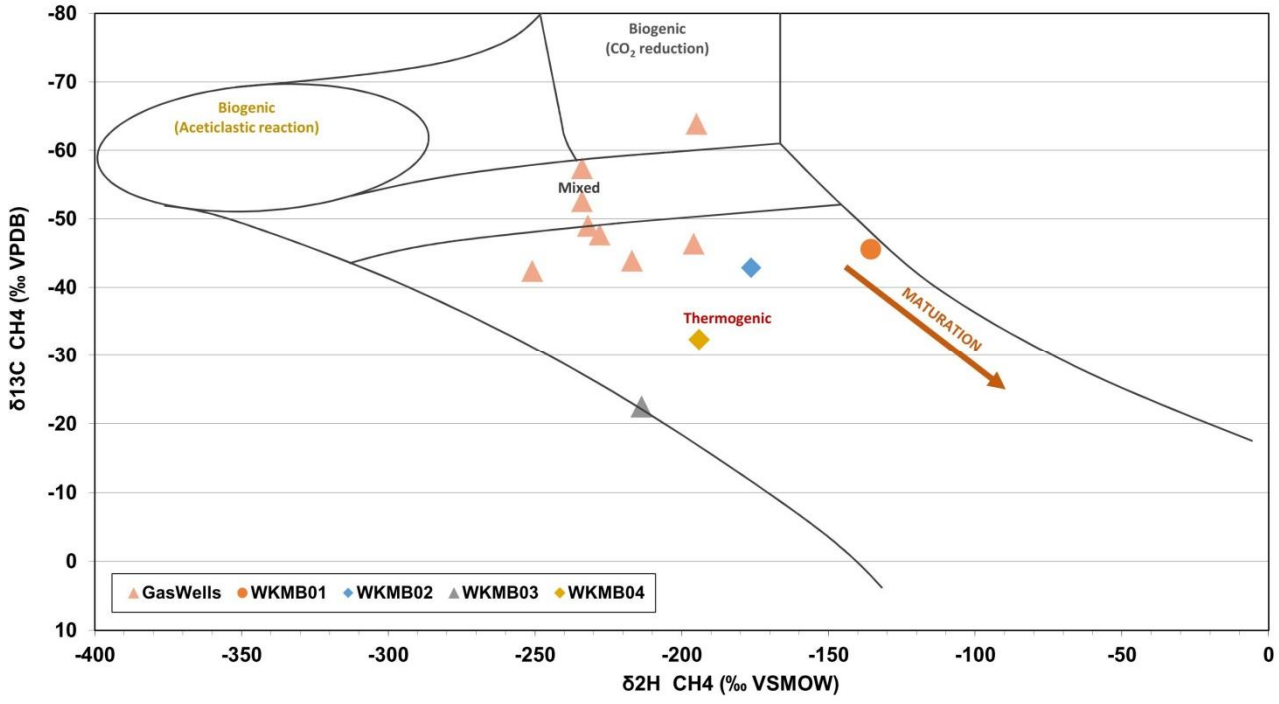


Figure 6.3 ^{13}C-CH_4 versus ^{2}H-CH_4 for the Waukivory monitoring bores

6.3.4 Chlorine-36

Chlorine-36 has a half-life of 301,000±2,000 years and is capable of dating groundwater with an age range of 46,000 to 1,000,000 years old. Chlorine-36 was selected as an age dating method as radiocarbon activities indicated groundwater age for targeted sections of the Gloucester Coal Measures was beyond the limit of radiocarbon dating. Chlorine-36 results are presented in Table 6.8.

The ^{36}Cl/Cl ratios of both gas wells still carry a meteoric recharge signature. That is, the ^{36}Cl/Cl ratio is above the *in situ* background value (secular equilibrium) estimated for methane bearing coal seams (~4x10^{-15}) (Snyder and Fabryka-Martin 2007). An estimate of groundwater age was calculated using a literature ^{36}Cl/Cl ratio for south-eastern Australia (~60 x10^{-15}) (Davie et al. 1989) for the initial ^{36}Cl/Cl ratio.

Groundwater ages were calculated using the equation defined in Bentley et al. (1986) (Eqn 1). This equation assumes that chloride and ^{36}Cl are solely derived from atmospheric sources with no internal sources or sinks except for ^{36}Cl decay and nucleogenic ^{36}Cl production.

$$t = \frac{1}{\lambda_{36}} \ln \frac{R - R_{se}}{R_0 - R_{se}}$$ *Eqn 1*

Where $\lambda 36$ is the decay constant for ^{36}Cl, R is the $_{36}$Cl/Cl measured in groundwater, R_0 is the $_{36}$Cl/Cl initial value, and R_{se} is the $_{36}$Cl/Cl at secular equilibrium.

Based on calculated values, the age estimate for WKMB04 is 395±40 x10^3 years old.

The decrease in the ^{36}Cl/Cl ratio the initial ratio can either be due to decay, or dilution by other sources of ^{36}Cl (e.g. mixing with low ^{36}Cl waters; leaching of salts and dissolution of evaporates). Due to the lack of data for these sources, age estimate calculations did not include these, and assumed chloride and ^{36}Cl are solely derived from atmospheric sources with no internal sources or sinks except for ^{36}Cl decay and nucleogenic ^{36}Cl production. Therefore, these age estimates are likely to be an upper estimate.

Table 6.8 Chlorine-36 results for WKMB04

Gas well	^{36}Cl/Cl x10^{-15}	^{36}Cl x10^8 atoms/L	Age estimate (10^3 yrs)
WKMB04	26.6 ± 1.8	11.7 ± 0.0.8	395 ±40

7. Conclusions

Groundwater level and water quality data obtained from this drilling program support the hydrogeological model updated in the annual monitoring report for GGP (Parsons Brinckerhoff 2013b).

The conclusions from the current investigations are discussed below.

7.1 Groundwater levels

The groundwater level in the shallow rock monitoring bores WKMB01 and WKMB02 show a strong response to high rainfall events.

The limited datalogger data available for WKMB03 indicate that the groundwater level in the interburden also responds to rainfall events.

No groundwater level could be recorded at WKMB04 due to the presence of gas resulting in subsequent plugging and abandoning of the monitoring bore.

7.2 Groundwater quality

- Groundwater quality is marginal to moderately saline, with alkaline pH and strongly reducing to oxidizing conditions. Major ion chemistry is similar, although the relative concentrations vary between monitoring bores.
- Dissolved metal concentrations are typically low, however exceedances of the ANZECC (2000) guidelines were observed for aluminium, copper, lead, nickel and zinc in at least one monitoring bore. Ammonia, total phosphorus and reactive phosphorus were detected at concentrations above the ANZECC (2000) guidelines at all monitoring bores.
- TPH were detected at concentrations above the laboratory LOR at WKMB03 and WKMB04. PAHs and BTEX were below the laboratory LOR at all monitoring bores. Phenolic compounds were below the laboratory LOR at all monitoring bores, with the exception of phenol which was detected at WKMB03.
- Isotope data indicate that groundwater in all monitoring bores is of meteoric origin. Groundwater is several thousand years old in the shallow rock monitoring bores, more than ten thousand years old in the fault zone at WKMB03 (14,500 yrs BP) and much older again in the Roseville Coal Seam at WKMB04 (>40,000 yrs BP).
- Chlorine 36 dating of the deep groundwater at WKMB04 suggests the groundwater in the uppermost part of the Jilleon Formation at this location is around 395,000 yrs BP.
- Methane isotope data are below the LOQ and cannot be interpreted with a degree of confidence at WKMB01 and WKMB02; however values suggest a thermogenic origin. Methane isotope data indicates that methane is of early mature thermogenic origin at WKMB03 and WKMB04.

8. Recommendations

The following recommendations are made regarding these additional monitoring bores to the regional monitoring network and ongoing Gloucester Gas Project groundwater monitoring program:

- Continue electronic and manual groundwater level monitoring in 2014/15 to monitor and further understand the different groundwater systems and the hydrogeological environment over different seasonal conditions.
- Include the Waukivory groundwater monitoring bores (WKMB01, WKMB02 and WKMB03) in the groundwater monitoring plan for the Waukivory Pilot test due to commence in late-2014 (pending approvals).
- Install real-time telemetry recording groundwater level fluctuations to assist timely data collection and interrogation of groundwater levels during the proposed Waukivory Pilot flow test.
- Include the results from the groundwater level and groundwater quality monitoring into the next Gloucester Gas Project annual monitoring report (scheduled for September 2014).

9. Statement of limitations

9.1 Scope of services

This report has been prepared in accordance with the scope of services set out in the contract, or as otherwise agreed, between the client (AGL) and Parsons Brinckerhoff (scope of services). In some circumstances the scope of services may have been limited by a range of factors such as time, budget, access and/or site disturbance constraints.

9.2 Reliance on data

In preparing the report, Parsons Brinckerhoff has relied upon data, surveys, plans and other information provided by the client and other individuals and organisations, most of which are referred to in the report (the data). Except as otherwise stated in the report, Parsons Brinckerhoff has not verified the accuracy or completeness of the data. To the extent that the statements, opinions, facts, information, conclusions and/or recommendations in the report (conclusions) are based in whole or part on the data, those conclusions are contingent upon the accuracy and completeness of the data. Parsons Brinckerhoff will not be liable in relation to incorrect conclusions should any data, information or condition be incorrect or have been concealed, withheld, misrepresented or otherwise not fully disclosed to Parsons Brinckerhoff.

9.3 Environmental conclusions

In accordance with the scope of services, Parsons Brinckerhoff has relied upon the data and has conducted environmental field monitoring and/or testing in the preparation of the report. The nature and extent of monitoring and/or testing conducted is described in the report.

On all sites, varying degrees of non-uniformity of the vertical and horizontal soil or groundwater conditions are encountered. Hence no monitoring, common testing or sampling technique can eliminate the possibility that monitoring or testing results/samples are not totally representative of soil and/or groundwater conditions encountered. The conclusions are based upon the data and the environmental field monitoring and/or testing and are therefore merely indicative of the environmental condition of the site at the time of preparing the report, including the presence or otherwise of contaminants or emissions.

Within the limitations imposed by the scope of services, the monitoring, testing, sampling and preparation of this report have been undertaken and performed in a professional manner, in accordance with generally accepted practices and using a degree of skill and care ordinarily exercised by reputable environmental consultants under similar circumstances. No other warranty, expressed or implied, is made.

9.4 Report for benefit of client

The report has been prepared for the benefit of the client (and no other party). Parsons Brinckerhoff assumes no responsibility and will not be liable to any other person or organisation for or in relation to any matter dealt with or conclusions expressed in the report, or for any loss or damage suffered by any other person or organisation arising from matters dealt with or conclusions expressed in the report (including without limitation matters arising from any negligent act or omission of Parsons Brinckerhoff or for any loss or damage suffered by any other party relying upon the matters dealt with or conclusions expressed in the report). Parties other than the client should not rely upon the report or the accuracy or completeness of any conclusions and should make their own enquiries and obtain independent advice in relation to such matters.

9.5 Other limitations

Parsons Brinckerhoff will not be liable to update or revise the report to take into account any events or emergent circumstances or facts occurring or becoming apparent after the date of the report.

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Appendix A

Borehole logs

BORE COMPLETION REPORT - WKMB01

Project: AGL Gloucester Gas Project
Location: Waukivory
Easting: 402589.87 **Northing:** 6452584.93
TOC elevation: 101.2 mAHD (PVC casing)
Grid system: MGA 94 Zone 56 **Stick-up height:** 0.54 m

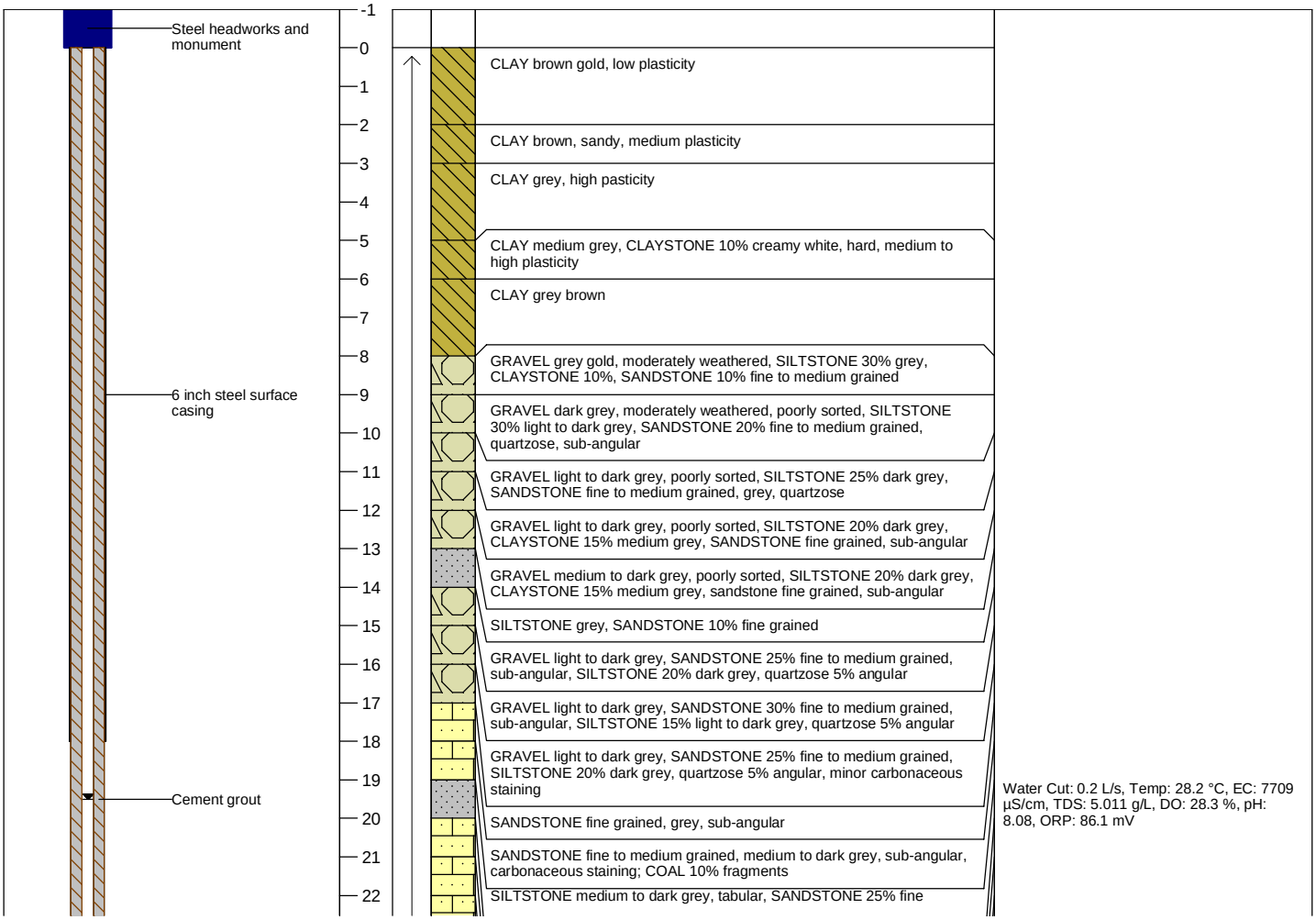
Drilling contractor: Highland Drilling
Driller: I. Palk **Rig:** Rig 10
Drilling method: Rotary Hammer

Borehole:	203	mm	0	- 18	m	**Bit:**	Blade
Borehole:	127	mm	18	- 54	m	**Bit:**	DHH

Purpose of bore: Groundwater monitoring bore
Screened Fmn: Leloma Formation
Logged by: N. Pearse-Hawkins
Start date: 30/01/2012 **Compl. date:** 31/01/2012
Total drilled depth: 54.0 m

Static WL: 82.2 mAHD 19.5 mBTOC
WL date: 31/1/12

Plain casing: 0-47.0 m: Class 50mm 18 PVC
Screen: 47.0-53.0m: 50mm PVC Class 18 (0.5mm slot)
Sump: 53.0-54.0m: 50mm PVC Class 18
Cement grout: 0-39.0m: 0.5m3
Gravel backfill: NA
Bentonite seal: 39.0-43.0 m
Gravel pack: 43.0-54.0m: 5mm washed gravel
Bentonite plug: NA



PARSONS BRINCKERHOFF

Drawing No.:	WKMB01 - Bore Construction		
Revision:	A	Date Drawn:	26/2/14
Drawn By:	K. Maher	Checked By:	J. Duggleby
Project No.	2162406C		

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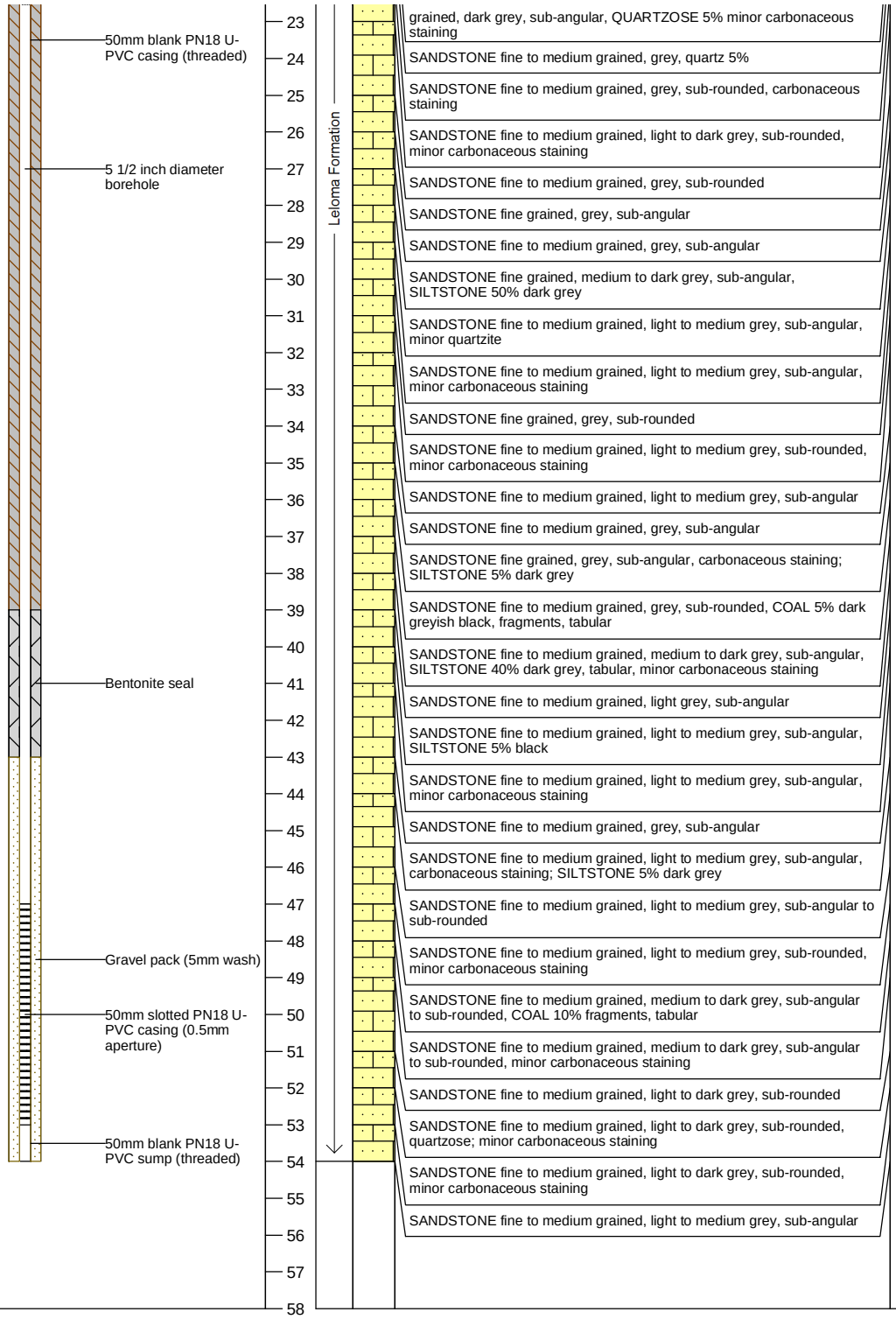
AGL Upstream Investments Pty Ltd
WKMB01

Waukivory Groundwater Monitoring Program

BORE COMPLETION REPORT - WKMB01



PARSONS BRINCKERHOFF

Drawing No.: WKMB01 - Bore Construction	
Revision: A	Date Drawn: 26/2/14
Drawn By: K. Maher	Checked By: J. Duggleby
Project No. 2162406C	

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WKMB01

Waukivory Groundwater Monitoring Program

BORE COMPLETION REPORT - WKMB02

Project: AGL Gloucester Gas Project
Location: Waukivory
Easting: 402575.54 **Northing:** 6452575.49
TOC elevation: 104.1 mAHD (PVC casing)
Grid system: MGA 94 Zone 56 **Stick-up height:** 0.59 m

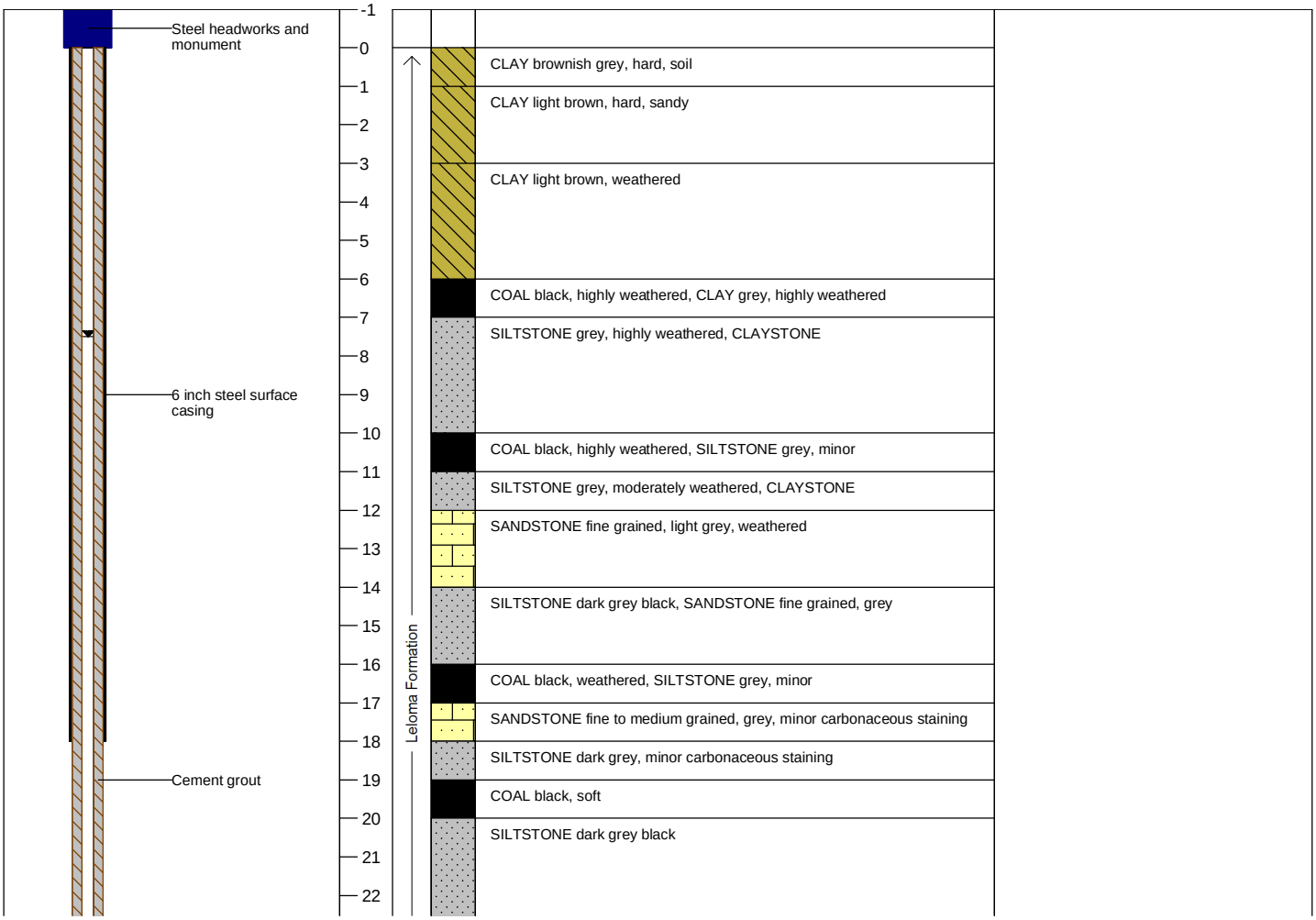
Drilling contractor: Highland Drilling
Driller: I. Palk **Rig:** Rig 10
Drilling method: Rotary Hammer

Borehole:	203	mm	0	- 18	m	**Bit:** Blade
Borehole:	140	mm	18	- 127	m	**Bit:** DHH

Purpose of bore: Groundwater monitoring bore
Screened Fmn: Leloma Formation
Logged by: N. Pearse-Hawkins
Start date: 8/05/2012 **Compl. date:** 18/05/2012
Total drilled depth: 127 m

Static WL: 96.60 mAHD 7.49 mBTOC
WL date: 4/06/2012

Plain casing: 0-51.0m: Class 50mm 18 PVC
Screen: 51.0-60.0m: 50mm PVC Class 18 (0.5mm slot)
Sump: 60.0-61.0m: 50mm PVC Class 18
Cement grout: 0-38.0 to: 0.5m3
Gravel backfill: 77.0-127.0m: 5-8mm washed blue metal gravel
Bentonite seal: 38.0-44.5m
Gravel pack: 44.5-61.0m: 5mm washed gravel
Bentonite plug: 72.0-77.0m



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Drawing No.:	WKMB02 - Bore construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	KJ. Duggleby
Project No.	2162406C		

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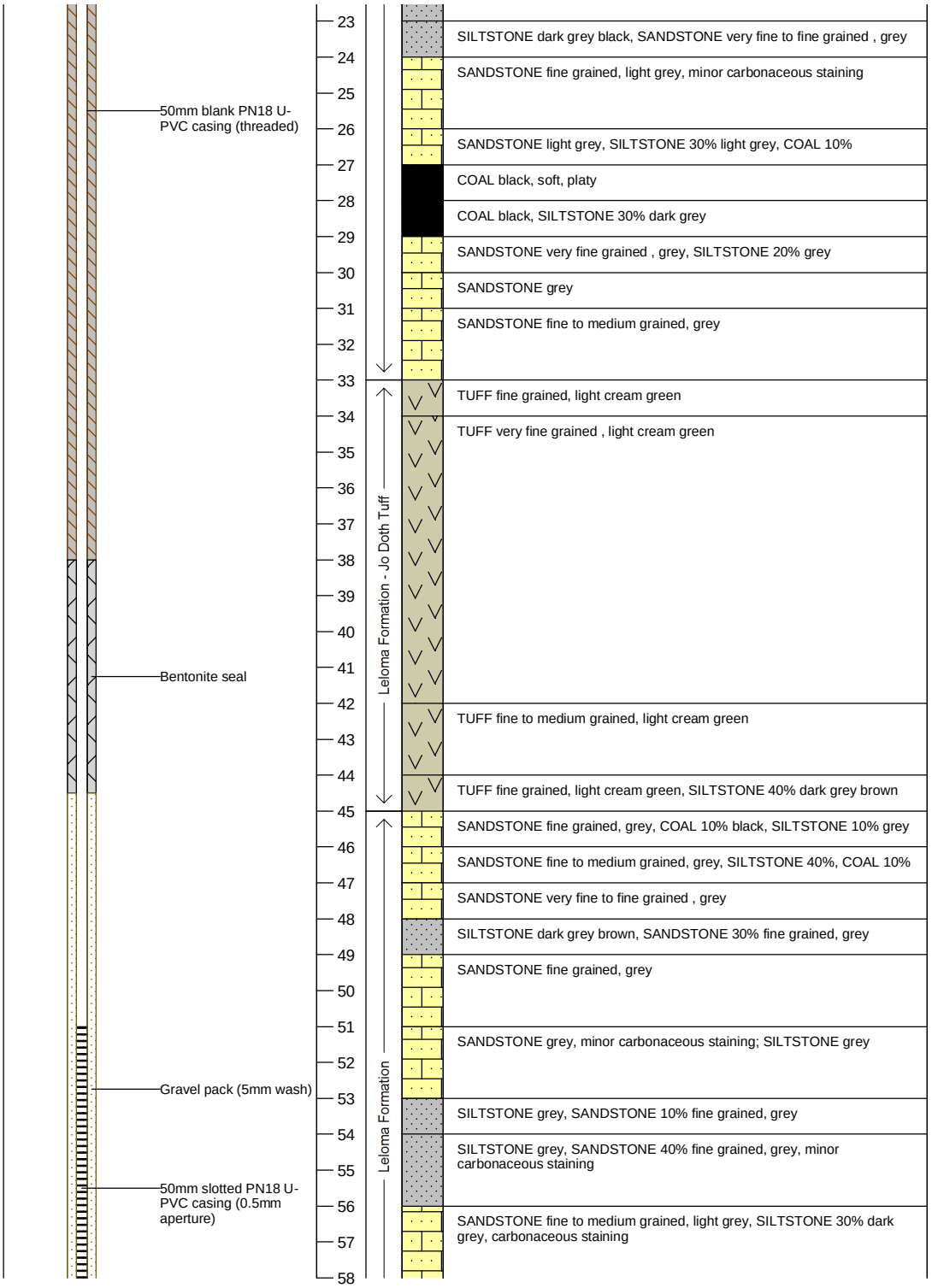
WKMB02

Waukivory Groundwater Monitoring Program

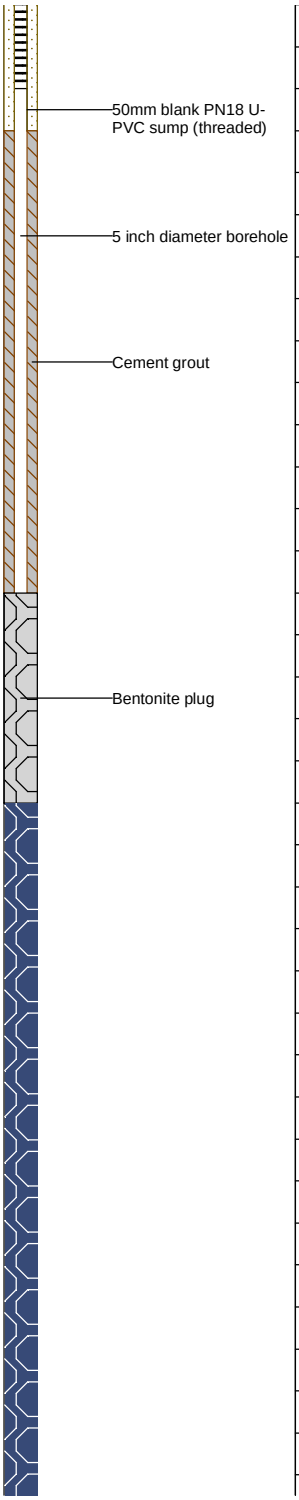
BORE COMPLETION REPORT - WKMB02



PARSONS BRINCKERHOFF	Drawing No.: WKMB02 - Bore construction		AGL Upstream Investments Pty Ltd WKMB02 Waukivory Groundwater Monitoring Program
	Revision: A	Date Drawn: 26/2/2014	
	Drawn By: K. Maher	Checked By: KJ. Duggleby	
	Project No. 2162406C		

BORE COMPLETION REPORT - WKMB02

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY



58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93

SANDSTONE fine grained, light grey, SILTSTONE 20% grey

SANDSTONE fine to medium grained, light grey, SILTSTONE 10% grey

Water Cut: 0.1 L/s, Temp: 19.74 °C, EC: 3501 µS/cm, TDS: 2.277 g/L, DO: 58.1 %, pH: 12.28, ORP: -29.9 mV

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Drawing No.:	WKMB02 - Bore construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	KJ. Duggleby
Project No.	2162406C		

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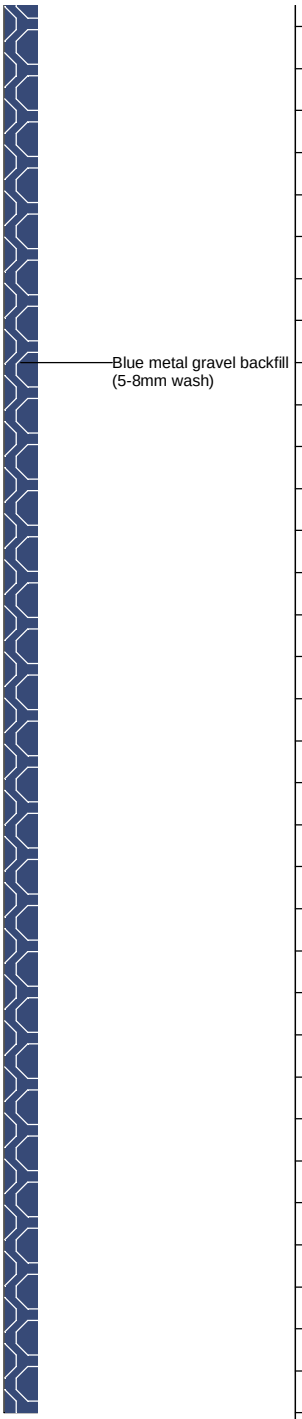
WKMB02

Waukivory Groundwater Monitoring Program

BORE COMPLETION REPORT - WKMB02

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY



94 95 96 97 98 99 100 101 102 103 104 105 106 107 108 109 110 111 112 113 114 115 116 117 118 119 120 121 122 123 124 125 126 127 128

PARSONS BRINCKERHOFF

Drawing No.:	WKMB02 - Bore construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	KJ. Duggleby
Project No.	2162406C		

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WKMB02

Waukivory Groundwater Monitoring Program

BORE COMPLETION REPORT - WKMB03

Project: AGL Gloucester Gas Project
Location: Waukivory
Easting: 402589.87 **Northing:** 6452584.93
TOC elevation: 86.6 m AHD (Gal casing)
Grid system: MGA 94 Zone 56 **Stick-up height:** 0.59 m

Drilling contractor: Highland Drilling
Driller: I. Palk **Rig:** Rig 10
Drilling method: Rotary Hammer

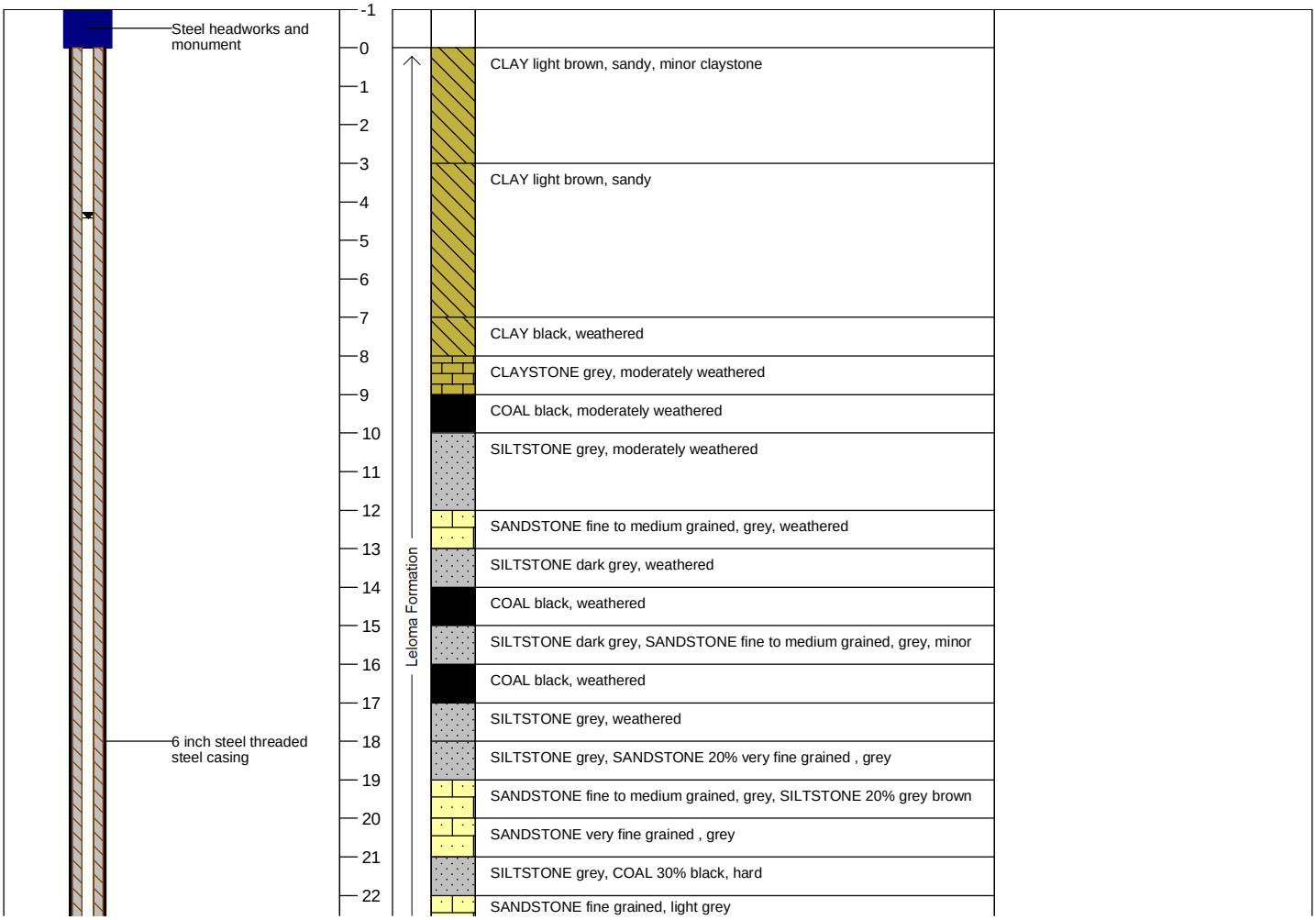
Borehole:	203	mm	0	- 36	m	**Bit:** Blade
Borehole:	140	mm	36	- 210.0	m	**Bit:** DHH

Purpose of bore: Groundwater monitoring bore
Screened Fmn: Leloma Formation
Logged by: N. Pearse-Hawkins
Start date: 23/05/2012 **Compl. date:** 30/05/2012
Total drilled depth: 210.0 m

Static WL: 98.39 mAHD 4.42 mBTOC
WL date: 13/08/2012

Plain casing: 0-200.0m: 50NB MED Gal pipe
Screen: 200.0-209.0m: 50mm 304SS (1mm slot)
Sump: 209.0-210.0m: 50NB MED Gal pipe sump
Cement grout: 0-114.0m to: 1.4m3
Gravel backfill: 115.0-189.0 m: 5-8mm washed blue metal gravel
Bentonite seal: 189.0-194.0m
Gravel pack: 194.0-210.0m: 5mm washed gravel
Bentonite plug: NA

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY



PARSONS BRINCKERHOFF

Drawing No.:	WKMB03 - Bore Construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	J. Duggleby
Project No.	2162406C		

AGL

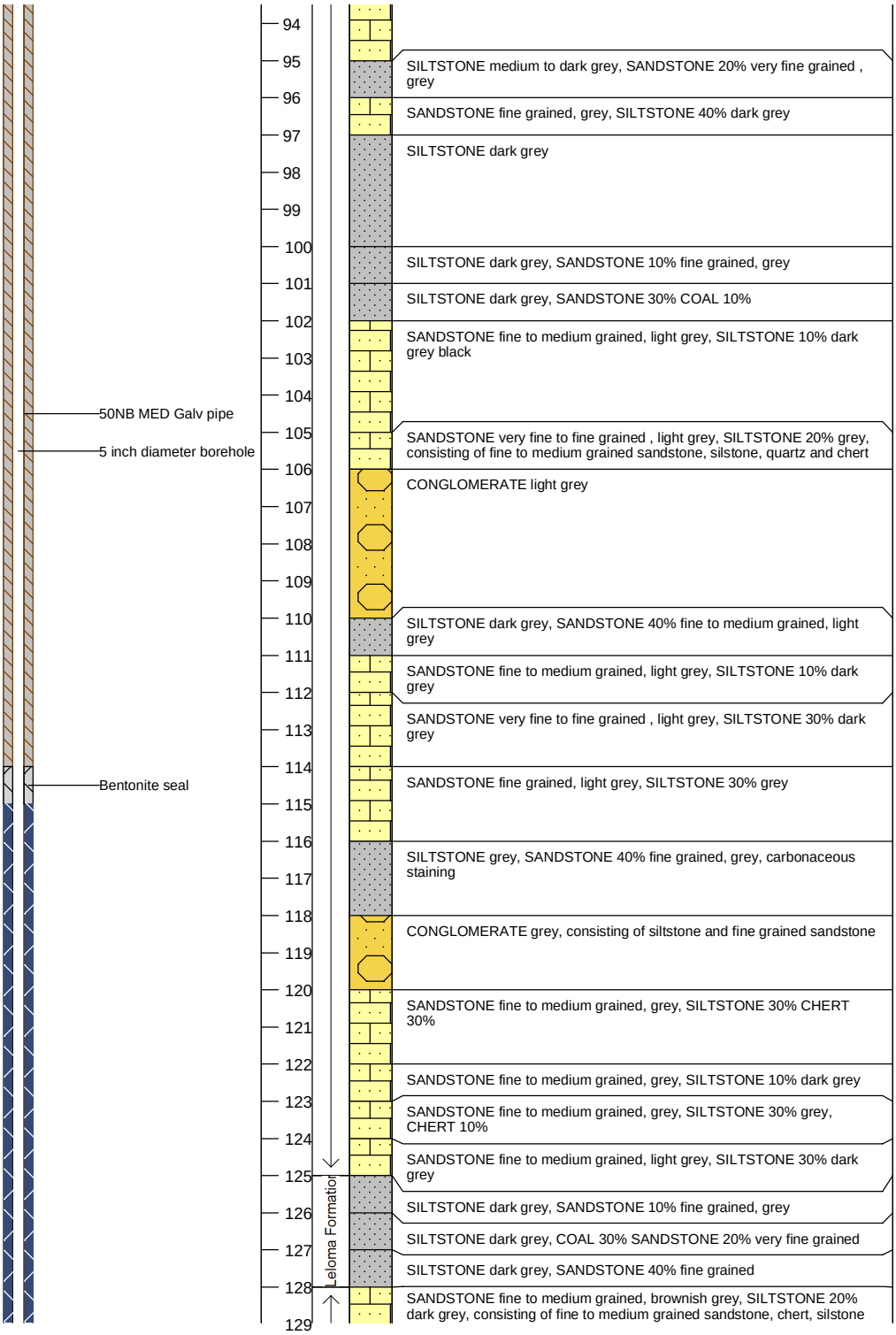
AGL Upstream Investments Pty Ltd
WKMB03

Waukivory Groundwater Monitoring Program

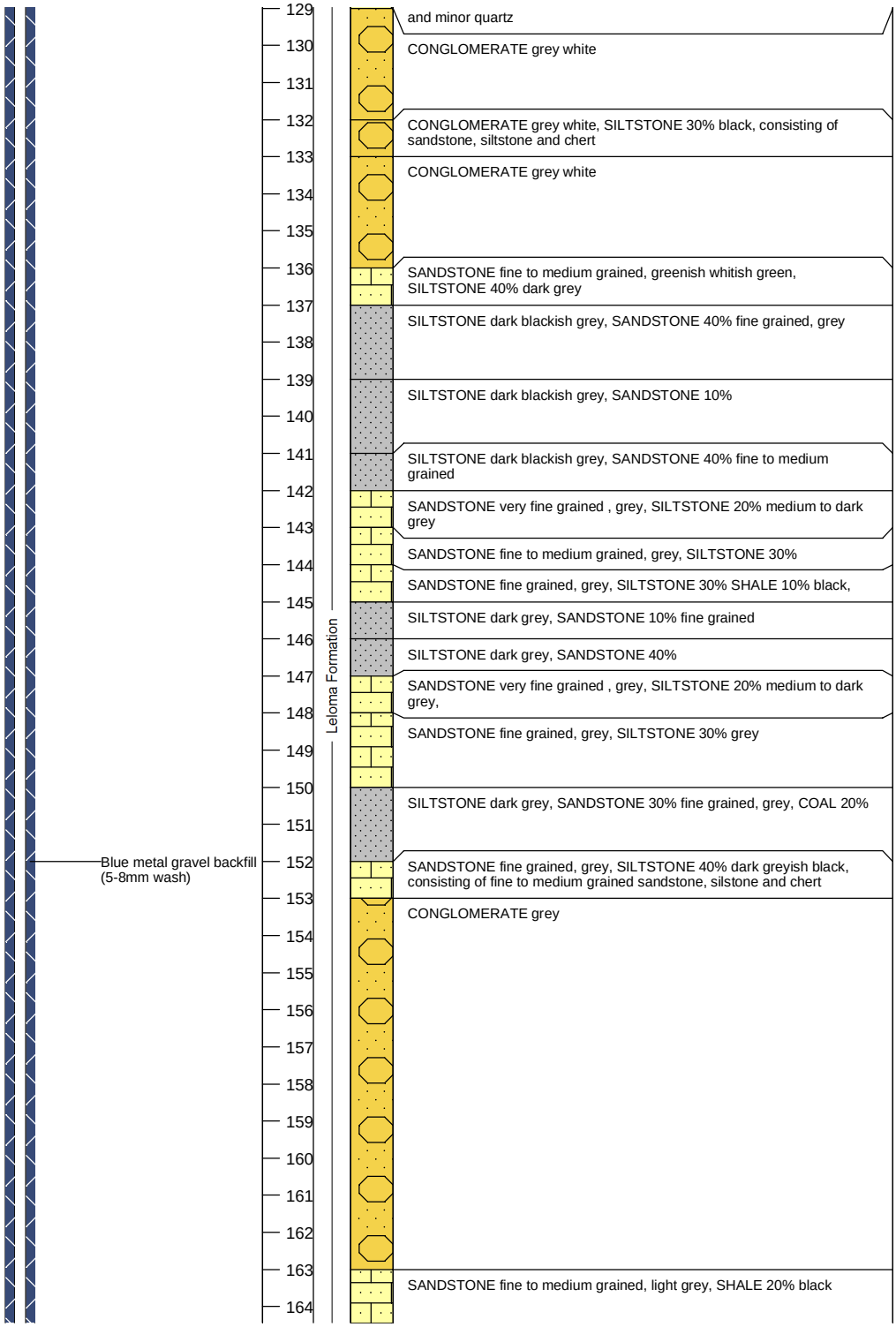
BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
	23			SILTSTONE grey, COAL 30% black	
	24			SANDSTONE fine grained, grey, SILTSTONE 30% grey	
	25			SANDSTONE grey	
	26				
	27			SHALE black, platy	
	28			SANDSTONE fine to medium grained, grey	
	29	Leloma Formation - Jo Doth Tuff		TUFF fine grained, light grey	
	30				
	31			TUFF light green cream	
	32				
	33				
	34				
	35				
	36			TUFF fine to medium grained, light green	Water Cut: 0.2 L/s, Temp: 22.32 °C, EC: 712 µS/cm, TDS: 0.463 g/L, DO: 4.25 %, pH: 7.14, ORP: 49.8 mV
	37				
	38			TUFF light green grey	
	39				
	40			TUFF light grey, COAL 40% SILTSTONE 10%	
	41			SANDSTONE fine grained, grey, carbonaceous staining, SILTSTONE 20% grey, COAL 10%	
	42			SILTSTONE dark grey, SANDSTONE 20% fine grained, grey, COAL 10%	
	43			SANDSTONE fine grained, grey	
	44			SILTSTONE dark grey	
	45			SANDSTONE fine grained, grey, carbonaceous staining	
	46			SANDSTONE very fine grained , grey	
	47				
	48			SANDSTONE fine to medium grained, grey, carbonaceous staining	
	49			SILTSTONE grey, SANDSTONE 20% fine grained, grey	
	50			SANDSTONE fine grained, grey, SILTSTONE 40% grey	
	51			SILTSTONE dark grey brown,	
	52			SILTSTONE dark grey brown, SANDSTONE 30% fine to medium grained, grey	
	53			SILTSTONE dark grey brown, COAL 10%, SANDSTONE fine to medium grained, light grey	
	54			SANDSTONE fine to medium grained, grey, SILTSTONE 10% grey	
	55				
	56				
Cement grout	57			SANDSTONE light grey	
	58				

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
	58	Leloma Formation		SILTSTONE dark grey, carbonaceous staining, SANDSTONE 20% fine to medium grained, light grey	
	59			SANDSTONE fine to medium grained, grey	
	60			SANDSTONE fine to medium grained, light grey, SILTSTONE 5% grey	
	61			SANDSTONE fine grained, grey, minor carbonaceous staining	
	62			SANDSTONE fine to medium grained, grey, SILTSTONE 10% grey, carbonaceous staining	
	63			SILTSTONE dark grey, SANDSTONE 20% fine to medium grained, light grey	
	64			SILTSTONE dark grey, COAL 10% SANDSTONE 10% fine grained	
	65			SANDSTONE very fine grained , grey, SILTSTONE 40% grey	
	66			SILTSTONE dark grey, SANDSTONE 20% fine to medium grained, light grey	
	67			SANDSTONE very fine grained , grey, COAL 10% black	
	68			SANDSTONE grey, SILTSTONE 10% grey	
	69				
	70			SANDSTONE grey, SILTSTONE 40% grey, COAL 10%	
	71			SANDSTONE fine grained, grey, SILTSTONE 40% grey	
	72				
	73			SANDSTONE very fine grained , grey, SILTSTONE 30%	
	74			SILTSTONE dark grey, SANDSTONE 20% fine grained, grey	
	75			SANDSTONE fine grained, grey, SILTSTONE 40% grey	
	76			SILTSTONE dark grey, SANDSTONE 20% very fine grained , grey	
	77			SANDSTONE very fine to fine grained , grey, SILTSTONE 20% grey, carbonaceous staining	
	78				
	79			SILTSTONE dark grey, SANDSTONE 30% very fine grained , grey	
	80			SANDSTONE fine to medium grained, grey, carbonaceous staining	
	81			SANDSTONE grey, COAL 40% SILTSTONE 10% grey	
	82			SANDSTONE fine grained, grey, SILTSTONE 40% dark grey	
	83			SANDSTONE fine to medium grained, grey	
	84			SANDSTONE light grey, SHALE 10% black	
	85				
	86				
	87			SILTSTONE dark grey, COAL 30% hard	
	88			SANDSTONE very fine grained , grey, SILTSTONE 20% dark grey	
	89				
	90			SANDSTONE fine to medium grained, light grey	
	91				
	92			SANDSTONE fine grained, grey, SILTSTONE 10% dark grey	
	93				

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY



BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY



BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
Bentonite seal	165	Leloma Formation - Deards Coal		SANDSTONE fine to medium grained, light grey, SILTSTONE 10% dark grey	
	166			SHALE black, platy, soft; SILTSTONE 30% dark grey, SANDSTONE 30% fine to medium grained, grey	
	167			SANDSTONE fine to medium grained, light brownish cream, COAL 30% SILTSTONE 30%	
	168			SANDSTONE fine to medium grained, light brownish cream, SILTSTONE 30% SHALE 20%	
	169			SANDSTONE very fine grained , light brownish cream, SHALE 40% black	
	170			SANDSTONE fine grained, light brownish cream, SILTSTONE 30% SHALE 10%	
	171			SANDSTONE fine to medium grained, light brownish cream, SILTSTONE 20% COAL 10%	
	172			SANDSTONE very fine to fine grained , light brownish cream, SILTSTONE 30% dark grey, SHALE 10%	
	173			SILTSTONE dark grey, SANDSTONE 30% very fine grained	
	174			SILTSTONE dark grey, COAL 30% SANDSTONE 20% fine grained, grey,	
	175			SANDSTONE very fine grained , grey, COAL 20% SILTSTONE 20% dark grey	
	176			SANDSTONE fine grained, grey, SILTSTONE 20% grey, COAL 10%	
	177			SANDSTONE fine to medium grained, grey, SILTSTONE 10%	
	178			SILTSTONE dark grey, SANDSTONE 40% fine grained, grey, COAL 10%	
	179			SILTSTONE dark grey, SANDSTONE 30%	
	180			SILTSTONE dark grey, SANDSTONE 40% COAL 10%	
	181			SANDSTONE fine to medium grained, light grey, SILTSTONE 40% dark grey, carbonaceous staining	
	182			SANDSTONE fine grained, light grey, SILTSTONE 30% COAL 10%	
	183			SANDSTONE light grey, COAL 40% SILTSTONE 10% grey	
	184			SANDSTONE very fine grained , light grey, SILTSTONE 40% COAL 10%	
	185			SANDSTONE fine to medium grained, light grey, SILTSTONE 20% COAL 20%	
	186			SANDSTONE fine to medium grained, light grey, SILTSTONE 20% COAL 10%	
	187			SANDSTONE very fine to fine grained , light grey, SILTSTONE 10% grey	
	188			SILTSTONE grey, SANDSTONE 40% fine to medium grained, light grey, COAL 10%	
	189			SANDSTONE fine grained, grey, COAL 30%, SILTSTONE 20% dark grey	
	190			SANDSTONE grey, SILTSTONE 40%, COAL 10%	
	191			SILTSTONE dark grey, SANDSTONE 20% fine grained, grey, COAL 10%	
	192			SILTSTONE dark grey, COAL 30%, SANDSTONE 30%	
	193			SANDSTONE very fine to fine grained , grey, SILTSTONE 30% COAL 10%	
	194			SILTSTONE dark grey black, SANDSTONE 40% fine grained, grey, COAL 10%	
	195			SANDSTONE fine grained, grey, SILTSTONE 40% dark grey	
	196				
	197				
	198				
	199				
	200				

PARSONS BRINCKERHOFF

Drawing No.: WKMB03 - Bore Construction	
Revision: A	Date Drawn: 26/2/2014
Drawn By: K. Maher	Checked By: J. Duggleby
Project No. 2162406C	

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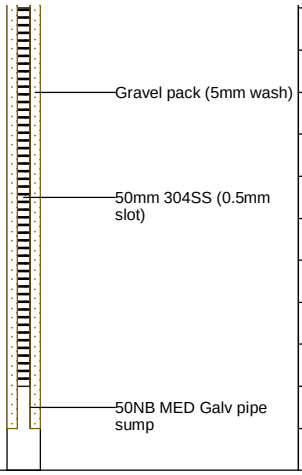
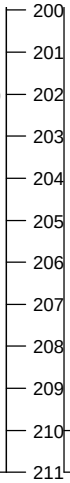
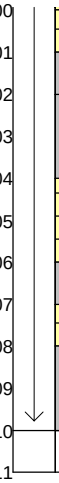
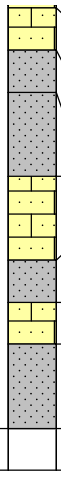
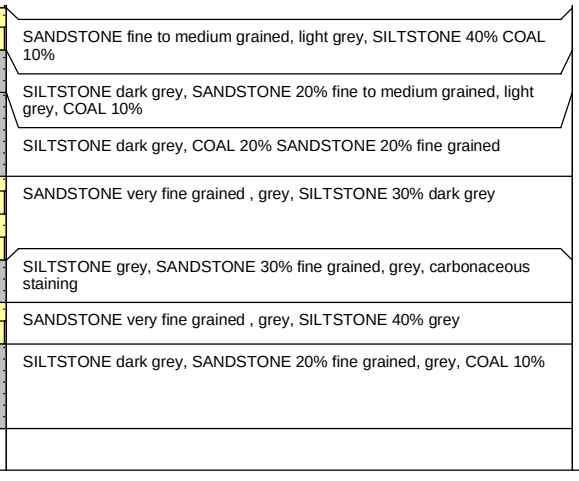
AGL Upstream Investments Pty Ltd
WKMB03

Waukivory Groundwater Monitoring Program

BORE COMPLETION REPORT - WKMB03

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
					

PARSONS BRINCKERHOFF

Drawing No.:	WKMB03 - Bore Construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	J. Duggleby
Project No.	2162406C		

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AGL Upstream Investments Pty Ltd

WKMB03

Waukivory Groundwater Monitoring Program

BORE COMPLETION REPORT - WKMB04

Project: AGL Gloucester Gas Project
Location: Waukivory
Easting: 402133.7 **Northing:** 6452567.5
TOC elevation: NA
Grid system: MGA 94 Zone 56 **Stick-up height:** NA

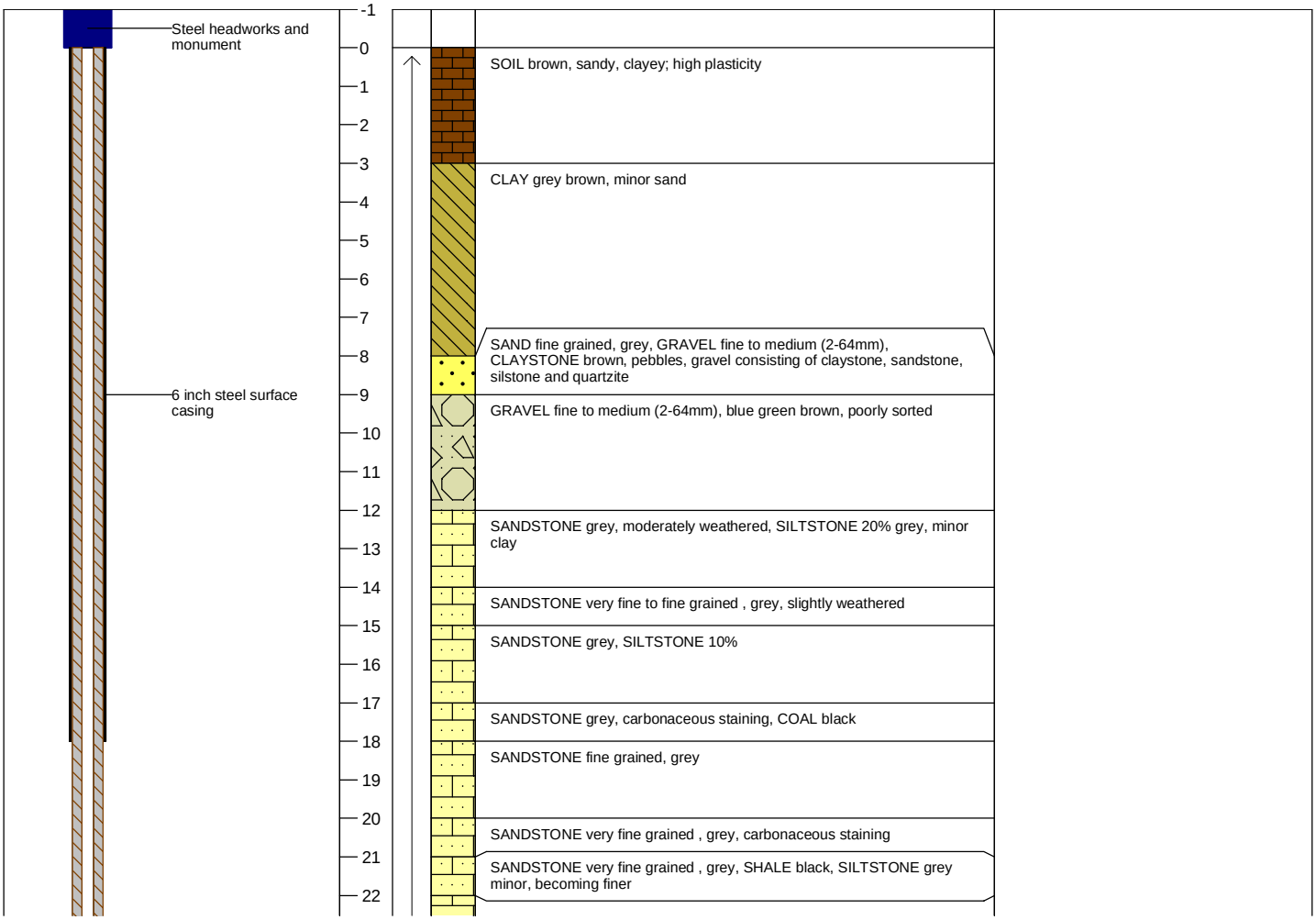
Drilling contractor: Highland Drilling
Driller: I. Palk **Rig:** Rig 10
Drilling method: Rotary Hammer

Borehole:	203	mm	0	- 1	m	**Bit:**	Blade
Borehole:	140	mm	18	- 360.0	m	**Bit:**	DHH

Purpose of bore: Groundwater monitoring bore
Screened Fmn: Jilleon Formation
Logged by: N. Pearse-Hawkins
Start date: 12/01/2012 **Compl. date:** 23/01/2012
Total drilled depth: 360.0 m

Static WL: NA mAHD NA mBTOC
WL date: NA

Plain casing: 0-335.0m: 50NB MED Gal pipe
Screen: 335.0-347.0m: 50mm 304SS (1mm slot)
Sump: 347.0-360m: 50NB MED Gal pipe sump
Cement grout: 0-318.0m: 4.0m3
Gravel backfill: NA
Bentonite seal: 318.0-323.0m
Gravel pack: 323.0-360.0m: 5mm washed gravel
Bentonite plug: NA



PARSONS BRINCKERHOFF

Drawing No.:	WKMB04 - Bore Construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	J. Duggleby
Project No.	2162406C		

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AGL Upstream Investments Pty Ltd
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
	23			SANDSTONE fine grained, grey	
	24				
	25			SANDSTONE very fine grained , grey, SILTSTONE grey, carbonaceous staining	
	26				
	27				
	28				
	29				
	30				
	31			SANDSTONE fine grained, grey	
	32			SANDSTONE fine to medium grained, grey	
	33				
	34				
	35			SANDSTONE very fine grained , grey, SILTSTONE grey, carbonaceous staining	
	36				
	37			SILTSTONE grey, carbonaceous staining, SANDSTONE 50% very coarse grained , grey	
	38			SANDSTONE fine to medium grained, grey, SILTSTONE 30% dark grey	
	39			SILTSTONE dark grey, SHALE 30% dark grey, SANDSTONE 20% fine grained, grey	
	40			SANDSTONE very fine grained , grey, SHALE black, minor	
	41				
	42				
	43				
	44			SANDSTONE fine grained, grey, carbonaceous staining	
	45			SANDSTONE fine grained, grey, SILTSTONE 20% dark grey	
	46				
	47			SANDSTONE very fine grained , grey	
	48				Water Cut: 0.1 L/s
	49			SANDSTONE fine grained, grey, SILTSTONE 10% grey	
	50				
	51				
	52			SANDSTONE very fine grained , grey, SHALE black, minor	
	53			SANDSTONE fine grained, grey, SHALE 40% black, minor coal	
	54			SANDSTONE fine grained, grey	
	55			SHALE black, hard, SANDSTONE 50% fine grained, grey	
	56			SANDSTONE fine grained, grey, SILTSTONE 10% grey	
	57	Lelorna Formation		SANDSTONE very fine grained , grey, SHALE black, minor	
	58				

PARSONS BRINCKERHOFF

Drawing No.:	WKMB04 - Bore Construction		
Revision:	A	Date Drawn:	26/2/2014
Drawn By:	K. Maher	Checked By:	J. Duggleby
Project No.	2162406C		

AGL

AGL Upstream Investments Pty Ltd
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE COMPLETION REPORT - WKMB04

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
	58	Leichhardt Formation		SANDSTONE very fine grained , grey	
	59			SANDSTONE fine grained, grey, SHALE 40% black	
	60			SANDSTONE very fine grained , grey, SHALE black, minor	Water Cut: 0.1 L/s
	61			SANDSTONE fine grained, grey, SHALE 20% dark grey	
	62				
	63				
	64			SANDSTONE grey, SILTSTONE minor carbonaceous staining	
	65				
	66				
	67			SILTSTONE dark grey, SANDSTONE 50% very fine grained , grey	
	68				
	69			SANDSTONE very fine to fine grained , grey, SILTSTONE 30% grey	
	70			SANDSTONE grey, SILTSTONE 10% carbonaceous staining, minor green white and grey chert	
	71				
	72			SANDSTONE grey	Water Cut: 0.2 L/s
	73			SILTSTONE dark grey, SANDSTONE 50% fine grained, grey	
	74				
	75			SANDSTONE very fine grained , dark grey, SHALE 20% black	
	76				
	77				
	78				
	79				
	80			SHALE black, light to medium, SILTSTONE 35% dark grey, carbonaceous staining, SANDSTONE 30% fine grained, grey	
	81			SILTSTONE dark grey, SANDSTONE 40% fine grained, grey, SHALE 20% black	
	82			SANDSTONE very fine grained , grey, SILTSTONE 30% dark grey, SHALE 10%	
	83				
	84			SILTSTONE dark grey, SHALE 10% black, SANDSTONE 10% fine grained, grey	
	85			SILTSTONE dark grey, SANDSTONE 40%	
	86			SANDSTONE fine grained, grey, SILTSTONE 30% grey	
	87				
	88			SANDSTONE fine grained, grey, SHALE 50% grey	
	89			SANDSTONE grey	
	90				
	91			SANDSTONE grey, carbonaceous staining, SILTSTONE 20%	
	92				
	93			SANDSTONE grey, SILTSTONE 50% grey	

PARSONS BRINCKERHOFF

Drawing No.:	WKMB04 - Bore Construction		
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Drawn By:	K. Maher	Checked By:	J. Duggleby
Project No.	2162406C		

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AGL Upstream Investments Pty Ltd

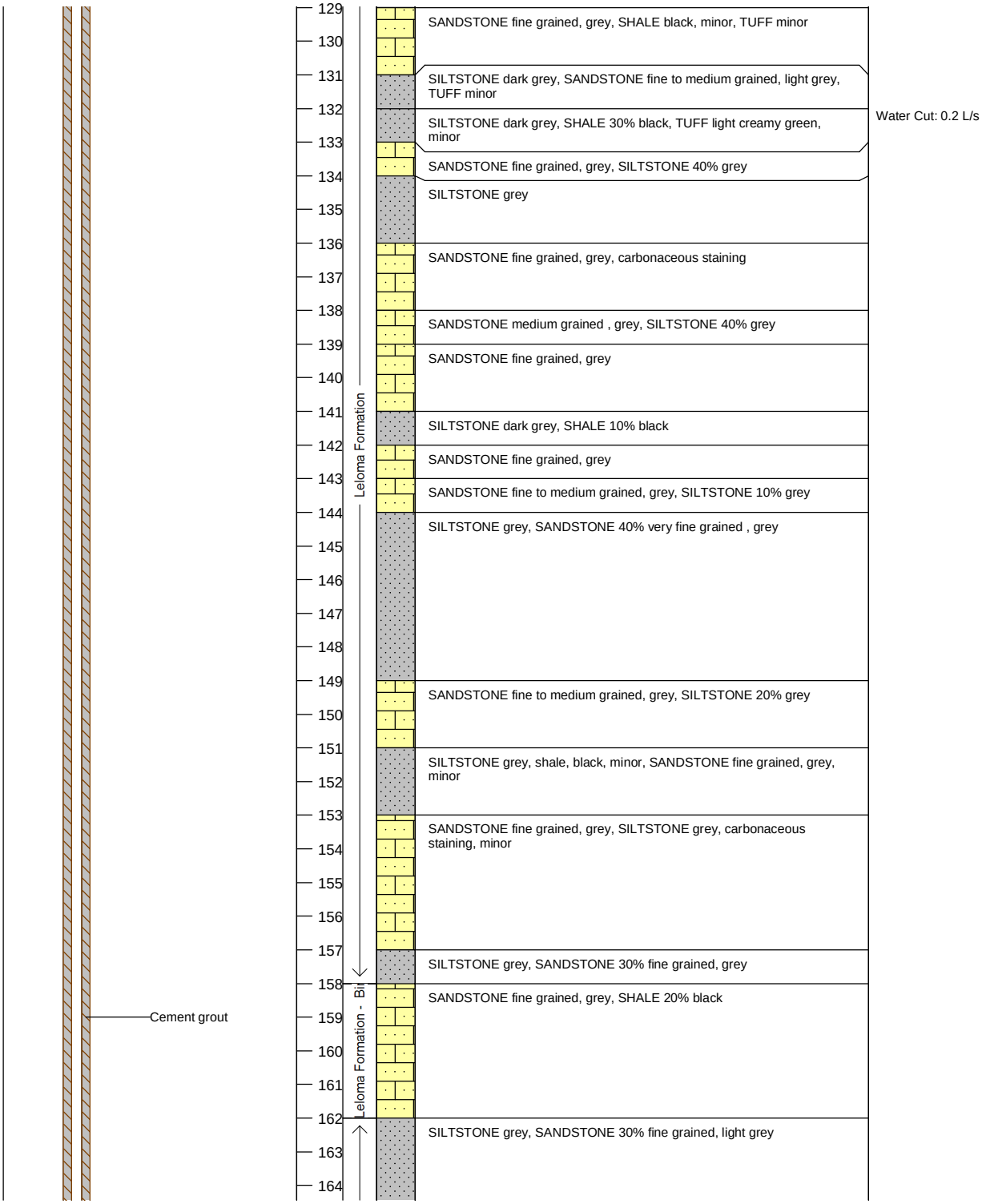
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
	94				
	95			SILTSTONE dark blackish grey	
	96			SANDSTONE fine grained, grey, SHALE 30% black, SILTSTONE 10% grey	
	97			SILTSTONE dark blackish grey	
	98			SANDSTONE very fine grained , grey, SHALE 10% black	
	99				
	100			SILTSTONE dark grey	
	101			SANDSTONE fine grained, grey, carbonaceous staining	
	102			SANDSTONE grey, SILTSTONE 40% dark grey	
	103			SILTSTONE dark blackish grey, SHALE 30% black, COAL minor	
	104			SANDSTONE very fine grained , grey, SILTSTONE 30% grey	
	105			SANDSTONE fine to medium grained, grey	
	106			SANDSTONE fine grained, grey, SILTSTONE 50% SHALE minor	
	107			SANDSTONE fine to medium grained, grey	
	108				
	109				
	110			SANDSTONE grey, carbonaceous staining, SILTSTONE 15% black, SHALE 15% black	
	111			SILTSTONE dark grey, SHALE 40% black	
	112			SILTSTONE dark grey, SANDSTONE very fine grained , grey, minor	
	113			SANDSTONE fine grained, grey, SILTSTONE 20% grey	
	114			SILTSTONE grey, SANDSTONE 30% fine grained, grey	
	115				
	116	Leloma Formation - Jo Doth Tuff		TUFF light creamy green, SILTSTONE 30% grey	
	117			TUFF light creamy green, SHALE black, minor	
	118				
	119				
	120			TUFF light creamy green, SHALE 30% black	
	121			TUFF light creamy green	
	122				
	123				
	124				
	125			TUFF creamy green	
	126			SANDSTONE very fine grained , grey, TUFF 10%, SHALE 10% black	
	127			SILTSTONE grey, SHALE black, minor	
	128				
	129				

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.



PARSONS BRINCKERHOFF	Drawing No.: WKMB04 - Bore Construction		AGL Upstream Investments Pty Ltd WKMB04 Waukivory Groundwater Monitoring Program
	Revision: A	Date Drawn: 26/2/2014	
	Drawn By: K. Maher	Checked By: J. Duggleby	
	Project No. 2162406C		

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
50NB MED Galv pipe 5 inch diameter borehole	165 166 167 168 169 170 171 172 173 174 175 176 177 178 179 180 181 182 183 184 185 186 187 188 189 190 191 192 193 194 195 196 197 198 199 200	Leloma Formation		SANDSTONE very fine grained , grey, SILTSTONE 20% grey SILTSTONE dark grey, SANDSTONE 20% fine grained, greyish brown SANDSTONE fine grained, grey, SILTSTONE 10% grey SILTSTONE dark grey, SANDSTONE 20% fine grained, grey SANDSTONE fine grained, grey, SHALE 20% black SILTSTONE grey, SHALE 10% black, SANDSTONE 10% fine grained, grey SANDSTONE fine to medium grained, grey, SILTSTONE 20% grey SILTSTONE dark grey, SHALE 40% black, SANDSTONE 20% fine grained, grey SANDSTONE fine to medium grained, light grey SILTSTONE grey, SHALE 20% black, SANDSTONE 20% fine grained, grey SANDSTONE fine grained, grey, SILTSTONE 20% grey, SHALE black, minor SILTSTONE dark grey, SANDSTONE 40% very fine grained , grey SILTSTONE dark grey SILTSTONE dark grey, SHALE 20% black, SANDSTONE 10% fine grained, grey SANDSTONE fine grained, grey, SILTSTONE 10% dark grey SANDSTONE very fine grained , grey, SILTSTONE 30% grey, carbonaceous staining SANDSTONE fine to medium grained, grey, carbonaceous staining SANDSTONE fine to medium grained, grey, SILTSTONE 40% dark grey SILTSTONE grey, SANDSTONE very fine grained , grey, carbonaceous staining SANDSTONE medium grained , light grey, SHALE 30% black SANDSTONE light grey SANDSTONE fine to medium grained, light grey, SILTSTONE 20% grey SANDSTONE fine to medium grained, light grey, carbonaceous staining SILTSTONE grey, carbonaceous staining	Water Cut: 0.3 L/s, Temp: 19.75 °C, EC: 21410 µS/cm, TDS: 8.068 g/L, DO: 8.4 %, pH: 7.51, ORP: -163.6 mV

PARSONS BRINCKERHOFF

Drawing No.: WKMB04 - Bore Construction	
Revision: A	Date Drawn: 26/2/2014
Drawn By: K. Maher	Checked By: J. Duggleby
Project No. 2162406C	

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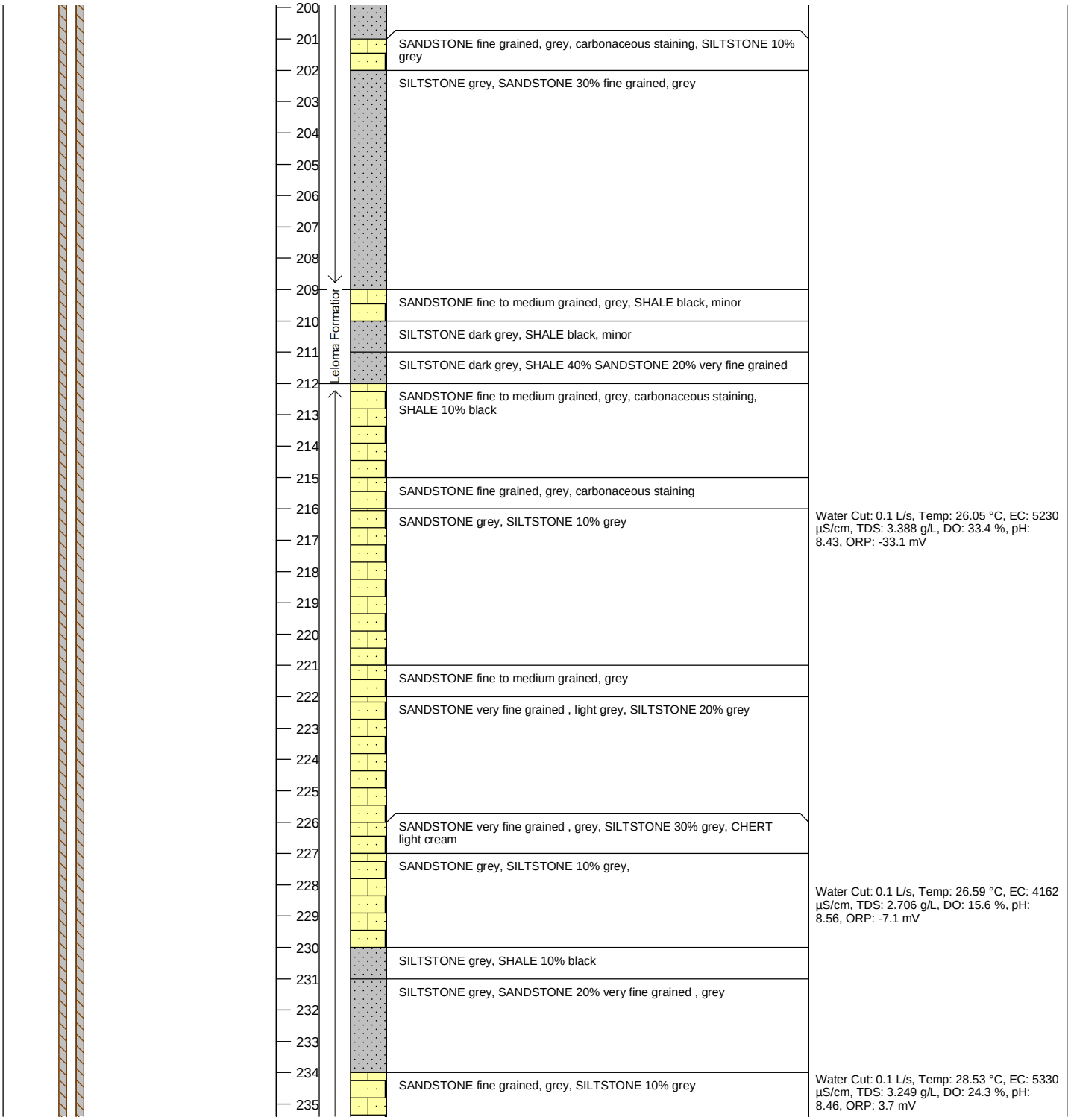
AGL Upstream Investments Pty Ltd
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.



PARSONS BRINCKERHOFF

Drawing No.: WKMB04 - Bore Construction	
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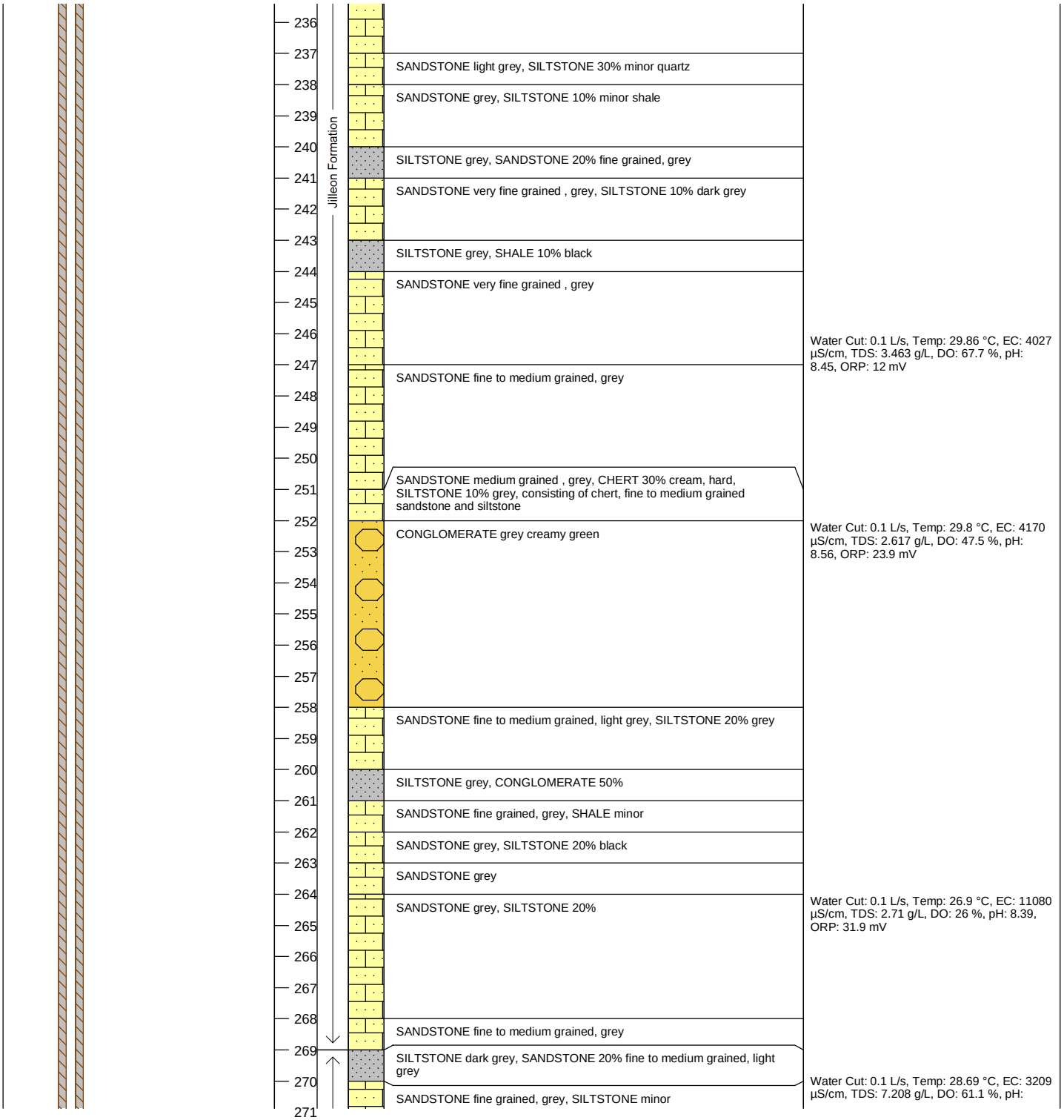
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.



PARSONS BRINCKERHOFF

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AGL Upstream Investments Pty Ltd
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE CONSTRUCTION	DEPTH (m)	STRATIGRAPHY	GRAPHIC LOG	LITHOLOGY	WATER QUALITY
	271	Jilleon Formation - Cloverdale Coal			8.19, ORP: 36.5 mV
	272				
	273			SANDSTONE grey, SILTSTONE 40% dark grey, COALY SHALE 30%	
	274				
	275			SILTSTONE grey, SANDSTONE 20% fine grained, light grey	
	276				Water Cut: 0.2 L/s, Temp: 28.88 °C, EC: 6703 µS/cm, TDS: 2.084 g/L, DO: 52.3 %, pH: 8.41, ORP: 33.8 mV
	277			SANDSTONE fine to medium grained, grey, SILTSTONE 20% grey	
	278				
	279				
	280			SILTSTONE dark grey, SANDSTONE 20% medium grained , light grey	
	281			SANDSTONE fine to medium grained, grey, SILTSTONE 40% dark grey	
	282			SILTSTONE dark grey	Water Cut: 0.1 L/s, Temp: 30.87 °C, EC: 11670 µS/cm, TDS: 4.36 g/L, DO: 54.8 %, pH: 8.27, ORP: 37.6 mV
	283			SILTSTONE dark grey, SANDSTONE 40% fine grained, light grey	
	284	Jilleon Formation		SANDSTONE medium grained , light grey	
	285				
	286				
	287			SANDSTONE light grey, SILTSTONE 20% grey	
	288				Water Cut: 0.1 L/s, Temp: 30.57 °C, EC: 11680 µS/cm, TDS: 7.589 g/L, DO: 57.3 %, pH: 8.29, ORP: 42.1 mV
	289			SANDSTONE light grey, SILTSTONE 40%	
	290				
	291			SANDSTONE fine grained, light grey	
	292				
	293			SANDSTONE fine grained, light grey, SILTSTONE 30% dark grey	
	294			SANDSTONE fine grained, light brownish grey, minor carbonaceous staining	Water Cut: 0.1 L/s, Temp: 30.29 °C, EC: 2688 µS/cm, TDS: 7.591 g/L, DO: 56.7 %, pH: 8.3, ORP: 41.2 mV
	295				
	296			SANDSTONE fine to medium grained, light grey, SILTSTONE 20% grey	
	297				
	298			SANDSTONE fine grained, light grey, minor carbonaceous staining	
	299				
	300			SANDSTONE fine grained, light grey, SILTSTONE 20% dark grey	
	301				
	302				
	303			SANDSTONE fine to medium grained, light grey, SILTSTONE 40% dark grey	
	304				
	305			SANDSTONE fine grained, light grey, carbonaceous staining, SILTSTONE 10% grey	
	306				Water Cut: 0.1 L/s, Temp: 28.68 °C, EC:

PARSONS BRINCKERHOFF

Drawing No.: WKMB04 - Bore Construction	
Revision: A	Date Drawn: 26/2/2014
Drawn By: K. Maher	Checked By: J. Duggleby
Project No. 2162406C	

AGL

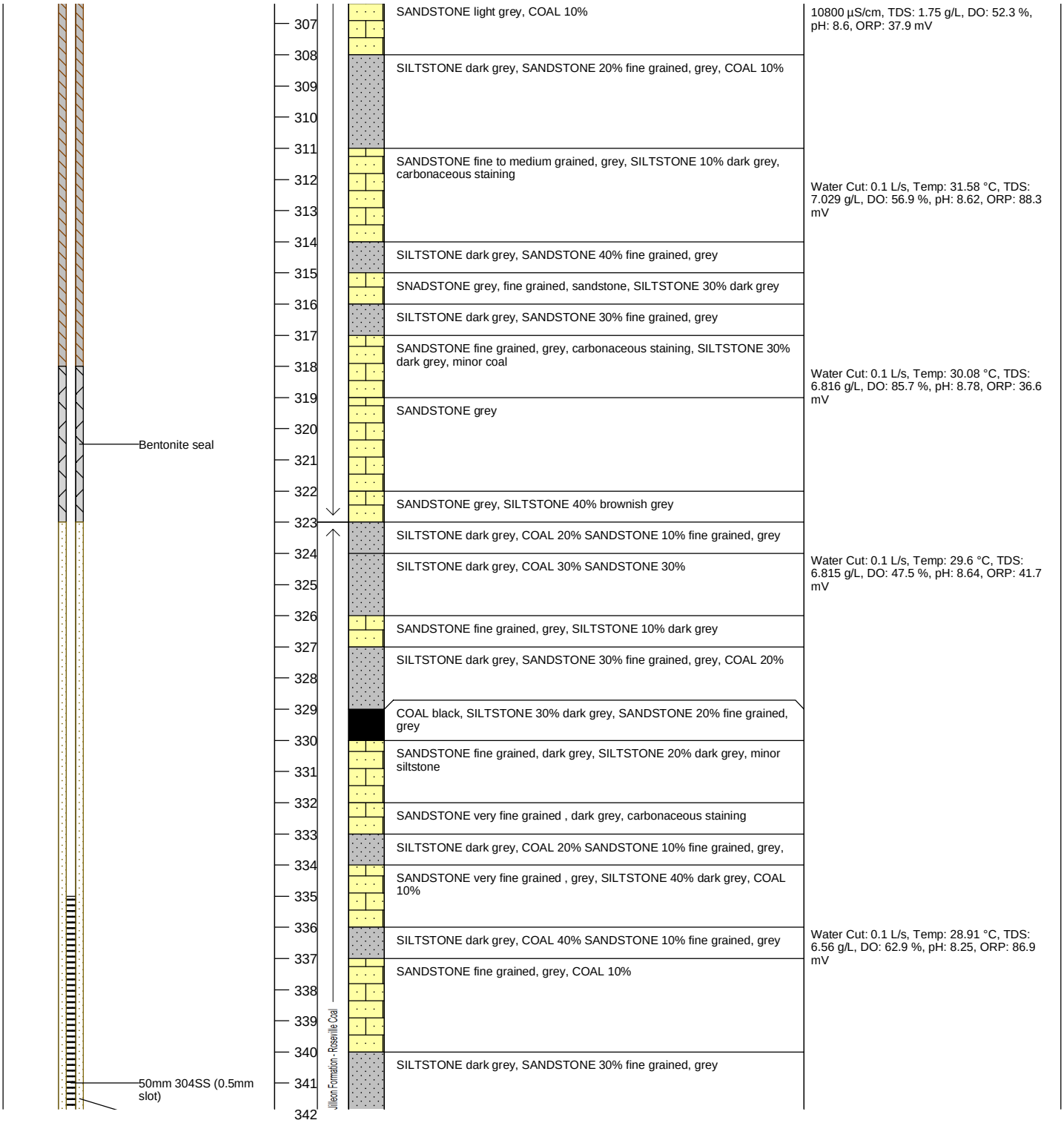
AGL Upstream Investments Pty Ltd

WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE COMPLETION REPORT - WKMB04



PARSONS BRINCKERHOFF

Drawing No.:	WKMB04 - Bore Construction
Revision: A	Date Drawn: 26/2/2014
Drawn By: K. Maher	Checked By: J. Duggleby
Project No. 2162406C	

AGL

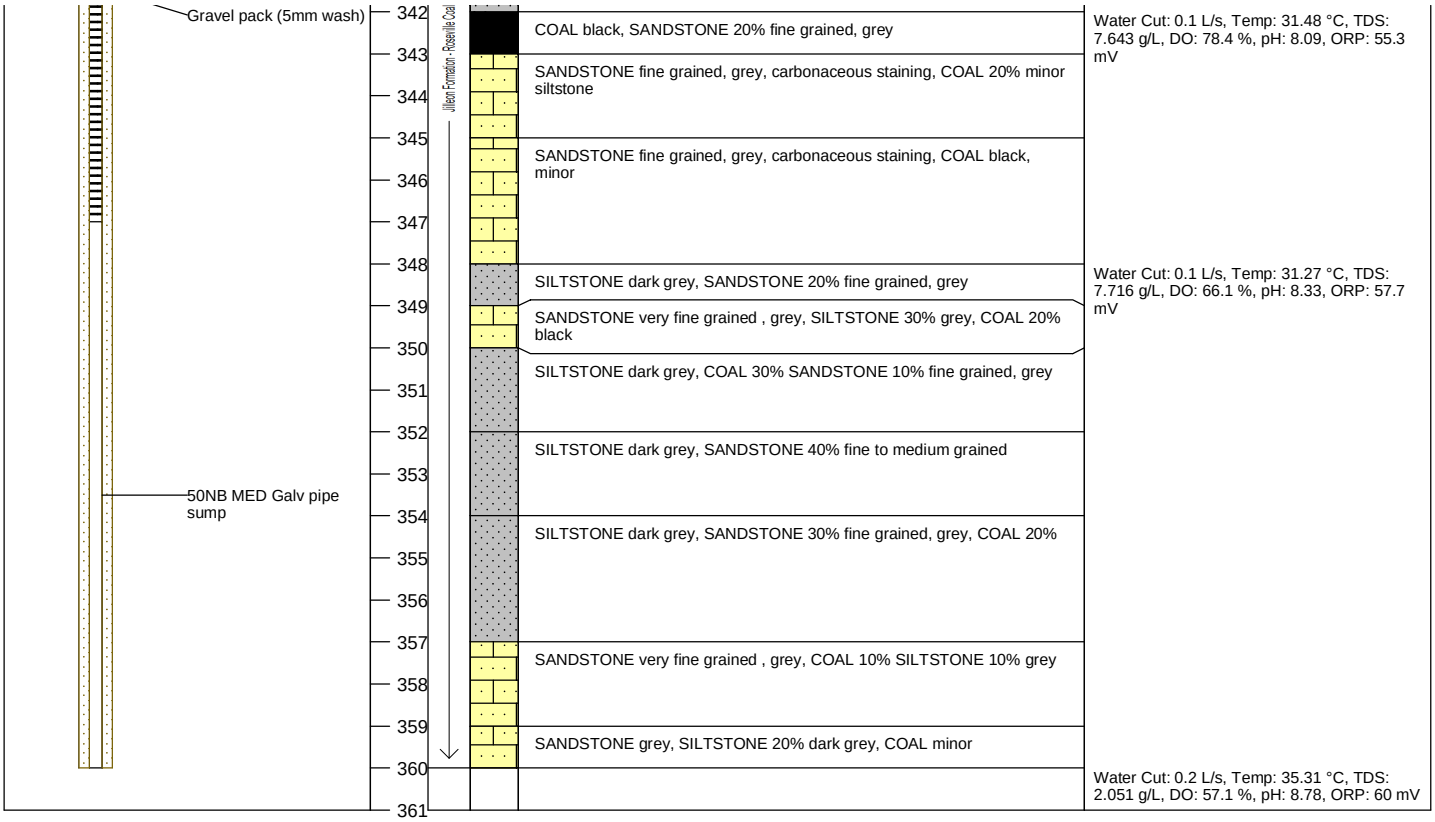
AGL Upstream Investments Pty Ltd

WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

BORE COMPLETION REPORT - WKMB04



PARSONS BRINCKERHOFF

Drawing No.: WKMB04 - Bore Construction	
Revision: A	Date Drawn: 26/2/2014
Drawn By: K. Maher	Checked By: J. Duggleby
Project No. 2162406C	

AGL Upstream Investments Pty Ltd
WKMB04

Waukivory Groundwater Monitoring Program

Note: WKMB04 was successfully plugged and abandoned by Gas Field Services in November 2013.

Appendix B

Geophysical logs

GROUNDSEARCH AUSTRALIA

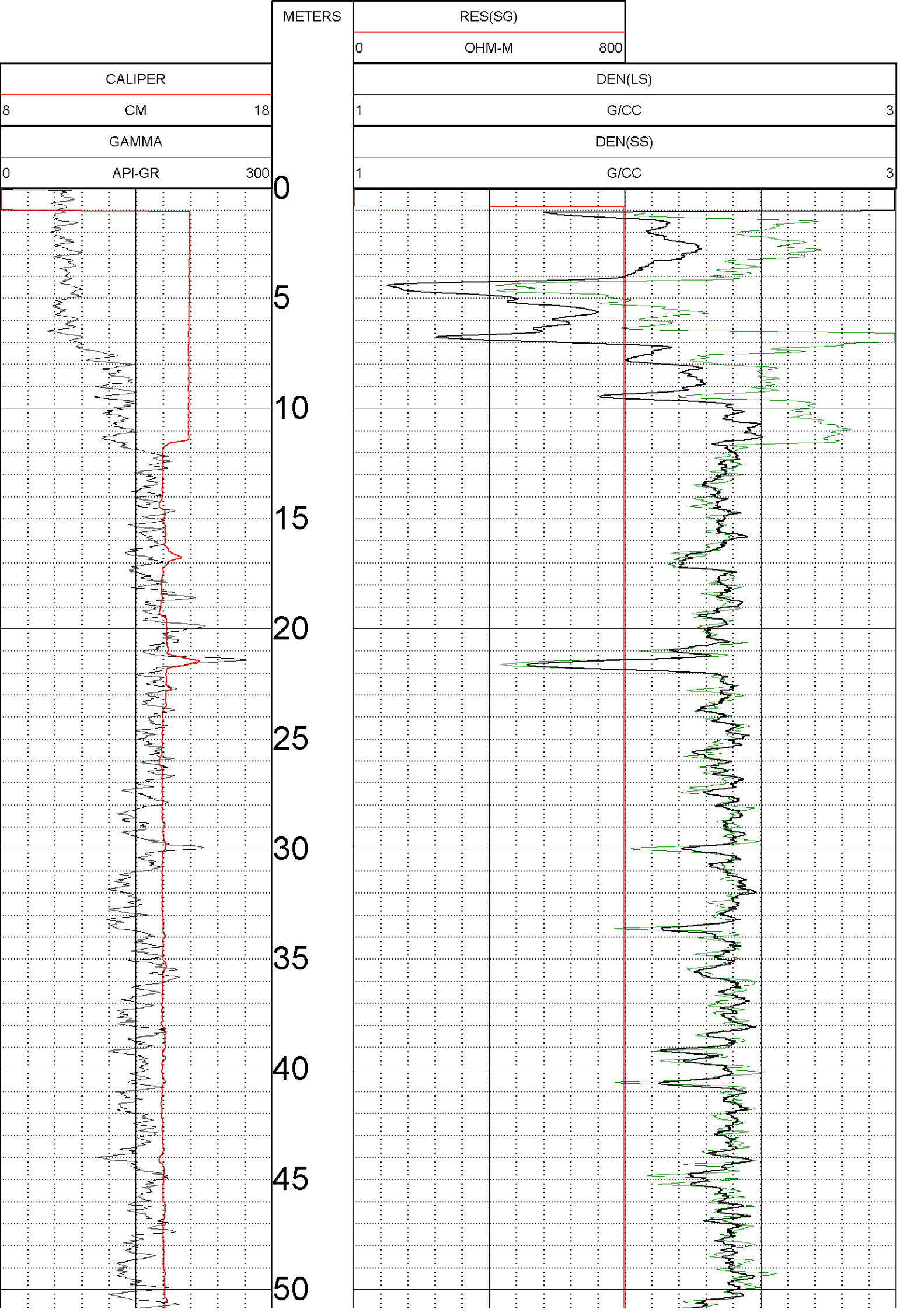
(ABN 11 057 389 152)

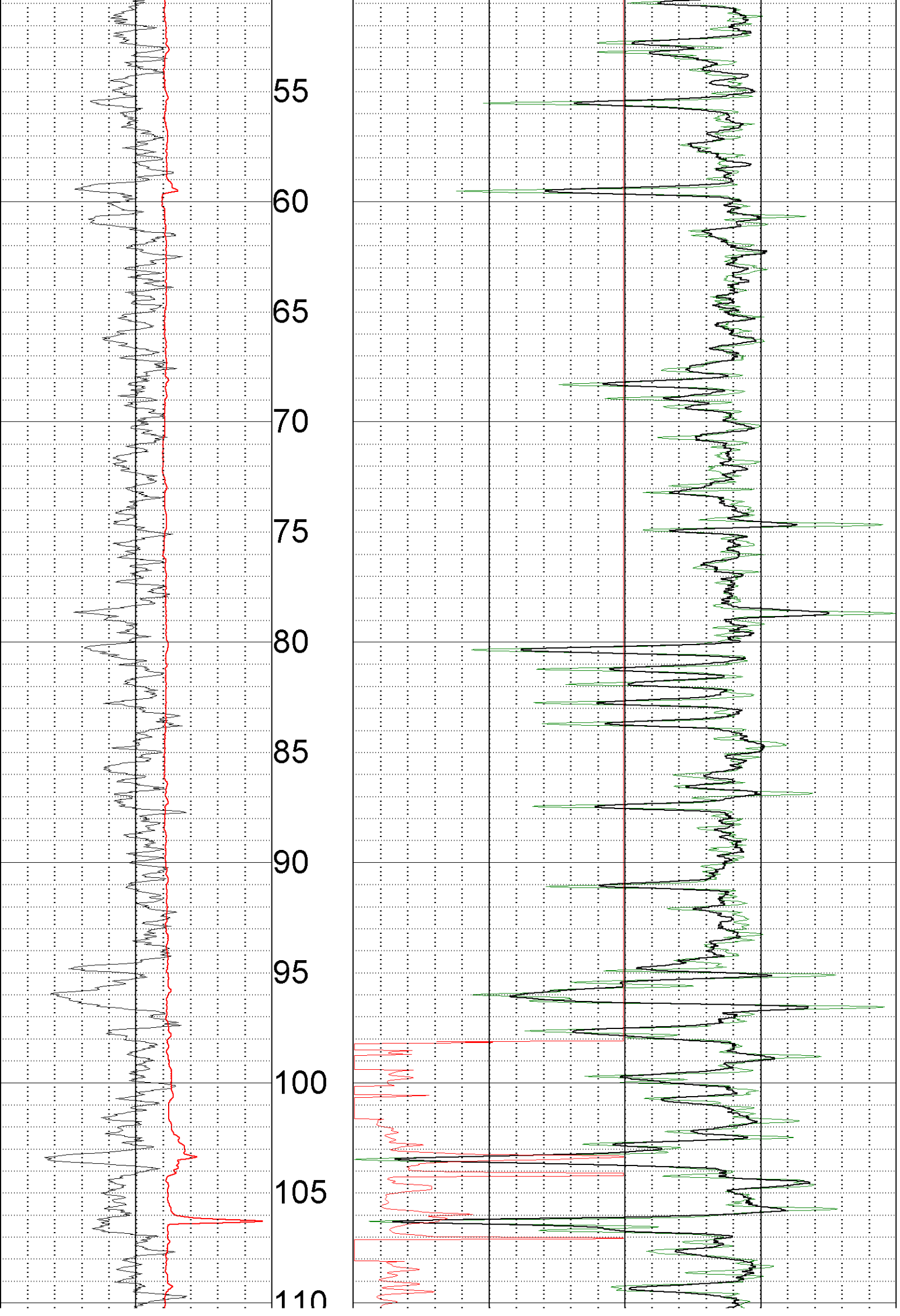
WKMB04 DENSITY 1:200

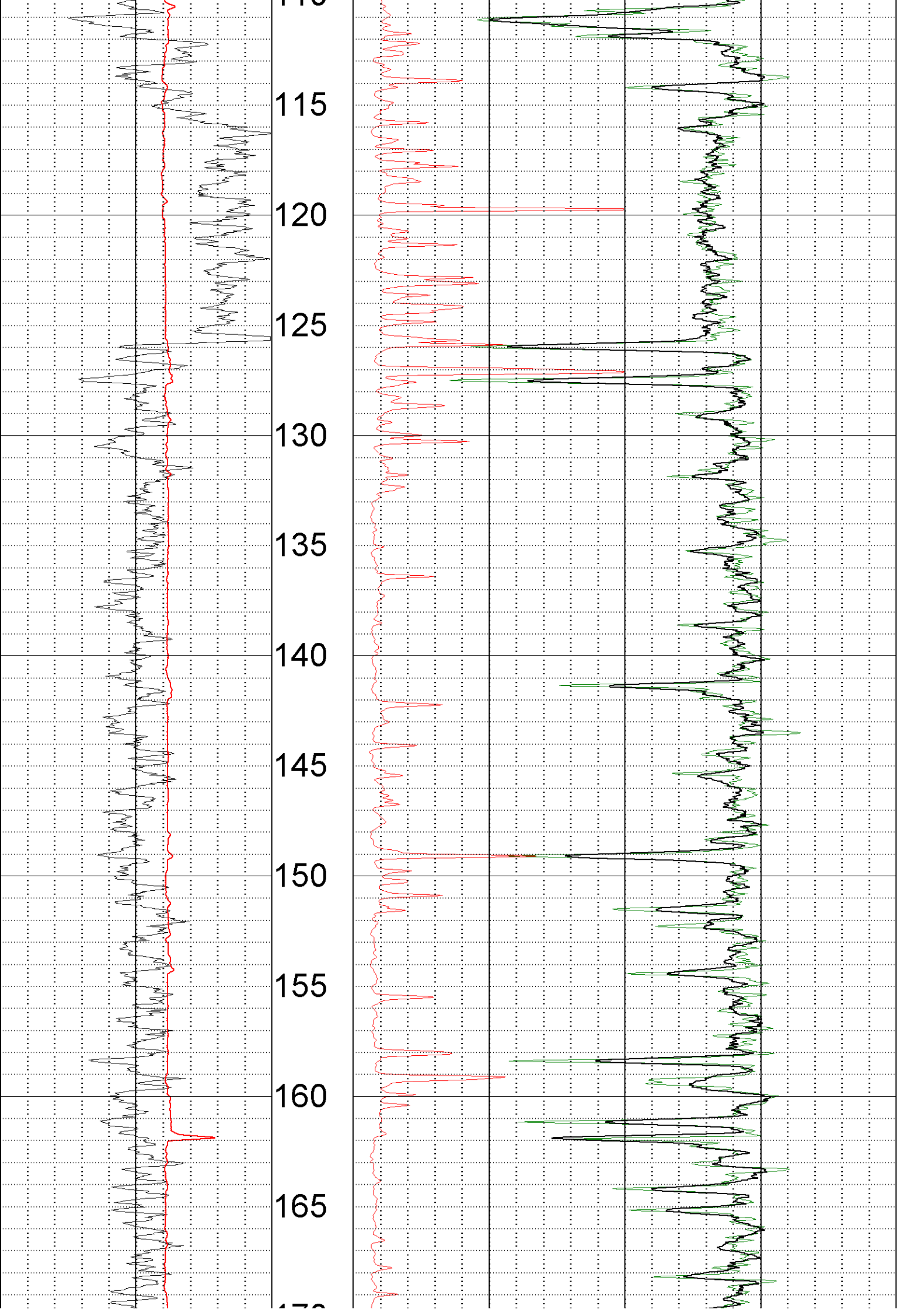
COMPANY	:	AGL			OTHER SERVICES:		
WELL	:	WKMB04 DENSITY 1:200			IND DEN		
LOCATION/FIELD	:	GLOUCESTER			NEU SON		
COUNTY	:	AUST			N/A		
LOCATION	:	N/A//					
SECTION	:	0	TOWNSHIP	: 0		RANGE	: 0
DATE	:	01/20/12	PERMANENT DATUM	: GL			
DEPTH DRILLER	:	50				KB	: N/A
LOG BOTTOM	:	359.12	LOG MEASURED FROM:	GL		DF	: N/A
LOG TOP	:	-1.23	DRL MEASURED FROM:	GL		GL	: -0.00
CASING DIAMETER	:	10.	LOGGING UNIT	: T110			
CASING TYPE	:	PVC	FIELD OFFICE	: RUTHERFORD			
CASING THICKNESS:		.5	RECORDED BY	: M LEA			
BIT SIZE	:	14.00	BOREHOLE FLUID	: 0		FILE	: PROCESSED
MAGNETIC DECL.	:	0	RM	: 0		TYPE	: 9035AA
MATRIX DENSITY	:	2.65	RM TEMPERATURE	: 0		LGDATE	: 01/20/12
NEUTRON MATRIX	:	SANDSTONE	MATRIX DELTA T	: 177			
						THRESH	: 99999

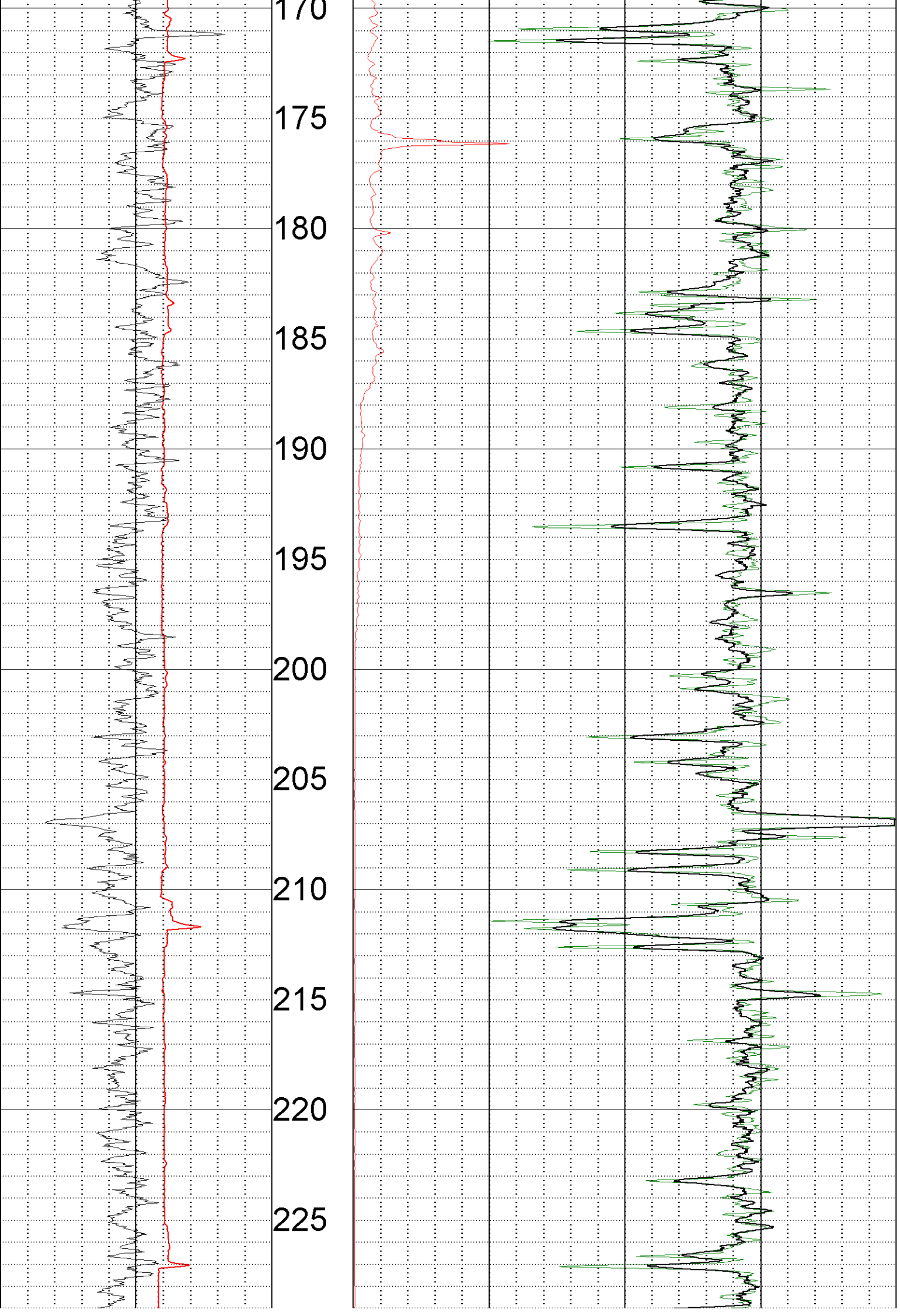
N/A

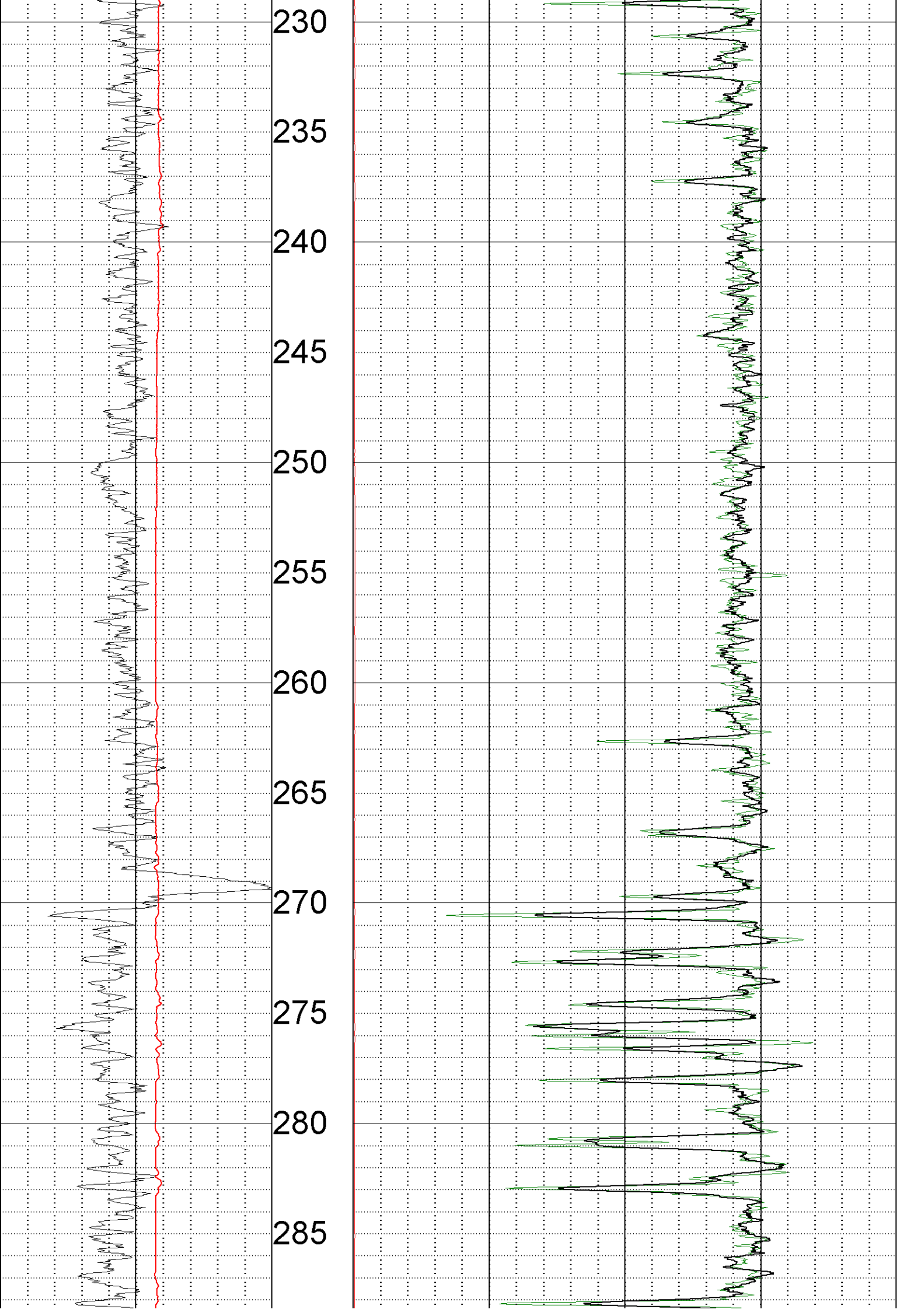
N/A

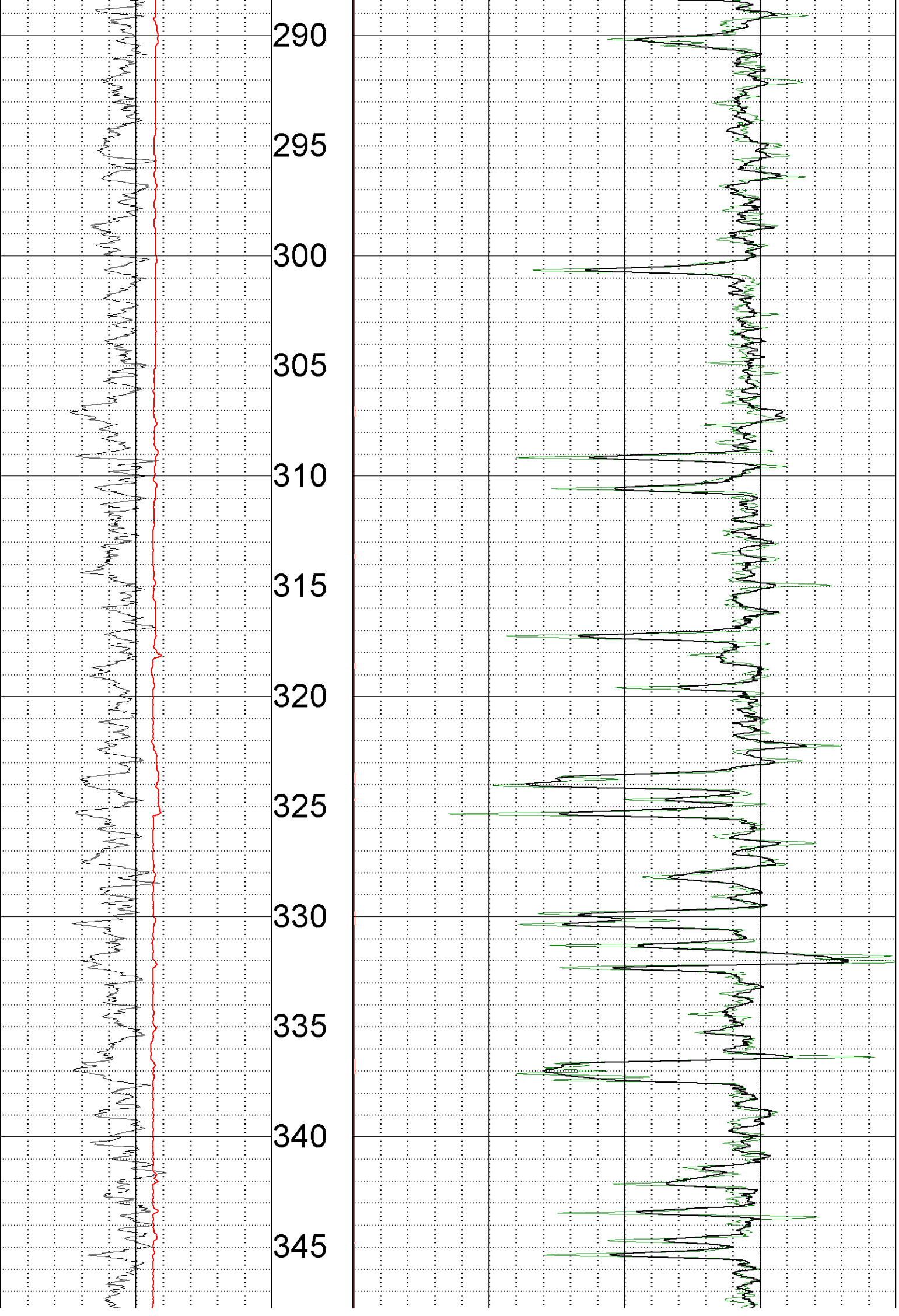

METERS
RES(SG)
0
OHM-M
800
CALIPER
8
CM
18
GAMMA
0
API-GR
300
DEN(LS)
1
G/CC
3
DEN(SS)
1
G/CC
3
0
5
10
15
20
25
30
35
40
45
50

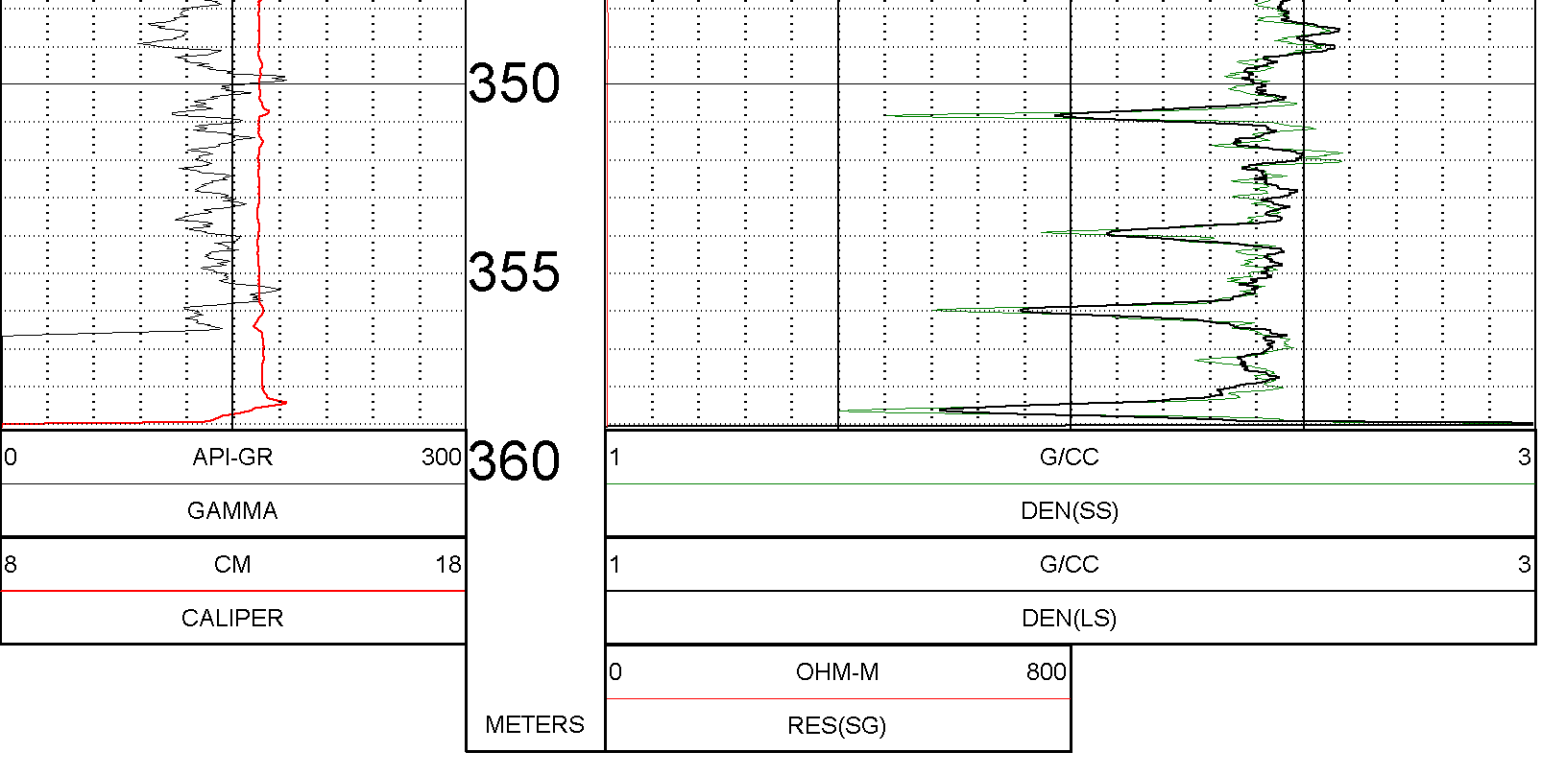

55
60
65
70
75
80
85
90
95
100
105
110


115
120
125
130
135
140
145
150
155
160
165


170
175
180
185
190
195
200
205
210
215
220
225


230
235
240
245
250
255
260
265
270
275
280
285


290
295
300
305
310
315
320
325
330
335
340
345



0	API-GR	300	1	G/CC	3
GAMMA			DEN(SS)		
8	CM	18	1	G/CC	3
CALIPER			DEN(LS)		
			0	OHM-M	800
METERS			RES(SG)		

GROUNDSEARCH AUSTRALIA

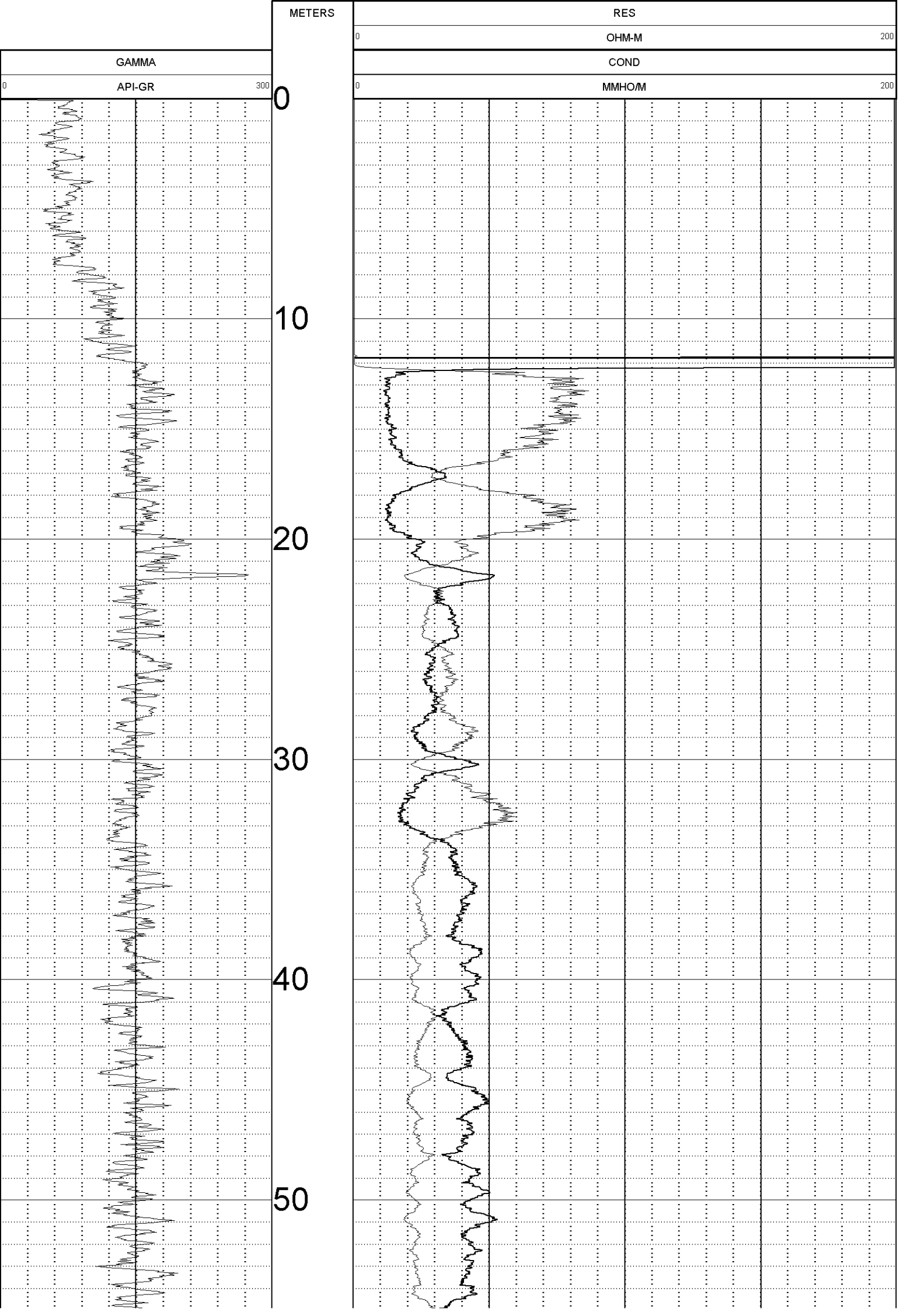
(ABN 11 057 389 152)

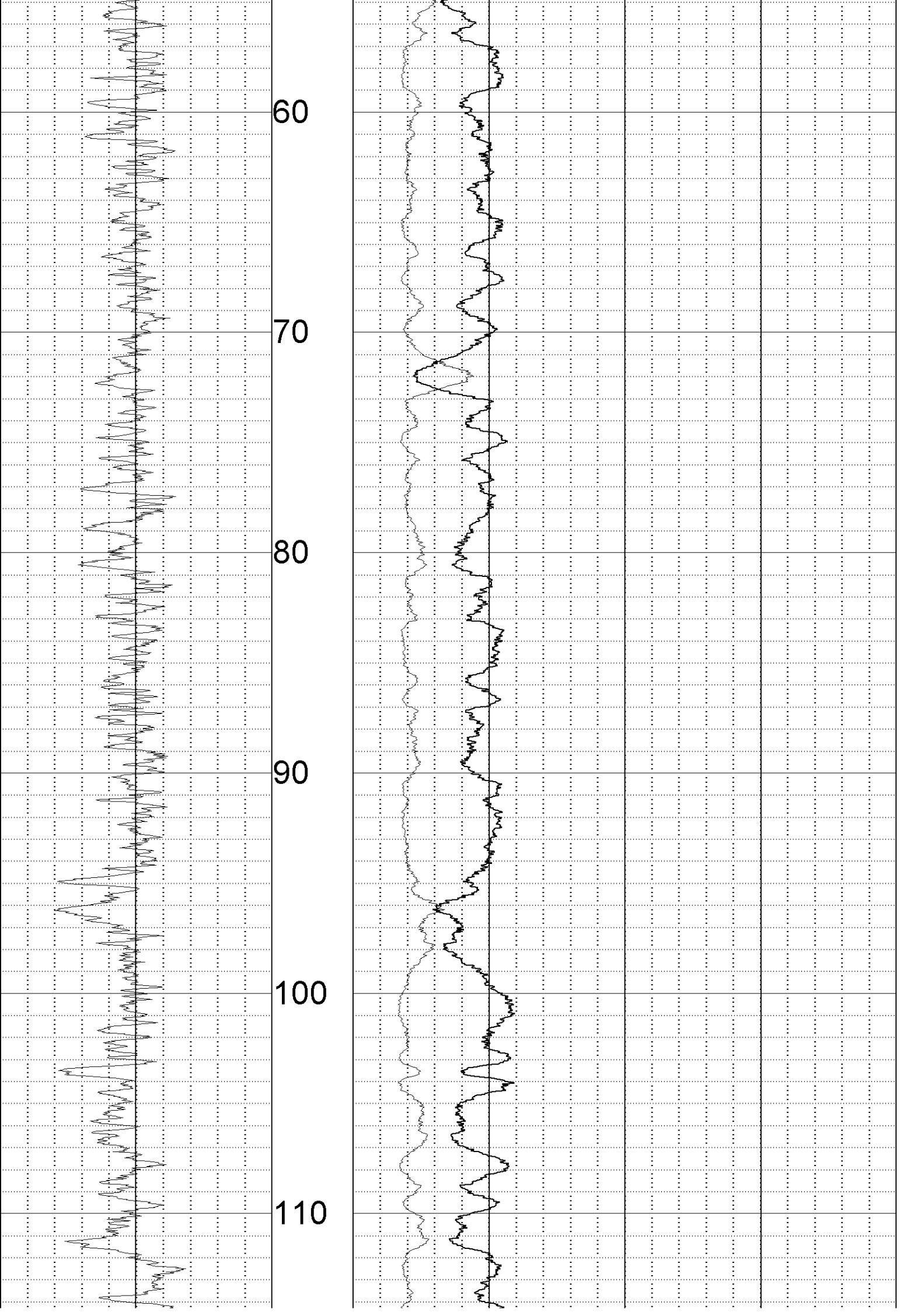
WKMB04 INDUCTION 1:200

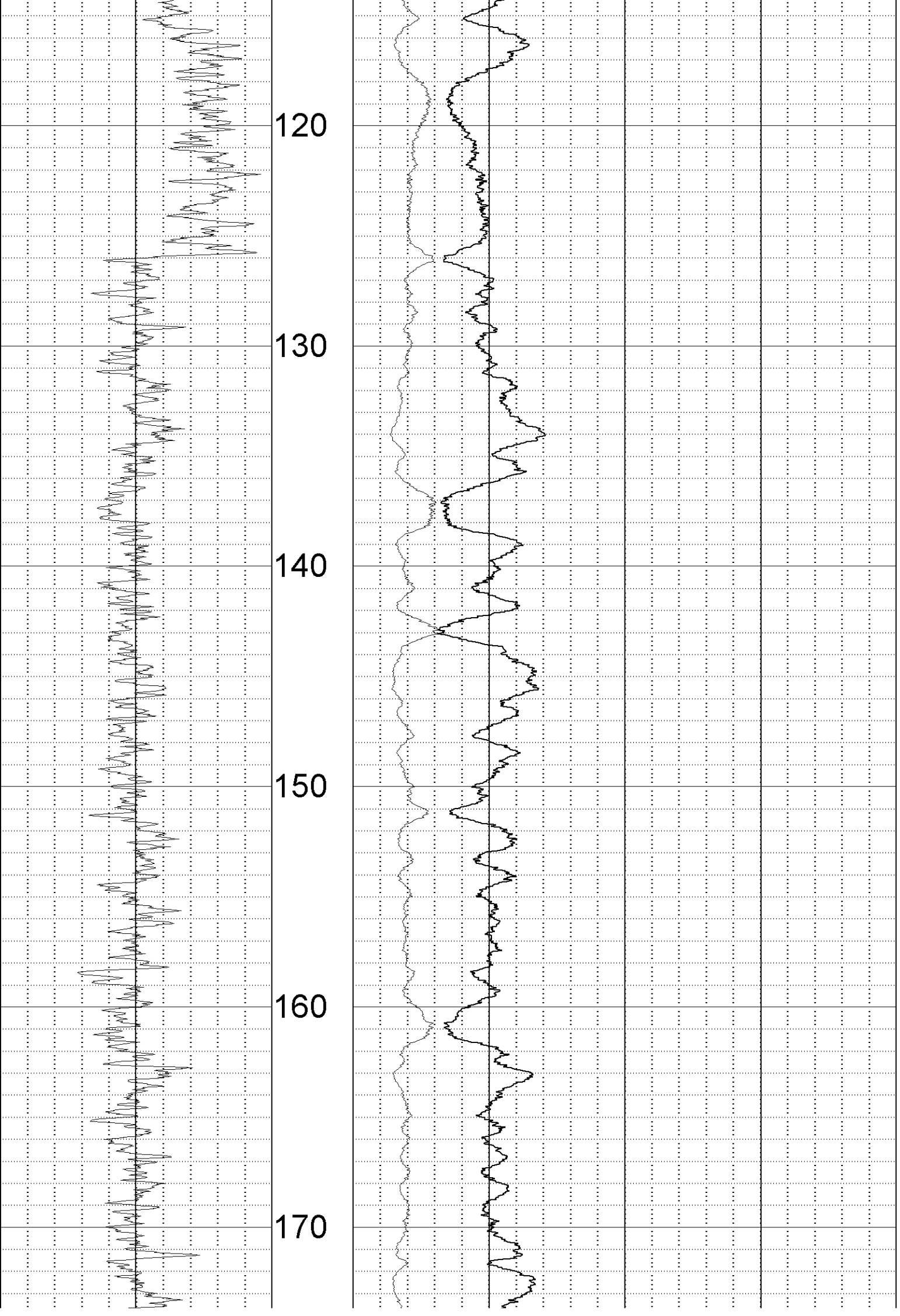
COMPANY	: AGL			OTHER SERVICES:	
WELL	: WKMB04 INDUCTION 1:200			IND DEN	
LOCATION/FIELD	: GLOUCESTER			NEU SON	
COUNTY	: AUST			N/A	
LOCATION	: N/A//				
SECTION	: 0	TOWNSHIP	: 0	RANGE	: 0
DATE	: 01/20/12	PERMANENT DATUM	: GL		
DEPTH DRILLER	: 50			KB	: N/A
LOG BOTTOM	: 360.71	LOG MEASURED FROM:	GL	DF	: N/A
LOG TOP	: -1.03	DRL MEASURED FROM:	GL	GL	: -0.00
CASING DIAMETER	: 10.	LOGGING UNIT	: T110		
CASING TYPE	: PVC	FIELD OFFICE	: RUTHERFORD		
CASING THICKNESS:	.5	RECORDED BY	: M LEA		
BIT SIZE	: 14	BOREHOLE FLUID	: 0	FILE	: PROCESSED
MAGNETIC DECL.	: 0	RM	: 0	TYPE	: 9510A
MATRIX DENSITY	: 2.65	RM TEMPERATURE	: 0	LGDATE	: 01/20/12
NEUTRON MATRIX	: SANDSTONE	MATRIX DELTA T	: 177	LGTIME	: 16:20:
				THRESH:	99999

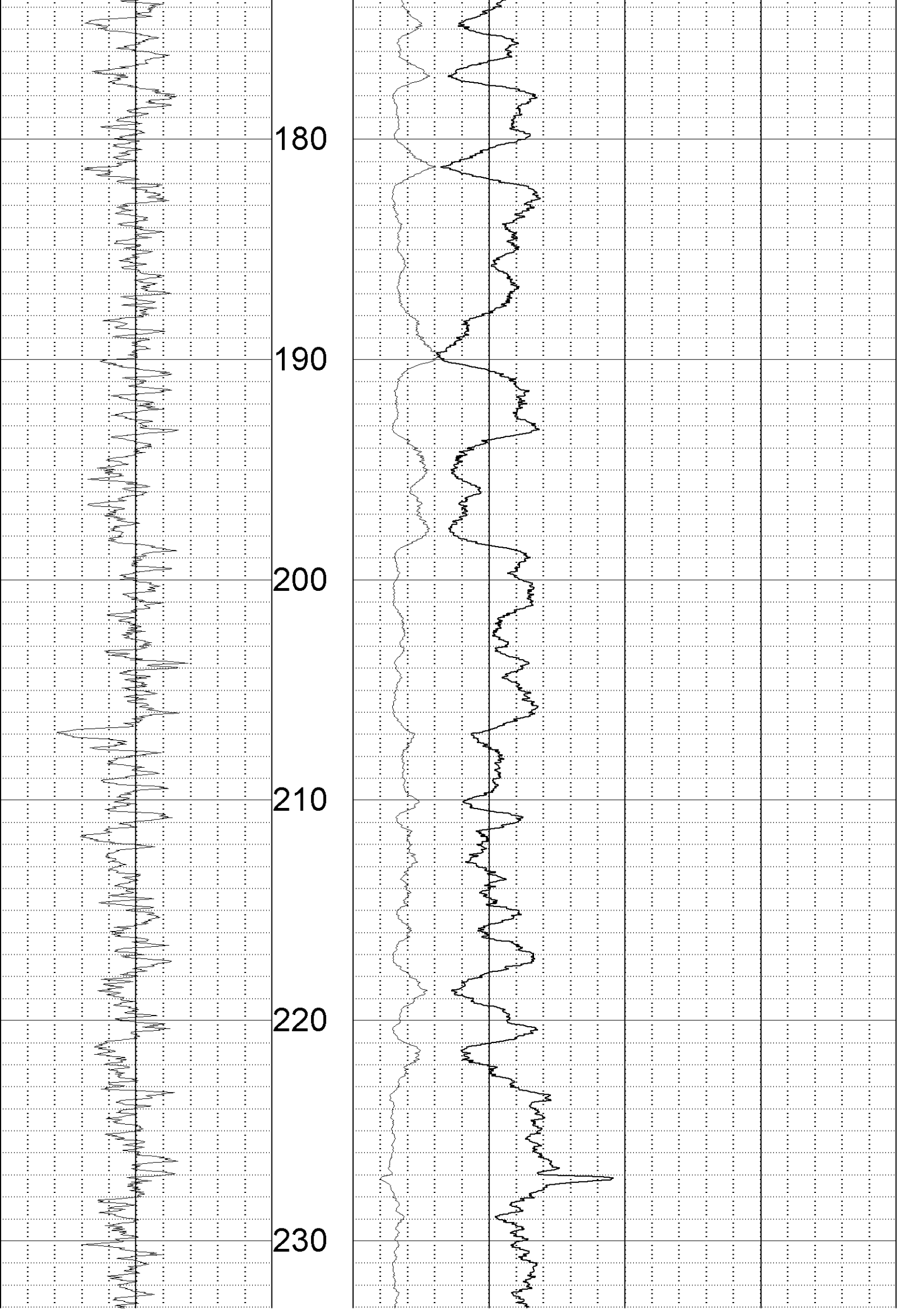
N/A

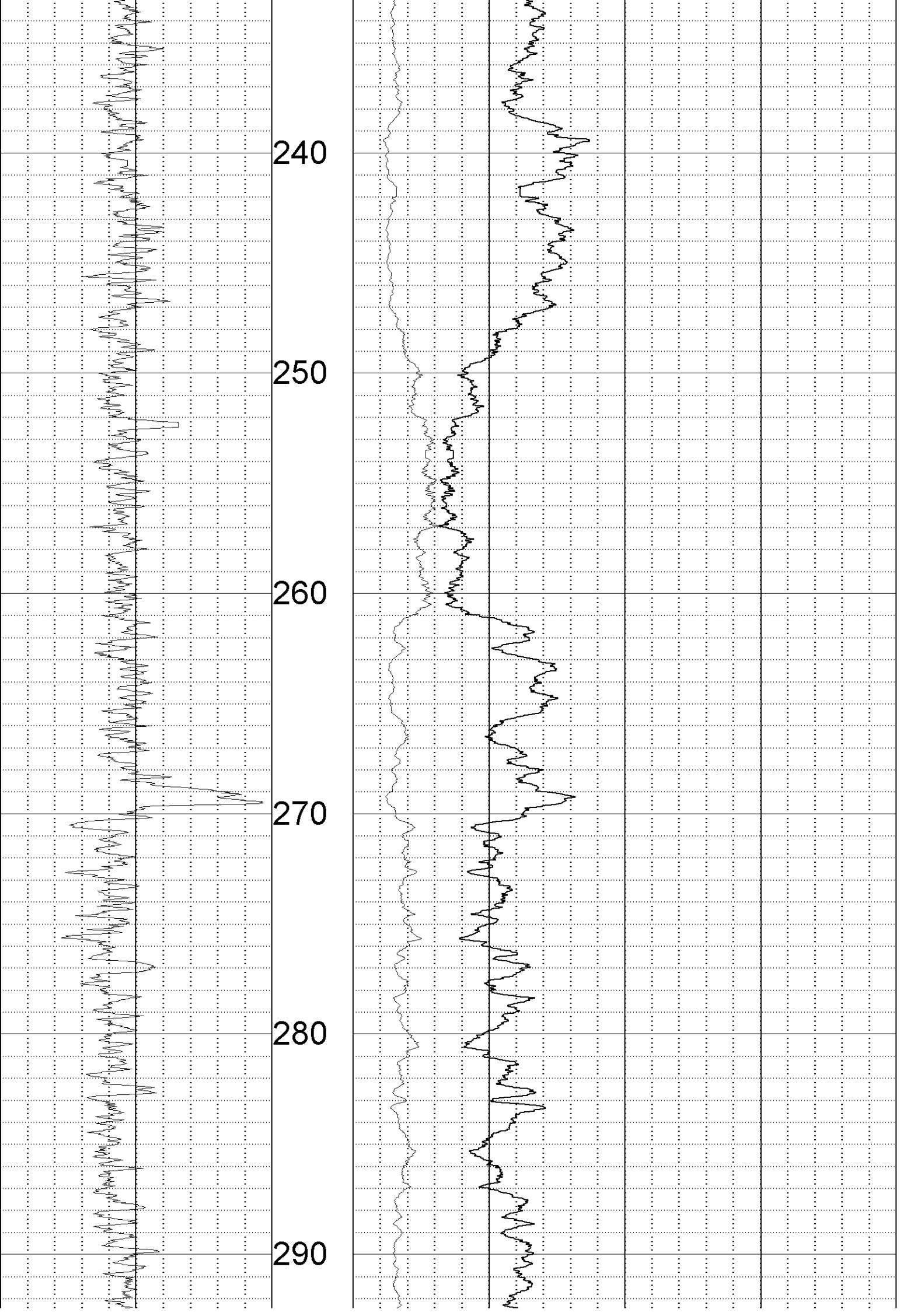
N/A

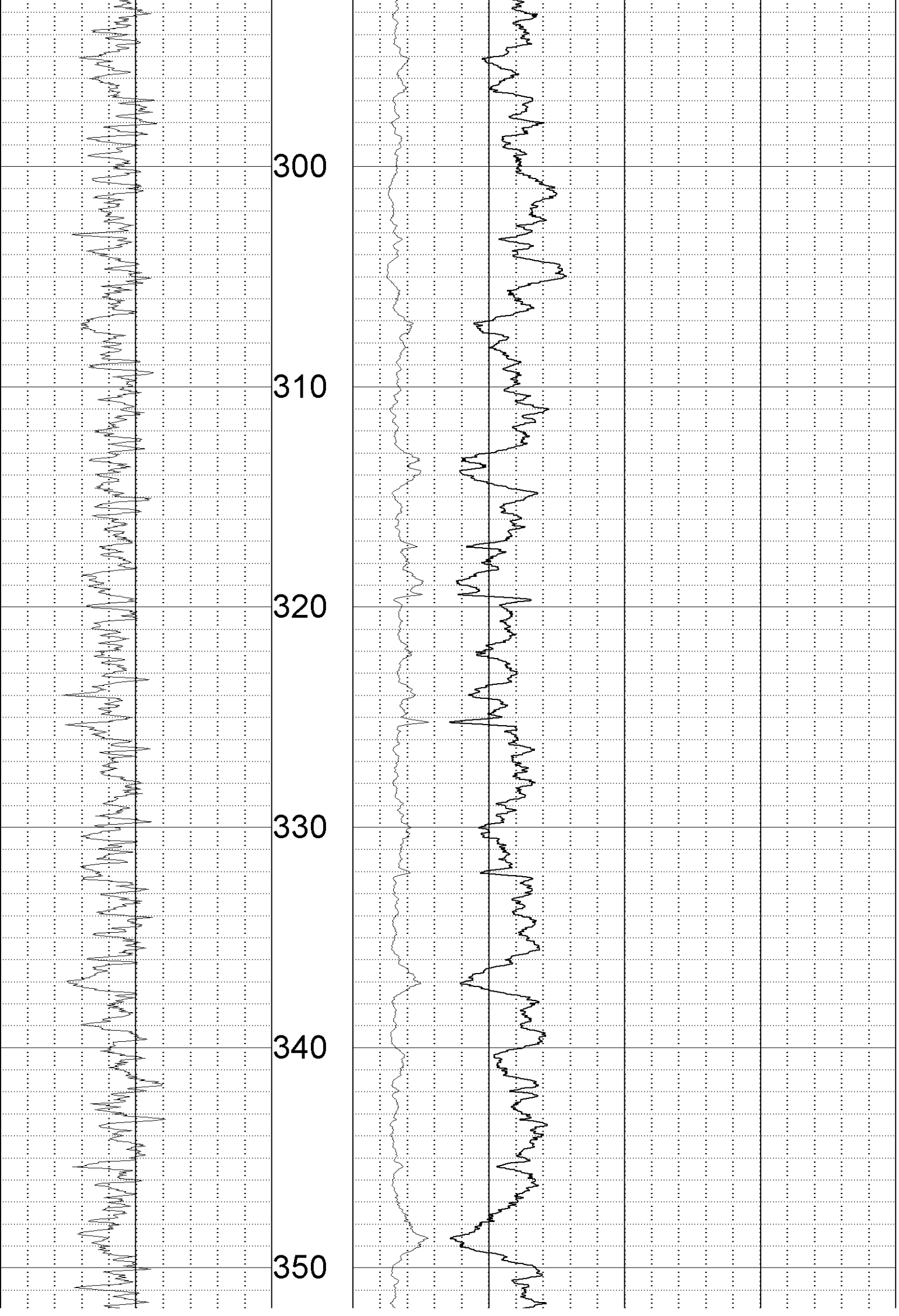

METERS
RES
0
OHM-M
200
GAMMA
COND
0
API-GR
300
0
MMHO/M
200
0
10
20
30
40
50

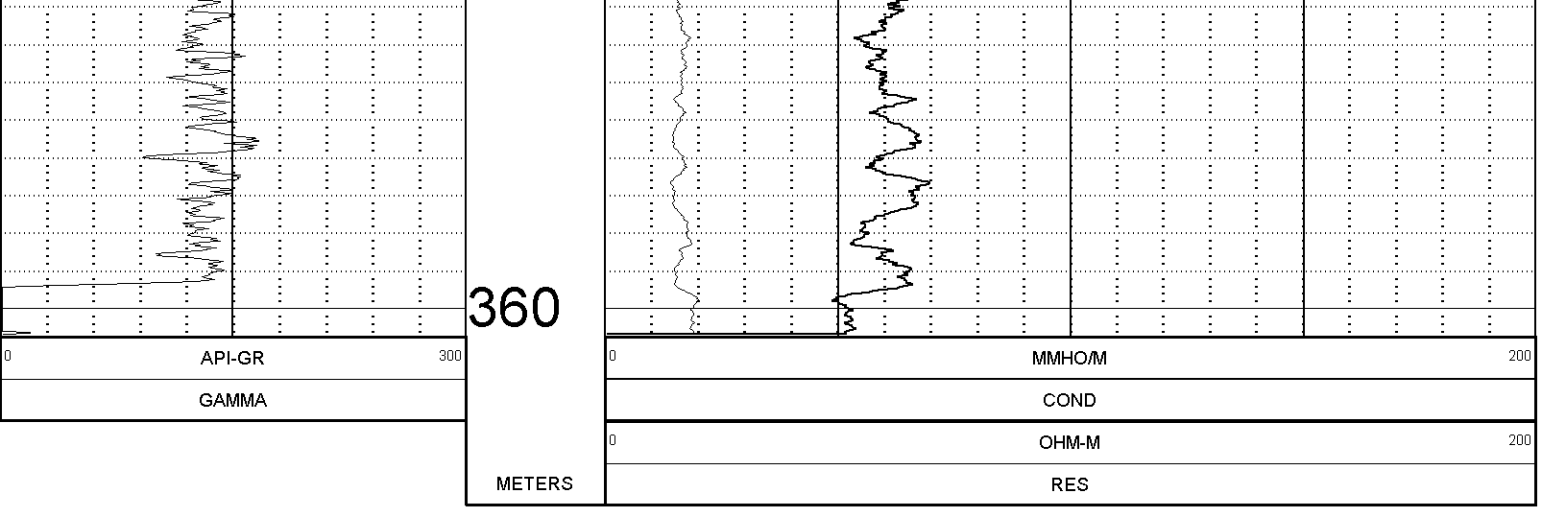

60
70
80
90
100
110


120
130
140
150
160
170


180
190
200
210
220
230


240
250
260
270
280
290


300
310
320
330
340
350


360
0
API-GR
300
GAMMA
0
MMHO/M
200
COND
0
OHM-M
200
RES
METERS

GROUNDSEARCH AUSTRALIA

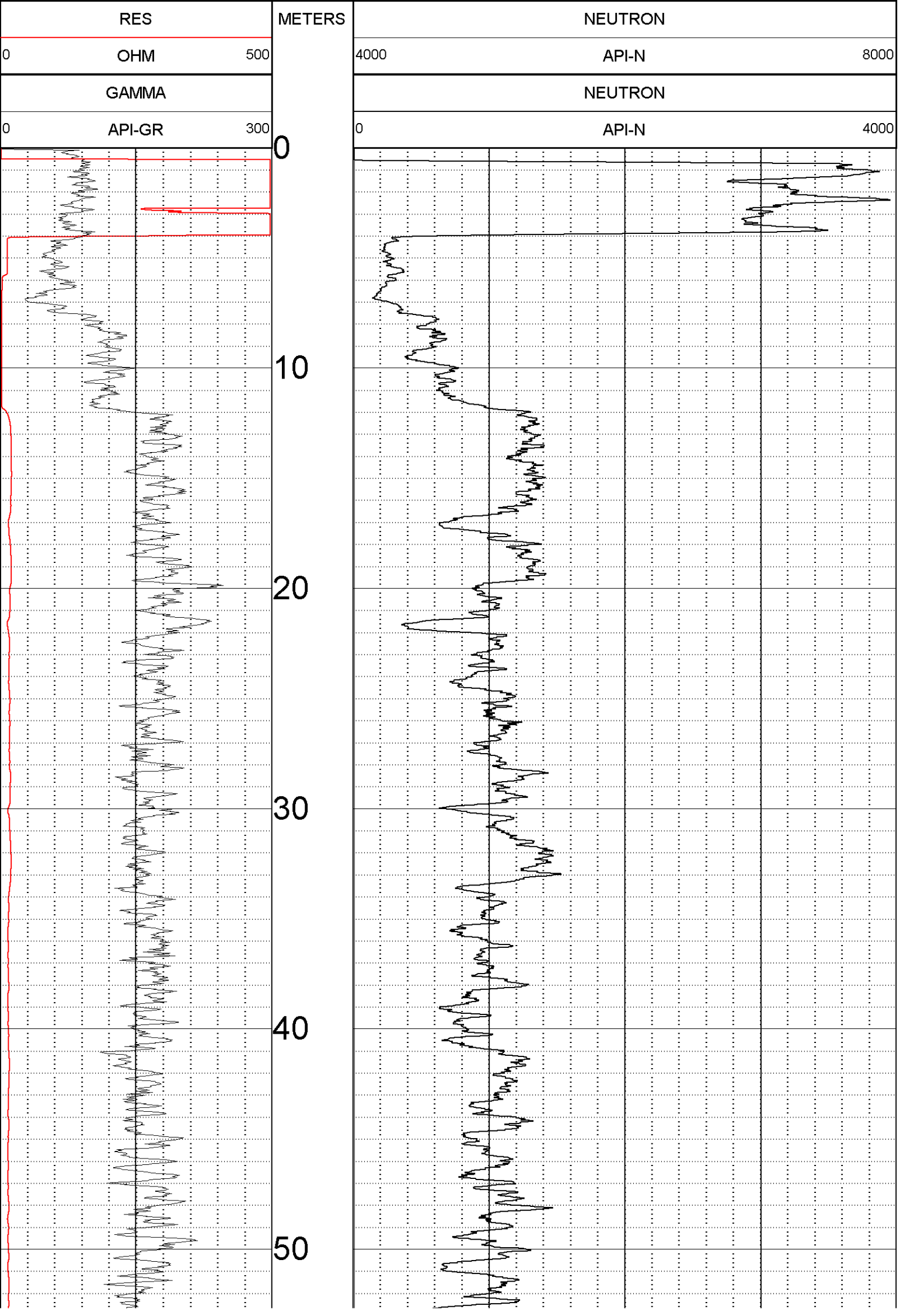
(ABN 11 057 389 152)

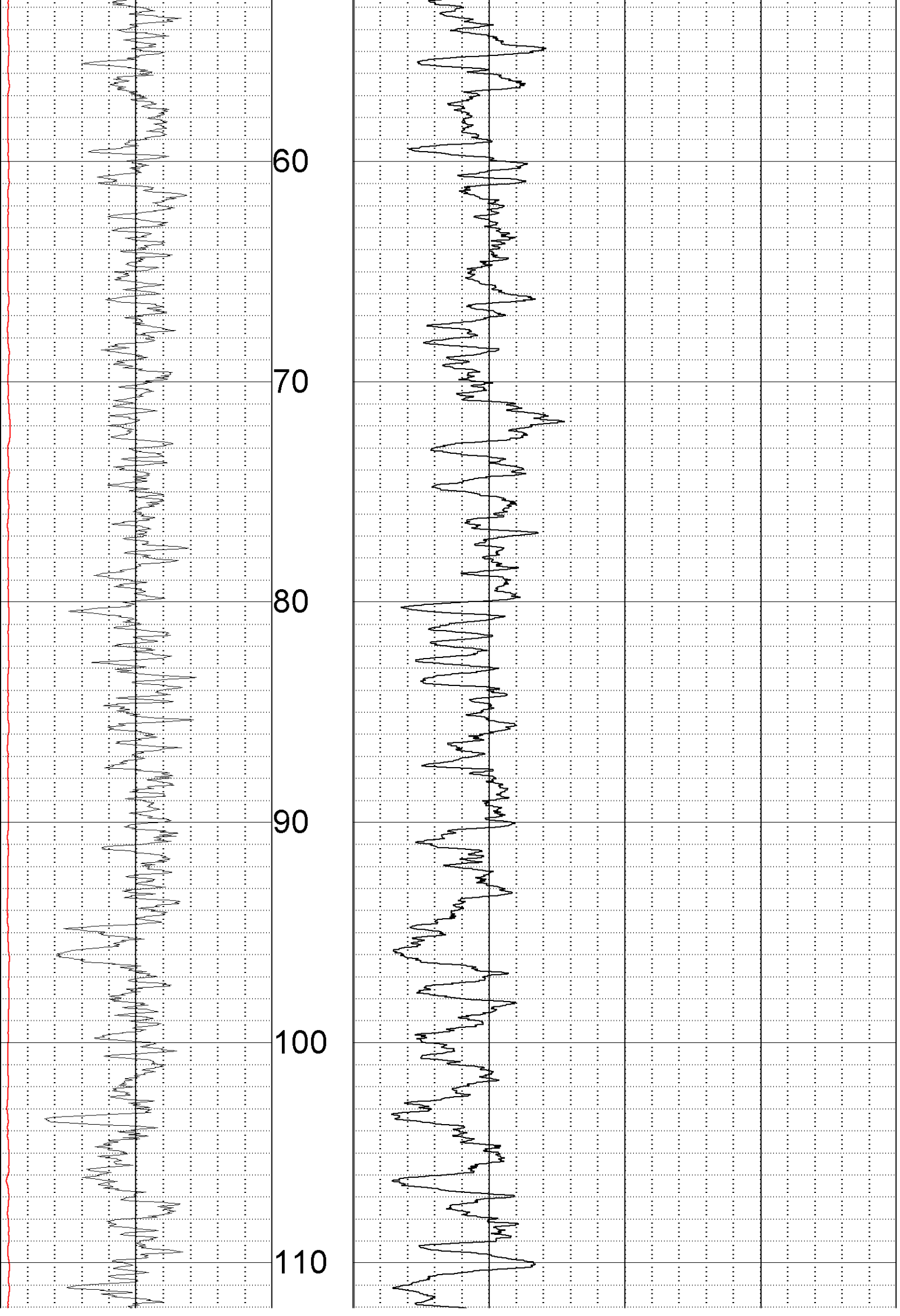
WKMB04 NEUTRON 1:200

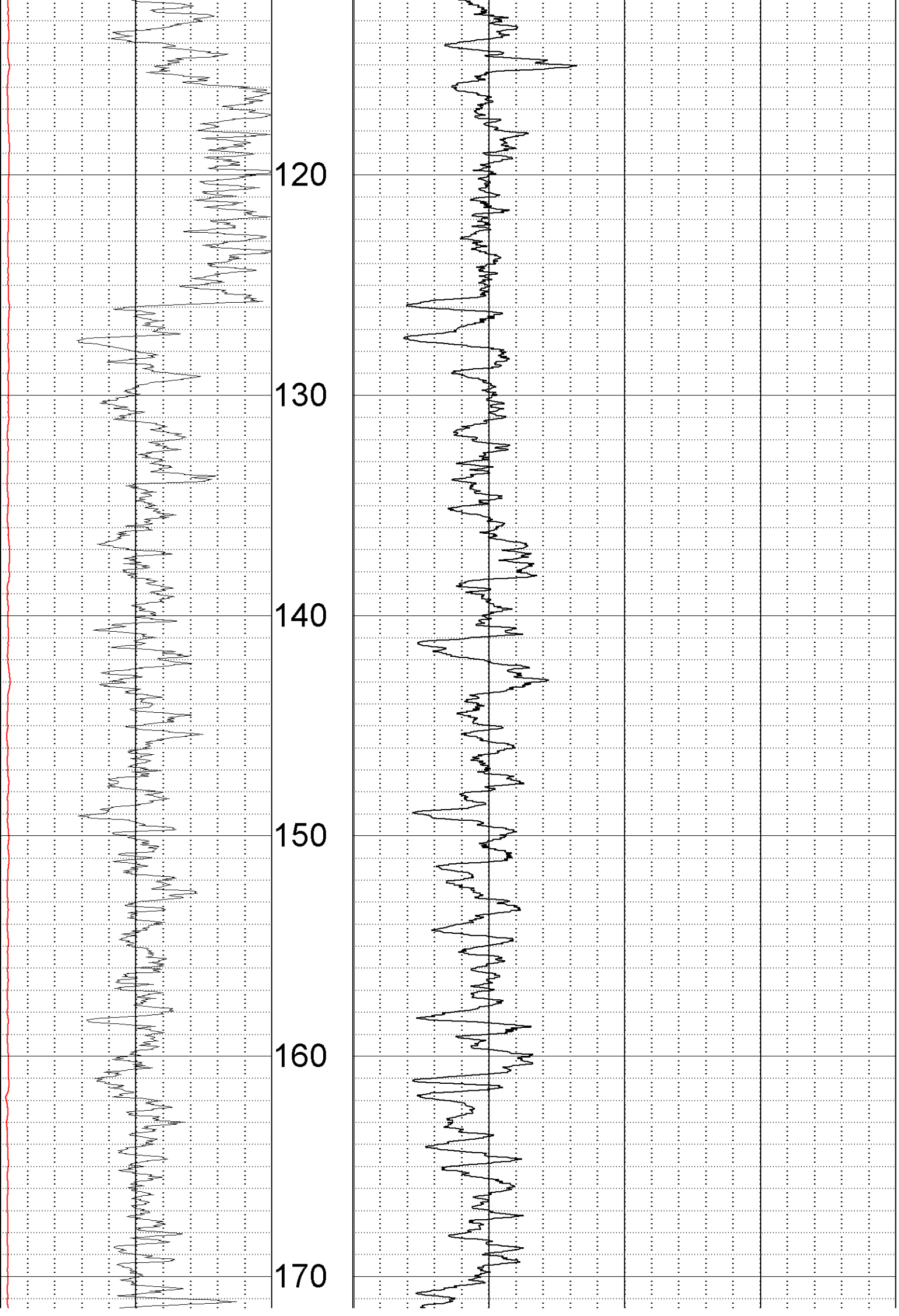
COMPANY	:	AGL					
WELL	:	WKMB04 NEUTRON 1:200					
LOCATION/FIELD	:	GLOUCESTER					
COUNTY	:	AUST					
LOCATION	:	N/A//					
SECTION	:	0	TOWNSHIP	:	0	RANGE	: 0
DATE	:	01/21/12	PERMANENT DATUM	:	GL		
DEPTH DRILLER	:	50				KB	: N/A
LOG BOTTOM	:	360.86	LOG MEASURED FROM:		GL	DF	: N/A
LOG TOP	:	-0.85	DRL MEASURED FROM:		GL	GL	: -0.00
CASING DIAMETER	:	10.	LOGGING UNIT	:	T110		
CASING TYPE	:	PVC	FIELD OFFICE	:	RUTHERFORD		
CASING THICKNESS:		.5	RECORDED BY	:	M LEA		
BIT SIZE	:	14	BOREHOLE FLUID	:	0	FILE	: PROCESSED
MAGNETIC DECL.	:	0.000	RM	:	0	TYPE	: 9057A
MATRIX DENSITY	:	2.65	RM TEMPERATURE	:	0	LGDATE	: 01/21/12
NEUTRON MATRIX	:	SANDSTONE	MATRIX DELTA T	:	177	LGTIME	: 09:04:
						THRESH:	99999

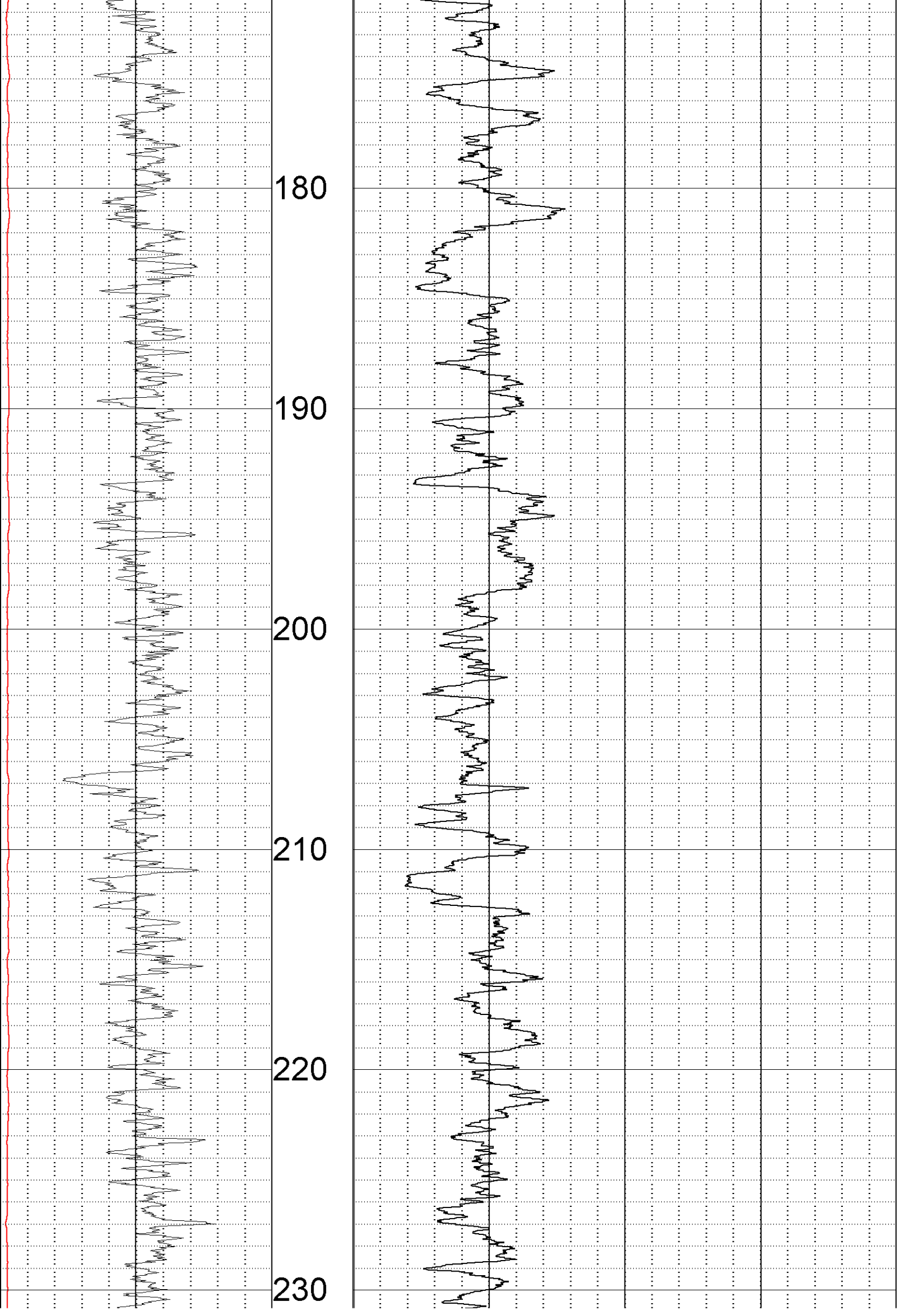
OTHER SERVICES:
IND DEN
NEU SON
N/A

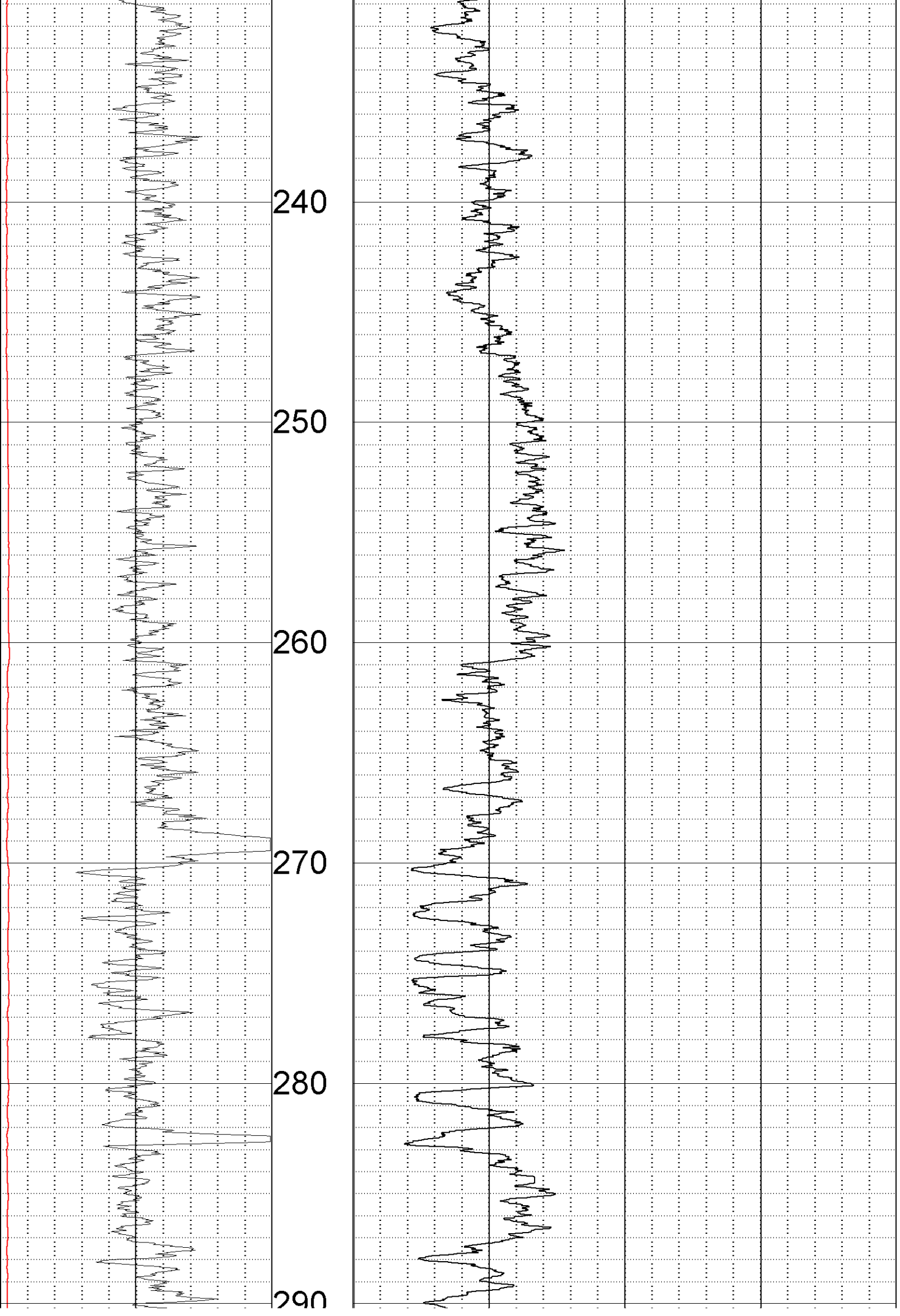
N/A
N/A

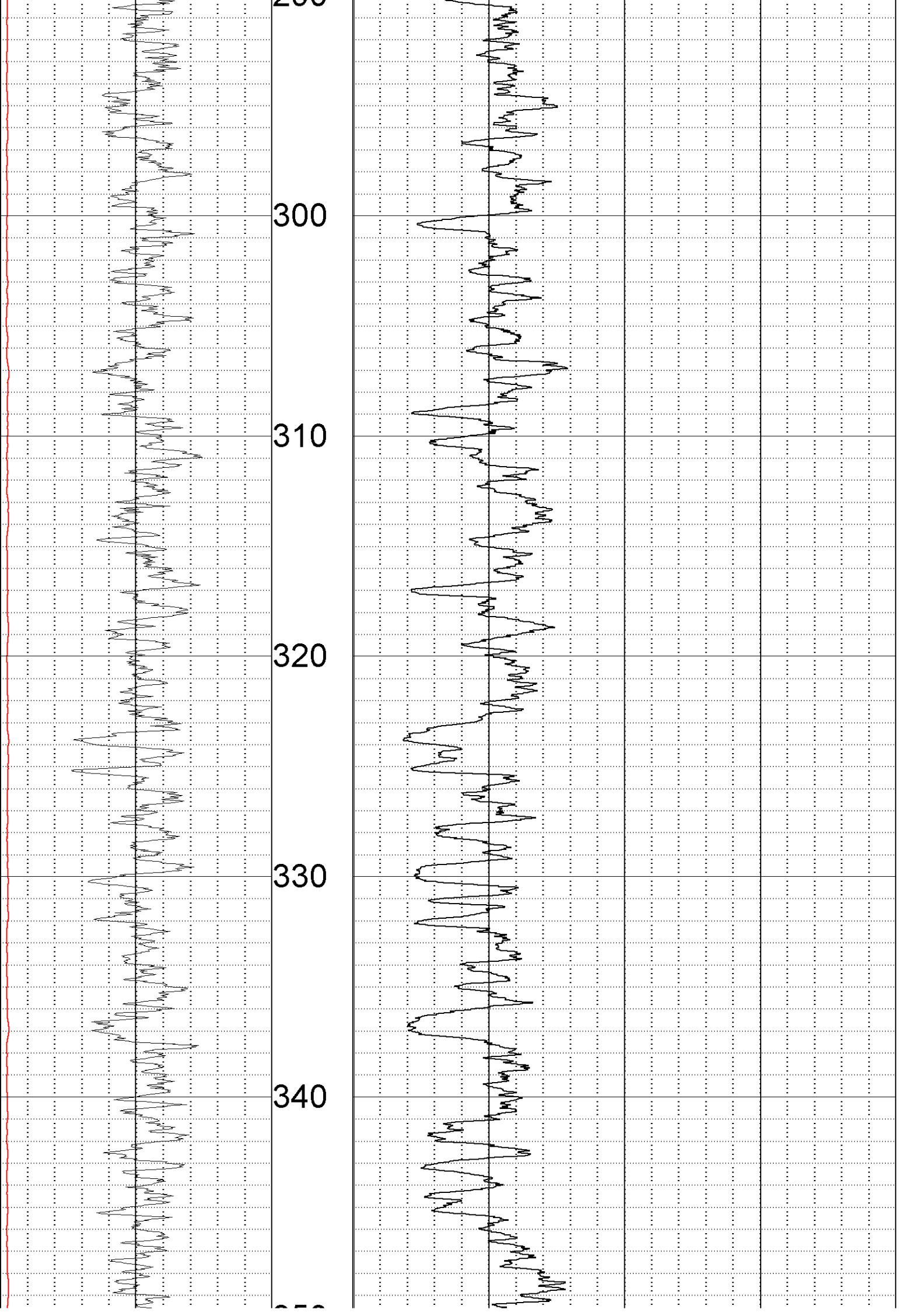

RES
METERS
NEUTRON
0
OHM
500
4000
API-N
8000
GAMMA
NEUTRON
0
API-GR
300
0
API-N
4000
0
10
20
30
40
50

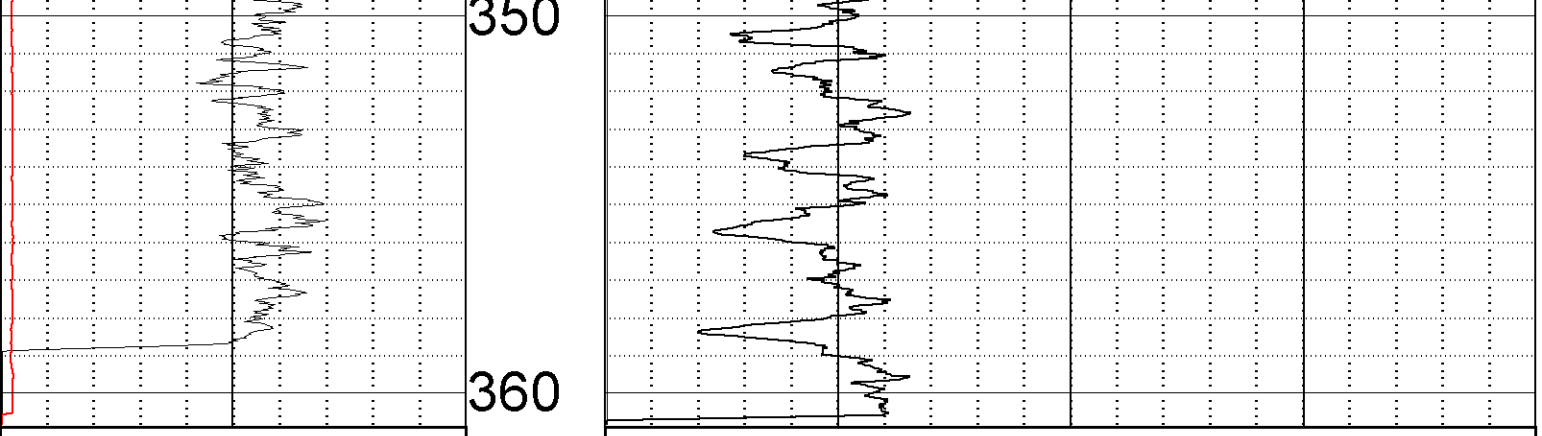

60
70
80
90
100
110


120
130
140
150
160
170


180
190
200
210
220
230


240
250
260
270
280
290


300
310
320
330
340



0	API-GR	300		0	API-N	4000
	GAMMA				NEUTRON	
0	OHM	500		4000	API-N	8000
	RES		METERS		NEUTRON	

GROUNDSEARCH AUSTRALIA

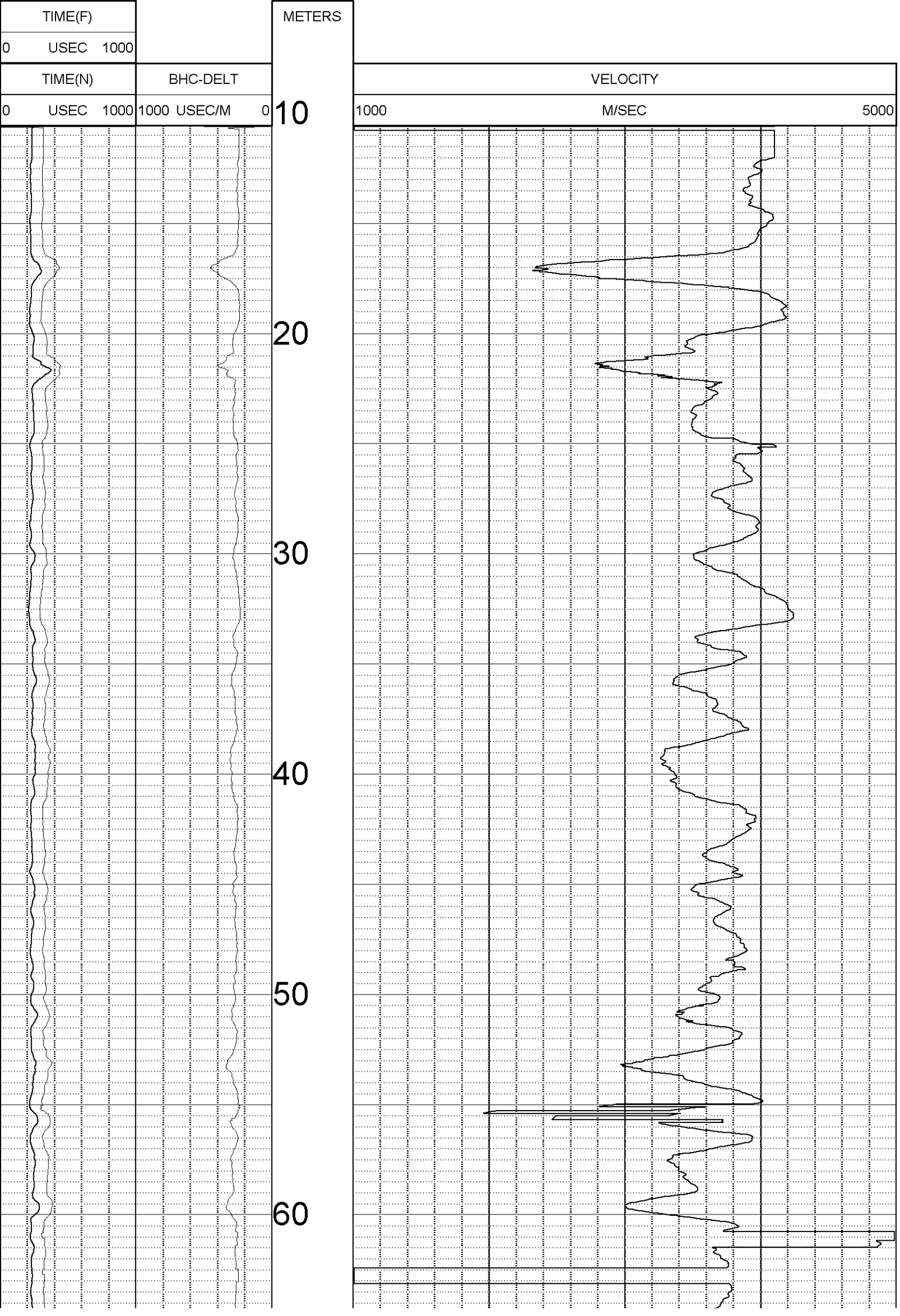
(ABN 11 057 389 152)

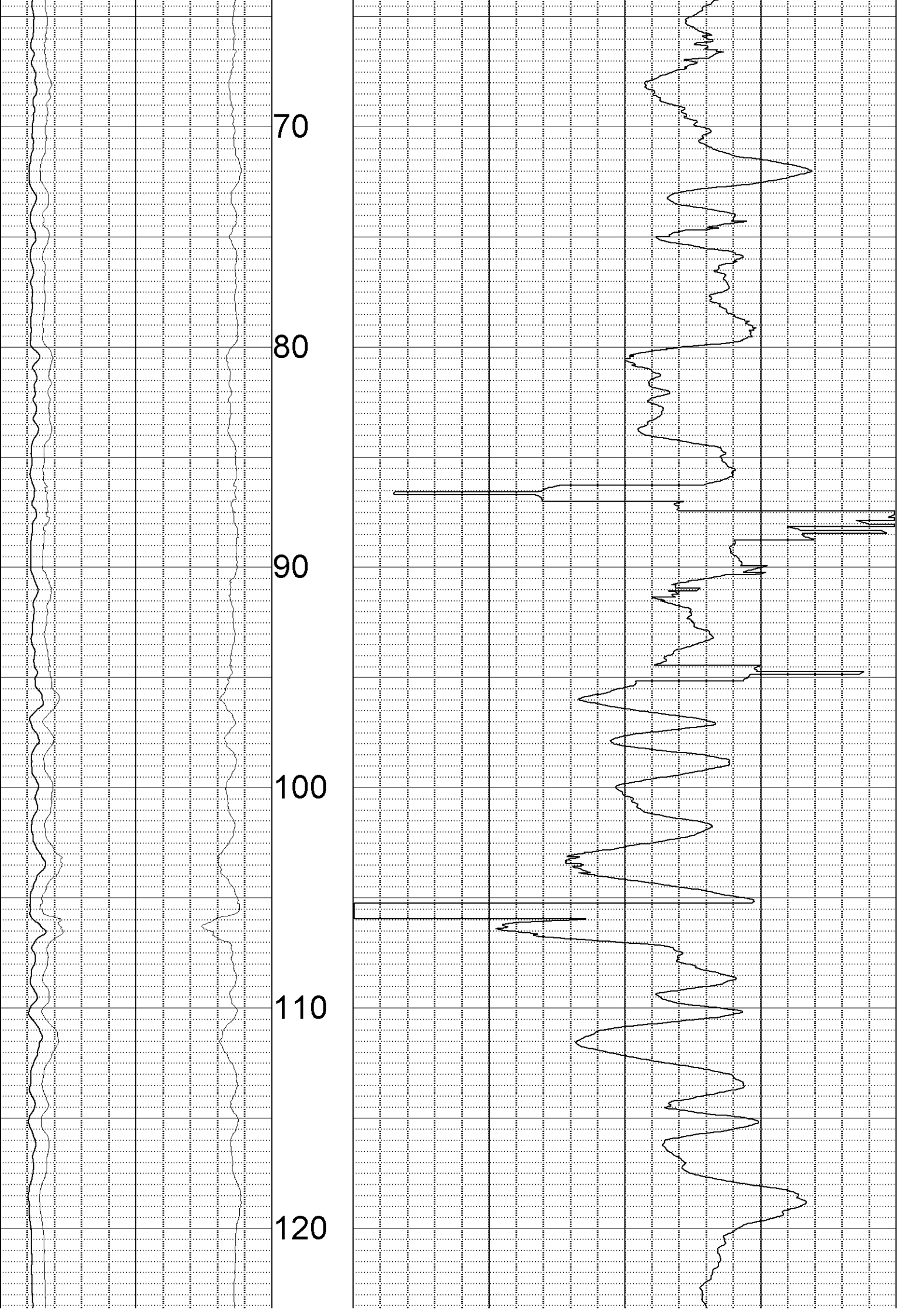
WKMB04 VELOCITY 1:200

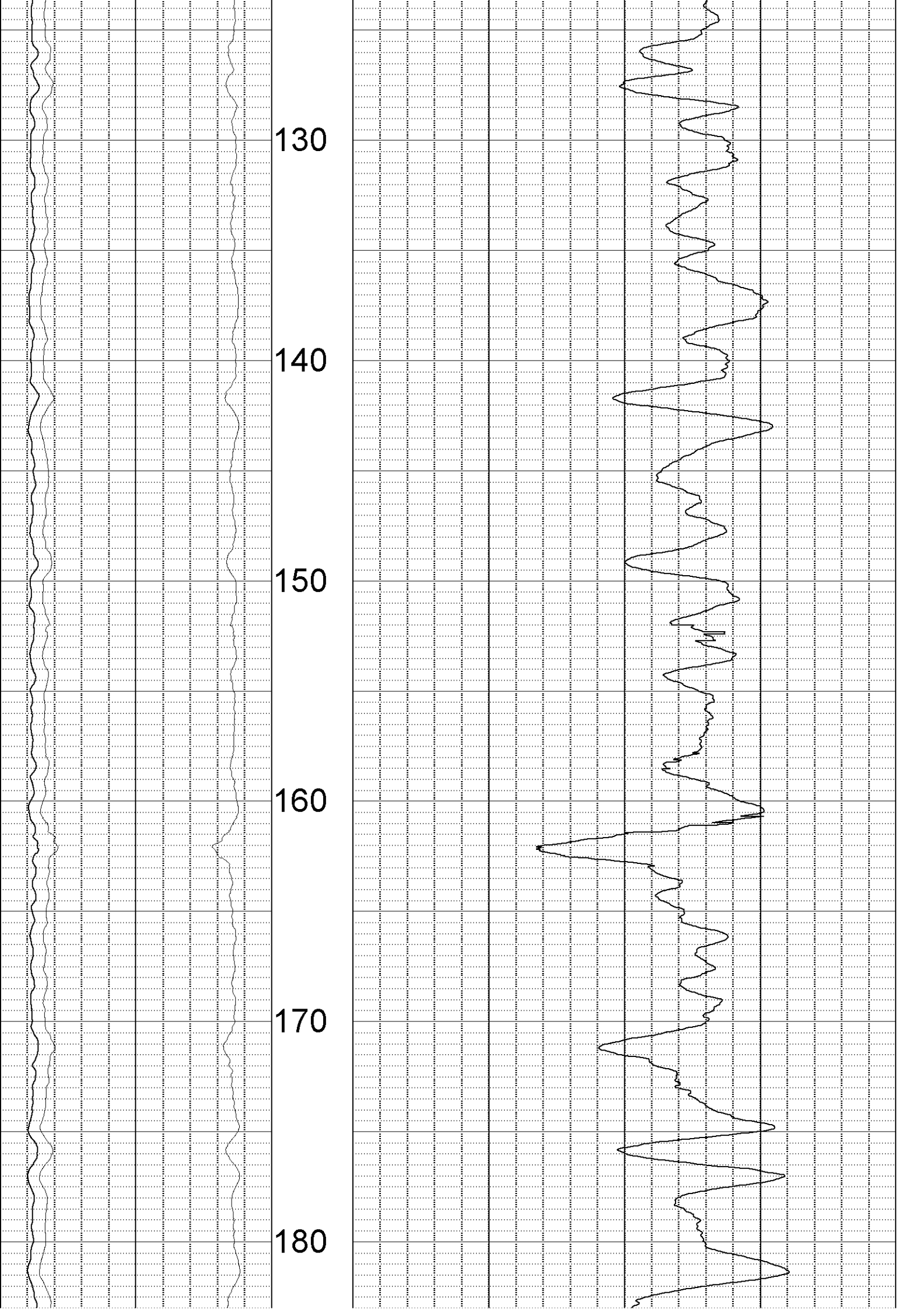
COMPANY	:	AGL					
WELL	:	WKMB04 VELOCITY 1:200					
LOCATION/FIELD	:	GLOUCESTER					
COUNTY	:	AUST					
LOCATION	:	N/A//					
SECTION	:	0	TOWNSHIP	:	0	RANGE	: 0
DATE	:	01/21/12	PERMANENT DATUM	:	GL		
DEPTH DRILLER	:	50				KB	: N/A
LOG BOTTOM	:	359.75	LOG MEASURED FROM:		GL	DF	: N/A
LOG TOP	:	10.55	DRL MEASURED FROM:		GL	GL	: -0.00
CASING DIAMETER	:	10.	LOGGING UNIT	:	T110		
CASING TYPE	:	PVC	FIELD OFFICE	:	RUTHERFORD		
CASING THICKNESS:		.5	RECORDED BY	:	M LEA		
BIT SIZE	:	14	BOREHOLE FLUID	:	0	FILE	: PROCESSED
MAGNETIC DECL.	:	0	RM	:	0	TYPE	: 9320A2
MATRIX DENSITY	:	2.65	RM TEMPERATURE	:	0	LGDATE	: 01/21/12
NEUTRON MATRIX	:	SANDSTONE	MATRIX DELTA T	:	177	LGTIME	: 09:54:
						THRESH:	99999

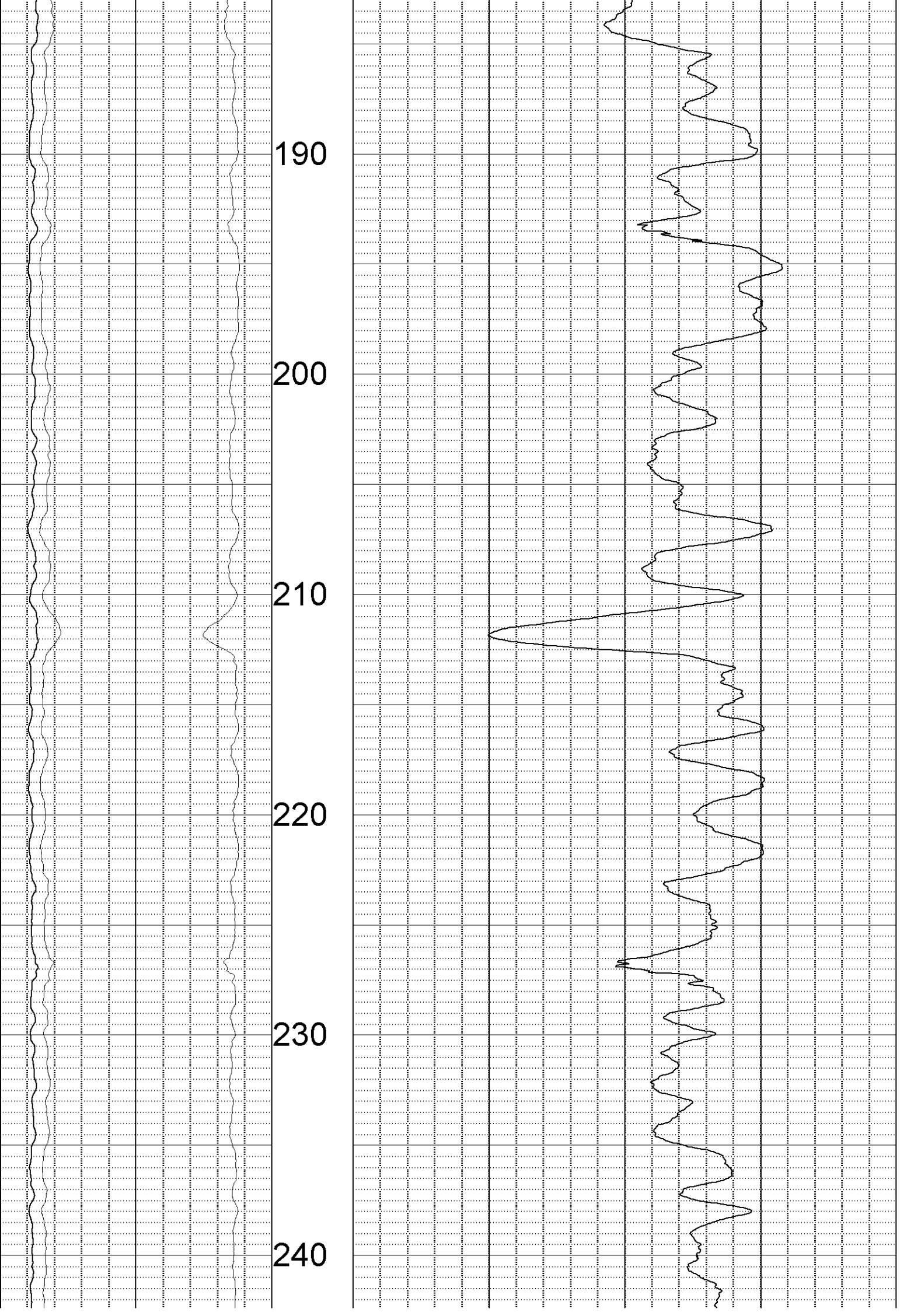
OTHER SERVICES:
IND DEN
NEU SON
N/A

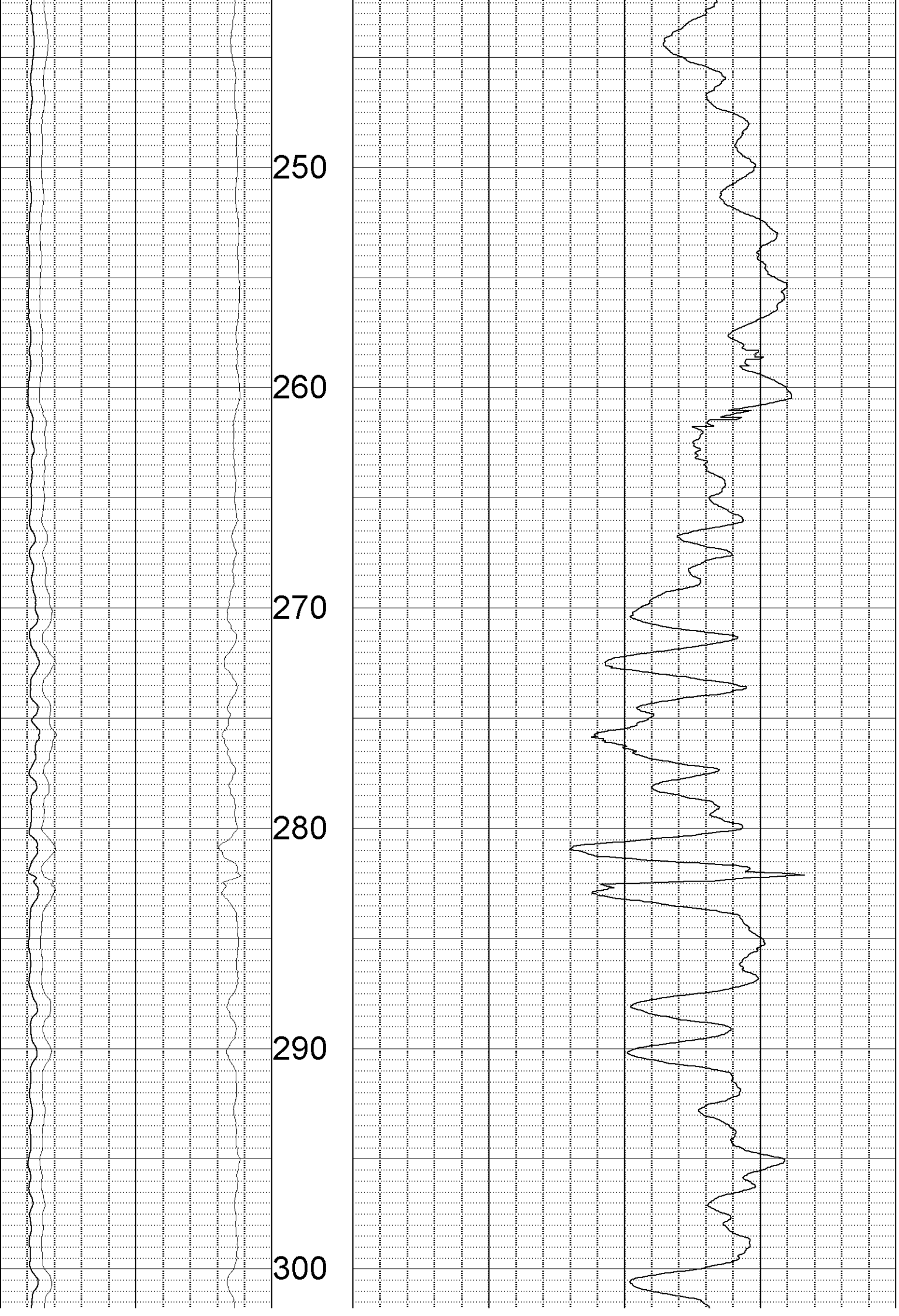
N/A
N/A

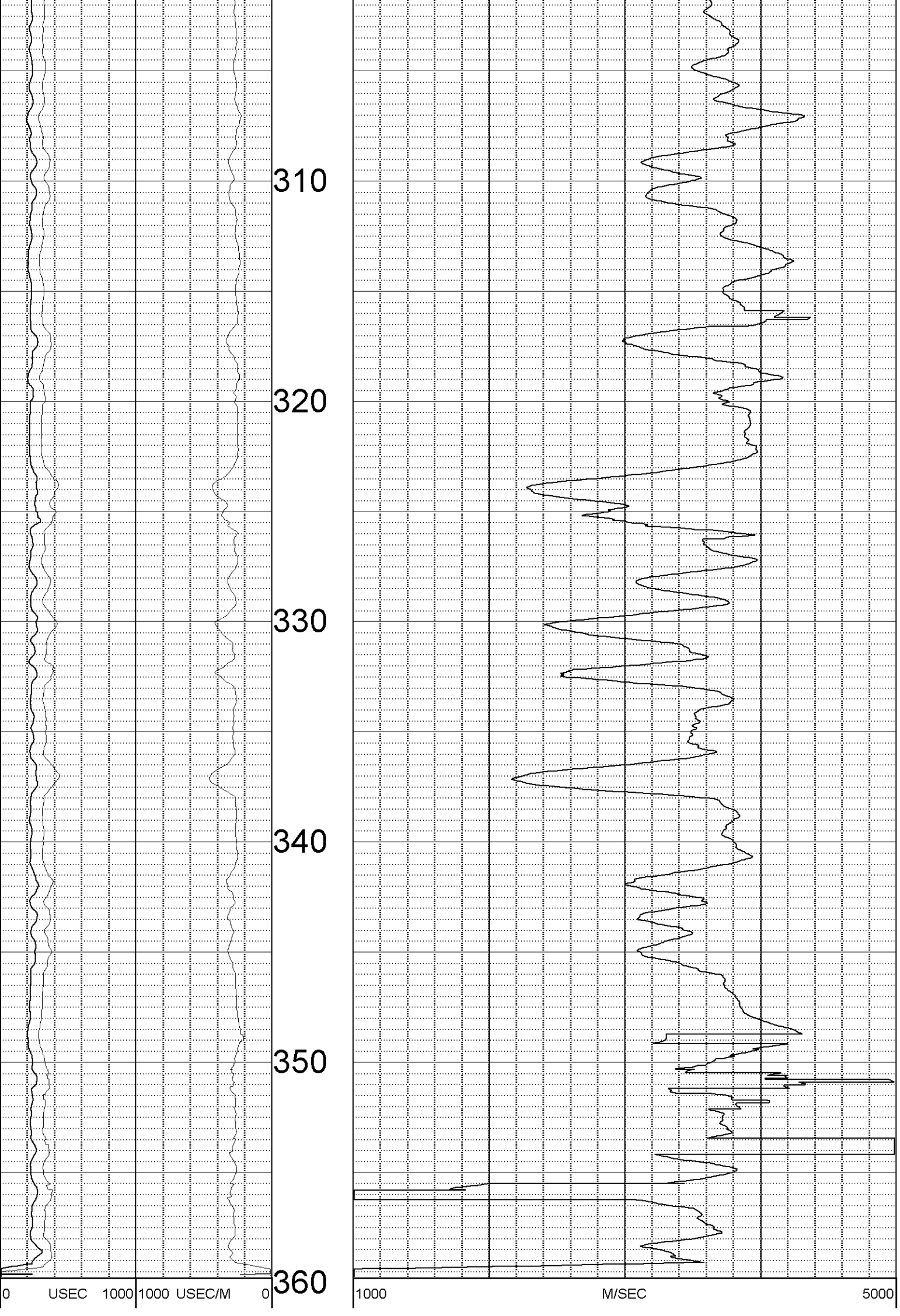

TIME(F)
0 USEC 1000
TIME(N)
0 USEC 1000
BHC-DELT
1000 USEC/M 0
METERS
10
20
30
40
50
60
VELOCITY
1000 M/SEC 5000


70
80
90
100
110
120


130
140
150
160
170
180


190
200
210
220
230
240


250
260
270
280
290
300


310
320
330
340
350
360
0 USEC 1000
1000 USEC/M 0
1000 M/SEC 5000

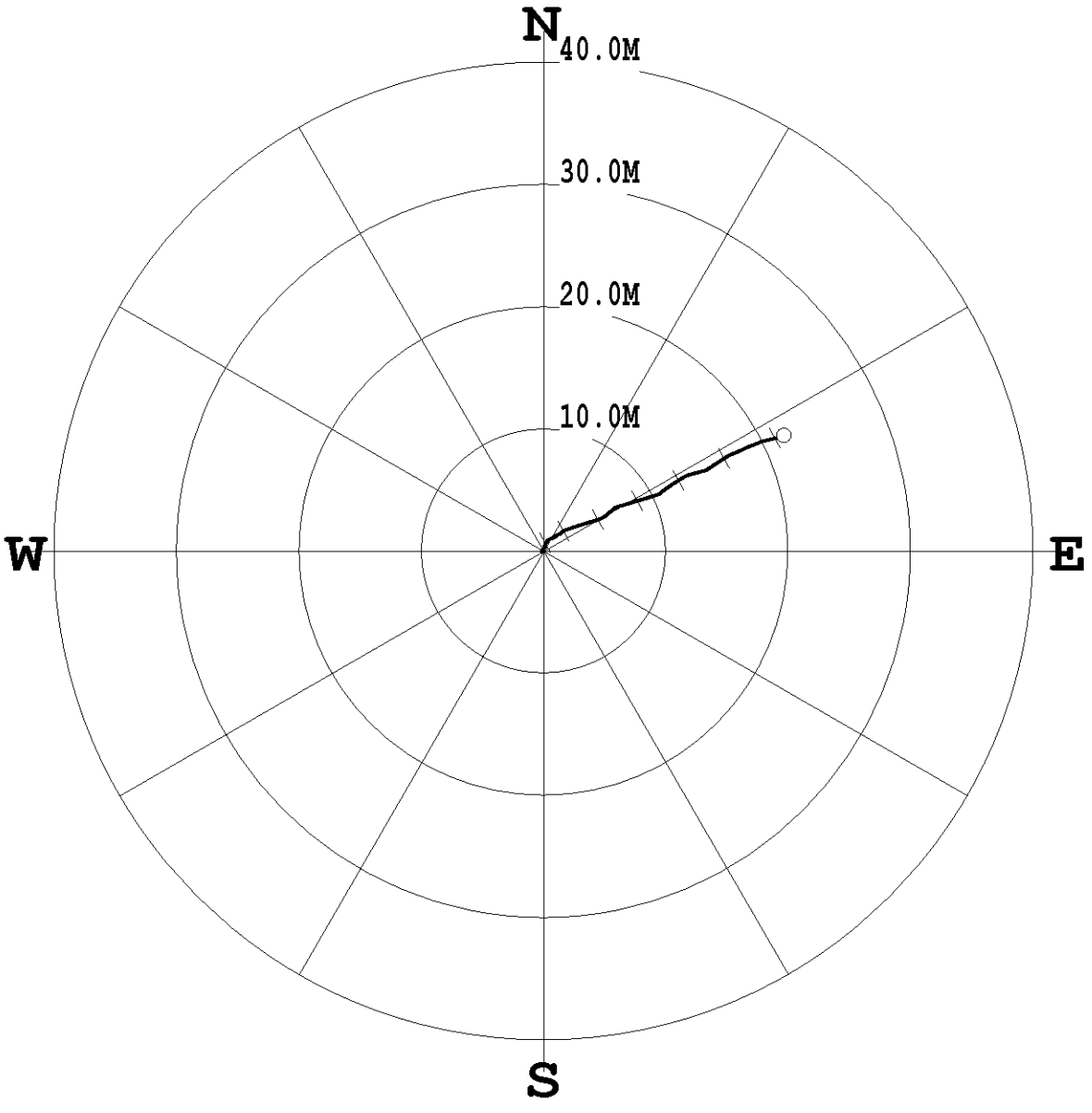
TIME(N)	BHC-DELT		VELOCITY
0 USEC 1000			
TIME(F)		METERS	

PLAN VIEW
COMPU-LOG DEVIATION

CLIENT: AGL
LOCATION: GLOUCESTER
HOLE ID: WKMB04 NEUTRON
DATE OF LOG: 01/21/12
PROBE: 9057A 2423

MAG DECL: 0.0

SCALE: 5 M/CM
TRUE DEPTH: 359.83 M
AZIMUTH: 64.3
DISTANCE: 21.8 M
+ = 50 M INCR
○ = BOTTOM OF HOLE



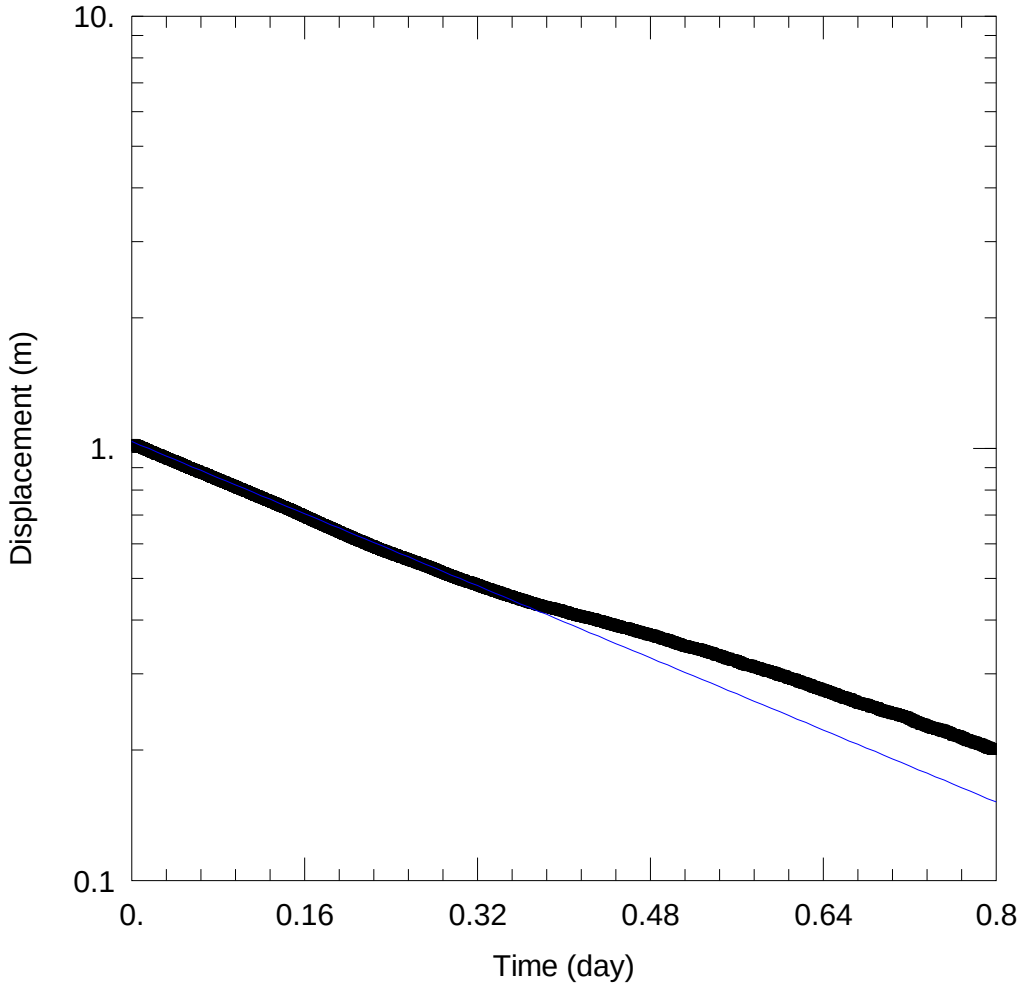
* * * * * * * COMPU-LOG - VERTICAL DEVIATION * * * * * * *

CLIENT : AGL
FIELD OFFICE : RUTHERFORD
DATA FROM : 0
MAG. DECL. : 0.000
HOLE ID. : WKMB04 NEUTRO
DATE OF LOG : 01/21/12
PROBE : 9057A , 2423
DEPTH UNITS : METERS
LOG: WKMB04NEUTRON_01-21-12_09-04_9057A_.01_-0.85_360.86_DEVI.log

CABLE DEPTH	TRUE DEPTH	NORTH DEV.	EAST DEV.	DISTANCE	AZIMUTH	SANG	SANGB
0.66	0.66	0.00	-0.00	0.0	338.6	0.3	338.6
10.00	10.00	-0.03	-0.07	0.1	248.5	0.3	245.4
20.00	20.00	0.06	-0.16	0.2	290.4	2.6	8.2
30.00	29.99	0.29	0.03	0.3	6.7	0.9	55.4
40.00	39.99	0.46	0.05	0.5	6.4	2.4	40.3
50.00	49.98	0.68	0.12	0.7	10.2	3.2	44.9
60.00	59.98	0.93	0.33	1.0	19.8	1.5	67.8
70.00	69.97	1.11	0.73	1.3	33.4	2.6	68.8
80.00	79.96	1.28	0.98	1.6	37.5	1.7	26.6
90.00	89.96	1.41	1.24	1.9	41.3	1.9	67.3
100.00	99.94	1.67	1.59	2.3	43.5	1.9	64.4
110.00	109.93	1.84	2.03	2.7	47.8	3.4	70.8
120.00	119.91	2.03	2.61	3.3	52.1	3.6	70.2
130.00	129.89	2.22	3.19	3.9	55.2	3.4	73.0
140.00	139.87	2.41	3.80	4.5	57.6	3.6	74.2
150.00	149.85	2.59	4.40	5.1	59.6	3.7	75.8
160.00	159.83	2.94	5.07	5.9	59.9	4.1	49.3
170.00	169.80	3.40	5.61	6.6	58.8	3.0	47.1
180.00	179.78	3.70	6.22	7.2	59.2	4.0	74.5
190.00	189.75	3.91	6.90	7.9	60.5	4.0	70.7
200.00	199.72	4.12	7.60	8.6	61.6	4.2	72.4
210.00	209.70	4.34	8.32	9.4	62.5	4.1	70.4
220.00	219.67	4.55	9.03	10.1	63.3	4.4	75.7
230.00	229.65	4.83	9.58	10.7	63.3	4.7	52.4
240.00	239.61	5.30	10.23	11.5	62.6	4.9	53.8
250.00	249.58	5.78	10.97	12.4	62.2	5.0	55.2
260.00	259.54	6.21	11.74	13.3	62.1	5.2	66.5
270.00	269.50	6.44	12.52	14.1	62.8	4.5	78.1
280.00	279.47	6.65	13.28	14.9	63.4	3.2	68.5
290.00	289.44	7.09	13.94	15.6	63.0	4.9	55.4
300.00	299.40	7.56	14.66	16.5	62.7	4.9	56.2
310.00	309.36	7.99	15.46	17.4	62.7	5.5	68.0
320.00	319.32	8.37	16.31	18.3	62.8	5.3	65.1
330.00	329.27	8.73	17.17	19.3	63.1	5.3	67.5
340.00	339.23	9.05	18.03	20.2	63.4	4.4	78.0
350.00	349.20	9.22	18.80	20.9	63.9	4.7	74.9
360.00	359.17	9.42	19.58	21.7	64.3	4.4	68.8
360.67	359.83	9.45	19.63	21.8	64.3	4.2	64.9

Appendix C

Hydraulic conductivity reports



WELL TEST ANALYSIS

Data Set: \...\WKMB01 D.aqt
Date: 08/16/12 Time: 16:26:28

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB01 falling C
Test Date: 16/5/12

AQUIFER DATA

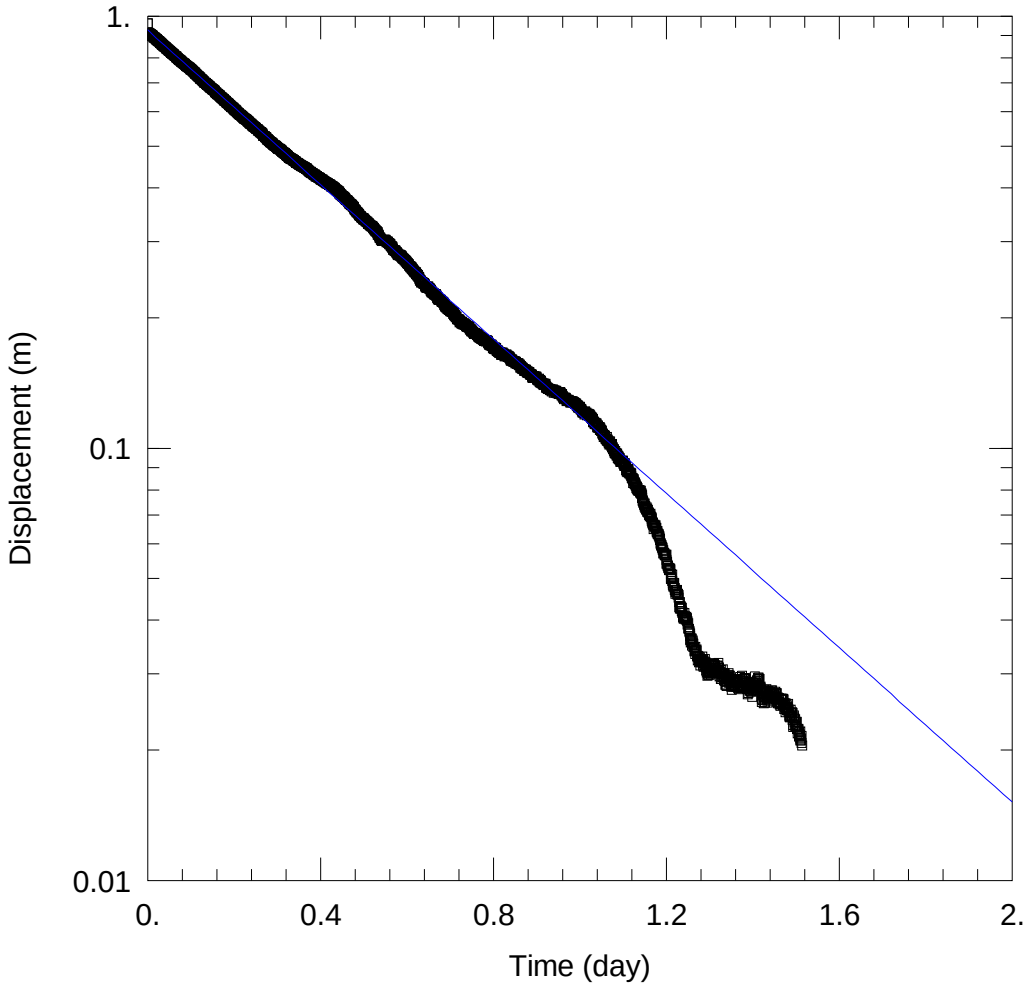
Saturated Thickness: 11. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 1.021 m
Total Well Penetration Depth: 48.17 m
Casing Radius: 0.025 m
Static Water Column Height: 48.17 m
Screen Length: 11. m
Well Radius: 0.07 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0003309 m/day
y0 = 1.036 m



WELL TEST ANALYSIS

Data Set: \...\WKMB01_B.aqt
Date: 08/16/12 Time: 16:13:16

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB01 rising
Test Date: 1/3/12

AQUIFER DATA

Saturated Thickness: 11. m Anisotropy Ratio (Kz/Kr): 1.

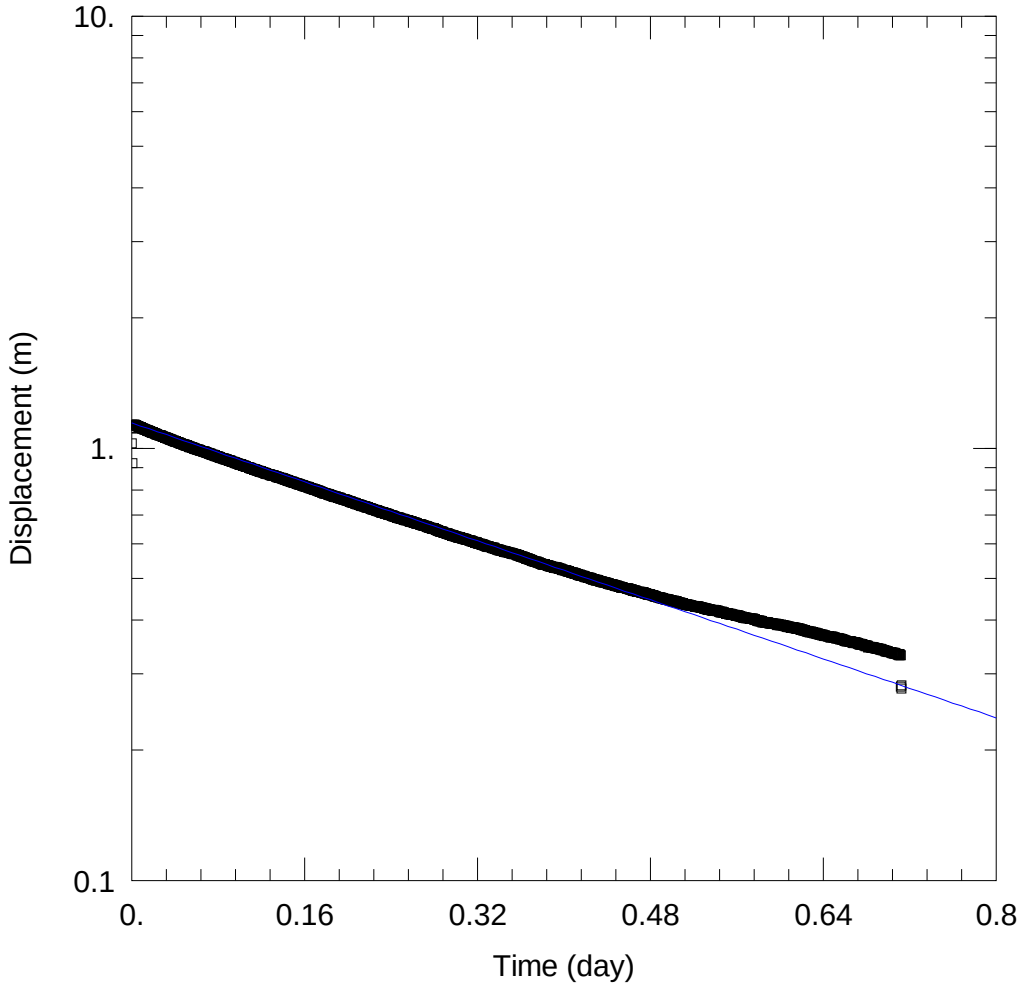
WELL DATA (WKMB01)

Initial Displacement: 0.9614 m Static Water Column Height: 48.59 m
Total Well Penetration Depth: 48.59 m Screen Length: 11. m
Casing Radius: 0.025 m Well Radius: 0.07 m

SOLUTION

Aquifer Model: Confined Solution Method: Bouwer-Rice

K = 0.0002838 m/day y0 = 0.9277 m



WELL TEST ANALYSIS

Data Set: \...\WKMB01_C.aqt
Date: 08/16/12 Time: 16:16:43

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB01 falling B
Test Date: 15/3/12

AQUIFER DATA

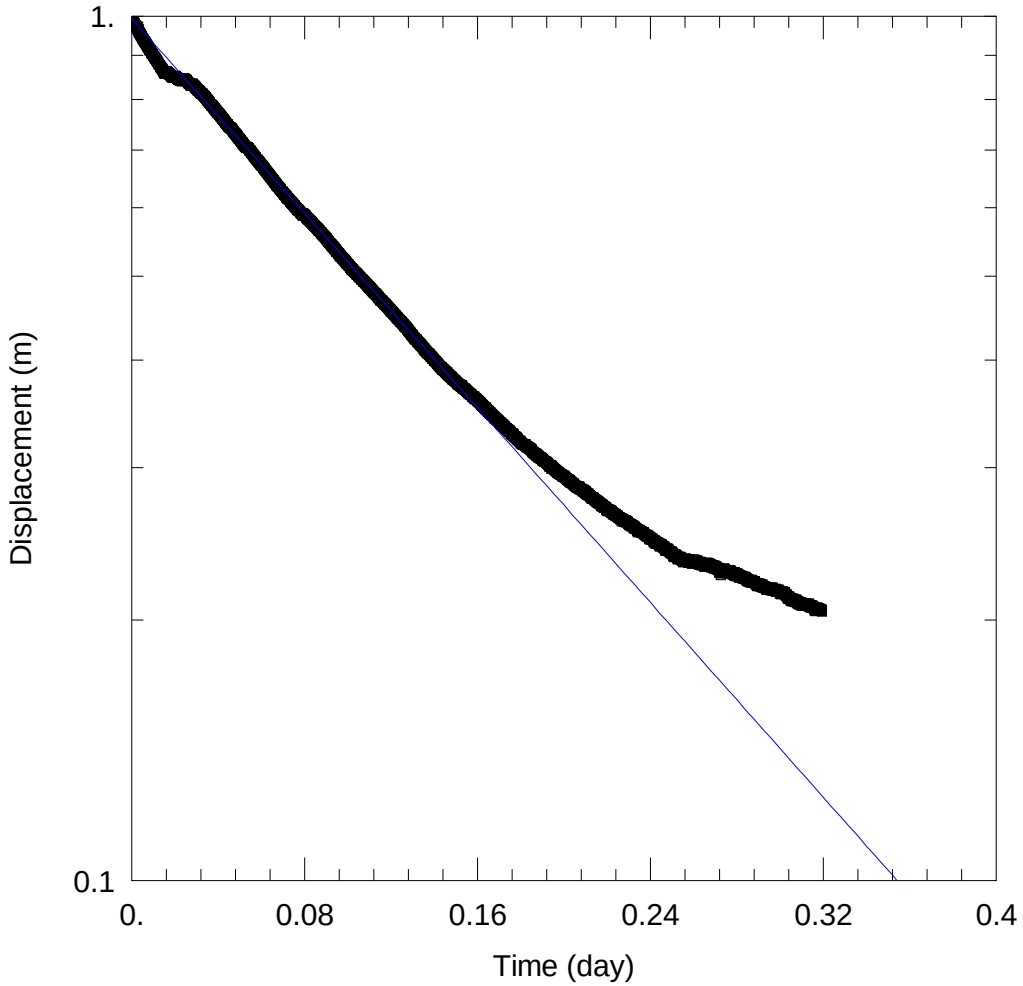
Saturated Thickness: 11. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 1.134 m
Total Well Penetration Depth: 48.59 m
Casing Radius: 0.025 m
Static Water Column Height: 48.59 m
Screen Length: 11. m
Well Radius: 0.07 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0002711 m/day
y0 = 1.145 m



WELL TEST ANALYSIS

Data Set: \...\WKMB02 A.aqt
Date: 08/16/12 Time: 13:50:55

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB02 falling head A
Test Date: 5/6/2012

AQUIFER DATA

Saturated Thickness: 16.5 m Anisotropy Ratio (Kz/Kr): 1.

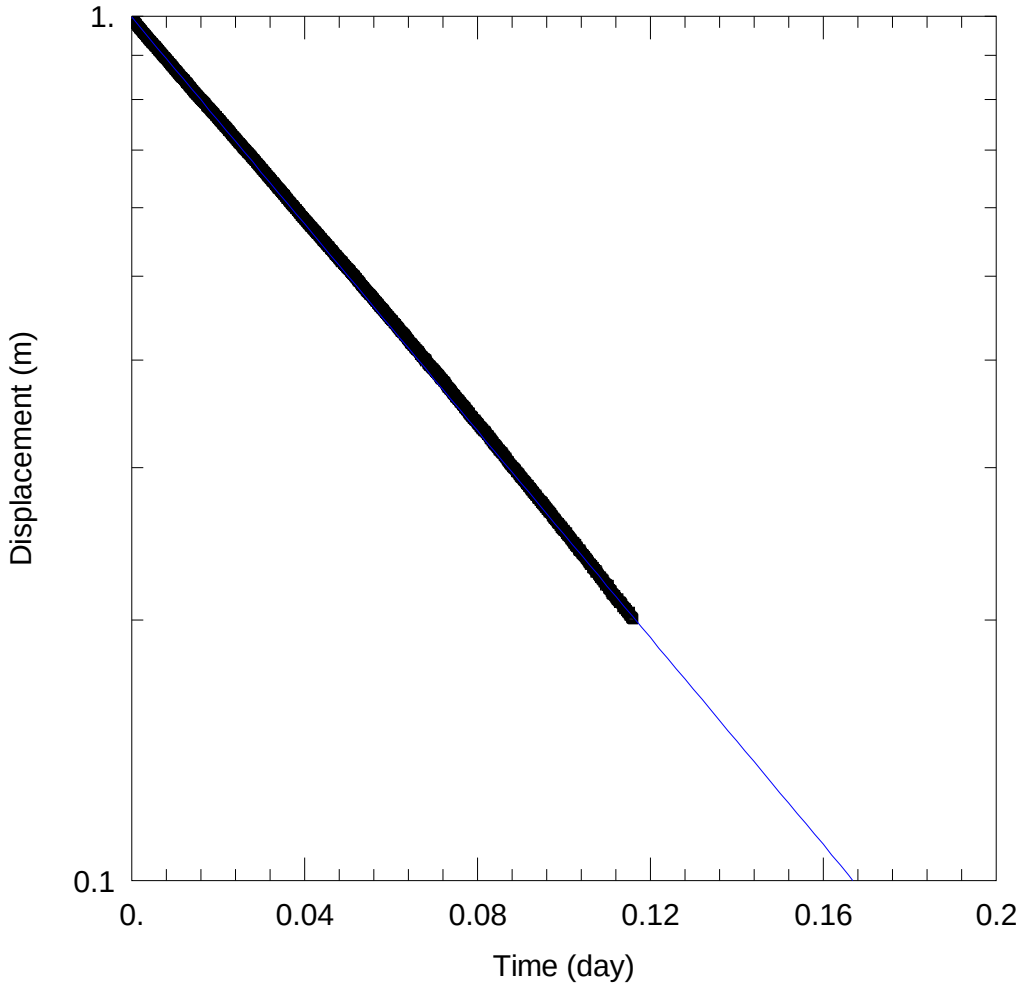
WELL DATA (New Well)

Initial Displacement: 0.9975 m
Total Well Penetration Depth: 53.53 m
Casing Radius: 0.025 m
Static Water Column Height: 53.53 m
Screen Length: 16.5 m
Well Radius: 0.0625 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice

K = 0.0006346 m/day
y0 = 0.9934 m



WELL TEST ANALYSIS

Data Set: \...\WKMB02 B.aqt
Date: 08/16/12 Time: 13:51:38

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB02 rising head
Test Date: 6/6/2012

AQUIFER DATA

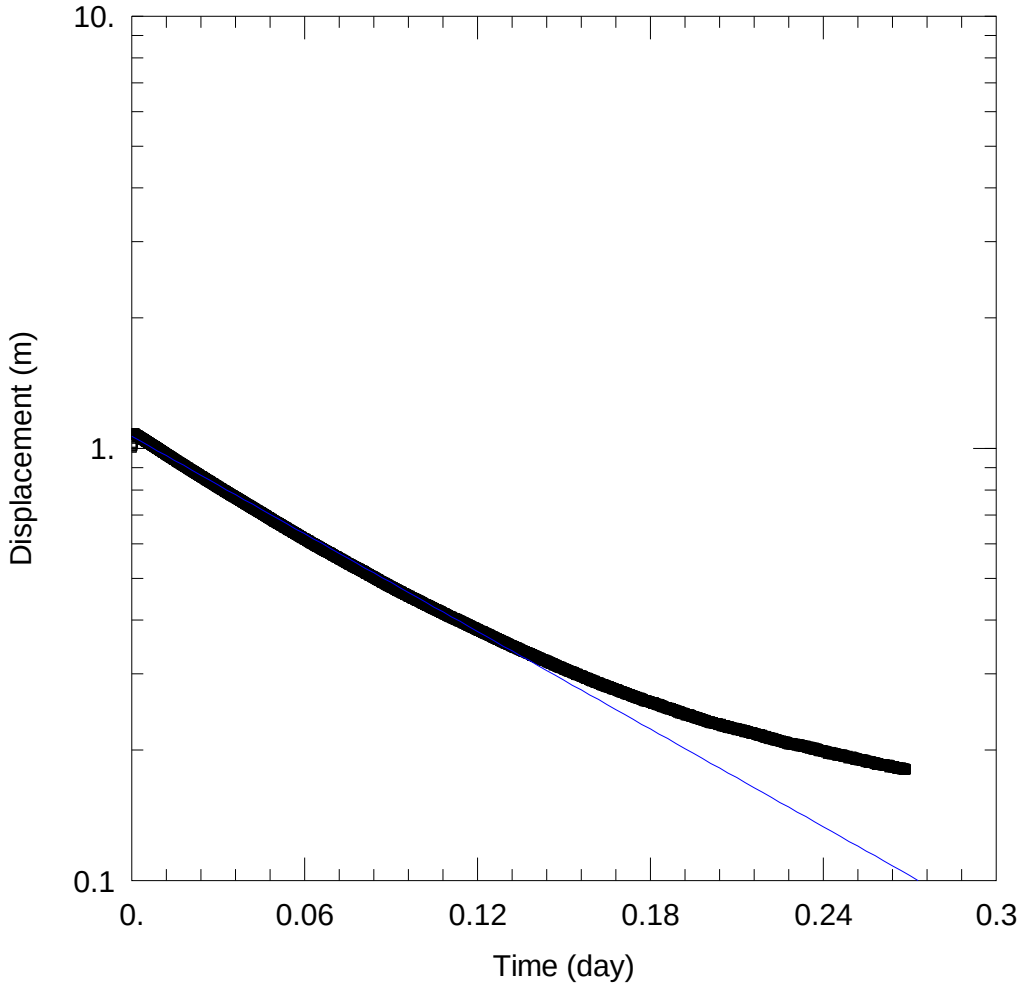
Saturated Thickness: 16.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 1.124 m
Total Well Penetration Depth: 53.53 m
Casing Radius: 0.025 m
Static Water Column Height: 53.53 m
Screen Length: 16.5 m
Well Radius: 0.0625 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.001349 m/day
y0 = 0.997 m



WELL TEST ANALYSIS

Data Set: \...\WKMB02 C.aqt
Date: 08/16/12 Time: 13:39:31

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB02 falling head B
Test Date: 7/6/2012

AQUIFER DATA

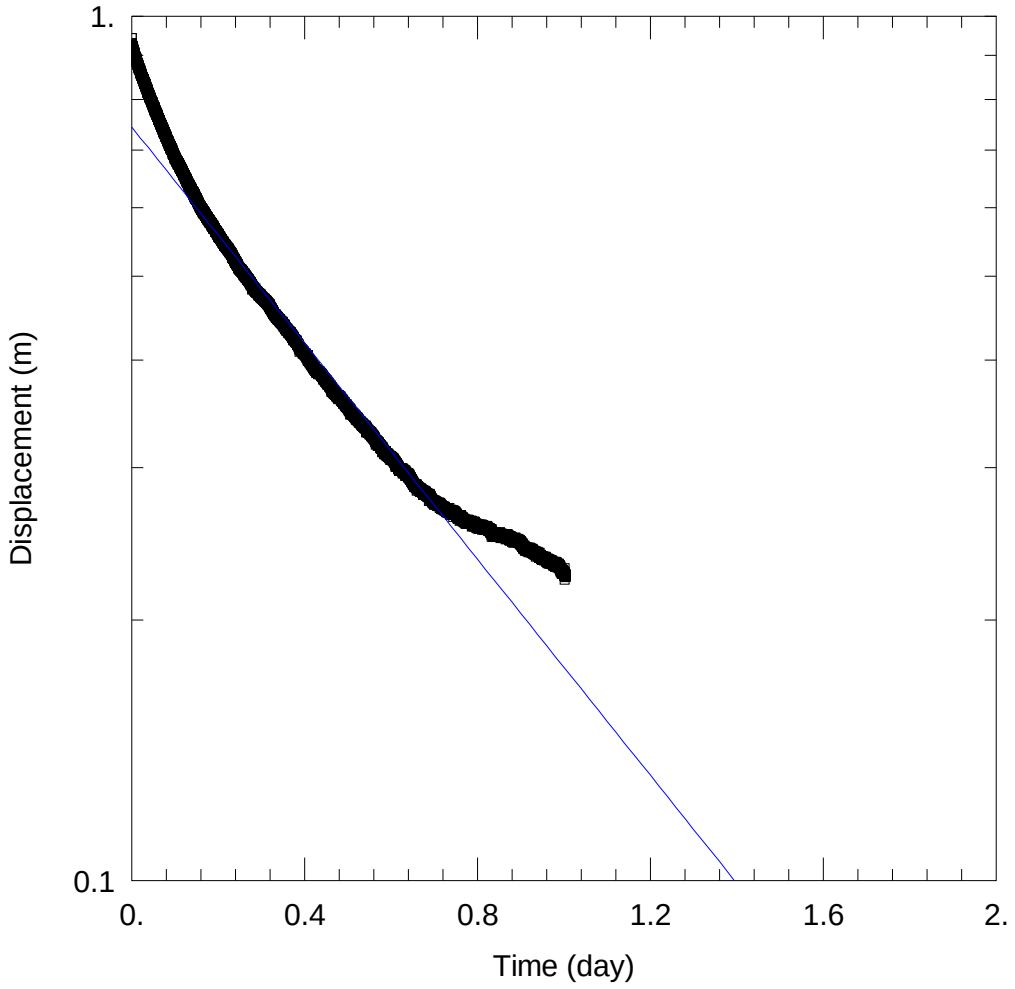
Saturated Thickness: 16.5 m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 1.085 m
Total Well Penetration Depth: 53.53 m
Casing Radius: 0.025 m
Static Water Column Height: 53.53 m
Screen Length: 16.5 m
Well Radius: 0.0625 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0008489 m/day
y0 = 1.066 m



WELL TEST ANALYSIS

Data Set: \...\WKMB03 A.aqt
Date: 08/16/12 Time: 13:58:43

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB03 falling head
Test Date: 12/6/2012

AQUIFER DATA

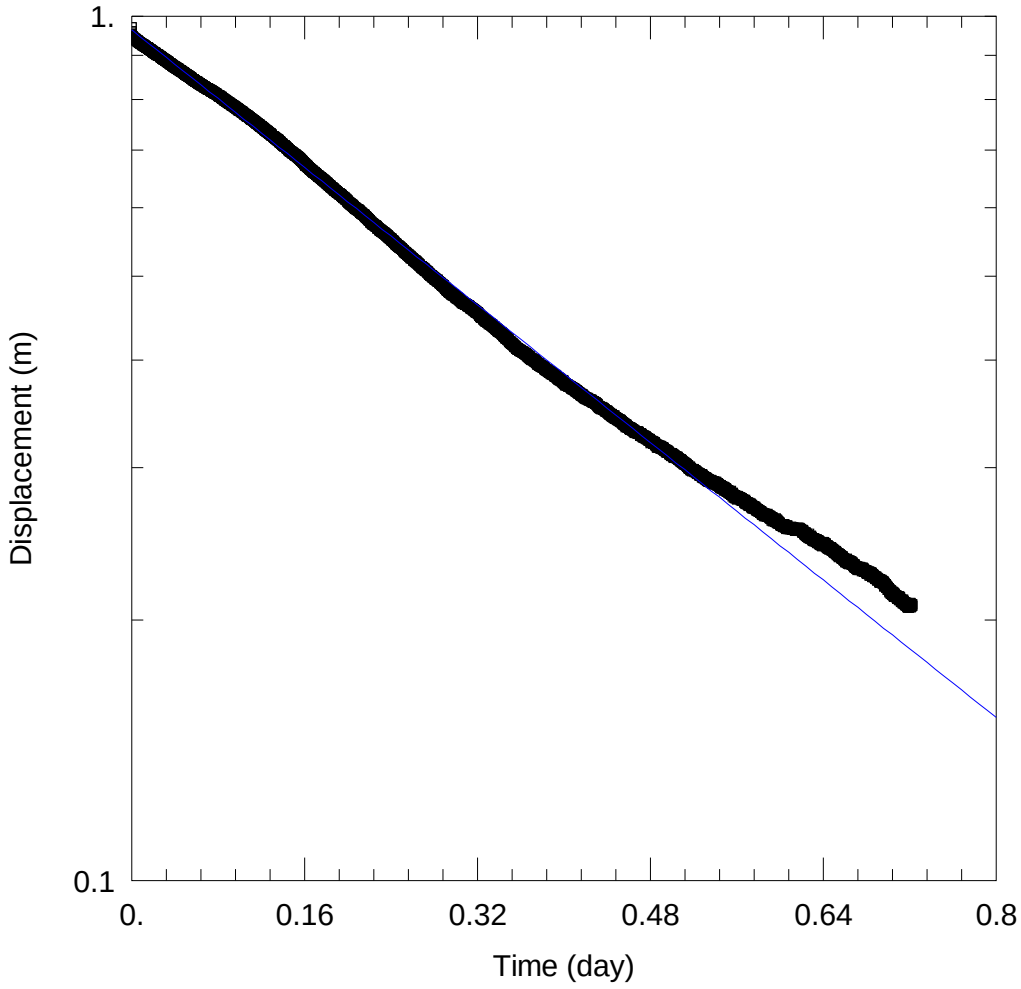
Saturated Thickness: 16. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

Initial Displacement: 0.9436 m
Total Well Penetration Depth: 203.9 m
Casing Radius: 0.025 m
Static Water Column Height: 203.9 m
Screen Length: 16. m
Well Radius: 0.0625 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0001684 m/day
y0 = 0.7443 m



WELL TEST ANALYSIS

Data Set: \...\WKMB03 B.aqt
Date: 08/16/12 Time: 14:04:13

PROJECT INFORMATION

Company: Parsons Brinckerhoff
Client: AGL Energy Ltd
Project: 2162406C
Location: Waukivory
Test Well: WKMB03 rising head
Test Date: 13/6/2012

AQUIFER DATA

Saturated Thickness: 16. m Anisotropy Ratio (Kz/Kr): 1.

WELL DATA (New Well)

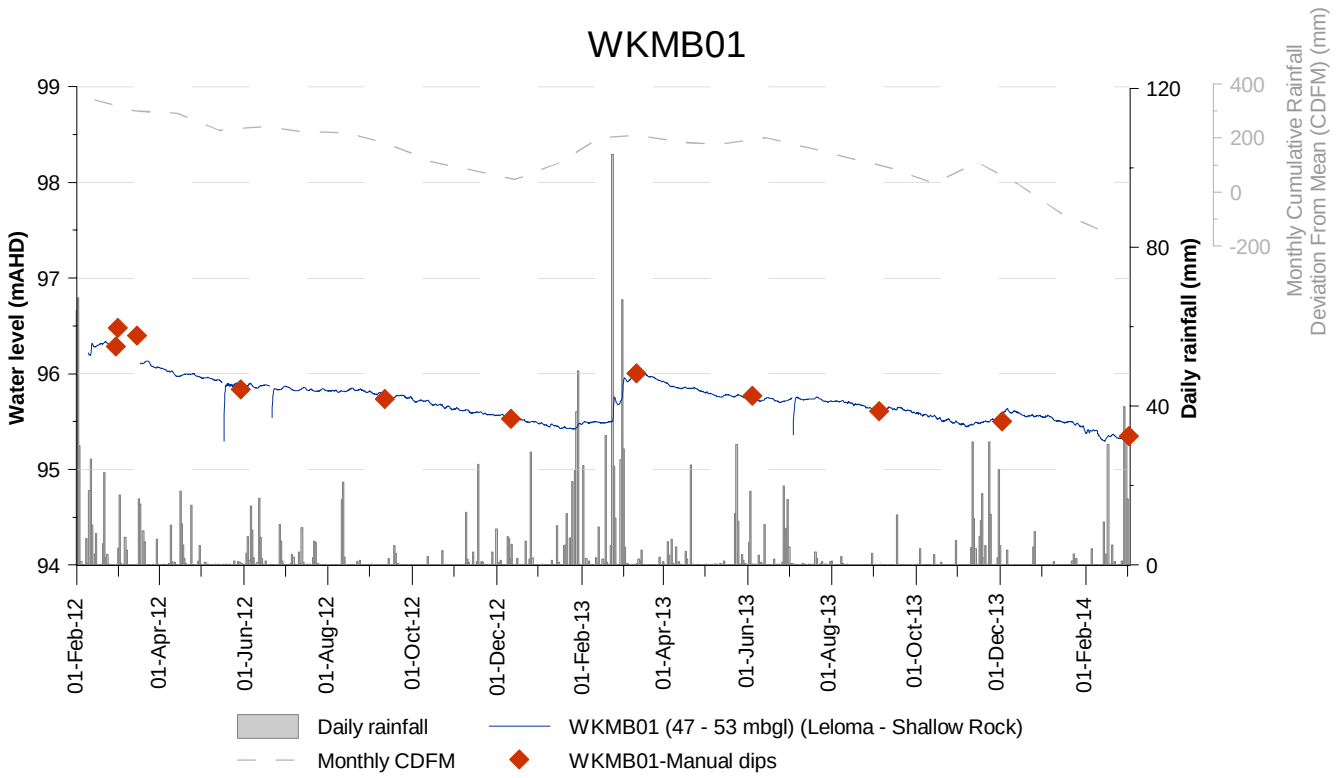
Initial Displacement: 0.9706 m
Total Well Penetration Depth: 203.9 m
Casing Radius: 0.025 m
Static Water Column Height: 203.9 m
Screen Length: 16. m
Well Radius: 0.0625 m

SOLUTION

Aquifer Model: Confined
Solution Method: Bouwer-Rice
K = 0.0002678 m/day
y0 = 0.9639 m

Appendix D

Hydrographs



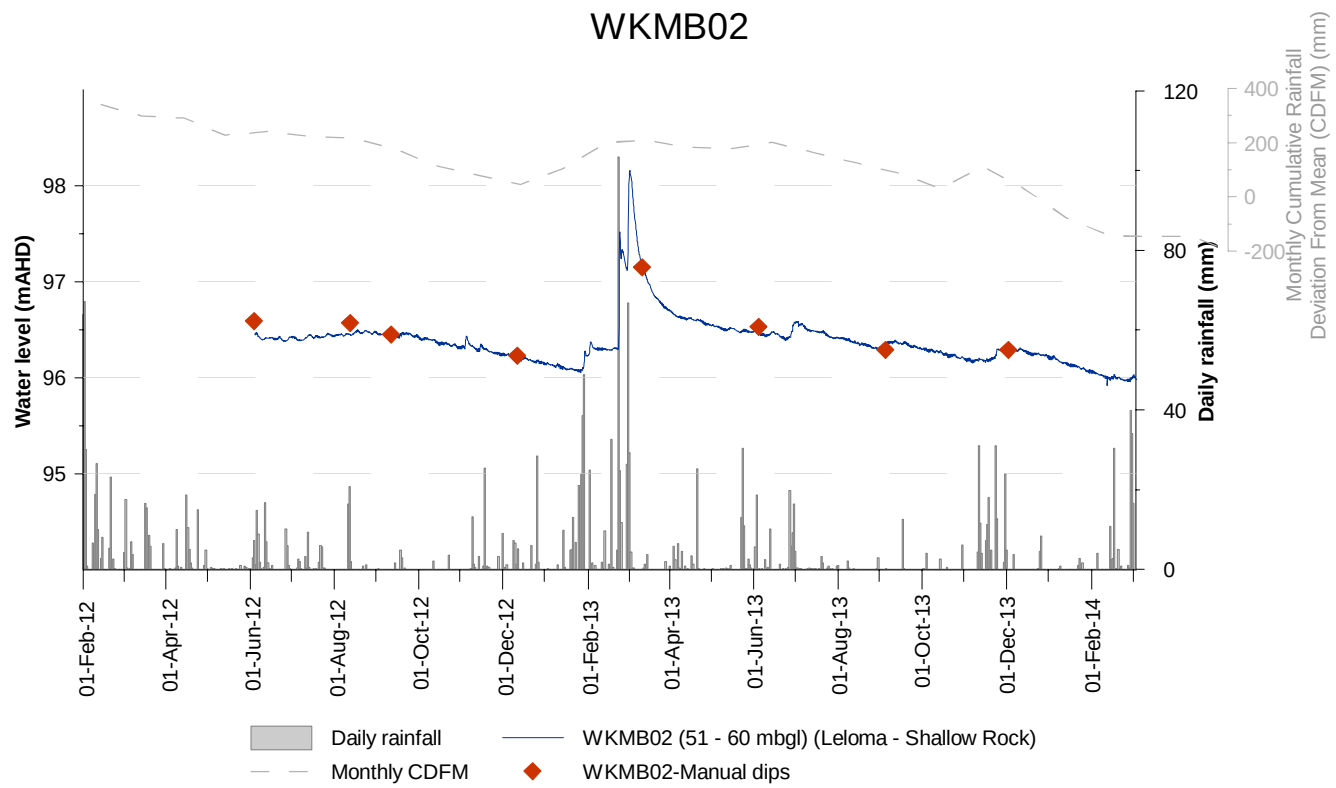


Figure D1: Groundwater and levels at WKMB01 and WKMB02

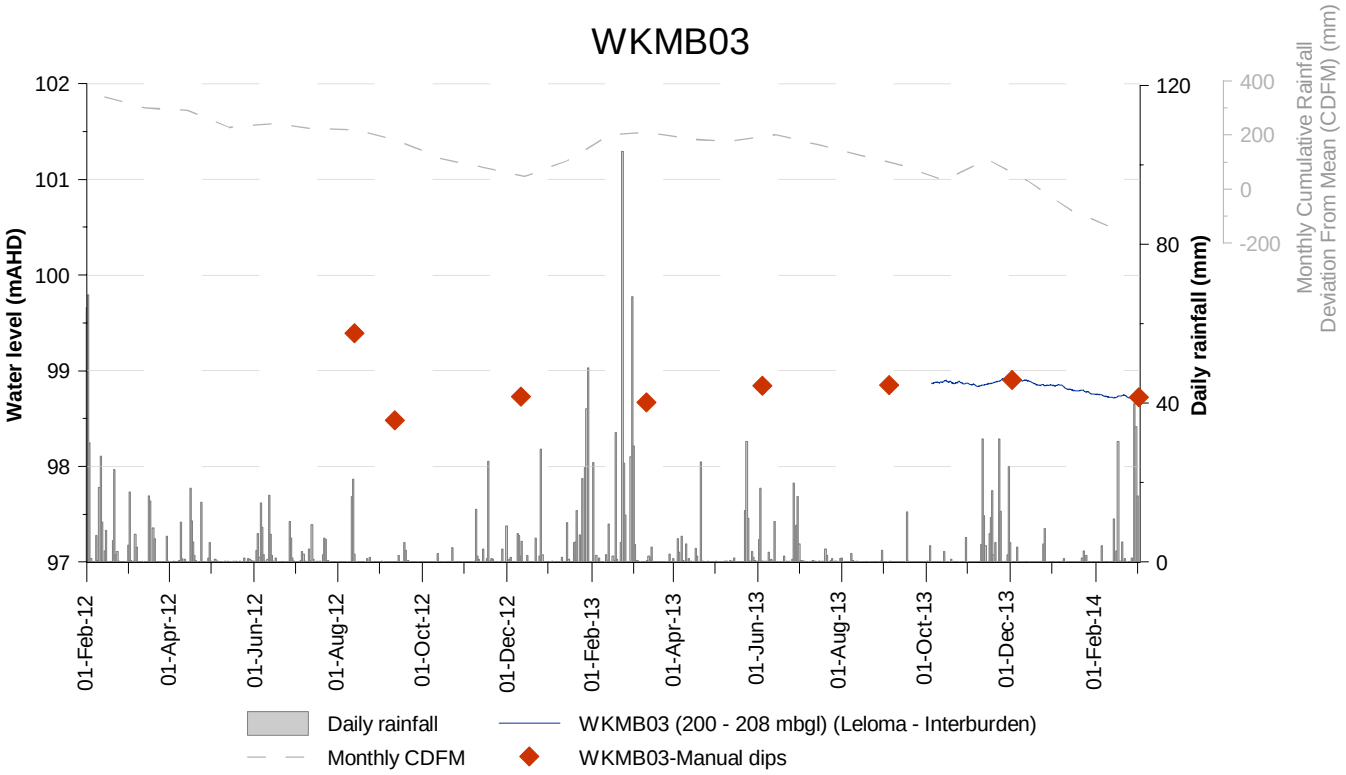


Figure D2: Groundwater levels and rainfall at WKMB03

Appendix E

Water quality summary table

Summary Table E.1: Waukivory water quality results

Analyte	Units	LOR	ANZECC 2000 Guidelines	WKMB01	WKMB02	WKMB03	WKMB04
Sample date				19/06/2012	21/08/2012	21/08/2012	23/10/2013
Lithology				Sandstone	Siltstone / sandstone	Siltstone / sandstone	Siltstone / sandstone / coal
Formation				Leloma	Leloma	Deards	Jilleon
Aquifer				Shallow bedrock	Interburden	Interburden	Interburden
Screen Depth (mbgl)				47 - 53	51-60	200-209	335-347
General parameters							
Conductivity (field)	µS/cm	1	125 - 2,200*	**5,436**	1,013	1,563	**16,420**
Conductivity (lab)				**6,100**	1,030	**3,050**	**16,500**
pH (field)	pH units	0.01	6.5-8.0*	7.87	**9.20**	**9.95**	**8.33**
pH (lab)				**8.27**	**9.07**	**10.00**	na
Temperature	^{o}C	0.1	-	17.76	17.26	18.02	29.00
Dissolved Oxygen	% sat	0.1	85-110 %* saturation	**3.6**	**37.4**	**80.9**	**41.9**
Dissolved Oxygen	mg/L	0.01	-	0.38	3.71	7.63	3.04
TDS (field)	mg/L	1	-	3.533	0.660	0.690	10.67
TDS (lab)				3,540	688	2,240	11,000
Redox	mV	0.1	-	-338.3	22.7	-19.6	34.8
Water type #	-	-	-	Na-Cl-HCO_3	Na-HCO_3-SO_4-Cl	Na-CO_3-Cl	Na-HCO_3-Cl
Laboratory Analytes							
Hydroxide alkalinity as $CaCO_3$	mg/L	1	-	<1	<1	<1	<1
Carbonate alkalinity as $CaCO_3$	mg/L	1	-	<1	73	688	375
Bicarbonate alkalinity as $CaCO_3$	mg/L	1	-	763	215	266	6,700
Total alkalinity as $CaCO_3$	mg/L	1	-	763	288	954	7,080
Sulfate as SO_4^{2-}	mg/L	1	-	349	129	94	<1
Chloride	mg/L	1	-	1,420	80	371	2,580
Calcium	mg/L	1	-	23	7	5	10
Magnesium	mg/L	1	-	28	<1	<1	47
Sodium	mg/L	1	-	1,470	236	625	4,650
Potassium	mg/L	1	-	7	7	35	25
Silica	mg/L	0.1	-	16.2	22.9	10.4	16.6
Fluoride	mg/L	0.1		0.4	0.3	1.4	0.6
Ions							
Total Anions	meq/L	0.01	-	62.6	10.7	31.5	214.0
Total Cations	meq/L	0.01	-	67.6	10.8	29.3	207.0
Ionic Balance	%	0.01	-	3.81	0.40	3.62	1.71
Dissolved Metals							
Aluminium	mg/L	0.01	0.055	**0.06**	**0.19**	**0.76**	0.02
Arsenic	mg/L	0.001	0.013 (As V)	0.002	0.002	0.003	0.002
Barium	mg/L	0.001	-	0.629	0.072	0.405	31
Beryllium	mg/L	0.001	ID	<0.001	<0.001	<0.001	<0.001
Cadmium	mg/L	0.0001	0.0002	<0.0001	<0.0001	<0.0001	<0.0001
Cobalt	mg/L	0.001	ID	<0.001	<0.001	<0.001	<0.001
Copper	mg/L	0.001	0.0014	<0.001	0.001	**0.004**	<0.001
Lead	mg/L	0.001	0.0034	<0.001	<0.001	**0.049**	0.002
Manganese	mg/L	0.001	1.9	0.101	0.002	0.008	0.014
Mercury	mg/L	0.0001	0.0006	na	na	na	<0.0001
Molybdenum	mg/L	0.001	ID	0.002	0.004	0.015	0.010
Nickel	mg/L	0.001	0.011	**0.014**	0.001	0.002	**0.012**
Selenium	mg/L	0.01	0.011 (total)	<0.01	<0.01	<0.01	<0.01
Strontium	mg/L	0.001	-	3.75	0.463	0.758	28.000
Uranium	mg/L	0.001	ID	0.005	<0.001	<0.001	0.001
Vanadium	mg/L	0.01	ID	<0.01	<0.01	<0.01	<0.01
Zinc	mg/L	0.005	0.008	**0.018**	**0.018**	**1.220**	**1.530**
Boron	mg/L	0.05	0.37	<0.05	<0.05	0.10	0.11
Iron	mg/L	0.05	ID	0.96	<0.05	0.20	0.52
Bromine	mg/L	0.1	ID	3.7	0.2	0.8	5.6
Nutrients							
Ammonia as N	mg/L	0.01	0.02b	0.75	0.44	13.50	3.70
Nitrite as N	mg/L	0.01	0.02b	<0.01	<0.01	<0.01	<0.01
Nitrate as N	mg/L	0.01	0.7	<0.01	<0.01	0.02	<0.01
Nitrite + Nitrate as N	mg/L	0.01	-	<0.01	<0.01	0.02	<0.01
Total Phosphorous	mg/L	0.01	0.05b	0.22	0.11	0.43	0.33
Reactive Phosphorous	mg/L	0.01	0.02b	0.10	0.07	0.04	0.04
Total Organic Carbon	mg/L	1	-	15	3	168	60
Dissolved Gases							
Methane	µg/L	10	-	7,400	4,340	32,100	3,150
Ethene	µg/L	10	-	<10	<10	<10	<10
Ethane	µg/L	10	-	<10	<10	<10	<10
Propene	µg/L	10	-	<10	<10	<10	<10
Propane	µg/L	10	-	<10	<10	<10	<10
Butane	µg/L	10	-	<10	<10	<10	<10
Butene	µg/L	10	-	<10	<10	<10	<10
Phenolic compounds							
Phenol	µg/L	1	320	<1	<1	1.3	<1
2-Chlorophenol	µg/L	1	490	<1	<1	<1	<1
2-Methylphenol	µg/L	1	-	<1	<1	<1	<1
3-&4-Methylphenol	µg/L	2	-	<2	<2	<2	<2
2-Nitrophenol	µg/L	1	ID	<1	<1	<1	<1
2.4-Dimethylphenol	µg/L	1	ID	<1	<1	<1	<1
2.4-Dichlorophenol	µg/L	1	160	<1	<1	<1	<1
2.6-Dichlorophenol	µg/L	1	ID	<1	<1	<1	<1
4-Chloro-3-Methylphenol	µg/L	1	-	<1	<1	<1	<1
2.4.6-Trichlorophenol	µg/L	1	20	<1	<1	<1	<1
2.4.5-Trichlorophenol	µg/L	1	ID	<1	<1	<1	<1
Pentachlorophenol	µg/L	2	ID	<2	<2	<2	<2
Polycyclic aromatic hydrocarbons							
Naphthalene	µg/L	1	0.016	<1	<1	<1	<1
Acenaphthylene	µg/L	1	-	<1	<1	<1	<1
Acenaphthene	µg/L	1	-	<1	<1	<1	<1
Fluorene	µg/L	1	-	<1	<1	<1	<1
Phenanthrene	µg/L	1	ID	<1	<1	<1	<1
Anthracene	µg/L	1	ID	<1	<1	<1	<1
Fluoranthene	µg/L	1	ID	<1	<1	<1	<1
Pyrene	µg/L	1	-	<1	<1	<1	<1
Benz(a)anthracene	µg/L	1	-	<1	<1	<1	<1
Chrysene	µg/L	1	-	<1	<1	<1	<1
Benzo(b)fluoranthene	µg/L	1	-	<1	<1	<1	<1
Benzo(k)fluoranthene	µg/L	1	-	<1	<1	<1	<1
Benzo(a)pyrene	µg/L	0.5	ID	<0.5	<0.5	<0.5	<0.5
Indeno(1.2.3.cd)pyrene	µg/L	1	-	<1	<1	<1	<1
Dibenz(a.h)anthracene	µg/L	1	-	<1	<1	<1	<1
Benzo(g.h.i)perylene	µg/L	1	-	<1	<1	<1	<1
Total petroleum hydrocarbons							
C6-C9 Fraction	µg/L	20	ID	<20	<20	<20	<20
C10-C14 Fraction	µg/L	50	ID	<50	<50	<50	<50
C15-C28 Fraction	µg/L	100	ID	<100	<100	270	14,700
C29-C36 Fraction	µg/L	50	ID	<50	<50	140	7,820
C10-C36 Fraction (sum)	µg/L	50	-	<50	<50	410	22,500
Total recoverable hydrocarbons							
C6-C10 Fraction	µg/L	20	-	<20	<20	<20	<20
C6-C10 Fraction minus BTEX (F1)	µg/L	20	-	<20	<20	<20	<20
>C10-C16 Fraction	µg/L	100	-	<100	<100	<100	100
>C16-C34 Fraction	µg/L	100	-	<100	<100	300	20,500
>C34-C40 Fraction	µg/L	100	-	<100	<100	<100	3,480
>C10-C40 Fraction (sum)	µg/L	100	-	<100	<100	300	24,100
Aromatic Hydrocarbons							
Benzene	µg/L	1	950	<1	<1	<1	<1
Toluene	µg/L	2	ID	<2	<2	<2	<2
Ethyl Benzene	µg/L	2	ID	<2	<2	<2	<2
m&p-Xylenes	µg/L	2	ID	<2	<2	<2	<2
o-Xylenes	µg/L	2	350	<2	<2	<2	<2
Total xlyenes	µg/L	2	-	<2	<2	<2	<2
Sum of BTEX	µg/L	1	-	<1	<1	<1	<1
Naphthalene	µg/L	5	-	<5	<5	<5	<5
Isotopes							
Oxygen-18	‰	0.01	-	-4.13	-4.27	-5.53	-6.94
Deuterium	‰	0.1	-	-22.5	-22.9	-30.2	-47.8
Carbon-13	‰	0.1	-	-15.6	-16.2	-1.8	33.05
Radiocarbon	pMC	0.1	-	67.07±0.2	36.09±0.1	11.9	0.43±0.07
Radiocarbon Age (uncorrected)	yrs BP	1	-	3,148±24	8,126±24	1,7041±48	43,634±1,324
Chlorine-36	^{36}Cl/Cl (x10^{-15})		-	na	na	na	26.6±1.8
Tritium	TU	0.01	-	0.12^±0.03	0.23±0.03	0.33±0.03	na
13C in Methane	VPDB		-	-45.6	-42.9^	-22.5	-32.38
2H in Methane	VSMOW		-	-135.6^	-176.4^	-213.7	-194.1
13C of Dissolved Inorganic Carbon	VPDB		-	na	na	na	32.45

Bold indicates exceedance of guideline value
na - not analysed
ID - Insufficient data
Calculated using Aquachem.

PARSONS BRINCKERHOFF

Guideline values

ANZECC 2000 - Water Quality Guidelines: 95% protection levels (trigger values) for the protection of freshwater aquatic ecosystems.

* ANZECC 2000 - Water Quality Guidelines: 95% protection levels (trigger values) for the protection of freshwater aquatic ecosystems, South-East Australia, low lying river ecosystems.

^ This result is below the Minimum Detectable Activity (MDA) and Limit of Quantification (Quant Limit) and therefore has an unacceptable level of uncertainty. Hence the data should only be used as an indicator of true concentration.

Appendix F

ALS laboratory reports

Environmental Division

CERTIFICATE OF ANALYSIS

Work Order	: **ES1215392**	Page	: 1 of 7
Client	: **PARSONS BRINCKERHOFF AUST P/L**	Laboratory	: Environmental Division Sydney
Contact	: MS NINA PEARSE-HAWKINS	Contact	: Loren Schiavon
Address	: GPO BOX 5394 SYDNEY NSW, AUSTRALIA 2001	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: npearsehawkins@pb.com.au	E-mail	: loren.schiavon@alsglobal.com
Telephone	: +61 02 9272 5100	Telephone	: +61 2 8784 8503
Facsimile	: +61 02 9272 5101	Facsimile	: +61 2 8784 8500
Project	: 2162406C	QC Level	: NEPM 1999 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 21-JUN-2012
Sampler	: NPH	Issue Date	: 28-JUN-2012
Site	: ----		
		No. of samples received	: 1
Quote number	: SY/394/09	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Ashesh Patel	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: WKMB01	----	----	----	----
				Client sampling date / time: 19-JUN-2012 15:00	----	----	----	----
				ES1215392-001	----	----	----	----
EA005P: pH by PC Titrator								
pH Value	----	0.01	pH Unit	**8.27**	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**6100**	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	GIS-210-010	1	mg/L	**3540**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	<1	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**763**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**763**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	**349**	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**1420**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**23**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**28**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**1470**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**7**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Aluminium	7429-90-5	0.01	mg/L	**0.06**	----	----	----	----
Arsenic	7440-38-2	0.001	mg/L	**0.002**	----	----	----	----
Beryllium	7440-41-7	0.001	mg/L	<0.001	----	----	----	----
Barium	7440-39-3	0.001	mg/L	**0.629**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Cobalt	7440-48-4	0.001	mg/L	<0.001	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	<0.001	----	----	----	----
Manganese	7439-96-5	0.001	mg/L	**0.101**	----	----	----	----
Molybdenum	7439-98-7	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.014**	----	----	----	----
Selenium	7782-49-2	0.01	mg/L	<0.01	----	----	----	----
Strontium	7440-24-6	0.001	mg/L	**3.75**	----	----	----	----
Uranium	7440-61-1	0.001	mg/L	**0.005**	----	----	----	----
Vanadium	7440-62-2	0.01	mg/L	<0.01	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**0.018**	----	----	----	----

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: WKMB01	----	----	----	----
				Client sampling date / time: 19-JUN-2012 15:00	----	----	----	----
				ES1215392-001	----	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued								
Boron	7440-42-8	0.05	mg/L	<0.05	----	----	----	----
Iron	7439-89-6	0.05	mg/L	**0.96**	----	----	----	----
Bromine	7726-95-6	0.1	mg/L	**3.7**	----	----	----	----
EG052G: Silica by Discrete Analyser								
Reactive Silica	----	0.10	mg/L	**16.2**	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.4**	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser								
Ammonia as N	7664-41-7	0.01	mg/L	**0.75**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser								
Nitrite as N	----	0.01	mg/L	<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser								
Nitrate as N	14797-55-8	0.01	mg/L	<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser								
Nitrite + Nitrate as N	----	0.01	mg/L	<0.01	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser								
Total Phosphorus as P	----	0.01	mg/L	**0.22**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser								
Reactive Phosphorus as P	----	0.01	mg/L	**0.10**	----	----	----	----
EN055: Ionic Balance								
Total Anions	----	0.01	meq/L	**62.6**	----	----	----	----
Total Cations	----	0.01	meq/L	**67.6**	----	----	----	----
Ionic Balance	----	0.01	%	**3.81**	----	----	----	----
EP005: Total Organic Carbon (TOC)								
Total Organic Carbon	----	1	mg/L	**15**	----	----	----	----
EP033: C1 - C4 Hydrocarbon Gases								
Methane	74-82-8	10	µg/L	**7400**	----	----	----	----
Ethene	74-85-1	10	µg/L	<10	----	----	----	----
Ethane	74-84-0	10	µg/L	<10	----	----	----	----
Propene	115-07-1	10	µg/L	<10	----	----	----	----
Propane	74-98-6	10	µg/L	<10	----	----	----	----
Butene	25167-67-3	10	µg/L	<10	----	----	----	----
Butane	106-97-8	10	µg/L	<10	----	----	----	----
EP075(SIM)A: Phenolic Compounds								
Phenol	108-95-2	1.0	µg/L	<1.0	----	----	----	----

Analytical Results

Sub-Matrix: WATER				Client sample ID	WKMB01	----	----	----	----
				Client sampling date / time	19-JUN-2012 15:00	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1215392-001	----	----	----	----
EP075(SIM)A: Phenolic Compounds - Continued									
2-Chlorophenol	95-57-8	1.0	µg/L		<1.0	----	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L		<1.0	----	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L		<2.0	----	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L		<1.0	----	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L		<1.0	----	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L		<1.0	----	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L		<1.0	----	----	----	----
4-Chloro-3-Methylphenol	59-50-7	1.0	µg/L		<1.0	----	----	----	----
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L		<1.0	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L		<1.0	----	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L		<2.0	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L		<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L		<1.0	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L		<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		<50	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft									

Analytical Results

Sub-Matrix: **WATER**

Compound	CAS Number	LOR	Unit	Client sample ID: WKMB01	----	----	----	----
				Client sampling date / time: 19-JUN-2012 15:00	----	----	----	----
				ES1215392-001	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft - Continued								
C6 - C10 Fraction	----	20	µg/L	<20	----	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	----	20	µg/L	<20	----	----	----	----
>C10 - C16 Fraction	----	100	µg/L	<100	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L	<100	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L	<100	----	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L	<100	----	----	----	----
EP080: BTEXN								
Benzene	71-43-2	1	µg/L	<1	----	----	----	----
Toluene	108-88-3	2	µg/L	<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L	<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L	<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L	<2	----	----	----	----
^ **Total Xylenes**	1330-20-7	2	µg/L	<2	----	----	----	----
^ **Sum of BTEX**	----	1	µg/L	<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L	<5	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates								
Phenol-d6	13127-88-3	0.1	%	**25.7**	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%	**61.3**	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%	**71.0**	----	----	----	----
EP075(SIM)T: PAH Surrogates								
2-Fluorobiphenyl	321-60-8	0.1	%	**70.1**	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%	**70.9**	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%	**90.8**	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	**101**	----	----	----	----
Toluene-D8	2037-26-5	0.1	%	**108**	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	**100**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	64.1
2-Chlorophenol-D4	93951-73-6	11.3	122.9
2.4.6-Tribromophenol	118-79-6	11.7	144.0
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	19.9	122.8
Anthracene-d10	1719-06-8	23.3	125.8
4-Terphenyl-d14	1718-51-0	20.3	134.5
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

CERTIFICATE OF ANALYSIS

Work Order	: **ES1220412**	Page	: 1 of 8
Amendment	: **1**		
Client	: **PARSONS BRINCKERHOFF AUST P/L**	Laboratory	: Environmental Division Sydney
Contact	: MR JAMES DUGGLEBY	Contact	: Loren Schiavon
Address	: GPO BOX 5394 SYDNEY NSW, AUSTRALIA 2001	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: jduggleby@pb.com.au	E-mail	: loren.schiavon@alsglobal.com
Telephone	: +61 02 9272 5100	Telephone	: +61 2 8784 8503
Facsimile	: +61 02 9272 5101	Facsimile	: +61 2 8784 8500
Project	: 2162406	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 22-AUG-2012
Sampler	: S.M	Issue Date	: 04-APR-2014
Site	: ----		
		No. of samples received	: 3
Quote number	: SY/394/09	No. of samples analysed	: 2

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Where a result is required to meet compliance limits the associated uncertainty must be considered. Refer to the ALS Contact for details.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

- **This report has been amended and re-released to allow the removal of additional analytical data.**

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	Position	Accreditation Category
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics
Sanjeshni Jyoti Mala	Senior Chemist Volatile	Sydney Organics
Sarah Millington	Senior Inorganic Chemist	Sydney Inorganics

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	WKMB02	WKMB03	----	----	----
				Client sampling date / time	21-AUG-2012 15:00	21-AUG-2012 15:00	----	----	----
					ES1220412-001	ES1220412-002	----	----	----
EA005P: pH by PC Titrator									
pH Value	----	0.01	pH Unit		**9.07**	**10.0**	----	----	----
EA010P: Conductivity by PC Titrator									
Electrical Conductivity @ 25°C	----	1	µS/cm		**1030**	**3050**	----	----	----
EA015: Total Dissolved Solids									
Total Dissolved Solids @180°C	----	10	mg/L		**688**	**2240**	----	----	----
ED037P: Alkalinity by PC Titrator									
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L		<1	<1	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L		**73**	**688**	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L		**215**	**266**	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L		**288**	**954**	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA									
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L		**129**	**94**	----	----	----
ED045G: Chloride Discrete analyser									
Chloride	16887-00-6	1	mg/L		**80**	**371**	----	----	----
ED093F: Dissolved Major Cations									
Calcium	7440-70-2	1	mg/L		**7**	**5**	----	----	----
Magnesium	7439-95-4	1	mg/L		<1	<1	----	----	----
Sodium	7440-23-5	1	mg/L		**236**	**625**	----	----	----
Potassium	7440-09-7	1	mg/L		**7**	**35**	----	----	----
EG020F: Dissolved Metals by ICP-MS									
Aluminium	7429-90-5	0.01	mg/L		**0.19**	**0.76**	----	----	----
Arsenic	7440-38-2	0.001	mg/L		**0.002**	**0.003**	----	----	----
Beryllium	7440-41-7	0.001	mg/L		<0.001	<0.001	----	----	----
Barium	7440-39-3	0.001	mg/L		**0.072**	**0.405**	----	----	----
Cadmium	7440-43-9	0.0001	mg/L		<0.0001	<0.0001	----	----	----
Chromium	7440-47-3	0.001	mg/L		<0.001	**0.007**	----	----	----
Cobalt	7440-48-4	0.001	mg/L		<0.001	<0.001	----	----	----
Copper	7440-50-8	0.001	mg/L		**0.001**	**0.004**	----	----	----
Lead	7439-92-1	0.001	mg/L		<0.001	**0.049**	----	----	----
Manganese	7439-96-5	0.001	mg/L		**0.002**	**0.008**	----	----	----
Molybdenum	7439-98-7	0.001	mg/L		**0.004**	**0.015**	----	----	----
Nickel	7440-02-0	0.001	mg/L		**0.001**	**0.002**	----	----	----
Selenium	7782-49-2	0.01	mg/L		<0.01	<0.01	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	WKMB02	WKMB03	----	----	----
				Client sampling date / time	21-AUG-2012 15:00	21-AUG-2012 15:00	----	----	----
					ES1220412-001	ES1220412-002	----	----	----
EG020F: Dissolved Metals by ICP-MS - Continued									
Strontium	7440-24-6	0.001	mg/L		**0.463**	**0.758**	----	----	----
Uranium	7440-61-1	0.001	mg/L		<0.001	<0.001	----	----	----
Vanadium	7440-62-2	0.01	mg/L		<0.01	<0.01	----	----	----
Zinc	7440-66-6	0.005	mg/L		**0.018**	**1.22**	----	----	----
Boron	7440-42-8	0.05	mg/L		<0.05	**0.10**	----	----	----
Iron	7439-89-6	0.05	mg/L		<0.05	**0.20**	----	----	----
Bromine	7726-95-6	0.1	mg/L		**0.2**	**0.8**	----	----	----
EG052F: Dissolved Silica by ICPAES									
Silica	7631-86-9	0.1	mg/L		**22.9**	**10.4**	----	----	----
EK040P: Fluoride by PC Titrator									
Fluoride	16984-48-8	0.1	mg/L		**0.3**	**1.4**	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**0.44**	**13.5**	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	<0.01	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	**0.02**	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.11**	**0.43**	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		**0.07**	**0.04**	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**10.7**	**31.5**	----	----	----
Total Cations	----	0.01	meq/L		**10.8**	----	----	----	----
Total Cations	----	0.01	meq/L		----	**29.3**	----	----	----
Ionic Balance	----	0.01	%		**0.40**	----	----	----	----
Ionic Balance	----	0.01	%		----	**3.62**	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		**3**	**168**	----	----	----
EP033: C1 - C4 Hydrocarbon Gases									
Methane	74-82-8	10	µg/L		**4340**	**32100**	----	----	----
Ethene	74-85-1	10	µg/L		<10	<10	----	----	----
Ethane	74-84-0	10	µg/L		<10	<10	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	WKMB02	WKMB03	----	----	----
				Client sampling date / time	21-AUG-2012 15:00	21-AUG-2012 15:00	----	----	----
					ES1220412-001	ES1220412-002	----	----	----
EP033: C1 - C4 Hydrocarbon Gases - Continued									
Propene	115-07-1	10	µg/L		<10	<10	----	----	----
Propane	74-98-6	10	µg/L		<10	<10	----	----	----
Butene	25167-67-3	10	µg/L		<10	<10	----	----	----
Butane	106-97-8	10	µg/L		<10	<10	----	----	----
EP075(SIM)A: Phenolic Compounds									
Phenol	108-95-2	1.0	µg/L		<1.0	**1.3**	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L		<1.0	<1.0	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L		<1.0	<1.0	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L		<2.0	<2.0	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L		<1.0	<1.0	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L		<1.0	<1.0	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L		<1.0	<1.0	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L		<1.0	<1.0	----	----	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L		<1.0	<1.0	----	----	----
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L		<1.0	<1.0	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L		<1.0	<1.0	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L		<2.0	<2.0	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									
Naphthalene	91-20-3	1.0	µg/L		<1.0	<1.0	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	<1.0	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	<1.0	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	<1.0	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	<1.0	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	<1.0	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	<1.0	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	<1.0	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	<1.0	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	<0.5	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	<1.0	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L		<1.0	<1.0	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L		<1.0	<1.0	----	----	----

Analytical Results

Sub-Matrix: **WATER** (Matrix: **WATER**)

Compound	CAS Number	LOR	Unit	Client sample ID	WKMB02	WKMB03	----	----	----
				Client sampling date / time	21-AUG-2012 15:00	21-AUG-2012 15:00	----	----	----
					ES1220412-001	ES1220412-002	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued									
^ **Sum of polycyclic aromatic hydrocarbons**	----	0.5	µg/L		<0.5	<0.5	----	----	----
^ **Benzo(a)pyrene TEQ (WHO)**	----	0.5	µg/L		<0.5	<0.5	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	<20	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	<50	----	----	----
C15 - C28 Fraction	----	100	µg/L		<100	**270**	----	----	----
C29 - C36 Fraction	----	50	µg/L		<50	**140**	----	----	----
^ **C10 - C36 Fraction (sum)**	----	50	µg/L		<50	**410**	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2010 Draft									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	<20	----	----	----
^ **C6 - C10 Fraction minus BTEX (F1)**	C6_C10-BTEX	20	µg/L		<20	<20	----	----	----
>C10 - C16 Fraction	>C10_C16	100	µg/L		<100	<100	----	----	----
>C16 - C34 Fraction	----	100	µg/L		<100	**300**	----	----	----
>C34 - C40 Fraction	----	100	µg/L		<100	<100	----	----	----
^ **>C10 - C40 Fraction (sum)**	----	100	µg/L		<100	**300**	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	<1	----	----	----
Toluene	108-88-3	2	µg/L		<2	<2	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	<2	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	<2	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	<2	----	----	----
^ **Total Xylenes**	1330-20-7	2	µg/L		<2	<2	----	----	----
^ **Sum of BTEX**	----	1	µg/L		<1	<1	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	<5	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	0.1	%		**23.9**	**15.9**	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**52.8**	**39.0**	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**78.5**	**53.8**	----	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	0.1	%		**71.9**	**68.1**	----	----	----
Anthracene-d10	1719-06-8	0.1	%		**75.7**	**69.1**	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**69.5**	**63.6**	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	WKMB02	WKMB03	----	----	----
			Client sampling date / time	21-AUG-2012 15:00	21-AUG-2012 15:00	----	----	----
Compound	CAS Number	LOR	Unit	ES1220412-001	ES1220412-002	----	----	----
EP080S: TPH(V)/BTEX Surrogates								
1.2-Dichloroethane-D4	17060-07-0	0.1	%	88.6	90.2	----	----	----
Toluene-D8	2037-26-5	0.1	%	105	92.4	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%	88.5	90.5	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	64.1
2-Chlorophenol-D4	93951-73-6	11.3	122.9
2.4.6-Tribromophenol	118-79-6	11.7	144.0
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	19.9	122.8
Anthracene-d10	1719-06-8	23.3	125.8
4-Terphenyl-d14	1718-51-0	20.3	134.5
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

CERTIFICATE OF ANALYSIS

Work Order	: **ES1323077**	Page	: 1 of 7
Client	: **PARSONS BRINCKERHOFF AUST P/L**	Laboratory	: Environmental Division Sydney
Contact	: MR JAMES DUGGLEBY	Contact	: Client Services
Address	: GPO BOX 5394 SYDNEY NSW, AUSTRALIA 2001	Address	: 277-289 Woodpark Road Smithfield NSW Australia 2164
E-mail	: jduggleby@pb.com.au	E-mail	: sydney@alsglobal.com
Telephone	: +61 02 9272 5100	Telephone	: +61-2-8784 8555
Facsimile	: +61 02 9272 5101	Facsimile	: +61-2-8784 8500
Project	: 2162406C	QC Level	: NEPM 2013 Schedule B(3) and ALS QCS3 requirement
Order number	: ----		
C-O-C number	: ----	Date Samples Received	: 24-OCT-2013
Sampler	: CHRIS RICHARD	Issue Date	: 30-OCT-2013
Site	: ----		
		No. of samples received	: 1
Quote number	: EN/008/13	No. of samples analysed	: 1

This report supersedes any previous report(s) with this reference. Results apply to the sample(s) as submitted. All pages of this report have been checked and approved for release.

This Certificate of Analysis contains the following information:

- General Comments
- Analytical Results
- Surrogate Control Limits

NATA Accredited Laboratory 825

Accredited for compliance with ISO/IEC 17025.

Signatories

This document has been electronically signed by the authorized signatories indicated below. Electronic signing has been carried out in compliance with procedures specified in 21 CFR Part 11.

Signatories	*Position*	*Accreditation Category*
Ankit Joshi	Inorganic Chemist	Sydney Inorganics
Celine Conceicao	Senior Spectroscopist	Sydney Inorganics
Hoa Nguyen	Senior Inorganic Chemist	Sydney Inorganics
Pabi Subba	Senior Organic Chemist	Sydney Organics

General Comments

The analytical procedures used by the Environmental Division have been developed from established internationally recognized procedures such as those published by the USEPA, APHA, AS and NEPM. In house developed procedures are employed in the absence of documented standards or by client request.

Where moisture determination has been performed, results are reported on a dry weight basis.

Where a reported less than (<) result is higher than the LOR, this may be due to primary sample extract/digestate dilution and/or insufficient sample for analysis.

Where the LOR of a reported result differs from standard LOR, this may be due to high moisture content, insufficient sample (reduced weight employed) or matrix interference.

When sampling time information is not provided by the client, sampling dates are shown without a time component. In these instances, the time component has been assumed by the laboratory for processing purposes.

Key : CAS Number = CAS registry number from database maintained by Chemical Abstracts Services. The Chemical Abstracts Service is a division of the American Chemical Society.
LOR = Limit of reporting
^ = This result is computed from individual analyte detections at or above the level of reporting

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)			Client sample ID	WKMB04	----	----	----	----
			Client sampling date / time	23-OCT-2013 09:45	----	----	----	----
Compound	CAS Number	LOR	Unit	ES1323077-001	----	----	----	----
EA010P: Conductivity by PC Titrator								
Electrical Conductivity @ 25°C	----	1	µS/cm	**16500**	----	----	----	----
EA015: Total Dissolved Solids								
Total Dissolved Solids @180°C	----	10	mg/L	**11000**	----	----	----	----
EA025: Suspended Solids								
Suspended Solids (SS)	----	5	mg/L	**3130**	----	----	----	----
ED037P: Alkalinity by PC Titrator								
Hydroxide Alkalinity as CaCO3	DMO-210-001	1	mg/L	<1	----	----	----	----
Carbonate Alkalinity as CaCO3	3812-32-6	1	mg/L	**375**	----	----	----	----
Bicarbonate Alkalinity as CaCO3	71-52-3	1	mg/L	**6700**	----	----	----	----
Total Alkalinity as CaCO3	----	1	mg/L	**7080**	----	----	----	----
ED040F: Dissolved Major Anions								
Silicon as SiO2	14464-46-1	0.1	mg/L	**16.6**	----	----	----	----
ED041G: Sulfate (Turbidimetric) as SO4 2- by DA								
Sulfate as SO4 - Turbidimetric	14808-79-8	1	mg/L	<1	----	----	----	----
ED045G: Chloride Discrete analyser								
Chloride	16887-00-6	1	mg/L	**2580**	----	----	----	----
ED093F: Dissolved Major Cations								
Calcium	7440-70-2	1	mg/L	**10**	----	----	----	----
Magnesium	7439-95-4	1	mg/L	**47**	----	----	----	----
Sodium	7440-23-5	1	mg/L	**4650**	----	----	----	----
Potassium	7440-09-7	1	mg/L	**25**	----	----	----	----
EG020F: Dissolved Metals by ICP-MS								
Arsenic	7440-38-2	0.001	mg/L	**0.002**	----	----	----	----
Cadmium	7440-43-9	0.0001	mg/L	<0.0001	----	----	----	----
Chromium	7440-47-3	0.001	mg/L	**0.001**	----	----	----	----
Copper	7440-50-8	0.001	mg/L	<0.001	----	----	----	----
Lead	7439-92-1	0.001	mg/L	**0.002**	----	----	----	----
Nickel	7440-02-0	0.001	mg/L	**0.012**	----	----	----	----
Zinc	7440-66-6	0.005	mg/L	**1.53**	----	----	----	----
EG035F: Dissolved Mercury by FIMS								
Mercury	7439-97-6	0.0001	mg/L	<0.0001	----	----	----	----
EK040P: Fluoride by PC Titrator								
Fluoride	16984-48-8	0.1	mg/L	**0.6**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WKMB04	----	----	----	----
				Client sampling date / time	23-OCT-2013 09:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1323077-001	----	----	----	----
EK055G: Ammonia as N by Discrete Analyser									
Ammonia as N	7664-41-7	0.01	mg/L		**3.70**	----	----	----	----
EK057G: Nitrite as N by Discrete Analyser									
Nitrite as N	----	0.01	mg/L		<0.01	----	----	----	----
EK058G: Nitrate as N by Discrete Analyser									
Nitrate as N	14797-55-8	0.01	mg/L		<0.01	----	----	----	----
EK059G: Nitrite plus Nitrate as N (NOx) by Discrete Analyser									
Nitrite + Nitrate as N	----	0.01	mg/L		<0.01	----	----	----	----
EK067G: Total Phosphorus as P by Discrete Analyser									
Total Phosphorus as P	----	0.01	mg/L		**0.33**	----	----	----	----
EK071G: Reactive Phosphorus as P by discrete analyser									
Reactive Phosphorus as P	14265-44-2	0.01	mg/L		**0.04**	----	----	----	----
EN055: Ionic Balance									
Total Anions	----	0.01	meq/L		**214**	----	----	----	----
Total Cations	----	0.01	meq/L		**207**	----	----	----	----
Ionic Balance	----	0.01	%		**1.71**	----	----	----	----
EP005: Total Organic Carbon (TOC)									
Total Organic Carbon	----	1	mg/L		**60**	----	----	----	----
EP033: C1 - C4 Hydrocarbon Gases									
Methane	74-82-8	10	µg/L		**3150**	----	----	----	----
EP075(SIM)A: Phenolic Compounds									
Phenol	108-95-2	1.0	µg/L		<1.0	----	----	----	----
2-Chlorophenol	95-57-8	1.0	µg/L		<1.0	----	----	----	----
2-Methylphenol	95-48-7	1.0	µg/L		<1.0	----	----	----	----
3- & 4-Methylphenol	1319-77-3	2.0	µg/L		<2.0	----	----	----	----
2-Nitrophenol	88-75-5	1.0	µg/L		<1.0	----	----	----	----
2.4-Dimethylphenol	105-67-9	1.0	µg/L		<1.0	----	----	----	----
2.4-Dichlorophenol	120-83-2	1.0	µg/L		<1.0	----	----	----	----
2.6-Dichlorophenol	87-65-0	1.0	µg/L		<1.0	----	----	----	----
4-Chloro-3-methylphenol	59-50-7	1.0	µg/L		<1.0	----	----	----	----
2.4.6-Trichlorophenol	88-06-2	1.0	µg/L		<1.0	----	----	----	----
2.4.5-Trichlorophenol	95-95-4	1.0	µg/L		<1.0	----	----	----	----
Pentachlorophenol	87-86-5	2.0	µg/L		<2.0	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons									

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WKMB04	----	----	----	----
				Client sampling date / time	23-OCT-2013 09:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1323077-001	----	----	----	----
EP075(SIM)B: Polynuclear Aromatic Hydrocarbons - Continued									
Naphthalene	91-20-3	1.0	µg/L		<1.0	----	----	----	----
Acenaphthylene	208-96-8	1.0	µg/L		<1.0	----	----	----	----
Acenaphthene	83-32-9	1.0	µg/L		<1.0	----	----	----	----
Fluorene	86-73-7	1.0	µg/L		<1.0	----	----	----	----
Phenanthrene	85-01-8	1.0	µg/L		<1.0	----	----	----	----
Anthracene	120-12-7	1.0	µg/L		<1.0	----	----	----	----
Fluoranthene	206-44-0	1.0	µg/L		<1.0	----	----	----	----
Pyrene	129-00-0	1.0	µg/L		<1.0	----	----	----	----
Benz(a)anthracene	56-55-3	1.0	µg/L		<1.0	----	----	----	----
Chrysene	218-01-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(b)fluoranthene	205-99-2	1.0	µg/L		<1.0	----	----	----	----
Benzo(k)fluoranthene	207-08-9	1.0	µg/L		<1.0	----	----	----	----
Benzo(a)pyrene	50-32-8	0.5	µg/L		<0.5	----	----	----	----
Indeno(1.2.3.cd)pyrene	193-39-5	1.0	µg/L		<1.0	----	----	----	----
Dibenz(a.h)anthracene	53-70-3	1.0	µg/L		<1.0	----	----	----	----
Benzo(g.h.i)perylene	191-24-2	1.0	µg/L		<1.0	----	----	----	----
^ Sum of polycyclic aromatic hydrocarbons	----	0.5	µg/L		<0.5	----	----	----	----
^ Benzo(a)pyrene TEQ (zero)	----	0.5	µg/L		<0.5	----	----	----	----
EP080/071: Total Petroleum Hydrocarbons									
C6 - C9 Fraction	----	20	µg/L		<20	----	----	----	----
C10 - C14 Fraction	----	50	µg/L		<50	----	----	----	----
C15 - C28 Fraction	----	100	µg/L		**14700**	----	----	----	----
C29 - C36 Fraction	----	50	µg/L		**7820**	----	----	----	----
^ C10 - C36 Fraction (sum)	----	50	µg/L		**22500**	----	----	----	----
EP080/071: Total Recoverable Hydrocarbons - NEPM 2013									
C6 - C10 Fraction	C6_C10	20	µg/L		<20	----	----	----	----
^ C6 - C10 Fraction minus BTEX (F1)	C6_C10-BTEX	20	µg/L		<20	----	----	----	----
>C10 - C16 Fraction	>C10_C16	100	µg/L		**100**	----	----	----	----
>C16 - C34 Fraction	----	100	µg/L		**20500**	----	----	----	----
>C34 - C40 Fraction	----	100	µg/L		**3480**	----	----	----	----
^ >C10 - C40 Fraction (sum)	----	100	µg/L		**24100**	----	----	----	----
^ >C10 - C16 Fraction minus Naphthalene (F2)	----	100	µg/L		**100**	----	----	----	----

Analytical Results

Sub-Matrix: WATER (Matrix: WATER)				Client sample ID	WKMB04	----	----	----	----
				Client sampling date / time	23-OCT-2013 09:45	----	----	----	----
Compound	CAS Number	LOR	Unit		ES1323077-001	----	----	----	----
EP080: BTEXN									
Benzene	71-43-2	1	µg/L		<1	----	----	----	----
Toluene	108-88-3	2	µg/L		<2	----	----	----	----
Ethylbenzene	100-41-4	2	µg/L		<2	----	----	----	----
meta- & para-Xylene	108-38-3 106-42-3	2	µg/L		<2	----	----	----	----
ortho-Xylene	95-47-6	2	µg/L		<2	----	----	----	----
^ **Total Xylenes**	1330-20-7	2	µg/L		<2	----	----	----	----
^ **Sum of BTEX**	----	1	µg/L		<1	----	----	----	----
Naphthalene	91-20-3	5	µg/L		<5	----	----	----	----
EP075(SIM)S: Phenolic Compound Surrogates									
Phenol-d6	13127-88-3	0.1	%		**43.6**	----	----	----	----
2-Chlorophenol-D4	93951-73-6	0.1	%		**66.8**	----	----	----	----
2.4.6-Tribromophenol	118-79-6	0.1	%		**79.2**	----	----	----	----
EP075(SIM)T: PAH Surrogates									
2-Fluorobiphenyl	321-60-8	0.1	%		**66.0**	----	----	----	----
Anthracene-d10	1719-06-8	0.1	%		**57.6**	----	----	----	----
4-Terphenyl-d14	1718-51-0	0.1	%		**77.9**	----	----	----	----
EP080S: TPH(V)/BTEX Surrogates									
1.2-Dichloroethane-D4	17060-07-0	0.1	%		**118**	----	----	----	----
Toluene-D8	2037-26-5	0.1	%		**130**	----	----	----	----
4-Bromofluorobenzene	460-00-4	0.1	%		**99.6**	----	----	----	----

Surrogate Control Limits

Sub-Matrix: **WATER**

Compound	CAS Number	Recovery Limits (%) Low	High
EP075(SIM)S: Phenolic Compound Surrogates			
Phenol-d6	13127-88-3	10.0	44
2-Chlorophenol-D4	93951-73-6	14	94
2.4.6-Tribromophenol	118-79-6	17	125
EP075(SIM)T: PAH Surrogates			
2-Fluorobiphenyl	321-60-8	20	104
Anthracene-d10	1719-06-8	27.4	113
4-Terphenyl-d14	1718-51-0	32	112
EP080S: TPH(V)/BTEX Surrogates			
1.2-Dichloroethane-D4	17060-07-0	71	137
Toluene-D8	2037-26-5	79	131
4-Bromofluorobenzene	460-00-4	70	128

Appendix G

GNS stable isotope laboratory reports

STABLE ISOTOPE RESULTS

National Isotope Centre
30 Gracefield Road
Lower Hutt 5010
PO Box 31 312
Lower Hutt 5040
New Zealand
T +64-4-570 1444
F +64-4-570 4657
www.gns.cri.nz

Wendy McLean
Level 27, 680 George St

Sydney 2001
Australia

Project Title
SIL Order No.: W-1204085
Client Ref.:
Date Received: 9/07/2012
Date Measured:
Approved By:
Date Reported: 26/07/2012

Invoice **Parsons Brinckerhoff**
Attn: **Wendy McLean**
Level 27, 680 George St
World Square, Sydney
NSW 2001
Australia

Sample Type: **water (H & O)**

SIL ID	External ID	δD Value	δ18O Value	Analysis Type	Overseas or NZ	Country Code	Collection Date/Time (Start)	Other Info
W-1204088	WKMB01	-22.5	-4.13	D, O18	OS	AS	17/06/2012	Groundwater

STABLE ISOTOPE RESULTS

National Isotope Centre
30 Gracefield Road
Lower Hutt 5010
PO Box 31 312
Lower Hutt 5040
New Zealand
T +64-4-570 1444
F +64-4-570 4657
www.gns.cri.nz

Wendy McLean
Level 27, 680 George St
World Square, Sydney
NSW 2001
Australia

Project Title
SIL Order No.: W-1204501
Client Ref.:
Date Received: 27/09/2012
Date Measured:
Approved By:
Date Reported: 24/10/2012

Invoice **Parsons Brinckerhoff**
Attn: **Wendy McLean**
Level 27, 680 George St
World Square, Sydney
NSW 2001
Australia

Sample Type: **water (H & O)**

SIL ID	External ID	δD Value	δ18O Value	Analysis Type	Overseas or NZ	Country Code	Collection Date/Time (Start)	Other Info
W-1204502	WKMB02	-22.9	-4.27	D, O18	OS	AS	21/08/2012	groundwater
W-1204503	WKMB03	-30.2	-5.53	D, O18	OS	AS	21/08/2012	groundwater

STABLE ISOTOPE RESULTS

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Lower Hutt 5010
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F +64-4-570 4657
www.gns.cri.nz

Parsons Brinckerhoff
Level 27, 680 George St
World Square, Sydney
NSW 2001
Australia

Project Title	2162406C - Waukivory	**Invoice**	**Parsons Brinckerhoff**
SIL Order No.:		**Attn:**	**Ellen Kwantes**
Client Ref.:			**Level 27, 680 George St**
Date Received:	5/11/2013		**World Square, Sydney**
Date Measured:			**NSW 2001**
Approved By:			**Australia**
Date Reported:	2/12/2013		

Sample Type: **water (H & O)**

SIL ID	External ID	δD Value	δ18O Value	Analysis Type	Overseas or NZ	State or Province	Country Code	Collection Date/Time (Start)	Other Info
W-1302892	WKMB04	-47.8	-6.94	D, O18	OS	New South Wales	AS	25/10/2013 9:45	Groundwater

Appendix H

Rafter radiocarbon laboratory reports

Rafter Radiocarbon

Accelerator Mass Spectrometry Result

This result for the sample submitted is for the exclusive use of the submitter. All liability whatsoever to any third party is excluded.

NZA 50832

R 40031/6

Job No: 190807

Measured: 16/08/2012

TW No: 2781

Date issued: 24 Aug 2012

Sample ID	WKMB01
Description	Groundwater
Fraction dated	Groundwater
Submitter	Wendy McLean Parsons Brinckerhoff

Conventional Radiocarbon Age (years BP)	**3148**	±	**24**	
$\delta^{13}C$ and Source of measurement	-15.6	±	0.1	C13
Fraction modern	0.6758	±	0.0020	
$\Delta^{14}C$ (‰) and collection date	-329.3	±	2.0	19 Jun 2012

Measurement Comment:

Sample Treatment Details

Sample was submitted in a nalgene bottle, was colourless with minimal brown particulate matter. Sample loaded with 4 ml phosphoric acid. CO2 was generated by water CO2 evolution 4.5 mg C was obtained. Sample was converted to graphite by reduction with hydrogen over iron catalyst.

Conventional Radiocarbon Age and $\Delta^{14}C$ are reported as defined by Stuiver and Polach, Radiocarbon 19:355-363 (1977) and $\Delta^{14}C$ is decay corrected to the collection date given, and not reported if no collection date was supplied. Fraction modern (F) is the blank corrected fraction modern normalized to $\delta^{13}C$ of -25 permil, defined by Donahue, D. J., T. Linick, and A. T. Jull, *Radiocarbon*, *32* (2):135-142 (1990). $\delta^{13}C$ was obtained from the source indicated. The reported errors comprise statistical errors in sample and standard determinations, combined in quadrature with a system error component based on the analysis of an ongoing series of measurements on an oxalic acid standard. Further details of pretreatment and analysis are available on request.

National Isotope Centre, GNS Science
PO Box 31-312 Lower Hutt, New Zealand Fax +64 4 570 4657 Phone +64 4 570 4644
Email radiocarbon@gns.cri.nz Website www.RafterRadiocarbon.co.nz

Rafter Radiocarbon

Accelerator Mass Spectrometry Result

This result for the sample submitted is for the exclusive use of the submitter. All liability whatsoever to any third party is excluded.

NZA 51702
R 40114/1
Job No: 192257
Measured: 12/11/2012
TW No: 2813
Date issued: 14 Nov 2012

Sample ID	WKMB02
Description	
Fraction dated	Groundwater
Submitter	Wendy McLean Parsons Brinckerhoff

Conventional Radiocarbon Age (years BP)	**8126**	±	**24**	
$\delta^{13}C$ and Source of measurement	-16.0	±	0.2	C13
Fraction modern	0.3636	±	0.0011	
$\Delta^{14}C$ (‰) and collection date	-639.1	±	1.1	21 Aug 2012

Measurement Comment:

Sample Treatment Details

Sample was submitted in: Semi-transparent plastic square bottle and some whitish precipitate with head space. Head space comment: big. Sample colour: colourless. Odour Description: no smell. CO2 was generated by phosphoric acid evolution, and carbonate content was 64.3mgC/kgH2O, total dissolved inorganic carbon (TDIC) 5.4mmol/kgH2O. Sample was converted to graphite by reduction with hydrogen over iron catalyst.

Conventional Radiocarbon Age and $\Delta^{14}C$ are reported as defined by Stuiver and Polach, Radiocarbon 19:355-363 (1977) and $\Delta^{14}C$ is decay corrected to the collection date given, and not reported if no collection date was supplied. Fraction modern (F) is the blank corrected fraction modern normalized to $\delta^{13}C$ of -25 permil, defined by Donahue, D. J., T. Linick, and A. T. Jull, *Radiocarbon*, *32* (2):135-142 (1990). $\delta^{13}C$ was obtained from the source indicated. The reported errors comprise statistical errors in sample and standard determinations, combined in quadrature with a system error component based on the analysis of an ongoing series of measurements on an oxalic acid standard. Further details of pretreatment and analysis are available on request.

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Rafter Radiocarbon

Accelerator Mass Spectrometry Result

NZA 52010
R 40114/2
Job No: 192258
Measured: 5/12/2012
TW No: 2821
Date issued: 17 Dec 2012

Sample ID	WKMB03
Description	
Fraction dated	Groundwater
Submitter	Wendy McLean Parsons Brinckerhoff

Conventional Radiocarbon Age (years BP)	**19528**	±	**63**	
$\delta^{13}C$ and Source of measurement	13.4	±	0.2	C13
Fraction modern	0.0880	±	0.0007	
$\Delta^{14}C$ (‰) and collection date	-912.7	±	0.7	21 Aug 2012

Measurement Comment:

Sample Treatment Details

Sample was submitted in: Semi-transparent plastic square bottle and some pale dark brownish precipitate and with head space. Head space comment: large head space. Sample colour: slightly dirty looking. Odour Description: no smell. CO2 was generated by phosphoric acid evolution, and carbonate content was 124mgC/kgH2O, total dissolved inorganic carbon (TDIC) 10.3mmol/kgH2O. The low yield meant that insufficient CO2 was obtained for further processing, and therefore the process was repeated and CO2 from both was combined. Gas was recombusted with silver wire to remove possible sulphur contamination. Sample was converted to graphite by reduction with hydrogen over iron catalyst.

Conventional Radiocarbon Age and $\Delta^{14}C$ are reported as defined by Stuiver and Polach, Radiocarbon 19:355-363 (1977) and $\Delta^{14}C$ is decay corrected to the collection date given, and not reported if no collection date was supplied. Fraction modern (F) is the blank corrected fraction modern normalized to $\delta^{13}C$ of -25 permil, defined by Donahue, D. J., T. Linick, and A. T. Jull, *Radiocarbon*, *32* (2):135-142 (1990). $\delta^{13}C$ was obtained from the source indicated. The reported errors comprise statistical errors in sample and standard determinations, combined in quadrature with a system error component based on the analysis of an ongoing series of measurements on an oxalic acid standard. Further details of pretreatment and analysis are available on request.

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Email radiocarbon@gns.cri.nz Website www.RafterRadiocarbon.co.nz

Rafter Radiocarbon

Accelerator Mass Spectrometry Result

This result for the sample submitted is for the exclusive use of the submitter. All liability whatsoever to any third party is excluded.

NZA 55400
R 40396/1
Job No: 197084
Measured: 25/11/2013
TW No: 2904
Date issued: 10 Jan 2014

Sample ID	WKMB04
Description	Groundwater
Fraction dated	Groundwater
Submitter	Ellen Kwantes Parsons Brinckerhoff

Conventional Radiocarbon Age (years BP)	**43643**	±	**1324**	
$\delta^{13}C$ and Source of measurement	33.0	±	0.2	C13
Fraction modern	0.0044	±	0.0007	
$\Delta^{14}C$ (‰) and collection date	-995.7	±	0.7	23 Oct 2013

Measurement Comment:

Sample Treatment Details

Sample was submitted in: 500ml plastic bottle tightly capped with no headspace or odour, layer of brown sediment at bottom. CO2 was generated by phosphoric acid evolution, and carbonate content was 131.5mgC/kgH2O, total dissolved inorganic carbon (TDIC) 11mmol/kgH2O. Sample carbon dioxide was converted to graphite by reduction with hydrogen over iron catalyst.

Conventional Radiocarbon Age and $\Delta^{14}C$ are reported as defined by Stuiver and Polach, Radiocarbon 19:355-363 (1977) and $\Delta^{14}C$ is decay corrected to the collection date given, and not reported if no collection date was supplied. Fraction modern (F) is the blank corrected fraction modern normalized to $\delta^{13}C$ of -25 permil, defined by Donahue, D. J., T. Linick, and A. T. Jull, *Radiocarbon*, *32* (2):135-142 (1990). $\delta^{13}C$ was obtained from the source indicated. The reported errors comprise statistical errors in sample and standard determinations, combined in quadrature with a system error component based on the analysis of an ongoing series of measurements on an oxalic acid standard. Further details of pretreatment and analysis are available on request.

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Appendix I

ANSTO Laboratory - Tritium results

Australian Government

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Institute for Environmental Research
Analytical Report

Client:	**Parsons Brinckerhoff** **GPO Box 5394** **Sydney** **NSW 2001**
Contact:	**Wendy McLean**
Tel:	**(02) 9272-5234**

Report Number:	**2012/0188**
Batch Description:	**tritium in water**
Samples Received:	**8**
Registration Date:	**5-Jul-2012**
Report Date:	**27-Aug-2012**
Logged By:	**Kellie-Anne Farrawell**
ANSTO Cost Code:	**0205V-1**
Funds Type:	**Project - Commercial**
Supervising Analyst:	**Robert Chisari**

Signature: Robert Chisari Date: 27/08/2012

Robert Chisari

Australian Government

Nuclear-based science benefiting all Australians

LIMS ID#	Client Identification	Sample Description
2012/0188-5	WKMB01	Groundwater

AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION

New Illawarra Road, Lucas Heights (Locked Bag 2001, Kirrawee DC NSW 2232) T +61 2 9717 3111 F +61 2 9543 5097

www.ansto.gov.au

Institute for Environmental Research
Analytical Report

Report Number: 2012/0188

Tritium Concentration at Sampling Date

Client Identification	Sample No.	Date Sample Collected	Tritium Ratio	Uncertainty [1]	Quant Limit [2]	Tritium Activity	Uncertainty [1]	MDA [2]
			TU	TU	TU	Bq/kg	Bq/kg	Bq/kg
WKMB01	5	14/06/2012	0.12^	0.03	0.14	0.014^	0.003	0.017

Notes:

1. Values reported are combined standard uncertainty, calculated to 1 sigma. A Coverage factor, *k*, of 2 may be used to calculate Expanded Uncertainty to 95% confidence.
2. The MDA (Minimum Detectable Activity) and Quant Limit (Limit of Quantification) are calculated to 95% confidence.

^ This result is below the MDA/Quant Limit and therefore has an unacceptable level of uncertainty. Hence, the data should only be used as an indicator of the true concentration

Signature:  Date: 27/08/2012

Robert Chisari

AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION
New Illawarra Road, Lucas Heights (Locked Bag 2001, Kirrawee DC NSW 2232) T +61 2 9717 3111 F +61 2 9543 5097
www.ansto.gov.au

Australian Government

Nuclear-based science benefiting all Australians

Institute for Environmental Research
Analytical Report

Client:	**Parsons Brinckerhoff** **GPO Box 5394** **Sydney** **NSW 2001**
Contact:	**Wendy McLean/ Nina Pearse-Hawkins**
Tel:	**(02) 9272-5234**

Report Number:	**2012/0283a**
Batch Description:	**Tritium activity in ground water**
Samples Received:	**19**
Registration Date:	**24-Sep-2012**
Report Date:	**8-Jan-2013**
Logged By:	**Robert Chisari**
ANSTO Cost Code:	**0205v-1**
Funds Type:	**Project - Commercial**
Supervising Analyst:	**Robert Chisari**

Signature: Robert Chisari Date: 8/01/2013

Robert Chisari

Australian Government

Nuclear-based science benefiting all Australians

LIMS ID#	Client Identification	Sample Description
2012/0283-1	WKMB02	Groundwater
2012/0283-2	WKMB03	Groundwater

AUSTRALIAN NUCLEAR SCIENCE AND TECHNOLOGY ORGANISATION
New Illawarra Road, Lucas Heights (Locked Bag 2001, Kirrawee DC NSW 2232) T +61 2 9717 3111 F +61 2 9543 5097
www.ansto.gov.au

Institute for Environmental Research
Analytical Report

Report Number: 2012/0283a

Tritium Concentration at Sampling Date

Client Identification	Sample No.	Date Sample Collected	Tritium Ratio	Uncertainty [1]	Quant Limit [2]	Tritium Activity	Uncertainty [1]	MDA [2]
			TU	TU	TU	Bq/kg	Bq/kg	Bq/kg
WKMB02	1	21/08/2012	0.23	0.03	0.14	0.028	0.003	0.017
WKMB03	2	21/08/2012	0.34	0.03	0.14	0.040	0.004	0.016

Continued...

Appendix J

UC Davis Stable Isotope Facility - Carbon-13 and methane results

Sample	δ^2H_{VSMOW}	Comments
Received 7/9/12		
WKMB01	-135.6	Below LOQ
Received 9/28/12		
WKMB02	-176.4	Below LOQ
WKMB03	-213.7	

CHECK STD		MEASURED	KNOWN
	UCDM2	-146.9	-149.0
	UCDM2	-149.8	-149.0
	UCDM2	-148.7	-149.0
	UCDM2	-149.2	-149.0
	UCDM2	-145.4	-149.0
	UCDM2	-148.2	-149.0
	UCDM2	-151.7	-149.0
	UCDM2	-148.3	-149.0
	avg	-148.5	
	sd	1.9	

CALIBRATION STDS		KNOWN
NG1	-189.0	-185.1
NG1	-189.2	-185.1
NG2	-235.5	-237.0
NG2	-235.4	-237.0
NG3	-167.5	-167.6
NG3	-165.1	-167.6

2nd CHECK STDS	MEASURED	KNOWN
NGS3	-177.8	-177.0
NGS3	-174.9	-177.0
B iso	-267.5	-266.7
B iso	-266.4	-266.7

Sample	δ^2H_{VSMOW}	Comments
WKMB04	-194.1	

CHECK STD (10 ppm)	MEASURED	KNOWN
UCDM3	-149.4	-149.0
UCDM3	-150.5	-149.0
UCDM3	-149.1	-149.0
UCDM3	-149.6	-149.0
UCDM3	-144.6	-149.0
UCDM3	-147.6	-149.0
avg	-148.5	
sd	2.1	

CALIBRATION STDS	MEASURED	KNOWN
NG1	-188.1	-185.1
NG1	-185.7	-185.1
NG2	-236.4	-237.0
NG2	-236.4	-237.0
NG3	-168.0	-167.6
NG3	-164.8	-167.6

2nd CHECK STDS	MEASURED	KNOWN
Mamm	-184.7	-189.1
H iso	-153.9	-155.7
B iso	-266.6	-269.1

Sample	$\delta^{13}C_{VPDB}$	Comments
Received 7/9/12		
WKMB01	-45.6	
Received 9/28/12		
WKMB02	-42.9	Below LOQ
WKMB03	-22.5	

CHECK STD	MEASURED	KNOWN
12.38 ppm tank std	-36.6	-36.8
12.38 ppm tank std	-37.2	-36.8
12.38 ppm tank std	-36.7	-36.8
12.38 ppm tank std	-37.2	-36.8
12.38 ppm tank std	-36.9	-36.8
12.38 ppm tank std	-36.9	-36.8
avg	-36.9	
sd	0.2	

CALIBRATION STDS		KNOWN
NG1	-34.2	-34.2
NG1	-34.3	-34.2
NG2	-68.9	-68.9
NG2	-68.9	-68.9
NG3	-43.6	-43.6
NG3	-43.5	-43.6

2nd CHECK STDS	MEASURED	KNOWN
NGS3	-44.9	-44.8
NGS3	-44.9	-44.8
NGS3	-73.4	-73.3
NGS3	-73.5	-73.3

Sample	$\delta^{13}C_{VPDB}$	Comments
WKMB04	-32.38	

CHECK STD (10 ppm)	MEASURED	KNOWN
UCDM3	-36.87	-36.7
UCDM3	-36.66	-36.7
UCDM3	-36.68	-36.7
UCDM3	-36.97	-36.7
UCDM3	-36.63	-36.7
UCDM3	-36.66	-36.7
avg	-36.74	
sd	0.14	

CALIBRATION STDS	MEASURED	KNOWN
NG1	-34.00	-34.2
NG1	-34.08	-34.2
NG2	-69.11	-68.9
NG2	-69.38	-68.9

2nd CHECK STDS	MEASURED	KNOWN
H iso	-23.70	-23.9
H iso	-23.62	-23.9
L iso	-66.11	-66.5
L iso	-66.31	-66.5
B iso	-54.66	-54.5
B iso	-54.89	-54.5
T iso	-38.50	-38.3
T iso	-38.63	-38.3

Sample	$\delta^{13}C_{VPDB}$	µg C/mL	Comments
WKMB04	32.45	1556.5	

Project: 2162406C
CHECK STD
0.2 ml 10mM Li2CO3 (Acros)

MEASURED	KNOWN
-13.43	-13.37
-13.29	MEAN
-13.31	-13.36
-13.36	SD
-13.38	0.05
-13.36	

Appendix K

ANU - Chlorine-36 results

Wheel C252 - 09 December 2013		
Sample	**^{36}Cl/Cl (x10^{-15})**	**Error**
Carolina Sardella, PB		
WKM B04	26.6	1.8