Plan

Acid and/or Metalliferous Drainage Management Plan

Environment

31 December 2014
100-PL-EN-1016

Fortescue
The New Force in Iron Ore

	Acid and/or Metalliferous Drainage Management Plan		**100-PL-EN-1016**
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TABLE OF CONTENTS

List of Tables

LIST OF FIGURES

LIST OF APPENDICES

1. INTRODUCTION

Fortescue Metals Group (Fortescue) is an integrated business comprised of mine, rail and port operations based in the Pilbara region of Western Australia, with its head office located in Perth.

Detailed background information regarding the timing and nature of Fortescue's environmental approvals under the *Environmental Protection Act 1986* (WA), the *Environment Protection and Biodiversity Conservation Act 1999* (Cth), current operations and plans for future expansion is contained in Appendix 1.

1.1 Requirement for Management Plan

The Acid and/or Metalliferous Management Plan (AMD MP) is required by the Minister of the Environment as part of the development approval of Fortescue related infrastructure in the Pilbara under Condition 12-3 Ministerial Statement 899 (Cloudbreak[1]), but will be applicable for all current and future Fortescue mine sites across all departments and for all stages.

Existing projects and future developments will be required to prepare and implement site-specific Management and Monitoring programs to support this Plan.

1.2 Objectives

The objective of AMMP is to assess the risk to the environment from the disturbance and exposure of the earth through mining activities.

The principals of assessing this risk follow a model used for contamination assessments of characterising the source, pathway and receptor to determine risk. Only when a source is in contact with a pathway, such as air or water that can transport potentially harmful substances to an environmental receptor, is there a risk of harm Table 1. Sources in this document refer to waste rock, tailings, tailings supernatant, ore stockpiles and pit walls. As waste rock and tailings material is heterogeneous, these materials should be constantly assessed to reduce uncertainty, in line with the level of detail required.

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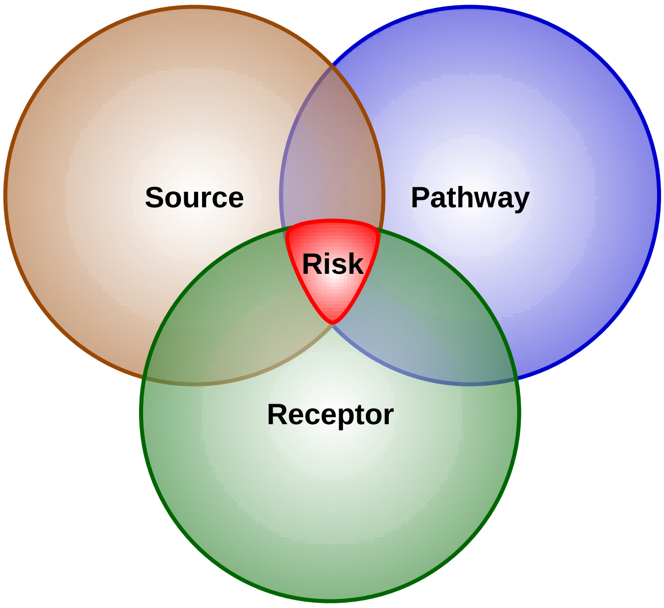
[1] EPA 2012, 'Statement that a Proposal May be Implemented - Cloud Break Life of Mine, Pilbara', Ministerial Statement No. 899, Office of the Environmental Protection Authority, Government of Western Australia, 5 June 2012, Pp. 132.

Figure 1: Risk Assessment Conceptual Site Model



1.3 Management of work

The following is addressed in this AMD MP:

- The required structured actions and deliverables for each stage of mining and that refers directly to the Global Acid Rock Drainage (GARD) Guide[2] and the 2007 Managing AMD Department of Industry Tourism and Resources (DITR) publication[3]:
    - Exploration;
    - Pre-Feasibility, feasibility and planning;
    - Construction and operations; and
    - Decommissioning and post-closure.

The following strategies and actions required are described should specific events be triggered:

- Monitoring;
- Long-term prevention;

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[2] INAP 2009, 'Global Acid Rock Drainage Guide', International Network for Acid Prevention. http://www.gardguide.com/

[3] DITR 2007, 'Managing Acid and Metalliferous Drainage', Department of Industry Tourism and Resources, Australian Government Leading Practice Sustainable Development Program for the Mining Industry, No. 8, Government of Western Australia, Pp. 107.

- Contingency; and
- Remediation.

This document assumes the reader has a working knowledge of AMD geochemistry and/or will refer to other more detailed documents. Technical details have been excluded and descriptions are condensed in this plan. A detailed glossary is included at the end of this plan to aid user comprehension, and the decision process for each mining stage has been presented as flow diagrams for ease of consultation. The management action matrix for each stage is given in Table 1and indicated throughout the Figures.

Table 1: Management Actions

Stage	Actions
Exploration	Solid sample collection and analyses
	preliminary water quality sample collection
	Assessment of receptors and conceptual site model
Pre-Feasibility	Sample waste material, classify and predict drainage
	Surface & groundwater regime and baseline sample collection
	Design WRL to account for potentially harmful wastes
	Include findings and prevention measures in environmental approvals
Feasibility	refine surface & baseline regime and baseline sample collection
Construction and Operations	Continue material classification
	Establish water baselines and trigger values, Install source specific monitoring bores, continue baseline sampling, conduct groundwater flow & pit lake modelling
	Monitor sources for exceedances, receptors for deterioration.
	Manage Contingency Actions
	Schedule waste from all sources to required final locations and demarcate material storage areas
Decommissioning and Closure	Validate and recalibrate hydro geologic and pit lake models
	Conduct contamination assessment, measure conditions against long-term closure objectives
	Cover and close WRLs

The deliverable reports and data collected per stage are given in Table 2. All reports must be document controlled and registered as per FMG's document control procedures (100-PR-DC-0002).

Table 2: Information Requirements

Stage	Deliverables
Exploration	Solid sample analyses reports
	Initial Groundwater Samples
	AMD potential report
	Conceptual site model
Pre-Feasibility	Solid sample analyses
	Waste classification and drainage prediction report
	Groundwater flow regime
	WRL plan & design
	Environmental Approval documentation, including AMD assessments
Feasibility	Waste classification and drainage prediction report
Construction and Operations	Solid sample analyses reports
	Classification of growth medium and construction material report, and ongoing waste classification
	Water Geochemistry baselines and trigger values report, Surface water samples and monitoring bores around sources and pit lake modelling reports (if required)
	Monitoring reports & Trigger value exceedance reports
	Waste deposition and schedule reports
Decommissioning and Closure	Solid sample analyses reports
	Validate and maintain water models
	Conduct contamination assessment, establish vegetation & rehabilitate

1.3.1 Site Specific Trigger Values

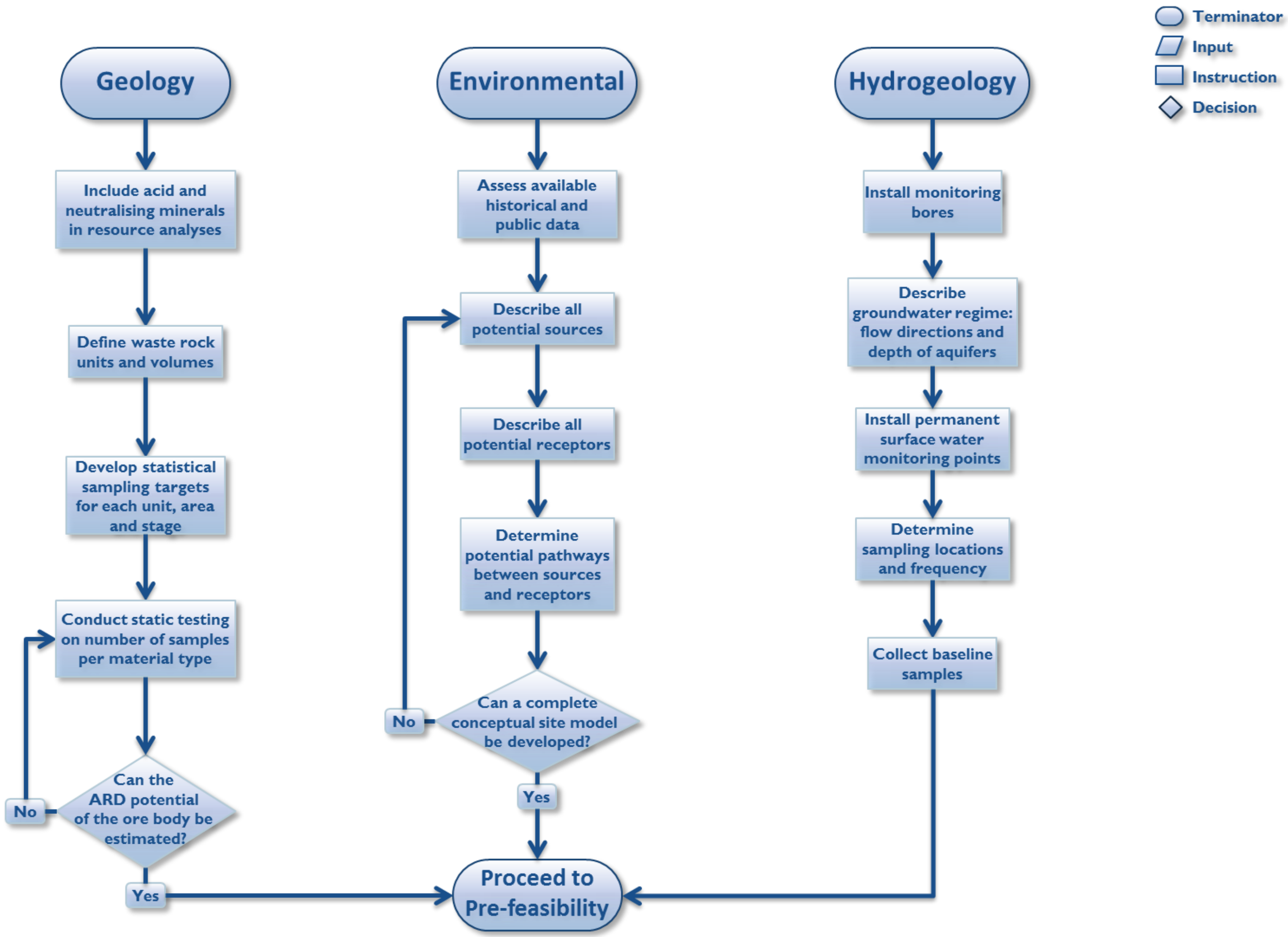
Fortescue is finalising site specific baseline trigger values for its Cloudbreak, Christmas Creek and Solomon Operations. These will be adopted in accordance with this plan in 2015, following the approval of the Chief Executive Officer of the OEPA.

2. EXPLORATION

2.1 Information Required

Figure 2 shows the procedure to follow during the exploration stage. During prospecting and exploration include sulphur and calcium oxide (CaO) in the list of elements being analysed for by x-ray fluorescence (XRF) screening for all samples tested. Where the geology of the deposit is known, static tests should be conducted for several representative samples of each key material type of ore and waste rock. Initial analyses of surface- and groundwater should include pH, electrical conductivity (EC), alkalinity, major ions and common toxic elements. Quality assurance/quality control (QA/QC) samples should be included to assess sampling techniques and laboratory quality. Refer to Acid Metalliferous Drainage Sampling Plan (100-PL-EN-1014) for detailed methods

Figure 2: Exploration Stage Procedure



2.2 Deliverables

2.2.1 Geology

By the end of the resource definition phase or exploration stage, there should be adequate geochemical information to characterise the AMD potential of the ore body (high and low grade), although further test work will normally be required to characterize the AMD potential of waste rock and tailings.

2.2.2 Hydrogeology –

A water quality sampling programme to establish characteristics of surface and groundwater catchments, and aquifers should be instituted.

2.2.3 Environmental

All potential sources, pathways and receptors should be described and a conceptual site model (CSM) constructed. The CSM should be updated through each stage and expanded when more detailed information is available.

3. PRE-FEASIBILITY, FEASIBILITY, MINE PLANNING AND DESIGN

3.1 Information required

These stages should represent the peak of characterisation efforts and sufficient waste rock samples should undergo static testing to identify placement of potential AMD material using the geologic block model. Kinetic and long-term leach testing of the different rock types should be conducted to inform geochemical models and disposal options. Figure 3 shows the prefeasibility stage procedure.

Sampling of surface and groundwater should commence and continue through the construction phase Figure 4 summarises the approach to establish baseline, low risk trigger values (LRTV) and investigative trigger values (ITV).

3.2 Long-term prevention

In order to prevent the long-term generation of acid and metalliferous drainage from mining activities, the lithology’s most at risk must be disposed of carefully to prevent either the ingress of oxygen and/or water. The position of potentially harmful lithotypes must be determined, and the mine schedule must include planning to store and dispose of these wastes appropriately as they are excavated. Leach testing will determine whether backfilling in mine voids (above or below the water table), encapsulation in waste rock landforms, or blending with neutralising material, is required to prevent environmentally harmful drainage. Exposure of reactive formations should be avoided during any activity including mining, bore placement, and construction. Figure 5 displays the procedure to classify mine waste material. See Glossary for an explanation of acronyms.

Planning for decommissioning and closure should be commenced at the feasibility stage. If mine voids are planned to remain after closure, groundwater and geochemical modelling will be required to predict pit lake water quality and to evaluate whether the void will become a source connected via a preferential pathway to a down gradient receptor. Leach testing of potentially harmful material should provide information as to the most effective method of disposal. The Environment and Mine Planning teams should then use this information to determine whether this material can be: backfilled above or below the water table, blended with neutralising material, left *in situ*, blended with benign waste, encapsulated or disposed of in a dedicated, lined cell.

If appreciable seepage is expected from waste rock landforms (WRL) or tailings storage facilities (TSF), then fate and transport modelling will be required for contaminants of concern.

3.3 Deliverables

A resource block model will be developed to locate lithology’s that may result in potentially acid or metalliferous drainage.

The mine schedule specifically plans at what stages potential AMD generating material will be excavated and how it will be stored and disposed. If necessary, lined storage areas may be required to be constructed prior to excavation and must be included in mine scheduling. Figure 6 shows how to plan waste rock landforms. Sufficient surface and groundwater samples should have been collected the completion of the feasibility stage to establish baseline and trigger values for compliance monitoring. It is worth noting that the baseline and trigger values may not necessarily be the same. If changes to surface and groundwater quality are unavoidable as a result of mining, dewatering and reinjection, then the maximum tolerance of the system should be determined and established as the trigger values in consultation with regulators.

Figure 3: Prefeasibility, Feasilbity, Mine Planning and Design Procedure

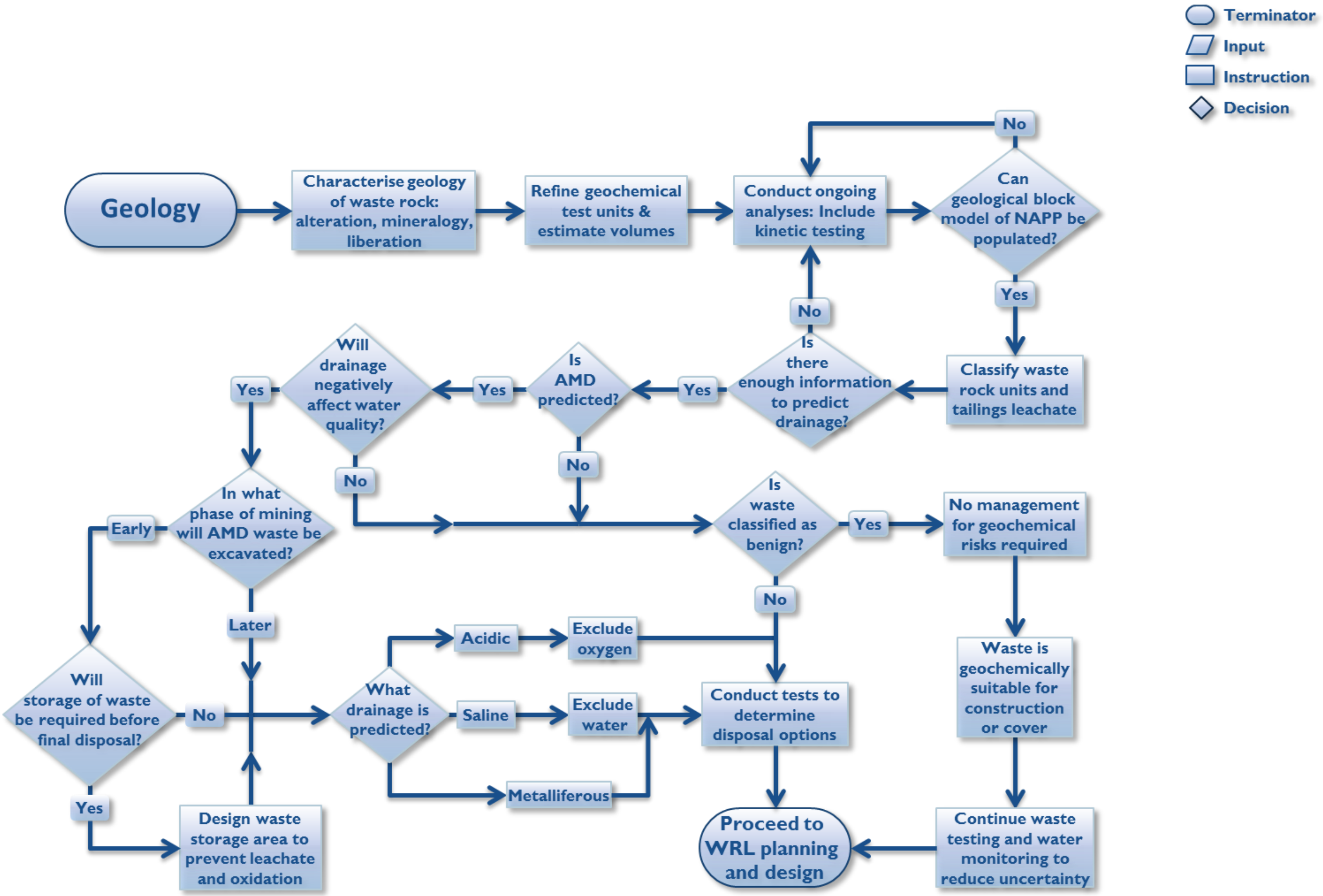


Figure 4: Establishing Trigger Values Procedure

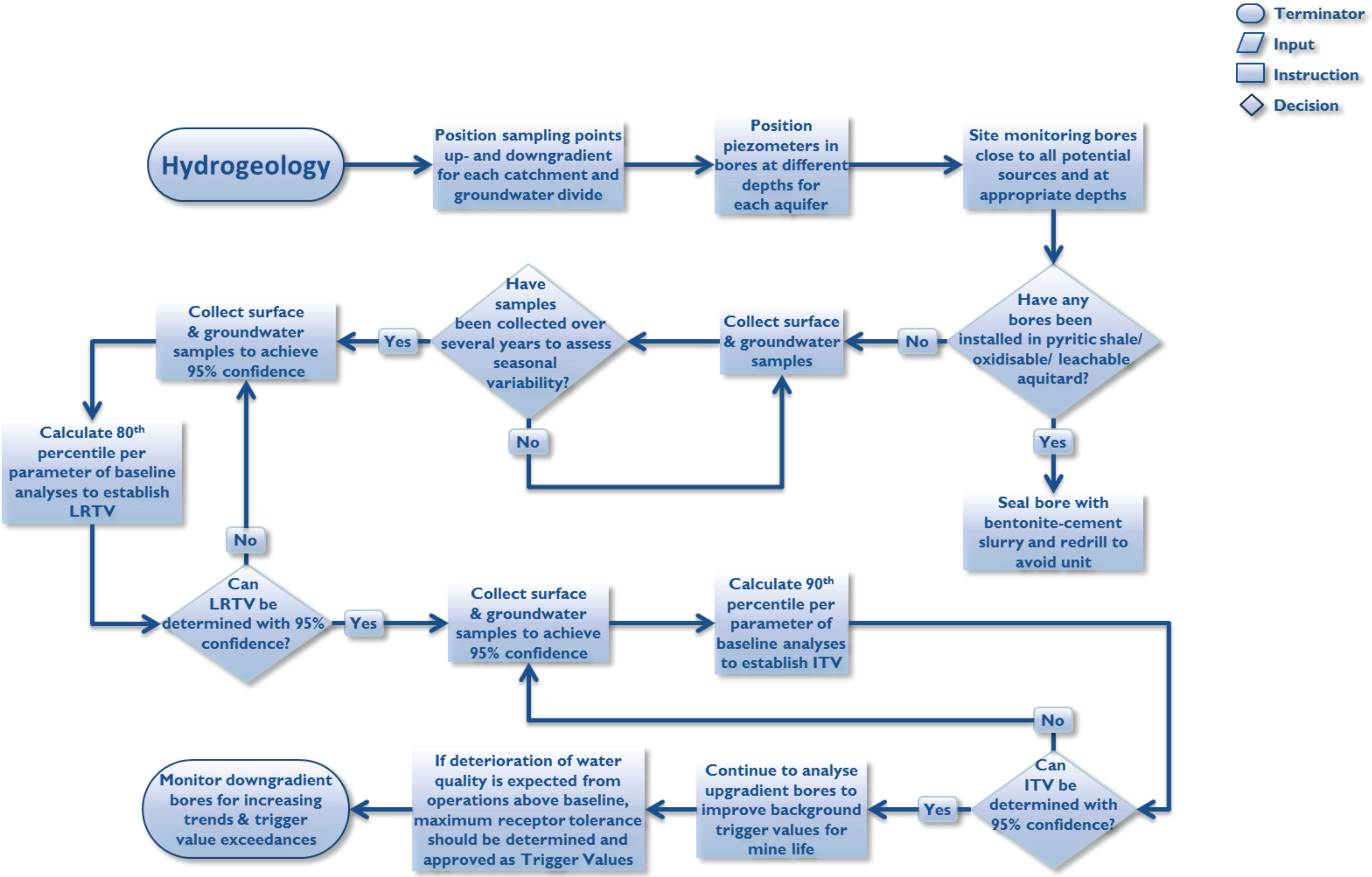
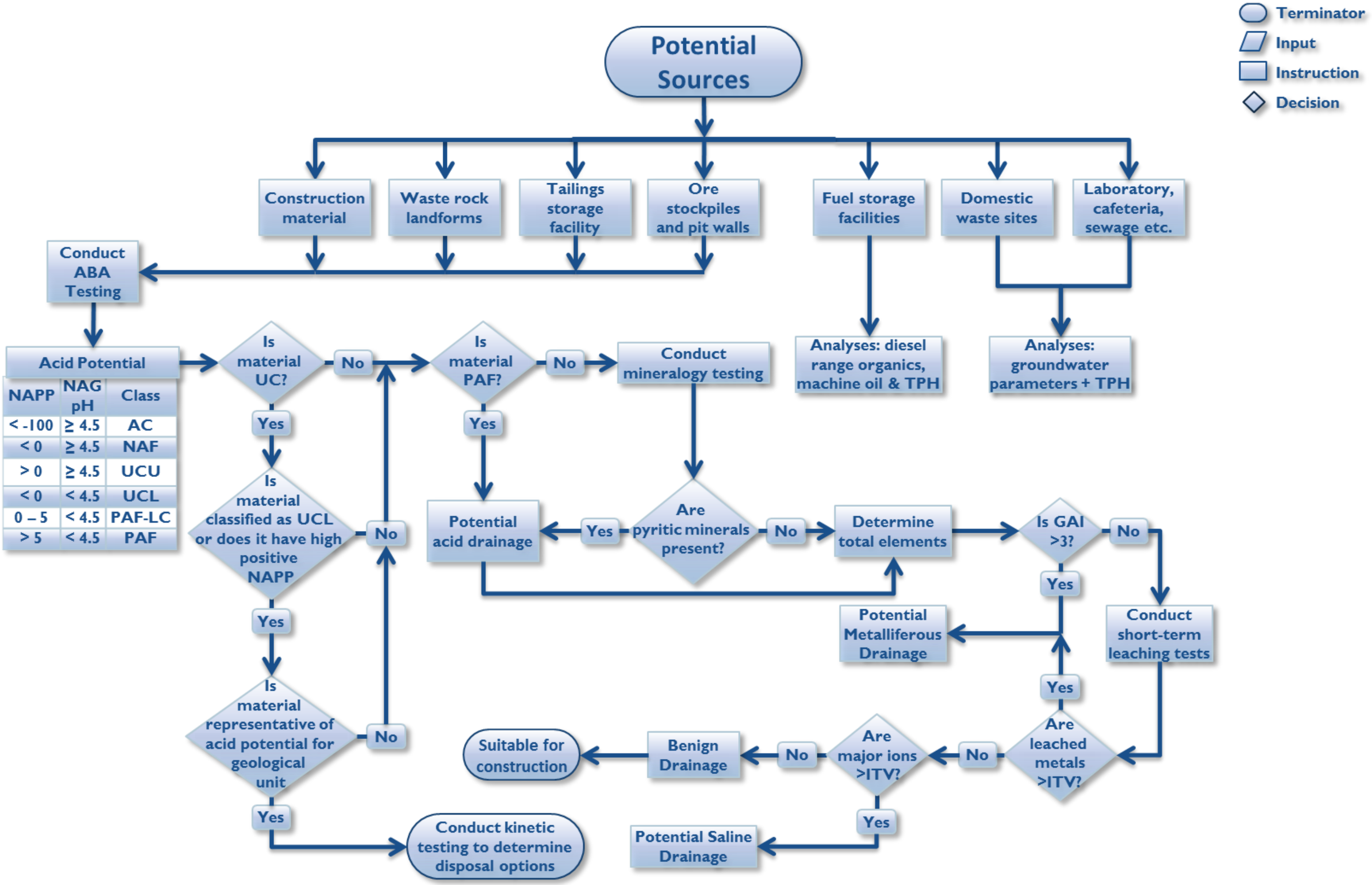
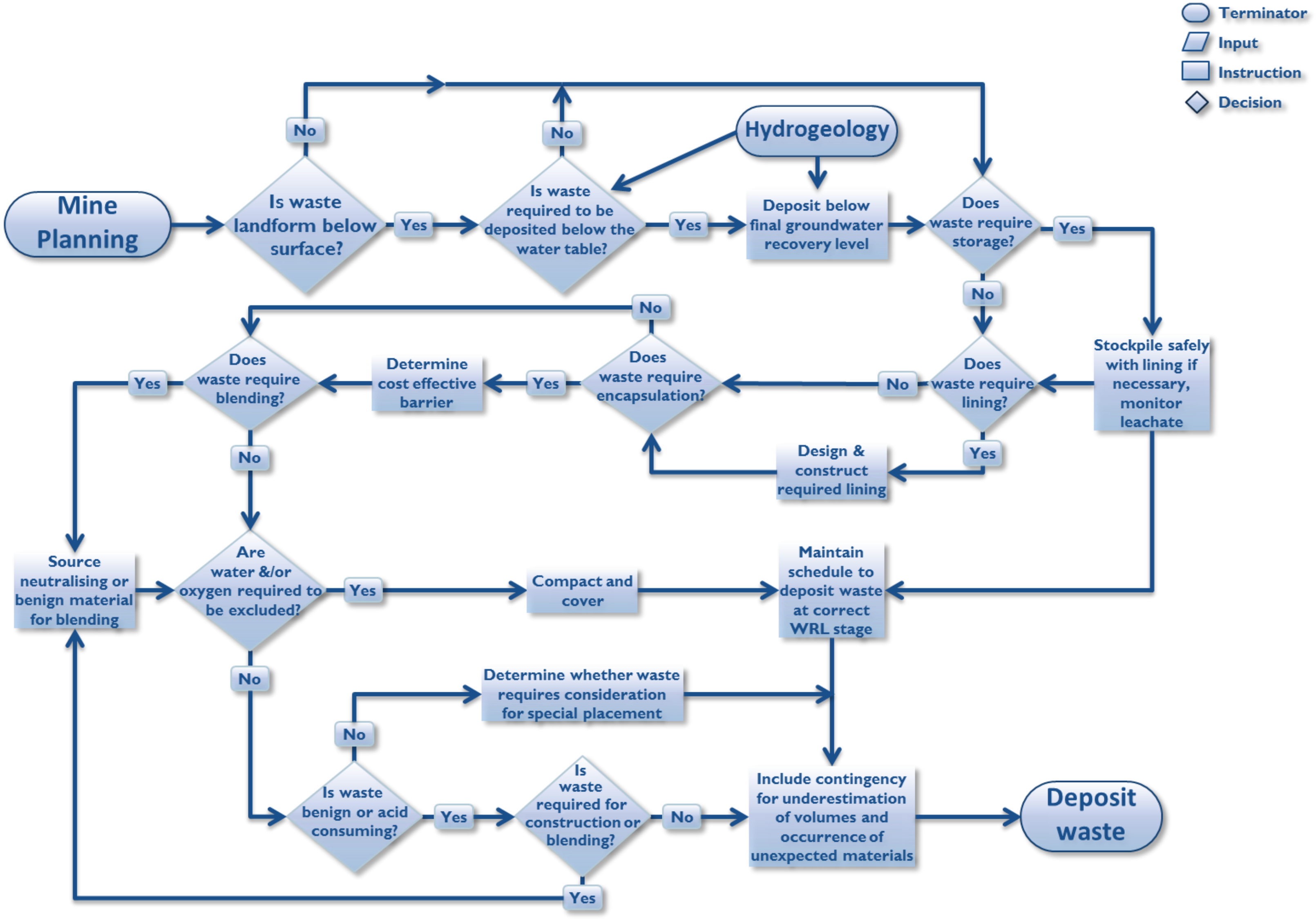


Figure 5: Waste and Groundwater Analyses and Classification Procedure



NAPP	NAG pH	Class
< -100	≥ 4.5	AC
< 0	≥ 4.5	NAF
> 0	≥ 4.5	UCU
< 0	< 4.5	UCL
0 – 5	< 4.5	PAF-LC
> 5	< 4.5	PAF

Figure 6: Waste Rock Landform Planning Procedure



4. CONSTRUCTION AND OPERATIONS

4.1 Sampling

All material to be used for construction should be, at a minimum, tested for acid potential. This material may only be used if it is classified as non-acid forming or acid consuming. **.**Figure 7 shows the procedure for construction stage activities. Figure 8 displays the procedure for operation stage activities.

4.2 Monitoring

Monitoring bores should be situated around all waste sources, such as fuel storage areas, WRLs, TSFs, landfills and domestic sewage and waste sites.

Analyses according to source type should be conducted. For example, if no petroleum is used on site then only diesel range organic analyses are necessary, and at sewage treatment plants only nutrient and bacterial analyses are required.

Surface and groundwater quality should be compared to baseline and trigger values established during the prefeasibility stage. Information gathered from up gradient sampling points can be included to improve baseline seasonal variation over the life of mine, as long as these positions are not affected by dewatering and mining activities. Figure 9 shows the trigger value exceedance procedure.

Other receptors affected by surface or groundwater quality should be monitored for deterioration.

Figure 7: Construction Stage Procedure

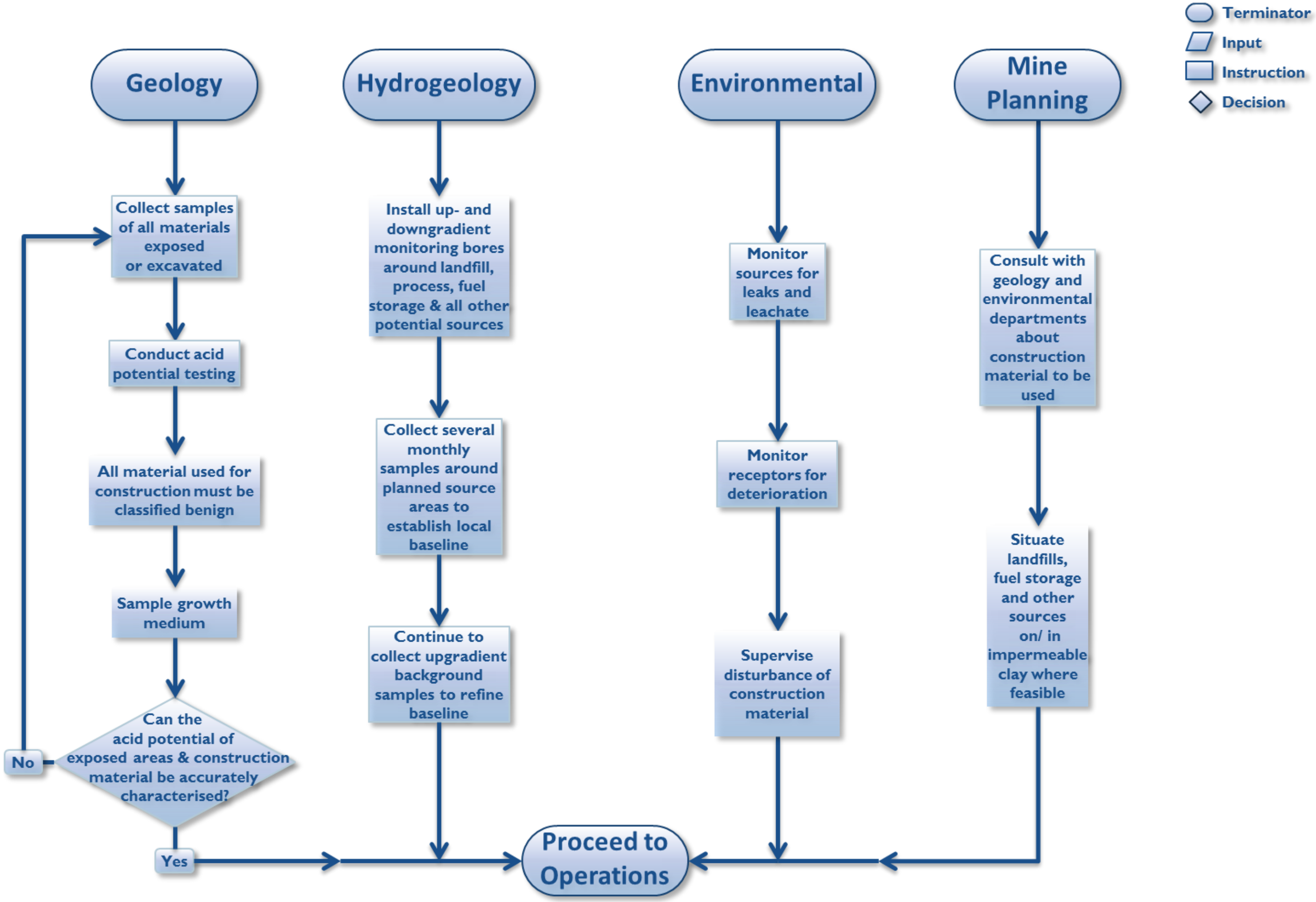


Figure 8: Operations Stage Procedure

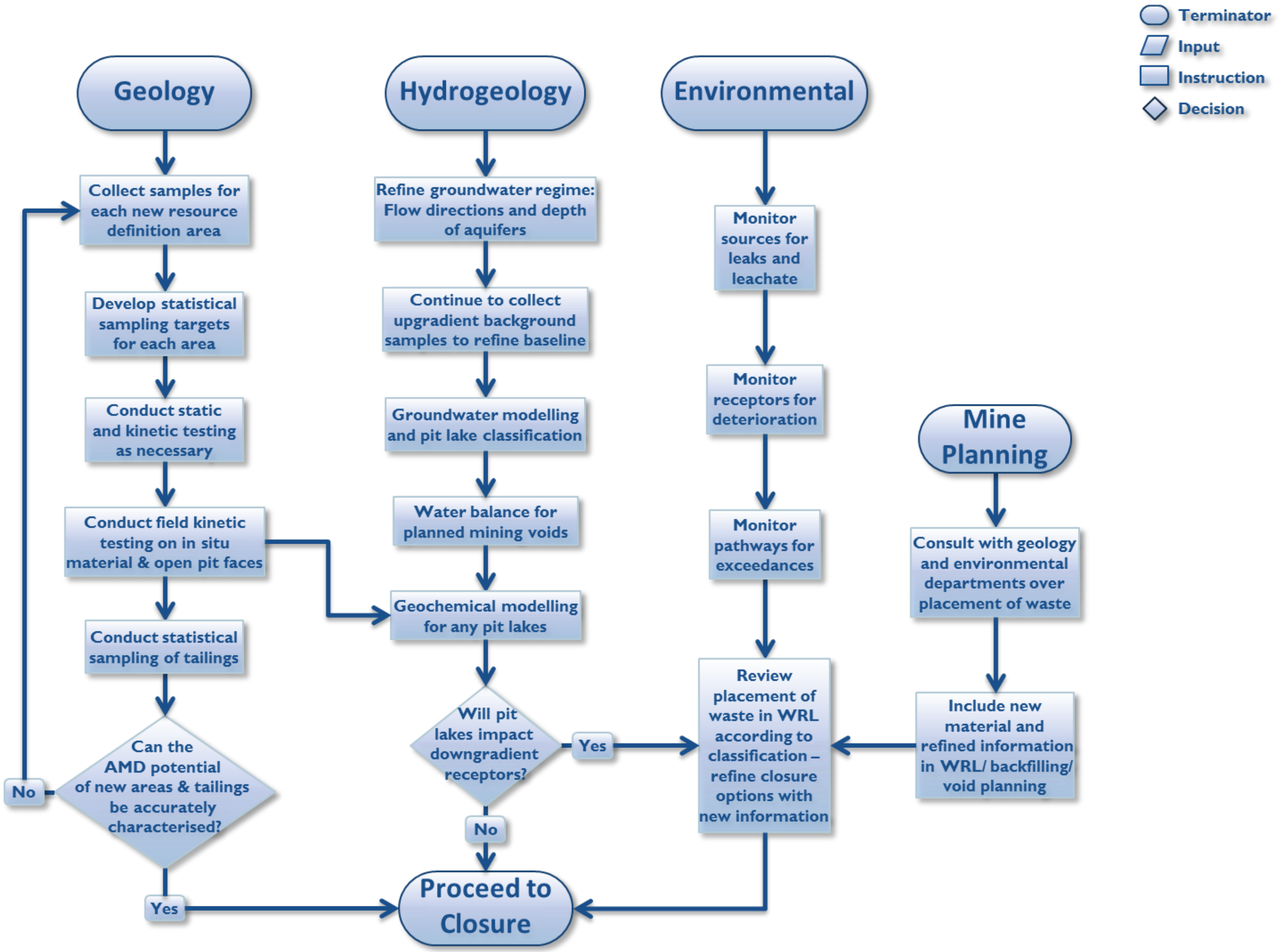
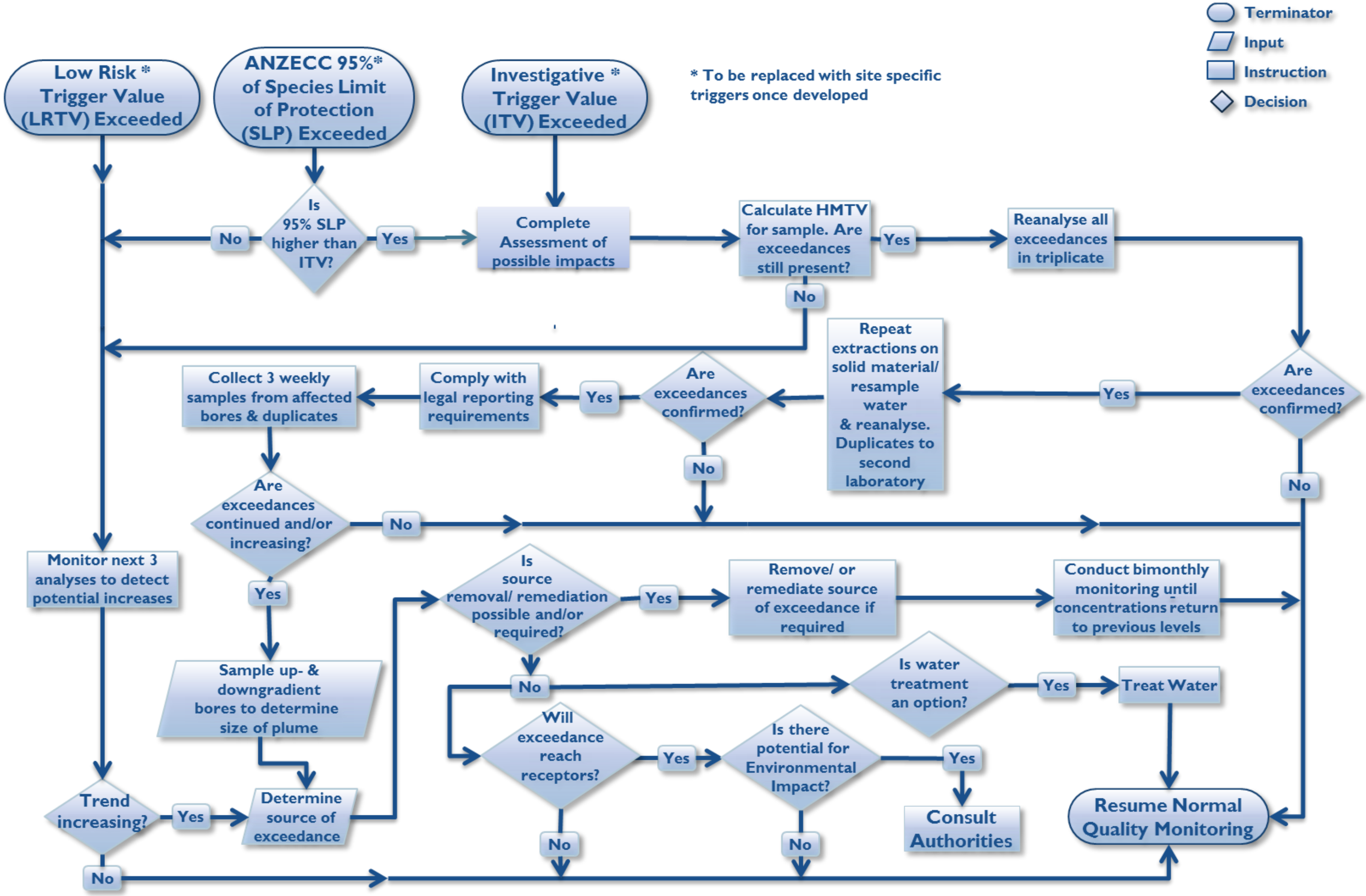


Figure 9: Trigger Value Exceedance Procedure



5. CONTINGENCY

The contingency actions that will be initiated if metalliferous waste or leachates are identified during this stage are shown in Table 3.

Table 3: Contingency Actions

Trigger	Contingency Actions
Confirmed water quality exceedance	• Enter exceedance in BMS and investigate (Figure 9) . • Where it is determined to be caused by Fortescue activities convene Management Team with representatives from Environment, Water, Geology and Mine Planning to develop a strategy to determine suitable management actions, measures while ensuring any contaminants are contained and reduced/removed to an approved level. • Increase monitoring of down gradient ground water and natural drainage lines in catchments where water quality has been compromised.
Material or waste with the potential to generate Acid and or Metalliferous drainage is inadvertently exposed or encountered during operations.	• Enter change in BMS and investigate • Convene Management Team with representatives from Environment, Water, Geology and Mine Planning to develop a strategy to determine and adopt suitable management actions (examples being, but not limited to: backfilling in mine voids (above or below the water table), encapsulation in waste rock landforms, treatment or blending with neutralising material, is required to prevent environmentally harmful drainage.(Figure 6) • The chosen option should ensure long term environmental impacts and financial liabilities are minimised • Mine Plans and schedules should be amended to estimate acid material or waste volume production and compare to inert waste availability to ensure that sufficient material will be available for chosen management option. • Increase monitoring and inspections to ensure that material or wastes is transported to the correct locations and placed as required.

Where possible situate surface sources on low permeability material (e.g. clay) to reduce likelihood of contamination pathways. Where temporary storage of metaliferous materials may be required, situate areas on clay formations and/or in bunded areas, and not on highly permeable material, or in surface drainage channels.

While some disturbance of water quality may be unavoidable, elevated concentrations of some toxic elements may not be tolerable to the system. If metalliferous leachate occurs, remediation may be required. Treatment of waste and/or water will be less costly to implement during the operations stage and if detected early, prevention measures can be instituted.

With additional detailed information gathered at each mining stage, predictive groundwater and geochemical models should be validated to existing conditions and recalibrated, if necessary.

6. DECOMMISSIONING AND POST CLOSURE

6.1 Remediation

Contaminated land assessments are required for all source areas that are planned to be demolished in accordance with National Environment Protection Measures (NEPM) and contaminated sites legislation. Samples should be compared to baseline concentrations in order to determine the presence of elevated concentrations. Figure 10 shows the decommissioning and closure procedures.

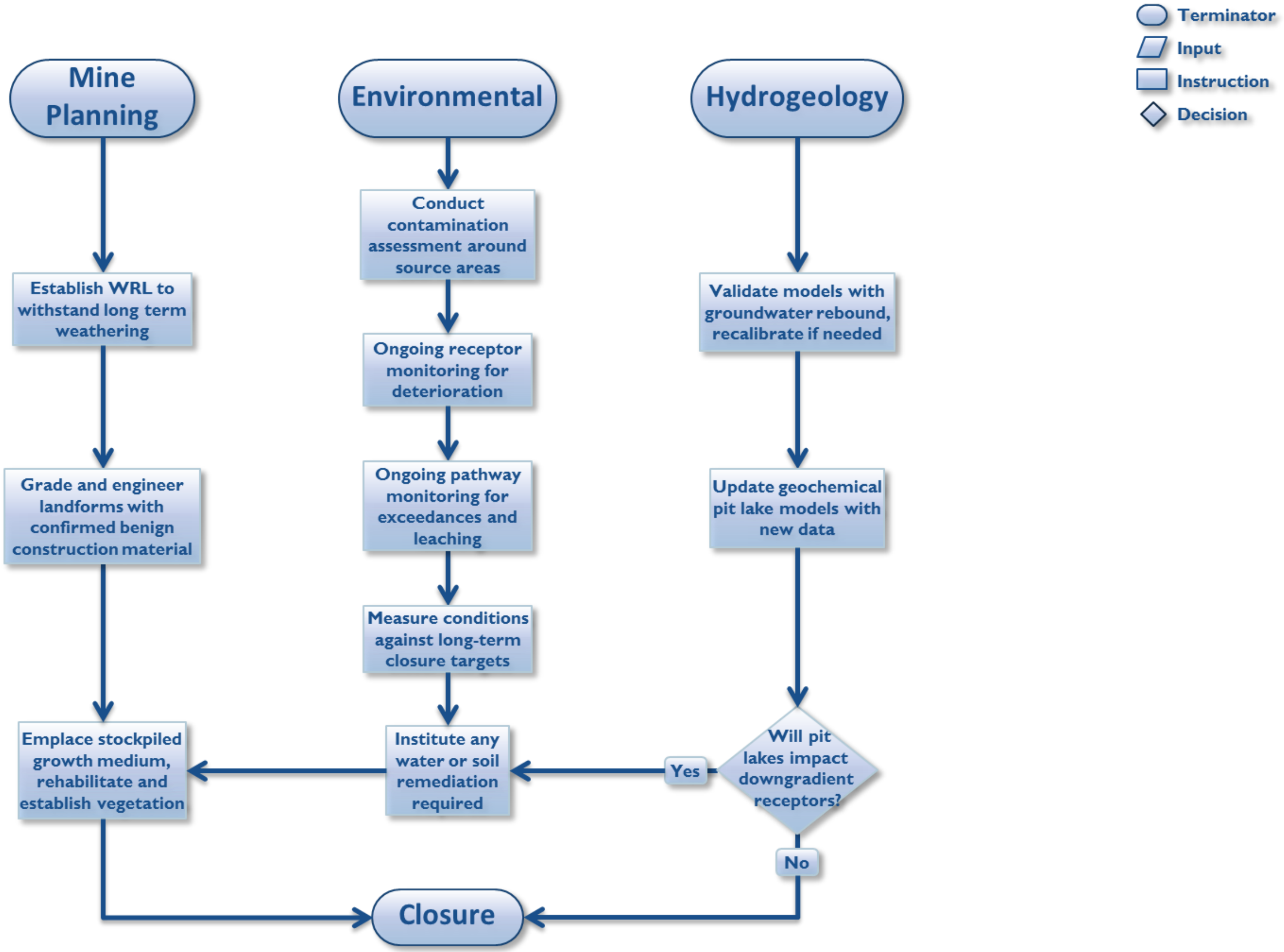
6.2 Rehabilitation

Waste rock landforms should be closed and capped, according to plans to reduce geochemical alteration of harmful materials, and rehabilitated to conform to the surrounding landscape. Benign material must be used for construction. Growth medium should be spread as a final cover and vegetation re-established.

6.3 Long-term monitoring

Long-term monitoring of surface and groundwater should be continued until it can be statistically proven that leachate containing concentrations above the established trigger values and closure targets is not occurring and no down gradient receptors are at risk.

Figure 10: Decommissioning, Rehabilitation and Post Closure Procedure



7. GLOSSARY

95% SLP – ANZECC Guidelines 95% of Species, Limit of Protection water quality guideline

AC - acid consuming- Material that contains a large proportion of carbonate minerals

Acid-base accounting (ABA) – An analytical technique applied to mine wastes and geologic materials that determines the potential acidity from sulphur analysis versus the neutralization potential. It is used to predict the potential of that material to be acid producing or acid neutralizing.

Acid generating – Refers to ore and mine wastes that contain sulphur or sulphides, which produce acid when oxidized. Acid can also be present as acid sulphates or generated by their weathering, produced originally from oxidation of sulphides.

Acid potential (AP) – The ability of a rock or geologic material to produce acid leachates; may also be referred to as acid generation potential or AGP.

Acid rock drainage (ARD) – A low pH, metal-laden, sulphate-rich drainage that occurs during land disturbance where sulphides are exposed also known as **acid and/or metalliferous drainage (AMD)** when it originates from mining areas.

AHD - **Australian Height Datum** – Elevation above sea level in metres above mean sea level

Alkalinity – The titratable alkalinity, using a standard acid titrant, reported as milligrams per litre as calcium carbonate (mg $CaCO_3$/L).

AMIRA – Australian Mineral Industries Research Association

ANC - acid neutralising capacity – neutralising potential determined by titration expressed as kg H_2SO_4/t

Anion – An ion with a negative charge.

ANZECC Guidelines – Australian and New Zealand Environmental and Conservation Council and Agriculture and Resources Management Council of Australia and New Zealand Guidelines for Fresh and Marine Water Quality. Volumes 1 & 2: The Guidelines; Chapters 1-8. National Water Quality Management Strategy: Document 4.

Aquifer – A geologic formation, group of formations, or part of a formation that contains sufficient saturated permeable material to yield significant quantities of water to springs and wells.

AS – Australian Standard

ASLP – Australian Standard Leaching Procedure

ASTM – American Standard Testing Method

ARMCANZ – Agriculture and Resources Management Council of Australia and New Zealand

Backfill – Geologic materials returned to an open pit or placed back into an underground mine, after desirable minerals have been removed, to bring a surface mine back to original contour, partially refill an open pit, or to improve stability of underground workings.

Baseline – A baseline measurement represents concentrations measured at some point in time and may or may not represent the true background. Baseline concentrations are typically expressed as a range, not as a single value.

Blending – Mixing materials either to dilute or neutralise potentially harmful leachate

Bore / monitoring well – The generalised term for any narrow shaft drilled in the ground, either vertically, horizontally, or inclined that reaches the water table.

Carbonates – A class of rocks containing calcium (Ca) and/or magnesium (Mg) carbonate, such as limestone and dolomite.

Catchment / Watershed – The land area that drains into a stream. The watershed for a major river may encompass a number of smaller watersheds that ultimately combine at a common point.

Cation – An ion with a positive charge.

COC - **Chain of Custody** – A document signed by all personnel handling environmental samples to guarantee no tampering and sample integrity.

Conceptual site model – A representation of a site and its environment that represents what is known or suspected about contaminant sources as well as the physical, chemical and biological processes that affect contaminant transport to potential environmental receptors.

Contaminant – Any physical, chemical, biological, or radiological substance or matter that has an adverse effect on human and ecological receptors as well as environmental media (e.g., air, water, soil, sediment).

DITR - Department of Industry, Tourism and Resources – Government of Western Australia

DMP - Department of Mines and Petroleum – Government of Western Australia

EC - electrical conductivity – Indicates the concentration of ionized constituents in a water sample or soil matrix.

EPA - Environmental Protection Agency – Government of Western Australia

GAI - Geochemical abundance index – Calculation to compare the total rock concentration of an element to the global average abundance to determine relative enrichment

GARD guide - Global acid rock drainage – http://www.gardguide.com/

Groundwater – Water in the zone below the surface of the earth where voids are filled with water. This is in contrast to surface water.

Groundwater parameters – List of analyses required may include: pH, EC, TDS, alkalinity, major ions, and metals/metalloids.

Hardness – Water hardness is a measure of the soluble, divalent, metallic cations (positive ions having a valence of 2) mostly calcium (Ca) and magnesium (Mg), although strontium, aluminium, barium, iron, manganese, and zinc also cause hardness in water, they are not usually present in large enough concentrations to contribute significantly to total hardness. Originally hardness was defined as the capacity of water to precipitate soap and cause scale. Hardness is calculated as the sum of Ca & Mg in mmolc/L, or meq/L, and expressed as mg $CaCO_3$/L. It is an important modifier when estimating the toxicity of cadmium, chromium, copper, nickel lead and zinc.

HMTV - Hardness modified trigger value – Calculation from ANZECC Guidelines (Volume 2) adjusting the trigger values for cadmium, chromium, copper, lead, nickel and zinc taking into account the hardness of the solution which reduces the toxicity of these elements when > 30 mg $CaCO_3$/L.

Hydraulic conductivity - A property of soil or rock that describes the ease with which water can move through pore spaces or fractures. It depends on the intrinsic permeability of the material and on the degree of saturation.

Ions – Elements or molecules that have either a positive or negative charge

***In situ* treatment –** Treatment performed in place, without disturbance, removal, or excavation of the material being treated.

INAP - International Network for Acid Prevention

Infiltration - The downward entry of water into a soil or other geologic material from the surface.

ITV – Investigative trigger value – defined by the ANZECC Guidelines Volume 2 as the 90th percentile of a continuous database.

Kinetic testing – Long-term leach testing to determine rate of weathering of neutralising or acid-forming material

Leaching - Removal by dissolution, desorption, or other chemical reaction from a solid matrix by passing liquids through the material.

Lining – Barrier constructed from either natural or synthetic material to prevent leaching

Lithology - The character of a rock described in terms of its structure, colour, mineral composition, grain size, and arrangement of its visible features that in the aggregate impart individuality to the rock. The term is often used to classify rock materials for characterization purposes along with the degree of alteration and acid-base characteristics.

LRTV - Low risk trigger value – defined by the ANZECC Guidelines Volume 2 as the 80th percentile of a continuous database.

Mbgl - metres below ground level – measurement of water level and depth of bores below surface

Metalloid - is a term used in chemistry when classifying the chemical elements. On the basis of their general physical and chemical properties, nearly every element in the periodic table can be termed either a metal or a non-metal. However, the elements: antimony, arsenic, boron and silicon, have intermediate properties and are referred to as **metalloids.**

Milling - The crushing and grinding of ore. The term may include the removal of harmful constituents or constituents without economic value from the ore and preparation for additional processing or sale to market.

Mine rehabilitation - Modern mine rehabilitation aims to minimize and mitigate the environmental effects of mining.

Mineralogy - The study of minerals and their formation, occurrence, use, properties, composition, and classification; also refers to the specific mineral or assemblage of minerals at a location or in a rock unit.

Mitigation - Correction of damage caused by mining activity (e.g., mine subsidence, wetland impacts, acid drainage).

Monitoring - The periodic or continuous surveillance or testing to determine the level of compliance with process or statutory requirements in various media or in humans, plants, and animals.

MPA - Maximum potential acidity – Total sulphur expressed in kg H_2SO_4/t

NAF - non-acid forming – Material that contains a greater proportion of neutralising minerals than acid-forming minerals

NAG - Net acid generation – Analytical test using peroxide to rapidly oxidise all reactive minerals in a sample and test resulting pH of solution for ultimate determination of acid potential. Does not take into account different rates of oxidation of minerals.

NAPP - Net acid production potential – NAPP = MPA-ANC

NATA - **National Association of Testing Authorities –** Standard methods for Australia

NEPM -National Environmental Protection Measure – Contaminated sites legislation

Neutral mine drainage - A neutral pH, metal-laden, sulphate-rich drainage that occurs during land disturbance where sulphur or metal sulphides are exposed to atmospheric conditions. It forms under natural conditions from the oxidation of sulphide minerals and where the alkalinity equals or exceeds the acidity.

Neutralisation potential (NP) - The amount of alkaline or basic material in rock or soil materials that is estimated by acid reaction followed by titration to determine the capability of neutralizing acid from exchangeable acidity or pyrite oxidation. May also be referred to as acid neutralization potential or ANP.

Neutralisation– A chemical reaction in which an acid and a base or alkali (soluble base) react to produce salt and water, which do not exhibit any of the acid or base properties.

Ore stockpiles - ore that requires blending either to achieve desired grade or reduce elevated concentrations of undesirable elements may be stockpiled for significant lengths of time that weathering may occur; and

OPF - Ore processing facilities – Plant where ore is processed by various means

Overburden – Material of any nature, consolidated or unconsolidated, that overlies a deposit of useful and minable materials or ores, especially those deposits that are mined from the surface by open cuts or pits.

Oxidation – A chemical process involving a reaction(s) that produces an increase in the oxidation state of elements such as iron and sulphur.

PAF - potentially acid forming – Material that contains a greater proportion of acid-forming minerals than neutralising minerals

Pathway – The physical course a chemical or pollutant takes from its source to an exposed organism.

pH – A measure of the acidity (pH less than 7) or alkalinity (pH greater than 7) of a solution; a pH of 7 is considered neutral. It is a measure of the hydrogen ion concentration (more specifically, the negative log of the hydrogen ion activity for glass electrodes) of a soil suspension or solution.

PER – Public Environmental Review

Piezometers – Casing pipes installed into the same monitoring bore to sample different water depths

Pit lake – Any perennial or ephemeral water body that occupies an excavation in the land surface created for the collection of ore material.

Porosity – A measure of the void spaces in a material. Expressed as a fraction between 0 and 1, or as a percentage between 0 and 100%.

Quality assurance/ quality control (QA/ QC) – A system of procedures, checks, audits, and corrective actions to ensure that all research design and performance, environmental monitoring and sampling, and other technical and reporting activities are of the quality that meets the testing objectives.

Receptor – An ecological entity exposed to a stressor.

Redox – Shorthand for reduction-oxidation. Describes all chemical reactions in which atoms have their oxidation number (oxidation state) changed, most commonly through the transfer of electrons.

Remediation – Clean-up or other methods used to remove or contain a toxic spill or hazardous materials from a site. It is the process of correcting, counteracting, or removing an environmental problem and often refers to the removal of potentially toxic materials from soil or water.

RPD - Relative per cent difference

Representative sample – A portion of material or water that is as nearly identical in content and consistency as possible to that in the larger body of material or water being sampled.

Risk assessment – A qualitative and/or quantitative evaluation of the risk posed to human health and/or the environment by the actual or potential presence and/or use of specific pollutants. Risk assessments are conducted to establish whether an ecological risk exists, to identify the need for additional data collection, to focus on a specific pollutant or specific site, and to develop contingency plans.

Sediment – any particulate matter that can be transported by fluid flow, and which eventually is deposited.

Shale – A thinly bedded or fissile sedimentary rock formed from clay or silt.

Slurry – Any mixture of solids and fluids that behaves as a fluid and can be transported hydraulically (e.g., by pipeline). See also **tailings**.

SSTV - Site specific trigger values – ANZECC guidelines are the most conservative limits that can be applied to water quality and may not be applicable for disturbed or highly saline environments. SSTVs must be developed for each new mining area prior to disturbance and take into account natural variations and conditions.

Static testing – Series of short-term tests for acid potential, total elements and leaching potential

Stratigraphy – The layering or bedding of varying rock types reflecting changing environments of formation and deposition.

Surface water – Water at or near the land surface, such as lakes and streams, as opposed to groundwater.

Tailings – The solid waste product resulting from the milling and mineral concentration process applied to ore. This term is usually used for sand to clay-sized refuse that is considered too low in mineral values to be treated further.

TPH – total petroleum hydrocarbons – Bulk (can be gravimetric) analysis for organic compounds, may include greases, fats and oils as well as petroleum compounds depending on analytical method used.

TSF - tailings storage facility – Any structure designed and constructed for the purpose of capturing and retaining liquid-solid slurries of mill tailings in which the solids settle. The liquid may or may not be discharged or captured for recycling after the solids have settled out of suspension.

Tailings supernatant – Liquid waste from any phase of the mineral processing stream, usually disposed of with tailings solids. Supernatant is the most mobile and most likely to enter the environment;

TDS - Total dissolved solids –The mass of both organic and inorganic matter, in solution in a volume of water. The amount of dissolved solids should by determined by filtering water through a 0.2 µm filter, drying to 180°C and weighing the residue remaining.

Toxicity – A property of a substance that indicates its ability to cause physical and/or physiological harm to an organism (plant, animal, or human), usually under particular conditions and above a certain concentration limit, below which no toxicity effects have been observed.

UCL/U – Uncertain Likely/ Unlikely – Classification according to the DITR: material classification is unclear, and depending on the magnitude of NAPP and the NAG pH further testing may be required

Waste rock – Barren or mineralized rock that has been excavated but is of insufficient value to warrant treatment and is removed ahead of the metallurgical processing and disposed of on site. The term is usually used for wastes that are larger than sand-sized material and can be up to large boulders in size; also referred to as *waste rock dump* or *waste rock landform.*

Water balance – An accounting of the inflow to, outflow from, and storage changes of water in a hydrologic unit over a fixed period.

Water quality standards – Ambient standards for water bodies. The standards prescribe the use of the water body and establish the water quality criteria that must be met to protect designated uses.

Weathering – Process whereby earthy or rocky materials are changed in colour, texture, composition, or form (with little or no transportation) by exposure to atmospheric agents.

WRL – **Waste rock landform** – Any structure constructed to contain waste in perpetuity, such a rock dump, tailings facility, backfilled pit etc.

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Appendix 1: Project Background

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Fortescue Metals Group Background

Fortescue Metals Group (Fortescue) is an integrated business comprised of mine, rail and port operations based in the Pilbara region of Western Australia with its head office located in Perth.

Fortescue has commenced operation of the Pilbara Iron Ore and Infrastructure Project (the Project), which consists of several iron ore mines and associated rail and port infrastructure in the Pilbara region of Western Australia.

The Project was granted Major Project Facilitation Status in December 2004 and Fortescue has signed two Agreements with the State of Western Australia:

- The Railway and Port (The Pilbara Infrastructure Pty Ltd) State Agreement for the port and rail infrastructure to transport ore from the mines to the port

- The Iron Ore (FMG Chichester Pty Ltd) Agreement for the iron ore mines

The Project has been developed in the following stages:

- Stage A, consisting of a two-berth iron ore export facility at Port Hedland and a north south railway from the central Pilbara to Port Hedland, approved under Ministerial Statement 690;

- Stage B, consisting of iron ore mines in the eastern Pilbara (Christmas Creek) and an east-west spur rail line connecting to the Stage A railway; approved under MinisterialStatement 707. (Note this approval included the Mindy Mindy mine site but this has not been developed to date);

- Cloudbreak iron ore mine west of the Christmas Creek area, approved under Ministerial Statement 721 and federal approval under the EPBC Act (EPBC 2005/2205);

- Port facility upgrade consisting of a fifth berth at Anderson Point, Port Hedland, approved under Ministerial Statement 771;

- Solomon iron ore project consisting of two new mines and a railway connecting to the existing Fortescue rail line, approved under Ministerial Statement 862 and federal approval under the EPBC Act (EPBC 2010/5567) in 2011;

- Additional rail infrastructure between Herb Elliot Port Facility and Cloudbreak Mine Site (EPBC 2010/5513);

- Christmas Creek water management scheme to increase the mine dewatering rate and to inject surplus water into two brackish and one saline injection zones, approved under Ministerial Statement 871;

- Cloudbreak Life of Mine, approved under Ministerial Statement 899 (supersedes the conditions of Ministerial Statement 721).

Changes to Ministerial Statements 690, 707, 721 and 771 were made and approved under Section 45 or 46 of the *Environmental Protection Act 1986* (EP Act).

Fortescue has extended its current operations in the Pilbara by developing the Northstar Project, which is located north east of the Solomon.

Fortescue is also conducting drilling programmes to further delineate resources and iron ore reserves within tenements surrounding Solomon and in additional locations throughout the Pilbara. In addition to its wholly owned tenements, Fortescue is party to joint ventures and agreements with other tenement holders within the Pilbara region and is the manager of iron ore exploration operations upon these tenements.

Appendix 2: Life of mine geochemistry programme: Acid Metalliferous Drainage Sampling Plan

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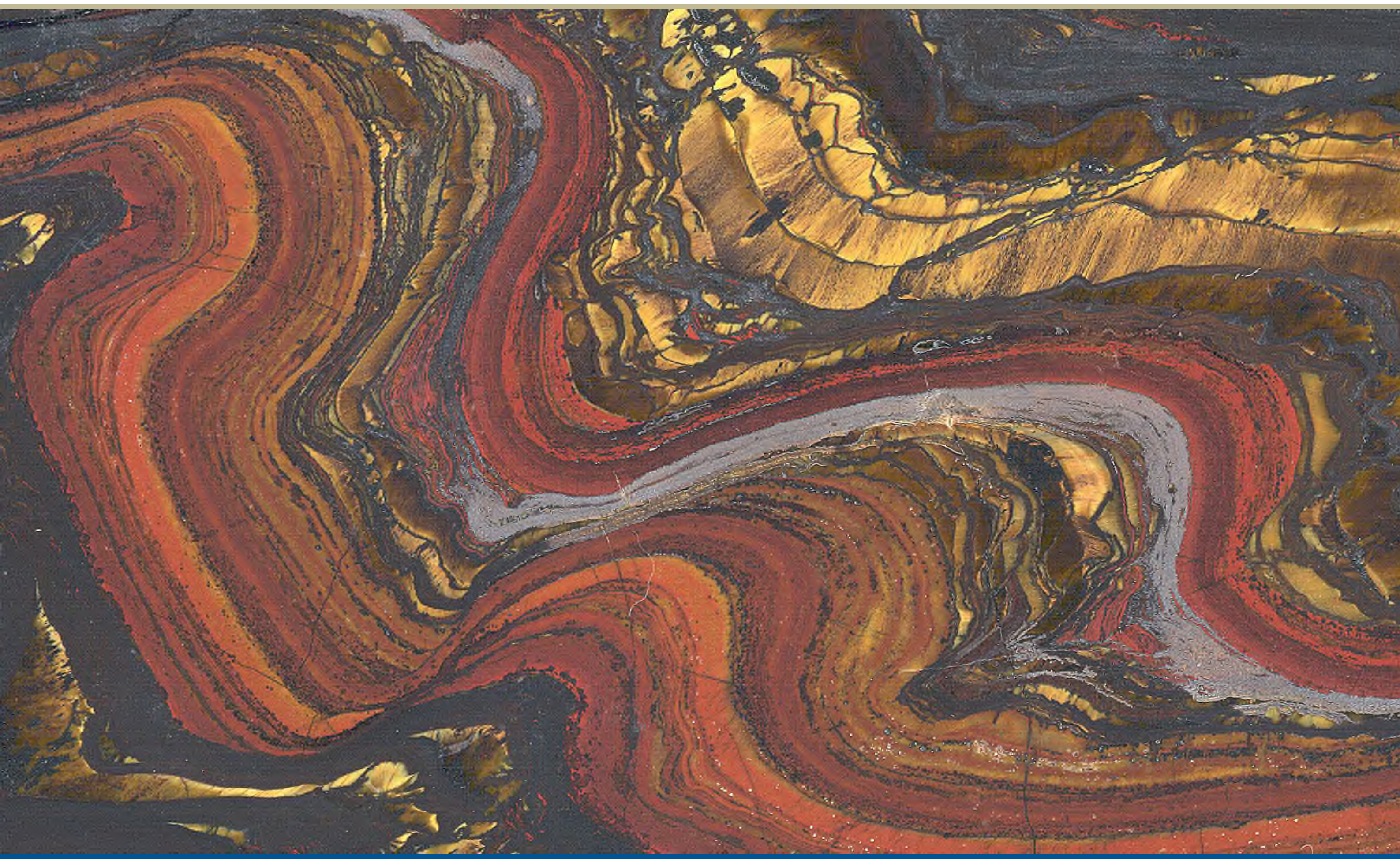
100-PL-EN-1014

Chichester and Solomon Operations **Original**

FORTESCUE
The New Force in Iron Ore

Life of Mine Geochemistry Programme

Acid Metalliferous Drainage Sampling Plan



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29 July 2014

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Life of Mine Geochemistry Programme

Acid Metalliferous Drainage Sampling Plan

#753-1495940300
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Restriction on Disclosure and Use of Data

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

LIST OF APPENDICES

ACRONYMS AND UNITS

Units of Measure

Centimetre	cm
Giga annum (billions of years)	Ga
Kilogram	kg
Kilogram sulphuric acid	kg H_2SO_4
Litre	L
Metre	m
Microgram	µg
Micro-Siemens	µS
Milligram	mg
Mega / Million tonnes	Mt
Metric tonne (1 000 kg)	t
Weight per cent	wt. %

Abbreviations and Acronyms

95% of Species Limit of Protection	95% SLP
Acid-base accounting	ABA
Acid consuming	AC
Australian Height Datum	AHD
Acid mine drainage	AMD
Australian Mineral Industries Research Association	AMIRA
Acid neutralising capacity	ANC
Acid rock drainage	ARD
Australian Mineral Industry Research Association	AMIRA
Australian and New Zealand Environmental and Conservation Council	ANZECC
Agriculture and Resources Management Council of Australia and New Zealand	ARMCANZ
Australian Standard	AS
Australian Standard Leaching Procedure	ASLP
American Standard Testing Method	ASTM
Banded Iron Deposit	BID
Banded Iron Formation	BIF
Calcrete	Cc
Chain of Custody	COC
Channel Iron Deposit	CID
Detrital Iron Deposit	DID
Electrical conductivity	EC
Environmental Protection Agency	EPA
Department of Mines and Petroleum	DMP
Department of Industry, Tourism and Resources	DITR
Glassy goethite	GGM
Global acid rock drainage	GARD
Geochemical abundance index	GAI
Hardcap	Hc
Hardcap unmineralised	Hso
Humidity cell test	HCT
Hardness Modified Trigger Values	HMTV
Inductively coupled plasma atomic emission spectroscopy	ICP-AES
Inductively coupled plasma mass spectrometry	ICP-MS
International Network for Acid Prevention	INAP

Limit of protection	LoP
Mineralised Marra Mamba Formation	MMM
Marra Mamba unmineralised basal	Mub
Marra Mamba unit hard/ medium/ friable	Mu h/m/f
Marra Mamba unmineralised clay	Muk
Marra Mamba unit shale	Mus
Marra Mamba unmineralised transition	Mut
Maximum potential acidity	MPA
Megawatt	MW
Metal leaching	ML
Metres below ground level	mbgl
Million tonnes per annum	Mtpa
Months	mo
National Association of Testing Authorities, Australia	NATA
Net acid producing potential	NAPP
Net acid generating	NAG
Net potential ratio	NPR
Non-acid forming	NAF
Oakover Formation	TO
Ore processing facilities	OPF
Public Environmental Review	PER
Potentially acid forming	PAF
Potential acid forming – high capacity	PAF-HC
Potentially acid forming – low capacity	PAF-LC
Quality assurance / quality control	QA/QC
Relative per cent difference	RPD
Site specific trigger value	SSTV
Tailings storage facility	TSF
Tertiary alluvium	Ta
Tertiary detritals	Td
Tertiary clay	Te
Total dissolved solids	TDS
Upper confidence level	UCL
Uncertain	UC
Hydrohematite-brown goethite	VGH
Waste rock landform	WRL
Wittenoom Formation	WF
X-ray diffraction	XRD
X-ray fluorescence	XRF
Year/ annum	yr/ a

1. INTRODUCTION

As part of Fortescue Metals Group (FMG) Chichester and Solomon Operations commitment to the environment, the Life of Mine Geochemistry Programme has been commissioned to continue to evaluate the potential for acid and metalliferous drainage at Cloudbreak and, Christmas Creek mines at the Chichester Hub and the Kings and Firetail mines at the Solomon Hub with a coordinated and standardised approach. In order to collect sufficient data and quality analyses this report details the Acid Metalliferous Drainage Sampling Plan for collection of waste material and water samples.

The issue of acid rock drainage (ARD) was not originally considered to be a concern in the Pilbara as a result of the low rainfall and high evaporation rates. Additionally the secondary depositional nature of the channel and detrital iron formations was thought to contain low amounts of organic matter where high sulfide material is expected. Acidic runoff after the heavy rains associated with Cyclone Bobby in 1995 indicated that the Whaleback and McRae shales of the Hamersley Group and the Jeerinah Formation from the Fortescue Group had the potential to be acid generating and it was determined that waste rock required characterisation and management (WRC 2001). In addition the scientific community has moved away from the operational premise that only high sulfide material has the potential to produce acidic drainage and that waste rock with trace sulfides and a coinciding low neutralisation capacity may also pose a risk.

The Fortescue Marsh (Marsh) is the largest ephemeral wetland in the Pilbara and supports a large variety of marginal ecological communities with high conservation value. As such the Department of Environment and Conservation listed the wetland as a Priority 1 Priority Ecological Community (PEC). In January 2012, the Department of Planning released the *Pilbara Planning and Infrastructure Framework*, which provides planning principles, goals, objectives and actions in relation to infrastructure, economic development, the natural environment and cultural heritage. This framework focused on mining and mining-related activities that may have the potential to impact water and environmental values within the Fortescue Marsh management area. This area is of primary importance to the direct management of the Marsh, particularly in relation to the natural water regime and ecological perspectives. As a result of this, mining activity in the area surrounding the marsh is now subject to greater oversight and a higher level of certainty in drainage quality is required. The Chichester operations are adjacent to Zone 1a, the Northern flank of the Marsh, which has been given a relative priority of Highest Environmental Significance (EPA 2013).

1.1 Ministerial approvals

Current operations are focused on the Chichester Hub, which includes the Christmas Creek and Cloudbreak mines and the Solomon Hub. The Christmas Creek and Cloudbreak operations were formally assessed for their potential environmental impacts under Part IV of the *Environmental Protection Act 1986*. Subject to conditions, Christmas Creek and Cloudbreak received environmental approval from the Minister for the Environment on 16 December 2005 and 24 April 2006 respectively. Mining and related activities at both operations are also covered under the *Iron Ore (FMG Chichester Pty Ltd) Agreement* approved by the Minister for State Development on 21st December 2006 under ministerial statement 707 for Christmas Creek (EPA 2005) and ministerial statements 721 (EPA 2006) and 899 (EPA 2012) for Cloudbreak.

Fortescue expanded mining operations in the Pilbara region through the development of the Firetail and Kings mines, as part of the Solomon Project. The Solomon Iron Ore project was assessed and granted approval on 20 April 2011 under ministerial statement 862 (EPA 2011) and production at Firetail and Kings Mines began in 2013 and 2014, respectively.

1.2 Site description

This section provides a general description and historical information associated with the mine sites. Figure 1 shows the three sites where Tetra Tech will be conducting site work: Cloudbreak, Christmas Creek and the Solomon Hub.

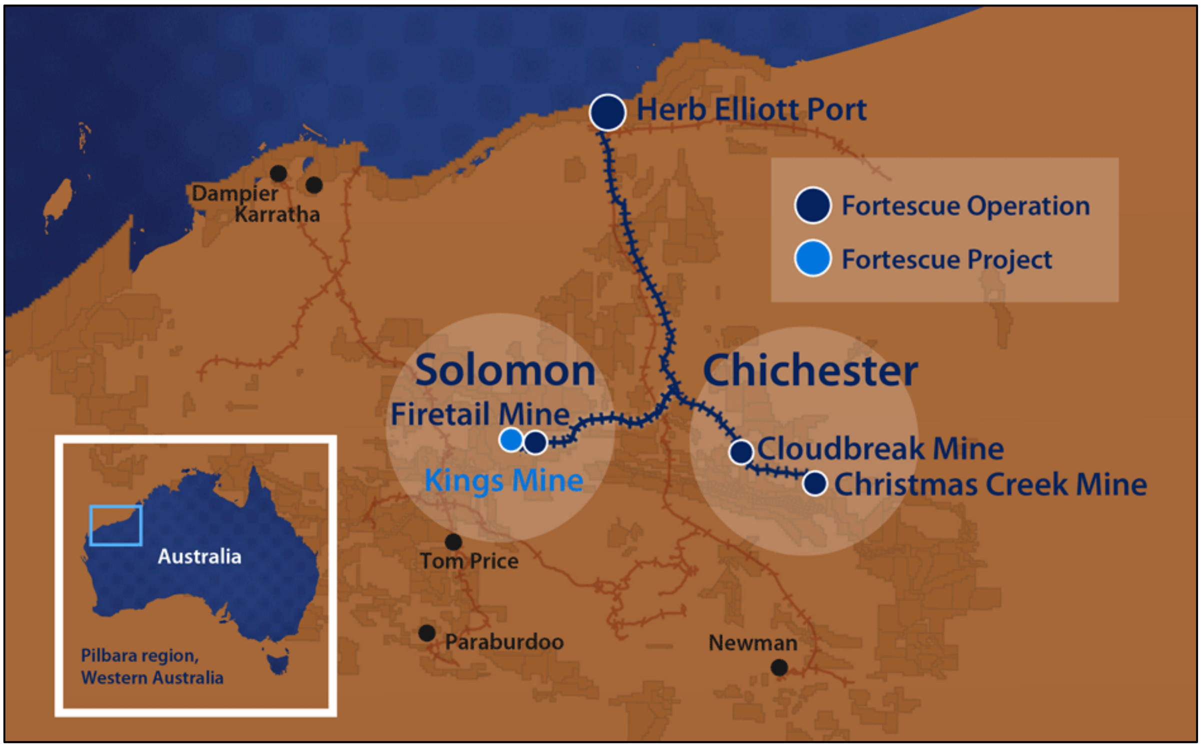

Figure 1: FMG Operations Map (taken from www.fmgl.com.au)

1.2.1 Chichester hub

The Chichester Hub consists of Cloudbreak and Christmas Creek mines. The two deposits cover an area approximately 100 km east/west and 8km north/ south separated by a central creek. The Chichester Hub is located in the north of WA, in the Pilbara region, approximately 120 km northwest of Newman. Both operations within the hub consist of several open pits on the southern slopes of the Chichester Ranges. The pits are progressively mined and backfilled to the extent that material is available, prior to rehabilitation. Cloudbreak currently runs at a capacity of 40 Mtpa railed product and Christmas Creek currently has a capacity of 50 Mtpa.

1.2.2 Solomon hub

The Solomon Project includes two new iron ore mining areas Firetail and Kings approximately 60 km north of Tom Price. The Solomon ore body was estimated at 1,739 million tonnes (Mt) of resource at the start of the project. The deposits will produce a combined total of up to 60 Mt of iron ore per annum. The Firetail deposit will produce up to 30 Mt per annum from a blend of bedded iron deposits (BID) and detrital iron deposits (DID). The Kings deposit will produce up to 50 Mt of ore per annum comprising mostly Channel Iron Deposits (CID), with some ore originating from the Brockman and Detrital Formations.

The Solomon site has two OPFs, three crushing hubs, a 125 MW power station, its own airstrip and three camps to house 3 000 people.

1.3 Existing environment

The Chichester Project is located on two active pastoral leases. Portions of these pastoral leases around the Fortescue Marshes have been nominated for conservation purposes when the pastoral leases expire on 20 June 2015. However, these areas have not yet been formally proposed as a Conservation Reserve and will be required to be assessed under Part 4 of the Land Administration Act 1997. The mining areas are located within the arid Pilbara Bioregion as described in the Interim Biogeographic Regionalisation for Australia (IBRA). The Cloudbreak and Christmas Creek mining areas are located on the lower flanks of the Chichester Ranges which is characterised by gently undulating topography with a maximum elevation of 600 m Australian Height Datum (AHD) and a minimum elevation of 450 m AHD downgradient in the Fortescue Valley.

1.3.1 Climate

The inland Pilbara region is classified as arid, with most rain falling during the hot summers. Peak rainfall occurs in the summer months between January and April and is influenced by tropical cyclone systems. Annual average rainfall for the Pilbara ranges from 180 mm to over 400 mm with the Bureau of Meteorology data indicating an average of 312 mm at Newman Aero. Average maximum summer temperatures are between 35°C and 40°C and winter maximum temperatures generally between 22°C and 30°C. Annual evaporation rates greatly exceed the mean annual rainfall.

1.3.2 Geology

The geology of the Hamersley Basin has three major groups collectively called the Mount Bruce Supergroup. These three groups are the Fortescue, Hamersley and Turee Creek Groups and they overlie the granites of the Pilbara Craton (2.8-3.5 Ga). The Archaean Era Fortescue Group contains the earliest sedimentary deposits consisting of shales, chert and sandstone (such as the Jeerinah Formation), with some basalt formations in the centre of the sequence. The Fortescue Group is conformably overlain by the Hamersley Group in which the Cloudbreak and Christmas Creek deposits are hosted in the banded iron formation (BIF), cherts and shales of the Nammuldi member of the Marra Mamba Iron Formation. The dominant lithology of the Firetail project is the Brockman Iron Formation which consists of the Dales Gorge, Whaleback and Joffre BIF, shales and cherts (Environ 2005). The Kings and Queens iron ore deposits were predominantly formed during the Tertiary period, where weathering and erosion of the Brockman Iron Formation deposited iron rich materials into incised palaeochannels or Channel Iron Deposits (CID) (FMG 2010).

1.3.3 Topography and drainage

Within the eastern Pilbara, the regional topography is dominated by the Hamersley Plateau in the south and the Chichester Ranges in the north, with the two features divided by the Fortescue Valley. The main drainage is the Fortescue River, which flows northwards on Ethel Creek Station and then flows north-west on Roy Hill Station into the Fortescue Marshes. The upper Fortescue River flows into the valley and forms the Fortescue Marshes which are separated from the lower portion of the Fortescue River by the Goodiadarrie Hills. The Fortescue Marshes are an extensive intermittent wetland occupying an area around 100 km long by ~10 km wide. Numerous ephemeral creeks also flow into the Marshes from the southern and northern flanks of the Fortescue Valley, including Goman Creek which passes through the Cloudbreak mine. Where the topography is more gently sloped and drainage lines less defined, areas may also be subject to sheet flow. Some vegetation communities, such as the Mulga (*Acacia aneura* and variants) flora are considered partially reliant on these surface water sheet flows (Environ 2005).

1.3.4 Groundwater

The Fortescue Marshes are recognised as predominantly a surface water feature and are not dependent on groundwater recharge. Groundwater both below and close to the Marshes is saline; while closer to the Chichester Ranges the water is fresher. Groundwater occurs throughout the Central Pilbara in the Proterozoic basement rocks and the Cenozoic deposits and originates from both direct rainfall recharge as well as runoff. Groundwater typically follows topography and flows from higher-elevation recharge areas, such as the flanks of the Chichester Ranges, to lower-elevation discharge areas, such as the Fortescue Marshes. Three main aquifer types affect the quality of the groundwater considerably at the mine sites. The unconfined, unconsolidated valley fill sedimentary aquifer comprises Quaternary alluvium and colluvium with clayey interbedded sand and gravel lenses and cobble-sized detritals in a clay matrix. Groundwater quality is fresh to marginal ranging between 200 – 1,000 mg/L total dissolved solids (TDS), which becomes hypersaline towards the Fortescue Marsh reaching salinities of 60,000 mg/L. The chemically deposited rock comprises Tertiary calcrete (Oakover Formation) and Robe pisolitic limonite (also referred to as the Channel Iron Deposit (CID) aquifer). Yields from the calcrete and CID are high and groundwater ranges in quality from fresh to marginal. Fractured rock aquifers are present within the Banded Iron Formations (BIF): Brockman and Marra Mamba; Wittenoom dolomite and the Hardey Sandstone. Groundwater quality is fresh to marginal and ranges from 150 mg/L to 1,500 mg/L (WRC 2001).

2. PURPOSE OF SAMPLING PLAN

2.1 Introduction

The ability of a particular rock to generate acid is a function of the relative content of acid generating minerals and acid consuming minerals. If sufficient acid consuming material exists then it is likely that drainage will remain neutral, however oxidation of material on a micro scale may increase the solubility of some elements and result in metal leaching. The lag time for acid drainage to occur is controlled by the reactivity of the iron sulfides and the availability of carbonate minerals. Acid may be generated and released by high sulfur wastes with small amounts of carbonate minerals a few days after exposure. Low sulfur (<2%) wastes containing some carbonate minerals may not release acid for years or decades. Minimising the generation of acid mine water is the best management approach.

Much of the variability in metal leaching and acid rock drainage (ML/ARD) potential, results from differences in geological properties. Thus, the first step of a prediction program is the identification, description and mapping of lithological units that will be exposed by mining.

Ideally, geological materials can be separated into discrete, homogeneous geological units. However, samples from a defined geologic unit may indicate significant variability in acid-generation potential and the unit may actually consist of sub-units from an acid perspective. Where geological variability makes it impossible to separate surficial materials or bedrock into uniform units, the geological material should be divided into manageable units based on practical constraints, such as size, location, access and future excavation.

2.2 Objectives

The primary purposes of geochemical characterisation of mine waste materials is to obtain high quality, representative (on the basis of physical and chemical homogeneity), samples of all geologic units to guide management decisions. Effective environmental management can only be achieved through the early recognition of the potential for ML/ARD.

Geochemical characterisation aims to identify the distribution and variability of key geochemical parameters (such as sulphur content, acid neutralizing capacity and elemental composition) and acid generating and element leaching characteristics.

Acid and metalliferous drainage can constitute a large problem for mines that would like to rehabilitate and close in a cost-effective and timely fashion if not managed properly from the beginning of the mine.

In order to characterise waste rock, sufficient samples, that are representative of the various rock types, both in number and spatial distribution, need to be assessed. Geostatistical methods that are used to define ore bodies may also be applied to the classification waste rock. Current practice has been to analyse a few samples from each unit and assume them to be representative of the geological unit as a whole, however there is a large risk that the samples chosen are not representative and that the unit is not homogenous. In order to assess the risk of acid and metalliferous drainage with a quantifiable confidence the number of samples collected must be proportional to the volume of the lithological unit that is to be disturbed. Large volumes of waste rock are generated in the FMG operations and many previous studies commissioned by FMG have generally found the material does not generate acid and that the risk of metalliferous drainage to be low. However, the number of samples analysed in these studies does not provide a high degree of confidence in these findings.

The purpose of this extended sampling programme is as follows:

- Characterise the waste rock to be excavated in progressive mining;
- Confirm initial assumptions that the majority of the waste rock is benign;
- Assess the heterogeneity of each lithological unit;
- Investigate the occurrence of high-sulfur material and assess the potential for acid generation;
- Investigate the metal leaching potential for non-acid generating material and compare to the natural groundwater environment;
- Assess potential impact on downgradient receptors;
- Generate data/ reports and populate the database that will inform the FMG mine planning team;
- Assist with the development of waste rock management schedules;
- Fulfil EPA reporting requirements; and
- Collect sufficient information in order to conduct predictive geochemical modelling.

It is generally accepted that the determination of what constitutes a representative sample of waste rock is challenging.

In order to further inform whether leaching will have, or has already had, an effect on the receiving environment, field work will also be conducted to sample surface water and groundwater bores.

2.3 Existing information

All of the geochemical testwork work conducted at Cloudbreak and Christmas Creek has been summarised in the Tetra Tech report no. (Tetra Tech 2014)

At Cloudbreak five separate studies have investigated a total of 513 samples for elemental composition by x-ray fluorescence (XRF), 15 samples for mineralogy by x-ray diffraction (XRD), 228 samples for acid-base accounting (ABA) and leached elements, 136 samples for total elements, 13 for asbestos and 8 samples were submitted for humidity cell testing (HCT) for various periods of time.

At Christmas Creek five separate studies have investigated a total 1 010 samples for elemental composition by XRF, 16 samples for mineralogy by XRD, 156 samples for ABA, 123 samples for total elements, 115 samples for leached elements, 6 samples for asbestos and 3 samples were submitted for HCT for 26 weeks. In conjunction with this testing for the Chichester hub tailings material has also been investigated. A total of 8 samples have been sent for mineralogy by XRD, 18 samples for ABA, 20 samples for total elements, 31 samples for leached elements and 3 samples were submitted for HCT for 26 weeks.

The results for these investigations indicate a very low potential for acid generation and a low potential for metal leaching. However, the amount of material tested is low and the representivity of the samples and the homogeneity of the geological units has not been assessed. The following lists some of the reports that will be included in assessing the potential for acid or metalliferous drainage. This list is not exhaustive.

- Groundwater Management Plan - Environment (FMG 2012a);
- Christmas Creek Groundwater Operating Strategy (FMG 2012b);
- Cloudbreak Annual Groundwater Monitoring Review (FMG 2012c);
- Christmas Creek Annual Groundwater Monitoring Review (FMG 2012d);
- Cloudbreak Groundwater Operating Strategy (FMG 2012e);
- Cloudbreak Hydrogeological Evaluation near Brampton, Cocos 2 and Green WRDs (Tetra Tech 2012);

- Sampling and Analysis Plan: Groundwater and Tailings Monitoring – Cloudbreak Metalliferous Drainage (Golder 2012a);
- Water Quality Assessment: Cloudbreak Mine (Golder 2012b); and
- Christmas Creek Mine - Groundwater Chemistry Baseline Study (Golder 2013)
- Cloudbreak Life of Mine Surface Water Monitoring Plan (FMG 2012f)

A waste characterisation project was conducted at Solomon in 2013 which assessed 50 samples for mineralogy, acid potential, total elements, leached elements and 5 samples for column leach testing for 52 weeks. This study indicated that acid forming potential was very low and that metal leaching potential was also low (Tetra Tech 2013).

2.4 Waste rock and tailings populations

The goal of sampling is to collect information about a population. The sample populations being investigated in this project are the waste rock, situated above, or that will be separated from the ore prior to processing, and tailings material. According to information supplied by FMG the volumes (or population size) of material to be excavated to produce waste rock or processed to produce tailings per site is given in Table 1.

Table 1: Estimated volume of waste rock and tailings to be generated per site

Site	Waste Rock (Mt/a)	Tailings 2014 (Mt)	Tailings 2015 (Mt)
Cloudbreak	160	4.29	8.15
Christmas Creek	150	2.64	3.41
Solomon	90	3.28	6.16
Total	**400**	**10.2**	**17.7**

In order to characterise these *target populations*, this investigation will be measuring the variables that describe acid generating potential, metal leaching potential, total element concentrations and mineralogy. Each population will be subdivided by lithologically similar sampling units. Samples will be collected from resource definition drilling spoil for ore to be excavated in the future mining activities. The drill chips are the *available population* units, a portion of which will be collected and comprise the *sampled population* (Gilbert 1987). An approximately 2.5 kg sample of drill chips will be collected and will represent the *sample support*. These data will provide information on the quantity, distribution and magnitude of the variability within each population. The greater the degree of variability that exists, the greater the volume of samples that will be needed (ADTI 2000; USEPA 2002) to describe the formation accurately.

2.5 Waste rock sampling design

If a population mean is being estimated, a sufficient number of samples should be collected using systematic or grid sampling in order to produce information on spatial patterns. There are two main categories of sampling programme: judgment based and probability based. In judgmental sampling, the selection of sampling units (i.e. the number and location and/or timing of collecting samples) is based on knowledge of the feature or condition under investigation and on professional judgment. Judgmental sampling is distinguished from probability-based sampling in that inferences are not statistical scientific theory (USEPA 2002).

Probability-based designs (such as random, systematic, grid, stratified, transect and composite sampling) apply statistical sampling theory and may involve random selection of sampling locations. The most important feature of this type of sampling is that each member of the population from which the sample is selected has a known probability of selection. Quantitative conclusions (or statistical inferences) can then be made about the sampled population from the analytical results. For example: the 95% upper confidence level (UCL) of the arithmetic mean can be calculated for a parameter of interest and the probability of that parameter occurring can then be assessed with a 95% level of confidence (NEPM 2013). The advantages of a probability-based sampling plan are:

- Designs are unbiased;
- Provides ability to calculate uncertainty associated with estimates;
- Provides reproducible results within uncertainty limits;
- Provides ability to make statistical inferences; and
- Can quantify decision error criteria.

This sampling programme will combine the stratified, systematic and grid sampling designs in order to identify formations that may contain areas of high metal or sulfide concentrations so that they may be managed differently.

2.5.1 Systematic and grid sampling

Systematic and grid sampling are used to search for areas of elevated concentrations and to infer means, percentiles or other parameters and are useful for defining spatial variability. Samples will be collected at regularly spaced intervals over the drilled area. An initial location will be chosen based on the location of resource drilling samples, and then the remaining sampling locations will be located at approximately even distances away, as far as is practicable.

2.5.2 Stratified sampling

In stratified sampling, the assessment area is separated into non-overlapping sub-areas, which in this instance are geological formations and specific rock type members such as banded iron formation (BIF), chert, shale, dolerite, alluvium, colluvium, calcrete etc. These strata are known or expected to be more homogeneous than the whole assessment area and will be assessed for variability with each unit. The advantages of this design are:

- Potential for achieving greater precision in estimates of the mean and variance where the measurement of interest is strongly correlated with the variable used to define the strata;
- Calculation of reliable estimates for subgroups of special interest; and
- The ability to refine sampling to strata of concern if other units are found to be homogenous and not of concern.

2.5.3 Sampling density and depth of sampling

Samples will be collected in proportion to the volume of waste rock material that occurs according to each geological classification. Only material situated directly over ore deposits will be collected and the majority of samples will be collected from the Quaternary and Tertiary Formations which comprise the bulk of waste rock material, with proportionally fewer samples being collected from formations which will occur at lower volumes. The distribution of samples depends on:

- The size of the area available to be sampled;
- The likely heterogeneity of geological units;
- The depth and thicknesses of units; and
- The effects of potential degradation processes and oxidation (drilling spoil that has been exposed on the surface for too long may have been altered by weathering and will not be representative of a fresh rock sample).

3. WASTE SAMPLING

3.1.1 Stratigraphy

The Solomon Hub is situated in the Hamersley range and Fortescue Valley. The Firetail mining operations comprise chiefly the Brockman Iron Formation whilst the Kings operations comprise valley Channel Iron Deposits. The Chichester Hub is situated in the Chichester Range and comprises ore in the Marra Mamba Iron Formation and Channel Iron Deposits. This stratigraphy is illustrated in Figure 2 and adapted from the Solomon Public Environmental Review (FMG 2010).

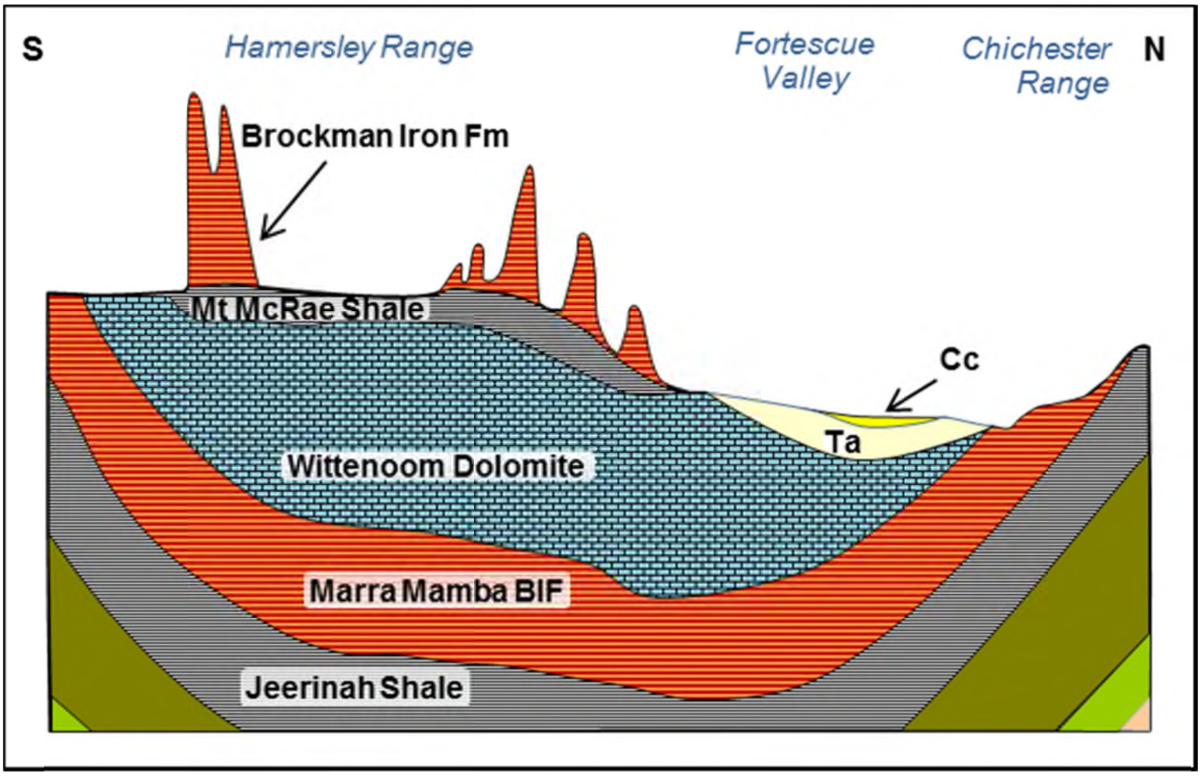

Figure 2: Regional stratigraphy

The stratigraphy of the Chichester is given in Table 2 and Figure 3 and adapted from Campbell (2005), Appendix O in the Cloudbreak Public Environmental Review (Environ 2005) and communication with FMG.

The stratigraphy of the Solomon Hub is given Table 3 and Figure 4. and adapted from FMG (2010).

These material classifications will be used to define waste rock units and identify units interbedded with ore that may be thick enough to be separated to waste. Material targeted for analysis will be alluvium, clays, the Oakover Formation, as well as subgrade CID and detrital material.

Table 2: Chichester stratigraphy and material description

Code	General Description	FMG Ore Code
Ta	Tertiary alluvium, variable clast composition	**Over-burden**
Te	Sediments including massive clays	
To	Oakover formation (including calcrete, silcrete and calcareous sediments)	
CID	Channel Iron Deposits (including Pisolite / Oolite)	
Td i/s/m	Tertiary detritals immature/ semi-mature/ mature	
Hc	Hardcap (commonly vuggy hard 'ore' with moderate glassy goethite (GGM) or hydrohematite-brown goethite (VGH)	**U8**
Hso	Secondary Mineralisation ('ore')	
Cf	Cavity Fill	**US13**
HD	Wittenoom Formation	
MN h/m/f	Mt Newman Member – Bedded Iron Mineralisation, hard/ medium/ friable	**U7u**
MNs	Mt Newman Member – Goethitic and hematitic shales (envisaged as potentially economic / enriched)	
MNk	Mt Newman Member – Shale unmineralised (envisaged as non-economic)	**US12**
MNt	Mt Newman Member – Transition Zone - Interbedded sequence of mineralised ore and poorer mineralised shales at the base of the bedded iron mineralization (usually above BIF, not top of sequence).	**U7l**
MNb	Mt Newman Member – BIF (chert, shales, carbonates)	**US11**
MM h/m/f	MacLeod member – Bedded Iron Mineralisation, hard/ medium/ friable	**U6**
MMs	MacLeod Member – Goethitic and hematitic shales (envisaged as potentially economic / enriched)	
MMk	MacLeod Member – Shale unmineralised (envisaged as non-economic)	**US10**
MMt	MacLeod Member – Transition Zone - Interbedded sequence of mineralised ore and poorer mineralised shales at the base of the bedded iron mineralization (usually above BIF, not top of sequence).	**U6l**
MMb	MacLeod member – BIF (chert, shales, carbonates)	**US9**
MU h/m/f	Nammuldi member – Bedded Iron Mineralisation, hard/ medium/ friable	**U5**
MUs	Nammuldi member – Goethitic and hematitic shales (envisaged as potentially economic / enriched)	
MUk	Nammuldi member – Shale unmineralised (envisaged as non-economic)	**US8**
MUt	Nammuldi member – Transition Zone - Interbedded sequence of mineralised ore and poorer mineralised shales at the base of the bedded iron mineralization (usually above BIF, not top of sequence).	**U5l**
MUb	Nammuldi member – BIF (chert, shales, carbonates)	**-**
Jr	Roy Hill Shale (commonly leached kaolinitic or black shale when fresh)	**-**
Fj	Jeerinah Formation (dolomites, volcanics, sandstones, conglomerates)	**-**

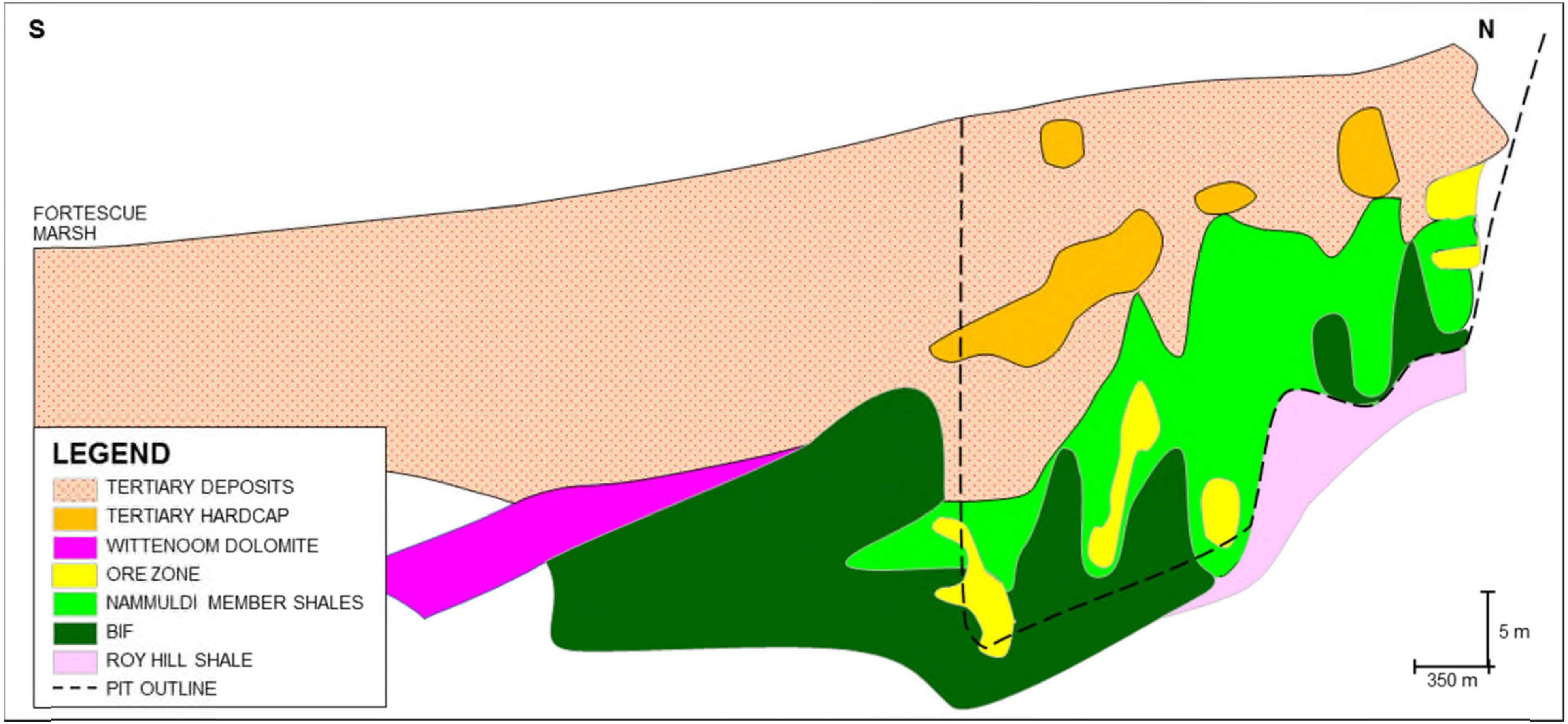

Figure 3: Cross section from Fortescue Marsh to Cloudbreak Daydream and Hook pit areas adapted from PER (Environ 2005).

Table 3: Solomon stratigraphy and material description

Code		Description
Ta		Tertiary alluvium, variable clast composition
Tc		Tertiary colluvium
Te		Tertiary sediments, including massive clays
To		Oakover formation (including calcrete, silcrete and calcareous sediments)
CIDh/ m/ f		Upper and Lower Channel Iron Deposits (including pisolite/ oolite) hard/ medium/ friable
CIDk		Channel Iron Deposits - Internal waste: Clay dominant lenses
CIDb		Basal Channel Iron Deposits - Relic oolitic to pisolitic and often conglomeritic texture, clay rich limonitic matrix
DID	**Tdi**	Tertiary immature detritals
	Tds	Tertiary semi-mature detrital
	Tdm	Tertiary mature detritals
BID		Bedded Iron deposits
Hc		Hardcap (commonly vuggy hard ‘ore’ with moderate hydrohematite-brown goethite (VGH))
		Brockman Iron Fm
HB	**BJ h/m/f**	Joffre Member bedded iron mineralisation hard/ medium/ friable
	BJs	Joffre Member - Goethitic and hematitic Shales (envisaged as potentially economic / enriched)
	BJb	Joffre Member Banded Iron Formation (BIF) Chert & shales
	BW h/m/f	Whaleback Shale Member - Bedded iron mineralisation hard/ medium/ friable
	BWs	Whaleback Shale Member - Goethitic and hematitic shales (envisaged as potentially economic / enriched)
	BWb	Whaleback Shale - Banded Iron Formation (BIF) Chert & shales.
	BD h/m/f	Dales Gorge Member- Bedded iron Mineralisation, hard/ medium/friable
	BDs	Dales Gorge Member - Goethitic and hematitic shales (envisaged as potentially economic / enriched)
	BDb	Dales Gorge Member - BIF chert and shales
HR		Mount McRae Shale Member- commonly leached shales or black shale when fresh
HS		Mount Sylvia Formation
		Wittenoom Fm
HD	**WDB**	Bee Gorge Member
	WDP	Paraburdoo Member
	WDA	West Angela Member
MMM		Marra Mamba BIF
Fj		Jeerinah Formation

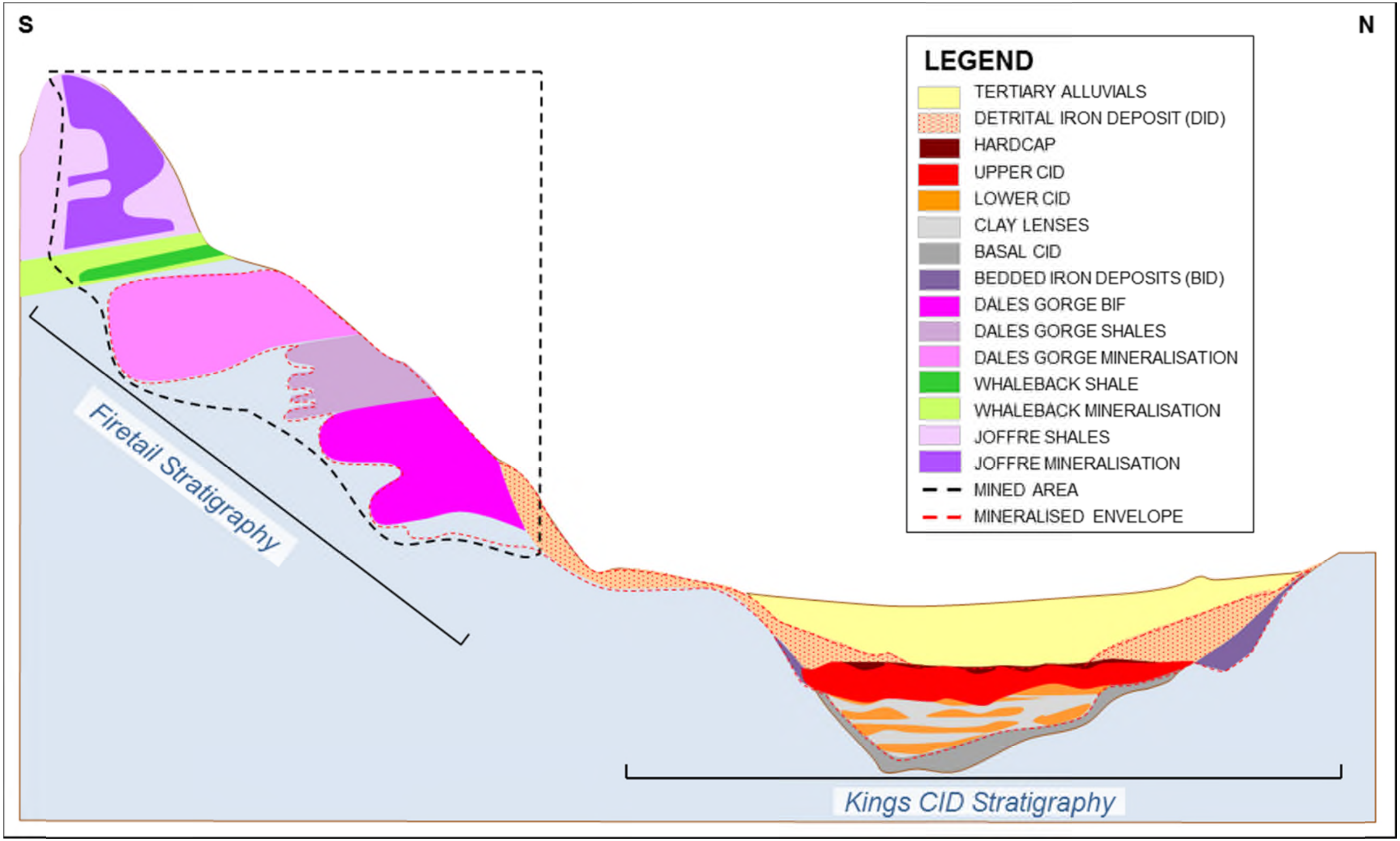

Figure 4: Cross section of typical stratigraphy at Solomon Hub adapted from PER (FMG 2010)

3.2 Source types

The types of source materials classified as waste are described as follows:

- Waste rock: Barren or mineralized rock that has been excavated, but is of insufficient value to warrant processing. Waste rock is separated from ore and is disposed of onsite. This waste can have variable size fractions from sand to boulder size. Waste rock should be sub-categorised according to broadly defined geological lithologies and/or alteration types. Waste rock is usually the source with the greatest volume available for sampling and the majority of analyses should be concentrated on defining variability;
- Tailings: Solid waste from crushing, washing, flotation, leaching and concentration processes applied to rock of ore grade. This waste is usually sand to clay sized;
- Tailings supernatant: Liquid waste from any phase of the mineral processing stream, usually disposed of with tailings solids. Supernatant is the most mobile and most likely to enter the environment;
- Ore stockpiles: ore that requires blending either to achieve desired grade or reduce elevated concentrations of undesirable elements may be stockpiled for significant lengths of time that weathering may occur; and
- Pit walls: *In situ* weathering of pit walls that have been exposed for significant lengths of time can be tested to assist in predicting how rock will weather and what leachate will be generated in real world conditions.

3.3 Sampling strategy and sample locations

The DITR (2007) states that several hundred representative samples of high and low grade ore, waste rock and tailings should be collected for geochemical test work. Sufficient numbers of waste rock samples should be analysed to characterise accurately the variability and central tendency (e.g. average, median, 10th, and 90th percentiles) of the different waste materials. This includes characterisations of localised areas of material with differences in physical, geochemical, mineralogical, weathering and leaching conditions that alter drainage chemistry (Price 2009). Analysing these differences translates to sufficient samples to populate a block model with a reliable distribution of net acid production potential (NAPP) data on ore, waste and wall rock.

In order to plan a sampling programme that is statistically relevant and from which accurate volumes of all types of material may be calculated and waste management plans formulated for the life of the mine, additional waste characterisation is required. According to MEND (1994) and Price (2009) and adapted from BCAMDTF (1989) a guideline to sampling, approximates a calculation, where waste rock tonnage is mass in millions of tons (Mt) as below and examples given in Table 4. Based on this guideline the sample volumes for the various sources are described in the following sections.

$$\text{Number of Samples } = 26 \text{ x} \sqrt{\frac{\text{Waste Rock Tonnage}}{1{,}000{,}000}}$$

Table 4: Recommended sample volumes based on total waste tonnage

Tonnage of unit	Tonnage as Mt	Minimum number of samples (MEND, 1994)
10,000	0.01	3
100,000	0.1	8
1,000,000	1	26
10,000,000	10	82
100,000,000	100	260
1,000,000,000	1,000	822
10,000,000,000	10,000	2,600

3.3.1 Waste rock

Based on the amount of waste rock material generated at each mine site a proportional number of waste rock samples will be collected as per the volumes given in Table 5.

Table 5: Waste rock sample volumes based on annual waste rock tonnage

Site	Tonnage as Mt	Number of samples collected per quarter	Number of samples annually
Cloudbreak	160	80	320
Christmas Creek	150	80	320
Solomon	90	60	240
10% Duplicates		22	88
Total		**242**	**968**

Samples will be collected in proportion to the relevant lithology of the waste material, which will be defined by rock type as: alluvium (gravels and clays), detrital (clays and pisolites), calcrete, chert, BID, CID, and shale. It is expected that the largest number of samples will be collected from alluvium and detrital material as these rock types are expected to comprise the largest volume of waste rock.

Waste rock samples will be collected from grade control drilling spoil. According to the grade control programme, the bore areas that are to be drilled in the next 6 months to a year have been mapped for each site and sampling locations chosen based on an evenly spaced grid. The number of samples that will be collected from each area will be in proportion to the volume and depth of waste rock that is expected above the ore in each area. Drilling spoil will be double bagged onsite by the drilling teams and stored for sample selection by the sampling geologist. When on site the sampling geologist will then select the required number of samples from the lithologies represented. The specific sample locations will vary according to the drilling schedule. The first quarter's sampling positions can be found in the following aerial figures showing areas to be drilled in the near future (Figures 5 to 7).

In addition to grade control drilling, random samples have been collected and stored for the purpose of the geochemical programme from Feb-13 to May-14. These samples will additionally be considered for analysis at Cloudbreak as they provide a larger spread over the mining area and are shown on Figure 5.

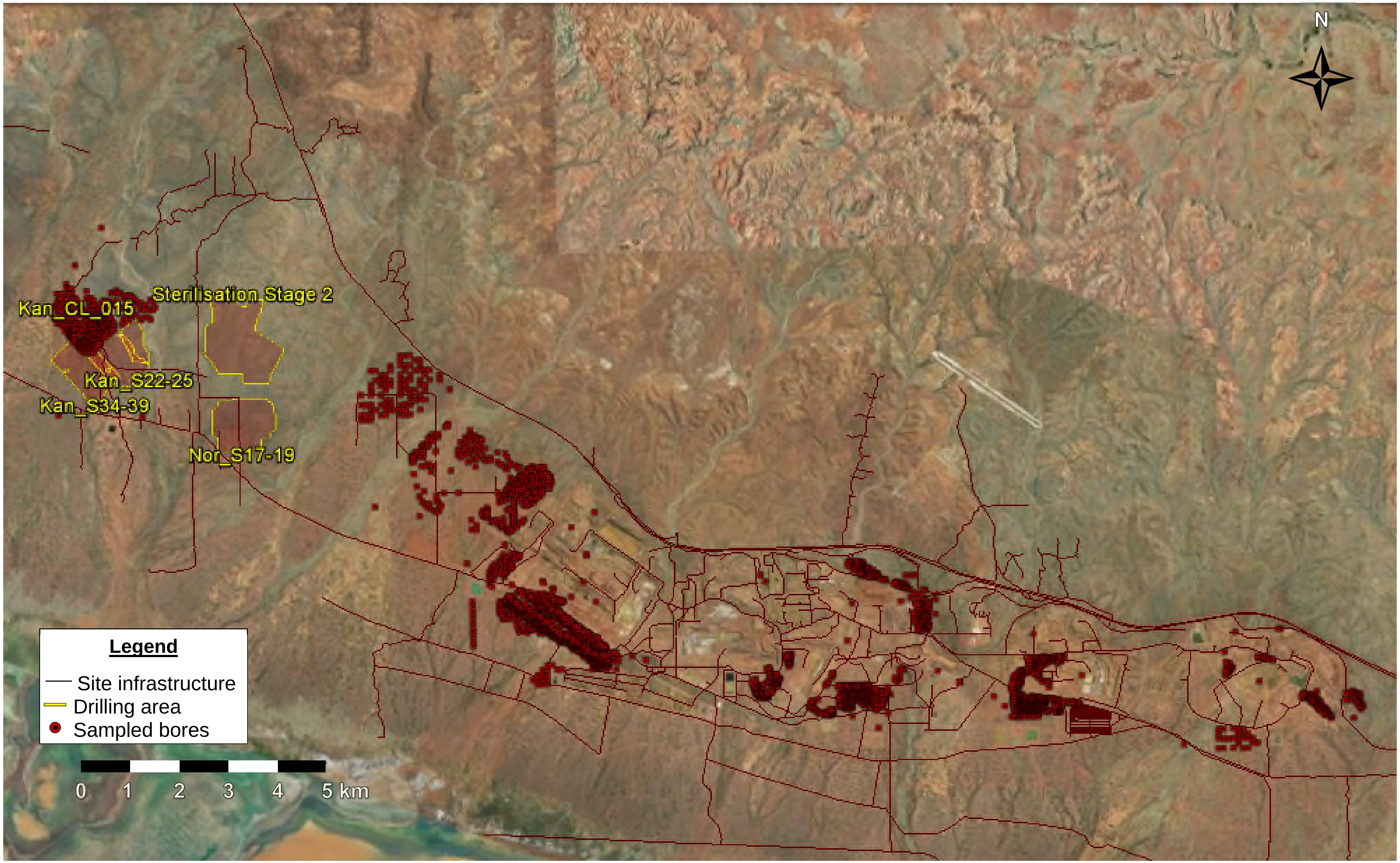

Figure 5: Aerial image showing grade control drilling areas and randomly sampled bores at Cloudbreak

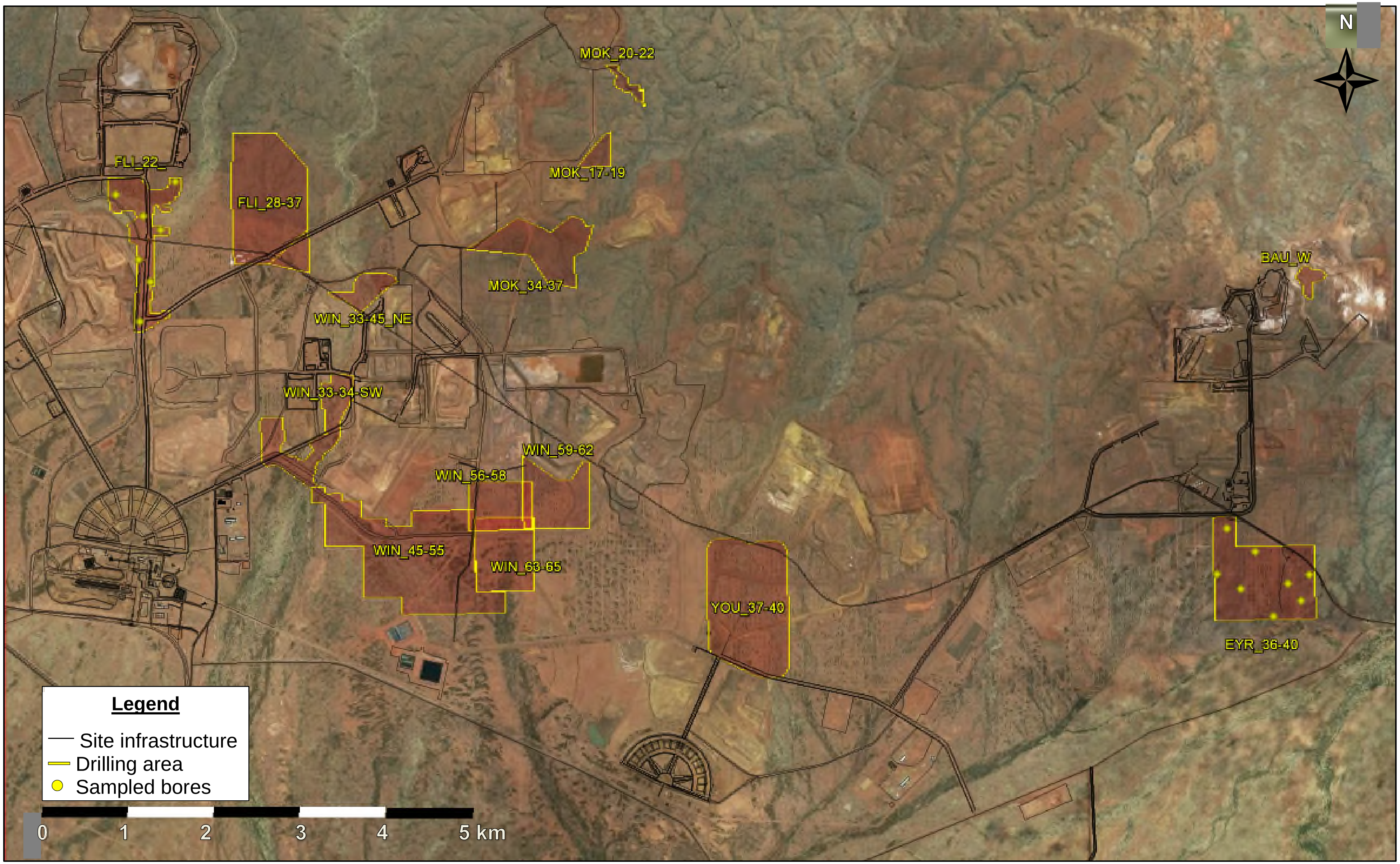

Figure 6: Aerial image showing grade control drilling areas at Christmas Creek

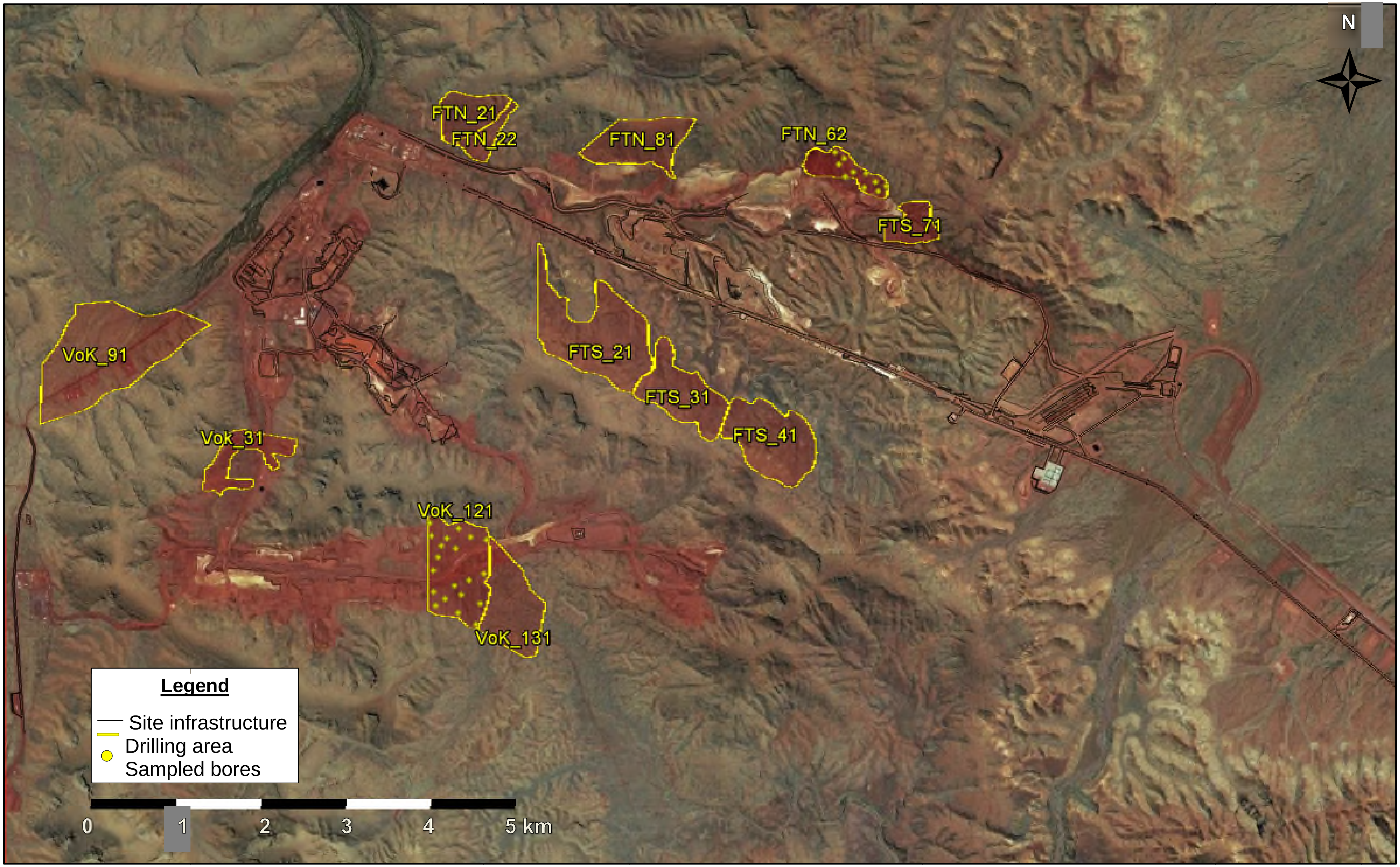

Figure 7: **Aerial image showing grade control drilling areas at Solomon**

3.3.2 Tailings

The volume of tailings material supplied per site, per contract year is given in Table 6. Tailings volume is given from the start of financial year 2015 which beings in June 2014. As tailings material is generated continuously, and to simplify the sampling process it is proposed that one sample of tailings material be collected at each site, once per week. While this does not exactly match the recommended number of samples, it will provide information concerning the temporal variation of tailings, and additional samples can be collected if required. This method will also ensure that FMG personnel can easily follow a routine and collection of samples will not become onerous. Storage and transport of samples will be coordinated with site personnel. Samples will be stored and sent for analysis once per month to reduce administration and transport costs.

Table 6: Recommended annual tailings sample volumes

Site	2015 Vol tailings (Mt)	2016 Vol tailings (Mt)	Samples 2015	Samples 2016	Simplified for ease of collection
Cloudbreak	7.2	8.8	70	77	52 per OPF per year (1 per week)
Christmas Creek OPF1	3.4	3.6	48	49	
Christmas Creek OPF2	4.5	4.9	55	58	
Solomon	6.0	6.0	64	64	
Duplicates			1 per OPF per quarter = 16 per year		
Total			**249**	**260**	**224**

A grab sample of tailings slurry will be collected directly from the OPF hopper on each site once per week.

3.3.3 Ore stockpiles

The following ore stockpile strategy is recommended and a number of samples estimated and budgeted are given in Table 7. In order to assess the risk of existing stockpiles, samples will be collected from the base of the piles, or either surrounding surface material or old stockpiled material.

Table 7: Ore stockpile sample volumes

Site	Number of base samples per year	Number of fresh ore samples per year
Cloudbreak	20	8
Christmas Creek	20	8
Solomon	20	8
10% Duplicates	6	3
Total	**66**	**27**

Ore stockpiles will be sampled at each site. Table 8 details the locations of ore stockpile samples.

Table 8: Ore stockpile sampling sites

Site	Designation	Latitude	Longitude	Storage time	Volume (t)	Storage reason
Cloudbreak	MSH_STPL20	-22.345408°	119.372542°	2 yrs	1,092,845	Sub-grade & high Mn
	BOW_STPL01	-22.338342°	119.449507°	1.5 yrs	985,132	Sub-grade & high As
	HOO_STPL01	-22.331861°	119.381364°	8 mos	605,333	Sub-grade, crushed
Christmas Creek	Cat_P304	-22.398015°	119.843465°	8 mos	258,530	Oversized
	OP2_P501	-22.416804°	119.796771°	13 mos	1,503,480	High silica
Solomon	VOK_S0202	-22.155969°	117.883724°	9 mo	716,321	Sub-grade
	FTN_S0201	-22.118220°	117.936404°	1.5 yrs	1,642,925	Sub-grade

3.3.4 Exposed pit walls

Fresh wall rock samples will be collected twice a year from each different lithology exposed in existing pit walls, at different sampling locations around each pit to provide spatial and lithological distribution of samples. Sample locations will be chosen based on length of time exposed and lithology. Eight different units have been proposed to be sampled at each site. Which units will be determined by what rock types are exposed and available to be sampled and which may include alluvium, detritals, pisolites, Oakover Fm clay, BID, CID and shale. These proposed sample volumes are given in Table 9.

Table 9: Pit wall sample volumes

Site	Number of pit wall samples biannually	Number of pit wall samples per year
Cloudbreak	8 lithologies biannually	16
Christmas Creek		16
Solomon		16
10% Duplicates	2	4
Total	**26**	**52**

Pit wall samples will be collected from exposed pits at each site. Table 10 details the locations of pit wall samples.

Table 10: Pit wall sampling sites

Site	Name	Latitude	Longitude	Time exposed
Cloudbreak	CB_PW1	-22.32820379	119.3574133	To be determined
	CB_PW2	-22.33895241	119.3895065	
	CB_PW3	-22.32952672	119.3702608	
Christmas Creek	CCK_PW1	-22.36866018	119.7191692	
	CCK_PW2	-22.37737775	119.7193110	
	CCK_PW3	-22.39194134	119.8022658	
Solomon	Sol_PW1	-22.11903015	117.9218584	
	Sol_PW2	-22.12109896	117.9327102	
	Sol_PW3	-22.15702322	117.9131689	

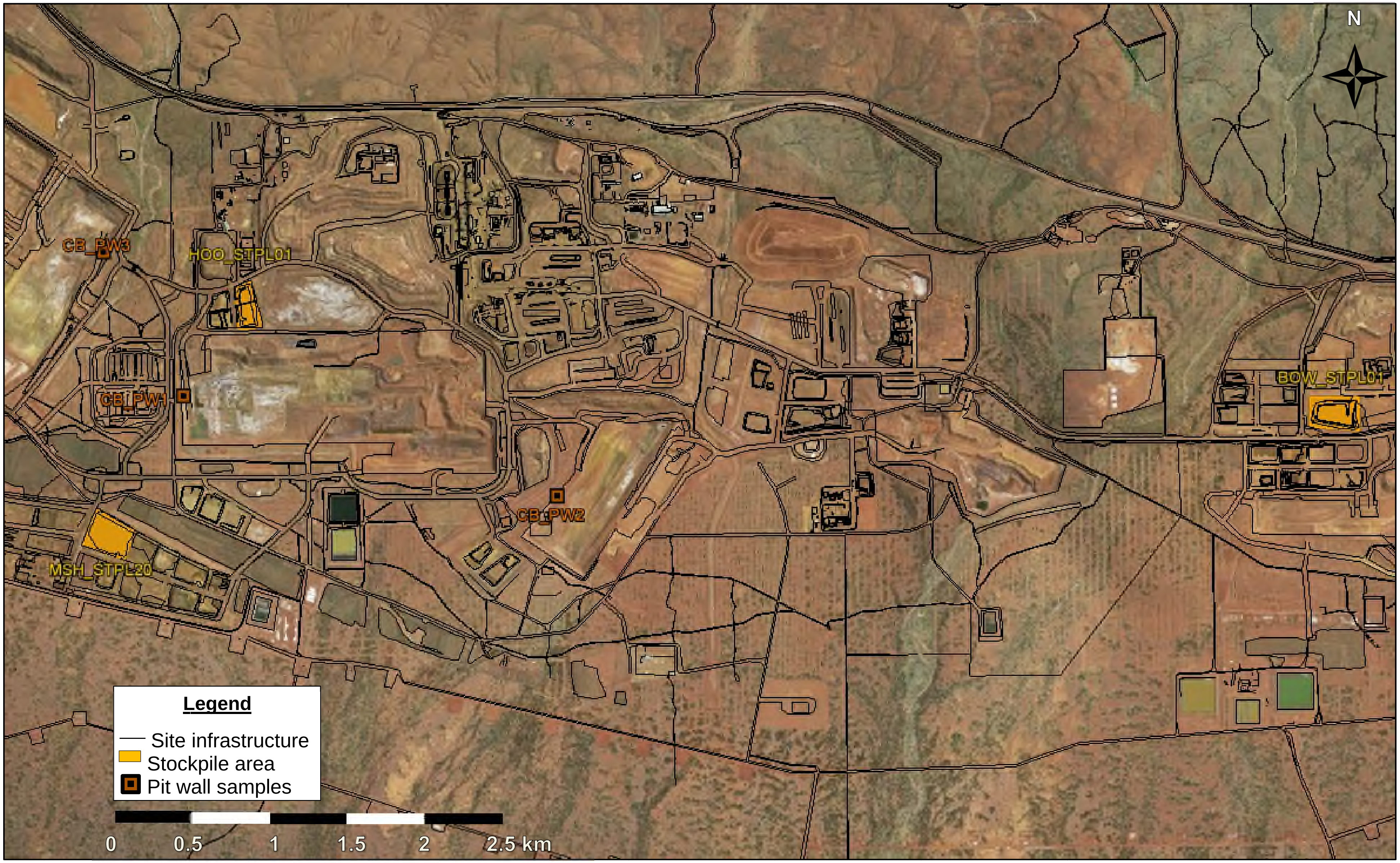

Figure 8: **Aerial image showing proposed pit wall and ore stockpiles sampling positions at Cloudbreak**

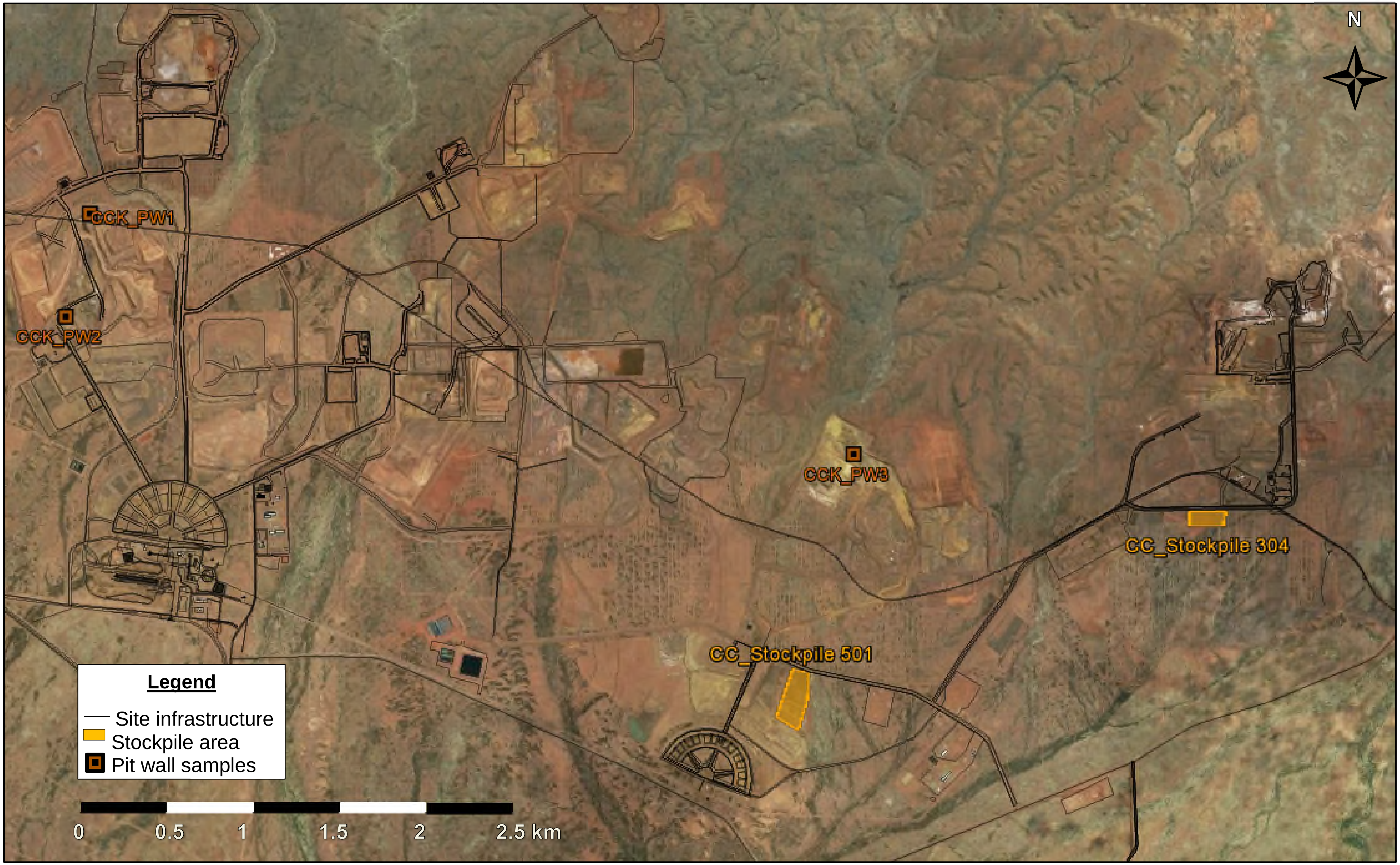

Figure 9: Aerial image showing pit wall and ore stockpiles sampling positions at Christmas Creek

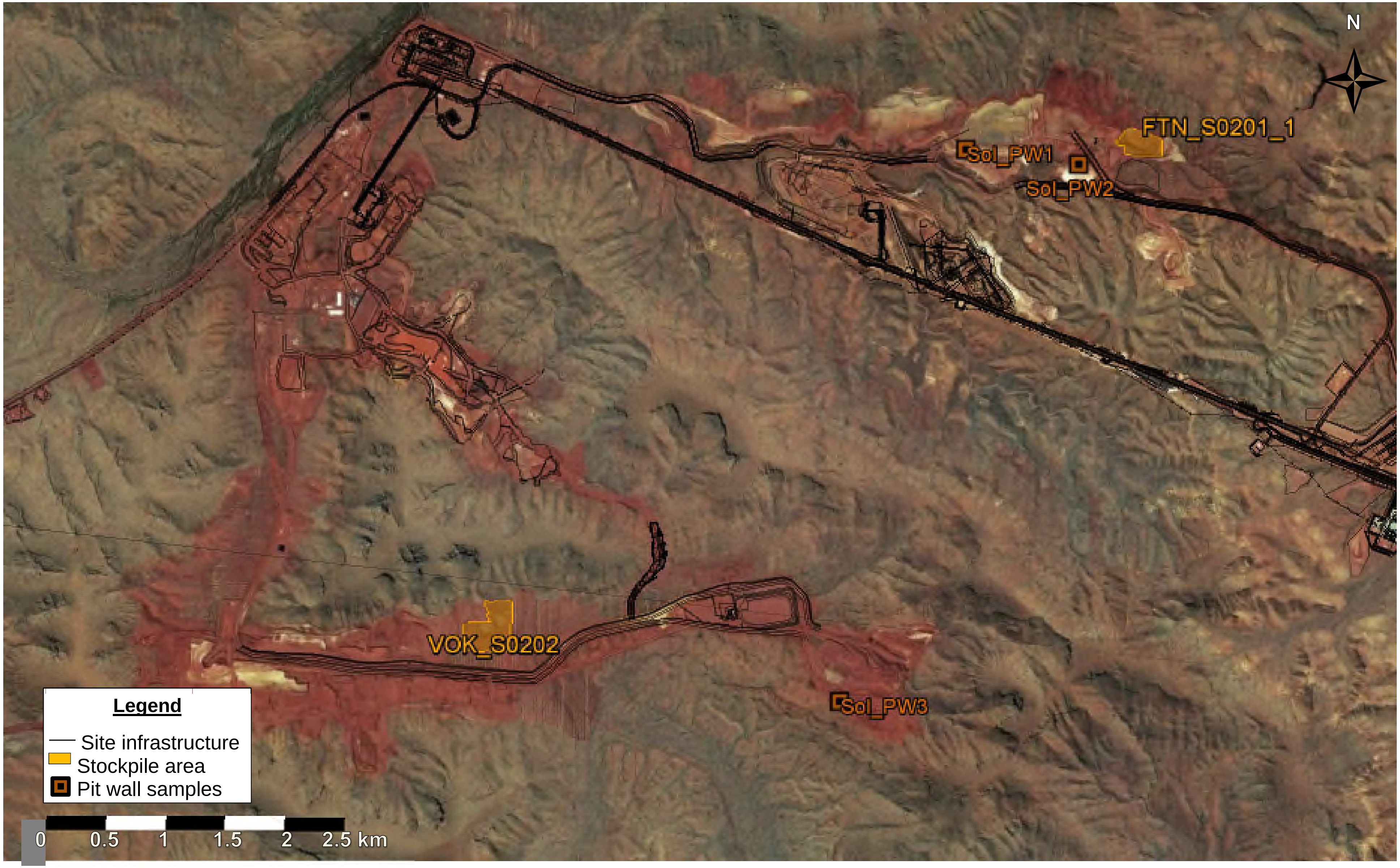

Figure 10: Aerial image showing pit wall and ore stockpiles sampling positions at Solomon

3.4 Sample collection

Tailings samples will be collected by FMG personnel once per week. A minimum of 2.5 kg solid sample and ~500 mL supernatant will be collected in a single opaque bucket with a sealable lid. Sample containers will be filled to exclude all air and no preservative will be added. Appendix B details the personnel currently responsible with collection of the sample at each site. These personnel may change as responsibilities, work instructions and job descriptions change and will not be the same personnel over the entire programme period. The chain of custody (COC) will be prepared and sent to each person responsible for collection, signed on site and will travel with each tailings sample to the laboratory. Tailings material will be stored and transported for analysis once a month to minimise administration and logistics costs.

Approximately 2.5 kg of waste rock chips, ore stockpile and pit wall samples will be collected with a hand trowel and geology pick hammer in a clear plastic sealable bag. Sampling technicians will annotate the bag with the grade control bore number, stockpile number or pit wall position, depth of sample and date. Photographs will be taken of pit wall and ore stockpile positions and of the bore drilling spoil at each waste rock sampling position, along with coordinates. Sample lithology will be recorded and sample described. Sampling bags will be deflated to exclude all air and no preservative will be added.

Waste rock sampling will be conducted on a quarterly basis with samples being sent directly from site to the laboratory. A sample COC will accompany every shipment and will be signed by each party responsible for handling the sample. Sampling sheets for rock material are detailed in Appendix C.

4. WATER SAMPLING

Surface and groundwaters contain a variety of chemical constituents at different concentrations. The greater part of the soluble constituents in these waters comes from soluble minerals in soils and rocks. Changes in the water chemistry can be used to track the movement of water or leachate, yielding information such as water residence time in the saturated zone, identifying recharge processes and the source of recharge water. Elevated concentrations of dissolved constituents may arise from weathering of source material, which can enter the subsurface environment and travel through the surface or groundwater pathway to downgradient receptors.

4.1 Monitoring points

The number of surface and groundwater monitoring points that will be sampled at each site twice a year is given in Table 11.

Table 11: Surface and groundwater sample volumes

Site	Bores sampled biannually	Surface water sites sampled biannually	Total water samples collected annually
Cloudbreak	20	5	50
Christmas Creek	20	5	50
Solomon	8	3	22
Duplicates + blanks	9	6	30
Total	**57**	**19**	**152**

4.2 Surface water sampling positions

As surface water flow is episodic at all sites, and cyclone weather prevents site work for 24 hours during an event, surface water samples are infrequently collected. Several passive sampling points have now been installed (Figure 11). These points were chosen for inclusion in this programme as they are the positions with existing data (FMG 2012f). Should any further samples be collected from other positions these will be included in the evaluation. The positions of surface water monitoring points are given in Table 12. Surface water samples will be collected periodically when perennial flows are present by FMG staff.

Table 12: Surface water collection positions

Site	Name	Latitude	Longitude
Cloudbreak	SWM1	-22.31215580	119.37637227
	SWM3	-22.33161392	119.49164119
	SWM4	-22.35633711	119.47842472
	SWM5	-22.35891291	119.42279532
	SWM6	-22.33722098	119.35710523
Christmas Creek	CC1	-22.40856667°	119.8733587°
	FC2	-22.39116549°	119.6902828°
	MC3	-22.42243948°	119.7399363°
	SF2-5	-22.40817213°	119.7081241°
	YC3	-22.45037858°	119.7647141°
Solomon	K07-SW	-22.1364050°	117.832024°
	K11-SW	-22.0980880°	117.876304°
	K12-SW	-22.1203640°	117.864137°

Figure 11: Passive surface water sampling point at Solomon

4.3 Groundwater sampling

Groundwater samples will be collected according to best sampling practices by low-flow/ low-stress purging at the ingress of the aquifer to reduce the introduction of air and entrainment of sediment into the sample. Water levels will be measured before, during and after sampling to ensure the extraction of fresh water from the aquifer and not the water column. In-field measurements will be collected while purging with the pH and EC monitored while samples are being collected through a flow-through cell until readings have stabilised. Detailed methods will be included in the sampling procedures.

4.3.1 Sampling strategy

It is generally accepted that water in the well casing is non-representative of the formation water and needs to be purged prior to collection of ground-water samples. However, the water moving through the screened interval may indeed be representative of the formation, depending upon well construction and site hydrogeology. Wells are purged to some extent for the following reasons:

- the presence of the air interface at the top of the water column results in an oxygen concentration gradient with depth;
- loss of volatiles up the water column;
- leaching from or sorption to the casing or filter pack;
- chemical changes as a result of clay seals or backfill; and
- surface infiltration.

The most common groundwater purging and sampling method is to purge a well using bailers or high speed pumps to remove 3 to 5 casing volumes followed by sample collection. This high turbidity method can cause adverse impacts on sample quality through collection of samples . This results in the inclusion of otherwise immobile particles which may produce an overestimation of certain analytes of interest (e.g. metals). Problems associated with filtration make this an undesirable method of correcting for turbidity and include the removal of potentially mobile particles during filtration, thus artificially biasing parameter concentrations too low. Sampling-induced turbidity problems can be mitigated by using low-flow purging and sampling techniques (USEPA 1996).

4.3.1.1 Field measurements

Some physicochemical parameters cannot be reliably measured in the laboratory as their characteristics change over a very short timescale. Parameters that should be measured in the field include pH, electrical conductivity (EC), temperature, dissolved oxygen (DO) and redox potential (Eh). If ferrous (Fe^{2+}) iron is one of the selected analytes, it also is best analysed in the field.

If DO, Eh or Fe^{2+} is required, field parameters must be measured in a flow-through cell to avoid contact between the groundwater and the atmosphere. A flow-through cell can also enable continuous measurement and monitoring of key parameters during purging to identify when a representative sample may be obtained. Currently as oxygen dependent variables are not being measured a flow-through cell is not planned to be used. In this sampling plan, these parameters have not been deemed necessary and will not be measured.

There is a wide range of equipment available for the measurement and logging of these parameters. It is important that quality assurance protocols are developed and implemented. The procedures should include the use of suitable calibration standards, where the calibration spans the anticipated range of results, and accuracy checks. Where measurements are made over a number of hours, periodic readings of appropriate reference solutions should be incorporated to ensure that the calibration is stable. Calibration procedures vary between meters and between manufacturers so it is important to follow the manufacturer’s instructions for correct and accurate operation of each piece of equipment (Sundaram et al. 2009).

4.3.2 Sampling equipment

The following sampling equipment is required:

- Water level / dip meter;
- pH/ EC meter and calibration fluids;
- Stainless steel submersible low-flow sampling pump with 12 V battery, or pneumatic bladder pump with controller and mini-compressor, LDPE/ Teflon tubing and either an airline or electrical cable for the depth of sampling;
- Sampling consumables: bottles, deionised water, cooler box with ice bricks, phosphate-free soap, collection bucket, sample measurement container H&S equipment and labelling and packaging supplies.

4.3.2.1 Equipment calibration

A good quality pH meter can detect minimum variations (sensitivity) of 0.01 pH units in water and can be calibrated at two or three pH levels. This type of instrument will give more accurate readings over a wider pH range than one-point calibration meters.

Meters must be calibrated with buffer solutions before each sampling trip and periodically during sampling, e.g. every tenth sample, to check if the meter has drifted off calibration. Your check on the calibration standard should be within ±0.1 pH units of the buffer used. If you are using a two-point calibration meter, use buffer solutions at 4.01 and 7.00. A buffer solution of pH 4.01 will last three months, but a solution of pH 7.00 will last six months if stored in a cool dark place.

1. Rinse the electrode well with deionised water.
2. Place the electrode in an aliquot of the buffer solution sample. Wait 2–3 minutes for the reading to stabilise but be aware that some change will occur as pH reacts with carbon dioxide dissolving from the air.
3. Record the result and date on equipment calibration sheet.
4. Periodically measure the pH of the calibration solution to test accuracy. If it has drifted, recalibrate the electrode using a new buffer solution.

A good conductivity meter should have, apart from the EC electrode, a temperature probe that enables measurement of temperature and automatic compensation for temperature in the conductivity reading. Be aware that conductivity meters with different EC ranges are available: 0 – 199 mS/m (approx. 0 – 1 275 mg/L TDS) and 0 – 1 990 mS/m (approx. 0 – 12 800 mg/L TDS). The latter range is the expected electrical conductivity range for the groundwater at the mine sites. Also make sure the correct units are recorded on the field forms, as some instruments will automatically swap between µS/cm, mS/cm and mS/m, depending on the EC range.

Note: 1 000 µS/cm = 100 mS/m = 1 mS/cm

Use a conductivity calibration solution (usually potassium chloride) to calibrate the meter to the range you will need. For these saline groundwaters a 0.1 M KCl solution with a conductivity of 1 282 mS/m at 25° C is required.

4.3.2.2 Decontamination

Decontamination of pumping and sampling equipment is recommended for all groundwater sampling work although it is not routine for major ion analyses. It is necessary if the sampling is for microbiological, pesticide and organic parameters. Decontamination prevents cross contamination from the previous sample and should be completed before each bore sampling. Any equipment introduced into the bore should be decontaminated.

As organic contamination is not expected in these bores, decontamination will be conducted with phosphate-free liquid detergent and deionised water. The 60 m of 10 mm ID tubing requires ~1 L of water to rinse once through completely. Between bores pump and tubing will be rinsed three times completely with 3 L of deionised water. At the end of each sampling day, the sampling pump will be submerged completely in 1 L soapy water and then rinsed three times with 3 L of deionised water. An equipment blank of deionised water will be collected at the close of each sampling day.

4.3.3 Low flow purge sampling

The following set of instructions must be followed in order on arrival at monitoring bore:

1. Remove bore lid – may need hex key or padlock key;
2. Insert dip meter into bore to measure water level and record;
3. Determine which piezometer in bore will be sampled – if WT (water table) piezometer is dry, dip S (shallow) piezometer;
4. Use dip meter to confirm depth of bore to determine whether piezometer is labelled correctly and whether any siltation has occurred, and record;
5. Use dip meter tape measure to confirm inner diameter of bore and halve it to obtain the radius;
6. Calculate volume for 0.5 m decrease in water level based on radius of piezometer ($V = h \times \pi \times r^2$). For example: if the piezometer radius is 25 mm, a 0.5 m decrease in water level ≈ 1 L volume removed i.e. $0.001 \text{ m}^3 = 0.5 \text{ m} \times 3.142 \times (0.025 \text{ m})^2$. $1 \text{ m}^3 = 1\ 000$ L;
7. Lower pump to 1) middle of screened casing depth, 2) first indication of water or 3) formation of highest hydraulic conductivity according to bore logs (monitoring bore logs attached in Appendix E), and proceed to remove volume calculated in previous step;
8. Stop pump and measure water level again to determine whether any change has occurred. If water level has decreased by ~0.5 m then lower pump to different depth or lower pumping speed and repeat until volume removed has no effect on water level. If several attempts have failed to situate the pump at groundwater inflow then purge three well volumes and collect a sample;
9. Begin sample measurements for pH/ EC/ Temp and record results. Pump groundwater until sample measurements have not changed for three measurements in a row. In addition, record

volume removed to the nearest litre, and periodically measure groundwater level to confirm that it has not decreased and inflows from the aquifer are matching the pumping speed;

10. Record final measurements and any observations as to colour, sediment, clarity and odour;
11. Collect sample in 1 x 500 mL plastic bottle and syringe filter into 1 x 100 mL plastic bottle for dissolved elements. Samples will be preserved at cold temperatures only, no other preservative is required;
12. Collect duplicate sample, if required, in measuring vessel before dividing into original and duplicate;
13. Measure water level again to be certain no decrease has occurred and record;
14. Secure all bore coverings and lids;
15. Record total amount of water removed from bore;
16. If groundwater is hypersaline, containers have been supplied near to the bore by Cloudbreak and Christmas Creek staff for safe disposal of this water, do not dispose to surface if this is the case;
17. Label sample bottles with site name, monitoring bore, piezometer number and date. Keep samples cold in cooler (4°C);
18. Proceed with pump and tubing decontamination;
19. Collect equipment blank with deionised water at the close of each sampling day or after sampling a bore with unusual measurements or observations, at the sampler's discretion. One of these will be selected per site for analyses and the remainder stored for reference, if required
20. Fill out COC form. Sampling sheets for groundwater are detailed in Appendix C1.

4.3.4 Groundwater monitoring bore positions

Monitoring bores were selected from the list of bores required to be monitored for regulatory conditions based on those bores with the largest amount of sampling information, construction, lithology and those closest to potential sources such as waste rock landforms (WRL), tailings storage facilities (TSF), excavations, operational process facilities (OPF) etc.

The details of monitoring bores are given in the following Tables 13 to 15 and Figures 12 to 14.

All attempts possible will be made to sample the monitoring bores detailed in this section, however as mining areas change some bores may be destroyed and others may be dry as a result of dewatering activities.

Table 13: Monitoring bores at Cloudbreak

Bore name	Latitude	Longitude	Description	Depth (mbgl)	Screen Interval (mbgl)	Water level (mbgl)	Formation or Lithology at screens
CBX05_WT (CBX05_S)	-22.31717562	119.3298391	Hillside West	23 40	17 – 23 28 – 40	17.3 17.3	Ta: silty gravel, chert Ta: clayey silt & Td: pisolite
CBX11_WT (CBX11_S)	-22.3643375	119.4192701	Saline Injection	23.5 48	11.5 – 23.5 44 – 48	7.2 9	Ta: Alluvium: gravel Td: pisolitic gravel and TO clay
CBX12_S	-22.35360022	119.4547599	Long Pit Area	29	23 – 29	12.6	Td: Pisolite
CBX16_S	-22.34444982	119.3813851	Hook Pit Area	40	28 – 40	36	Ta: gravelly clay & Td: pisolite
CBX35_S	-22.3534650	119.412156	Hamilton Pit Area	42	30 – 42	13.5	Td: Pisolite, BIF & chert minor goethite
CBX39_S	-22.3501250	119.392508	Hook Pit Area	36	24 – 36	11.3	Ta: Alluvium: gravel and Td: pisolite
COM01_S	-22.34478332	119.5015771	Cocos Pit Area	48	42 – 48	25	Hso: BIF & chert
HAMM05	-22.33523666	119.4224441	Hamilton Pit Area	65	29 – 65	23.6	Mut: BIF/ Chert ; Mub: chert/ shale
HSMB04_WT (HSMB04_S)	-22.31255074	119.2908602	Hillside West	42 58	30 – 42 52 – 58	11 11	Td: Pisolitic gravel To: CC/ clay & Td: pisolitic gravel
HSMB05_WT (HSMB05_S)	-22.32016744	119.3143873	Hillside West	29 41.7	17 – 29 35.7 – 41.7	13 13	Ta: Alluvium and Td: Pisolitic gravel Hc: Hardcap
*HSMB07_S	-22.30376233	119.3217645	Hillside West	43 / 56	37 – 43	22	Hc: vitreous goethite
HSMB09_WT (HSMB09_S)	-22.33861477	119.3721321	Brampton Pit Area	23 32	17 – 23 26 – 32	20 20	Td: Pisolitic gravel Td: Pisolitic gravel
HSMB011_WT (HSMB011_S)	-22.3429000	119.361415	Brampton Pit Area	33 44	21 – 33 38 – 44	13 13.5	Ta: Alluvium: gravel Td: pisolitic gravel
HSMB13_WT (HSMB13_S)	-22.35188115	119.4275256	Hamilton Pit Area	24 33	18 – 24 17 – 33	15 15	Ta: Alluvium BIF/ shale/ chert Td: Pisolitic gravel
HSMB17_WT HSMB17_S	-22.34762955	119.4779261	Long Pit Area	28 36	16 – 28 30 – 36	22 22	Td: Pisolitic gravel Hc: Hardcap
HSMB19_WT	-22.30562416	119.2598115	Hillside West	24	18 – 24	9	Ta: Alluvium BIF/ shale/ chert
HSMB23_S	-22.35618542	119.4934606	Cocos Pit Area	46.4	40.4 – 46.4	17	Td: Pisolitic gravel
LHMB03_WT (LHMB03_S)	-22.27423597	119.1849524	Left Handers	24 42	18 – 24 30 – 42	8 8	Ta: Alluvium Hc: Hardcap
*LPMB08	-22.34937955	119.4459120	Long Pit Area	76 / 79	46 – 76	20.5	Td: Pisolitic gravel, goethite, hematite, shale & chert
MDMW04	-22.32496649	119.3634214	Brampton Pit Area	46.6	11 – 46.6	36	Martite, magnetite and chert

Note: WT = Water Table; S = Shallow; I = Intermediate; D = Deep: If WT piezometer is dry, S piezometer will be sampled. *Bore log has errors – depth to be confirmed in field
BIF: Banded Iron Formation; Cc: Calcrete; Hc: Hardcap; Hso: Hardcap unmineralised; Mub: Marra Mamba unmineralised basal; MMM: Mineralised Marra Mamba Fm; Muh: Marra Mamba unit hard; Mut: Marra Mamba unmineralised transition; Ta: Tertiary alluvium; Td: Tertiary detritals; TO: Oakover Fm; WF: Wittenoom Fm.

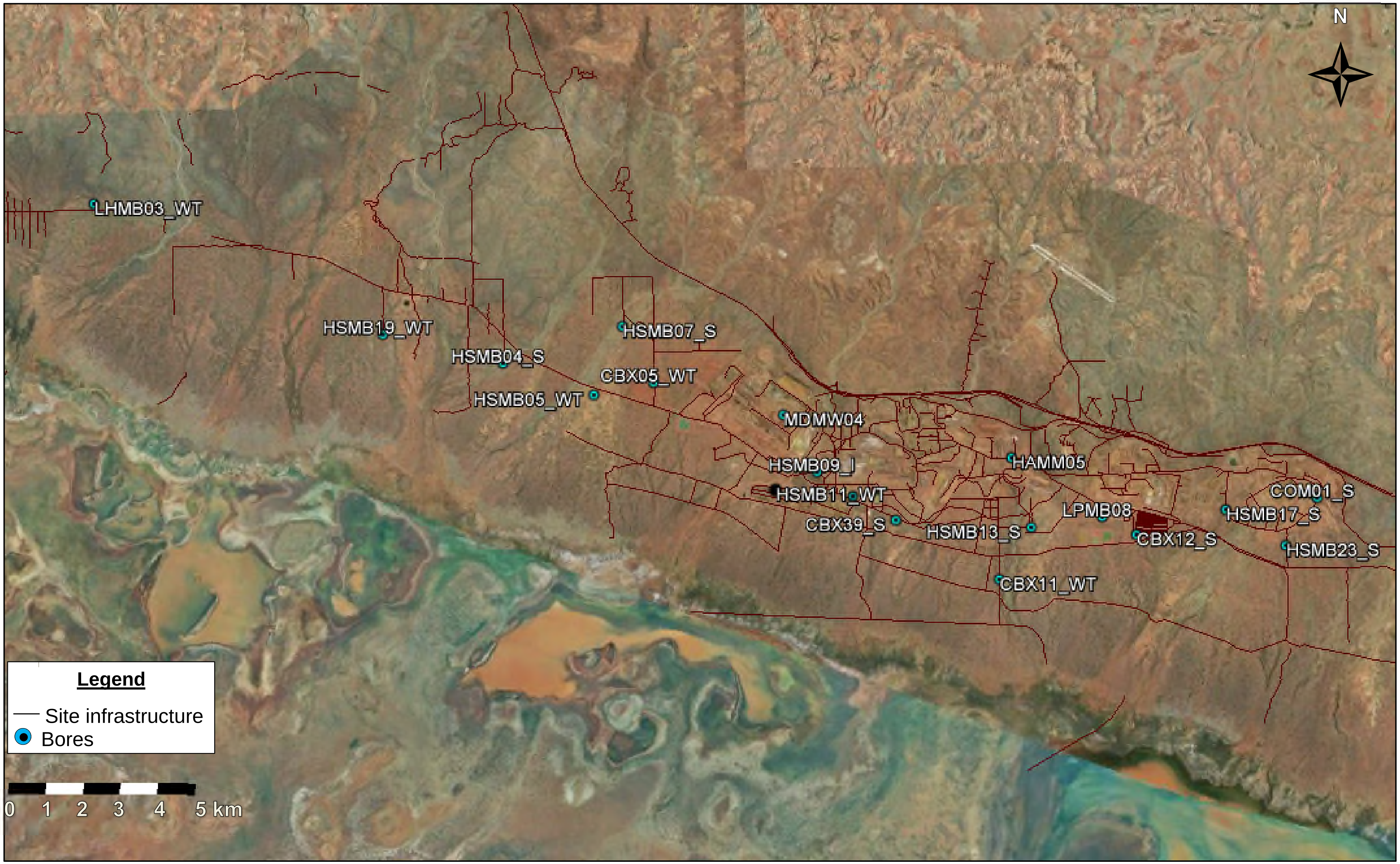

Figure 12: Aerial image showing monitoring bores at Cloudbreak

Table 14: Monitoring bores at Christmas Creek

Bore name	Latitude	Longitude	Description	Depth (mbgl)	Screen Interval (mbgl)	Water level (mbgl)	Formation and lithology at screens
CCE04MB_WT CCE04MB_S	-22.38915104	119.6964193	Christmas Creek	36 54	24 – 36 48 – 54	16.7 16.8	Ta: Alluvium TO: dolomite, silt and clay
CCE12MB_S	-22.40431743	119.766285	Christmas Creek	36	24 – 36	19.9	Ta: Alluvium / CID: pisolites
CCE14MB_WT CCE14MB_S	-22.42385889	119.8095268	Christmas Creek	42 72	24 – 42 48 – 72	16.8 17.2	Td: alluvium TO: calcified silts and clays, mostly calcretes
CCF01B_S	-22.44164807	119.7788247	Christmas Creek	20	0 – 20	8.5	Clay with alluvial fragments
CCF07B_S	-22.42255137	119.7395281	Christmas Creek	27	0 – 27	14	Ta: Alluvium
CCM03_S	-22.38951424	119.7426569	Christmas Creek	No bore log available			Ta: Alluvium & detrital
FLM08_S	-22.36812945	119.7073472	Flinders Pit Area	36	30 – 36	25	Mut / Mub: Chert and non-enriched shale
HSMB29_S	-22.37281534	119.6342054	Hillside East	30.6	18 – 30	19.4	Td: Pisolitic gravel and pisolites
SAM13_S	-22.42420343	119.709645	CC Saline Injection	28.3	22 – 28	13.5	Td: gravelly silt, chert and shale
SCX03_S	-22.37601873	119.6181417	Hillside East	30	12 – 30	17.1	Ta: Alluvium and silty detrital
SCX05_S	-22.4032877	119.6652946	Hillside East	30	13 – 30	8.7	Ta: Alluvium silty clay, detrital, calcrete & gravel.
SPM01_S	-22.4160038	119.8438809	Spinifex Pigeon	No bore log available			Ta: Alluvium & detrital
VAM01	-22.35643798	119.7238763	Vasse Pit Area	46	40 – 46	31.2	BIF and Shale
VAM04	-22.3472356	119.7343932	Vasse Pit Area	64.3	58 – 64	58.3	Shale and Chert
WDM04	-22.391167°,	119.771856°	Windich Pit Area	48	38 – 44	25	MMM: Goethite and Hematite & Mut: Goethite and chert
WDM06	-22.383980°,	119.775442°	Windich Pit Area	70	40 – 46	35	BIF & Chert
WDM08	-22.37906872	119.7791219	Windich Pit Area	56	50 – 56	16.5	Chert
WDM12	-22.38561156	119.7657274	Windich Pit Area	50	37 – 49	35.5	Chert and Shale
YGM01	-22.408156°,	119.818290°	Young Pit Area	70	15 – 70	27	MMM: Goethite & Hematite, Mub: BIF & Chert
YGM02	-22.412532°,	119.815124°	Young Pit Area	76	22 – 76	23	Alluvium above Hc

Note: WT = Water Table; S = Shallow; I = Intermediate; D = Deep: If WT piezometer is dry, S piezometer will be sampled.
BIF: Banded Iron Formation; Mub: Marra Mamba unmineralised basal; MMM: Mineralised Marra Mamba Fm; Muf: Marra Mamba unit friable; Mum: Marra Mamba unit medium; Mus: Marra Mamba unit shale; Mut: Marra Mamba unmineralised transition; Ta: Tertiary alluvium; Td: Tertiary detritals; Te: Tertiary clay; TO: Oakover Fm; WF: Wittenoom Fm.

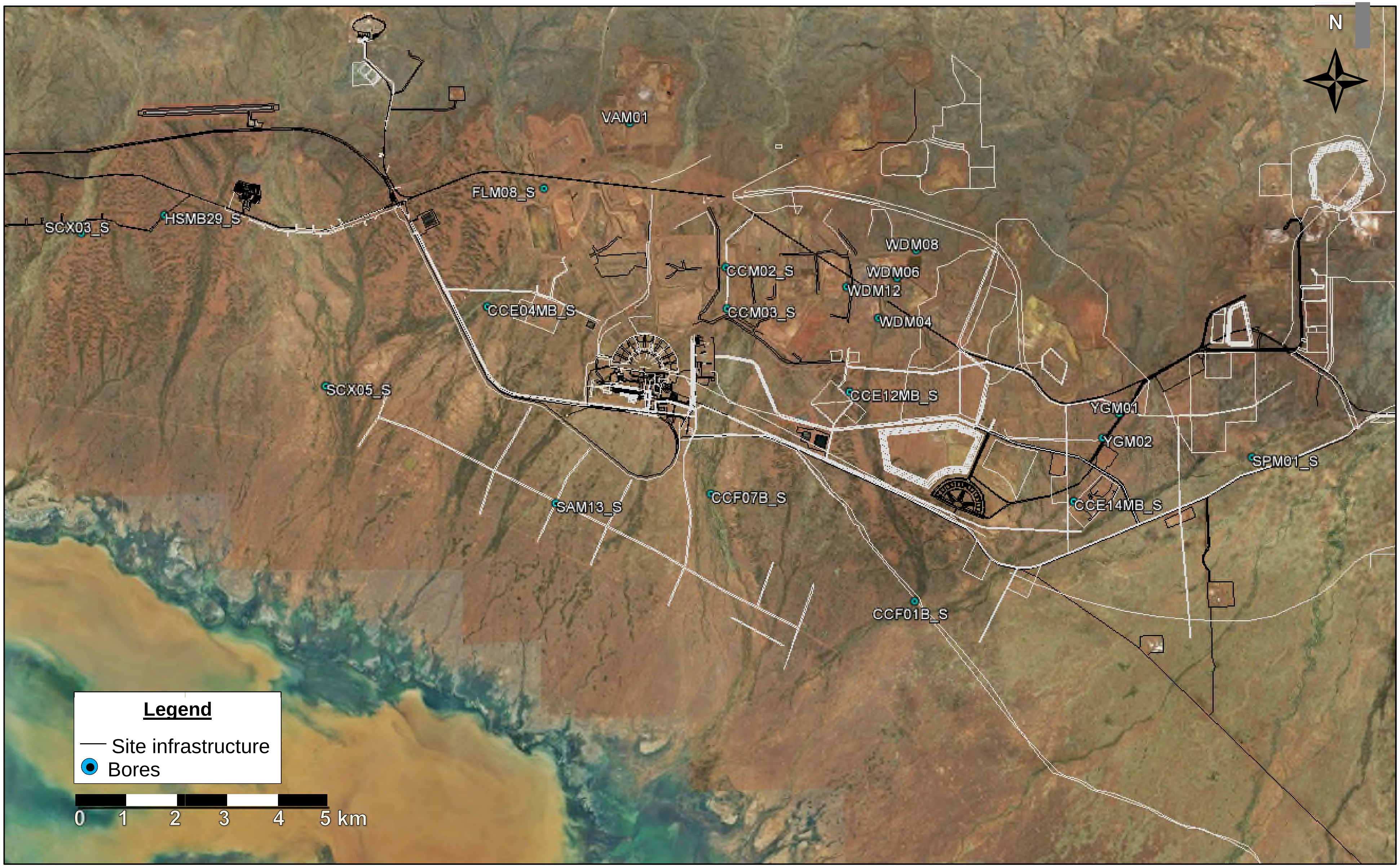

Figure 13: Aerial image showing monitoring bores at Christmas Creek

Table 15: Monitoring bores at Solomon

Bore name	Latitude	Longitude	Description	Depth (mbgl)	Screen Interval (mbgl)	Water level (mbgl)	Formation and lithology at screens
FITL-MB-001	-22.1457601	117.9655974	Stockyards (SY)	80	56 – 80	59	Td to shale to Wittenoom dolomite
King Flowing Bore	-22.196740	117.909964	Kings	47	11 – 47		CIDm, CIDk, CIDb to black shale with minor chert
KMB12S	-22.1071326	117.8776647	Kangeenarina (KA)	6	3 – 6	1.8	Silt & Gravel: silty gravel
SMB1005	-22.140522	117.814565	Queens	48	24 – 48	dry	Td: some clay, hematite & minor chert
SMB1008	-22.13675738	117.8426339	Trinity	59	23 - 59	12.8	CID: hematite, goethite Bedrock: BIF, hematite banded, shale & chert
SMB1021	-22.179302	117.835574	Kings	50	44 – 50	23	CIDm: goethite clays, pisolitic & minor chert CIDk: martite, chert & mineralisation
SMB1032	-22.18503957	117.9244964	Kings	15	11 – 15	4.23	Alluvium / Detritals: yellow-brown clay & sand
TRIN-MB-002	-22.12066517	117.843246	Trinity (TR)	14	8 – 14	4.2	CID Basal & BIF
Warp16	-22.21204267	117.8261354	Queens (QU)	60	23 – 59		No bore log available

Note: WT = Water Table; S = Shallow; I = Intermediate; D = Deep: If WT piezometer is dry, S piezometer will be sampled.
BIF: Banded Iron Formation; CID (kmhb): Channel Iron Deposits (clay, medium, hard, basal); Ta: Tertiary alluvium; Td: Tertiary detritals; Te: Tertiary clay; TO: Oakover Fm;

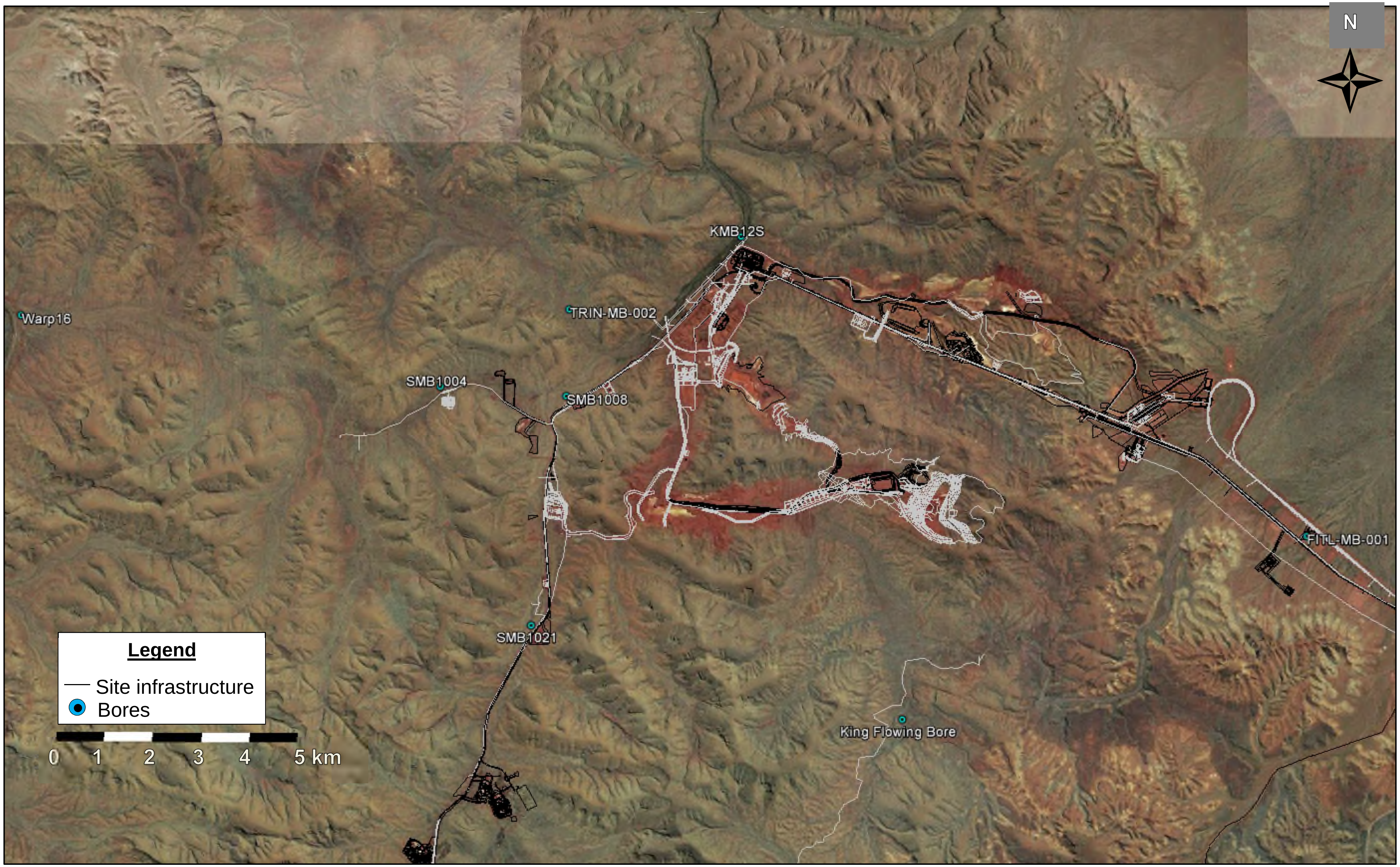

Figure 14: Aerial image of monitoring bores at Solomon

5. QUALITY ASSURANCE / QUALITY CONTROL

Quality Assurance/Quality Control (QA/QC) is a set of operating principles that is adopted to help produce data that is of known, consistent and defensible quality. The QA/QC process is used to check the accuracy and precision of field sampling procedures and laboratory analyses and is done by taking duplicate, spike and equipment blank samples. For a sampling program to meet its objectives, a rigorous and thorough program of checks, comparisons and communication must be implemented.

Quality control (QC) is a sample or procedure intended to verify performance characteristics of a system. Water sampling QC should focus on ensuring that the results obtained by analysing samples represent the groundwater as it was when the sample was collected. That is, if there is any significant change in, or contamination of, the sample due to containers, handling and transportation, it will be picked up by QC.

The QA/QC is determined through the use of blank samples and duplicate samples.

A blank is a portion of deionised water that is carried through all or part of the sampling and analytical process and is designed to provide an indication of contamination. It is important that the volume used for blanks be the same as the samples. The various types of blanks include:

- **Trip blanks:** A trip blank is a sample of analyte-free deionised water that will be transported from laboratory to site and returned to the laboratory for blind analysis. These blanks are used to monitor potential sample contamination during shipping and storage. These blanks are sent from the laboratory with empty bottles and remain with other samples throughout the sampling trip but are not opened in the field. One trip blank per sampling round will be analysed.
- **Equipment blank:** The purpose of these blanks is to check on the decontamination process of the pump system. The equipment blank sample comprises deionised water put through the pump and tubing under field conditions including filtration. As the pump and tubing will be used to sample multiple wells, an equipment blank will be collected once per day, after daily cleaning and stored for reference purposes, or at the sampler’s discretion should any bore sample appear likely to contaminate the pumping equipment. One equipment blank per site will be selected randomly and analysed per site per sampling program. In addition a single sample of site deionised water will be collected and stored for reference purposes.
- **Duplicate Samples:** These samples are collected to test for analytical precision in the laboratory and put through the same filtering, storage and analysis processes. One sample from the selected bore is split and each is given its own identification number. Duplicate samples, will be collected for every ten samples. The relative percentage differences (RPDs) of the analysed parameters can be calculated to observe the variation in duplicates.

6. REFERENCE STANDARDS

In order to evaluate analytical data, elemental concentrations are required to be compared to standards.

The acid-base accounting analyses are evaluated using the Australian Mineral Industry Research Association (AMIRA) acid rock drainage (ARD) test handbook (AMIRA 2002) in conjunction with the Department of Industry, Tourism and Resources Australia: Leading Practice in Sustainable Development in Mining handbook (DITR 2007). The additional division of the Uncertain classification into Likely and Unlikely is according to the GARD Guide (INAP 2009). This classification is given in Table 16.

Table 16: Acid-base accounting classification criteria (DITR 2007)

Material classification	NAPP (kg H_2SO_4/t)	NAG pH
Potentially acid forming (PAF)	> 5 -20	< 4.5
Potentially acid forming – low capacity (PAF-LC)	0 to 5 -20	< 4.5
Non-acid forming (NAF)	< 0	≥ 4.5
Acid consuming (AC)	< -100	≥ 4.5
Uncertain (UC) - Unlikely	> 0	≥ 4.5
Uncertain (UC) - Likely	< 0	< 4.5

With historical data, where NAG pH has not been determined, the alternative classification scheme as detailed in Table 17 according to (Price 2009) is used. This alternative classification scheme will be given for comparison purposes with the Price (2009) international classification scheme.

Table 17: Acid-base accounting classification criteria (Price 2009)

Material classification	NAPP (kg H_2SO_4/t)	NPR (ANC/MPA)
Potentially acid forming (PAF)	> 0	< 2
Non-acid forming (NAF)	< 0	> 2
Uncertain (UC)	< 0	< 2

The Western Australia Environmental Protection Authority mandated that in the absence of site specific reference/baseline trigger values, water quality data should be compared to the ANZECC Guidelines for Fresh and Marine Water Quality at the 95% of Species Limit of Protection (SLP) for a Slightly to Moderately Disturbed System (ANZECC & ARMCANZ 2000a).

Where applicable, the 95% SLP Trigger Values (TV) will be modified for the relative hardness of the water (ANZECC & ARMCANZ 2000b). In 2013 FMG commissioned Golder Associates to establish site specific trigger values (SSTV) for Cloudbreak (Golder 2012b) and Christmas Creek (Golder 2013) to which soluble element concentrations may be compared. These are given in Table 18. In 2014 a further study was commissioned to establish groundwater trigger values relating to reinjection operations, which will be included where applicable (Rockwater 2014).

The results for total whole rock elemental analyses are used to calculate a geochemical abundance index (GAI) according to the Global Acid Rock Drainage (GARD) guide (INAP 2009) which compares the sample concentration to the average crustal abundances and/or specific rock type median concentrations. Various crustal abundances are given for reference from various sources in Table 18.

Table 18: Water quality and total element reference standards

Analyte	Dissolved trigger values (mg/L)			Total element geochemical abundance reference values (mg/kg)				
	ANZECC 95% SLP	CCK SSTV	CB SSTV	[1]Relative Proportion	[2]Crustal Abundance	[3]Sedimentary		
						Shales	Sand-stones	Carbonates
pH	6.5-9.0	-	6.5	-	-	-	-	-
EC (mS/m)	10 - 500	-	-	-	-	-	-	-
Ag	0.00005	-	-	0.07	0.05	0.07	0.0X	0.0X
Al	0.055	-	-	82,000	80,400	80,000	25,000	4,200
As^{III}	0.024	-	-	1.5	1.5	1.3	1	1
As^{V}	0.013	0.014	0.013					
B	0.37	2.4	-	950	15	100	35	20
Ba	-	-	-	500	550	580	X0	10
Be	0.00013[§]	-	-	2.6	3	3	0.X	0.X
Bi	0.0007[§]			0.048	0.127	-	-	-
Ca	-	-	-	41,000	30,000	22,100	39,100	302,300
Cd	0.0002*	0.003	0.010	0.11	0.098	0.3	0.0X	0.035
Cl^{-}	-	-	-	130	-	180	10	150
Co	0.0028[+]	0.09	0.011	20	10	19	0.3	0.1
Cr	0.001*	0.02	0.016	100	35	90	35	11
Cu	0.0014*	0.16	0.083	50	25	45	X	4
F	-	-	-	950	-	740	270	330
Fe	0.3[§]	-	-	41,000	35,000	47,200	9,800	3,800
Hg	0.0006	-	-	0.05	-	0.4	0.03	0.04
K	-	-	-	21,000	28,000	26,600	10,700	2,700
Mg	-	-	-	23,000	13,300	15,000	7,000	47,000
Mn	1.9	-	-	950	600	850	X0	1,100
Mo	0.034[§]	-	-	1.5	1.5	2.6	0.2	0.4
Na	-	-	-	23,000	28,900	9,600	3,300	400
Ni	0.011*	0.06	0.038	80	20	68	2	20
P	-	-	-	1,000	700	700	170	400
Pb	0.0034*		0.045	14	20	20	7	9
S	-	-	-	260	-	2,400	240	1,200
Sb	0.009[§]	-	-	0.2	0.2	1.5	0.0X	0.2
Se	0.011	-	-	0.05	50	0.6	0.05	0.08
Sn	0.003[§]	-	-	2.2	5.5	6	0.X	0.X
Sr	-	-	-	370	350	300	20	610
Th	-	-	-	12	10.7	12	1.7	1.7
Ti	-	-	-	5,600	3,000	4,600	1,500	400
Tl	0.00003[§]			0.6	0.75	1.4	0.82	0.0X
U	0.0005[§]	-	-	2.4	2.8	3.7	0.45	2.2
V	0.006[§]	-	-	160	60	130	20	20
Zn	0.008*	0.300	0.397	75	71	95	16	20

* Indicates Trigger Values that can be modified for hardness >30 mg CaCO$_3$
[§] Indicates Low reliability Trigger Values; SSTV – site specific trigger value
X indicates that no accurate value can be given only an estimate of magnitude
1 (Bowen 1979) ; 2 (Taylor & McLennan 1995); 3 (Price 1997)

7. LABORATORY

The preferred laboratory to be used in this project is ChemCentre, to which all samples will be sent. ChemCentre is the Western Australian Government statutory authority that provides analytical and scientific information to government, industry and the community. ChemCentre laboratories are accredited and compliant with all National Association of Testing Authorities (NATA) requirements for Chemical Testing and Forensic Science and consequently, comply with all relevant clauses of ISO/IEC 17025 and ISO 9001. ChemCentre also holds accreditation with selected industry bodies and regularly undergoes compliance and quality audits.

7.1 Laboratory quality assurance/ quality control

ChemCentre is widely recognised as being a centre for scientific excellence and supports government departments and agencies with advice, investigations, interpretation, understanding and policy decisions around chemistry related incidences. Staff profiles are unique with highly qualified experienced scientists and chemists. Laboratories are state of the art and purpose built with the reputation of being the best in state. ChemCentre is the longest continually accredited laboratory in the country and have many NATA auditors as employees. A dedicated Corporate Quality Manager coordinates two Quality Officers who operate across ChemCentre to manage all aspects of quality control, from validation and auditing of methodology to proficiency testing to ensure clients receive quality analyses and results they can rely on. Quality control and assurance is managed through a series of networked processes and measures.

7.2 Analytical parameters

The following parameters will be analysed for in the solid material (Table 19) and water samples (Table 20).

Table 19: Analytical parameters for waste rock and tailings

Analysis	Output
Acid base accounting	
Net Acid Generation (NAG)	NAG capacity in kilograms of H_2SO_4 per tonne and NAG pH
Acid Neutralising Capacity (ANC)	kilograms of H_2SO_4 per tonne
Acid Soluble Sulfur by ICP-AES	sulfate (SO_4)
Sulfur Levels by Combustion	Total Sulfur
Short term leach tests with deionised water and tailings supernatant	
pH	pH
EC	EC in millisiemens per metre (mS/m) at 25˚C
Total Dissolved Solids (TDS)	Calculated TDS in milligrams per litre
Chloride by Ion Selective Electrode (ISE)	chloride
Alkalinity by Titration	acidity, alkalinity
Dissolved elements by ICP-AES	aluminium, boron, barium, beryllium, bismuth, calcium, cerium, cobalt, chromium, caesium, iron, potassium, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorous, rubidium, antimony, strontium, scandium, sulfate, tin, thorium, titanium, thallium, uranium, vanadium, tungsten, zinc
Dissolved elements by Inductively Coupled Plasma Mass Spectrometry (ICP-MS) Testing	silver, arsenic, cadmium, copper, lead, mercury, selenium
Total elements by acid digestion	

Analysis	Output
Total elements by ICP-AES	aluminium, boron, barium, beryllium, bismuth, calcium, cerium, cobalt, chromium, caesium, iron, potassium, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, nickel, phosphorous, rubidium, antimony, scandium, tin, strontium, thorium, titanium, thallium, uranium, vanadium, tungsten, zinc
Total elements by ICP-MS	silver, arsenic, cadmium, copper, lead, mercury, selenium
Chloride by ISE	chloride
Kinetic testing	
pH	tested weekly – pH
EC	tested weekly – EC in millisiemens per metre (mS/m) at 25˚C
Total Dissolved Solids (TDS)	calculated weekly – milligrams per litre
Alkalinity by Titration	tested weekly – acidity, alkalinity
Sulfate by ICP-AES	tested weekly – SO_4
Dissolved Major Cations by ICP-AES	tested weekly – calcium and magnesium
Chloride by ISE	tested weekly for the first 4 weeks of humidity cycles, then monthly to the end of the test period – chloride
Dissolved elements by ICP-AES	tested weekly for the first 4 weeks of humidity cycles, then monthly to the end of the test period – aluminium, boron, barium, beryllium, bismuth, cerium, cobalt, chromium, caesium, potassium, iron, lanthanum, lithium, manganese, molybdenum, sodium, nickel, rubidium, antimony, scandium, strontium, tin, thorium, titanium, thallium, uranium, vanadium, tungsten, zinc
Dissolved elements by ICP-MS	tested weekly for the first 4 weeks of humidity cycles, then monthly to the end of the test period – silver, arsenic, cadmium, copper, lead, mercury, selenium
Mineralogy by x-ray diffraction (XRD)	Mineral identification and quantification

Table 20: Analytical parameters for water and tailings supernatant samples

Analysis	Output
pH	pH
EC	EC in millisiemens per metre (mS/m) at 25˚C
Total Dissolved Solids (TDS)	Calculated TDS in milligrams per litre
Major Anions by ISE	chloride and fluoride
Total Alkalinity by Titration	total alkalinity as $CaCO_3$, bicarbonate alkalinity, carbonate alkalinity
Minor Anions	Nitrite + nitrate as N and phosphate
Dissolved elements by ICP-AES	aluminium, boron, barium, beryllium, bismuth, calcium, cerium, cobalt, chromium, caesium, potassium, iron, lanthanum, lithium, magnesium, manganese, molybdenum, sodium, nickel, potassium, rubidium, antimony, scandium, strontium, sulfate, tin, thorium, titanium, thallium, uranium, vanadium, tungsten, zinc
Dissolved elements by ICP-MS	silver, arsenic, cadmium, copper, lead, mercury, selenium

7.3 Analytical methods

Static test results are used to evaluate the potential for acid formation and short-term release of elements. Kinetic tests are used to determine the long-term leaching potential. Waste rock and tailings samples will undergo the following analytical tests:

- Acid-base Accounting (ABA);
- Whole rock/total element analysis;
- Leaching testing; and
- Mineralogical identification by x-ray diffraction (XRD).

The analytical methods are further described in the following sections.

7.3.1 Acid-base accounting

Acid-base accounting (ABA) estimates the capacity of material to produce or neutralise acid. ABA methods compare the maximum potential acidity (MPA) with the acid neutralisation capacity (ANC) for a given material, using either the total sulfur (AMIRA 2002) or sulfide content (Price 2009) to calculate MPA.

The total sulfur of a solid sample is determined by high temperature combustion. Using total sulfur as a measure of MPA is conservative and over-estimates the acid generation. As a consequence sulfate concentration is in addition determined and the total sulfide concentration calculated by the difference.

The ANC is determined by the modified Sobek method (Sobek et al. 1978) where a known amount of standardised hydrochloric acid (HCl) is added to an accurately weighed sample, allowing the sample time to react (with heating), then back-titrating the mixture with standardised sodium hydroxide (NaOH) to determine the amount of unreacted HCl. The amount of acid consumed by reaction with the sample is then calculated. The determinations of MPA and ANC are then normalised for atomic mass and expressed in the same units of kg H_2SO_4/t so that they can be compared.

Net Acid Generation (NAG) testing is used to determine the contact pH and acid generation potential of rock samples after complete sulfide mineral oxidation using 15 % hydrogen peroxide. Each sample is combined with hydrogen peroxide and allowed to react for 24 hours before the pH and acidity is measured. Samples with NAG pH levels below 4.5 are usually classified as acid generating while pH values above 6 are regarded as non-acid generating.

ABA results are used to determine the Neutralisation Potential Ratio (where NPR = ANC/MPA) and the Net Acid Production Potential (where NAPP = MPA-ANC). The NAPP in conjunction with the NAG pH are used to categorise material into potentially acid forming (PAF), potentially acid forming – low-capacity (PAF-LC), non-acid forming (NAF), acid consuming (AC) or uncertain (UC). Table 16 gives the criteria for the classification of material according to AMIRA (2002) and DITR (2007). Material classified as having uncertain acid-forming potential may be recommended to undergo additional testing to assess the dissolution rates of acid-forming (e.g. pyrite) and acid-neutralising (e.g. calcite) minerals via kinetic tests. The NAPP used to classify material as potentially acid forming will be taken as >5 kg H_2SO_4/t.

7.3.2 Leach testing

Leaching tests are conducted to determine the potential for release of water soluble elements as a result of precipitation and runoff in compliance with the Australian standard leaching procedure (ASLP) AS 4439.2 (Standards Australia 1997a) and AS4439.3 (Standards Australia 1997b)). The procedure utilizes 500 mL of de-ionised water and 25 g of sample to give a water to solid ratio of 20:1. The samples are shaken for 18 hours, with the pH periodically measured and buffered at a value of ~5, before being filtered and the extract analysed for dissolved elements.

7.3.3 Total elemental analysis

Multi-element analysis on whole rock acid digested sample provides the near-total elemental composition and gives an indication of the maximum potential load of constituents to the environment. The total element concentration is then used to determine a geochemical abundance index (GAI) calculated by utilizing the median concentration for that particular element in the most relevant media (e.g. crustal abundance). The method for calculating GAI is given on the International Network for Acid Prevention (INAP 2009) website and typical distributions for element concentrations for sedimentary rocks are given in Appendix 3 of Price (1997). The calculated GAI provides an indication of whether any elemental enrichment exists. The GAI is expressed as an integer where a 0 indicates the element is present at similar concentrations to the median concentration used and a value of 3 indicates a concentration 12-times that of the median value, which is considered to be significant enrichment and may be of concern should leaching take place into a pathway leading to an environmental receptor.

7.3.4 Kinetic testing

Kinetic tests provide a temporal indication of the rate of acid production and consumption and metal leaching. The humidity cell test (HCT) method follows American Standard Testing Method (ASTM) D5744-12 which is designed to enhance weathering and transport rates by producing conditions conducive to sulfide oxidation by means of cycles of humid and dry air followed by weekly leaches (ASTM 2000). Material is exposed to moist, oxygenated air which accelerates the weathering of sulfidic minerals. Each HCT produces a weekly effluent that is characterised for dissolved weathering products and analysed.

7.3.5 Mineralogy

Qualitative X-ray diffraction (XRD) will be conducted on selected samples submitted for leaching and elemental analysis. Samples are lightly ground such that 90% passed through a 20 µm mesh to eliminate preferred orientation during analysis. The International Centre for Diffraction Database (ICDD) is used to identify all crystalline material, which typically has a detection limit of ~1%, depending on the instrument. Crystalline material below 1% is not likely to be detected, and thus low concentrations of the dominant sulfide mineral, pyrite, are often not recorded by XRD.

7.3.6 Other testing

In provision for solid material to undergo kinetic testing, provision has been made for up to three kinetic cells, for each lithology, at each mine to be conducted for a minimum of 6 months. Eight lithologies per mine have been assumed. The break-down of sample volumes is given in Table 21.

It is anticipated that the environmental authorities will require additional leach tests with groundwater concentration analogues in order to determine the effect of high salinity water on waste rock that will be used to backfill pits, and the release of neutral pH anions. This process will be undertaken in consultation with ChemCentre with whom FMG are conducting research into leaching processes. These additional leaching tests are not included in this programme.

Table 21: Kinetic testing sample volumes for 6 months

Site	Number of humidity cells per lithology	Number of assumed lithologies	Sub-total
Cloudbreak	3	8	24
Christmas Creek	3	8	24
Solomon	3	8	24
Total	**9**	**64**	**72**
Mineralogical analyses (XRD) before and on completion of cell			144

8. SAMPLING LOGISTICS

8.1 Sample handling

Samples need to be labelled so they can be identified by the laboratory. As samples are kept cold condensation can affect label adhesive and ink. All sample labels will be sealed and secured with clear packing tape after recording to preserve ink. Labels will record bore name with solid sample depth or groundwater sample piezometer, site name and date.

Water samples will be additionally secured with packing wrap to prevent spillage and breakage in a hard cased, insulated cooler box with refreezable ice-bricks.

8.2 Sample storage and transport

During transport and storage, it is vital that all procedures and rules are followed thoroughly to ensure that samples are not significantly altered and arrive at the laboratory in a state fit for analysis. Samples can easily be contaminated during transport due to container cross-contamination, packaging material or chilling. During storage, samples can degrade due to lack of preservation, inappropriate storage conditions, excessive storage time and sample cross-contamination. Containers should be sealed with packing tape and a tamper-proof seal, carefully packed with appropriate packing material, chilled and transported in a cooler or fridge.

Tailings material will be collected by site personnel once per week and stored at the dispatch area.

Waste rock material for selected bores will be collected fresh after drilling and stored in the lay-down area to prevent disturbance. The sampler will select samples for laboratory analysis that will then be packed and transported directly from site to the laboratory.

All groundwater samples will be transported to the laboratory by the sampler to ensure cold temperatures at all times.

8.3 Chain of custody

Chain of Custody procedures and documentation demonstrate sample control. This gives confidence that the samples are representative of the sampled material, and are imperative if the samples are to be used in legal proceedings, or if there is any suspicion that they might be tampered with at any stage of the process. Chain of Custody documentation is used to trace possession and handling of a sample from collection through to analysis, reporting and disposal.

The basis of Chain of Custody control measures is that a sample is always in someone’s custody and they are responsible for it at that time. A sample is considered to be in someone’s custody if it is in that person’s physical possession, in their sight, secured in a tamper-proof way by that person or secured in an area restricted by them to authorised personnel.

It is important to realise that couriers will often not recognise the contents of a sample container, but only take responsibility for the container itself. As such, sample containers should be secured with tamper-proof tape, seal or lock. This will quickly show if a sample or sample container has been tampered with.

The sampler should complete Chain of Custody forms before packing the samples in the field. The original Chain of Custody form shall remain with the sample at all times so that custody details can be completed at each stage, from transportation to analysis and reporting

A copy of the final completed Chain of Custody Record sheet from the laboratory to confirm receipt and appropriate transfer and handling will be included in the report.

Site investigators will complete chain-of-custody (COC) documentation which details the following information:

- Site name;
- Sampler name;
- Nature of the sample;
- Collection time and date;
- Analyses to be performed; and
- Sample preservation method.

All parties in the sample handling chain (sampler, dispatcher, courier and laboratory) must sign the chain-of-custody documentation on receipt of samples to indicate acceptance of custody and integrity of samples. A blank COC document can be found in Appendix A.

9. HEALTH AND SAFETY PLAN

9.1 Emergency numbers

Service	Location / Details	Phone
Cloudbreak 24 hour Emergency	Cloudbreak Site	0418 911 553
Christmas Creek 24 hours Emergency	Christmas Creek	08 9177 7333
Hospitals		
Newman Hospital	54 Mindarra Drive, Newman, WA 6753	08 9175 8333
Paraburdoo Hospital	Rocklea Road, Paraburdoo, WA 6754	08 9159 8222
Tom Price Hospital	Mine Road, Tom Price, WA 6751	08 9159 5222

9.2 Purpose and policy

9.2.1 Introduction

This project Health and Safety Plan (HASP) was prepared for Tetra Tech Australia Pty Ltd (Tetra Tech) employees performing a specific scope of work. It was prepared based on the best available information regarding the physical and chemical hazards known or suspected to be present on the project site. While it is not possible to discover, evaluate, and protect in advance against all possible hazards, which may be encountered during the completion of this project, adherence to the requirements of the HASP will significantly reduce the potential for occupational injury.

This HASP has been written for the exclusive use of Tetra Tech, its employees, and subcontractors. The plan is written for specified site conditions and tasks and should be amended if conditions change.

9.2.2 Regulatory framework

This HASP and site activities strive to be in compliance with the requirements of the Fortescue Metals Group Health and Safety and Environmental policy and to operate within the remit of Australian Occupational Health and Safety guidelines.

9.2.3 Stop work authority

All site personnel are empowered, expected, and have the responsibility to stop their own work and the work of co-workers, FMG employees, or other contractors if any person's safety or the environment is at risk. No repercussions will result from this action.

Site or project conditions that may warrant a stop work order and modifications to the HASP include:

- Site temperatures outside the range predicted in this HASP (possibly resulting in greater risk of heat or cold stress);
- PPE breakthrough or unexpected degradation; and
- Hazardous conditions at designated sampling site, requiring intervention from FMG personnel.

This list is not comprehensive and should be used only as guidance. Site hazards should be assessed on an ongoing basis and activities modified based on changing conditions.

9.3 Scope of work

Fortescue Metals Group Ltd (FMG) requires Tetra Tech to assess the geochemical classification of material disturbed and generated in the mining process, including monitoring of groundwater bores, aboveground and in pit waste stockpiles, focusing on acid and metalliferous drainage (AMD) and potential environmental degradation, at FMG's:

a) Cloudbreak and Christmas Creek mine sites in the Chichester Ranges, located 120 kilometres north of Newman in the East Pilbara region of Western Australia; and

b) Solomon mine site, located 60 kilometres north of Tom Price in the Pilbara region of Western Australia.

Tetra Tech will:

- Conduct sampling and analysis of various materials for AMD potential;
- Provide auditable reports of the waste characterisation on site; and
- Provide guidance on potential environmental risk.

9.3.1 Waste rock sampling

Waste rock samples will be collected by FMG staff fresh from drilling spoil, bagged and stored for later selection by Tetra Tech staff for analyses. Sampling includes logging and recording of overburden material to be sent to the laboratory.

9.3.2 Groundwater monitoring bore sampling

Groundwater samples will be collected from monitoring wells with a portable, electric, submersible pump using low-flow sampling techniques. Sampling activities include lowering equipment into bores, measuring pumped groundwater, cleaning and packaging samples.

9.4 Project hazards and control measures

The following hazards are anticipated to be present on all the sites for the activities being completed by Tetra Tech employees and sub-consultants onsite (Table 22). These hazards are described more thoroughly in the following sections.

Table 22: Expected hazards

Safety hazards:	
Slip, trips and falls	Entanglement
Sharp objects	Pinch points (e.g. cuts to hands, crushed fingers or toes)
Electrical or other energized equipment	Back strain or injury
Vehicle traffic	Working on/near water
Physical hazards	
Noise	Heat & cold stress
Muscle strain	Wet conditions
UV / sunlight	Weather Hazards

Additional hazards may be noted on the Job Safety Analyses (JSAs) for the individual tasks (Appendix D).

9.4.1 Slips, trips and falls

A variety of conditions may exist that may result in injury from slips, trips, falls, and protruding objects. Slips and trips may occur as a result of wet, slippery, or uneven walking surfaces. To prevent injuries from slips and trips, always keep work areas clean; keep walkways free of objects and debris; and report/clean up liquid spills. Protruding objects are any object that extends into the path of travel or working area that may cause injury when contacted by personnel. Always be aware of protruding objects and when necessary remove or label the protruding object with an appropriate warning.

Slippery, uneven footing and tripping hazards will likely be present at the site. Be vigilant, avoid puddles, and wear footwear with slip resistant soles.

Walk around, not over or on top of debris or trash piles. When carrying equipment, identify a path that is clear of any obstructions. It might be necessary to remove obstacles to create a smooth, unobstructed access point to the work areas on site.

Maintaining a work environment that is free from accumulated debris is the key to preventing slip, trip and fall hazards at sites. Essential elements of good housekeeping include

- Orderly placement of materials, tools and equipment-free areas;
- Placing trash receptacles at appropriate locations for the disposal of miscellaneous rubbish; and,
- Prompt removal and secure storage of items that are not needed to perform the immediate task at hand.

9.4.2 Manual lifting

The human body is subject to severe damage in the forms of back injury, muscle strains, and hernia if caution is not observed in the handling process. Whenever possible, use mechanical assistance to lift or move materials and at a minimum, use at least two people to lift, or roll/lift with your arms as close to the body as possible. Never bend over to lift always bend at the knees and keep your back at a straight angle.

9.4.3 Hand injuries and pinch points

Tetra Tech employees and sub-consultants will be collecting environmental samples while at FMG sites, which will require handling equipment and sampling tools. When sampling there is potential for hand injuries/pinches while using sampling equipment.

To prevent hand injuries, the following precautions will be taken:

- Wearing gloves to avoid direct contact with environmental samples – both nitrile gloves and leather gloves.
- Training in equipment usage to avoid any equipment handling errors leading to injuries;
- Cables, leads, wires will be stored on reels to avoid pinch points to hands;
- Materials will be inspected for jagged or sharp edges prior to handling;
- Fingers will be kept away from pinch and shear points, especially when setting down materials.

9.4.4 Foot injuries

Foot injuries can occur as a result of slips, trips and falls covered in Section 9.4.1. The following precautions will be taken to prevent foot injuries while onsite:

- Wipe off greasy, wet, slippery or dirty surfaces if necessary prior to walking;
- Use two people to lift heavy or unwieldy equipment to avoid dropping and causing injury;
- Keep work area tidy and clutter free to avoid trip hazards.

9.4.5 Noise

The potential for exposure to noise above the regulated noise level of 80 dB is considered low for the work Tetra Tech will be completing on FMG sites; however, as Tetra Tech employees and sub-consultants will be completing fieldwork on operational FMG sites, there is the potential for exposure to high noise levels.

FMG's Noise Management Procedure (45-PR-SA-0029) details the procedure to avoid an employee's or contractor's exposure to noise above regulated noise action levels (80 dB or more). As a contractor to Fortescue, Tetra Tech will adhere to the FMG set in this procedure.

Where noise levels unavoidably exceed the regulated noise level (80 dB) a mandatory hearing protection area will be established, by a competent person, which fully encompasses all areas where hazardous noise levels are present (80 dB or greater). These hearing protection areas will be adhere to the standards set out in FMG's Noise Management Procedure (45-PR-SA-0029), and appropriate signage and training will be provided for working in these areas. Refer to 45-PR-SA-0029, Noise Management Procedure, for additional information and requirements.

9.4.6 Heat stress

FMG's Heat Management Procedure (45-PR-SA-0014) details the risks and procedures for heat management whilst onsite.

Working in high heat environments has the potential to impair the body's ability to dissipate heat leading to heat stress. If not controlled, exposure to heat may lead to serious illness including heat stroke which may be fatal. The risk of heat related illness in the Pilbara is high, particularly for outdoor workers, for as much as six months of the year (October to March).

Hot areas or activities where employees have experienced or could experience excessive fatigue, muscle cramp, dehydration, dizziness and other symptoms of heat stress must be identified and the risks managed.

To manage extreme risk activities, the following controls should be considered:

- Personal hydration testing (urine specific gravity);
- Suitable work / rest regimes based on measurements taken by a competent person;
- Relocation of tasks to a cooler area or reschedule work to cooler times of the day or night shift where practicable (ensure any additional risks area managed such as fatigue);
- Use of mechanical aids to reduce the level of physical work; and
- Provision of cooling vest / collars.

9.4.7 Biological hazards

When working onsite, employees and contractors should be aware that there are a variety of biological hazards present in the Pilbara region that are venomous, contain toxins, or have the potential to cause irritation. The Pilbara is home to numerous biological hazards, including:

- Wild animals: such as snakes, other reptiles such as lizards, dingoes, kangaroos and etc. These animals can bite, scratch or inject venom.
- Insects: such as mosquitoes, ticks, bees and wasps. Mosquitoes in the Pilbara region can carry and transmit Ross River Virus (RRV), Barmah Forest Virus (BFV), and Kunjin Virus.
- Plants, which may cause skin irritation or rashes on exposed skin.

Precautionary measures need to be taken including:

- Avoid contact with any of the flora and fauna;
- Wear long sleeved shirts and trousers to avoid exposure;

- Exercise caution if disturbing an isolated area, as snakes / spiders and various animals and insects may hide under objects. Carry insecticide spray for groundwater wells as spiders may be nesting in casing where equipment will need to be lowered; and
- Use insect repellent containing diethyltoluamide (DEET) when working in an area where mosquitoes are present.

In the event of a bite/sting/irritation, incidents must be reported within 24 hours and medical attention should be sought immediately following the incident. FMG's Incident Event Management Procedure (100-PR-SA-0011) should be followed regarding the reporting of incidents.

9.4.8 Working on or near the water

Tetra Tech may conduct surface water sampling, and as such will be working close to water. It is expected that the water level will be variable as a result of seasonal rainfall. The following measures and precautions will be taken to reduce risks when working near water:

- Utilising the buddy system whenever there is the possibility of falling into water, in which two people operate as a single unit in order to monitor and assist each other in performing tasks;
- Reduce proximity to water, and therefore decrease risk of falling into the water, by using a long pole upon which the sampling container will be attached to ensure the sampling technician does not have to enter the water or stand too close to the water;
- Take special care on slippery rocks along shorelines, lakeshores, riverbanks, and creeks;
- Always look ahead at the ground when walking around the water's edge and avoid stepping on stones that have algal growth, especially those in intertidal areas, as these are extremely slippery.

It is suggested that workers not be permitted to access areas where these slip/fall hazards exists, especially in locations containing tidal water flow.

9.4.9 Driving / journey management

Tetra Tech will be completing fieldwork on FMG sites, which will require journeys to remote areas on site. Tetra Tech employees will be chaperoned at all times whilst on FMG sites, by a Fortescue employee and will not be responsible for driving while onsite. Tetra Tech employees will adhere to FMG's Journey Management Procedure (100-PR-EM-0005_Rev0). This procedure includes the following minimum standards:

- When taking trips to remote locations the person(s) travelling will submit a Journey Management Plan (JMP) to a nominated contact location for authorisation;
- The person(s) travelling shall complete the following prior to commencing the journey:
    - Complete vehicle inspection;
    - Set vehicle trip meter to zero;
    - Communicate with the contact location and confirm, receive updated road and weather conditions;
    - Comply with all instructions and communication plans as per JMP;
    - Stick to route of travel nominated in the JMP;
    - Drive the vehicle in accordance with Vehicles and Driving Procedure (45-PR-SA-0043);
    - If trip extends beyond time stated in the JMP, inform contact location of new planned arrival time;
    - Upon arrival at site the traveller must immediately communicate with the contact location and inform them that they have arrived safely.

9.4.10 Weather hazards

The Pilbara region experiences various weather systems and conditions, including cyclones, lightning storms, heavy rainfall leading to flash flooding, and high sun and UV light exposure. Severe weather can occur with little warning. Employees and contractors will be vigilant for potential storms, lightning, high winds, and flash flood events.

9.4.10.1 Cyclones

The coastal Pilbara region experience cyclones occasionally, as such Fortescue have a Cyclone Management Procedure (100-PR-EM-0001) and the Cyclone Emergency Management Plan (100-PL-EM-0004). This procedure details action required in the event of a cyclone. The Cyclone Management Procedure is applicable to all FMG's operational, project, construction and exploration sites.

As contractors to Fortescue, Tetra Tech employees and sub-consultants will adhere to the Cyclone Management Procedure and Cyclone Emergency Management Plan in the event of a cyclone whilst on one of FMG's sites.

9.4.10.2 Heavy rainfall and flash flooding

Flash floods can occur quickly during storms. In the event that employees and contractors are caught in heavy rain, vehicles should be parked at a high level, away from river beds

To avoid being caught out in a flash flood, take precautions before setting out into the field and monitor the weather.

9.4.10.3 Lightning storms

In the event of a lightening, there are precautionary measures in place to ensure employee and contractor safety at Fortescue. If lightning and thunder are observed, the time between the two is an indication of the distance of the storm front. If there is less than a 30 second delay between flash and sound, this indicates that the lightning is within 10 km.

When lightning is observed the following precautions should be taken:

- Avoid performing tasks which require close proximity to machinery, such as drill rigs, or other heavy machinery;
- Seek shelter in a substantial building;
- If close to a vehicle and not a building, get into the vehicle;
- Seek low ground and avoid ground and elevated positions such as hilltops, ridges and rooftops;
- Crouch close to the ground with feet together as a last resort.

In the event of lightning the following actions are forbidden:

- Sheltering under isolated trees;
- Touching, handling or standing too close to any metallic objects that may become a discharge path for the lightning such as towers, mobile plant, power lines, pipes, rails and fences.

Fortescue onsite lightning alerts are as follows:

- A = Alpha 30 km >
- B = Bravo 15 km > 30 km
- C = Charlie <15 km
- ALL CLEAR

9.4.10.4 Ultraviolet /sun exposure

The Pilbara region area frequently reports very high to extreme Ultraviolet (UV) light index i.e. UV index greater than 8. Workers performing field work outdoors may be susceptible to sunburn if not properly protected with sunscreen or protective clothing and hats. Skin can burn in minutes when the UV Index is very high. Protective measures are advisable, these protective measures include:

- Frequent application of high factor sunscreen (SPF 30+) as sweating impacts efficacy;
- Wearing a wide brimmed hat, or attaching a brim to hard hat where hard hats are required;
- Wearing protective sunglasses that block at least 99% of all UV rays, to protect eyes;
- Wearing a long sleeved shirt;
- Take extra precaution when working outdoors between 10 am and 3 pm, when the UV radiation is most intense;
- Seek shade regularly;
- Drink water regularly (at least 2 litres of water per day).

Heatstroke and dehydration can cause confusion or irregular behaviour and personnel in danger may not realise it. Be aware of the warning signs of heatstroke such as headache, thirst, dark urine colour or cessation of sweating. If person has stopped sweating he/she is at severe risk of dehydration and/or heatstroke.

9.5 Roles and responsibilities

All Tetra Tech and subcontractor personnel must adhere to the procedures outlined in this HASP during the performance of work. Each person is responsible for completing tasks safely, and reporting any unsafe acts or conditions to the supervisor. No person may work in a manner that conflicts with these procedures. After due warnings, the PM will dismiss from the site any person or subcontractor who violates safety procedures.

All Tetra Tech personnel have been trained in accordance with applicable regulations, and are familiar with the requirements and procedures contained in this HASP. The roles of Tetra Tech personnel and subcontractors are outlined in Table 23.

Table 23: Contact details

Individual:	Role:	Contact Phone:
Chris Counsell	FMG Project Manager	0457 806 692
Colleen Burgers	Tetra Tech Health and Safety Officer	0417 986 865
Katie Joyce	Site Safety officer	0477 893 764
Ian Anderson	Field Geologist	0419 906 498

9.5.1 Health and safety officer

The Health and Safety Officer (HSO) is responsible for ensuring that activities conducted at the Site are performed in conformance with this HASP and applicable contractors/subcontractors HASP(s). He/she has the authority to stop work if actions or conditions are judged unsafe or not in conformance with the HASP(s), including, but not limited to, inadequate or improper use of required PPE. Should unexpected conditions arise during fieldwork that warrant changes to this or other HASP(s), those changes must be reviewed and approved by him/her. The responsibilities of the Health & Safety Officer will be:

- Establish and direct the safety program;
- Assure all personnel assigned to the site are acquainted with the HASP;
- Ensure all pre-mobilization health and safety training for field team members is completed; and
- Advise and consult with the Site Safety Officer (SSO) and the Site Responsible Supervisor (SRS) (Fortescue) on all matters related to the health and safety of those involved in site operations.

9.5.2 Site safety officer

The Site Safety Officer (SSO) is responsible for ensuring that day-to-day onsite activities are performed in conformance with this HASP and applicable contractors/subcontractors HASP(s). He/she has the authority to stop work if actions or conditions are judged unsafe or not in conformance with the HASP(s), including, but not limited to, inadequate or improper use of required PPE. An appropriate person will serve as the alternate Site Safety Officer when the primary Site Safety Officer is not on site. The responsibilities of the Site Safety Officer will be:

- Assure that appropriate PPE is available and is properly utilized by all onsite contractor personnel;
- Assure that personnel are aware of the provisions of this plan and are instructed in the work practices necessary to ensure safety and the procedures for dealing with emergencies;
- Assure that personnel are aware of potential hazards associated with the site;
- Monitor the safety performance of all personnel to ensure that the required work practices are employed;
- Immediately stop work and correct any work practices or conditions that may result in injury or unsafe conditions;
- Conduct safety inspections;
- Prepare accident/incident reports; and
- Consult with the HSO.

9.5.3 Field workers

All field workers, including contractors/subcontractors, are responsible for their personal health and safety and the safety of their co-workers. All field team members are responsible for reading and complying with this and other project HASP(s). As required by this HASP they are responsible for becoming aware of any hazardous site conditions, wearing the appropriate PPE, paying attention at all times, and stopping work and reporting any unsafe working conditions to the Site Safety Officer or Field Supervisor. No person shall perform an activity that he or she believes may endanger his or her health and safety or the health and safety of others. Everyone has the responsibility to stop work in the face of unsafe working conditions or practices.

9.6 General safety practices

9.6.1 Alcohol and drug policy

FMG's Policy 100-PR-SA-0013 outlines the Alcohol and Drug Policy. Fortescue has a zero tolerance to alcohol and drugs in the workplace.

FMG also prohibits any individual to be under the influence of, or to sell, distribute or possess alcohol (with the exception of authorised Special Events), illicit drugs or intoxicating or deleterious compounds when reporting for work, while working or while on active work duties or premises.

Facilities Management staff shall ensure that the sale and service of alcohol at Fortescue facilities is in accordance with legal obligations and license conditions, and designated camp rules.

Arrangements for managing the consumption of over the counter medication and prescription medications are detailed in this procedure.

9.6.2 Personal protective equipment

Fortescue's Procedure 100-PR-SA-0039 outlines the Personal Protective Equipment (PPE) standards required. In addition to Fortescue's Procedure, Tetra Tech adheres to its Personal

Protective Equipment Programme (DCN 02-07), and uses the Tetra Tech PPE Checklist (DCN.02-07F).

Fortescue's Procedure 100-PR-SA-0039 states, that PPE must be provided in accordance to the Western Australia Mines Safety and Inspection Act 1994, Section 9 and the Western Australia Occupational Safety and Health Act, 1984 Section 19; where it is not practicable to avoid exposure to hazards. As contractors to Fortescue, Tetra Tech must also provide their personnel with PPE that meets the standards within this procedure.

All PPE selected must conform to the appropriate Australian Standard, equivalent International Standard and / or industry requirements

Applicable Australian Standards and manufacturer's instructions must be followed for the selection, use and maintenance of PPE

- Personnel must be trained in the selection, use and maintenance of PPE where applicable
- PPE must be inspected by the wearer prior to use to ensure it is functioning properly
- Defective or damaged PPE must be immediately removed from use and replaced
- Sites must define and signpost mandatory PPE areas - the signs must comply with AS 1319
- Fortescue and Contractor workplaces must maintain adequate stocks of PPE for each work area on site

As a contractor for Fortescue, Tetra Tech Australia will meet the Fortescue Standards, and ensure all employees and contractors are provided with the appropriate level of PPE for the work being conducted onsite. The PPE required for Tetra Tech employees and sub-consultants whilst working on Fortescue sites is detailed in Table 24:

Table 24: PPE requirements

Type	Material	Additional Information
Minimum PPE:		
Safety Vest with long sleeved shirt underneath -OR- Long sleeved high visibility shirt	High-visibility	Must have reflective tape and be visible from all sides
Boots	Leather	Leather steel toe-capped boots
Safety Glasses	Clear & dark required	Australian Standards Approved
Hard Hat		Australian Standards Approved
Brim attachment for Hard Hat		Sun protection
Long Trousers		No shorts / cut-offs
Additional PPE:		
Hearing Protection	Ear plugs	If operating in hazardous noise environments
Gloves	Leather / Kevlar	When working with sharp objects, glass or powered equipment
Protective Chemical Gloves	Disposable - Nitrile	When collecting environmental samples

9.6.3 Occupational hygiene

Fortescue's Occupational Hygiene Management Procedure (45-PR-SA-0050) outlines the health risks associated with potential exposure to chemical, physical and biological agents and has been developed to aid in effectively recognising hazards in order to prevent occupational illness and disease. Tetra Tech, as a contractor, to Fortescue will adhere to this procedure, and ensure appropriate duty of care is taken.

9.6.4 Fatigue management

Fortescue's Fatigue Management Procedure (100-PR-MM-0013) outlines the duty of care to employees and contractors completing activities on Fortescue sites. Tetra Tech, as a contractor, to Fortescue adheres to this procedure, and ensures appropriate duty of care is taken.

Tetra Tech's General Safe Work Practices for Field Work (SWP 5-1) outlines Tetra Tech's duty of care to employees and subconsultants, and states that no one will be permitted to work when ability or alertness is impaired by fatigue, illness, or other causes that might unnecessarily expose the employees or others to injury.

9.6.5 Site-specific training

Prior to commencing any fieldwork all employees and sub-consultants will undergo Fortescue inductions. These include the following:

- Online Inductions:
  - Fortescue General Induction;
  - Fortescue Christmas Creek Induction;
  - Fortescue Cloudbreak Induction;
  - Fortescue Solomon Induction;
  - Hearing Conservation Awareness.
- Safety Induction:
  - Chichester Site induction
  - Leighton Site Induction
- Site Specific Inductions upon arrival at site.

The inductions will ensure all Tetra Tech employees and sub-consultants are fully trained in site health and safety procedures and will adhere to Fortescue Procedures whilst completing fieldwork onsite.

9.6.6 Incident reporting

In the event an incident occurs while Tetra Tech employees or sub-consultants are onsite, the Incident Event Management Procedure (100-PR-SA-0011) will be followed in order to report and record any health, safety, environment, security, property damage, production loss, quality and heritage incidents.

If an event / incident takes place while a Tetra Tech employee is onsite the incident must be reported to the Fortescue supervisor, who in turn will report the incident to:

- Line manager – within the shift when the incident occurs
- Line manager to report the incident to the Fortescue Representative or Contract Owner within 24 hours of the incident occurring.

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APPENDIX A: CHAIN OF CUSTODY

South Wing, Building 500, Curtin University,
cnr South Entrance and Manning Road,
Bentley, WA, 6102
Phone: +61 8 9422 9821
Attention: Stuart Rietkerk
Mobile: +61 467 781 248
Email: SRietkerk@chemcentre.wa.gov.au

ChemCentre
EXPERT SOLUTIONS

370 Murray Street,
Perth,
WA, 6000
Phone: +61 8 6313 3200 Fax: +61 8 6313 3201
Attention: Colleen Burgers
Email: colleen.burgers@tetratech.com
Results email:admin.perth@tetratech.com

TETRA TECH

Please sign and return, results to include laboratory QA/QC

Project: 753-1495940300 Life of Mine Geochemistry

Laboratory code	Sample Marks	Date	Container	Solid	Liquid	Preservative	Analysis						Comments
	Name						ABA	Leach test$_{1, 2 \& 3}$	Total Elements $^{2, 3}$	Water analysis$^{1,2\&3}$	NO_3+NO_2		(Label container with sample date and OPF #, sign when relinquishing to courier) Sampler to write name in comments when sample collected
													Tailings: Filter supernatant and analyse **ABA** – TS, TOS, ANC, NAG + NAGpH
													Leach Test: DI Water, bottle roll List 1 + ICP-AES List 2 + ICP-MS List 3
													Total Elements: Acid Digest ICP-AES List 2 + ICP-MS List 3

Signature:		Date & Time		Received By:		Date & Time	
Relinquished by:				Received By:		Date & Time	
Samples intact: *Yes / No*		Temperature: *Ambient / Chilled / NA*		Sample Security sealed: *~~Yes~~ / ~~No~~ /* ***NA***		Quarantine: *~~Yes~~ /* ***No***	

^{1}**List**	pH, EC, TDS (calc), Alkalinity, Acidity, Cl,	**Page of**
^{2}**ICP-AES**	Al, B, Ba, Be, Bi, Ca, Ce, Co, Total Cr, Cs, Fe, K, La, Li, Mg, Mn, Mo, Na, Ni, Rb, S, Sb, Sc, Sn, SO_4, Sr, Th, Ti, Tl, U, V, W, Zn	
^{3}**ICP-MS**	Ag, As, Cd, Cu, Pd, Se, Hg	

APPENDIX B: TAILINGS COLLECTION

Current site contacts responsible for tailings collection – may vary over time

Site	Name	Email	Contact
Cloudbreak	Lindsey Hole	lhole@fmgl.com.au	0457 104 606
	Amy Scholz	ascholz@fmgl.com.au	0457 104 606
	Tseko Mokebe	tmokebe@fmgl.com.au	0439 097 471
	Anthony Kurniawan	akurniawan@fmgl.com.au	0439 097 471
Christmas Creek	Carl Wilson	cwilson@fmgl.com.au	0437 024 521
	Jeremy Chong	jchong@fmgl.com.au	0439 913 880
	David Zakarias	dzakarias@fmgl.com.au	0417 872 313
Solomon	Colin Bensley	cbensley@fmgl.com.au	0419 517 889

APPENDIX C: SAMPLING SHEETS

TETRA TECH

Tetra Tech Australia Pty Ltd.
370 Murray Street | Perth, WA 6000 | Australia | P.O. Box 7322, Cloisters Square PO | Perth, WA 6850 | Australia
Tel +61 (0) 8.6313.3200 Fax +61 (0) 8.6313.3201 tetratech.com

Groundwater Sample Description Form for Low Flow Purging

Site name:	**Project number:**	**Date & time:**
Bore Name:		
Collar Height:		
Pipe Radius:		
Well Depth (mbc):		
Water level (mbc):		

Time	**Vol**	**WL**	**pH**	**EC**	**°C**	**Time**	**Vol**	**WL**	**pH**	**EC**	**°C**	**Time**	**Vol**	**WL**	**pH**	**EC**	**°C**

Description: Colour, clarity, sediment			
Odour:			
Purge Vol:			
Purge Water level: (mbc)			
Sample Name			
Duplicate Name			
Equipment blank			
Disposal of purge water:			

*Scan and save in project folder

TETRA TECH

Tetra Tech Australia Pty Ltd.
370 Murray Street | Perth, WA 6000 | Australia | P.O. Box 7322, Cloisters Square PO
Perth, WA 6850 | Australia
Tel +61 (0) 8.6313.3200 Fax +61 (0) 8.6313.3201 tetratech.com

Rock Sample Description Form

Site name:

Project number: **753-14959403**

Date & time:

Sampler:

Bore:

Bore:

Depth (mbs)	**Description**	**Samples collected**	**Depth (mbs)**	**Description**	**Samples collected**

APPENDIX D: JOB SAFETY ANALYSES

Tetra Tech AMD Sampling: Groundwater

1. PURPOSE

The purpose of this Safe Work Instruction is to provide guidance on the potential hazards faced when conducting groundwater sampling.

2. SCOPE

This details an outline of the basic steps to be followed and the potential hazards that may be faced. Observations for specific hazards at each sampling position should be conducted and a JSA performed if not within the scope of this SWI. A copy of this information is to be in possession of the sampler at all times during the undertaking of this task.

3. AREA

- Multiple sampling areas around the plant, waste rock dumps, tailings dam and remote areas away from operations. Specific points are given in the detailed sampling plan.

4. REFERENCES / ASSOCIATED DOCUMENTATION

- The FMG LOM Sampling plan details full health and safety requirements and all specific job steps and information required to perform the task. Document reference: Chichester and Solomon Operations - Acid Metalliferous Drainage Sampling Plan. Tetra Tech Document Control Number 753- 1495940300-REP-R0002-00
- SDS: pH4 calibration fluid, pH 7 calibration fluid, EC 12.88 mS/cm calibration fluid

5. REQUIREMENTS

- Delete in the electronic version PPE not relevant.

PERSONAL PROTECTIVE EQUIPMENT (PPE)							
							

WORK CERTIFICATES / PERMIT REQUIREMENTS					
Confined Space Entry	☐	Work Box	☐	Work Permit	☐
Live Electrical Work	☐	Non Standard Lift	☐	Master Permit	☐
Excavation / Penetration	☐	Work at Height	☐	HV Electrical Certificate	☐
Hot Work	☐	O/Side Vessel – Platform	☐	Environmental	☐
Floor Roof Wall Opening	☐	Power Vicinity / Corridor Access	☐		☐

JOB SPECIFIC RESOURCES							
Barricading	☒	Sentry & Sentry Board	☐	Fire Blankets	☐	Phones	☒
Drinking Water	☒	Running Water	☐	Voltage Reducer	☐	Extinguishers	☐
Warning Signs	☒	Fire Watch	☐	Radio	☒	First Aid Kit	☒

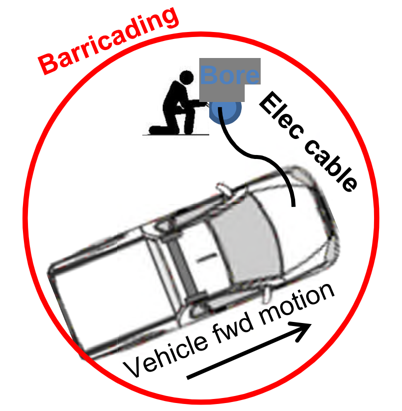
JOB SPECIFIC EQUIPMENT							
Low flow pump	☒	Low flow pump controller	☒	Air compressor	☒	Vehicle	☒
Dip meter	☒	pH/ EC meter	☒	Tubing	☒	Cooler & ice bricks	☒
Bucket	☒	Distilled water	☒	Bottles	☒		☐

6. DESCRIPTION OF WORK

The following set of instructions must be followed in order on arrival at monitoring bore:

1. Remove bore lid – may need hex key or padlock key;
2. Insert dip meter into bore to measure water level and record;
3. Determine which piezometer in bore will be sampled – if WT (water table) piezometer is dry, dip S (shallow) piezometer;
4. Use dip meter to confirm depth of bore to determine whether piezometer is labelled correctly and whether any siltation has occurred, and record;
5. Use dip meter tape measure to confirm inner diameter of bore and halve it to obtain the radius;
6. Calculate volume for 0.5 m decrease in water level based on radius of piezometer ($V = h \times \pi \times r^2$). If the piezometer radius is 25 mm, a 0.5 m decrease in water level $\approx$ 1 L volume removed;
7. Lower pump to middle of screened casing depth, first indication of water or formation of highest hydraulic conductivity according to bore logs, & remove volume calculated in previous step;
8. Remove pump and measure water level again to determine whether any change has occurred. If water level has decreased by ~0.5 m then lower pump to different depth or lower pumping speed and repeat until volume removed has no effect on water level. If several attempts have failed to situate the pump at groundwater inflow then purge three well volumes and collect a sample;
9. Begin sample measurements for pH/ EC/ Temp and record results. Pump groundwater until sample measurements have not changed for three measurements in a row;
10. Record final measurements and any observations as to colour, sediment, clarity and odour;
11. Collect sample in 1 x 500 mL plastic bottle and syringe filter into 1 x 100 mL plastic bottle for dissolved elements. Samples will be preserved at cold temperatures only, no other preservative is required;
12. Collect duplicate sample, if required, in measuring vessel before dividing into original and duplicate;
13. Measure water level again to be certain no decrease has occurred and record;
14. Secure all bore coverings and lids;
15. Record total amount of water removed from bore;
16. Label sample bottles with site name, monitoring bore, piezometer number and date. Keep samples cold in cooler (4°C);
17. Proceed with pump and tubing decontamination;
18. Collect equipment blank with deionised water at the close of each sampling day or after sampling a bore with unusual measurements or observations at the sampler's discretion.
19. Fill out COC form.

7. JOB STEP AND CONTROL METHODS

No.	**Job Steps**	
	Hazards	**Controls**
7.1	**Calibration of monitoring equipment**	
	Skin or eye contact with calibration chemicals	Wear disposable gloves and safety glasses and avoid direct contact with calibration solutions.
		Properly dispose of calibration solution wastes.
7.2	**Set up and installation of low-flow pump**	
	Minor potential hand injuries: pinch points	When lowering and pulling the pump and assembly, wear leather gloves.
	Physical hazards associated with manual lifting.	Lift heavy objects using the legs and not the back. Use wheeled transport equipment for heavy loads. Get assistance when handling loads > 25 kg.
	Unexpected release of pressure form gas cylinder or air compressor.	Cylinder must be secured in a stable vertical position before pressure regulator is attached. Remove regulator and replace cap when transporting cylinders. Check for damaged air lines and replace if compromised.
7.3	**Connecting pump to car battery**	
	Vehicle movement crushing sampler	Position vehicle side on to work area between bore and nearest road
		Ensure vehicle is secure: wheel chocks, hand brake up
		Ensure that vehicle potential forward movement is away from sampler
	Electrical shocks	Connect terminals with turned car off: Red to red, black to black – Wear leather gloves
		Connect all air hoses to equipment
		Start car and leave running
		Switch on compressor and allow hose to pressurise.
		Report all shocks immediately
7.4	**Sample Collection**	
	Contact with potentially contaminated groundwater	Wear disposable gloves and safety glasses when collecting sample to minimize contact with groundwater.
	Tripping potential on sample discharge line.	Organize line to keep out of way as much as possible, mark potential tripping hazards with caution tape or safety cones.
	Back strain when transporting coolers full of collected samples.	Use proper lifting techniques. Get assistance when possible, especially for containers > 25 kg.
	Uneven terrain: Slips, Trips, and	All personnel should be constantly watching for trip hazards such as uneven terrain, stretched wires or ropes, or any other materials or

FMG	Department **HSES**	Document Number **45-FR-SA-0024**
	Section **SAFE WORK INSTRUCTION**	Title **Rock Sampling**

Tetra Tech AMD Sampling: Rock

1. PURPOSE

The purpose of this Safe Work Instruction is to provide guidance on the potential hazards faced when conducting rock sampling.

2. SCOPE

This details an outline of the basic steps to be followed and the potential hazards that may be faced. Observations for specific hazards at each sampling position should be conducted and a JSA performed if not within the scope of this SWI. A copy of this information is to be in possession of the sampler at all times during the undertaking of this task.

3. AREA

- Multiple sampling areas around the plant, ore stockpiles, pit walls geology lay down areas. Specific points are given in the detailed sampling plan.

4. REFERENCES / ASSOCIATED DOCUMENTATION

- The FMG LOM Sampling plan details full health and safety requirements and all specific job steps and information required to perform the task. Document reference: Chichester and Solomon Operations - Acid Metalliferous Drainage Sampling Plan. Tetra Tech Document Control Number 753- 1495940300-REP-R0002-00

5. REQUIREMENTS

PERSONAL PROTECTIVE EQUIPMENT (PPE)							
							

WORK CERTIFICATES / PERMIT REQUIREMENTS					
Confined Space Entry	☐	Work Box	☐	Work Permit	☐
Live Electrical Work	☐	Non Standard Lift	☐	Master Permit	☐
Excavation / Penetration	☐	Work at Height	☐	HV Electrical Certificate	☐
Hot Work	☐	O/Side Vessel – Platform	☐	Environmental	☐
Floor Roof Wall Opening	☐	Power Vicinity / Corridor Access	☐		☐

JOB SPECIFIC RESOURCES							
Barricading	☒	Sentry & Sentry Board	☒	Fire Blankets	☐	Phones	☐
Drinking Water	☒	Running Water	☐	Voltage Reducer	☐	Extinguishers	☐
Warning Signs	☒	Fire Watch	☐	Radio	☒	First Aid Kit	☒

JOB SPECIFIC EQUIPMENT							
Stainless steel trowel	☒	Logging sheets	☒	Sampling bags	☒		☐

6. DESCRIPTION OF WORK

The following set of instructions must be followed when sampling:

1. Logging waste rock at geology laydown area;
2. Sampling waste rock at geology laydown area;
3. Collect samples from ore stockpiles;
4. Collect samples from pit walls;
5. Fill out COC form.

7. JOB STEP AND CONTROL METHODS

No.	**Job Steps**	
	Hazards	**Controls**
7.1	**Sample Collection**	
	Physical injury from hand tools	Stand clear of person wielding geology pick or shovel. Use proper technique to avoid back strain. Wear leather gloves when using hands for activities other than sampling.
	Sampling *in situ* at rock face or stockpile	**JHA is required to assess hazards of specific areas**– loose material can fail catastrophically burying worker and large falling boulders can come loose suddenly resulting in broken bones or death No sampling at rock face higher than 2 m within 2 m from the edge of such a height, is allowed without fall protection as this is Working at Heights
	Inhalation of dirt or dust during work activities.	To avoid inhalation of dust, wear a disposable dust mask
	Dermal contact of dirt or dust during sampling	Wear rubber or latex gloves to prevent contact with hands and long sleeves for arms.
	Eye contact with dust	Wear eye protection, dark when in sun and clear when in low light.
	Traffic (including pedestrian)	Use cones, signs, flags or other traffic control devices as necessary
	Back strain while logging.	Sit where possible, crouch or squat with back straight when not sitting
	Back strain when lifting.	Use proper lifting techniques, lift with knees keep back straight. Get assistance when possible, especially for containers > 25 kg.
	Uneven ground - Slips, Trips & Falls	All personnel should be constantly watching for trip hazards such as uneven terrain, stretched wires or ropes, or any other materials or pieces of equipment in their path.
	Hand injuries during manual handling of materials.	Workers should inspect materials for slivers, jagged or sharp edges, and rough or slippery surfaces. .
		Workers should keep fingers away from pinch and shear points, especially when setting down materials
	Foot injuries	Workers should wipe off greasy, wet, slippery, or dirty surfaces before attempting to traverse them.
	Sun Burn	Wear a wide-brimmed hat to protect face from the sun
		Wear sun screen to prevent sun burn
	Heat exhaustion or stroke.	Find cool, shady area for breaks or respite from heat.
		Avoid strenuous work in ambient temperatures over 30° C.
		Wear light-coloured clothing, shaded sunglasses, and hat that provides shade and adequate air movement.
		If worker feels dizzy, has a headache, has cool, moist, or pale skin or is weak, immediately move to a cooler environment, loosen tight clothing, provide air circulation to area, and provide small amounts of cool water to drink.
		If worker has a change in level of consciousness, high body temperature, red, hot skin, rapid or weak pulse, or rapid or shallow breathing, call the emergency phone number and give care in accordance with #4 above.
	Biological Hazards: Insects, Snakes, Wildlife, Vegetation	Use insect repellent if observe mosquitoes/gnats Open enclosures slowly
		Survey site for presence of biological hazards and maintain safe distance

APPENDIX E: MONITORING BORE LOGS

aquaterra

Suite 4, 125 Melville Parade
Como
WA 6152
Australia
Tel: (+61) (08) 9368 4044
Fax: (+61) (08) 9368 4055

COMPOSITE WELL LOG

Well No: AQ5

Client: FMG
Project: Cloud Break Monitoring Bores

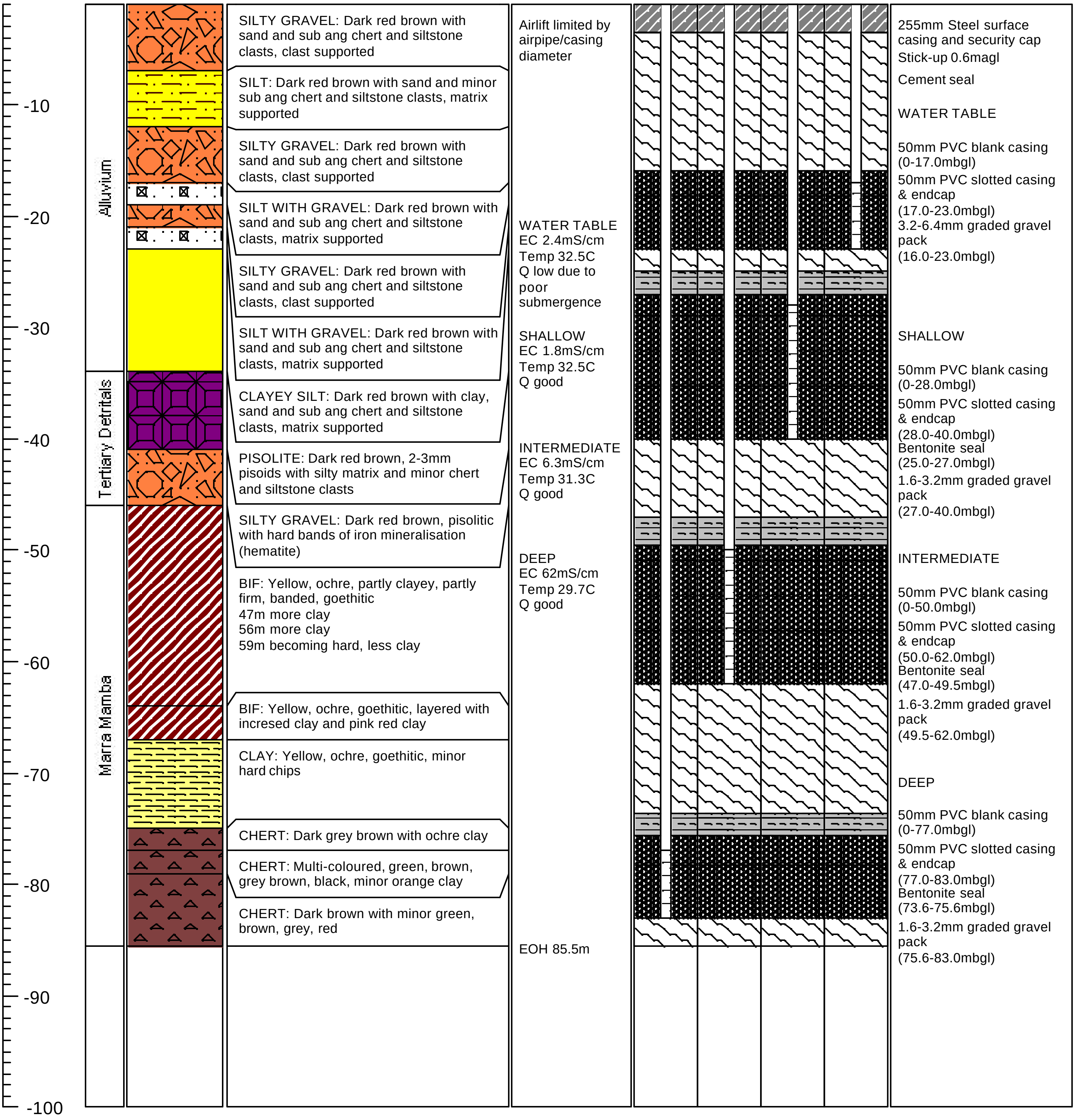
Commenced: 25-Aug-06
Completed: 26-Aug-06
Drilled: DGS (GW)
Logged By: IRL

Method: Mud Rotary
Fluid: Aus-Gel
Bit Record: 0-3m 12 1/4"
3-75m 8 1/2"

Area: Cloud Break
East: 739998mE
North: 7530213mN
Elevation: 432m (GPS)

Static Water Level: WT 17.32mbgl; S 17.29mbgl;, Int 17.34mbgl;, D 19.30mbgl
Date: 14-Sept-06

Depth (mbgl)	**Geology**	**Graphic Log**	**Lithological Description**	**Field Notes**	**Well Completion**	
					Diagram	**Notes**



Lithological Description

SILTY GRAVEL: Dark red brown with sand and sub ang chert and siltstone clasts, clast supported

SILT: Dark red brown with sand and minor sub ang chert and siltstone clasts, matrix supported

SILTY GRAVEL: Dark red brown with sand and sub ang chert and siltstone clasts, clast supported

SILT WITH GRAVEL: Dark red brown with sand and sub ang chert and siltstone clasts, matrix supported

SILTY GRAVEL: Dark red brown with sand and sub ang chert and siltstone clasts, clast supported

SILT WITH GRAVEL: Dark red brown with sand and sub ang chert and siltstone clasts, matrix supported

CLAYEY SILT: Dark red brown with clay, sand and sub ang chert and siltstone clasts, matrix supported

PISOLITE: Dark red brown, 2-3mm pisoids with silty matrix and minor chert and siltstone clasts

SILTY GRAVEL: Dark red brown, pisolitic with hard bands of iron mineralisation (hematite)

BIF: Yellow, ochre, partly clayey, partly firm, banded, goethitic
47m more clay
56m more clay
59m becoming hard, less clay

BIF: Yellow, ochre, goethitic, layered with incresed clay and pink red clay

CLAY: Yellow, ochre, goethitic, minor hard chips

CHERT: Dark grey brown with ochre clay

CHERT: Multi-coloured, green, brown, grey brown, black, minor orange clay

CHERT: Dark brown with minor green, brown, grey, red

Field Notes

Airlift limited by airpipe/casing diameter

WATER TABLE
EC 2.4mS/cm
Temp 32.5C
Q low due to poor submergence

SHALLOW
EC 1.8mS/cm
Temp 32.5C
Q good

INTERMEDIATE
EC 6.3mS/cm
Temp 31.3C
Q good

DEEP
EC 62mS/cm
Temp 29.7C
Q good

EOH 85.5m

Notes

255mm Steel surface casing and security cap
Stick-up 0.6magl

Cement seal

WATER TABLE

50mm PVC blank casing (0-17.0mbgl)
50mm PVC slotted casing & endcap (17.0-23.0mbgl)
3.2-6.4mm graded gravel pack (16.0-23.0mbgl)

SHALLOW

50mm PVC blank casing (0-28.0mbgl)
50mm PVC slotted casing & endcap (28.0-40.0mbgl)
Bentonite seal (25.0-27.0mbgl)
1.6-3.2mm graded gravel pack (27.0-40.0mbgl)

INTERMEDIATE

50mm PVC blank casing (0-50.0mbgl)
50mm PVC slotted casing & endcap (50.0-62.0mbgl)
Bentonite seal (47.0-49.5mbgl)
1.6-3.2mm graded gravel pack (49.5-62.0mbgl)

DEEP

50mm PVC blank casing (0-77.0mbgl)
50mm PVC slotted casing & endcap (77.0-83.0mbgl)
Bentonite seal (73.6-75.6mbgl)
1.6-3.2mm graded gravel pack (75.6-83.0mbgl)

aquaterra

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COMPOSITE WELL LOG

Well No: AQ11

Client: FMG

Project: Cloud Break Monitoring Bores

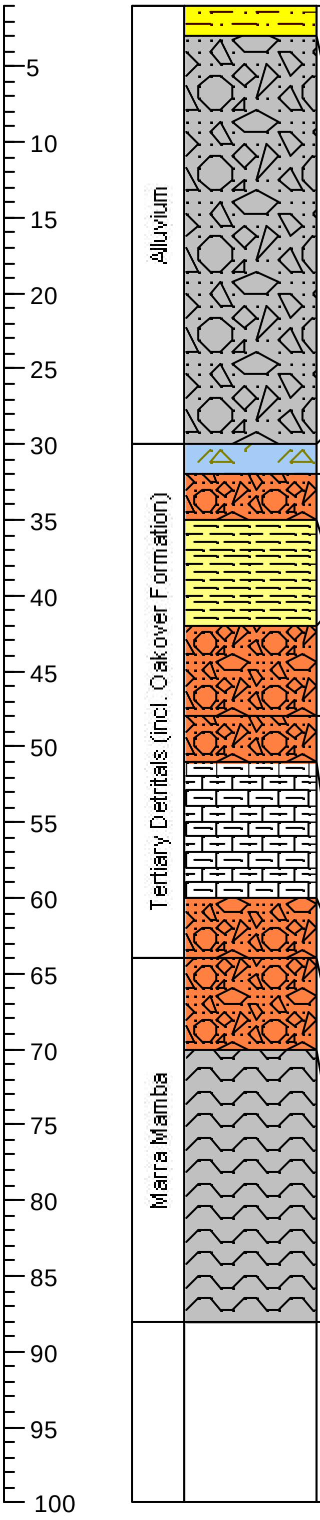
Commenced: 16-Nov-06
Completed: 19-Nov-06
Drilled: DGS (GW)
Logged By: NW

Method: Mud Rotary
Fluid: Aus-Gel
Bit Record: 0-3m 12 1/4"
3-88m 8 1/2"

Area: Cloud Break
East: 749134mE
North: 7524845mN
Elevation: 418m (GPS)

Static Water Level: WT 7.17mbgl; Shllw 9.06**Date:**gl; 20-Nov-06; Inter 8.06; Deep 9.98 mbgl

Depth (mbgl) | **Geology** | **Graphic Log** | **Lithological Description** | **Field Notes** | **Well Completion** — **Diagram** | **Notes**



Lithological Description

SILT: Red-brown gravelly silt. Gravels fine to coarse, angular to sub-rounded of chert and mudstone. Poorly sorted.

GRAVEL: Red-brown/grey slightly sandy gravel as above of predominantly chert and mudstone.
13-16m As above, slightly clayey, sandy gravel
16-21m Becoming sandy
21-30m Slightly clayey, silty gravel as above with rare friable siltstone. Clay content increasing with depth. Softer clay / silt bands throughout.

CLAYEY GRAVEL: Red-brown/grey clayey gravel.

GRAVELLY CLAY: Red-brown gravelly clay. Gravels fine to medium grained, angular to sub-rounded of mudstone and some goethite.

CLAY: Red-brown slightly silty clay.

GRAVELLY CLAY: Offwhite gravelly clay with pisoliths of pale grey-blue-green-white moderatlely soft clay. Gravels fine, angular to sub-angular of chert, calcrete and minor goethite.

GRAVELLY CLAY: Pale grey-green moderately firm gravelly clay. Gravels fine, angular to sub-rounded of Mn-rich goethite and calcrete. Occasional bright green clays oxidising to grey-green.
49-51m As above but clays greeny-brown khaki colour

CALCRETE: Off-white clayey gravel of calcrete, fine to coarse, angular to sub-angular. Clays are soft. Minor pink-red staining and rare pale green (Mn?) staining.

GRAVELLY CLAY: Off-white/green-brown clayey gravel of calcrete as above. Clays form matrix to fine gravel of ht stainined mudstone / goethite.

GRAVELLY CLAY: Dark grey-brown moderately firm sandy gravelly clay with some firm tan clay. Gravels fine, angular to sub-rounded of gt and ht goethite. Rare red-brown mudstone. Rare mineralisation.

GOETHITE: Dark grey-brown sandy gravel of goethite. Medium to coarse, angular to sub-angular. Some ht staining and some mid-brown-red mudstone.
86-88m As above with hard chert bands (and rare pale grey-blue finely crystalline dolomite?)

Field Notes

Nearest RC hole CB0459, 750m N and 350m E of AQ11. Line 50.4

Airlift limited by airpipe/casing diameter

Discharge water from deep and intermediate piezos frothy due to high salinity

WATER TABLE

EC 15mS/cm
Temp 30.0C
pH 7.0
Q moderate

SHALLOW

No yield

INTERMEDIATE

EC 50mS/cm (?)
Temp 31.9C
pH 6.9
Q moderate-good

DEEP

EC >200mS/cm
Temp 31.9C
pH 6.9
Q good

EOH 88m

Notes

255mm Steel surface casing and security cap
Stick-up 0.6magl

Cement seal

WATER TABLE

50mm PVC blank casing (0-11.5mbgl)
50mm PVC slotted casing & endcap (11.5-23.5mbgl)
Cement seal (0-0.5mbgl)
Bentonite seal (9.0-9.5mbgl)
3.2-6.4mm graded gravel pack (9.5-40.5mbgl)

SHALLOW

50mm PVC blank casing (0-44.0mbgl)
50mm PVC slotted casing & endcap (44.0-48.0mbgl)
Bentonite seal (40.5-42.0mbgl)
1.6-3.2mm graded gravel pack (42.0-49.0mbgl)

INTERMEDIATE

50mm PVC blank casing (0-52.0mbgl)
50mm PVC slotted casing & endcap (52.0-58.0mbgl)
Bentonite seal (49.0-50.5mbgl)
1.6-3.2mm graded gravel pack (50.5-62.0mbgl)

DEEP

50mm PVC blank casing (0-72.0mbgl)
50mm PVC slotted casing & endcap (72.0-84.0mbgl)
Bentonite seal (62.0-63.5mbgl)
1.6-3.2mm graded gravel pack (63.5-85.4mbgl)
Bentonite seal (85.4-87.0mbgl)

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COMPOSITE WELL LOG

Well No: AQ12

Client: FMG **Project:** Cloud Break Monitoring Bores

Commenced: 11-Nov-06
Completed: 12-Nov-06
Drilled: DGS (GW)
Logged By: NW

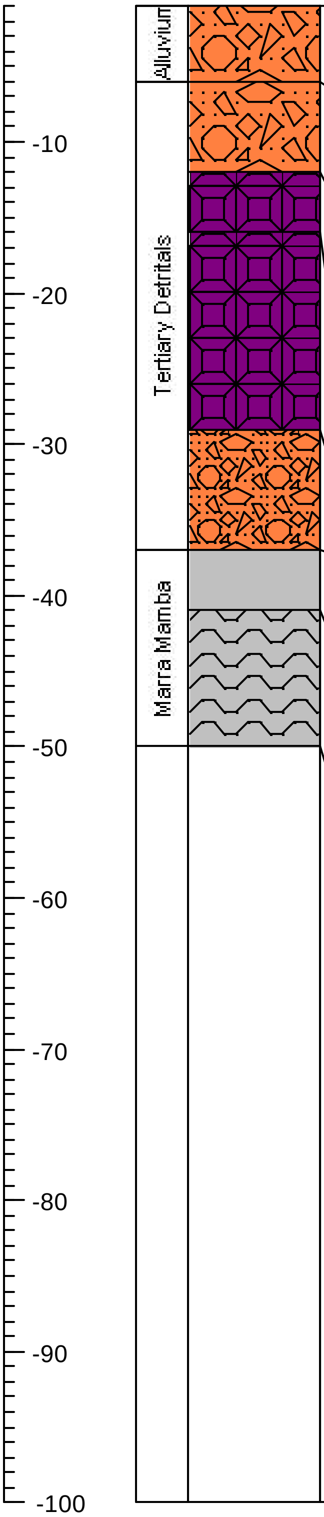
Method: Mud Rotary
Fluid: Aus-Gel
Bit Record: 0-3m 12 1/4"
3-50m 8 1/2"

Area: Cloud Break
East: 752805mE
North: 7525975N
Elevation: 417m (GPS)

Static Water Level: Shallow 12.55mbgl, Deep 12.45mbgl

Date: 13-Nov-06

Depth (mbgl) | **Geology** | **Graphic Log** | **Lithological Description** | **Field Notes** | **Well Completion: Diagram, Notes**



Lithological Description

SILTY GRAVEL: Reddish-brown A-SR silty gravel of grey-red/brown mudstone and chert. Gravels fine-coarse, poorly sorted.

SILTY GRAVEL: Reddish-brown/grey, angular to rounded silty gravel of goethite and pisolite. Pisolite <15%, 1-2mm. Fine to coarse, poorly sorted but cleaner gravel than above.

PISOLITE: Reddish-brown/clayey gravel with silt. Gravel is fine to coarse, sub angular to rounded of goethite, chert and pisolite (<15%). Some goethite with glassy / metallic appearance and macropores. Moderately well sorted. Clast supported.

PISOLITE: Reddish-brown/grey fine to coarse pisolitic gravel with silt. Gravel is sub angular to rounded of mudstone, goethite and pisolite. Moderately well sorted. Pisolite increases with depth, typically 50%.
16-18m Clayey gravel
23-25m Clayey gravel

GRAVELLY CLAY: Reddish-brown gravelly clay. Gravel fine to coarse, poorly sorted of mudstone, goethite and minor pisolite. Matrix supported.

HARDCAP: Grey-brown hardcap. Goethite, vuggy with some infill of voids/macropores with white clay, some fragments have glassy / siliceous lustre. Hard.

GOETHITE: Grey/brown goethite and ht goethite. Angular, blocky fragments of friable goethite. Samples have 'scrunchy' feel. Hard.
49-50m Samples become rich in redbrown, off white and grey mudstone and siltstone. Base of mineralisation?

Field Notes

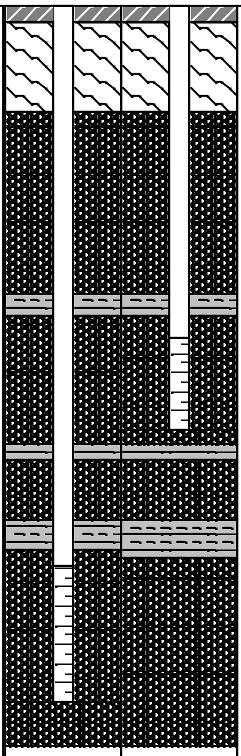
Airlift limited by airpipe/casing diameter

SHALLOW
EC 6mS/cm
Temp 33.5C
Q good

DEEP
EC 25mS/cm
Temp 32.5C
Q good

EOH 50m

Well Completion



255mm Steel surface casing and security cap

Stick-up 0.65magl

Cement seal

Backfill (0-8.0mbgl)

SHALLOW

50mm PVC blank casing (0-23.0mbgl)

50mm PVC slotted casing & endcap (23.0-29.0mbgl)

1.6-3.2mm graded gravel pack (8.0-20.0mbgl)

Bentonite seal (20.0-21.5mbgl)

1.6-3.2mm graded gravel pack (21.5-30.0mbgl)

Bentonite seal (30.0-30.75mbgl)

Backfill (30.75-35.0mbgl)

DEEP

50mm PVC blank casing (0-38.0mbgl)

50mm PVC slotted casing & endcap (38.0-47.0mbgl)

Bentonite seal (35.0-37.0mbgl)

1.6-3.2mm graded gravel pack (8.0-20.0mbgl)

Monitoring Bore Completion Log

CBX16 B02obs40

FMG
Fortescue Metals Group Ltd
87 Adelaide Terrace, East Perth WA 6008
Ph:+ 61 8 6218 8888 Fax: + 61 8 6218 8880

Start Date:	6-May-07
Completion Date:	7-May-07
Method:	Mud Rotary
Drilled by:	Connector
Total Depth:	64m

RL (mAHD)	423m	
Easting	745262m	
Northing	7527108m	
SWL	S:13.39 D: 13.9	[8-Jun-07]
Bore Diameter	each 50mm	

Depth (mbgl) | **Lithological Description** | **Geological Log** | **Airlift Yield (L/s)** | **Water Quality** | **Construction Details** | **Construction Log** | **Depth** | **Comment**

Depth (mbgl): 0, 10, 20, 30, 40, 50, 60, 70, 80

Lithological Description

_ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _ _

SILTY GRAVEL: Orange/brown to blue/grey, medium to very coarse mix of 4-20mm, A-SA gravelly chert and siltstone frags in a silty clay matrix. Minor white calcrete/clay from 16m.

GRAVELLY CLAY: Orange/brown to dark brown, large, WR (to 40mm dia) well cemented pale grey/white clay clasts. High % of blocky, A chert gravel to 28m then finer gravel.

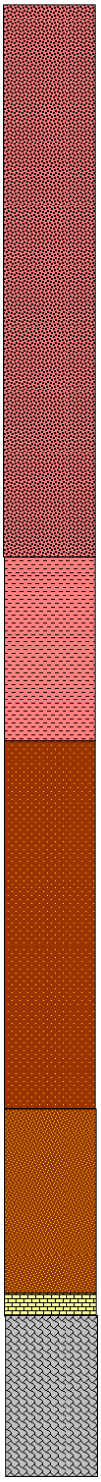
PISOLITIC GRAVEL (CLAYEY): Dark to more pale brown, medium to coarse (to 10mm dia), SR-WR pisolitic gravel frags (blue/grey with red staining) in a soft brown silty matrix. Minor A-SA vitreous goethite gravel.

PISOLITE: Dark brown to dark blue/grey, pred well sorted, finer pisoliths (R-WR) with a reasonable % of goethite, pisolite & chert with predominantly calcareous sediment & clay.

CALCRETE: Cream/white, clayey.
GOETHITE: (Marra Mamba) Lost circulation prevented sample return. VERY HARD.

CLOUD BREAK - 3 BEARS DEWATERING

Geological Log



Airlift Yield (L/s)

Pilot hole (Reamed hole)

Shallow (S)
Dual Tube
Airlift
Max Yield
<0.5L/s
(after 1hr bore went dry, water & air escaping into formation)

Deep (D)
Dual Tube
Airlift
Max Yield
2.7L/s

Water Quality

UNITS
EC: µS/cm
TDS: mg/L
pH: no units
SWL: mbgl

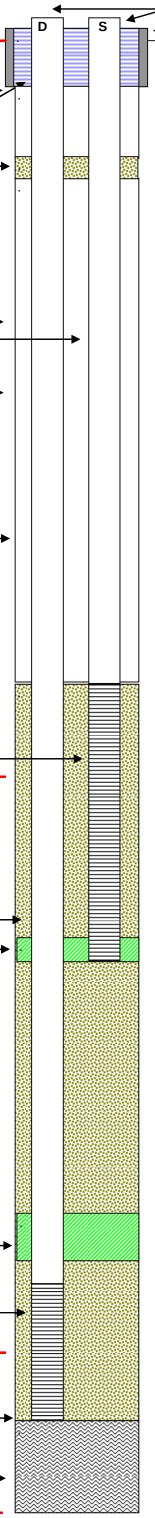
EC: 2,240
TDS: 1,120
pH: 8.32

EC: 17,610
TDS: 8,740
pH: 7.81

Construction Details

ALLUVIALS
6" Plain Steel Surface Casing
(Grouted with Gypset and A/B foam)
Concrete plug in annulus
Bridge / Blockage
50mm Cl 12 Plain PVC
152mm drillhole
3.2-6.4mm Graded Gravel
50mm Cl 12 Slotted PVC
DETRITALS
3.2-6.4mm Graded Gravel
Bentonite Seal
3.2-6.4mm Graded Gravel
(Backfill)
Bentonite Seal
50mm Cl 12 Slotted PVC
Oakover Formation
MARRA MAMBA FM
(unmineralised)
3.2-6.4mm Graded Gravel
Fallback

Construction Log



Depth

0.73magl
0.36magl
2 mbgl
6mbgl
28mbgl
39mbgl
40mbgl
51mbgl
53mbgl
54mbgl
60mbgl
64mbgl

Comment

Bit Record
0-2m: 6.5" air hammer
2-18m: 6" mud rotary (tricone)
18-57m: 6" mud (blade)
57-64m: 6" mud rotary (tricone)

*Drilled east of B02

*Using 'Blade Bit' made drilling a lot quicker.

* Blockage or gravel bridge at 6mbgl may have prevented gravel in annulus from reaching the top of the shallow (S) piezometer slotted interval.

(During airlifting the discharge was a dirty mud colour and the piezo did not properly develop itself)

28-48m: VERY QUICK DRILLING (penetration ~ 6m/min)

36m: Minor fracturing & hard bands.

48-54m: A few hard bands but predominantly soft drilling. (then at 54m into harder, more competent ground)

57m: LOST CIRCULATION

57-64m: HARD DRILLING (into Marra Mamba)

64m: EOH

Logged by: **D. Greenhalgh**

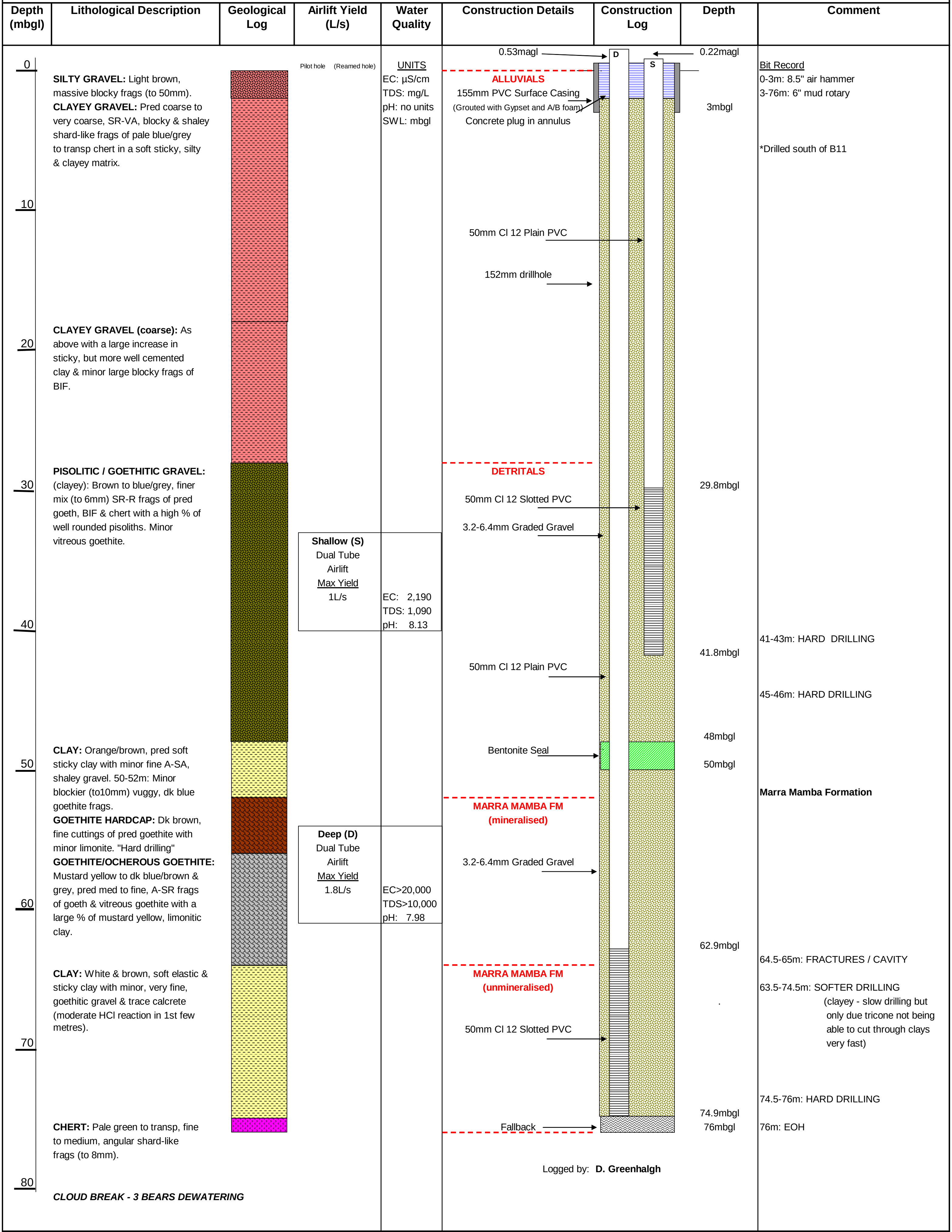
Monitoring Bore Completion Log

CBX35 B11obs600

Fortescue Metals Group Ltd
87 Adelaide Terrace, East Perth WA 6008
Ph:+ 61 8 6218 8888 Fax: + 61 8 6218 8880

Start Date:	7-Jun-07
Completion Date:	8-Jun-07
Method:	Mud Rotary
Drilled by:	Connector
Total Depth:	76m

RL (mAHD)	424.37m	
Easting	748415.503m	
Northing	7526059.085m	
SWL	S:13.46 D:13.68	[8-Jun-07]
Bore Diameter	each 50mm	



SILTY GRAVEL: Light brown, massive blocky frags (to 50mm).

CLAYEY GRAVEL: Pred coarse to very coarse, SR-VA, blocky & shaley shard-like frags of pale blue/grey to transp chert in a soft sticky, silty & clayey matrix.

CLAYEY GRAVEL (coarse): As above with a large increase in sticky, but more well cemented clay & minor large blocky frags of BIF.

PISOLITIC / GOETHITIC GRAVEL: (clayey): Brown to blue/grey, finer mix (to 6mm) SR-R frags of pred goeth, BIF & chert with a high % of well rounded pisoliths. Minor vitreous goethite.

CLAY: Orange/brown, pred soft sticky clay with minor fine A-SA, shaley gravel. 50-52m: Minor blockier (to10mm) vuggy, dk blue goethite frags.

GOETHITE HARDCAP: Dk brown, fine cuttings of pred goethite with minor limonite. "Hard drilling"

GOETHITE/OCHEROUS GOETHITE: Mustard yellow to dk blue/brown & grey, pred med to fine, A-SR frags of goeth & vitreous goethite with a large % of mustard yellow, limonitic clay.

CLAY: White & brown, soft elastic & sticky clay with minor, very fine, goethitic gravel & trace calcrete (moderate HCl reaction in 1st few metres).

CHERT: Pale green to transp, fine to medium, angular shard-like frags (to 8mm).

CLOUD BREAK - 3 BEARS DEWATERING

UNITS
EC: µS/cm
TDS: mg/L
pH: no units
SWL: mbgl

Airlift Yield	Water Quality
Shallow (S) Dual Tube Airlift Max Yield 1L/s	EC: 2,190 TDS: 1,090 pH: 8.13
Deep (D) Dual Tube Airlift Max Yield 1.8L/s	EC>20,000 TDS>10,000 pH: 7.98

Bit Record
0-3m: 8.5" air hammer
3-76m: 6" mud rotary

*Drilled south of B11

41-43m: HARD DRILLING

45-46m: HARD DRILLING

Marra Mamba Formation

64.5-65m: FRACTURES / CAVITY

63.5-74.5m: SOFTER DRILLING (clayey - slow drilling but only due tricone not being able to cut through clays very fast)

74.5-76m: HARD DRILLING

76m: EOH

Logged by: **D. Greenhalgh**

Monitoring Bore Completion Log

CBX39 B16obs500

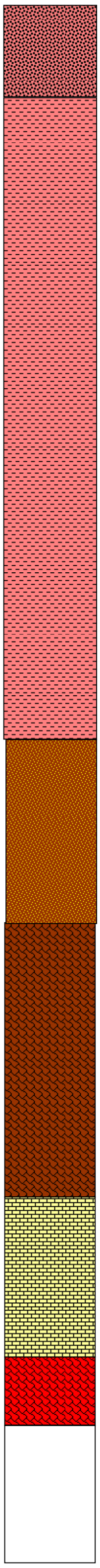
Start Date:	11-Sep-07
Completion Date:	13-Sep-07
Method:	Mud Rotary
Drilled by:	Connector
Total Depth:	68m

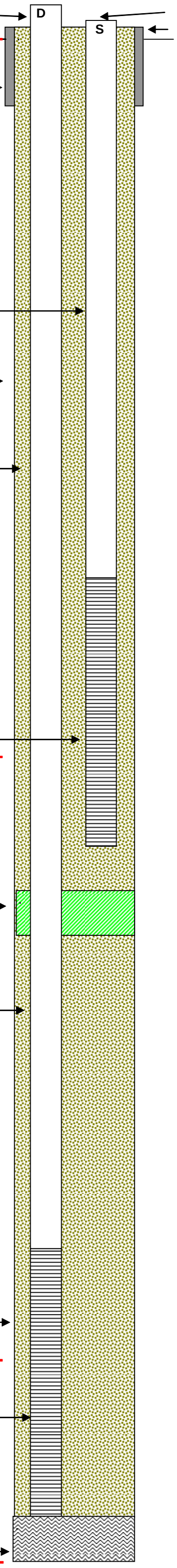
RL (mAHD)	420.61m	
Easting	746397.2m	
Northing	7526461.43m	
SWL	S:11.31,D:10.93	[13-Sep-07]
Bore Diameter	each 50mm	

Fortescue Metals Group Ltd

87 Adelaide Terrace, East Perth WA 6008

Ph:+ 61 8 **6218 8888** Fax: + 61 8 **6218 8880**





Depth (mbgl)	Lithological Description	Geological Log	Airlift Yield (L/s)	Water Quality	Construction Details	Construction Log	Depth	Comment
0	**SILTY AGGREGATE:** Brown to blue/ purple, medium to coarse, blocky (SR) to SA frags of BIF, chert and yellow siltstone in silty, friable clay. **GRAVELLY CLAY:** Orange/brown, pred soft & sticky to friable, SR clasts with coarse to blocky gravel consisting of pred SA chert (black/ blue to white & transp) with BIF/ festone (flat, SR), pale grey shaley siltstone & minor pisoliths & white clays.		Pilot hole (Reamed hole)	UNITS EC: µS/cm TDS: mg/L pH: no units SWL: mbgl	??magl ALLUVIALS 10" Steel Surface Casing (Grouted with Gypset and A/B foam)		??magl ??magl 3mbgl	Bit Record 0-3m: 12" air hammer 3-68m: 8" mud rotary *Note: Co-ords estimated from map. *Drilled north of B16obs250
10					50mm Cl 12 Plain PVC 200mm drillhole			
20					3.2-6.4mm Graded Gravel		24mbgl	
30	**PISOLITE:** Purple/dk brown to black predominantly medium, WR pisoliths with crystalline & vitreous goethite & dark coloured, SA-A chert & minor white clays in a friable silty, light brown clay matrix.		**Shallow (S)** Dual Tube Airlift Max Yield ??	EC: 17,930 pH: 7.4	50mm Cl 12 Slotted PVC DETRITALS Bentonite Seal		36mbgl 38mbgl	
40	**HARDCAP (goethite):** Purple/dark brown, fine to medium SR frags of goethite/vitreous goethite & pisoliths (fallback?) & a high % of SA chert (coarse). Minor to trace, calcareous sediment.				50mm Cl 12 Plain PVC		40mbgl	Into Hard Ground
50	**CALCRETE:** White/off-yellow & cream, fine & earthy sediment (calcareous) grading to large SR, soft clasts of calcareous clay, cavities. Expect to be "high water-yielding" zone.		**Deep (D)** Dual Tube Airlift Max Yield ??		Oakover Formation 3.2-6.4mm Graded Gravel		54mbgl	54-55m: Minor LOST CIRCULATION (calcretes) 58-60m: LARGE CAVITY (lost circ)
60	**SHALE:** Dark grey to black, large (to 30mm) flat clasts of very soft shale (clayey). **LOST CIRCULATION:** No sample.			EC: 1,388 pH: 7.5	MARRA MAMBA FM (unmineralised) 50mm Cl 12 Slotted PVC Fallback		66mbgl 68mbgl	68m: EOH
70								
80								

CLOUD BREAK - 3 BEARS DEWATERING

Logged by: **D. Greenhalgh**

MONITORING BORE LOG

BOREHOLE NUMBER
COM01

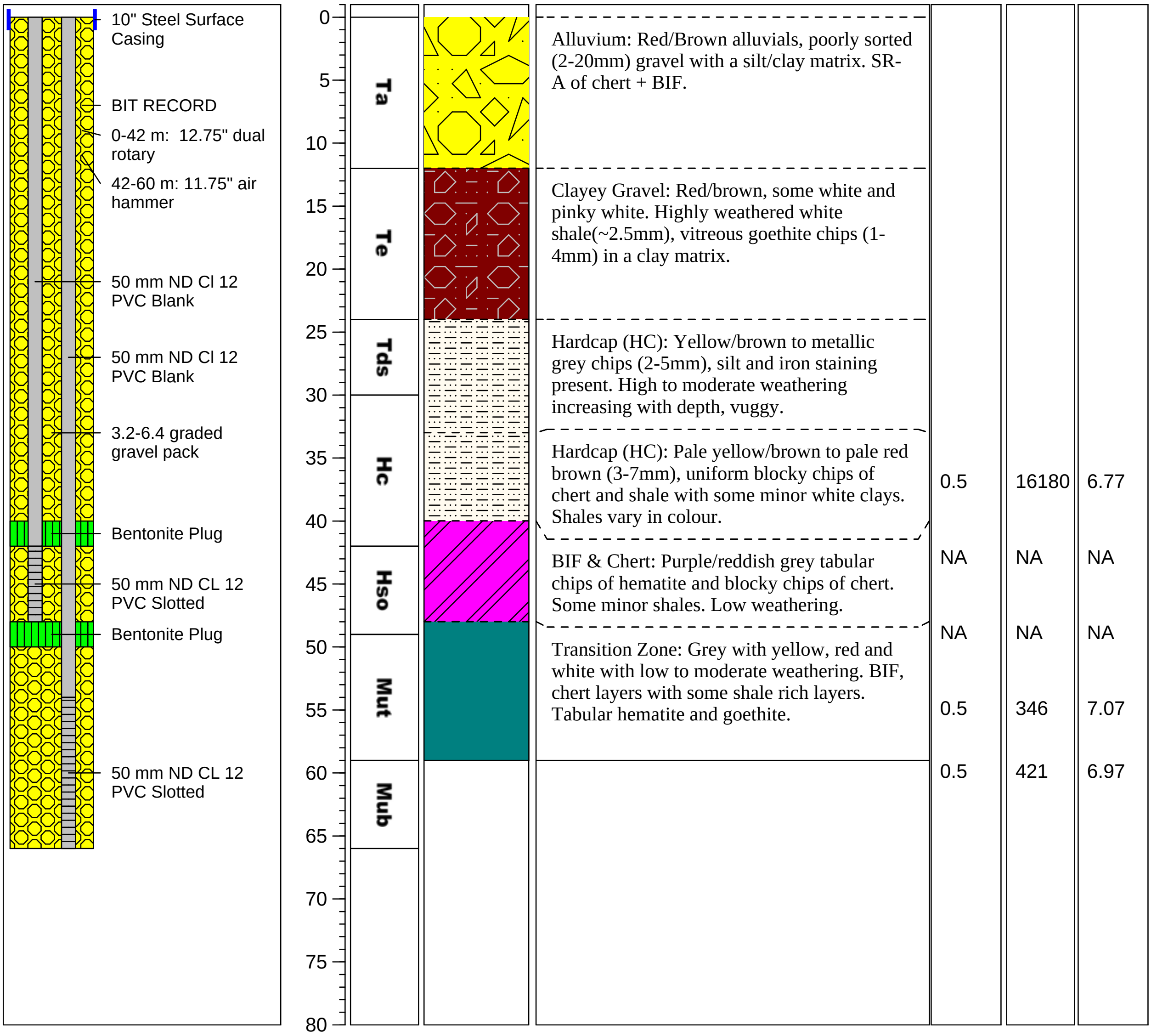
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Cocos Monitoring**
LOCATION: **Cloudbreak**
DRILLING CO: **Barber Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **Z. Boniecki, T.Wilkinson**
FIELD BOOK NO: **CB Book 13**
EASTING: **757644.67 m**
NORTHING: **7526870.31 m**
TOP of CASING ELEVATION: **436.2 mRL**
DATE BEGUN: **07/12/2010** DATE COMPLETED: **10/12/2010**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	
Drilled Depth (mbgl):	60			
Cased Depth (mbgl):	60		48	
Stick Up (magl):				
Airlift Yield (l/s):				
Water Level (mbtoc) & Date:	24.81		24.78	
Quallity - pH & EC (mS/cm)	7.88 / 2590	/	7.87 / 4110	/

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Alluvium: Red/Brown alluvials, poorly sorted (2-20mm) gravel with a silt/clay matrix. SR-A of chert + BIF.

Clayey Gravel: Red/brown, some white and pinky white. Highly weathered white shale(~2.5mm), vitreous goethite chips (1-4mm) in a clay matrix.

Hardcap (HC): Yellow/brown to metallic grey chips (2-5mm), silt and iron staining present. High to moderate weathering increasing with depth, vuggy.

Hardcap (HC): Pale yellow/brown to pale red brown (3-7mm), uniform blocky chips of chert and shale with some minor white clays. Shales vary in colour.

BIF & Chert: Purple/reddish grey tabular chips of hematite and blocky chips of chert. Some minor shales. Low weathering.

Transition Zone: Grey with yellow, red and white with low to moderate weathering. BIF, chert layers with some shale rich layers. Tabular hematite and goethite.

YIELD (l/s)	EC (µS/cm)	pH
0.5	16180	6.77
NA	NA	NA
NA	NA	NA
0.5	346	7.07
0.5	421	6.97

MONITORING BORE LOG

BOREHOLE NUMBER

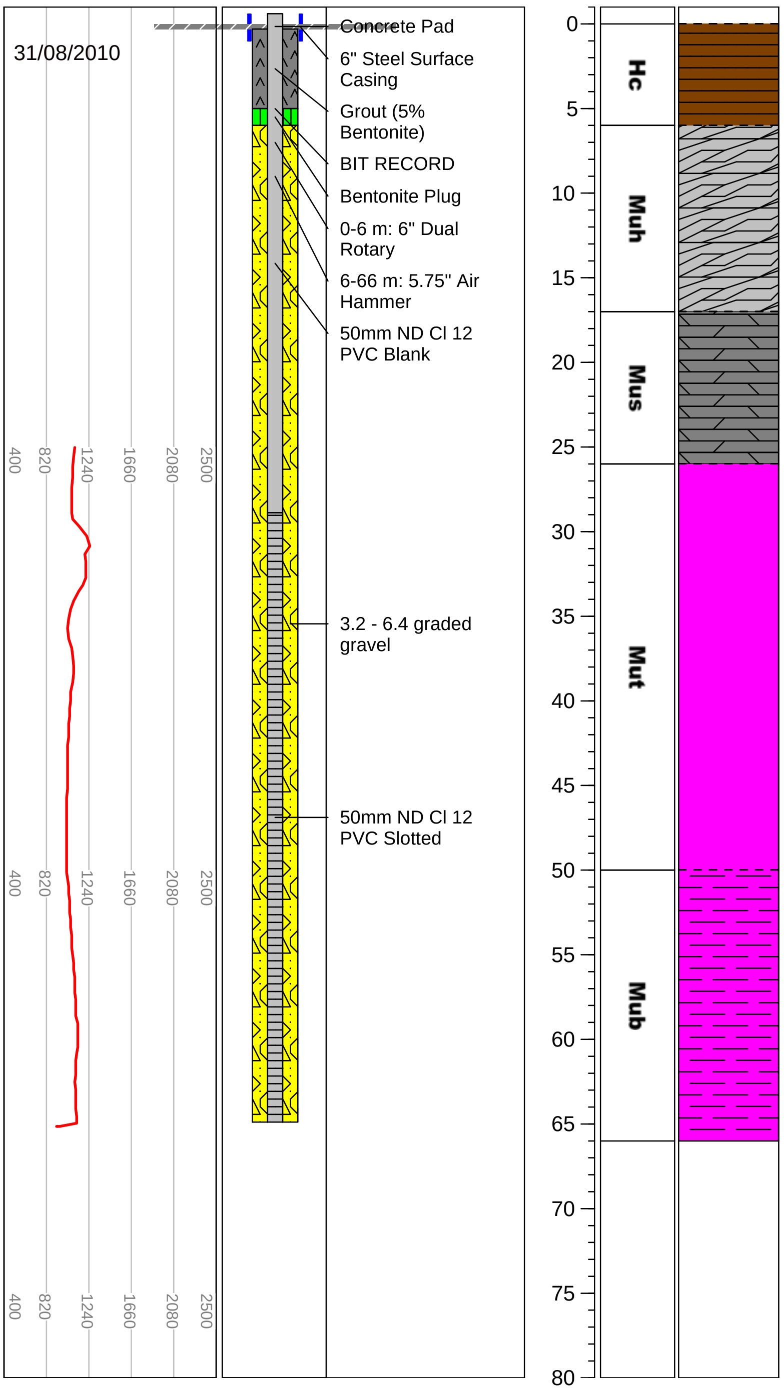
HAMM05

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Hamilton Pit Dewatering**
LOCATION: **Cloudbreak**
DRILLING CO: **Barber Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **J. Enkelmann**
FIELD BOOK NO: **CB Book 13**
EASTING: **749508.297 m**
NORTHING: **7528060.997 m**
TOP of CASING ELEVATION: **435.496 mRL**
DATE BEGUN: **23/08/2010** DATE COMPLETED: **24/08/2010**

FINAL BORE DETAILS	
Drilled Depth (mbgl):	66
Cased Depth (mbgl):	64.89
Stick Up (magl):	0.60
Airlift Yield (l/s):	2
Water Level (mbtoc) & Date:	23.62 26/08/10
Quallity - pH & EC (uS/cm):	7.21 2,068

SALINITY PROFILE (uS/cm)	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (uS/cm)	pH



STRAT	DESCRIPTION
Hc	Hardcap (HC): Brown A vitreous and vuggy goethite chips 8-15mm. Minor VA hard hematite 3-8mm. Grey brown silt matrix.
Muh	Hematite (HOH): Grey VA, SW to FR hematite chips well sorted 2-6mm. Size increasing and sorting decreasing with depth (3-20mm @17m). Increase in weathering at 24m with minor white and red claystone. Sand-sized grainy matrix grey brown becoming red with depth.
Mus	Hematite & Goethite (GHM): Grey hematite and goethite, poorly sorted SA to SR. Platy pebbles to 25mm. Minor ocherous goethite. 10% vuggy at 21-27m. Fine yellow to dull grey matrix.
Mut	Chert & BIF (CH / BI): Interbedded chert and hematitic shale. Chert angular moderately sorted 2-5mm, clear, white and grey colour. Blocky khaki chert band at 36-37m. Minor yellow ochre coloured claystone (kaolinite) at 28-36m. Hard setting yellow clay matrix becoming red clay from 36m.
Mub	Chert & Non-enriched Shale (CH & SH): Black A, SW chert chips 2-15mm. Minor vsoft black schale chips, extremely low strength. Minor yellow and brown colour chert around 53m. Very minor ocherous goethite, red and white claystone around 56m. White claystone softening and increasing with depth from 56m to become 30% soft high plasticity white clay matrix at 59-60m. Moderately sorted FR black chert 60-66m with trace of pyrite.

YIELD (l/s)	EC (uS/cm)	pH
0.5		6.38
0.5		6.41
0.5		7.25
1		7.12
1		
1-2		7.01
2		7.21

MONITORING BORE LOG

BOREHOLE NUMBER

HSMB04

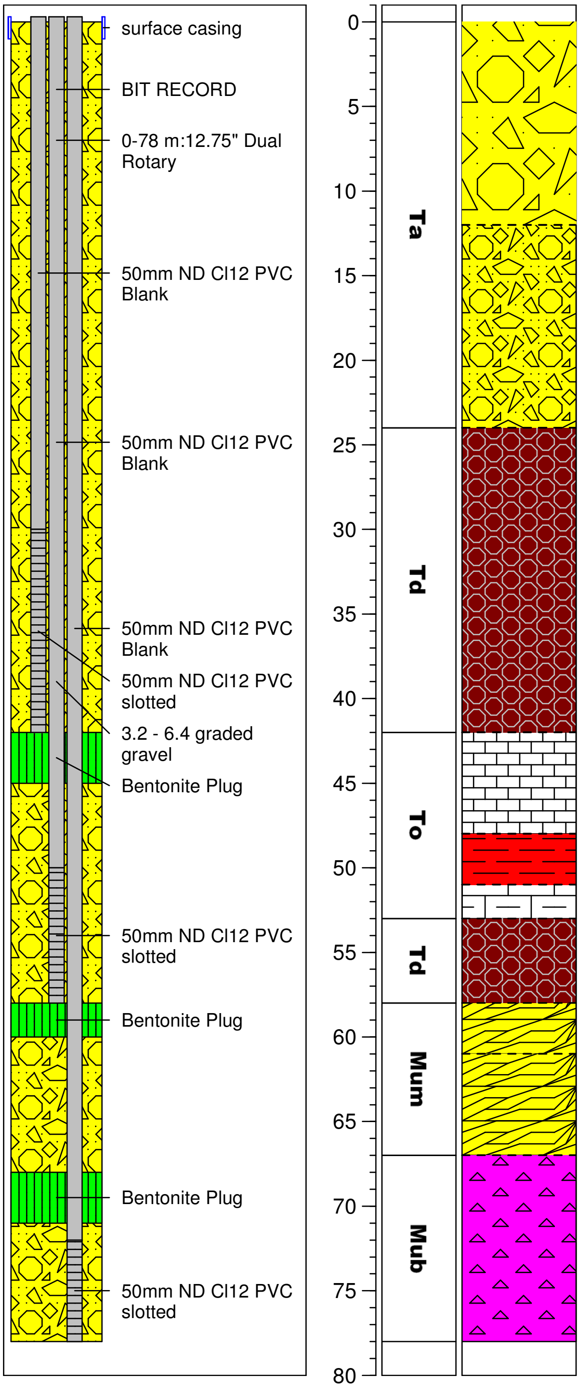
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Hillside Monitoring**
LOCATION: **Cloudbreak**
DRILLING CO: **Barber Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **L. Frankcombe**
FIELD BOOK NO: **CB Book 6**
EASTING: **735987.916 m**
NORTHING: **7530785.601 m**
TOP of CASING ELEVATION: **421.354 mRL** 28/02/09
DATE BEGUN: **21/02/2009** DATE COMPLETED: **27/02/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Water Table
Drilled Depth (mbgl):	78		78	78
Cased Depth (mbgl):	77.1		58	42
Stick Up (magl):	0.32		0.12	0.32
Airlift Yield (l/s):	good			moderate
Water Level (mbtoc) & Date:	12.05		11.27	11.18
Quallity - pH & EC (mS/cm)	/	/	/	7.6 /7630

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH



Alluvium: SA-A with little to no fine matrix, dark grey to red

Gravel: R-SR gravel comprising pebble clasts <100 mm, polymictic matrix, chert, siltstone, sandstone

Pisolitic Gravel: Pisolitic/sub angular gravelly matrix with ~50% pisoliths, 50% angular clasts with minor grey/red calcrete <1-2%

Calcrete: Bleached/weathered calcrete, vuggy clasts with little to no clay content, beige/white

Clay: Red/earthy clay

Calcrete/Clay: Calcrete with interbedded clays, earthy red, weathered clasts

Pisolitic Gravel: Dominated by pisoliths, ocherous goethite increases with depth, minor martite/vitreous goethite

Ocherous Goethite (OGF): ocherous goethite with minor white calcrete and minor clays <2%

Ocherous Goethite (OGF): with BIF and vitreous goethite, <5% clay - red/brown and grey with mustard yellow, coarse fragments >70mm

Chert (CH): with minor BIF, silicic unit with minor clays, grey/white/cream

YIELD (l/s)	EC (µS/cm)	pH
FWS		
~1 2		
~2.5		
3	1,598	7.61
5	1,243	7.74
8	2,855	7.67
+20	10,680	7.93
>25	56,000	8.01

MONITORING BORE LOG

BOREHOLE NUMBER

HSMB05

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

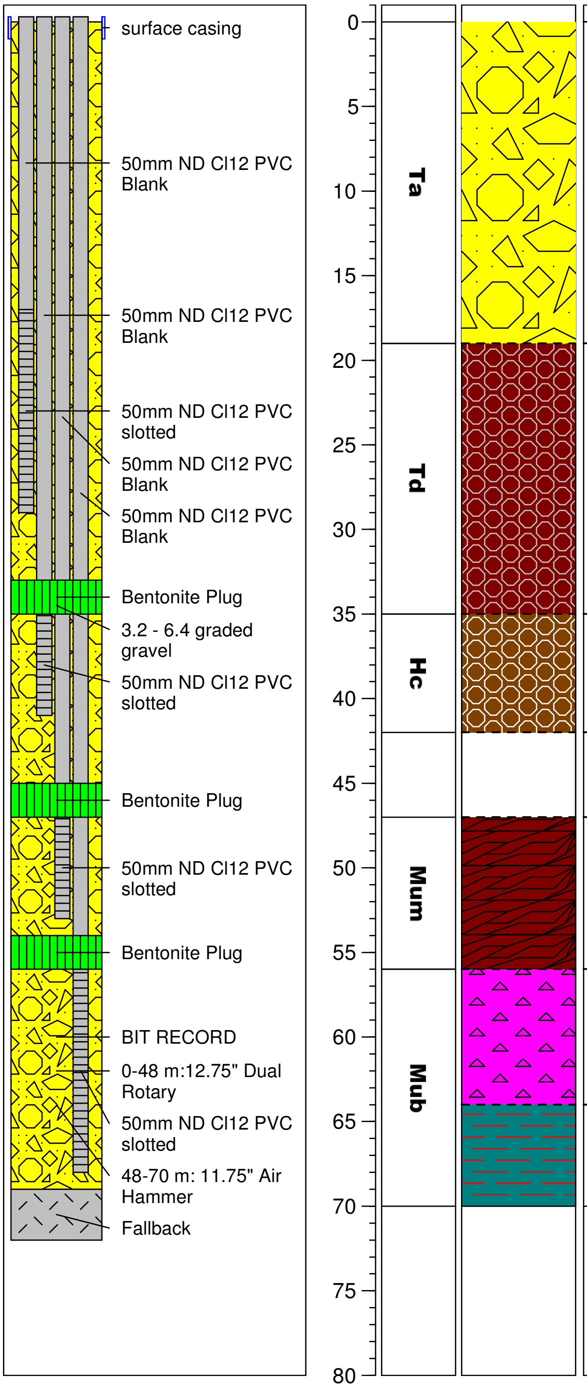
PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**D. Greenhalgh & L. Frankcombe**
FIELD BOOK NO:	**CB Book 6**
EASTING:	**738399.6 m**
NORTHING:	**7529905 m**
TOP of CASING ELEVATION:	**423.578 mRL** 28/03/09

DATE BEGUN: **16/02/2009** DATE COMPLETED: **20/02/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Water Table
Drilled Depth (mbgl):	70	70	70	70
Cased Depth (mbgl):	69.3	53	41.7	29
Stick Up (magl):	0.49	0.471	0.446	0.338
Airlift Yield (l/s):	moderate	moderate	moderate	poor
Water Level (mbtoc) & Date:	13.61	13.23	13.05	12.96
Quallity - pH & EC (mS/cm)	7.89 />20,000	7.92 /18,370	7.73 / 1,836	7.48 / 156000

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Alluvium: SA to A clasts <30 mmm. Poorly sorted polymictic gravel with fine sand matrix...dominantly large clasts. Grey to Red

Pisolitic Gravel: Pisoid rich gravel with minor SA clasts. Earthy red

Hardcap (HC): Earthy goethite dark grey with hint of vitreous mustard goethite

NO SAMPLE

Goethite (Mum): Goethite and hematite with ochreous goethite, minor chert increasing with depth

Chert (CH): Cherty BIF- BIF decreasing with depth. Silicic Chert greyish pink

Shale and chert: Cherty shale with minor BIF. Silicic chert and dark grey black shale

YIELD (l/s)	EC (µS/cm)	pH
minor flows (blocked)		
1		
6		
6		
6	1,372	7.38
Cavities lge Qincr	1,491	7.35
>20	10,580	7.23
>20	25,000	7.31
>20	27,400	7.64

MONITORING BORE LOG

BOREHOLE NUMBER

HSMB07

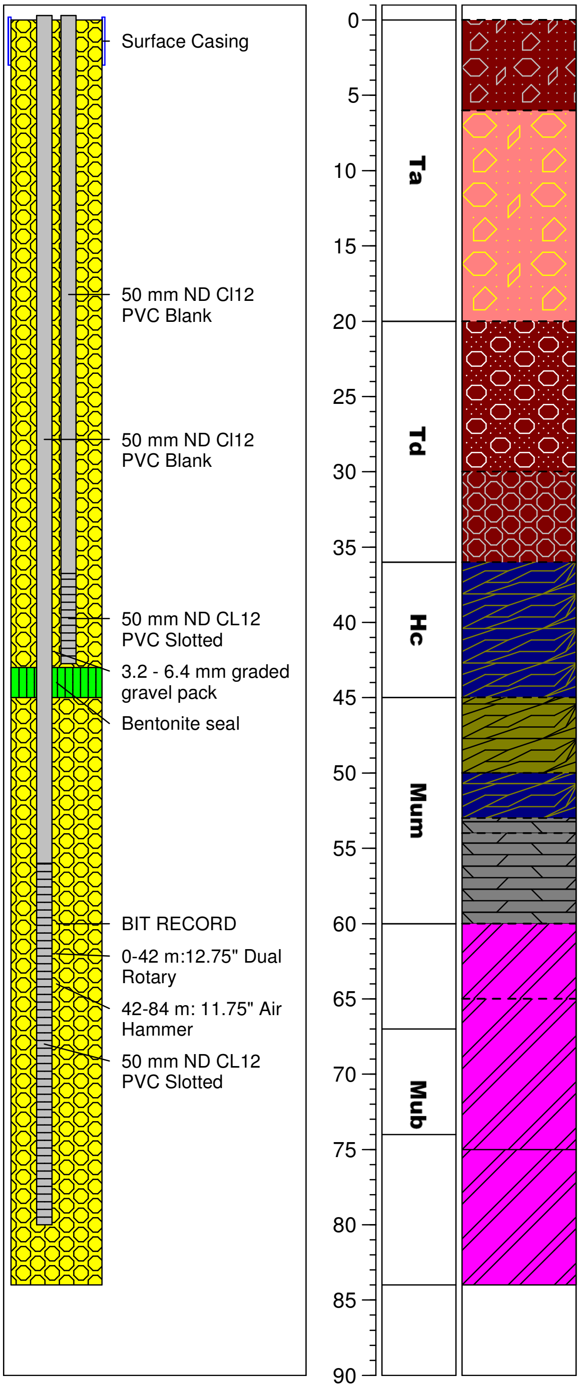
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**K. Everitt**
FIELD BOOK NO:	**CB Book 6**
EASTING:	**739187.681 m**
NORTHING:	**7531710.267 m**
TOP of CASING ELEVATION:	**432.516 mRL**
DATE BEGUN:	**11/02/2009**
DATE COMPLETED:	**14/02/2009**

FINAL BORE DETAILS

	Shallow	Intermediate	Deep
Drilled Depth (mbgl):	84		84
Cased Depth (mbgl):	56		80
Stick Up (magl):	0.403		0.400
Airlift Yield (l/s):	poor		poor
Water Level (mbtoc) & Date:	21.45		21.38 27/02/09
Quallity - pH & EC (mS/cm)	7.84 / 1095	/	7.71 / 5530

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
Silty Gravel: Poorly sorted fragnments to 35 mm, A-SR, grey/red/brown/purple BIF, chert and shale in a brown silt matrix			
Gravelly Silt: moderately sorted fragments to 15 mm, rarely to 20 mm. High proportion of 2-3 mm round fragments with some chert, BIF and shale as above in a red silt matrix			
Pisolitic Clay: Well-rounded, red/brown, well sorted pisoliths, 1-3 mm. From 27-30 m trace vitreous goethite, dark grey angular small fragments to ~3 mm			
Pisolitic Gravel: Pisoliths as above, ~80% to 4 mm, some mustard yellow colour. Minor vitreous goethite			
Vitreous Goethite: yellow/brown and dark grey. 2-3 mm fragments. Minor 10-15 mm fragments of earthy to vitreous goethite, vuggy (hardcap). Minor pisoliths as above, decreasing downhole	FWS minor flows		7.50
Goethite (GOM): Dark grey, red, yellow/brown roundish shaped fragments, 5-15 mm (~vitreous). Red hematite staining, trace ocherous staining. Trace hard clay red, yellow, brown	~5	729	7.35
Vitreous Goethite: Angular, hard, elongate, Dark grey, to 15 mm with minor friable yellow/brown ocherous goethite	6-8	764	7.45
Hematite & Goethite (GHM): Goethite as above, with strong red hematite, ~50% fragments to 15 mm. Minor ochre staining		2200	7.25
Hematite & Goethite (GHM): ~50% as above but smaller. Plus cream, tan, light red, hard clay fragments. Clay dec to ~15% at 60 m		1416	7.33
BIF: Dark grey, hard angular BIF, ~20 mm. Minor red hematite and yellow/brown ochre staining		1780	7.56
BIF: As above, generally <5 mm, ochre staining and plasticky cream/yellow clay		2198	7.63
BIF			

MONITORING BORE LOG

BOREHOLE NUMBER
HSMB09

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

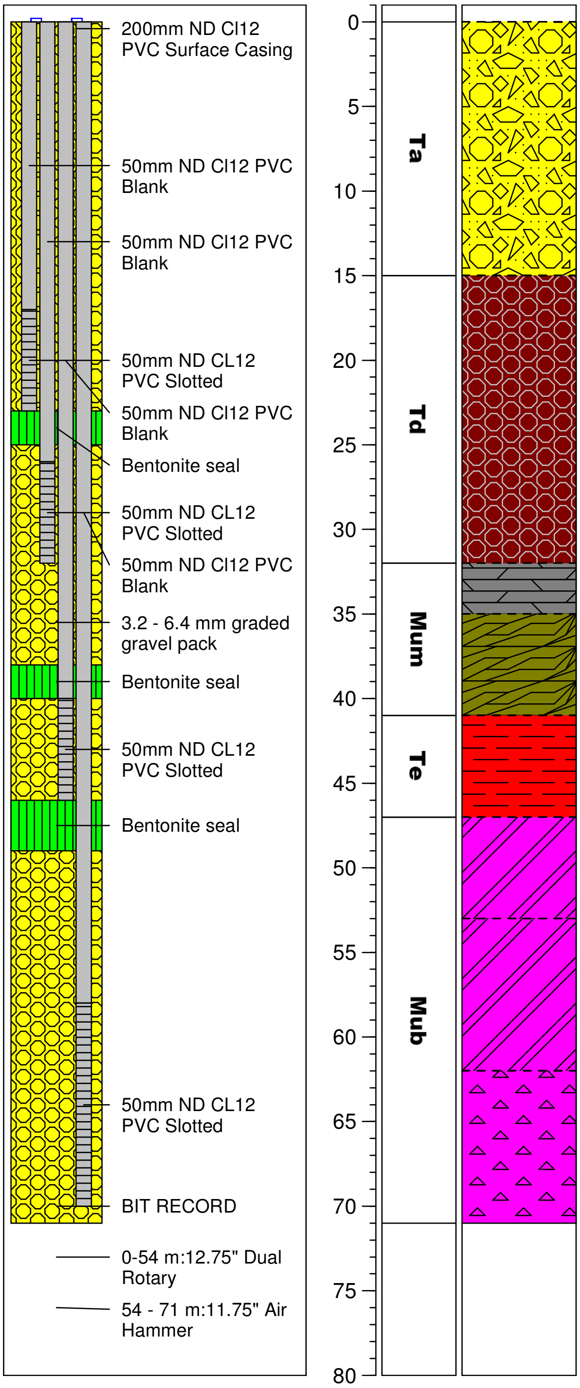
PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**L. Frankcombe**
FIELD BOOK NO:	**CB Book 7**
EASTING:	**744317.997 m**
NORTHING:	**7527769.469 m**
TOP of CASING ELEVATION:	**427.523 m RL** 11/02/09

DATE BEGUN: **06/02/2009** DATE COMPLETED: **7/02/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	71	71	71	71
Cased Depth (mbgl):	70	46	32	23
Stick Up (magl):	0.68	0.69	0.77	0.78
Airlift Yield (l/s):	poor	moderate	poor	mist
Water Level (mbtoc) & Date:	20.01	20.01	20.1	20.1
Quallity - pH & EC (mS/cm)	7.92 /20830	7.90 /1184	8.04 / 344	8.06 / 11270

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
Gravel: Sub-angular, <40 mm chips comprising sedimentary/cherty rocks in a fine sandy matrix. Poorly sorted red to grey colour			
Pisolitic Gravel: R-SR pisolitic gravel with minor/trace SA gravel. Pisoliths <10 mm in a clay matrix, earthy red			
Hematite & Goethite (GHM): Ocherous/hematite rich, fine, SA-A clasts, poorly sorted, little to no fine clay. Goethite content increases with depth, red/grey with minor mustard colouring			
Goethite (GOM): Vuggy ocherous Goethite with minor vitreous goethite, SA-SR clasts with minor fine sand/clay composition, mustard yellow with dark grey and minor red hematite and remnant/immature pisoliths also present <1%, <25 mm	1-2 8	296	7.66
Clay: Bleached weathered SA-A clasts with white clay, pink clay roughly 15%. Clasts are weathered on rims. Poorly sorted hematite/kaolinite dominant zone, <18 mm	10	294	7.45
BIF: SA-A clasts, with minor chert fragments and little to no fines. goethtite is present, <5% minor magnetite,<10 mm	10-11	630	7.75
BIF & Chert: Chert dominanted BIF unit, SA-A. Unit weakly weathered with minor clays but dominantly clast supported matrix, white/cream/yellow, tan, <25 mm			
Chert (CH): SA-A chert with minor/trace BIF, hard drilling, grey to dark grey and minor burgandy (2%).	12	944	7.88
	18	2,530	7.66

MONITORING BORE LOG

BOREHOLE NUMBER
HSMB11

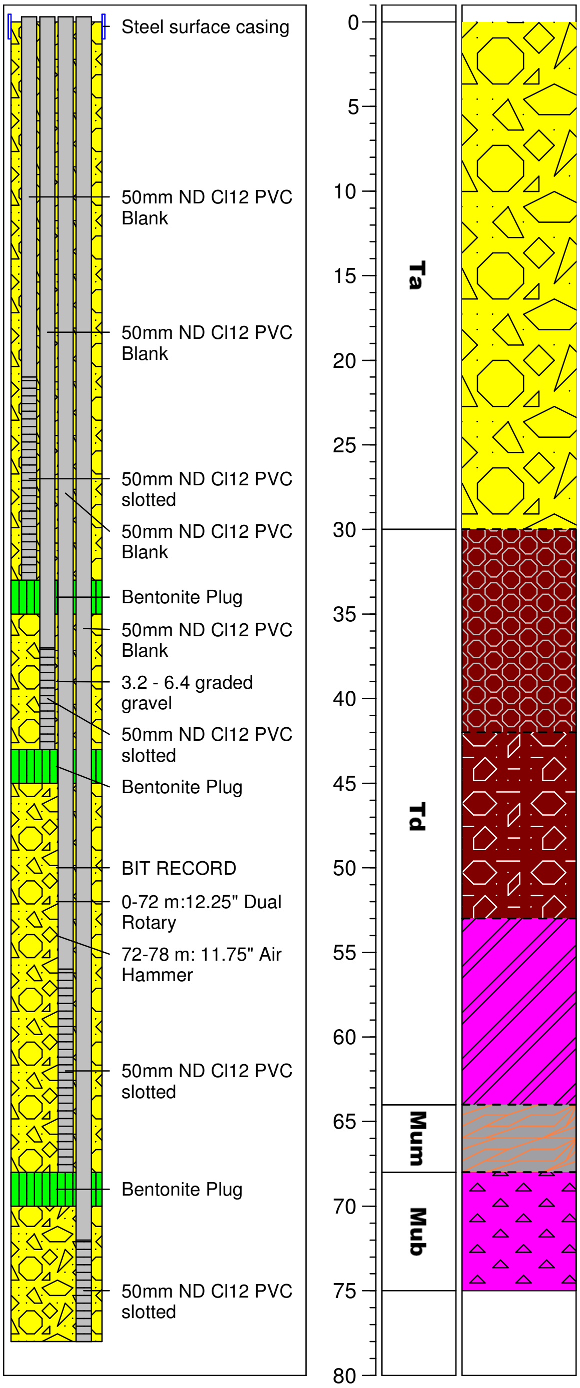
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Hillside Monitoring**
LOCATION: **Cloudbreak**
DRILLING CO: **Barber Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **L.Frankcombe**
FIELD BOOK NO: **CB Book 8**
EASTING: **743206.181 m**
NORTHING: **7527312.242 m**
TOP of CASING ELEVATION: **422.163 mRL** 24/05/09
DATE BEGUN: **03/05/2009** DATE COMPLETED: **06/05/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Water Table
Drilled Depth (mbgl):	78	78	78	32.78
Cased Depth (mbgl):	78	69.45	43.73	32.7
Stick Up (magl):	0.252	0.153	0.145	0.102
Airlift Yield (l/s):	Good	Good	Good	Poor
Water Level (mbtoc) & Date:	14.83	13.82	13.53	13.03
Quallity - pH & EC (mS/cm)	7.41 /53,200	7.57 /36,000	7.57 / 18,200	7.39 / 9160

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH



Alluvium: Hematite rich Alluvial SR to SA clasts in a fine sand/clay matrix. Towards end of interval % of pisoids in samples increase.

Pisolitic Gravel: Pisoid and Ooid rich interval with fine silt/clay matrix. The Gravel component also comprises A to SA clasts

Clay & Gravel: Clay nodule rich Hematite zone with minor SA to A clasts reddy-blood red colour.

BIF: Reworked BIF, weathered BIF with interbedded clay zones evidenced by ~20% clay. Sample clasts are vugghy and some semi mature pisoids are also present evidence for weathering. Vugghy ocherous goethite is also present in sample

Martite-Ochreous Goethite: With clay rich intervals, metallic lustre martite with crystalline form present. Increase in chert towards end of intereval.

Chert (CH): Chert with minor BIF present. Chert has ochre staining and is weathered. Weathered white chert is friable and slightly hard.

YIELD (l/s)	EC (µS/cm)	pH
1	4170	8.22
1.2	4180	7.74
3.5	9250	7.53
4	17350	7.75
40	61000	7.43
40	81200	7.66

MONITORING BORE LOG

BOREHOLE NUMBER

HSMB13

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

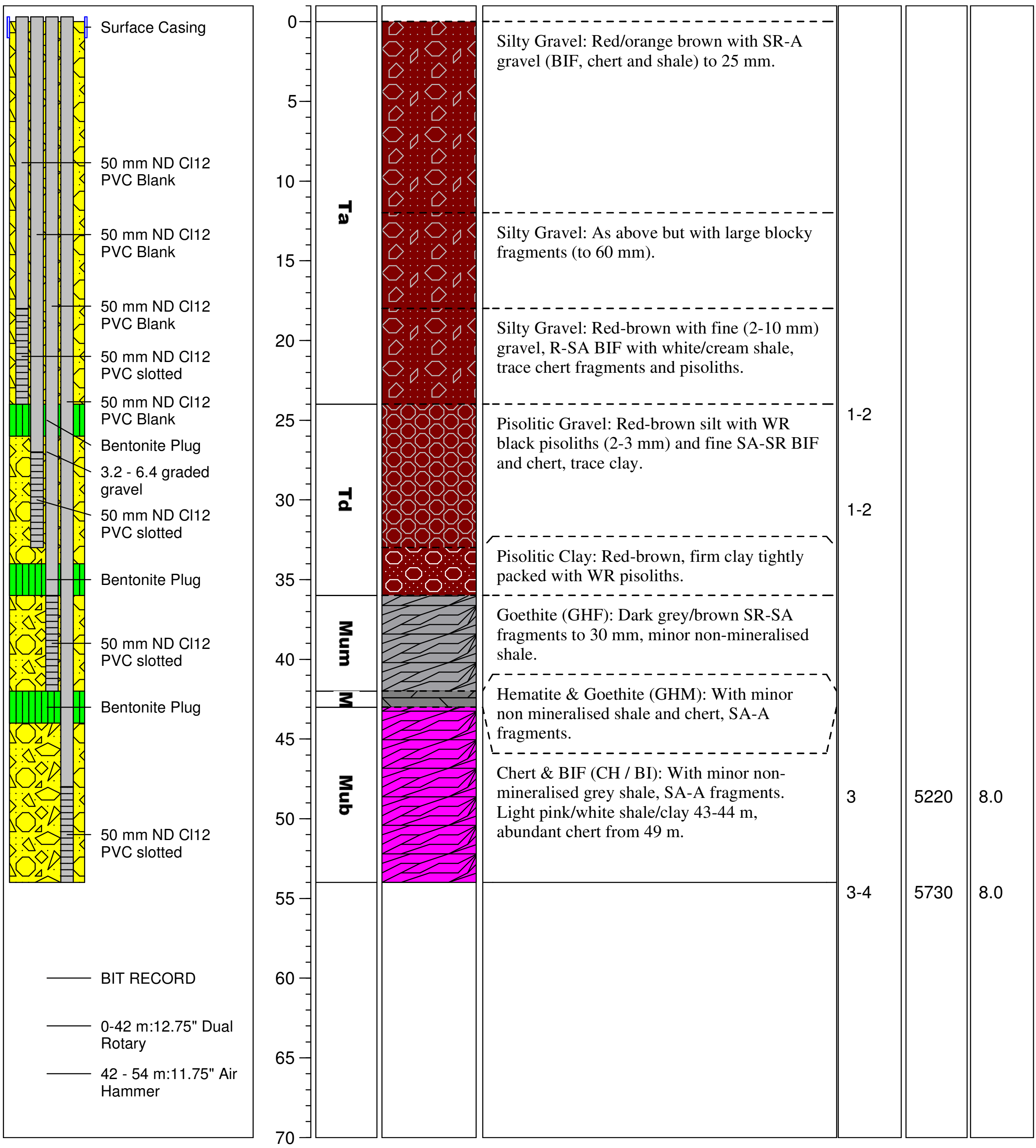
PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**D. Mains**
FIELD BOOK NO:	**CB Book 8**
EASTING:	**750001.8 m**
NORTHING:	**7526209 m**
TOP of CASING ELEVATION:	**424.711 mRL**

DATE BEGUN: **07/04/2009** DATE COMPLETED: **09/04/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Water Table
Drilled Depth (mbgl):	54	54	54	54
Cased Depth (mbgl):	54	42	33	24
Stick Up (magl):	0.504	0.468	0.527	0.247
Airlift Yield (l/s):	poor	poor	poor	trace
Water Level (mbtoc) & Date:	15.8	15.78	15.32	15.28
Quallity - pH & EC (mS/cm)	8.1 /3640	8.16 /3880	8.0 /3460	/

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Silty Gravel: Red/orange brown with SR-A gravel (BIF, chert and shale) to 25 mm.

Silty Gravel: As above but with large blocky fragments (to 60 mm).

Silty Gravel: Red-brown with fine (2-10 mm) gravel, R-SA BIF with white/cream shale, trace chert fragments and pisoliths.

Pisolitic Gravel: Red-brown silt with WR black pisoliths (2-3 mm) and fine SA-SR BIF and chert, trace clay.

Pisolitic Clay: Red-brown, firm clay tightly packed with WR pisoliths.

Goethite (GHF): Dark grey/brown SR-SA fragments to 30 mm, minor non-mineralised shale.

Hematite & Goethite (GHM): With minor non mineralised shale and chert, SA-A fragments.

Chert & BIF (CH / BI): With minor non-mineralised grey shale, SA-A fragments. Light pink/white shale/clay 43-44 m, abundant chert from 49 m.

YIELD (l/s)	EC (µS/cm)	pH
1-2		
1-2		
3	5220	8.0
3-4	5730	8.0

MONITORING BORE LOG

BOREHOLE NUMBER

HSMB17

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

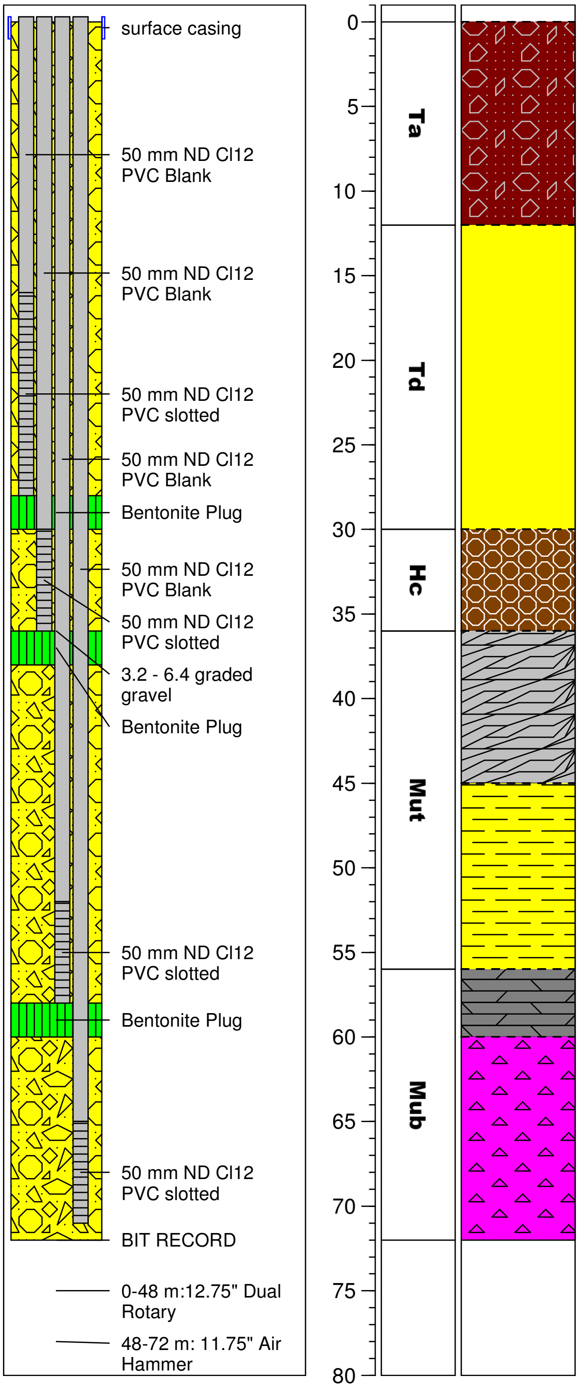
PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**D. Mains**
FIELD BOOK NO:	**CB Book 7**
EASTING:	**755202.500 m**
NORTHING:	**7526595.337 m**
TOP of CASING ELEVATION:	**433.124 mRL** 15/03/09

DATE BEGUN: **25/02/2009** DATE COMPLETED: **28/02/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Water Table
Drilled Depth (mbgl):	72	72	72	72
Cased Depth (mbgl):	71	58	36	28
Stick Up (magl):	0.35	0.35	0.35	0.35
Airlift Yield (l/s):	moderate	low	low	trace
Water Level (mbtoc) & Date:	21.99	22.00	21.98	22.12
Quallity - pH & EC (mS/cm)	8.0 /15740	8.0 /10050	8.0 /1840	/

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH



DEPTH	STRAT	DESCRIPTION
0-12	Ta	Silty Gravel: Red/brown silt with sub-round to angular gravel, BIF and chert to 25 mm, with minor clay
12-30	Td	Silty Clay: Gravel, red/brown with well-round black pisoliths and sub-round to sub-angular BIF and trace shale
30-36	Hc	Hardcap (HC): Vitreous goethite with minor hematite, goethite and pisoliths, fine fragments <5 mm
36-45	Mut	Hematite (HOH): With white and red shales, slightly weathered, sub-round to sub-angular fragments to 8 mm
45-56	Mut	Goethitic Shale (GSF): Hematitic/Geothitic Shales with minor hard goethite and hematite fragments
56-60	Mub	Hematite & Goethite (GHM): Dark grey angular fragments, trace chert 59-60 m
60-72	Mub	Chert (CH): with minor BIF and unmineralised shale, blue/grey/white chert, sub-angular to angular fragments to 10 mm, minor white soft clays, coarser from 68 m (to 25 mm)

DEPTH	YIELD (l/s)	EC (µS/cm)	pH
39	FWS		
43	0.5		
49	1	1,020	7.1
55	2	2,140	7.1
61	~3	2,190	7.4
67	~3	2,710	7.4
73	~3	6,140	7.5

MONITORING BORE LOG

BOREHOLE NUMBER

HSMB19

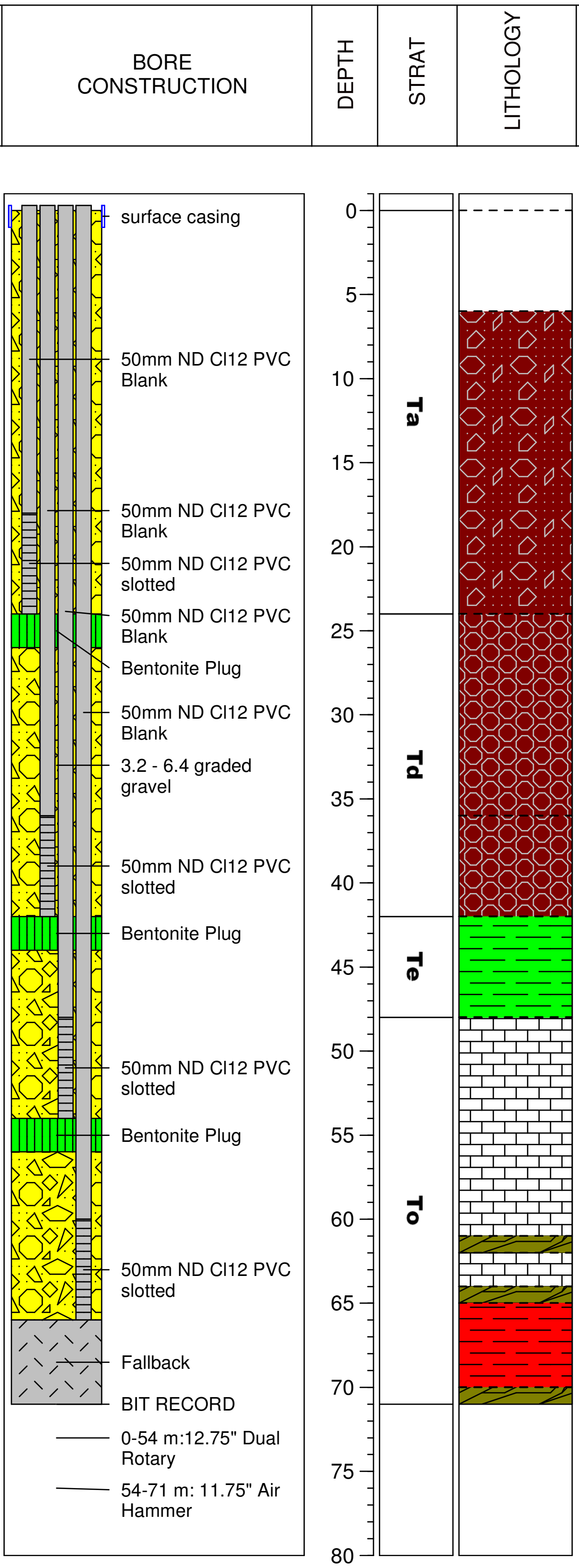
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**K. Everitt**
FIELD BOOK NO:	**CB Book 8**
EASTING:	**732799.7 m**
NORTHING:	**7531601 m**
TOP of CASING ELEVATION:	**418.506 mRL** 16/04/09

DATE BEGUN: **11/04/2009** DATE COMPLETED: **14/04/2009**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Water Table
Drilled Depth (mbgl):	71	71	7.67	71
Cased Depth (mbgl):	66	54	42	24
Stick Up (magl):	0.118	0.181	0.185	0.092
Airlift Yield (l/s):	Moderate	Moderate	Moderate	Poor
Water Level (mbtoc) & Date:	9.08	9.07	9.1	9.02
Quallity - pH & EC (mS/cm)	7.32 / 60,300	7.72 /9700	7.90 / 4020	7.6 /9.15



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
Drilling mud: Mud used downhole, unidentifiable sample			
Silty Gravel: Poorly sorted, A-SR, red/brown/green/yellow chert, BIF and shale frags to 30 mm, with minor SR pisoliths to 3 mm in red/brown silt	FWS 6		
Pisolitic Gravel: Minor gravel frags as above, ~20% in SR-WR dark grey-dark brown 2-3 mm pisoliths, moderately sorted. 30-36 m, mostly pisoliths & bleached shale and goethite	10		
Pisolitic Gravel: Poor sample - mud downhole. Smaller pisoliths, 1-2 mm, brown/red with clayey/shaley brown/red friable frags	~20		
Shale: Cream/orange, smooth, fine grained ~waxy frags, easily broken by hand	~20	3,240	8.07
Calcrete: White, hard, angular fine grained with sticky white clay,plus minor cream chert. 55-57 m, trace light green waxy firm clay	~20 ~20	4,600 6,200	8.27 8.56
Goethite (GOM): Darkgrey/red rubbly goethite	~20	15,470	8.59
Calcrete: White calcrete as for 48-61 m, with yellow/brown plasticky clay and trace goethite as above			
Goethite (GOM): As for 61-62 m, minor yellow/brown plasticky clay, minor calcrete	~20	22,390	8.77
Clay: White, sticky, 66-67 m ~50% Fe-stone	~20	26,200	8.45
Goethite (GOM): Very hard, vuggy, dark brown, angular, small frags ~10 mm			

MONITORING BORE LOG

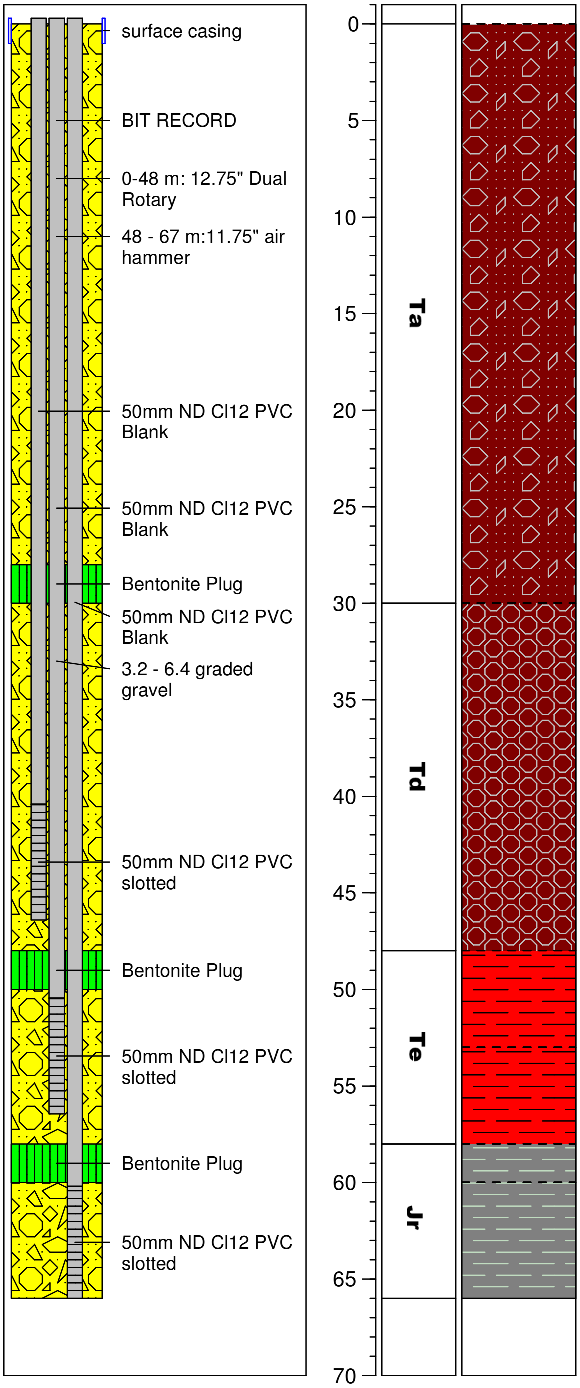
BOREHOLE NUMBER
HSMB23

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	**Hillside Monitoring**
LOCATION:	**Cloudbreak**
DRILLING CO:	**Barber Drilling**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**D. Mains**
FIELD BOOK NO:	**CB Book 6**
EASTING:	**756787.433 m**
NORTHING:	**7525621.216 m**
TOP of CASING ELEVATION:	**428.995 mRL**
DATE BEGUN:	**09/03/2009**
DATE COMPLETED:	**11/03/2009**

FINAL BORE DETAILS

	Shallow	Intermediate	Deep
Drilled Depth (mbgl):	66.2	66.2	66.2
Cased Depth (mbgl):	46.4	56.45	66.2
Stick Up (magl):	0.25	0.27	0.18
Airlift Yield (l/s):	low	moderate	moderate
Water Level (mbtoc) & Date:	17.08	17.85	17.64 12/03/09
Quallity - pH & EC (mS/cm)	7.8 / 7550	7.8 / 7,430	7.8 / 6,390



GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
			Ta		Silty Gravel: Red/orange brown with sub-round to sub-angular gravel (BIF, chert and shale to 20 mm) Minor pisoliths in last 6 m sample			
			Td		Pisolitic Gravel: Red brown with well rounded black pisoliths to 3 mm, and sub-round to sub-angular chert and BIF to 30 mm, most <10 mm	1		
			Te		Clay: Clay, white/yellow with hematite/goethite fragments slightly weathered, sticky, high plasticity clay			
					Clay: White/yellow/brown/purple with more hematite/goethite fragments than for 48-53 m, fragment size to 40 mm, sub-angular to rounded	~2	7,110	6.3
			Jr		Shale (Jr): Roy Hill Shale, black/white, slightly weathered, wash down of fragments from above	~3	6,100	
					Shale (Jr): Black, fresh oily shale with wash down from above	~5 ~8	6,470 6,400	7.1 7.2

MONITORING BORE LOG

BOREHOLE NUMBER

LHMB03

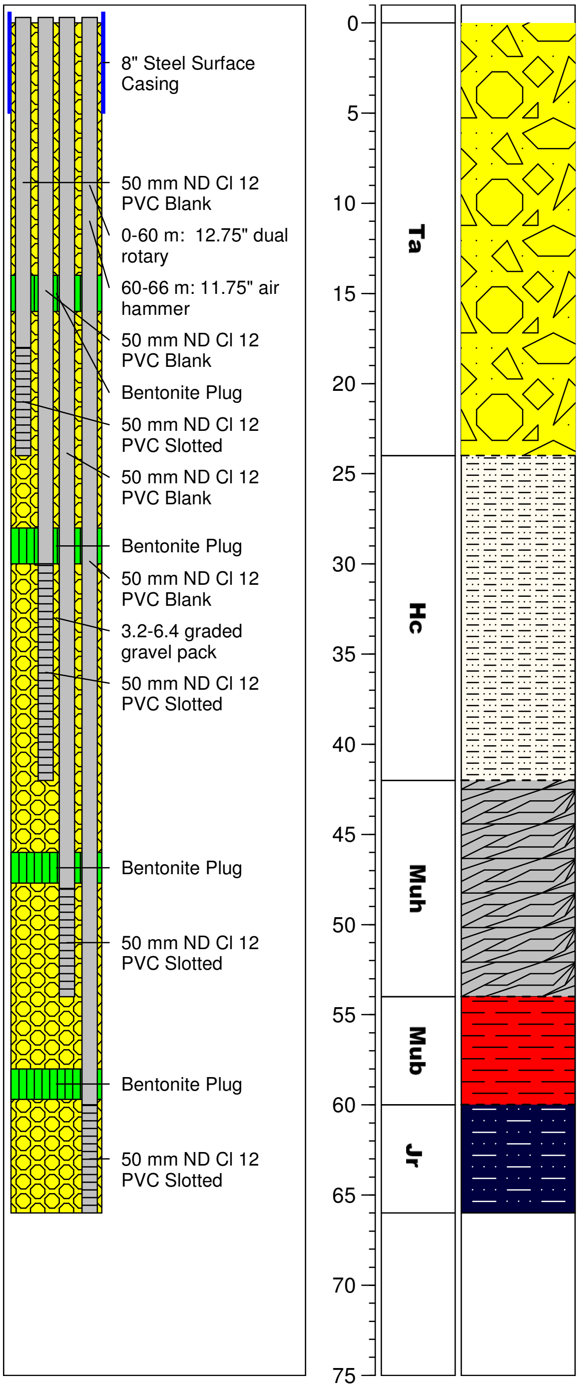
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Lefthanders Injection**
LOCATION: **Cloudbreak**
DRILLING CO: **Barber Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **L. Frankcombe**
FIELD BOOK NO: **CB Book 11**
EASTING: **725135.75 m**
NORTHING: **7535190.76 m**
TOP of CASING ELEVATION: **417.50 mRL** 14/03/10
DATE BEGUN: **08/03/2010** DATE COMPLETED: **10/03/2010**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	66	66	66	66
Cased Depth (mbgl):	66	54	42	24
Stick Up (magl):				
Airlift Yield (l/s):				
Water Level (mbtoc) & Date:	8.53	8.50	7.99	7.75
Quallity - pH & EC (mS/cm)	7.49 /62.67	7.22 /26559	/3.07	/2.09

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Alluvium: Alluvials polymictic poorly sorted gravels SA-SR with minor clays (no pisoids/ooids)

Hardcap (HC): Vuggy weathered zone. Highly porous clasts with clay content increasing with depth

Hematite (HOH): Hematite beds with strong weathered zone at base of interval (hematitic clays) and bleached kaolinitic beds with thin zones of greasy black beds of weathered shales

Clay: Massive clays hematite and carbon enriched as well as ochreous goethite mustard staining

Black Shale (BS): Thick black seam of shale, soft, greasy beds interbedded with more competent units

EC (µS/cm)	pH
2710	7.82
2430	7.52
6330	7.23
9430	7.23
14150	7.50
22770	7.62

MONITORING BORE LOG

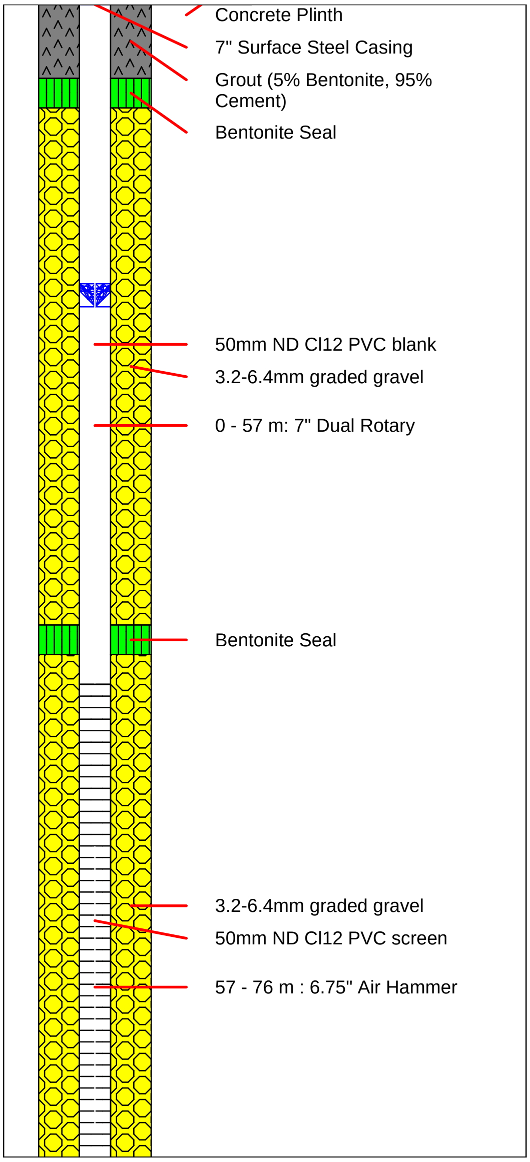
BOREHOLE NUMBER
LPMB08

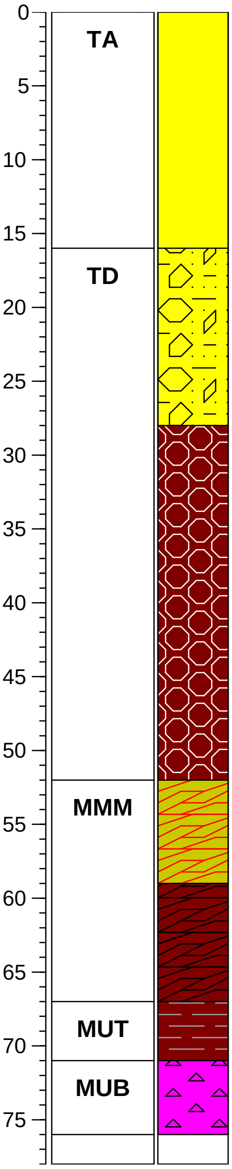
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Long Pit S3-5**
LOCATION: **Cloubreak**
DRILLING CO: **Eastern Well**
DRILLING METHOD: **Dual Rotary/Air Hammer**
LOGGED BY: **A. Mattvey**
FIELD BOOK NO: **Long Book 1**
EASTING: **751900.76**
NORTHING: **7526455.43**
ELEVATION (mAHD): **427.73**
DATE BEGUN: **2013-05-19** DATE COMPLETED: **2013-05-20**

FINAL BORE DETAILS		
Drilled Depth (mbgl):	76	
Cased Depth (mbgl):	78.75	
Stick Up (magl):	0.495	
Airlift Yield (L/s):		
Water Level (mbgl) & Date:	20.465	
Quallity - pH & EC (uS/cm):		

BORE CONSTRUCTION	DEPTH (mbgl)	STRATIGRAPHY	LITHOLOGY	DESCRIPTION	YIELD (L/s)	EC (µS/cm)	pH





STRATIGRAPHY	DESCRIPTION
TA	GRAVELLY SILT: Brown silty matrix. subangular-subrounded alluvial garvels. medium-highly weathered fragments. 2-50mm. poorly sorted. low-moderate porosity
TD	GRAVELLY CLAY: Red brown clay matrix. angular slightly weathered fragments. minor white kaolinitic clays. 2-20mm. poorly sorted. low porosity.
	PISOLITIC GRAVEL: Red brown dilty matrix. subrounded-rounded pisolitic gravels. minor subangular cherts present well sorted. low porosity. low-medium permeability
MMM	GOETHITE & HEMATITE: Brown-mustard ocherous goethite (70%) and hematite (30%). highly weathered poorly sorted fragmenst. minor kaolinitic clays present at depth. medium porosity and permeability
	HEMATITE: Red silty matrix. Hematitic material (60%), white kaolinitic clays (20%), some cherts (~5%) and minor hematised shales present. soft weathered subangular rock. >20mm. moderate sorting. medium porosity/permeability
MUT	HEMATISED SHALE: Black lamintaed hematised shales. highly weathered. minor kaolinitic clays and cherts. some weathering. medium porosity
MUB	CHERT: Green ocherous stained cherts. very hard rock. angular-subangular rock. low posoity. medium permeability

YIELD (L/s)	EC (µS/cm)	pH
2.5	9740	6.34
2.5	9160	6.5
2.5	15450	6.87
2.5	19980	7.21
2.5	32800	7.27
2.5	41800	7.36

MONITORING BORE LOG

BOREHOLE NUMBER

MDMW04

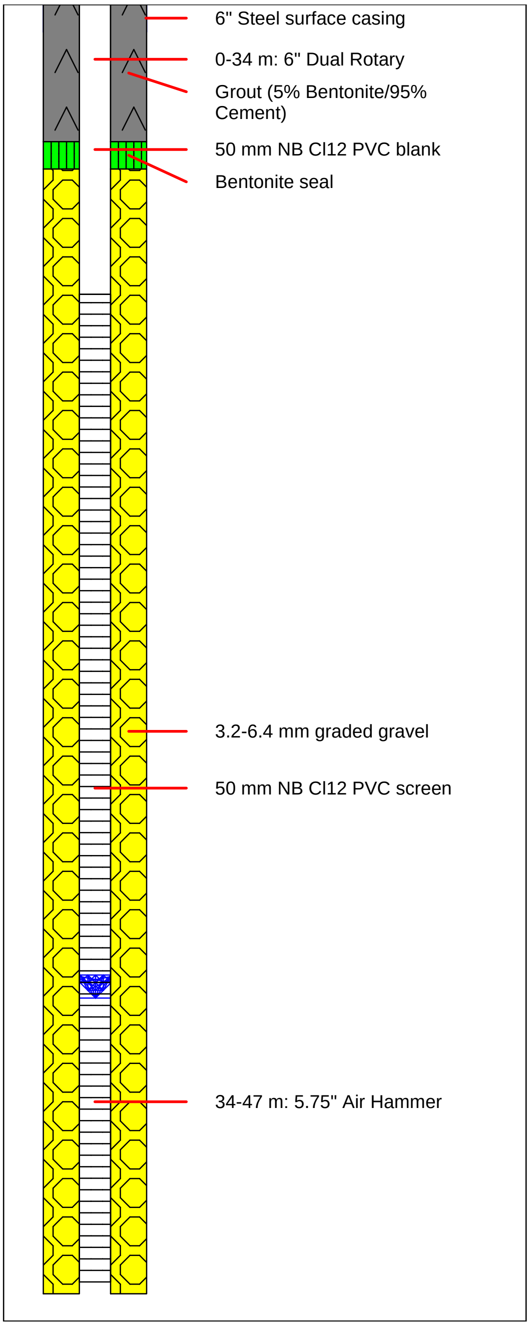
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	**Brampton TSF**
LOCATION:	**Cloudbreak**
DRILLING CO:	**FMG**
DRILLING METHOD:	**Dual Rotary/Air Hammer**
LOGGED BY:	**JU**
FIELD BOOK NO:	**Misc Bores ogbook 1**
EASTING:	**743444.09**
NORTHING:	**7529295.09**
ELEVATION (mAHD):	**429.70**

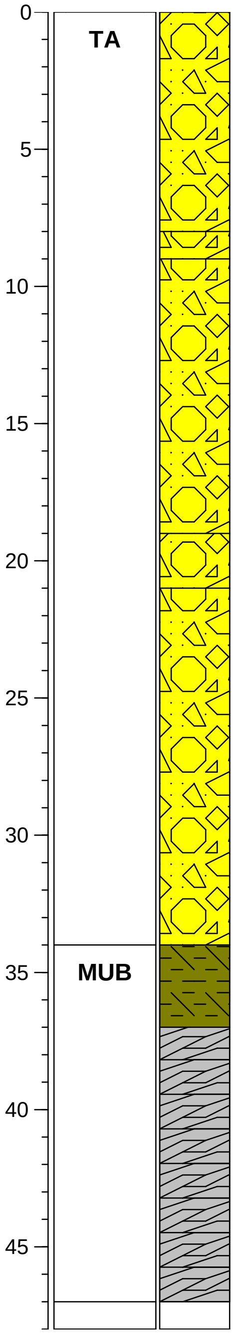
DATE BEGUN: **2013-06-29** DATE COMPLETED: **2013-06-30**

FINAL BORE DETAILS		
Drilled Depth (mbgl):	47	
Cased Depth (mbgl):	46.57	
Stick Up (magl):	0.43	
Airlift Yield (L/s):		
Water Level (mbgl) & Date:	36.22	24/07/2013
Quallity - pH & EC (uS/cm):		

BORE CONSTRUCTION



DEPTH (mbgl) | STRATIGRAPHY | LITHOLOGY



STRATIGRAPHY	DESCRIPTION	YIELD (L/s)	EC (µS/cm)	pH
TA	FILL: Gravely Silt, red brown to dark brown, gravels are poorly sorted, SR, 1-20mm			
	FILL: Gravel, dark brown, 10-30 mm, SA, minor sit			
	FILL: Gravely silt, red brown, graves are poory sorted, 1-20 mm, SR - SA			
	FILL: Gravely silt, pale brown, gravels are poorly sorted, SR-SA, with some large HC derived gravels, A, vuggy, 20-50mm			
	FILL: Gravely silt, red brown, poorly sorted, 1-20 mm, SR and minor SA			
MUB	GOETHITE & CHERT: Goethite, hematite and Cherts in silty cay matrix, samples were damp but no free flowing water			
	MARTITE: Magnetite (80%), chert(15%) minor Hematite (5%) in clayey silt matrix			
		0.5	968	7.22

MONITORING BORE LOG

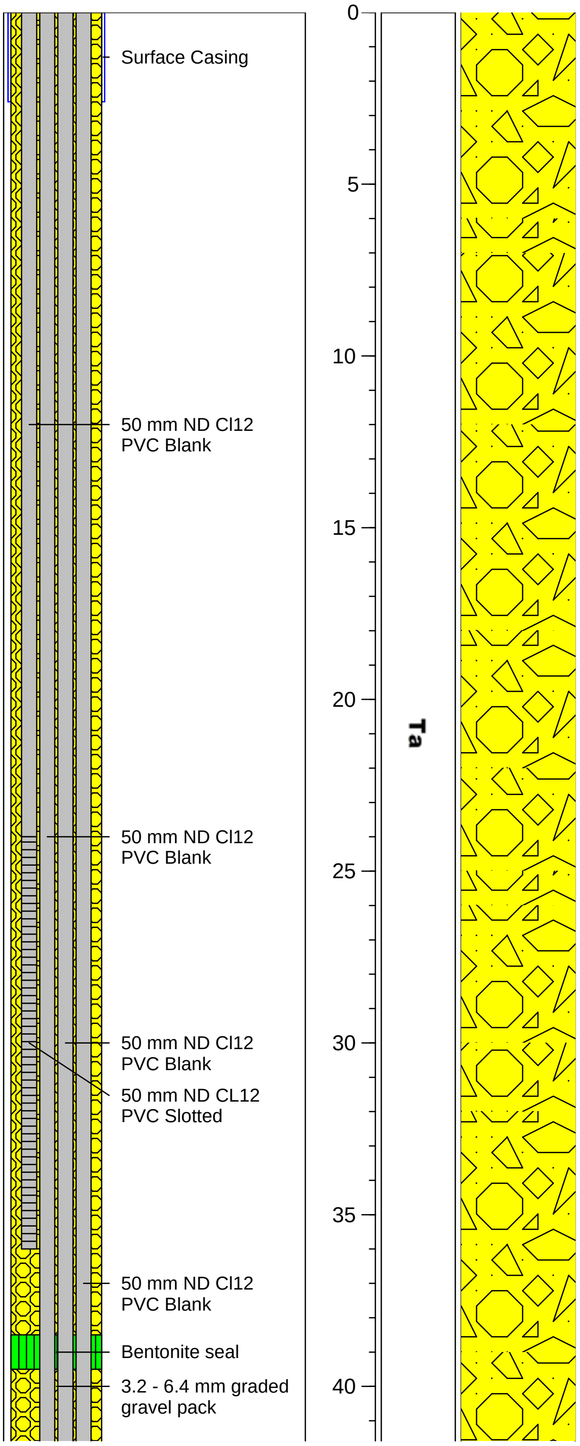
BOREHOLE NUMBER
CCE04_MB

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **CCE**
LOCATION: **Christmas Creek**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Mud Rotary**
LOGGED BY: **F. Doedens**
FIELD BOOK NO: **CC Exploration Book 1**
EASTING: **777634.16**
NORTHING: **7521608.83**
TOP of CASING ELEVATION: **427.25** 04/09/09
DATE BEGUN: **19/07/09** DATE COMPLETED: **28/07/09**

FINAL BORE DETAILS				
	Deep	Intermediate	Shallow	very Shallow
Drilled Depth (mbgl):				
Cased Depth (mbgl):	80	66	54	36
Stick Up (magl):	0.3	0.3	0.3	0.3
Airlift Yield (l/s):	1.8	2.5	0.75	0.75
Water Level (mbtoc) & Date:	19.3	17.1	16.8	16.7
Quallity - pH & EC (mS/cm)	9 /94600	9 /16500	9 /10080	9 /3510

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Alluvium: Red-brown silty gravels. Poorly sorted silts (>50%), sub-angular to sub-rounded gravel to , containing fragments of chert,, shale, ~3-20 mm. Chert is dominant, minor quartz.

Alluvium: Red-brown silt, chert, and shale gravel as above, some hematite shale and minor maghemite, but smaller <5mm, rarely >10 mm. Poorly sorted, sub angular to sub-rounded.. Alluvials.

Alluvium: Red-brown silts with gritty sands (>70%), white to reddish shale, sub-angular to sub-rounded (<20%), greenish chert (<10%). All fragments less than 15mm. Trace chalcedony. Alluvium.

Alluvium: Red-brown silts with minor clay, minor fragments <10% and <5mm. Fragments sub-angular hematitic shales with minor chalcedony.

Alluvium: Red-brown silts with minor clay and sand and traces of grit (70%). Angular to sub-angular, reddish shales (20%), white to green hert and chalcedony (10%). Alluvium. Fragments <10mm, contains a trace of carbonates.

Alluvium: Red brown silts with minor clay approximately 50%. Sub-angular to angular fragments of shale (40%), chalcedony (5%) and minor sliceous goethite and chert. Fragments to 15mm. Some weathered carbonate (dolomite?).

Alluvium: Red-brown silts and minor clay (90%), minor reddish chert (5%), and trace of shales. Sub-angular fragments to 10mm.

Alluvium: Red-brown silts with minor sand and clay (70%), sub-angular fragments of hematite shale (25%), chert/chalcedony (5%), and shale (5%). Most fragments around 5mm, largest to 10mm.

Alluvium: Red-brown silt with minor clay, sand and grit (80%). Sub-angular fragments of of hematitic shale (15%), shale (3%), goethite and chert (2%). Fragments to 10mm. Alluvium.

YIELD (l/s)	EC (µS/cm)	pH
0.75	3510	9

Alluvium: Red-brown silts (80%). Fragments sub-angular to sub-rounded, mostly hematite shales with minor chert. Goehitic pisolites, sub-rounded to rounded mostly 5mm. Probably thin detrital layers in alluvium.

MONITORING BORE LOG

BOREHOLE NUMBER

CCE04_MB

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **CCE**

LOCATION: **Christmas Creek**

DRILLING CO: **Connector Drilling**

DRILLING METHOD: **Mud Rotary**

LOGGED BY: **F. Doedens**

FIELD BOOK NO: **CC Exploration Book 1**

EASTING: **777634.16**

NORTHING: **7521608.83**

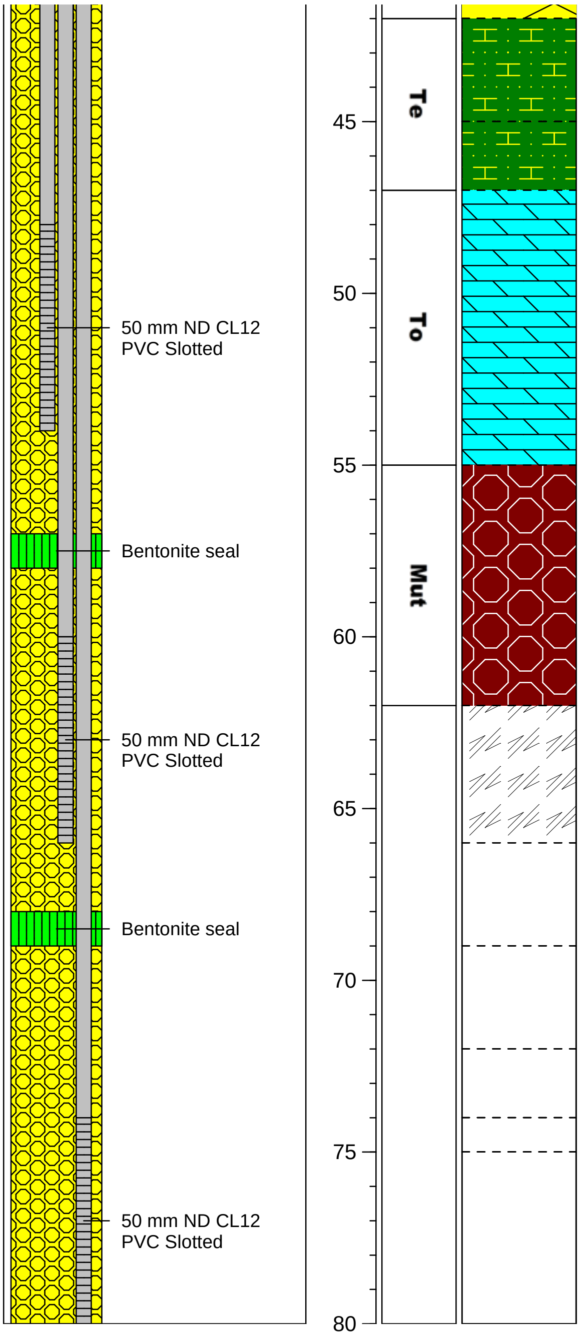
TOP of CASING ELEVATION: **427.25** 04/09/09

DATE BEGUN: **19/07/09** DATE COMPLETED: **28/07/09**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	very Shallow
Drilled Depth (mbgl):				
Cased Depth (mbgl):	80	66	54	36
Stick Up (magl):	0.3	0.3	0.3	0.3
Airlift Yield (l/s):	1.8	2.5	0.75	0.75
Water Level (mbtoc) & Date:	19.3	17.1	16.8	16.7
Quallity - pH & EC (mS/cm)	9 /94600	9 /16500	9 /10080	9 /3510

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
Alluvium: Red-brown silts (90%), minor sands and grits. Fragments sub-rounded, mostly hematitic shale. One 12mm goethitic shale fragment has a fracture surface coated with fresher hematite. Very minor pisolites and dolomite. Alluvium with detrital layers.			
Clay and Silt: Dark reddish brown clay-silt with minor sands and grits (95%+). Fragments to 8mm, sub- angular to sub-rounded. Mostly made of shale with a trace quartz. Lacustrine.			
Clay and Silt: Dark reddish brown gritty clay-silt lumps (95%+). Fragments to 10mm, but most to 5mm, sub- angular to sub-rounded shales with minor chert. Lacustrine.	0.75	10080	9
Dolomite: Cream-white silt (80%), clay (10%) and porcellaneous dolomite fragments with included pyrolusite dendrites and veinlets. Fresh angular fragments with solution and accretion features. Oakover Formation.			
Goethitic Gravel: Fracture at 57m and cavity at 58m. Goethitic layer mainly composed of silt (70%) and clay (10%) with fragments of ocherous goethite and goethite (15%) and minor dolomite (contamination?), iron rich chert and shale.			
Fault: Major fracture with loss of water, unable to recover any sample from this interval to end of hole. Soft drilling.	2.5	16500	9
Hard drilling, no sample.			
Soft drilling			
Hard drilling			
Easier drilling possibly porous			
Hard drilling			

MONITORING BORE LOG

BOREHOLE NUMBER

CCE12_MB

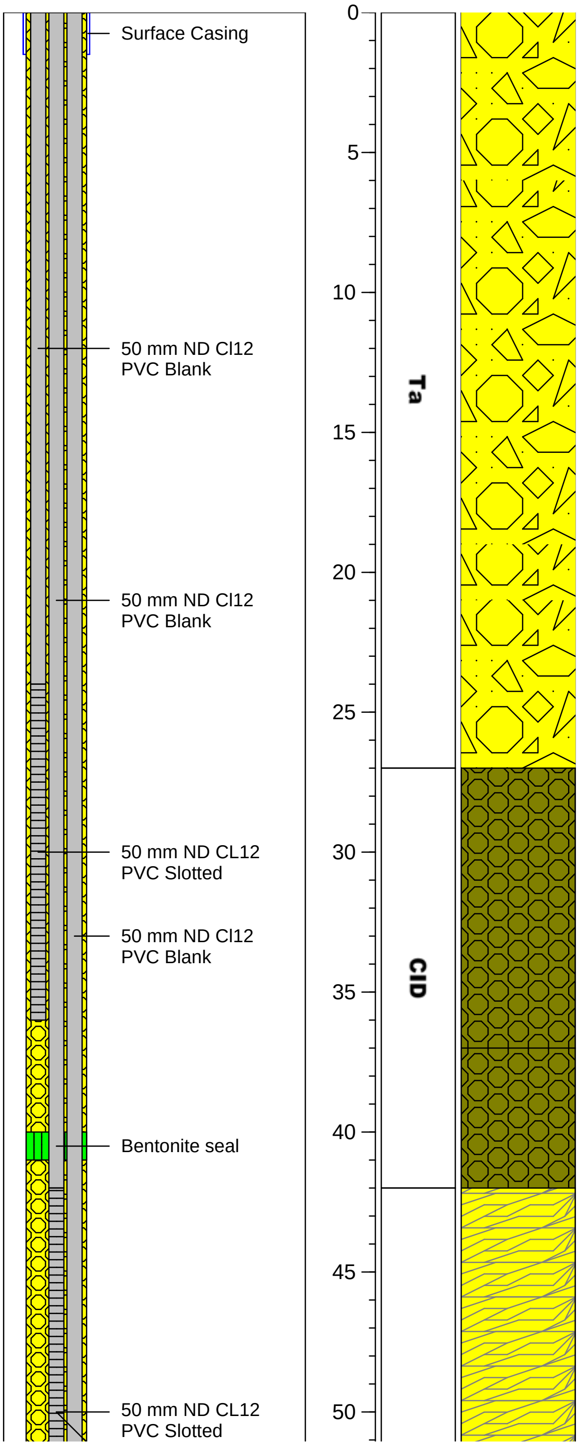
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **CCE**
LOCATION: **CHRISTMAS CREEK**
DRILLING CO: **CONNECTOR DRILLING**
DRILLING METHOD: **MUD ROTARY**
LOGGED BY: **M. Klug**
FIELD BOOK NO: **CC EXPLORATION BOOK 2**
EASTING: **784800.83 m**
NORTHING: **7519797.85 m**
TOP of CASING ELEVATION: **429.56**
DATE BEGUN: **20/08/09** DATE COMPLETED: **22/08/09**

FINAL BORE DETAILS

	Shallow	Intermediate	Deep
Drilled Depth (mbgl):			100
Cased Depth (mbgl):	36	58	94
Stick Up (magl):	0.6	0.6	0.6
Airlift Yield (l/s):	0.44	2	1.7
Water Level (mbtoc) & Date:	19.9	20.1	21.3 03/09/09
Quallity - pH & EC (mS/cm)	7 / 2530	7 / 3470	6 / 148700

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH



Alluvium: Light brown sand/silt 30%, SA-SR fragments to 25mm, shale 40%, chert 30%, minor quartz

Alluvium: Grey brown sandy silt 20%, SA-SR fragments to 10mm, shale 50%, chert 20%, quartz 5%, pisolites 5%, MGM 2%, minor KLM. 16-19m more brown clay, fragments to 20mm

Alluvium: Red brown silty clay 75%, SA-RR fragments to 20mm, shale 15%, chert 10%, minor OGF, MGM and pisolites

Alluvium: Red brown clayey silt 40%, SR-RR fragments to 15mm, pisolites 30%, shale 20%, chert 10%

CID: Red brown silt 10%, SR-RR fragments to 10mm, pisolites 80%, shale 5%, chert 5%. From 31m less chert, but more MGM and pisolites up to 90%

CID: Greenish brown silt 10%, SA-RR fragments to 5mm, pisolites 20%, MGM 20%, shale 20%, GOM 20%, chert 10%, quartz 5%

Goethite/Martite: Olive green brown silt/clay 20% contains GHF and OGF, SA-RR fragments to 10mm, GOM 40%, MGM 30%, shale 20% (HSM), minor pisolites and quartz. From 47m more blueish and more MGM (40%) then GOM(30%)

YIELD (l/s)	EC (µS/cm)	pH
0.44	2530	7

MONITORING BORE LOG

BOREHOLE NUMBER

CCE12_MB

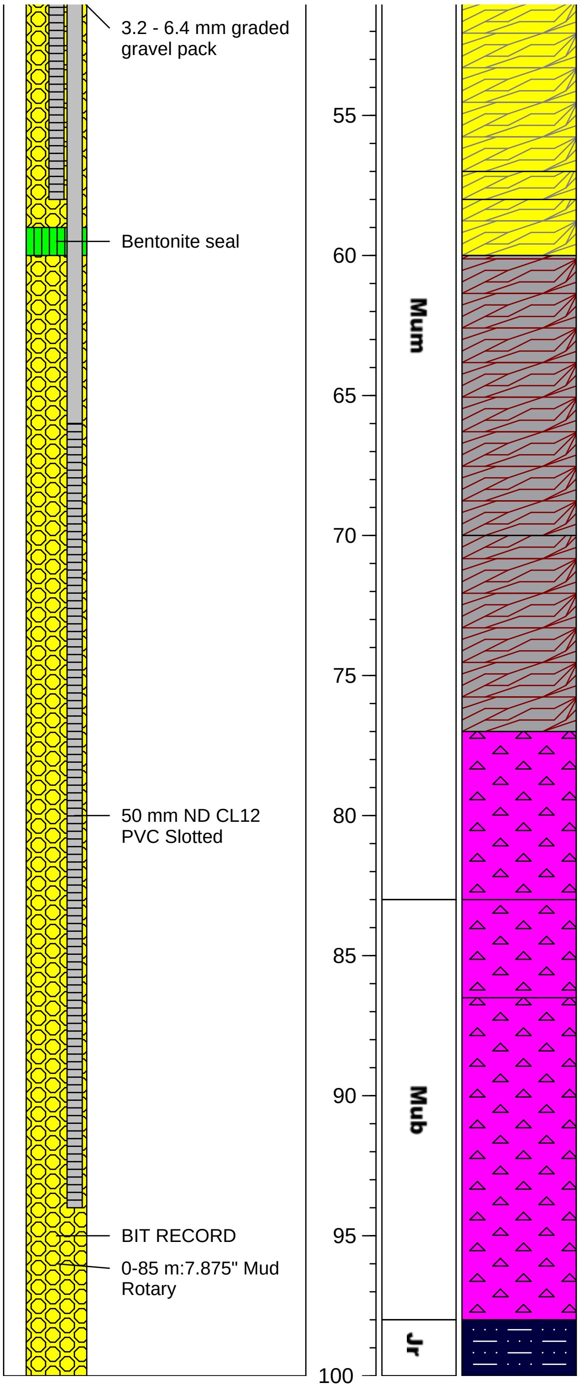
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **CCE**
LOCATION: **CHRISTMAS CREEK**
DRILLING CO: **CONNECTOR DRILLING**
DRILLING METHOD: **MUD ROTARY**
LOGGED BY: **M. Klug**
FIELD BOOK NO: **CC EXPLORATION BOOK 2**
EASTING: **784800.83 m**
NORTHING: **7519797.85 m**
TOP of CASING ELEVATION: **429.56**
DATE BEGUN: **20/08/09** DATE COMPLETED: **22/08/09**

FINAL BORE DETAILS

	Shallow	Intermediate	Deep
Drilled Depth (mbgl):			100
Cased Depth (mbgl):	36	58	94
Stick Up (magl):	0.6	0.6	0.6
Airlift Yield (l/s):	0.44	2	1.7
Water Level (mbtoc) & Date:	19.9	20.1	21.3 03/09/09
Quallity - pH & EC (mS/cm)	7 / 2530	7 / 3470	6 / 148700

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
Goethite/Martite: Greenish blue silt/clay 40%, SA-SR fragments to 8mm, MGM 20%, MNM 20%, GOM 15%, hematitic shale 5%			
Goethite/Martite: Greenish blue silt/clay 30%, SA-SR fragments to 10mm, MGM 25%, HSM 15%, GOM 15%, GHM 10%, pisolites 5%, GSM 3%, chert 2%, minor MNF 1%	2	3470	7
Martite-Brown Goethite: Blue grey sand 20%, SA-AA fragments to 10mm, Magnetite 40%, MGM 30%, hematitic shale 5%, GOM 5%. 69-70m more GOM			
Martite-Brown Goethite: Blueish grey sand 15%, SA-AA fragments to 10mm, MGM 50%, chert 15%, GOM 10%, hematitic shale 10%			
Chert (CH): Greyish green sand 10%, VA fragments to 10mm, chert 70%, shale 30% (HSM). 81-83m: clay/silt 5%			
Chert (CH): Dark brown silt 10% including GSP, AA fragments to 5mm, chert 70%, GSM 20%, GOM 5%, HSM 5%			
Chert (CH): Blue grey silt/sand 5%, AA fragments to 10mm, chert 20%, siliceous shale with trace pyrite 70%, HSM 5%	1.7	148700	6
Black Shale (BS): Dark grey silt 5%, SA-AA fragments to 10mm, black carbonaceous shale with pyrite 90%, chert 5%			

MONITORING BORE LOG

BOREHOLE NUMBER

CCE14_MB

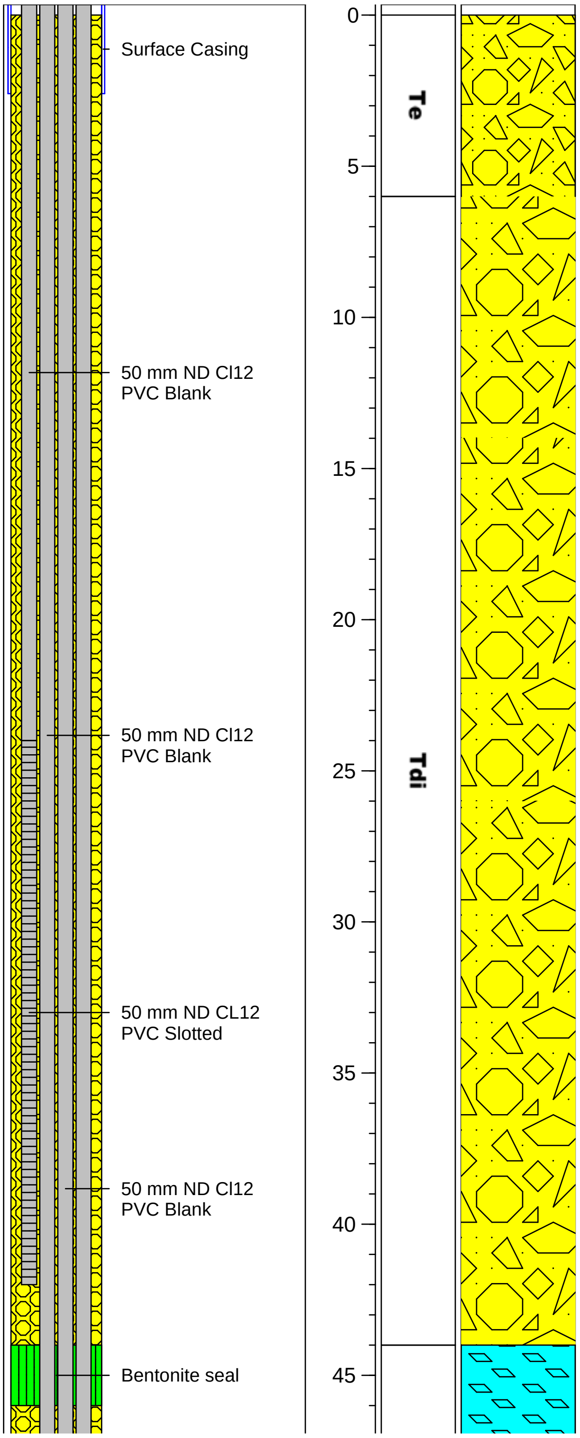
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **CCE**
LOCATION: **Christmas Creek**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Mud Ratary**
LOGGED BY: **F. Doedens**
FIELD BOOK NO: **CC Exploration Book 3**
EASTING: **789214.78 m**
NORTHING: **7517550.24 m**
TOP of CASING ELEVATION: **425.89 mRL** 03/09/09
DATE BEGUN: **11/08/09** DATE COMPLETED: **15/08/09**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Very Shallow
Drilled Depth (mbgl):	134			
Cased Depth (mbgl):	126	92	72	42
Stick Up (magl):	0.4	0.4	0.4	0.4
Airlift Yield (l/s):	2.5	1.8	1	0.5
Water Level (mbtoc) & Date:	23.2	20.8	17.2	16.8
Quallity - pH & EC (mS/cm)	8 /168400	8 /125900	8 /72.100	9 /29800

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Colluvium: Red brown silts with 5%clays total 60%, cherts 30% and hale 10%. Fragments to 20mm. Sub-angular to sub-rounded. Sheet wash/alluvial/colluvium.Ta.

Alluvium: Pinkish brown silts and sands 20%, green cherts 30%, shales 30%,pisolites 15% and goehite 5%. Angular to rounded. Detritals. Fragments to 15mm. Poorly sorted. Immature. Tdi

Alluvium: Red brown silts and sands (sands rounded with abundant pisolites) 40%, clay 10%, chert 20%, goethitic pisolites 20%, shales 10%. Fragments to 6mm. Well sorted. Detrital. Sub-angular to sub-rounded.

Alluvium: Light red brown sands and silts 30%, clay 5%. Fragments rounded to aqngular. Chert 20%, goethitic pisolites 30%, shales 10% and carbonates 5%. Poorly sorted fragments to 20mm. Detrital. Tdi.

YIELD (l/s)	EC (µS/cm)	pH
0.5	29800	9

Calcified: Cream to yellow silts and clays 50%, mostly consists of calcreted and silcreted lithologies. Coarser fragments are mostly siliceous 40% with some OGF, GGM

MONITORING BORE LOG

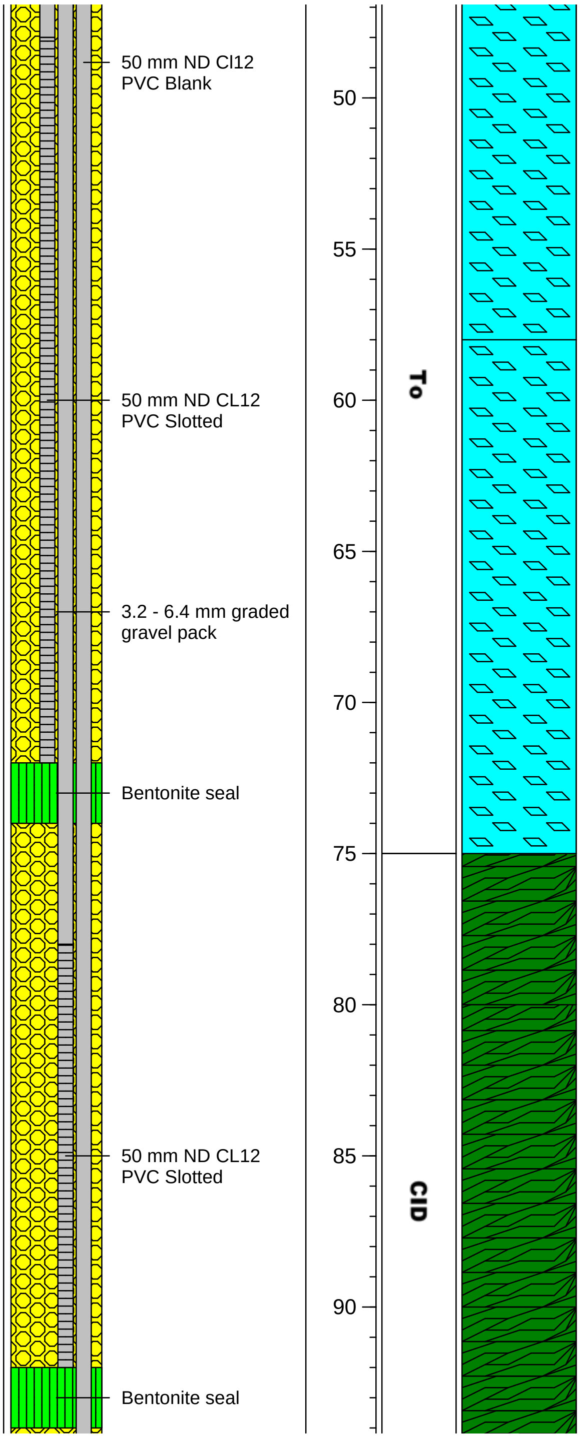
BOREHOLE NUMBER

CCE14_MB

PROJECT NAME: **CCE**
LOCATION: **Christmas Creek**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Mud Ratary**
LOGGED BY: **F. Doedens**
FIELD BOOK NO: **CC Exploration Book 3**
EASTING: **789214.78 m**
NORTHING: **7517550.24 m**
TOP of CASING ELEVATION: **425.89 mRL** 03/09/09
DATE BEGUN: **11/08/09** DATE COMPLETED: **15/08/09**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Very Shallow
Drilled Depth (mbgl):	134			
Cased Depth (mbgl):	126	92	72	42
Stick Up (magl):	0.4	0.4	0.4	0.4
Airlift Yield (l/s):	2.5	1.8	1	0.5
Water Level (mbtoc) & Date:	23.2	20.8	17.2	16.8
Quallity - pH & EC (mS/cm)	8 /168400	8 /125900	8 /72.100	9 /29800



GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
					and minor MGM 10%. Fragments to 10mm, weathered, angular to sub-rounded			
					Calcified: Pale grey to grey silts with minor clay, mostly calcreted. Siliceous fragments with minor goethitic shale 10%. Majority is quartz and silcrete. Sub-angular to sub-rounded 5mm max.			
					Goethite & Chert (Mut): Light greenish brown with minor silt (<5%), sand sized fragments 75% (quartz 15%, shale 10%, goethite 50%, GHM 20% and GSM 5%). Remaining 20% is coarser fragments to 5mm, composed largely of quartz, GOM and HSM/GSM in equal proportions. Fragments angular. Between 79-80, ore is more prevalent. 70-80% is GHM, GOM.	1	72100	8
					Goethite & Chert (Mut): Light yellowish brown, 10% silt, 10% weathered goethitic clay, sand 70% (mostly GOM/GHM with 20% quartz). Fragments to 6mm, mostly GHM/GOM, remainder is quartz and HSM. Fragments angular to sub-angular. Soft drilling between 91-98m. More goethitic with little quartz or shale. Hard band at 98m. Possibly CID with active iron replacement.	1.8	125900	8

MONITORING BORE LOG

BOREHOLE NUMBER
CCE14_MB

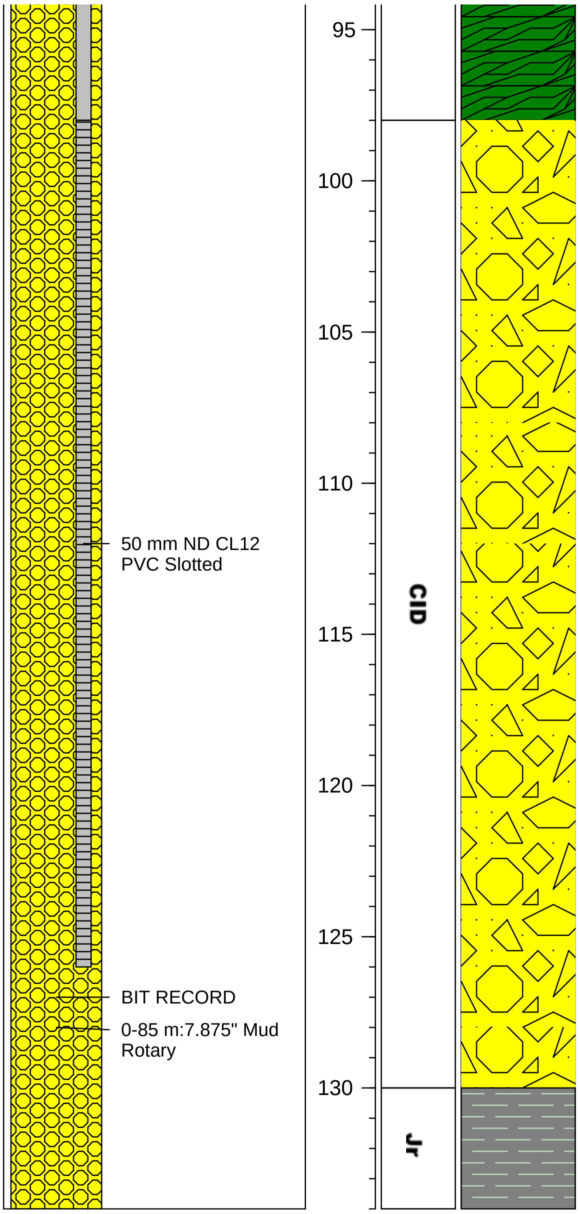
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	**CCE**
LOCATION:	**Christmas Creek**
DRILLING CO:	**Connector Drilling**
DRILLING METHOD:	**Mud Rotary**
LOGGED BY:	**F. Doedens**
FIELD BOOK NO:	**CC Exploration Book 3**
EASTING:	**789214.78 m**
NORTHING:	**7517550.24 m**
TOP of CASING ELEVATION:	**425.89 mRL** 03/09/09
DATE BEGUN:	**11/08/09** DATE COMPLETED: **15/08/09**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	Very Shallow
Drilled Depth (mbgl):	134			
Cased Depth (mbgl):	126	92	72	42
Stick Up (magl):	0.4	0.4	0.4	0.4
Airlift Yield (l/s):	2.5	1.8	1	0.5
Water Level (mbtoc) & Date:	23.2	20.8	17.2	16.8
Quallity - pH & EC (mS/cm)	8 /168400	8 /125900	8 /72.100	9 /29800

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Alluvium: Light brown to brown fined silts with minor clay 70%. Fragments 15% GOM, 5% GGM, 5% HSM, 3% chert and 2% silica. Minor pisolitic gravel. Fragments to 10mm, angular to sub-rounded. Loss of drilling mud through this zone.

Alluvium: Dark purplish brown fine silts with minor clay 40%, chert 20%, GSM 10%, HSM 20% and 10% MGM. A band of red clay (HSF?) at 111m. Gravel very angular to sub-rounded. Minor pisolites approx 2%. Fragments to 12mm.

Alluvium: Grey brown more sandy, silts and clays 20%, 50% sand (quartz 25%, MGM 15%, HSM 10%). Fragments to 10mm,consisting of 20% HSM, 5% GGM and 5% chert. Sub-angular to sub-rounded.

Alluvium: Blueish grey sandy silt with minor clay 30%, chert 50%, shale 20% and minor GGM, GOH and quartz. Sub-angular to sub-rounded to 5mm.

YIELD (l/s)	EC (µS/cm)	pH
2.5	168400	8

Shale (Jr): Dark blueish grey sandy silt 30%, chert 30%, black shale 30%, hematitic shale 5% and quartz 5%. Sub-angular, fragments to 10mm.

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COMPOSITE WELL LOG

Well No: F01B

Client: Fortescue Metals Group
Project: Christmas Creek Piezometer Monitoring Bore

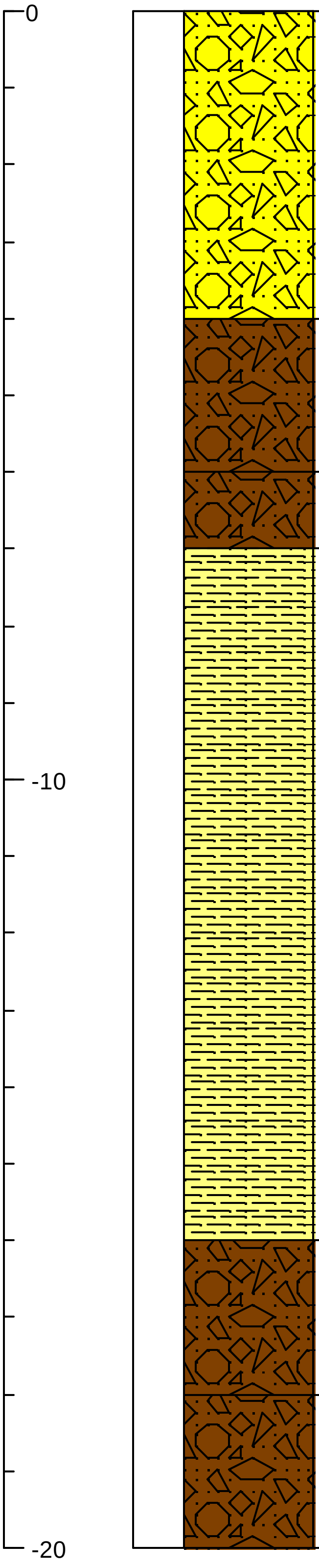
Commenced: 10/09/2004
Completed: 10/09/2004
Drilled: Connector
Logged By: RFToll

Method: Airlift to 20m EOH.
Fluid: 2000 cfm 700 psi (Hydco C4)
Bit Record: 5 3/8"

Area: Christmas Creek
East: 786009m(AMG)
North: 7515646m(AMG)
Elevation:

Static Water Level: 8.46 mbgl
Date: 10/09/2004; 07:00hrs

Depth (mbgl)	Geology	Graphic Log	Lithological Description	Field Notes	Well Completion Diagram	Well Completion Notes



COLLUVIUM: Red-brown highly ferruginised lateritic chert fragments poorly sorted predominantly angular <3cm diamter

ALLUVIAL: Red-brown colluvium with 30% poorly aggregated clay

ALLUVIAL: Red-brown 80% alluvial fragments <4cm diameter with 20% poorly consolidated clay

CLAY: Red-brown clay 70% with minor alluvial fragmentals <1cm

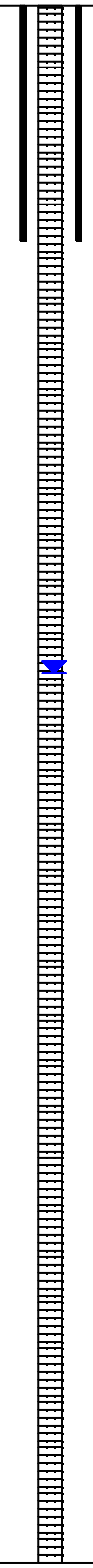
ALLUVIAL: Red-brown moist/damp alluvial fragments highly ferruginous

ALLUVIAL: Red-brown damp moderately consolidated clay with 40% alluvial fragments

16-17m: Minor aquifer damp slurry sampled- no TDS

19-20m: Water sampled for analysis

EOH at 20mbgl



150 mm PVC collar (0-3mbgl)

2.5" Slotted PVC (0-20mbgl)

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COMPOSITE WELL LOG

Well No: F07B

Client: Fortescue Metals Group

Project: Christmas Creek Piezometer Monitoring Bore

Commenced: 13/09/2004
Completed: 13/09/2004
Drilled: Connector
Logged By: RFToll

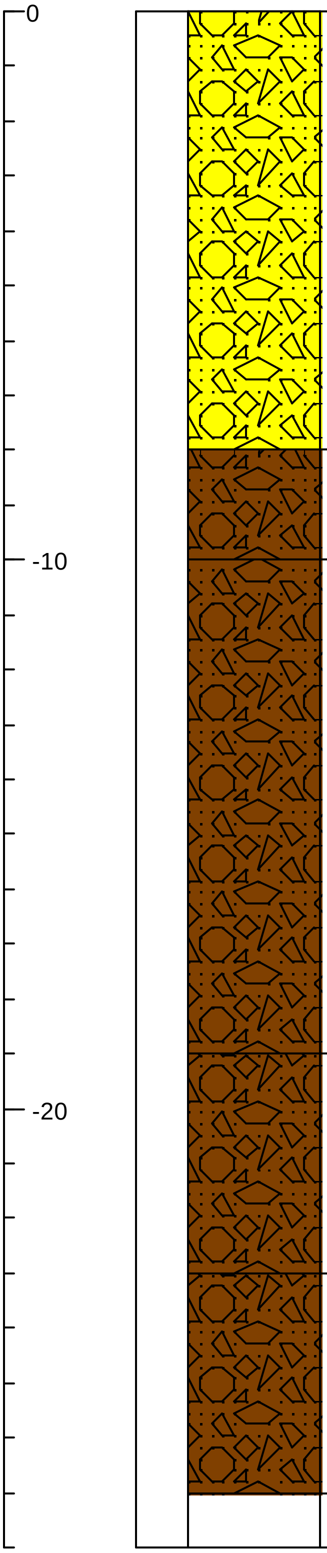
Method: Airlift to 27m EOH.
Fluid: 2000 cfm 700 psi (Hydco C4)
Bit Record: 5 3/8"

Area: Christmas Creek
East: 782004m(AMG)
North: 7517844m(AMG)
Elevation:

Static Water Level: 14.0 mbgl

Date: 14/09/2004; 07:00hrs

Depth (mbgl) | **Geology** | **Graphic Log** | **Lithological Description** | **Field Notes** | **Well Completion: Diagram** | **Notes**



Lithological Description

COLLUVIUM: Red-brown highly ferruginised lateritic chert fragments poorly sorted predominantly angular <3cm diameter with 30% poorly consolidated clay

ALLUVIAL: Red-brown highly oxidised alluvials as 80% in zone comprising chert fragments poorly sorted subangular <1mm diameter with 20% poorly aggregated clay

ALLUVIAL: Red-brown highly ferruginised lateritic chert fragments poorly sorted predominantly angular <3cm diameter with 30% poorly consolidated clay

ALLUVIAL: Red-brown highly oxidised alluvials as 80% in zone comprising chert fragments poorly sorted subangular <1mm diameter with 20% poorly aggregated clay

ALLUVIAL: Red-brown highly oxidised wet moderater flow in alluvial chert fragments poorly sorted subangular-subrounded <3cm diameter with moderately consolidated clay as 20% wet zone

Field Notes

26-27m:

2.94 ppt TDS, 8.64 pH, 5.88 mS initial test time 1 minutes

3.25 ppt TDS, 8.92 pH, 6.40 mS test time 10 minutes

8.1 ppt TDS, 8.61 pH, 16.2 mS test time 15 minutes

>10 ppt TDS , > 20 mS; test time 30 minutes - indicates only limited available fresh water

water sampled for analyis 40 minutes

27m:>2.94ppt TDS 10 minutes test

8.64 pH @ 40 metres at 10 minutes of testing

>5.88 mS 10 minutes of testing

20 minutes into test 3.25ppt TDS,8.72 pH, 6.4 mS

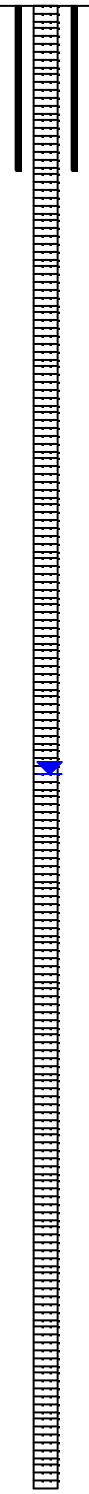
30 minutes into test 8.1 ppt TDS, 8.61 pH, 16.22 mS

40 minutes into test >10.0 ppt TDS Sample taken for lab. (This sample's chemistry to be compared/related to tested water from 80 metres in F7A)

Airlift final test only available through reverse circulation method 20litres/13 seconds-as lost outside return from 47 metres

EOH at 27mbgl

Well Completion



150 mm PVC collar (0-3mbgl)

Slotted PVC with top cap and end cap (0-27mbgl)

MONITORING BORE LOG

BOREHOLE NUMBER
CCM02

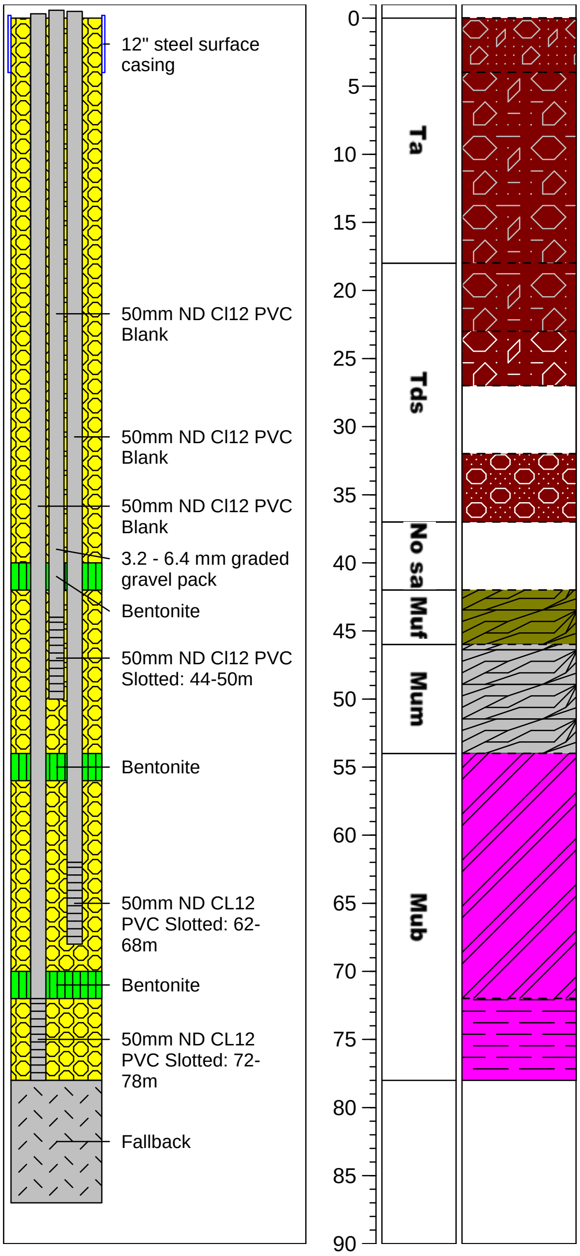
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Christmas Creek Dewatering**
LOCATION: **Christmas Creek**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Air Rotary**
LOGGED BY: **B. Willis-Jones**
FIELD BOOK NO: **CC Book 1**
EASTING: **782386.3m**
NORTHING: **7522299.1m**
TOP of CASING ELEVATION: **438.42mRL**
DATE BEGUN: **6/09/2008** DATE COMPLETED: **10/09/2008**

FINAL BORE DETAILS

	Shallow	Intermediate	Deep
Drilled Depth (mbgl):	87	87	87
Cased Depth (mbgl):	50	68	78
Stick Up (magl):	0.58	0.49	0.32
Airlift Yield (l/s):			
Water Level (mbtoc) & Date:	28.19	28.1	27.58 11/09/08
Quallity - pH & EC (mS/cm)	8.11 / 1790	7.96 / 2820	7.7 / 4350

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (mS/cm)	pH



Silty Gravel: Red brown. Sub angular. Chert & BIF gravel.

Clayey Gravel: Red bown, gravel as above. Clayey matrix. Some clay dominant lenses.

Clayey Gravel: With pisolites. As above with ferriginous pisolites.

Gravelly Clay: Pisolitic. Red brown clay. Minor rounded ferriginous pisoliths (<5mm dia)

No sample

Pisolitic Clay: Red brown. Minor pisoliths.

No sample.

Goethite & Ochreous Goethite (GOM & OGF): Friable, pale brown and yellow.

Martite: Goethite, martite iron formation (Mum). Dark brown, grey & weathered brown to yellow martite xstals. Mod hard and broken. Trace yellow shale at base.

BIF & Chert: Dark grey, with hematite and martite xstals. Reddish brown. Weathered surfaces. Minor banded chert (pale grey). Mod fractured.

Chert & Non-enriched Shale (CH & SH): Dark grey chert, minor bands of black shale.

MONITORING BORE LOG

BOREHOLE NUMBER
FLMB08_D & S

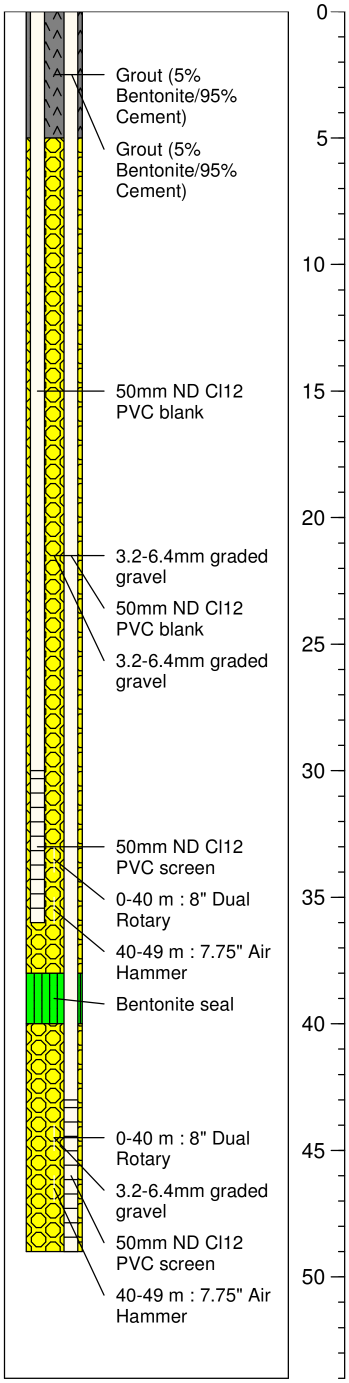
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

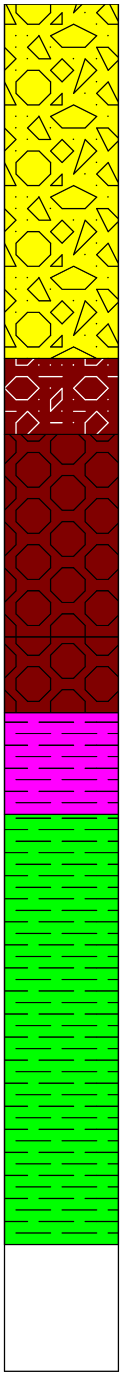
PROJECT NAME: **Flinders**
LOCATION: **Christmas Creek**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Dual Rotary/Air Hammer**
LOGGED BY: **L. Frankcombe**
FIELD BOOK NO: **CC Book 1**
EASTING (m): **778801.867**
NORTHING (m) : **7523917.355**
GROUND LEVEL (mRL): **436.061**
DATE BEGUN: **28/04/2011** DATE COMPLETED: **1/05/2011**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	49			
Cased Depth (mbgl):	49.26			
Casing Stick Up (magl):	0.382999999999981			
Airlift Yield (l/s):				
Water Level (mbtoc) & Date:	24.98			
Quality - pH & EC (uS/cm)	/	/	/	/

GEOCHEMISTRY | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY | DESCRIPTION | YIELD (l/s) | EC (µS/cm) | pH





STRAT	DESCRIPTION
TA	ALLUVIUM: polymictic poorly sorted alluvials SA to SR clasts in a minor clayey matrix
TE	CLAY & GRAVEL: Clay rich gravels minor clasts entrained in thick clay
TD	DETRITALS: pisoid ooid rich gravels with minor SA to A clasts also present
	DETRITALS: Transition zone from pisoid rich gravels into cherty/subeconomic shales
MUT	CHERT & NON-ENRICHED SHALE (CH & SH): Cherty zone with interbedded unmineralised shales also present.
MUB	SHALE: Predominantly Chert zone with interbedded unmineralised shales also present.

YIELD (l/s)	EC (µS/cm)	pH
3.39	1140	7.57
8.51	1832	7.52
8.51	1947	7.52
9	1919	7.56

MONITORING BORE LOG

BOREHOLE NUMBER
HSMB29

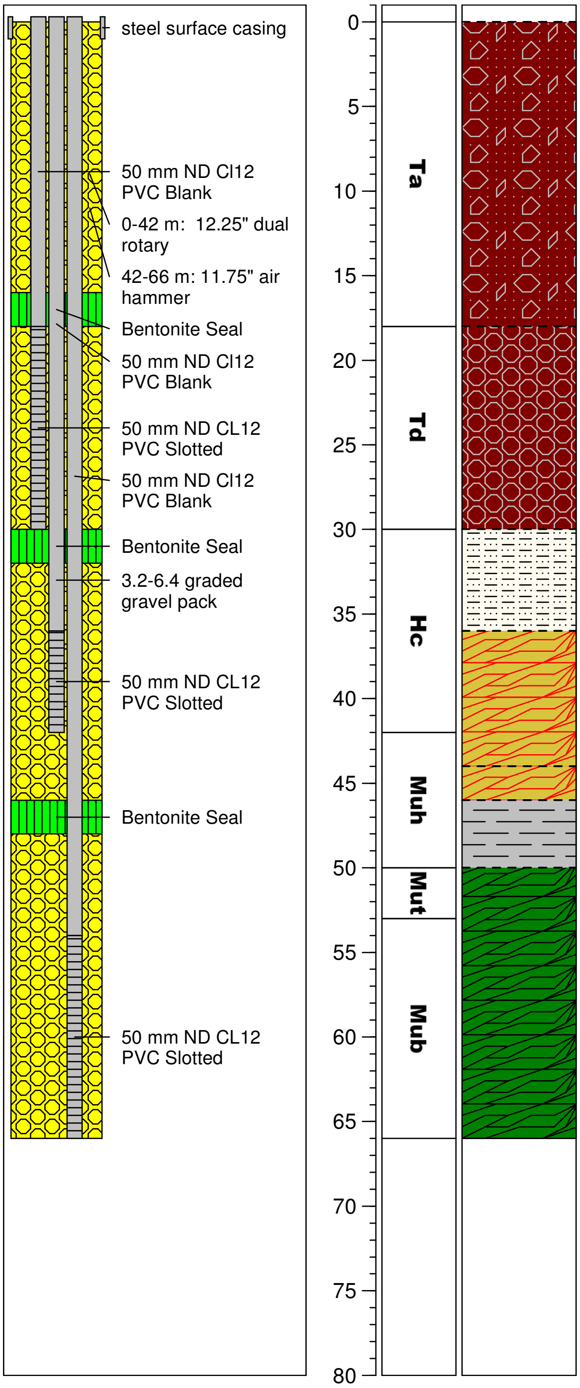
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Hillside East Monitoring**
LOCATION: **Cloudbreak**
DRILLING CO: **Barber Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **K. Everitt**
FIELD BOOK NO: **CB Book 10**
EASTING: **771256.803 m**
NORTHING: **7523532.057 m**
TOP of CASING ELEVATION: **430.078 mRL**
DATE BEGUN: **3/12/2009** DATE COMPLETED: **04/12/2009**

FINAL BORE DETAILS

	Shallow	Intermediate	Deep
Drilled Depth (mbgl):	66	66	66
Cased Depth (mbgl):	30.63	41.29	66
Stick Up (magl):	0.460	0.380	0.310
Airlift Yield (l/s):	trace	low	moderate
Water Level (mbtoc) & Date:	19.36	19.29	19.33 06/12/09
Quallity - pH & EC (mS/cm)	/	8.26 / 4,680	8.15 / 17,300

GEOCHEMISTRY	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



Silty Gravel: Poorly sorted chert, shale and BIF, pink, grey, purple, translucent and brown, angular to sub-round, to 30 mm in a minor brown/orange silty matrix

Pisolitic Gravel: to 24 m, 1-2 mm red/brown pisoliths, to 30 m, up to 5 mm dark grey to dark brown pisoliths. Gravel includes dark brown to dark grey goethite and hematite, med to hard, vuggy, rubbly texture, to 30 mm. Trace white ~waxy shale

Hardcap (HC): Dark grey, dark brown, with purple/red and yellow/brown patches. Hard, rubbly, vuggy. patchy hematite alteration. Trace Pisoliths

Goethite & Hematite : Dark grey, yellow/brown, hard, blocky, goethite and hematite, plus soft ocherous goethite, 42-43 m quite vuggy

Goethite & Hematite : As above, but with shale and chert. Ore colour change to grey/red, higher proportion of hematite. Plus minor weathered shale and chert

Hematised Shale: Platy, grey/red soft-medium hematised shale to 30 mm with minor green and grey ~laminated chert fragments

Hematite & Chert: ~60% angular chert to 25 mm, cream, green, grey, plus platy red/grey hematised shale as above, minor ~chalky white shale. @55 m:quite sandy @56 m:with goethite fragments and purple plasticky clay @59 m:sandy with some leached shale @60 m: minor sticky purple clay, predominantly green chert

YIELD (l/s)	EC (µS/cm)
0.5	399
0.5	2,155
2	1,770
2	1,432
5	2,260
5-8	7,080
10	7,600
10	11,040
10	17,620

MONITORING BORE LOG

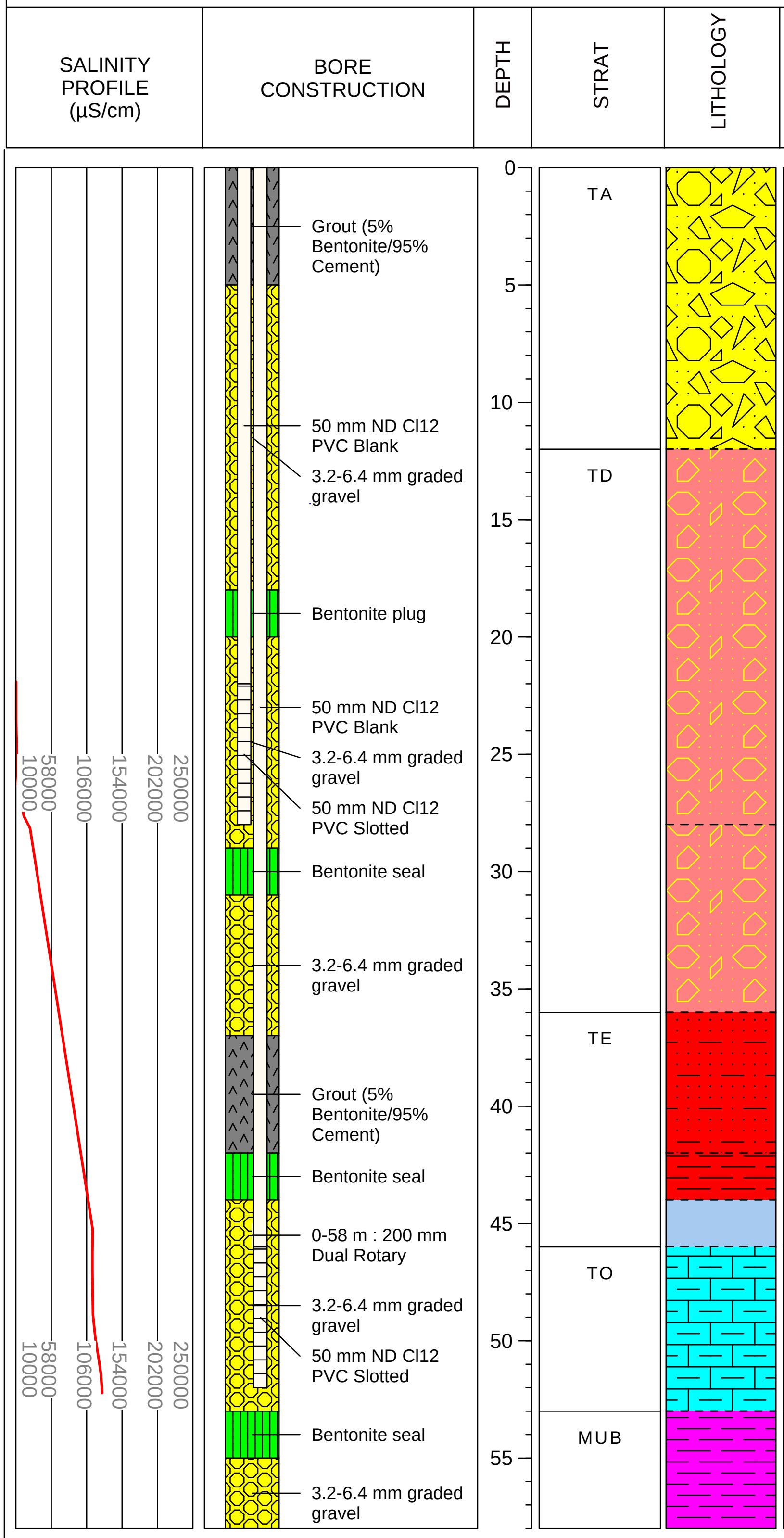
BOREHOLE NUMBER
SAM13

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Saline Program**
LOCATION: **Christmas Creek**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **N. Buchanan**
FIELD BOOK NO: **CC Book 1**
EASTING (m): **778926.611**
NORTHING (m) : **7517701.225**
GROUND LEVEL (mAHD): **419.45** 27/06/11
START DATE: **23/06/2011** COMPLETION DATE:**25/06/2011**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	58		58	
Cased Depth (mbgl):	52.3		28.25	
Casing Stick Up (magl):	0.347		0.403	
Airlift Yield (l/s):	n/a		n/a	
Water Level (mbgl) & Date:	14.32		13.46	
Quality - pH & EC (uS/cm)	/	/	/	/



STRAT	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
TA	ALLUVIUM: Clay matrix, chert, shale; grey and brown; sub-angular to angular; poorly-sorted.			
TD	GRAVELLY SILT: Silt matrix, chert, shale; grey and brown; sub-angular to angular; poorly-sorted. First water strike (FWS) at 22m (5L/s)).	5	8370	7.84
	GRAVELLY SILT: Silt matrix, chert, shale and calcrete; grey and brown (chert and shale) and white (calcrete); sub-angular to angular; poorly-sorted; calcrete is vuggy.	5 5	15450 17550	7.75 7.58
TE	SILT & CLAY: Silt and clay; brown, red and grey.			
	CLAY: Clay; light grey.			
	CALCAREOUS CLAY: Clay with minor calcrete; dark grey.	3	81000	7.32
TO	CALCRETE: Calcrete and minor clay and hematite; grey and white; calcrete is moderately weathered and crumbly.	5	107800	7.33
MUB	BIF & SHALE: BIF, shale and minor siltstone ; dark grey and dark (mustard) yellow.			

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COMPOSITE WELL LOG

Well No: SCX3

Client: Fortescue Metals Group **Project:** Sandy Creek Exploration Drilling

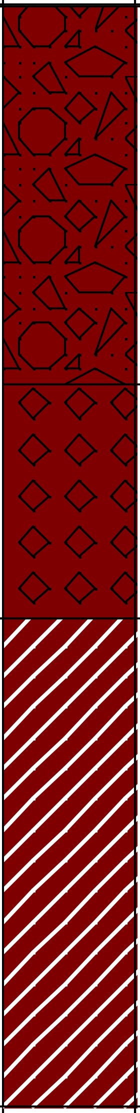
Commenced:	15/08/2005	**Method:**	Mud Rotary	**Area:**	Sandy Creek
Completed:	16/08/2005	**Fluid:**	Mud	**East:**	769600m
Drilled:	Connector	**Bit Record:**	0-6m 9.5", 6-61m 6"	**North:**	7523200m
Logged By:	S. Collett		Dual Observation Bore	**Elevation:**	426m

Static Water Level: D:17.1, S:17.1mbgl **Date:** 24/08/2005

Depth (mbgl) | **Geology** | **Graphic Log** | **Lithological Description** | **Field Notes** | **Well Completion** (**Diagram**, **Notes**)

Depth (mbgl): 0, -10, -20, -30, -40, -50, -60, -70, -80

Geology: Tertiary; Marra Mamba Formation



Lithological Description

ALLUVIUM: Light brown, silty aggregate. Aggregate very coarse, moderately sorted (18-21m).

DETRITAL: Light red/brown, silty detritals. Detritals appear to contain chert clasts to 20% of sample. Mineral exploration hole made water from 33m (maybe small, well sorted layers of aggregate).

BIF: Dark brown, goethite grading to vitreous, lost circulation (40-43m) in vuggy goethite. Yellow ochorous goethite (57-58m) - softer drilling, slightly hematitc to 61m.

Field Notes

*Note: Airlift Yields taken from 25mm dia poly pipe inside 50mm dia PVC casing so yields not indicative of aquifer potential.

1.6-3.2mm Graded Gravel-pack (11-30.2mbgl)

PIEZO D (deep)

Casing height: +0.45magl

Max Airlift Yield 1.9L/s

E.C. = 1.25mS/cm

TDS= 0.62ppt

pH = 6.3

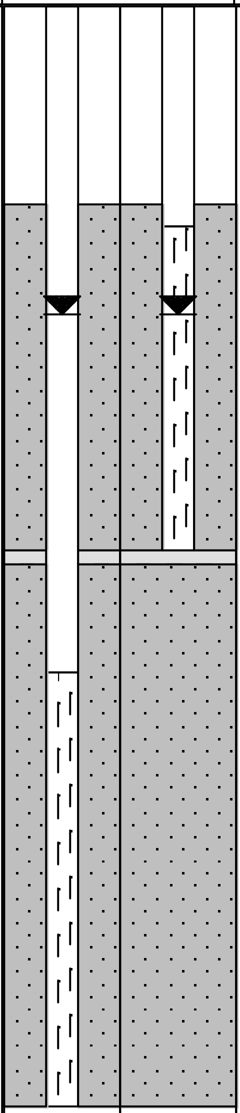
Bentonite Seal (30.2-31mbgl)

50mm Blank Class 9 PVC (0-37mbgl)

1.6-3.2mm Graded Gravel-pack (31-61mbgl)

50mm Slotted Class 9 PVC (37-61mbgl)

EOH at 61mbgl



Notes

6" Cl 9 PVC Surface Casing (0-5.6mbgl)

Surface Casing height: +0.42magl

PIEZO S (shallow)

Casing height: +0.45magl

Max Airlift Yield 0.2L/s

E.C.= 0.61mS/cm

TDS= 0.31ppt

pH = 7

50mm Blank Class 9 PVC (0-12.2mbgl)

50mm Slotted Class 9 PVC (12.2-30.2mbgl)

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COMPOSITE WELL LOG

Well No: SCX5

Client: Fortescue Metals Group
Project: Sandy Creek Exploration Drilling

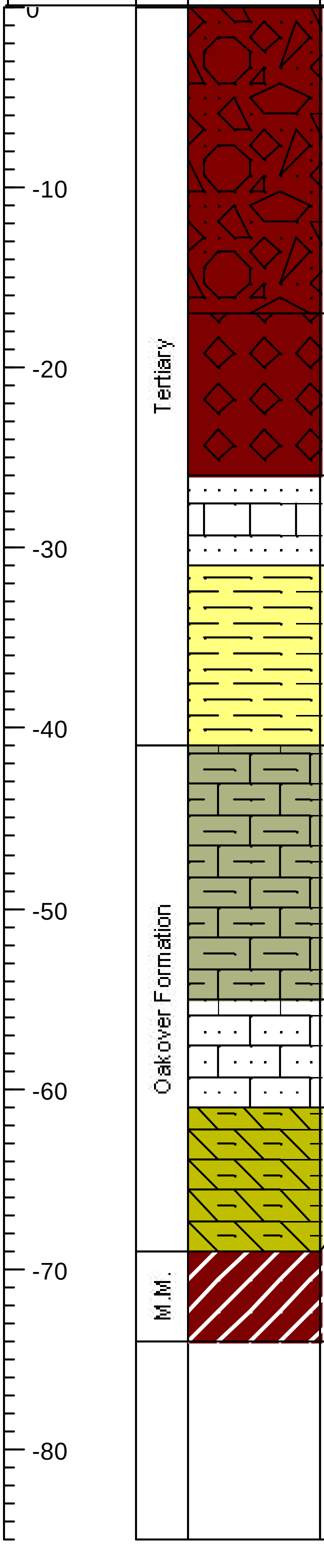
Commenced: 17/08/2005
Completed: 20/08/2005
Drilled: Connector
Logged By: D. Greenhalgh

Method: Mud Rotary
Fluid: Mud
Bit Record: 0-6m 9.5", 6-74m 6"
Dual Observation Bore

Area: Sandy Creek
East: 774400m
North: 7520100m
Elevation: 415m

Static Water Level: D:10.2mbgl, S:8.7mbgl **Date:** 24/08/2005

Depth (mbgl) | **Geology** | **Graphic Log**



Geology	Lithological Description
Tertiary	ALLUVIUM: Silty, clayey aggregate. Red/brown to pale grey and blue, poorly sorted, well-rounded to angular, silty gravel. Predominantly angular chert with minor calcrete/silcrete and trace BIF.
	DETRITAL: Rich brown, fine-grained goethitic/pisolitic gravel with minor to trace chert.
	CALCRETE & GRAVEL: Red/brown to white/pale grey, clayey, medium-grained pisolitic/goethitic gravel with a high % of calcrete (1-10mm dia). Minor chert.
	CLAY: Pale to orangy brown, soft, sticky clay with up to 30% fine to medium grained goethitic gravel.
Oakover Formation	MARL: and Calcareous Clay. 41-43m: White/off-white, soft, elastic clay with minor gravelly fragments. 43-47m: Off-white/yellow to mustard brown, predominantly firm elastic clay. 47-55m: White to off-yellow, soft elastic marl, clay with much higher % of calcareous material. Drilling becoming crunchy, cuttings vuggy.
	CALCRETE AND CLAY: White to off-yellow, predominantly fine to medium grained mix of earthy calcrete sediments in a soft, sticky, clay matrix.
	DOLOMITIC CLAY: Pale grading to dark grey/brown, firm to well cemented, elastic, weathered dolomitic clays. Minor to trace calcrete. 66-69m: Grey/brown to off white/pale grey colour. 20-30% ochorous goethite and BIF.
M.M.	BIF: Grey/brown with minor mustard yellow, goethite and ochorous goethite fragments, chert and up to 10% firm, fine white calcareous clay cuttings. M.M. = Marra Mamba Formation

Field Notes

*Note: Airlift Yields taken from 25mm dia poly pipe inside 50mm dia PVC casing so yields not indicative of aquifer potential.
1.6-3.2mm Graded Gravel-pack (11-30.3mbgl)

PIEZO D (deep)

Casing height: +0.44magl

Max Airlift Yield 0.45L/s

E.C. > 20mS/cm

TDS > 10ppt

pH = 5.7

50mm Blank Class 9 PVC (0-53.5mbgl)

43-47m: Thick elastic clays (change to blade bit).

Bentonite Seal (51-52mbgl)

50mm Slotted Class 9 PVC (53.5-62.5mbgl)

1.6-3.2mm Graded Gravel-pack (52-62.5mbgl)

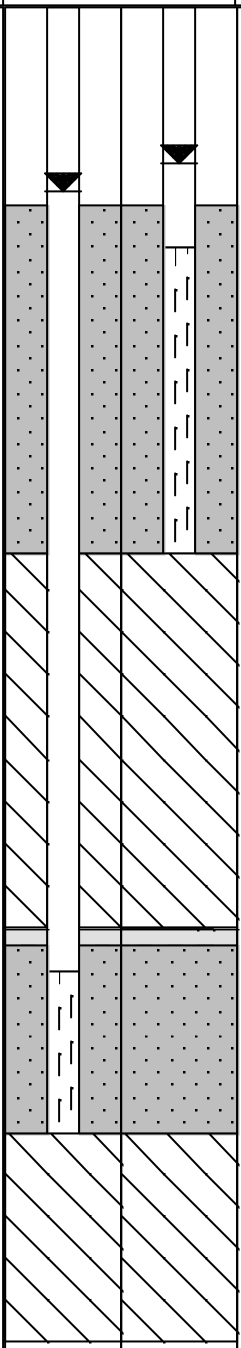
Backfill (62.5-74mbgl)

71-74m: Very hard drilling

EOH at 74mbgl

Well Completion

Diagram



Notes

6" Cl 9 PVC Surface Casing (0-5.6mbgl)

Surface Casing height: +0.38magl

PIEZO S (shallow)

50mm Blank Class 9 PVC (0-13.3mbgl)
Casing height: +0.44magl

Max Airlift Yield 0.22L/s
E.C.= 9.88mS/cm

TDS= 4.93ppt

pH = 6.6

50mm Slotted Class 9 PVC (13.3-30.3mbgl)

MONITORING BORE LOG

BOREHOLE NUMBER
VAM01

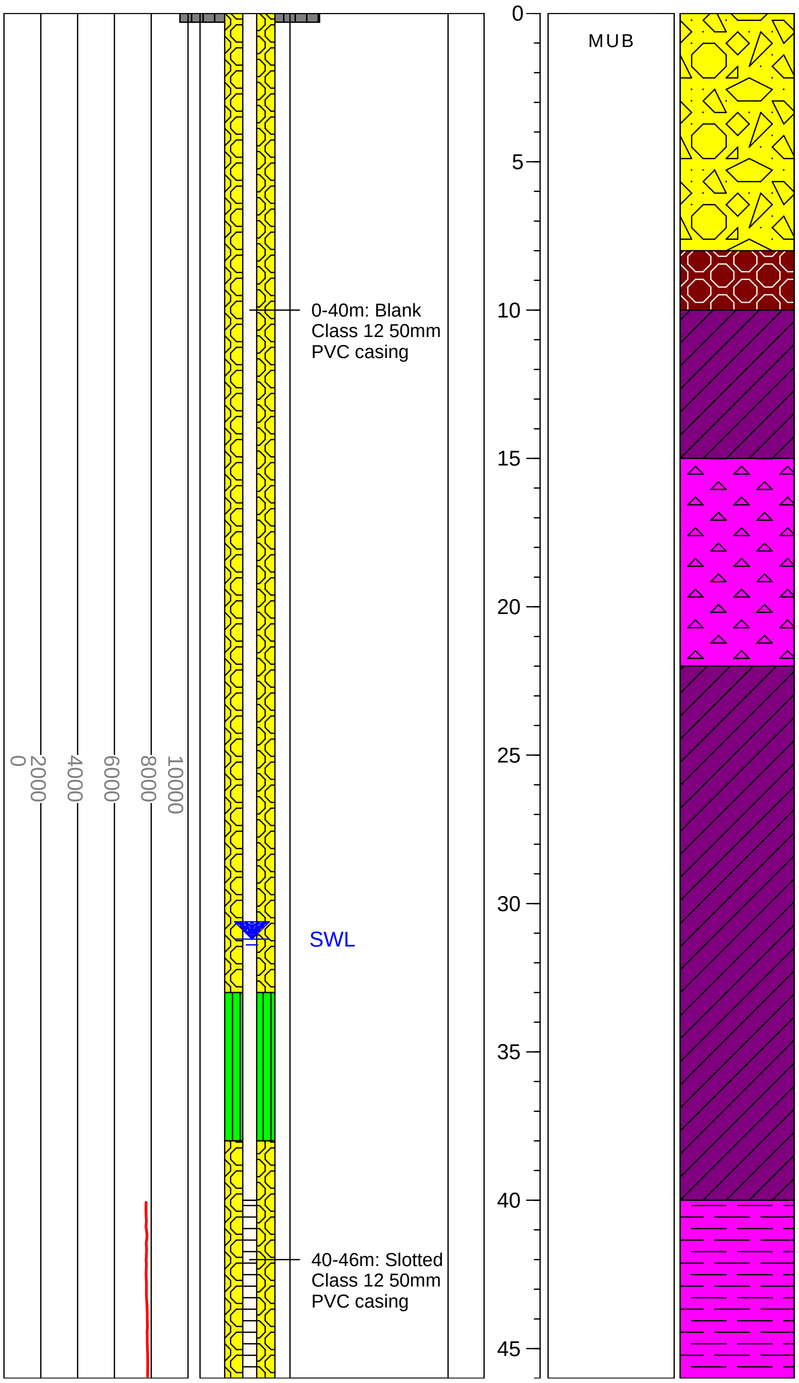
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	
LOCATION:	**Vasse**
DRILLING CO:	**Eastern Well**
DRILLING METHOD:	**Dual Rotary/Air Hammer**
LOGGED BY:	**D. Villablanca**
EASTING (m):	**780528.39**
NORTHING (m) :	**7525181.80**
GROUND LEVEL (mAHD):	**449.00**
START DATE:	**2012-11-19**
COMPLETION DATE:	**2012-11-21**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	46			
Cased Depth (mbgl):	46			
Casing Stick Up (magl):	0.57			
Airlift Yield (l/s):	0.5			
Water Level (mbtoc)	31.2			
Quality - pH & EC (uS/cm)	7.52 / 6070	/	/	/

SALINITY PROFILE (µS/cm) | BORE CONSTRUCTION | DEPTH | STRAT | LITHOLOGY



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
COLLUVIUM: Goetithe glassy, SR-SA, very weathered, yellow-orange, interbedded with pisolitic caps.			
PISOLITIC GRAVEL: pesolitic clast, R, sub-sph, clay matrix (20%)			
BIF & CHERT: BIF, chert, minor goethite very weathered (yellow).			
CHERT: Coarse interlaminated chert. Harder to drill.			
BIF & CHERT: BIF, chert (interlaminated), wet samples 38-40m. FWS@40m. Very small fracture			
BIF & SHALE: grey chert not laminated, harder shale, and BIF. Rare white clay. Low yield under 1 L/s.	1	6070	7.52

MONITORING BORE LOG

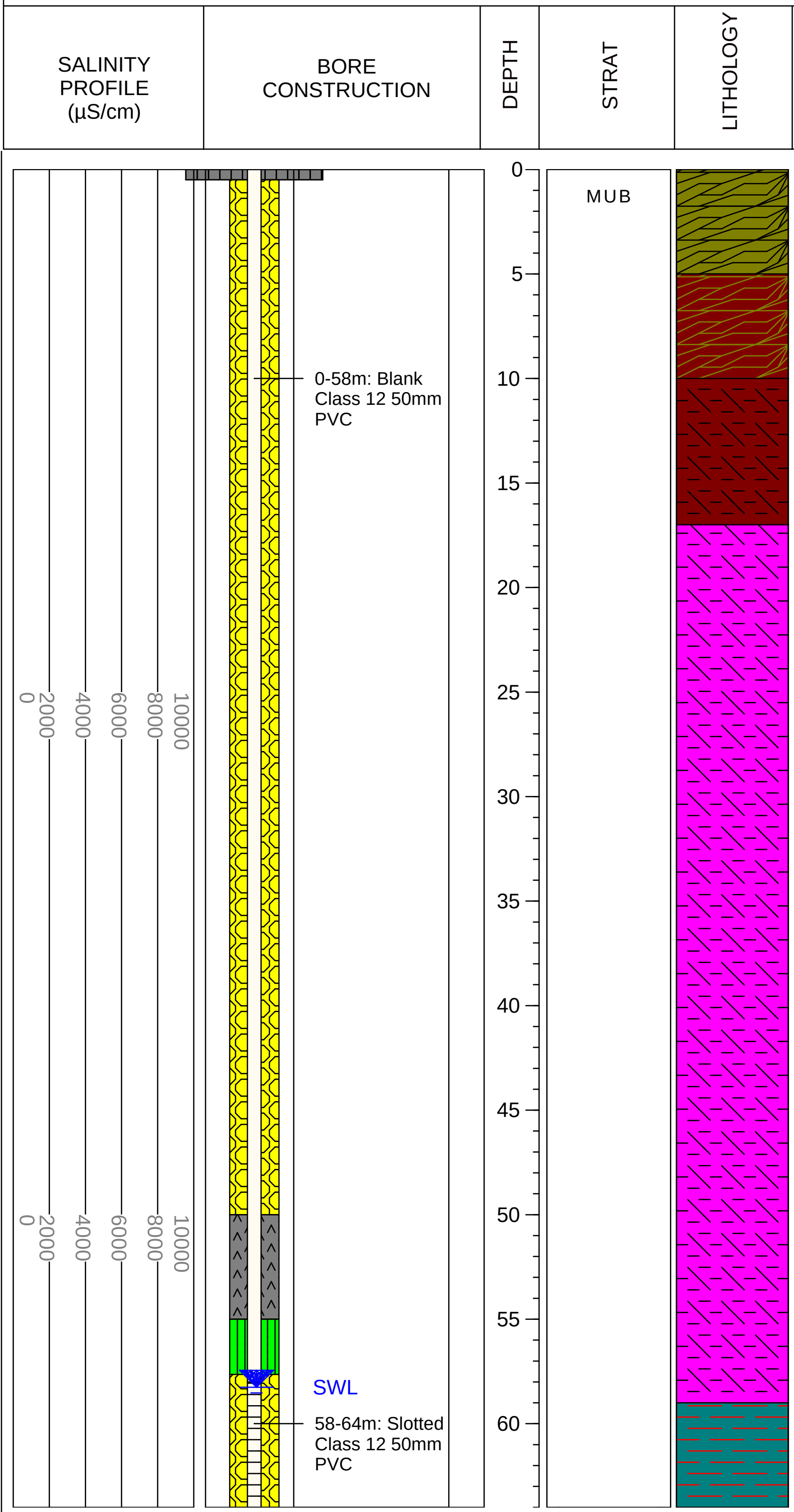
BOREHOLE NUMBER
VAM04

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	
LOCATION:	**Vasse**
DRILLING CO:	**Eastern Well**
DRILLING METHOD:	**Dual Rotary/Air Hammer**
LOGGED BY:	**T Wilkinson**
EASTING (m):	**781630.62**
NORTHING (m) :	**7526181.60**
GROUND LEVEL (mAHD):	**466.75**
START DATE:	**2012-12-02**
COMPLETION DATE:	**2012-12-03**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	64			
Cased Depth (mbgl):	64.3			
Casing Stick Up (magl):	0.48			
Airlift Yield (l/s):	0.5			
Water Level (mbtoc):	58.26			
Quality - pH & EC (uS/cm)	7.74 / 7630	/	/	/



DESCRIPTION

YIELD (l/s)

EC (µS/cm)

pH

GOETHITE: Glassy goethite, hard, yellow, weathered. Outcropping nearby

HEMATITE & GOETHITE: Hematite, goethite, grey, purple, hard,

HEMATITE & CHERT: Hematite, chert (BIF), purple, hard

CHERT & SHALE: Chert, shale bands, minor glassy goethite, brown, white. Colour varies with shale bands. Ground is hard. FWS @ 52m 0.5L/s. very small fracture

SHALE & CHERT: Shale, chert, brown. Much ofter.

MONITORING BORE LOG

BOREHOLE NUMBER

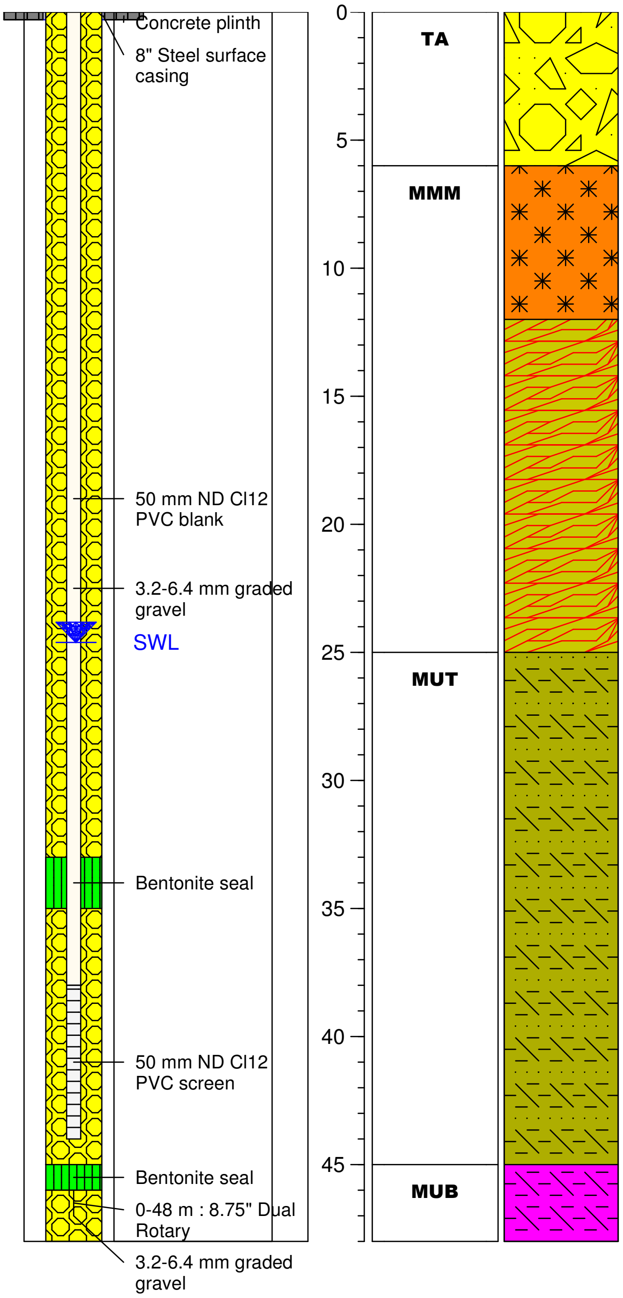
WDM04

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	
LOCATION:	**Christmas Creek**
DRILLING CO:	**Eastern Well**
DRILLING METHOD:	**Dual Rotary**
LOGGED BY:	**D. Villablanca**
EASTING (m):	**785401.55**
NORTHING (m) :	**7521244.10**
GROUND LEVEL (mAHD):	**433.41**
START DATE:	**2012-07-18**
COMPLETION DATE:	**2012-07-20**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	48			
Cased Depth (mbgl):	45.5			
Casing Stick Up (magl):	0.44			
Airlift Yield (l/s):				
Water Level (mbgl)				
Quality - pH & EC (uS/cm)	7.9 /4320	/	/	/



STRAT	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
TA	ALLUVIUM: Brown material, mainly compound of clay and minor polymitic detritals (<1 cm), R-SR. Towards base there are some pisolitic gravels interbedded.			
MMM	HARDCAP: Brown-dark grey material with vuggy chips, SR, <1cm, yellow-mustard to brown, and interbedded detritals of BIF and chert.			
	GOETHITE & HEMATITE: FWS@33m. Dark grey and hard Goethite, Goethite ocherous (yellow and softer), and hematite shale.			
MUT	GOETHITE & CHERT: Dark grey goethite and abundant clast SR of chert of @3cm.	1 2	3070 2150	7.66 7.31
MUB	CHERT & SHALE: Grey-blue material, mainly chert (80%) with interbedded black and soft shale. The last meter represent a transition zone towards Roy Hill Shale Formation.	3.5	3160	7.44

MONITORING BORE LOG

BOREHOLE NUMBER

WDM06

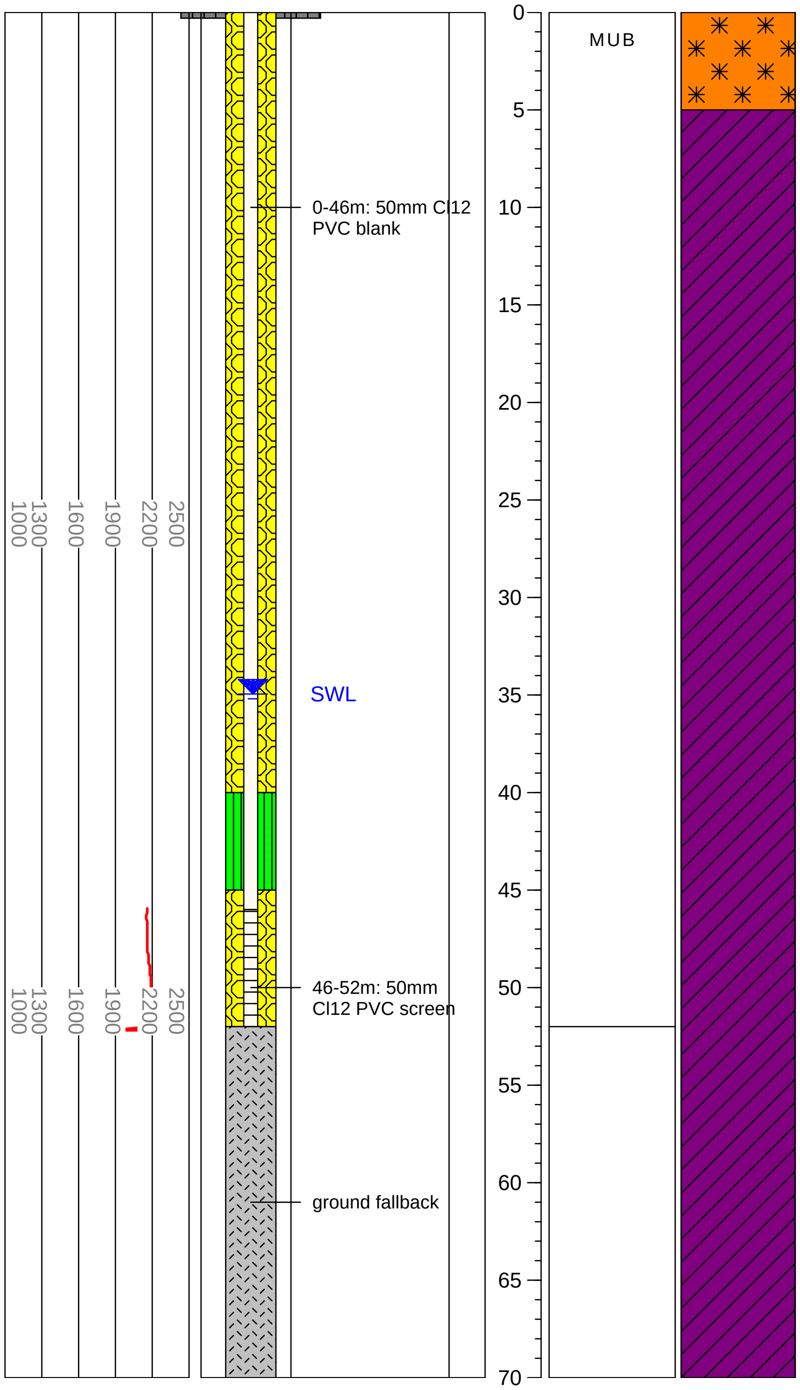
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:
LOCATION: **Windich Tailings**
DRILLING CO: **Ausdrill**
DRILLING METHOD: **Air hammer**
LOGGED BY: **Aline Barrabes, Daniela Villablanca**
EASTING (m): **785785.70**
NORTHING (m) : **7522033.51**
GROUND LEVEL (mAHD): **443.69**
START DATE: **2012-08-27**
COMPLETION DATE: **2012-08-28**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	70			
Cased Depth (mbgl):	52			
Casing Stick Up (magl):	0.16			
Airlift Yield (l/s):				
Water Level (mbtoc)	34.95			
Quality - pH & EC (uS/cm)	/	/	/	/

SALINITY PROFILE (µS/cm)	BORE CONSTRUCTION	DEPTH	STRAT	LITHOLOGY	DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH



HARDCAP: Vitreous goethite and maghemite pisoids; vuggy and weathered; yellow brown.

BIF & CHERT: BIF, chert, dark grey, numerous shale bands, very small fractures near base

MONITORING BORE LOG

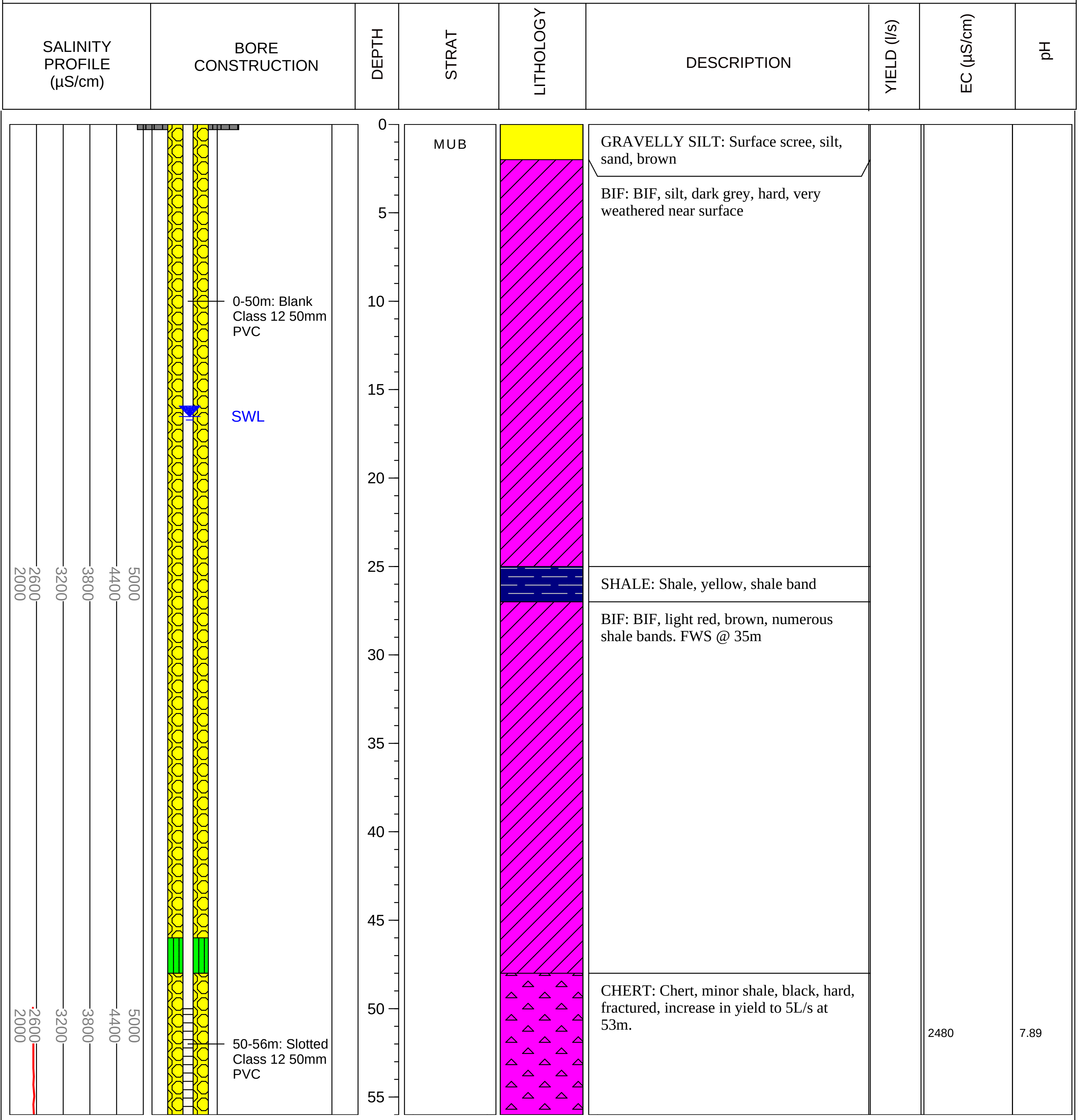
BOREHOLE NUMBER
WDM08

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:
LOCATION: **Windich Tailings**
DRILLING CO: **Connector Drilling**
DRILLING METHOD: **Dual Rotary/Air Hammer**
LOGGED BY: **Tim Wilkinson**
EASTING (m): **786174.91**
NORTHING (m) : **7522570.60**
GROUND LEVEL (mAHD): **461.45**
START DATE: **2012-09-06**
COMPLETION DATE: **2012-09-08**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	56			
Cased Depth (mbgl):	56			
Casing Stick Up (magl):	0.137			
Airlift Yield (l/s):				
Water Level (mbtoc)	16.52			
Quality - pH & EC (uS/cm)	7.63 / 2310	/	/	/



GRAVELLY SILT: Surface scree, silt, sand, brown

BIF: BIF, silt, dark grey, hard, very weathered near surface

SHALE: Shale, yellow, shale band

BIF: BIF, light red, brown, numerous shale bands. FWS @ 35m

CHERT: Chert, minor shale, black, hard, fractured, increase in yield to 5L/s at 53m.

MONITORING BORE LOG

BOREHOLE NUMBER

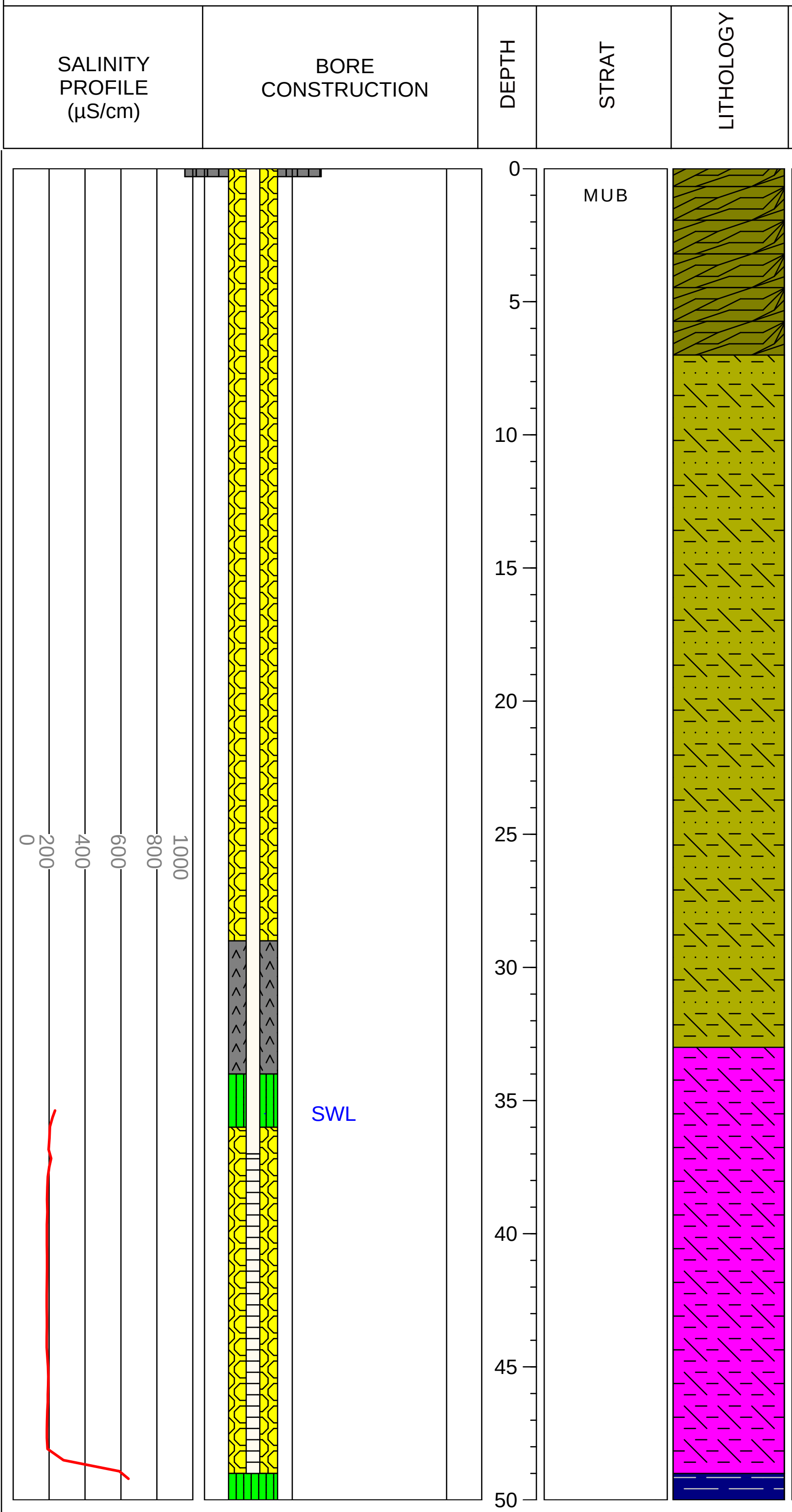
WDM12

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:
LOCATION: **Windich Tailings**
DRILLING CO: **Eastern Well**
DRILLING METHOD: **Dual Rotary/Air Hammer**
LOGGED BY: **D. Villablanca**
EASTING (m): **784781.54**
NORTHING (m) : **7521871.21**
GROUND LEVEL (mAHD): **442.85**
START DATE: **2012-12-03**
COMPLETION DATE: **2012-12-05**

FINAL BORE DETAILS

	Deep	Intermediate	Shallow	WT
Drilled Depth (mbgl):	50			
Cased Depth (mbgl):	49			
Casing Stick Up (magl):	0.85			
Airlift Yield (l/s):				
Water Level (mbtoc)	35.49			
Quality - pH & EC (uS/cm)	7.72 / 1802	/	/	/



DESCRIPTION	YIELD (l/s)	EC (µS/cm)	pH
GOETHITE: yellow goethite, dark grey goethite and minor chert. No economic ore.			
GOETHITE & CHERT: dark grey goethite, grey-cream chert, minor dark grey shale			
CHERT & SHALE: grey-cream and red chert, clay and minor BIF (brown, harder). FWS@46m. Very low yield and muddy (no sample), but increase towards base to 2 L/s.	2	1611	7.88
SHALE: grey shale, soft and dry samples.			

MONITORING BORE LOG

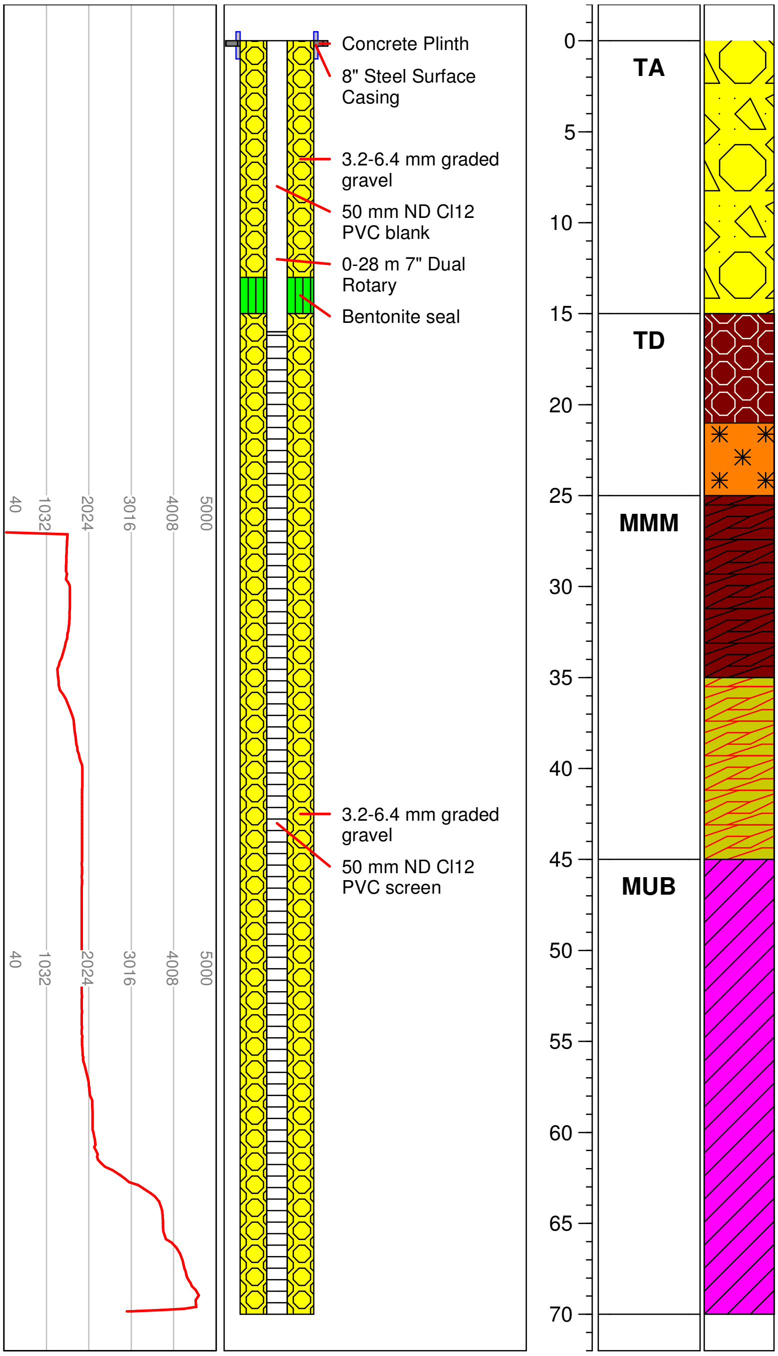
BOREHOLE NUMBER
YGM01

Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME: **Young Strip 50-58 60-62**
LOCATION: **Young Pit**
DRILLING CO: **Eastern Well**
DRILLING METHOD: **Dual Rotary**
LOGGED BY: **Z. Boniecki**
FIELD BOOK NO:
EASTING: **790150.14**
NORTHING: **7519273.33**
ELEVATION (mAHD): **436.40**
DATE BEGUN: **2013-05-25** DATE COMPLETED: **2013-05-26**

FINAL BORE DETAILS		
Drilled Depth (mbgl):	70	
Cased Depth (mbgl):	70.4	
Stick Up (magl):	0.635	
Airlift Yield (L/s):		
Water Level (mbgl) & Date:	27.02	
Quallity - pH & EC (uS/cm):	7.85	3310

SALINITY PROFILE (uS/cm) | BORE CONSTRUCTION | DEPTH (mbgl) | STRATIGRAPHY | LITHOLOGY | DESCRIPTION | YIELD (L/s) | EC (µS/cm) | pH



ALLUVIUM: Chert 60% blocky SA-A hard 3-30 mm, Hematite and Shale 20% SR, silt 20%, clast support, poorly sorted, unconsolidated, red brown

PISOLITIC GRAVEL: well formed spherical pisolites in silt matrix, minor amounts of vitreous geothite hardcap increasing with depth gradual change between predominantly pisolites and hardcap. Red-brown - brown

HARDCAP: well formed vitreous geothite 80% with geothite cemented pisolites 20%, high hardness, minor chips vuggy, moderately uniform chip size 3-10 mm

HEMATITE: Predominantly hematite 90% high hardness uniform chip size 2-5 mm, tabular to blocky, minor to no weathering. Larger chips with weathered surfaces at 28 and 34 m. Dark grey

GOETHITE & HEMATITE: Geothite 50% Hematite 40% and ocherous geothite 10% high hardness, tabular and platey small uniform chips 2-3 mm no visible signs of major fractures yellow brown to brown

BIF: Chert 60% Shale 25% and hematite 15% moderately uniform chips size 3-15 mm low to no weathering high hardness, sharp transition from MMM, varies in shale content, grey. Large chips with weathering at 48-50 m, 53 m and 55 m. Purple weathered hematitic shal

YIELD (L/s)	EC (µS/cm)	pH
1	6840	8.3
1	7950	8.01
1	7820	7.88
1	6600	7.82
1	6580	7.82
1	5070	7.82
2	2141	7.8
2	3050	7.84
2	3180	7.92
2	3820	7.85
3	1431	7.94
3	4040	7.89
3	2620	7.89

MONITORING BORE LOG

BOREHOLE NUMBER
YGM02

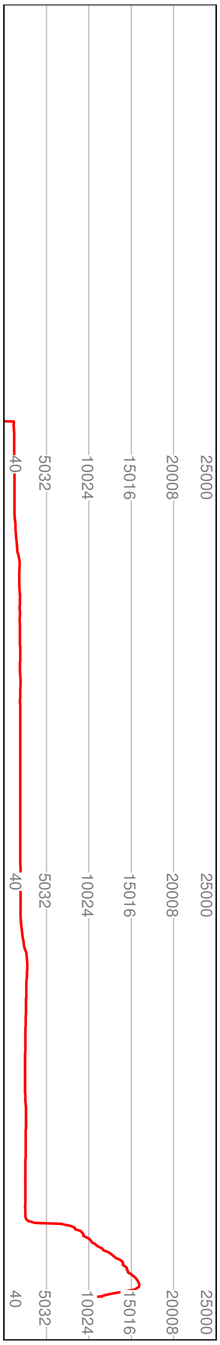
Fortescue Metals Group Ltd
Level 2, 87 Adelaide Terrace
East Perth, WA 6004
PH: 08 62188888 FAX: 08 62188880

PROJECT NAME:	**Young Strip 50-58 60-62**
LOCATION:	**Young Pit**
DRILLING CO:	**Eastern Well**
DRILLING METHOD:	**Dual Rotary/Air Hammer**
LOGGED BY:	**Z. Boniecki**
FIELD BOOK NO:	
EASTING:	**789814.79**
NORTHING:	**7518794.34**
ELEVATION (mAHD):	**432.18**

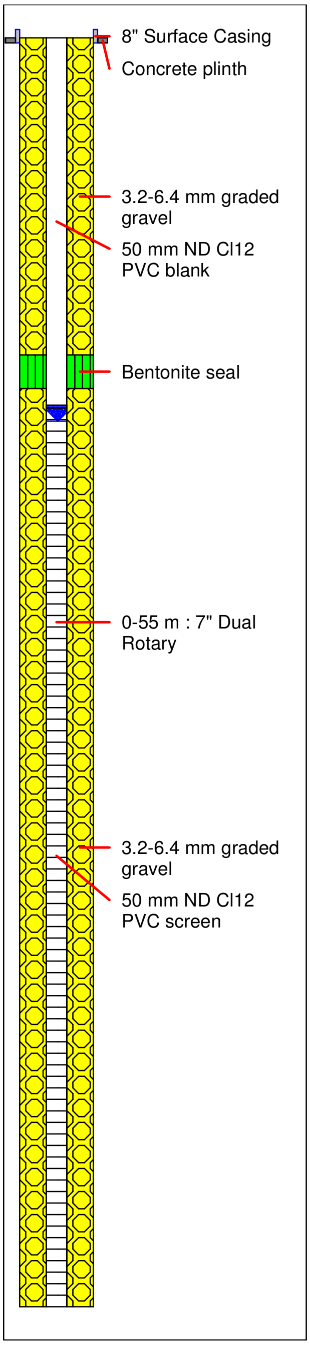
DATE BEGUN: **2013-05-23** DATE COMPLETED: **2013-05-25**

FINAL BORE DETAILS		
Drilled Depth (mbgl):	76	
Cased Depth (mbgl):	76.4	
Stick Up (magl):	0.684	
Airlift Yield (L/s):		
Water Level (mbgl) & Date:	22.96	
Quallity - pH & EC (uS/cm):	7.97	5310

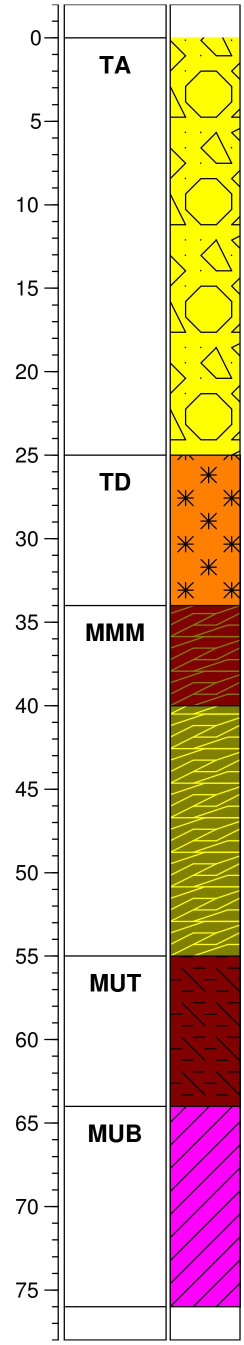
SALINITY PROFILE (uS/cm)



BORE CONSTRUCTION



DEPTH (mbgl) | STRATIGRAPHY | LITHOLOGY



STRATIGRAPHY	DESCRIPTION
TA	ALLUVIUM: Predominantly clasts of 60% chert A-SA blocky 2-30 mm size, 20% hematite SR 2-6 mm size and 10% shale SR tabular in 20% silt matrix. Poorly sorted minor pisolites near base, unconsolidated; red brown
TD	HARDCAP: Vitreous geothite well formed hardwith minor silt. Some remenent chert alluvium visible at 29 m. mostly small uniform chips 3-6 mm, larger vuggy and fractured chips at 30-34 m; consolidated
MMM	HEMATITE & GOETHITE: Highly weathered hematite and geothite low to mod hardness silty and dark brown. Becoming fresher with depth minor vitreous geothite, non-uniform chip size 2-20 mm, fracturing evident 36-40 m
	GOETHITE & OCHEROUS GOETHITE: Geothite, hematite and ocherous geothite, platey + tabular chips mod-high hardness mostly non-uniform chips 3-20 mm. Fracturing, precipitation and weathering visible on chips 42-48 m, clay silt infill at 49 m, large chips + weathering at 52-55m; yellow br
MUT	HEMATITE & CHERT: Purple platey hematite 50% and blocky chert 50% mostly uniform chips; larger weathered chip at 61-64 m
MUB	BIF: Predominantely chert >60% with geothite, hematite and shale moderately weathered at 64 m, becoming fresher with depth, fairly consistant chip size 2-6 mm, black shale visible in water, very little in chips at 75 m.

YIELD (L/s)	EC (µS/cm)	pH
1	9240	7.56
1	2660	7.63
1	2460	7.65
3	1725	7.65
3	3010	7.68
5	2003	7.75
5	2252	7.82
5	2125	7.79
5	2580	7.83
5	2550	7.84
5	3120	8.09
6	2590	7.97
6	2770	8.1
6	2640	8.25
6	3980	8.3
6	10320	8.27

Name	Depth Top	Depth Base	Material	Comment
FITL-MB-002	-0.55	0	Surface casing	Blue Steel Enviro Cap
FITL-MB-002	0	0.3	Cement	Concrete Plinth
FITL-MB-002	0.3	66	Backfill	Drill cuttings
FITL-MB-002	66	72	Bentonite seal	Bentonite seal 66 - 72m
FITL-MB-002	0	72	Nothing	0 - 72 m: 61/4" Mud Rotary (roller bit)
FITL-MB-002	0	74	Blank	50 mm Class 12 uPVC Blank
FITL-MB-002	97.9	98	Endcap	PVC End Cap
FITL-MB-002	72	98	Gravel pack	3.2-6.4mm graded gravel
FITL-MB-002	74	98	Slotted PVC	50 mm Class 12 uPVC Screen
FITL-MB-002	98	99	Fallback	Fallback
FITL-MB-002	72	99	Nothing	72 - 99m : 61/4" Mud Rotary (Blade bit)
King Flowing Bore	3	3	Bit Record: 0 - 47 m : Reverse Circulation - Resource exploration drilling	
King Flowing Bore	0	5	Blank	PVC Drill Collar
King Flowing Bore	-1.63	11	Blank	100 mm Class 12 uPVC Blank
King Flowing Bore	46.9	47	Endcap	PVC End Cap
King Flowing Bore	0	47	Gravel pack	Gravel pack - bridging possible
King Flowing Bore	11	47	Slotted PVC	100 mm Class 12 uPVC Slotted
KMB12S	-0.69	0	Surface casing	Blue Steel 'Enviro Cap'
KMB12S	0	0.3	Cement	Concrete Plinth
KMB12S	-0.69	3	Blank	50 mm Class 12 uPVC Blank
KMB12S	0	3	Collar	254 mm Steel Collar
KMB12S	3	3	Bit Record: 0 - 3m: 254 mm Air Hammer; 3 - 9m: 203 mm Mud Rotary	
KMB12S	5.9	6	Endcap	PVC End Cap
KMB12S	0	6	Gravel pack	3.2-6.4mm graded gravel
KMB12S	3	6	Slotted PVC	50 mm Class 12 uPVC Screen
KMB12S	6	9	Fallback	Fallback
SMB1005	-0.38	0.12	Surface casing	215.2 mm OD x 6.35 mm WT Steel Surface Casing
SMB1005	0	0.3	Cement	Concrete Plinth
SMB1005	0	2	Cement	Cement and Bentonite Seal (0-2 m)
SMB1005	-0.35	23.5	Blank casing	Blank 50 mm PN12 uPVC Casing (+0.35-23.5 m)
SMB1005	47.4	47.5	Endcap	PVC Endcap
SMB1005	2	47.5	Gravel pack	Gravel Pack (3.2-6.4 mm)
SMB1005	23.5	47.5	Slotted casing	Slotted 50 mm PN12 uPVC Casing (23.5-47.5 m)
SMB1005	47.5	52	Fallback	Fallback
SMB1005	0	52	Bit Record: 0 - 42m : 203.2 mm Dual Rotary. 42 - 52m: 197 mm Air Rotary	
SMB1008	-0.45	0.05	Surface casing	215.2 mm OD x 6.35 mm WT Steel Surface Casing
SMB1008	0	0.3	Cement	Concrete Plinth
SMB1008	0	3	Cement	Cement and Bentonite Seal (0-3 m)
SMB1008	-0.39	23	Blank casing	Blank 50 mm PN12 uPVC (Casing 0.39-23 m)
SMB1008	58.9	59	Endcap	PVC Endcap
SMB1008	3	59	Gravel pack	Gravel Pack (3.2-6.4 mm)
SMB1008	0	59	Bit Record: 0 - 53m : 203.2 mm Dual Rotary. 53 - 59m: 197 mm Air Rotary	
SMB1008	23	59	Slotted casing	Slotted 50 mm PN12 uPVC Casing (23-59 m)
SMB1021	-0.3	0	Cement	Concrete Plinth

Name	Depth Top	Depth Base	Material	Comment
SMB1021	3	3	Bit Record: 0 - 90m	
SMB1021	-0.57	3	Surface casing	Collar
SMB1021	0	39	Backfill	Backfill
SMB1021	39	40	Bentonite	Bentonite seal
SMB1021	-0.54	43.5	Blank	2" NB Blank PVC Casing
SMB1021	40	49.5	Gravel pack	1.6-3.2mm graded gravel
SMB1021	43.5	49.5	Slotted PVC	2" Slotted PVC Casing
SMB1032	-0.3	0	Cement	Concrete Plinth
SMB1032	3	3	Bit Record: 0 - 15m : Air Hammer	
SMB1032	-0.81	3	Surface casing	Blue Steel 'Enviro Cap'
SMB1032	0	9	Gravel pack	3.2-6.4mm graded gravel
SMB1032	9	11	Bentonite	Bentonite seal
SMB1032	-0.81	12	Blank	50 mm Class 12 uPVC Blank
SMB1032	11	15	Gravel pack	3.2-6.4mm graded gravel
SMB1032	12	15	Slotted PVC	50 mm Class 12 uPVC Screen
TRIN-MB-002	0	0	Surface casing	Steel surface casing (unknown size and type)
TRIN-MB-002	0	0.3	Cement	Concrete Plinth
TRIN-MB-002	0	3	Collar	8" steel collar
TRIN-MB-002	0	3	Bit Record: 0 - 3 m: 95/8" collar	
TRIN-MB-002	0	8	Blank	50 mm Class 12 uPVC Blank
TRIN-MB-002	13.9	14	Endcap	PVC End Cap
TRIN-MB-002	0.3	14	Gravel pack	3.2-6.4mm graded gravel
TRIN-MB-002	3	14	Bit Record: 0 - 14m : 61/4" Mud Rotary	
TRIN-MB-002	8	14	Slotted PVC	50 mm Class 12 uPVC Screen