



# Waste Rock Management Plan





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## 1 INTRODUCTION

### 1.1 Purpose

This Waste Rock Management Plan (WRMP) builds on the commitments made in the Environmental Assessment (EA) and provide further details on the measures to be implemented during the operational phase of the Woodlawn Project (Project) to ensure that the Project's actual environmental impacts are consistent with those evaluated in the EA. The WRMP also provides the mechanism to adapt new measures throughout the ongoing operation to improve the management and identification of waste rock characteristics.

The WRMP forms one component of the overall Project Environmental Management Strategy (EMS). The EMS includes a number of commitments and component management plans which together form the basis for the ongoing operation of the Woodlawn Mine.

### 1.2 Scope

This WRMP covers the required testing and identification of potentially acid forming materials on site and provides a mechanism for handling such material in accordance with Schedule 4 Condition 19 of the Project Approval.

### 1.3 Key Personnel and Responsibilities

Management responsibility for the Woodlawn Mine are as follows.

**Table 1 - Management Responsibilities**

Position	Personnel	Company	Responsibility	Contact Details
Managing Director	Wayne Taylor	Heron	Overall responsibility for the construction and operation of the Woodlawn Project	02 9119 8111
Chief Operating Officer	Andrew Lawry	Heron	Responsible for project delivery and operations	02 4816 6341
General Manager	Brian Hearne	Heron	Conduct of mining operations	02 4816 6344
Mine Manager	Simon Fitzgerald	Heron	Management of mining operations and engineering	02 4816 6323
Mine Technical Superintendent	Tim Brettell	Heron	Mine Planning and Design	02 4816 6349
Geology Superintendent	Katie Yamaguchi	Heron	Resource evaluation and waste rock identification and modelling	02 4816 6325
Environmental Officer	Dr Zoe Read Kat McGilp	Heron	On site environmental management	02 4816 6335
Environmental Consultant	Robert Byrnes	IEC	Conduct of environmental management and compliance	02 4878 5502

The above table will be updated as required during the course of the project.



## 1.4 Legislative Requirements

The key legislation relative to the management of waste rock on site is the Environmental Planning and Assessment Act 1979 (EP&A Act) from which the Project Approval was granted. The Project Approval specifies the requirement to prepare a plan to manage waste rock generated by the project, and in particular, to establish procedures and management initiatives to ensure that waste rock which has the potential to create acid drainage is managed so as not to cause environmental issues during the operation and final closure of the Woodlawn Mine. Other legislation relevant to the management of waste rock are listed below:

**Mining Act 1992** – This Act covers all mining activities on the surface and underground and includes provisions for the management and rehabilitation of wastes. The Woodlawn Mine operates in accordance with a Mining Operations Plan prepared in accordance with the Mining Act which includes provisions for managing potential acid forming materials, monitoring of surface sites which generate acidic and metalliferous waters and the final rehabilitation of these areas. This WRMP conforms to the current MOP however any future changes to either this plan or the MOP will need to be aligned.

**Protection of the Environment Operations Act 1997 (POEO Act)** - The POEO Act is administered by the EPA and requires licensing for environmental protection, including waste generation and disposal, water, air and noise pollution. Under the POEO Act, an EPL is required for the Woodlawn Mine as it is defined as a scheduled activity. The Woodlawn Mine will operate under the provisions of EPL 20821 which currently does not include any specific conditions in relation to waste rock but covers the generation of greater than 100 tonnes of mineral wastes per annum. Conditions relevant to this plan include the monitoring of seepage from the Rehabilitated Waste Rock Dump and disposal of wastes to be conducted in a competent manner.

## 1.5 Project Approval Requirements

The Woodlawn Project received Project Approval on 4<sup>th</sup> July 2013 with subsequent modifications received on 22<sup>nd</sup> April 2016 and 6<sup>th</sup> July 2017. The approval was obtained under the provisions of Part 3A of the Environmental Assessment Act 1979 and following the public exhibition of an Environmental Assessment document.

The EA contained a number of environmental commitments while the Project Approval and subsequent modification was also subject to conditions. Table 2 lists the conditions and proponent commitments relating to the preparation of this WRMP:

**Table 2 - Consent Conditions Relating to Waste Rock Management**

Condition	Description	Where Addressed
Sch 3 Condition 6	Any seepage from the waste rock dumps to be contained and treated on the site	Section 3.3
Sch 4 Condition 3	Within 5 years of the date of this approval, the Proponent shall identify the passive system to treat seepage from the existing Waste Rock Dump in consultation with DRG, and implement the preferred system to the satisfaction of the Secretary	Section 3.3
Sch 4 Condition 4c	A program to monitor ... potential acid rock drainage from the waste rock dumps.	Section 4.2
Sch 4 Condition 4d	A program to monitor .... the effectiveness of the seepage collection, treatment and storage system associated with the tailings dams, waste rock dumps, evaporation dams and all other water storages that receive contaminated or salt-laden water	Section 4.2
Sch 4 Condition 4e	a Surface and Ground Water Response Plan that includes .... trigger levels for investigating any potential adverse surface water and groundwater impacts of the project, including but not limited to seepage of contaminated water from the tailings dams, waste rock dumps, evaporation dams and the Woodlawn Landfill	Section 5.3



Sch 4 Condition 19	<p>The Proponent shall prepare and implement a Waste Rock Management Plan to the satisfaction of the Secretary. The plan must:</p> <p>(a) be developed in consultation with DRG, EPA and DPI-Water;</p> <p>(b) be submitted for the approval of the Secretary prior to commencing underground mining operations;</p> <p>(c) include a detailed description of the procedures to be implemented to monitor and manage potential acid forming material, including:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> testing for potentially acid forming waste (PAF) rock prior to it being brought to the surface;</li> <li><input type="checkbox"/> prioritising the relocation of PAF material to suitable underground locations prior to oxidation;</li> <li><input type="checkbox"/> using all reasonable and feasible measures to prevent waste rock emplaced underground from further oxidising or causing impacts on groundwater;</li> <li><input type="checkbox"/> trigger levels for any material that has oxidised to the extent that it cannot be placed underground without impacting groundwater quality, and procedures for adequate capping and sealing of such material at the surface;</li> <li><input type="checkbox"/> effective isolation and/or neutralisation of PAF material in waste rock dumps; and</li> </ul> <p>(d) reflect the groundwater and surface water monitoring programs to monitor PAF waste rock and any leachate generated, including appropriately designed detection and response systems for acid generation</p>	<p>This Plan</p> <p>Section 1.6</p> <p>Noted</p> <p>Section 3.2</p> <p>Sections 3.2.4, 3.2.5</p> <p>Section 3.2</p> <p>Section 3.2.5</p> <p>Section 2.3</p> <p>Sections 4.1 and 4.2</p>
<b>Statement of Commitments</b>		
Item 5A Soils & Waste	<p>The EMS to be developed and implemented for the Project Site would include procedures for the identification and management of acid-producing waste rock; the storage and handling of chemicals and hydrocarbons; storage, handling and transportation of mineral concentrates; and the management and disposal of tailings.</p>	Section 3.2
Item 5E Soils & Waste	<p>A waste management plan would be developed to address the core objectives of waste minimisation and recycling throughout the Project. The plan would include:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> carefully separating potentially acid forming (PAF) waste rock from non-acid forming (NAF) waste rock;</li> <li><input type="checkbox"/> designing the waste rock emplacement to 'enclose' PAF rock to mitigate against acid generation;</li> <li><input type="checkbox"/> diverting any surface run-off or seepage from the waste rock emplacement to TSF4;</li> <li><input type="checkbox"/> tracking hazardous waste through the establishment of a hazardous waste tracking system;</li> <li><input type="checkbox"/> undertaking targeted rock testing on rock samples from the WUP geological core library, to develop a sulfidic waste management and monitoring plan; and</li> <li><input type="checkbox"/> disposing of PAF waste in underground voids, in the tailings dams or in a dump that is capped and rehabilitated.</li> </ul>	Section 3.2
Item 5I Soils & Waste	<p>Waste rock would be progressively characterised for net acid generating potential, both through physical identification by geologists and laboratory analysis.</p>	Section 4.1

## 1.6 Consultation

Schedule 4 Condition 19 of the Project Approval requires this WRMP to be prepared in consultation with the NSW Department of Planning Division of Resources and Geoscience (DRG), Environmental Protection Authority (EPA) and the NSW Department of Primary Industries - Water (DPI-Water) prior to being submitted to the Secretary of the Department of Planning and Environment (DPE) for approval. No comments were received prior to the preparation of version 5.

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Version 4 of the WRMP was prepared for the purposes of consultation with government agencies. Version 5 includes comments received from the Department of Planning and Environment as listed in the table below. No other comments have been received.

**Table 3 - Comments from Department of Planning and Environment**

Condition	Action Required	Where Addressed
19(a) of Sch 4	Provide evidence of consultation with EPA, DRG and DPI-Water	Correspondence provided separately
19(b) of Sch 4	No further action	Noted
19(c) of Sch 4	No further action required	Noted
19(d) of Sch 4	<p>Table 5 Monitoring Parameters and Testing Frequency include testing parameters for waste rock prior to it being brought to the surface (as detailed in section 3.2).</p> <p>The plan states that waste rock may be stored in the Waste Rock Emplacement for up to 2 years. It is recommended that the plan include details of how the relocation of potential acid forming material from the Waste Rock Emplacement to suitable underground locations will be prioritised prior to oxidation.</p> <p>Confirm if other measures will be used in addition to blending to prevent waste rock emplaced underground from further oxidising.</p> <p>Provide trigger levels for any material that has oxidised to the extent that it cannot be placed underground without impacting groundwater quality, and procedures for adequate capping and sealing of such material at the surface.</p> <p>Discuss the frequent testing of parameters currently indicated as “sufficient for full characterisation”, how the site geologist will determine that full characterisation has been achieved and what the frequency of testing will be following characterisation.</p>	<p>Clarification provided in Table 6</p> <p>Section 3.2.3</p> <p>Section 3.2.4</p> <p>Tables 7 and 10</p> <p>Section 4.2</p>
3(d) Sch 4	<p>It is recommended that the requirements of Schedule 3 Condition 19 (d) be reflected in the plan. In particular:</p> <ul style="list-style-type: none"> <li>• trigger levels for the parameters tested in on-site leachate storages and management or treatment actions;</li> <li>• trigger levels in groundwater or downstream surface water to trigger incident reporting or management actions;</li> <li>• surface water and groundwater values (e.g. ecosystem, stock watering) in the water sources potentially impacted by the mine.</li> <li>• Proposed controls to contain leachate;</li> <li>• how proposed groundwater and surface water monitoring programs are designed to monitor the effectiveness of controls to contain leachate in leachate storages;</li> <li>• the status of historic contamination of groundwater (if any) and trends in groundwater quality in relation to leachate management.</li> </ul>	<p>Table 10</p> <p>Table 7</p> <p>Table 7</p> <p>Section 3.4</p> <p>Section 4.2</p> <p>Section 4.3</p> <p>Section 3.4</p>
3 of Sch 4	<p>provide an estimated timeframe for the commencement of trials using the passive leachate treatment system.</p> <p>Please provide evidence of consultation with DRG on the passive system to treat seepage from the existing Waste Rock Dump.</p>	<p>Section 3.3</p> <p>Correspondence provided separately</p>
Condition 3(c) of Sch 6	No further Action	Noted



## 2 ENVIRONMENTAL MANAGEMENT

### 2.1 Purpose of Waste Rock Management

Project Approval Schedule 4 Condition 19 requires this WRMP to include procedures for identification of potentially acid forming (PAF) waste rock at the underground source, its use in backfilling underground voids and prevention of PAF, isolation during storage in a temporary waste rock emplacement and procedures for relocating into a tailings storage facility or back into underground voids. The purpose of this plan is to document these procedures to ensure potentially acid forming material is managed effectively.

### 2.2 Objectives and Outcomes

The overriding objective is to prevent the escape of acid leachate from the stockpiled waste rock. Production of acid leachate from sulphide rich rock will continue to occur whenever the material is exposed to water and air. It occurs naturally when the ore body weathers near the surface but is accelerated when placed in above ground storages and emplacements. A key outcome of this WRMP is to minimise the formation of acid drainage on the surface. Table 3 lists the objectives and outcomes for the WRMP.

**Table 4 Objectives and Outcomes**

Objective	Outcome
Procedures are developed to ensure that potential acid forming (PAF) waste rock is identified during ongoing underground mining operations and is stockpiled in the appropriate designed temporary potentially acid forming waste rock waste emplacement.	Identification of PAF material within the underground workings. Isolation of PAF material within the waste stream for separate handling, treatment and disposal.
Competence training will be implemented to ensure relevant employees and contractors manage PAF waste rock material appropriately.	Employees and contractors fully engaged in managing PAF waste rock material.
Ensure that the temporary waste rock emplacement is designed to contain and manage any potential acid rock drainage.	Drainage is contained within Tailings Dam North. No offsite discharge. Impact on surface and groundwater is negligible.
Effective isolation and/or neutralisation of potential acid forming material in waste rock dumps	Impact on surface and groundwater is negligible.
To ensure that PAF material is relocated to underground voids, buried within reprocessed tailings storage facilities or reused if appropriate as soon as available to prevent further oxidation of the material.	Reduction in acid generation on the surface No offsite discharge Facilitate long term rehabilitation success prioritising the relocation of potential acid forming material to suitable underground locations prior to oxidation
Establish trigger levels for any material that has oxidised to the extent that it cannot be placed underground without impacting groundwater quality, and procedures for adequate capping and sealing of such material at the surface	Triggers established for groundwater quality. Trigger levels established based on NAPP and NAG pH results
Ensure any seepage from the waste rock dumps are contained and treated on site	Minimise long term rehabilitation liability Improve water quality within existing pollution control structures
Develop a long term passive treatment system for seepage from the existing Waste Rock Dump	Minimise long term rehabilitation liability Improve water quality within existing pollution control structures Trials to commence in 2027 and fully operational within 2 years of final mine closure



### 2.3 Characterisation of Acid Forming Materials

The target ore is hosted within a bedded volcanogenic massive sulphide deposit which is itself hosted within the Woodlawn Felsic Volcanics. The volcanics are flanked by sedimentary strata consisting of mudstone, pyritic black shale, sandstone, conglomerate and limestone. The package is intruded by dolerite sills and dykes associated with the overlying basalts. The package has been subject to low grade metamorphism.

The host package was emplaced in a marine environment before depositional filling and subsequent uplift. Further igneous activity occurred during the uplift and which was then followed by regional scale folding and subsequent complex faulting. From an environmental perspective, the resulting geology presents a highly complex mixture of acidic, neutral, alkaline, saline, non-saline, high and low sulphide and metal bearing strata.

The felsic volcanics consist primarily of rhyolite, and volcanoclastic debris which are typically stable non-acid forming unless affected by alteration associated with the mineralisation event, which results in variable amounts of pyrite and other sulphide minerals being added to the rock. Marine mudstones, black shales and marine sandstones can be mildly acid forming on account of sea water sulphate being entrained in the sediments, usually as pyrite. Dolerites and basalts are typically stable non-acid forming rocks while marine limestones are often acid consuming rocks.

Rocks with high sulphide content include pyrite, sphalerite, galena and chalcopryrite have the potential to form acidity when exposed to air and water. The associated metals that are present tend to mobilise as pH falls. The trigger usually is elevated sulphide which also increases conductivity, but the salt is predominantly sulphate based rather than the more typical sodium chloride.

Sulphide minerals such as pyrite ( $\text{FeS}_2$ ), sphalerite ( $\text{ZnS}$ ), galena ( $\text{PbS}$ ) and chalcopryrite ( $\text{CuFeS}_2$ ) are the main sources of potentially acid forming materials or PAF. The zinc, lead and copper based minerals are the target minerals for processing while pyrite is not.

The minerals surrounding the target ore are referred to as gangue minerals. These consist of quartz, talc, chlorite and calcite which are generally non-acid forming or NAF but can include other minerals such as pyrite which are potentially acid forming. It is often the gangue minerals which need to be extracted around the ore lens in order to maximise the recovery of the target ore. The gangue minerals generally report to the process waste stream and will be converted to NAF via the production of paste.

Also surrounding the ore lenses is waste rock with little or no recoverable metals. There are economic imperatives in minimising the amount of waste rock and gangue minerals extracted within the stopes in order to reduce mining and processing costs. The access drives however are generally developed in waste rock. This material is predominantly rhyolite and dolerite which are chemically stable, benign, non-acid forming hard rock widely used for construction purposes.

This plan recognised that the target ore is, by definition, PAF. The existing tailings dams on site are acid forming largely because the previous processing operation failed to extract sufficient minerals but also left abundant free sulphate. The Rehabilitated Waste Rock Dump generates acid drainage because although mostly consisting of benign felsic volcanics such as rhyolite and dolerite it also contained high quantities of pyrite associated with mudstones, black shales and altered rocks near the ore body.

The management of waste rock moving forward will have two separate components, namely:

- The identification and separation of waste rock containing sufficient sulphide minerals such as pyrite to cause acid generation (ie PAF materials).

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- ❑ Reducing the concentration of PAF materials in both existing tailings and future tailings material through more efficient processing technologies and fixing any residuals by correcting with lime and cement to form a backfill paste.

The identification process will occur underground from a combination of geological modelling, regular laboratory testing of rock and visual identification. Once waste material is identified as PAF its “life cycle” will be determined and documented. This may include leaving it in-situ, relocating it to a designated underground stowage area or taking it to the surface for temporary storage within the designated PAF emplacement site.

The reduction in concentration of PAF materials within the existing tailings dams will occur as a result of reprocessing while new tailings produced from the processing plant will be used to produce cement paste for backfilling underground stopes. This process will chemically correct potential acid generation through lime amendment while the cementation process will provide a permanent matrix to exclude air and water.

The implementation of the management plan is described in the following chapter.

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### 3 IMPLEMENTATION OF WASTE ROCK MANAGEMENT

#### 3.1 Waste Rock Production

Waste rock will be generated throughout the project life. Shallow weathered rock will be removed for the box cut and minor quantities during the construction phase. The decline will enter unweathered volcanic rock, predominantly felsic but could include PAF materials.

The new decline will intersect the original decline which will require refurbishment. This process will produce waste including both NAF and PAF materials. As the underground mine develops, waste will be produced from new drives and production stopes. The drives will necessarily intersect both felsic volcanics and massive sulphides in order to access the ore lenses. However, the design of the stopes will minimise the production of waste rock which is a critical function of mine design in order to minimise production costs.

Non-acid forming waste generated during the early stages of the development will be stockpiled at surface for use in the construction of the new tailings dam (TSF4) wall or to dress the Run-of-Mine pad. Any PAF material identified in the initial development down to the existing decline will be stockpiled at the designated waste rock dump site above and draining into the proposed TSF4.

The majority of material mined within the stopes will be PAF and will generally be brought to the surface and processed to recover the metals or if non-economic grade will be stowed underground in available voids. NAF material generated by ongoing access road development may either be stowed underground or if needed, can be brought to the surface for construction activities. There will be an ongoing need for non acid forming construction materials throughout the life of the project. The first stage of the TSF4 dam wall has been completed using NAF however stages 2 and 3 will require further NAF construction materials. This material will be stored near the dam wall to reduce construction costs when raising the TSF4 wall is required.

Veolia also has an ongoing need for NAF material and operates a dolerite stockpile area adjacent to the mine entry. They can also use some PAF material so long as it hasn't oxidised. This stockpile may be added to with new NAF material from the underground workings.

#### 3.2 Waste Rock Management

Day to day management of acid-generating materials will involve a process of identification of acid risk materials, characterisation of the material, segregation, selective placement or blending and treatment. This process will be integrated with mine planning and operations and involve trained staff supported by laboratory analysis and refinement of the geological model.

As Woodlawn has an identified acid generation risk, measures are required to reduce the potential for acid generation from both the existing mine and future mining operations.

##### 3.2.1 Waste Rock Characterisation Procedures

A mine PAF/NAF model will be developed from existing drilling programs to identify potential high sulfur waste zones within the designated underground mining area. Samples collected will be analysed for Net Acid Production Potential (NAPP), Net Acid Generating (NAG) testing (static testing) as well as kinetic testing which involves using leach columns to simulate field weathering conditions.

NAPP gives a theoretical prediction of whether the acid production potential of a material is greater than its acid consumption capacity. The results are usually provided as either a positive or negative number. NAPP is a worse case scenario test and is therefore useful for screening purposes. NAG testing determines the balance between the acid producing and acid consuming components of tailings/waste rock samples. Net Acid Generation results provide the acid rock drainage characteristics based on the complete oxidation of the sample's sulphide content (as well as ferrous iron from siderite dissolution). Acid that is produced by oxidation is consumed by carbonates

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and/or other acid consuming components of the material. The pH of the solution is measured (NAG pH). The acid remaining after the reaction is titrated with standardised NaOH to determine the net acid generated.

The methodology for characterising the waste rock following the NAG testing is provided in Table 4. The dominant sulphide minerals at Woodlawn are as follows:

- ❑ Within complex ore zones are predominantly pyrite, sphalerite, galena and chalcocopyrite along with minor arsenopyrite, tetrahedrite, tennantite, stannite, bismuthinite, marcasite, pyrrhotite and electrum.
- ❑ Within copper ore zones are pyrite–chalcocopyrite assemblage, together with lesser sphalerite, galena, and pyrrhotite.
- ❑ Decline waste zones are predominantly devoid of sulphides however local fault structures and minor mineralised zones may be encountered.
- ❑ The rocks immediately surrounding the ore lenses are volcanoclastic and shale rocks. They consist of dolerite, tuffs and schists; chlorite schist is commonly in the footwalls and less common in the hanging walls.

Using static NAPP and NAG tests on selected samples Heron will classify waste rock types into PAF, low risk PAF, NAF and NAF (Alkaline). Kinetic tests will also be performed to quantify the rate at which the different waste types may begin to oxidise and to further analyse samples when the static test results are not definitive. As the dominant sulphide species at Woodlawn is pyrite, the rate of oxidation of the waste rock is expected to be rapid, however given the likelihood that the PAF could be mixed with NAF that has acid neutralising capacity, the actual rate could vary significantly. The kinetic test program will enable Heron to determine the rate at which different PAF material types are likely to oxidise to make more appropriate management decisions particularly in relation to how long the material can be stockpiled and the need for blending or treatment.

The process for determining how waste rock mined will be classified and ultimately where the waste rock will be stored will be the function of the mine geological personnel. They will classify material on a mining block basis to assist in determining where this material is to be disposed.

Geologists will be trained to identify sulphide zones within the waste material. This process will be validated by completing static tests (NAPP) on underground rock chip samples where appropriate. This process of visual inspection supported by validation through sampling will ensure geologists will be familiar with the rock type characterisation techniques for identifying NAF and PAF waste material.

The following table summarises the classification system for waste rock while the full Trigger Action Response Plans are provided in Tables 7 to 10 in Chapter 5.

**Table 5 – General Waste Rock Classification and Management**

Waste Rock Classification	Management Procedures
<b>Coded: Green Material</b>	
Non Acid Forming (NAF) NAPP value negative pH≥4.5 from static NAG.	Use in construction of TSF4 and ROM pad. General surface construction Stowage underground. Can be used for blending with PAF
Non Acid Forming (Alkaline) NAPP <0 and/or APP >0 and NAG pH >7 and/or ANC > 5 kg H <sub>2</sub> SO <sub>4</sub> per tonne	As for NAF but can also be used for: rehabilitation of the tailings dams lining of drainage channels separated for specific acid neutralisation activities.



<b>Coded: Yellow Material</b>	
Uncertain NAPP value positive but NAG pH ≥ 4.5 NAPP value negative but NAG pH < 4.5	Undertake kinetic testing to further define or treat as PAF low capacity If classification is still uncertain the material is to be treated as PAF-LC
Potentially Acid Forming – Low Capacity (PAF LC) NAPP 0 to 10 kg H <sub>2</sub> SO <sub>4</sub> /T and NAG pH <4.5 NAPP value negative but NAG pH between 3 and 4.5. Low Risk	Material to be identified Use in low risk applications only Can be used in underground stowage Blending required if used in surface applications other than within the designated Waste Rock Emplacement Potential use by Veolia in low risk applications.
<b>Coded: Red Material</b>	
Potentially Acid Forming (PAF) NAPP value > 10 kg H <sub>2</sub> SO <sub>4</sub> /T and NAG pH <4.5 High Risk	Material to be designated as PAF May remain underground If brought to the surface must be stored in the designated Waste Rock Emplacement for no more than 2 years. Surface stockpiled PAF to be removed or treated after 2 years Surface disposal only in tailings dams

### 3.2.2 Disposal and Stockpiling of Waste Rock (NAF)

The majority was waste rock produced during the box cut and decline will be Non-Acid Forming. Verification of NAF status will be done through NAPP and NAG testing. Until the underground workings have been accessed and opened up, NAF waste will need to be brought to the surface. NAF material suitable for construction will be used directly in the TSF4 dam wall and ROM Pad. Some stockpiling may be necessary and would occur adjacent to the construction site to minimise double handling costs.

The TSF4 wall required approximately 150,000 m<sup>3</sup> of rock fill in the first lift with additional material required for the ROM pad and general construction fill. This material was sourced from the box cut and decline construction. Additional material from the decline development, that has been identified as NAF, will be stockpiled near TSF4 to enable ease of constructing the second and third stages. Should PAF material be encountered during the decline development, this material will be separated and temporarily stored at the Waste Rock Emplacement or ROM pad for processing.

### 3.2.3 Disposal and Stockpiling of Waste Rock (PAF)

Until the underground workings have been accessed, all waste generated will be emplaced on the surface. This will include the initial box cut and decline material. This material has been tested and demonstrated to be NAF.

As shown on Plan 2, a designated Waste Rock Emplacement has been located to the west of the new TSF4. The site was chosen because it includes existing disturbance and drains into Tailings Dam North (TDN). Part of the site was previously used for retreatment of tailings in TDN and is therefore already contains PAF materials. It is also accessed from the haul road which links the mine to the ROM pad making delivery of PAF materials easy.

All PAF material encountered during the construction of the decline will either be temporarily contained in the Waste Rock Emplacement or processed if economically recoverable resource. The dumping will first commence in the existing disturbed area.

This material will be relocated to either the underground mine for general stowage in underground voids not subject to paste filling or be buried within a reprocessed tailings dam. Other uses may be suitable such as building dividing walls within the tailings dams as part of the reprocessing operation. As the tailings dams will always be identified as PAF, the use of waste rock of similar PAF content will have no additional environmental or rehabilitation liability.



The Waste Rock Emplacement is for temporary storage of PAF only. Material should not be stored for more than 2 years without approval of the Mine Manager and Environmental Officer. The decision to relocate or otherwise treat the PAF material will depend on the results of further testing. Should the results show that the material is, or is still at risk, of producing acid drainage, a program will be developed to relocate or treat the material. Should relocation be necessary, the material will be progressively removed over the subsequent 6 month period.

Once underground production has advanced, backfill areas underground will be available. PAF material will be either:

- transported from the mined area directly to an available backfill or stowage area;
- blended with NAF prior to backfill directly underground; or
- transported to the processing plant bound with ore which will ultimately be returned as paste used for backfilling completed stopes.

No PAF material that has been previously brought to the surface will be transported back underground without prior treatment and retesting to ensure it is no at risk of developing acid generation, that is, having a Net Acid Production Potential value greater than 10 kg H<sub>2</sub>SO<sub>4</sub>/T and NAG pH <4.5.

### 3.2.4 Treatment of PAF Waste Rock

The use of paste fill as the predominant backfilling method for mining voids will significantly reduce acid generation potential in these areas of the mine. The production of paste is an effective treatment process. It involves combining the crushed rock waste with hydrated lime and cement which will raise the pH of the material to at least pH10. Unprocessed waste rock can be added to the paste if available which increases the strength of the cured paste.

The hydraulic conductivity of the cemented paste backfill will be between 1x10<sup>-8</sup> to 1x10<sup>-10</sup> m/s. This is a very low permeability value which is typically lower than the host sulphide volcanic strata which is often fractured. The paste filling process would therefore limit the normal flow of groundwater through the mined area and in turn reduce the natural formation of acidity.

Other treatment measures are available including:

- Oxygen exclusion – this can be achieved by capping or wet cover such as disposal in the tailings dams. Following the completion of mining activities, groundwater will be allowed to inundate the mine workings. This will eliminate the availability of oxygen preventing oxidation of the PAF material for the long term.
- Hardpan development to reduce oxidation of the underlying materials. This option can include permanent rock cover for sealing
- Bacteria inhibitors – using chemicals to inhibit the growth of the *Thiobacillus ferrooxidans* bacteria may slow the rate of acid production. Anionic surfactants act as bactericides and kill these bacteria by effectively stopping the reactions where pyrite (ferric sulphide) is converted to soluble iron (ferrous sulphate) and where the soluble iron is further converted to ferric sulphate. By halting the production of the ferrous sulphate, further degeneration of the cycle of the pyrite to create sulphuric acid is halted.
- Using alkaline material such as limestone and dolomite to chemically alter the PAF waste rock permanently. The rate of alkali can be determined through calculating the required nett acid neutralisation requirement.

Given the demand for paste over the life of the operation, it is anticipated that the majority of PAF material that needs to be brought to the surface will end up being used for paste manufacture. PAF material unsuitable for processing and temporarily stored in the Waste Rock Emplacement will likely to be relocated to a reprocessed tailings dam. While the tailings dams are being reprocessed, there will also be a demand for material to construct dividing walls and ramps within each tailings dam. As the tailings dams will always be a source of acid

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generation, the use of PAF material is suitable for this purpose. The rehabilitation methods for the tailings dams assume permanent separation between the tailings material and surface capping and growing media will be required.

### 3.2.5 Blending of PAF Waste Rock

Although the majority of waste rock produced by the underground mine will be brought to the surface, there will be opportunistic direct deposition into stopes or stowage areas. In these circumstances, blending and/or co-disposal of PAF material will be used as a means of reducing the total acid producing potential of the material. The process involves mixing material that has a higher potential to produce acid with material with an acid neutralising potential. The blended material will result in a reduced total acid production potential.

Based on recent acid generation tests, there are several rock types on site which have high Acid Neutralising Capacity (ANC). Material generated from the decline have ANC values of between 7 and 8 kg of H<sub>2</sub>SO<sub>4</sub>/tonne equivalent neutralising capacity and a pH of up to 8. This may be the result of carbonates in the weathered surface material which could differ from deeper unweathered Woodlawn lithologies.

As the underground mine develops, the opportunities for blending may increase. The developing geological model will enable characterisation of waste rock prior to removal. The model, coupled with ongoing NAPP and NAG testing, will endeavour to predict the outcome of separation and blending of acid forming materials stowed underground. The aim of this will be to reduce the overall acid generation potential of the waste rock disposed underground as a result of mining.

### 3.2.6 Management of Waste Rock in Practice

Management of waste rock will be an ongoing and detailed task requiring complex scheduling. The principles of how this will work in practice is as follows:

- Rock located away from the mineralised ore body and at shallow depth has been tested and has been confirmed as Non-Acid Forming. This material will generally be extracted during decline and access road construction and will be brought to the surface if stowage underground is not possible.
- NAF material brought to the surface will be used for construction purposes and stockpiled adjacent to the area of next intended use. This will include TSF4 to enable Stages 2 and 3 to be constructed, near the existing tailings dams where dividing walls are to be constructed, road construction sites or nominated rehabilitation areas or delivered to Veolia as directed by them.
- Mineralised rock containing high pyrite content has the potential to be acid forming. Based on the results of the testing outlined in Table 5, the material will be coded Green, Yellow or Red and managed accordingly.
- Mineralised rock will be encountered from time to time within decline or access development. This material will generally need to be brought to the surface due to the practicalities of constructing single drive declines and level development where no space exists for underground stowage.
- Mineralised rock primarily occurs within the stopes which is all likely to be classified as PAF.
- The majority of the stoped material will be brought to the surface and processed to extract the ore. The majority of waste from this process will be sent to the Paste Plant and used for stope filling. The process of paste manufacture is expected to convert the PAF material to NAF however this will be confirmed by testing.
- Tailings not required for paste manufacture will be pumped into the existing tailings dams. This material, including the reprocessed tailings, is still likely to be acid forming and will be rehabilitated in accordance with the approved Revegetation and Rehabilitation Management Plan.
- Some PAF material will remain underground within the stopes or other stowage areas. This is not considered environmentally hazardous to groundwater as the material was originally located underground and will simply remain underground.

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- ❑ All material is brought to the surface using underground haulage trucks which are unsuitable for general surface transport. Therefore, it will be necessary to have some rehandling of the material where it is essentially transferred from the underground mining equipment to surface trucks. During the decline construction phase the staging area will be the general material stockpile while during mining operations the underground haul trucks will also dump PAF material at the ROM pad. PAF material unsuitable for processing will then be transported to either the Waste Rock Emplacement or the tailings dams.
- ❑ PAF material contained in the Waste Rock Emplacement will be either treated, blended or disposed of in the final tailings dams prior to rehabilitation within 2 years.
- ❑ PAF material brought to the surface that has a NAPP value of  $>10 \text{ kg H}_2\text{SO}_4/\text{T}$  and NAG pH  $<4.5$  will not be returned to the underground workings.

The management of waste rock will be further refined based on the ongoing testing regime and mine development. Any significant changes to the management of waste rock will be included in a revision to the plan and provided to DPE for review.

### 3.3 Management of Existing and Historic Waste Rock Materials

During previous mining of the Woodlawn open cut, more than 80 million tonnes of waste rock was placed in an out of pit waste dump. This waste comprised primarily rhyolite, welded tuff, tuffaceous shale and dolerite which are characteristically non-acid forming. However, high concentrations of pyrite were also present in certain rock units, with sulphur levels of up to 7% which have a high propensity to form acid drainage. As the waste was dumped as mined and not adequately mixed with materials with higher acid neutralisation capacity, the emplacement leaches low pH metal rich water.

The leachate is collected in a purpose built dam referred to as the Rehabilitated Waste Rock Dam (RWRD). Collected water is pumped to ED1 via a dedicated pump and delivery pipeline. The pump is controlled by float switching which maintains sufficient free board to contain storm runoff. The dam does not discharge and has been successful in managing acid leachate from the now rehabilitated waste rock dump for in excess of 30 years.

Condition 3 of Schedule 4 of the Project Approval requires Heron to identify an appropriate passive treatment system which can be implemented to provide long term treatment of acid leachate without the need for active management such as pumping. The implementation of the passive treatment system needs to be functional and operational prior to final mine closure.

As the current collection and pumping system has been in operation for 30 years, there is a great deal of monitoring and operational details which can be utilised in the design. Leachate volume from the emplacement is quite small and generally only occurs following prolonged rainfall. Therefore the pumping system operates on a very intermittent basis, and in some cases has not been required for several months at a time. During these periods, evaporation losses are greater than inflows. The water quality within the dam has also not varied significantly over time indicating that the acid load has peaked. The pH has remained relatively stable at just over pH 3 although has increased to 6.3 during heavy rainfall periods. The water contains high sulphates and metals. Conductivity is high however this is predominantly the result of the sulphate content.

Passive treatment using limestone, aeration and settlement followed by passage through an artificial wetland is considered the most appropriate long term treatment method. This method is proven in documented examples while failure of these systems is usually the result of a dramatic change in water quality and/or volume. These failure modes would not apply at Woodlawn. The main elements of the passive treatment system would be as follows:

- ❑ Establish a permanent drainage collection system utilising the existing collection dam (RWRD). The collection system may include existing and new channels leading into the RWRD.

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- Establish a protected spillway and limestone aggregate lined channel down the slope of the RWRD. The length of the channel will be governed by the calculated acid load. This process also provides a cascade aeration system.
- Construction of an additional collection pond for settlement of solids and metal precipitates.
- Construction of an artificial high organic wetland either in the downstream area below the RWRD or in the area above the RWRD. The design of the wetland will include composted material from Veolia's MBT Plant.
- Construction of an exit point from the wetland which will be designed to deliver treated water safely to the existing natural creek. Natural remediation will be enhanced by additional tree planting along the creek line.

The design of the system will require trials which will occur at least two years prior to closure. As the system necessarily would require discharges from the site to occur it cannot be implemented until final closure. The final closure process will involve at least two years of ongoing monitoring prior to lease relinquishment in line with normal rehabilitation status monitoring. Fine tuning of the passive treatment system will occur during this period. Although the current mine life is expected to be in excess of 10 years, it is proposed to commence the trials of the passive treatment system in 2027.

Other sources of acid generation on site include the existing tailings dams and evaporation dams. The tailings dams will be retreated to remove available metals. This will in turn reduce the acid generation potential however the final rehabilitation program for the tailings dams will include an acid protecting cap and permanent protection against acid seepage off site.

### 3.4 Future Management of Acid Leachate

The Woodlawn Mine operates as a nil discharge site. Other than clean water diversions and the Process Plant Pollution Control, water storages on site tend to be acidic and metal rich. The pollution control pond located below the processing plant site mainly contains surface runoff from areas disturbed during construction activities but is still managed so as not to discharge.

The main sources of acid drainage are historic including the old tailings dams, Evaporation Dams and Rehabilitated Waste Rock Dam. The latter receives water draining from the original overburden emplacement formed during the open cut development which also contained PAF material. The ongoing management of acid mine drainage and leachate control is summarised below:

- The Rehabilitated Waste Rock Dam (RWRD) will continue to be managed by automatic pumping to ED1. A passive treatment system will be installed at least 2 years prior to final mine closure.
- Existing tailings dams will remain nil discharge. These will be progressively rehabilitated when complete.
- Existing evaporation dams will remain nil discharge.
- Existing groundwater monitoring bores located downstream of acid water storages will continue to be monitored in accordance with the Environment Protection Licence and TARPs contained in Section 5.3.
- Evidence of leakage or impacts to groundwater will be reported to the EPA and DPE.
- The existing surface water monitoring program will continue in accordance with the Environment Protection Licence.
- Triggers in relation to water monitoring data are listed in Tables 7 to 9 of this management plan. Adherence to these and actions will assist in maintaining an acceptable level of impact from the ongoing mining operation.

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The surface and groundwater monitoring program at Woodlawn have been in operation for over 20 years. This has yielded an excellent database to use to assess the environmental performance of the operation. Historical data provides assurance that there are no adverse impacts on the environment outside the mining lease as a result of the mining operations. There are known to be very localised impacts associated with the evaporation ponds, tailings dams and Waste Rock Dump however these impacts do not extend beyond the mine footprint.

The monitoring data is reported each year in the Annual Review which includes an analysis of the mine's performance against the assessment criteria, performance measures and TARPs.

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## 4 MONITORING OF ACID FORMING MATERIAL

The first step in managing acid rock drainage is to identify the wastes that have the potential to form acid. This is required prior to any management initiatives being implemented. The identification process will involve a combination of geological modelling to identify high risk strata. The process of determining the risk starts with laboratory analysis. This includes initial screening tests, geochemical static tests, solubility tests and kinetic tests. These tests are outlined below.

### 4.1 Laboratory Testing

All testing will initially be performed at a NATA compliant laboratory. As Woodlawn Mine has specialist laboratory testing facilities available on site, some routine testing will be performed on site.

#### 4.1.1 Acid Producing Potential (APP)

APP is a measure of the total acid producing potential of a material, irrespective of whether that material may also have the potential to produce alkali. APP is determined from the analysis of total sulphur in the sample and is calculated assuming a total conversion of sulphur to sulphuric acid. APP is reported as kg H<sub>2</sub>SO<sub>4</sub> per tonne. This test is quick and useful for an initial screening of acid potential.

#### 4.1.2 Acid Neutralising Capacity (ANC)

ANC measures the capacity of a sample to neutralise any acid that is produced. In the ANC analysis a finely ground sample is reactive with a known amount of hydrochloric acid. The resultant solution is back titrated to pH 7.0 with sodium hydroxide to determine the amount of acid neutralised by the carbonates and other acid consuming minerals present in the original sample. ANC is reported by the laboratory as either Kg CaCO<sub>3</sub> or Kg H<sub>2</sub>SO<sub>4</sub> equivalent per tonne. This test is useful when blending or co-disposal of acid forming materials with non acid forming materials in order to achieve a non acid forming final blend for disposal.

#### 4.1.3 Net Acid Production Potential (NAPP)

NAPP gives a theoretical prediction of whether the acid production potential of a material is greater than its acid consumption capacity. The results are usually provided as either a positive or negative number. NAPP is a worse case scenario test and is therefore useful for screening purposes. It tends to over predict the acid production potential because it does not differentiate between acid producing and non-acid producing forms of sulphur.

#### 4.1.4 Net Acid Generation (NAG)

NAG, also referred to as NAP or net acid production is a static method using hydrogen peroxide to oxidise any sulphides present in the sample. The acid produced from the oxidation reaction may subsequently be partially or totally consumed by acid neutralising components of the sample. Any remaining acidity is determined by back titration to both pH 4.5 and pH 7.0 and reported as NAG. It is expressed in kg H<sub>2</sub>SO<sub>4</sub> equivalent per tonne. Combined with NAPP, these are the main test to be performed which will determine whether or not a particular waste rock is classified as Potentially Acid Forming (PAF) or Non Acid Forming (NAF).

#### 4.1.5 Kinetic Testing

Free draining kinetic leach columns are used to compliment environmental geochemical investigations on mine rock and waste materials and are used to determine drainage chemistry. Free draining leach columns simulate field weathering conditions to provide information on a range of issues including sulphide reactivity, oxidation kinetics, metal solubility and the leaching behaviour of the test materials. Kinetic testing will be performed where PAF materials need to be stored above ground for period greater than 2 years. The test will also be performed on final tailings produced from the new processing plant when the material is to be stored above ground rather than used in the formation of paste for underground backfilling.

#### 4.1.6 General Water Chemistry Testing

Monitoring of surface water and groundwater will continue to be undertaken in order to determine whether mine activities are causing adverse impacts upon the surrounding environment. Water will be sampled for

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specific parameters as required by the Environmental Protection Licence as well as historical points of known potential contamination such as the evaporation dams and tailings dams. The results will continue to be reported in the Annual Review and compared with historical data.

Water tests include general physical parameters such as pH, conductivity, cations and anions as well as a range of metals which are typical of the Woodlawn volcanics. The data will be used to provide a first indicator of the presence of additional acid formation over and above the influence of natural geological conditions.

Natural background water quality has been demonstrated to be heavily influenced by geology. The volcanogenic massive sulphide deposit forms part of a wider regional north-west plunging syncline which not only hosts metal rich ore lenses but also a range of metamorphosed sedimentary rocks of both marine and volcanic origin.

Marine deposits are naturally high in salt content. The ore body is naturally high in sulphides and the target ore lenses represent concentrations of metals including zinc, copper, lead, gold and silver. Together, it is referred to as the Woodlawn Volcanics.

Water quality has been characterised according to its host or source. Sedimentary strata usually produces more typical water quality with pH generally above 6, relatively low salinity and sulphate levels and low metals. These areas are the easiest to detect the influence of acid rock drainage. More difficult is in areas naturally influenced by the sulphide volcanic which can mask the presence of additional mine related sources of acidity and metal rich drainage.

## 4.2 Testing Regime

The testing regime is outlined in Table 6. The program includes some cross over with normal surface water quality testing. This component may vary over time in response to changes with licence conditions.

**Table 6 Monitoring Parameters and Testing Frequency**

Material type or location	Testing Parameters	Frequency
Hickory Paddock PCD	Physical and Chemical	Quarterly
Tailings Dams	Physical and Chemical	Quarterly
Evaporation Dams	Physical and Chemical	Quarterly
Rehabilitated Waste Rock Dam	Physical and Chemical	Quarterly
Felsic Volcanic Strata*	ANC, NAPP	Sufficient for full characterisation**
Metamorphic Strata*	ANC, NAPP	Sufficient for full characterisation**
Sulphide Volcanics*	NAPP, APP, NAG	Sufficient for full characterisation**
Blended underground stowage*	NAPP, NAG	Sufficient for full characterisation**
Run of Mine Ore	NAG	Sufficient for full characterisation**
Process Tailings	NAG	Sufficient for full characterisation**
Paste Fill	Kinetic leach, NAG, NAPP	Sufficient for full characterisation**
PAF Waste Rock Emplaced material	Kinetic leach, NAG, NAPP	Once off after year 2 Annual thereafter while stored
NAF Waste Rock used on surface	Kinetic leach, NAG, NAPP	Sufficient for full characterisation**
New tailings not used for paste fill	NAPP, APP, NAG, Kinetic leach	Sufficient for full characterisation**
Paste	Physical	Daily when Paste Plant operational
	Strength	Average Weekly
	NAPP and Kinetic leach	Six Monthly
Underground mine water	Physical and chemical	Monthly
Groundwater bores	Physical and chemical	Quarterly



\* Note: this material will generally be sampled from the underground workings prior to being brought to the surface. This may not be possible in some situations where safety concerns prohibit underground sampling

\*\* Note: full characterisation may require multiple tests to be performed on each rock type.

The number of samples required in order to achieve full characterisation will depend on the advice of Heron's Geology Department. Samples are characterised on a matrix of lithology, alterations and mineralisation. The geochemical analysis for each sample is matched to the NAPP and NAG test result plotted on the AMIRA 2002 "Preventing Acid and Metalliferous Drainage" guideline for classification, also the basis of classification within this management plan. Correlation plots of the geology characteristics and the NAPP/ NAG results will determine the population variance and requirement for number of samples within population types. Results will be compiled into a block model that represents the classification and risk for blocks of material within the mine plan.

When determining acid potential of blended material, testing will involve composite sampling methodologies with each composite representing no less than 3 sub-samples and thoroughly combined.

A summary of the results will be provided in the Annual Review.

### 4.3 Interpretation and Assessment of Monitoring Results

There are three components to the monitoring program. The first is the establishment of background surface and groundwater quality. This data is used to establish the baseline against which the potential impacts of the operation can be assessed. The second is the monitoring of site impacts and to ensure that there is a low potential for impacts to occur. This management plan details this second component specifically in relation to managing waste rock. The third component is monitoring of the receiving environment which allows for the comparison of trends or changes to determine the level of impacts, if any, that may occur as a result of mining.

The monitoring network covers surface storages on site, groundwater bores located around the site, receiving surface waters external to the site and specific monitoring sites below the main water storages. The program is described in more detail in the following sections.

#### 4.3.1 Groundwater

The Woodlawn mine has a network of over 50 monitoring bores and piezometers which monitor the tailings dams, evaporation dams, waste rock dump and plant / processing / administration areas. The location, parameters to be measured and frequency are detailed in EPL 20821 and shown on Plan 3. The groundwater monitoring points are listed below.

EPA site Identification number	Location description	Frequency
11	<b>MB4</b> - East side of void, Near DG22	Quarterly
12	<b>MB5</b> - South face of waste rock dump	Quarterly
13	<b>MB6</b> – Adjacent to mine entry	Quarterly
14	<b>MB8</b> – Adjacent to Collector Road and downstream of proposed processing plant site	Quarterly
15	<b>MB12</b> – Below ED2 dam wall	Quarterly
16	<b>MB13</b> – Western premises boundary	Quarterly
17	<b>MB14</b> – Background ground water	Quarterly
18	<b>MB15</b> – To measure seepage from rehabilitated waste rock dump	Quarterly
21	<b>MB11</b> – Below ED2 dam wall	Quarterly
22	<b>MB16</b> – To measure seepage from rehabilitated waste rock dump	Quarterly
23	<b>MB17</b> – To measure seepage from rehabilitated waste rock dump	Quarterly



EPL 20821 requires the following parameters to be tested each quarter.

Pollutant	Unit of measurement	Comments
Alkalinity (as CaCO <sub>3</sub> )	Milligrams per litre	
Total Al, As, Ba, Cd, Ca, Cl, Co, Cr, Cu, F, Pb, Mg, Mn, Hg, K, Na, S, Zn	Milligrams per litre	Total metals
Nitrate, Nitrite, Nitrogen (ammonia)	Milligrams per litre	
pH	pH	
Electrical Conductivity (EC)	Microsiemens per cm	
Total dissolved solids (TDS)	Milligrams per litre	
Total organic carbon (TOC)	milligrams per litre	
Standing water level	metre	In situ

Groundwater parameters detailed in EPL 20821 to be tested annually are listed below.

Pollutant	Unit of measurement	Comments
Chromium (hexavalent)	Milligrams per litre	
Benzene, Ethyl Benzene, Toluene, Xylene (BTEXN)	Milligrams per litre	
Organochlorine pesticides (OCP), Organophosphate pesticides (OPP), Polycyclic aromatic hydrocarbons (PAH), Total Petroleum Hydrocarbons (TPH), Total Phenolics	Milligrams per litre	

In addition to the groundwater sample collection points detailed in EPL 20821, Heron Resources also monitors the standing water level and water quality in additional bores located across the Site as listed below. The majority of these are specific to storage facilities containing acid waters and are used to determine leakage.

Site identification	Site description	Frequency
NTP2	North Tailings Dam East wall	Bi-annually
SP3C	North Tailings Dam East wall	Bi-annually
ETP8	North Tailings Dam East wall	Bi-annually
SP11B	North Tailings Dam East Wall	Bi-annually
E3	South Tailings Dam South Wall	Bi-annually
F1	South Tailings Dam South Wall	Bi-annually
F7	South Tailings Dam South Wall	Bi-annually
X1	South Tailings Dam East Wall	Bi-annually
X2	South Tailings Dam East Wall	Bi-annually
Y1	South Tailings Dam East Wall	Bi-annually
Z1	South Tailings Dam South Wall	Bi-annually
MB21D	East of South Tailing Dam	Quarterly
MB22S	East of South Tailing Dam	Quarterly
MB19	West of Evaporation Dam 2	Quarterly
MB20	West of Evaporation Dam 2	Quarterly

These sites are tested for the following analytes.

Analyte	Unit of measurement	Comments
Alkalinity (as CaCO <sub>3</sub> )	Milligrams per litre	
Total Al, As, Ba, Cd, Ca, Cl, Co, Cr, Cu, F, Pb, Mg, Mn, Hg, K, Na, S, Zn	Milligrams per litre	Total metals
Nitrate, Nitrite, Nitrogen (ammonia)	Milligrams per litre	
pH	pH	
Electrical Conductivity (EC)	Microsiemens per centimetre	
Total dissolved solids (TDS)	Milligrams per litre	

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Total organic carbon (TOC)	milligrams per litre	
Standing water level	metre	In situ

The results of the program are provided each year in the Annual Review.

#### 4.3.2 Surface Water

The purpose of the surface water monitoring system is to determine:

- the effectiveness of the water management system;
- surface water flows, quality and impacts on other water users;
- potential acid rock drainage from the waste rock dumps; and
- potential seepage from tailings and evaporation dams.

The monitoring sites are described below and shown on Plan 3.

EPA site ID No	Location description	Frequency
6	Site 115 - Allianoyonyiga Ck	Quarterly
7	Site 105 - Crisps Creek	Quarterly
8	Site 100 – Woodlawn/Willaroo boundary South, (below waste rock dam)	Quarterly
9	Site 109 – Pylara Boundary below South Tailings Dam	Quarterly
10	Site 300 – Processing plant pollution control dam – Final dam below new processing facility	Quarterly
19	Evaporation Dam 2 (ED2)	Quarterly
20	Tailings Storage Facility 4 (TSF 4)	Quarterly
24	Mine water monitoring at the discharge point into the holding dam being used at the time of monitoring	Monthly

The parameters tested include:

Pollutant	Unit of measurement
BOD	Milligrams per litre
pH	pH
Electrical Conductivity	Microsiemens per centimeter
Dissolved Oxygen	Milligrams per litre
Sulphate	Milligrams per litre
Metals: Zn, Fe, Cu, Pb	Milligrams per litre
Nitrogen (ammonia)	Milligrams per litre
Potassium	Milligrams per litre
Redox potential	Milligrams per litre
Total dissolved solids (TDS)	Milligrams per litre
Total organic carbon (TOC),	Milligrams per litre

The results of the monitoring program will be compiled and presented in the Annual Review along with an interpretation of the results.



## 5 REVIEW AND COMPLIANCE

### 5.1 Competence Awareness Training

Waste rock awareness training will be a component of the competency based site training program. All personnel involved in the identification and management of waste rock materials on site will receive specific training including:

- significance of acid mine drainage, its formation, controls and importance to the environmental management of the site both now and at final closure.
- Procedures for identifying and classifying PAF material.
- Awareness of monitoring requirements both on the surface and underground.
- Procedures for relocating, storage and blending of PAF materials.
- Procedures for temporarily storing PAF material at surface.

The Mine Manager will be responsible for ensuring the key personal have received appropriate waste rock training.

### 5.2 Evaluation of Compliance

Heron will conduct periodic evaluation of compliance with the following reported within the Annual Review.

- An overview of waste rock extracted from the underground mine.
- On overview of the amount of potential acid-forming waste rock extracted and the procedures implemented to ensure emplacement in designated areas.
- Results from waste rock and water samples.
- Actions undertaken, if required, to ensure potential acid-forming waste rock material does not impact on water quality in the surrounding area.

### 5.3 Corrective and Preventative Measures

The following TARPs include the surface and groundwater TARPs contained in the Water Management Plan. These have been included for completeness as they overlap with the specific Waste Rock management processes. A summary of the key actions to be undertaken should any specific trigger be exceeded is as follows:

- Arrange for further sampling to confirm initial monitoring results.
- Report exceedences to DPE, EPA and DPI-Water as appropriate.
- Investigate the cause of the exceedance and report the results to relevant government agencies.
- If exceedances are confirmed and in consultation with the relevant government agency, implement the necessary containment and neutralising measures to ensure impacts are minimised.
- Re-evaluate the containment of potentially acid forming material and determine the measures to be implemented to further prevent any potential discharges of acid leachate.

**Table 7 - Trigger Action Response Plan – Water Quality**

Component	Parameter	Trigger	Action
Surface Water			
Site 115 Allianoyonyiga Creek	pH	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting



Component	Parameter	Trigger	Action
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Conductivity	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
Site 105 Crisps Creek	pH	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Conductivity	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
Site 100 Woodlawn/Willeroo Boundary	pH	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DPE and EPA
	Conductivity	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting



Component	Parameter	Trigger	Action
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
Site 109 Pylara Boundary	pH	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Conductivity	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
Farm Road Crossing (FRC)	pH	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Conductivity	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
Mine Dewatering Stage 2A-2D	Ammonia	<1000 mg/L	Continue pumping
		Varied readings but average over 3 samples less than 1000 mg/L	Continue pumping but increase monitoring frequency to daily
		Rising trend over 3 samples above 1500 mg/L	Dilute with ED3 stormwater to reach 1000 mg/L
		Single Sample above 2000 mg/L	Cease pumping until pilot treatment is available
	BOD	<120 mg/L	Continue pumping



Component	Parameter	Trigger	Action
		Fluctuating readings but average over 3 samples less than 200 mg/L	Continue pumping but increase monitoring frequency to daily
		Rising trend over 3 samples above 300 mg/L	Dilute with treated leachate to reach 120 mg/L
		Single Sample above 500 mg/L	Cease pumping until pilot treatment is available
	Odour	Within estimated levels for Stage 1	Continue pumping
		50% above estimated levels with rising trend	Assess odour impacts by remodelling site
		Odour levels estimated to increase at nearest receptor	Cease pumping until pilot treatment process operational
Mine Dewatering Stage 3	Ammonia	<1000 mg/L	Continue pumping
		3 consecutive samples above 1,000 mg/L	Advise EPA Ensure mine water is contained within a lined dam
	BOD	<120 mg/L	Continue pumping
		3 consecutive samples above 120 mg/L	Advise EPA Ensure mine water is contained within a lined dam
Groundwater Monitoring Bores	pH	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Conductivity	< 20% trend change over longterm average over 12 months	Continue monitoring and reporting
		> 20% trend change over longterm average over 12 months	Investigate rainfall patterns and dam levels Inspect for signs of leakage Continue monitoring and reporting
		> 20% trend change over longterm average over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Ammonia	0-10mg/L	Continue monitoring and reporting
		>20 mg/L with rising trend over 3 samples	Investigate nearby storages for leachate content Advise DPE, DRE and EPA of results
		>50 mg/L and rising trend over 6 samples	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DRE, DPE and EPA
	Hydrocarbons (TPH)	0-100 µg/L, ie undetectable at laboratory	Continue monitoring and reporting
		> 100 µg/L	Investigate source of hydrocarbons and report to DPE, DRE and EPA



Table 8 below specifically deals with groundwater level TARPs. These TARPs are specified in the DPI-Water approved Interim Bore Management Plan (August 2018) which relate to Works Approval 40WA417428 condition DS6041-00001 but are included in this management plan as they relate to overall groundwater monitoring.

**Table 8 – Trigger Action Response Plan - Groundwater**

Monitoring Bore	Trigger Level	Response Action
MB3	Recorded water level in MB3 is between 5 – 6 mbgl during a quarterly period for 3 consecutive quarterly periods	Response Action 1
	Recorded water level in MB3 is greater than 6 mbgl during the normal monitoring period	Response Action 2
MB8	Recorded water level in MB8 is between 7.5 – 8.5 mbgl during a quarterly period for 3 consecutive quarterly periods	Response Action 1
	Recorded water level in MB8 is greater than 8.5 mbgl during the normal monitoring period	Response Action 2
MB17	Recorded water level in MB17 is between 7 – 8 mbgl during a quarterly period for 3 consecutive quarterly periods	Response Action 1
	Recorded water level in MB17 is greater than 8 mbgl during the normal monitoring period	Response Action 2
MB13	Recorded water level in MB13 is between 6 – 7 mbgl during a quarterly period for 3 consecutive period	Response Action 1
	Recorded water level in MB13 is greater than 7 mbgl during the normal monitoring period	Response Action 2

**Abbreviations:**

Term	Meaning
mbgl	metres below ground level
Response Action 1	Investigation and advise Department of Industry - Water and the Natural Resources Access Regulator within 5 business days of detection.
Response Action 2	Investigate and advise Department of Industry - Water and the Natural Resources Access Regulator within 5 business days of trigger exceedance and undertake remedial measures to address impacts from mining operations on groundwater supply for all affected landholders.
Remedial measures	Remedial measures should include but not restricted to the lowering of pumps, reconstruction of existing bores, construction of new bores, monetary compensation for increased pumping costs and/or for securing water from alternative sources.
Normal monitoring period	monthly
Quarterly period	A period of three consecutive months

The above groundwater triggers are tied to the Water Access Licence Works Approvals and contained in the approved Water Management Plan. They are included in this management plan for completeness.

**Table 9 – Trigger Action Response Plan - Paste**

Component	Parameter	Trigger	Action
Paste Strength	14 day strength	>140 kPa	No action, continue monitoring
		<140 kPa	Increase binder content to reach strength requirement
leachability	Permeability	>2.0 x 10 <sup>-8</sup> m/s	No action, continue monitoring
		<2.0 x 10 <sup>-8</sup> m/s	Increase binder content to achieve required permeability
Paste quality	Acid generation	NAPP <0	Non-acid forming, continue monitoring
		NAPP >0	Potentially acid forming, increase cement and/or lime to paste mix to meet NAPP criteria



		NAG pH >4.5	Non-acid forming, continue monitoring
		NAG pH <4.5	Potentially acid forming, increase cement and/or lime to paste mix to meet NAG criteria
Mine Water Quality	pH	< 20% trend change above SSTV over 12 months	Continue monitoring and reporting
		> 20% trend change above SSTV over 12 months	Investigate and report to DPE on potential causes and develop remedial actions if considered necessary
		> 20% trend change above SSTV over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DPE, DPI and EPA
	metals	< 20% trend change above SSTV over 12 months	Continue monitoring and reporting
		> 20% trend change above SSTV 12 months	Investigate and report to DPE on potential causes and develop remedial actions if considered necessary
		> 20% trend change above SSTV over 24 months	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DPE, DPI and EPA

**Table 10 – Trigger Action Response Plan – Waste Rock Acid Mine Drainage**

Component	Parameter	Trigger	Action
Waste Rock	Non-Acid forming	NAPP <0 and NAG pH ≥4.5	No action required Material can be used for construction purposes Can be used for blending with PAF
	Non Acid Forming Alkaline material	NAPP <0 and/or APP >0 and NAG pH >7 and/or ANC > 5 kg H <sub>2</sub> SO <sub>4</sub> per tonne	Material to be identified Material can be used for construction or blending purposes
	Uncertain	NAPP value positive but NAG pH ≥ 4.5 NAPP value negative but NAG pH < 4.5	Undertake kinetic testing to further define or treat as PAF low capacity If classification is still uncertain the material is to be treated as PAF-LC
	Low Capacity Potentially Acid Forming	NAPP 0 to 10 kg H <sub>2</sub> SO <sub>4</sub> /T and NAG pH <4.5 NAPP value negative but NAG pH between 3 and 4.5	Material to be identified Use in low risk applications only Can be used for underground stowage Blending required if used in surface applications
	High Risk Potentially Acid Forming	NAPP value > 10 kg H <sub>2</sub> SO <sub>4</sub> /T and NAG pH <4.5	Material to be identified Surface storage only for 2 years in designated Waste Rock Emplacement Cannot be relocated underground without prior treatment Relocation and/or treatment after 2 years
Waste Rock Surface emplacement	Leave on surface	NAF	Material can remain on surface
	Treat or Blend	PAF – Low Capacity	Material to be retested following treatment to reach NAF status Material can be used on surface once NAF status confirmed



			Material can be used underground without further treatment
	Use in Paste manufacture	PAF – High Risk	For use in paste manufacture Must be treated or blended prior to transporting back underground
Acid Water Storage/Leachate storage	pH	< 20% trend change above 10 year average	Continue monitoring and reporting
		> 20% trend change above 10 year average	Investigate and report to DPE on potential causes and develop remedial actions if considered necessary
		> 20% trend change above 10 year average	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DPE, DPI and EPA
	metals	< 20% trend change above 10 year average	Continue monitoring and reporting
		> 20% trend change above 10 year average	Investigate and report to DPE on potential causes and develop remedial actions if considered necessary
		> 20% trend change above 10 year average	Engage external consultant to investigate causes and to provide recommended remedial actions Report results to DPE, DPI and EPA

The results of the monitoring work and any actions taken in response to each trigger will be reported each year in the Annual Review.

### 5.4 Review

In accordance the Project Approval, this WRMP will be reviewed and, if required, revised within three months of:

- the submission of an annual review under Condition 4 of Schedule 5;
- the submission of an incident report under Condition 7 of Schedule 5;
- the submission of an independent audit report under Condition 9 of Schedule (5); and
- any modification to the conditions of Project Approval.

This review will include the adequacy of strategies, plans and programs as required under the Project Approval. Recommendation for appropriate measures or action to improve the environmental performance of the mine and or any assessment, plan or program will be incorporated into this WRMP.





## **8 APPENDICES**

Appendix 1 – Plans

Appendix 2 - Definitions

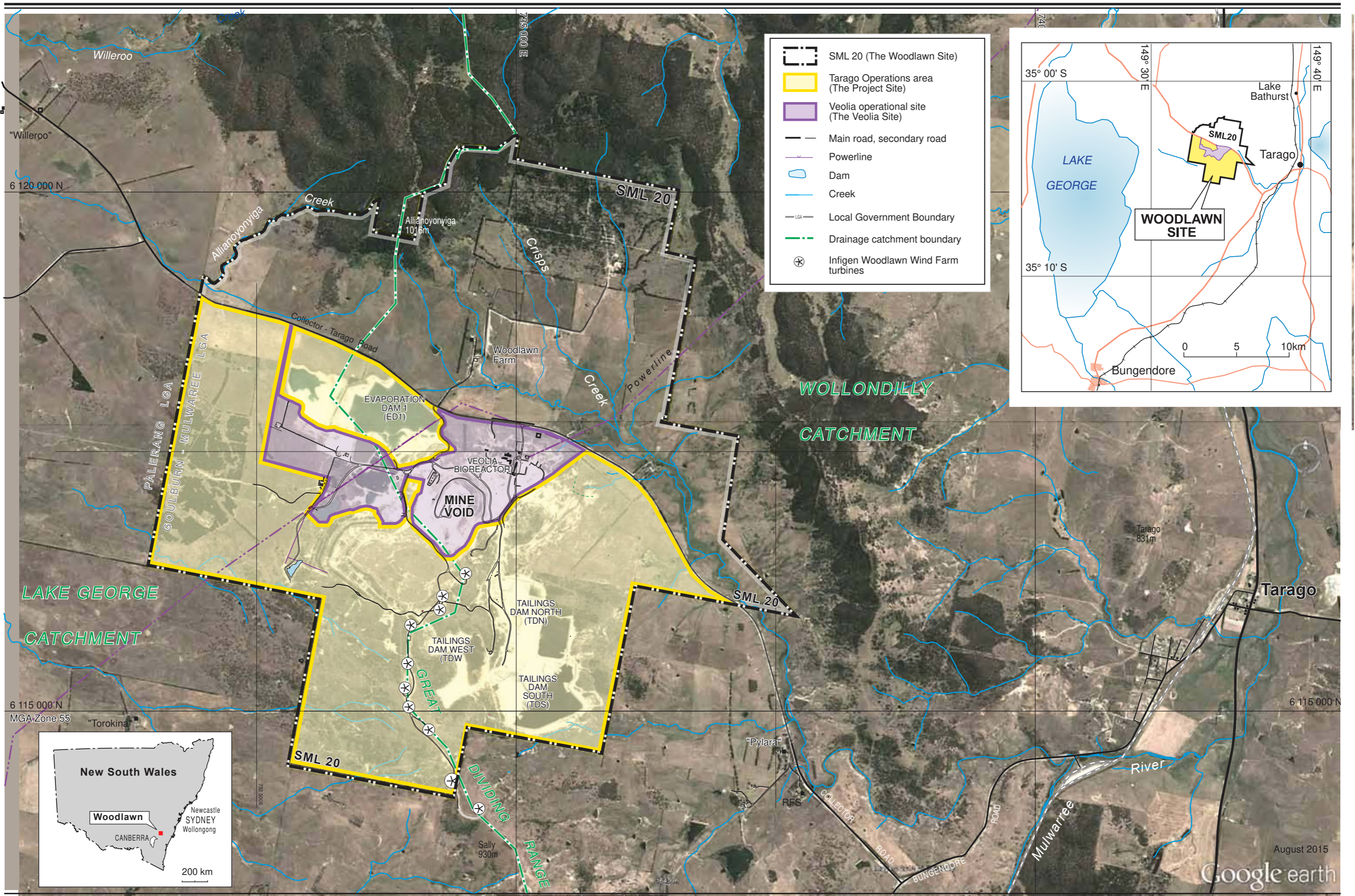
Appendix 3 – Roles and Responsibilities

Document Owner: Jeffrey Lewis		Authorised By: Andrew Lawry		
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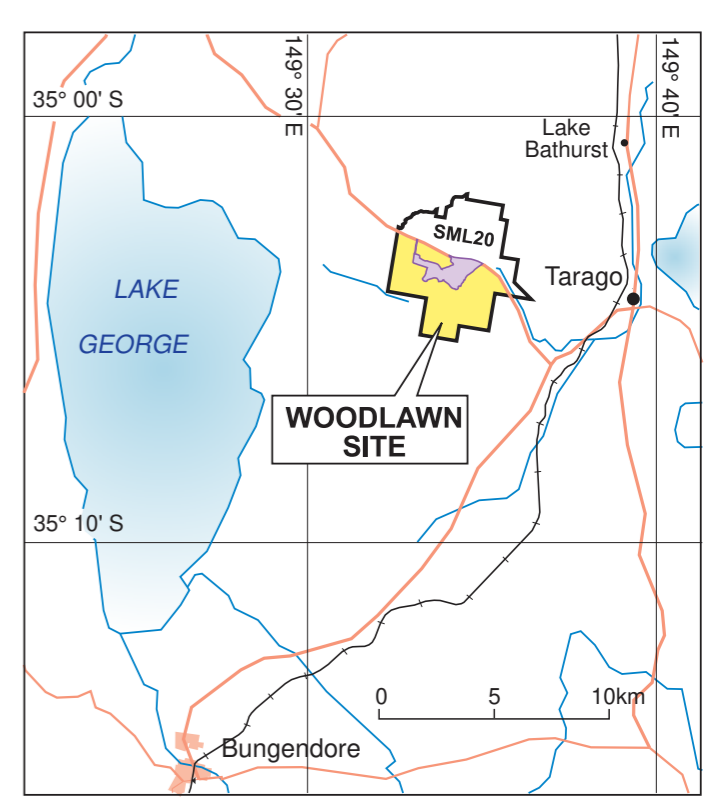


**Appendix 1 – Plans**

Document Owner: Jeffrey Lewis		Authorised By: Andrew Lawry		
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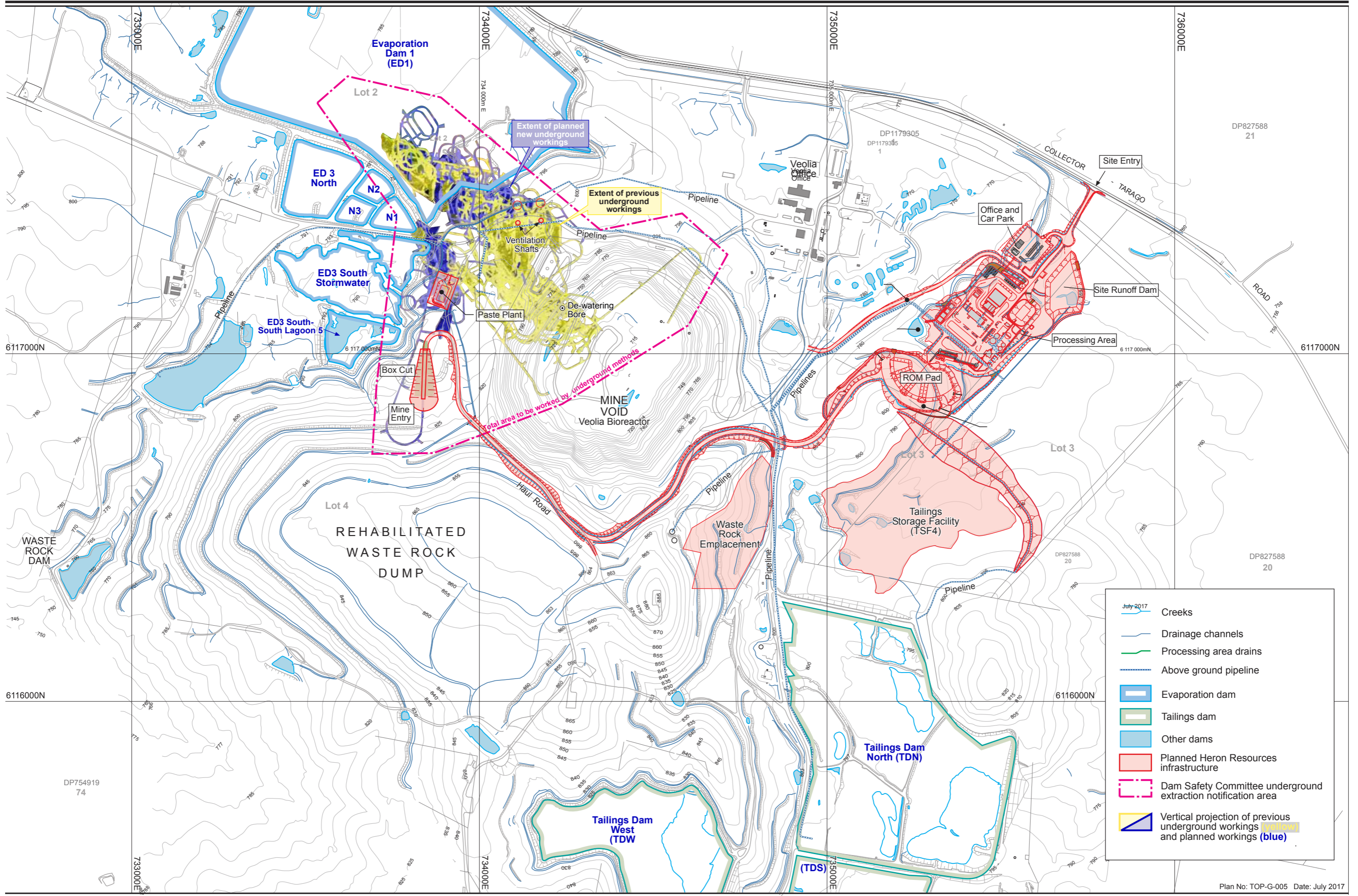


	SML 20 (The Woodlawn Site)
	Tarago Operations area (The Project Site)
	Veolia operational site (The Veolia Site)
	Main road, secondary road
	Powerline
	Dam
	Creek
	Local Government Boundary
	Drainage catchment boundary
	Infigen Woodlawn Wind Farm turbines



Topographic map source : Lake Bathurst 8827-4-N

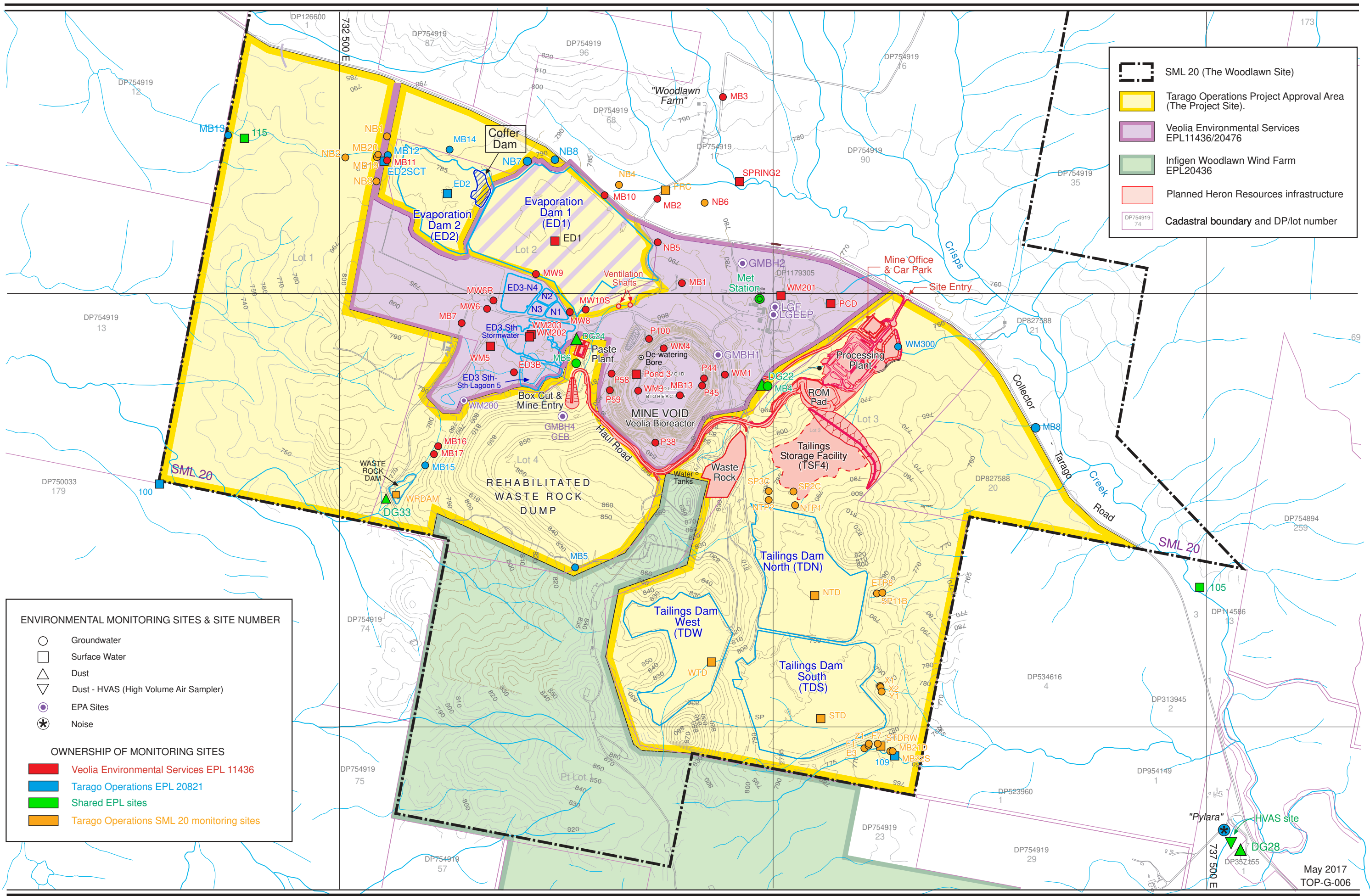




- |  |   |
|--|---|
|  | July 2017 Creeks  |
|  | Drainage channels   |
|  | Processing area drains  |
|  | Above ground pipeline   |
|  | Evaporation dam   |
|  | Tailings dam  |
|  | Other dams  |
|  | Planned Heron Resources infrastructure  |
|  | Dam Safety Committee underground extraction notification area                             |
|  | Vertical projection of previous underground workings (yellow) and planned workings (blue) |

Datum : GDA MGA Zone 55  
 0 100 200 300 400 500 metres  
 Scale 1:10000 at A3





- SML 20 (The Woodlawn Site)
- Tarago Operations Project Approval Area (The Project Site).
- Veolia Environmental Services EPL11436/20476
- Infigen Woodlawn Wind Farm EPL20436
- Planned Heron Resources infrastructure
- Cadastral boundary and DP/lot number

**ENVIRONMENTAL MONITORING SITES & SITE NUMBER**

- Groundwater
- Surface Water
- Dust
- Dust - HVAS (High Volume Air Sampler)
- EPA Sites
- \* Noise

**OWNERSHIP OF MONITORING SITES**

- Veolia Environmental Services EPL 11436
- Tarago Operations EPL 20821
- Shared EPL sites
- Tarago Operations SML 20 monitoring sites

Datum : GDA MGA Zone 55  
 0 500 1000 m





## Appendix 2 – Definitions

TERM	DEFINITION
AEMR	The Annual Environmental Management Report
ANZECC	Australian and New Zealand Environment and Conservation Council
ANC	Acid Neutralising Capacity
APP	Acid Producing Potential
ARA	Appropriate Regulatory Authority
Blue Book	Managing Urban Stormwater: Soils and Construction – 4th Edition, Landcom 2004
CCC	Community Consultation Committee
CEMP	Construction Environmental Management Plan
COO	Chief Operating Officer
Company	Heron Resources Limited - Tarago Operations Pty Limited
DPE	Department of Planning and Environment
DPI- Water	Department of Primary Industries - Water
DRG	Division of Resources and Geosciences
EA	Environmental Assessment
ED	Evaporation Dam
EMP	Environmental Management Plan
EMS	Environmental Management Strategy
EPA	Environment Protection Authority
EPL	Environmental Protection Licence
IEC	International Environmental Consultants
Infigen	Woodlawn Windfarm
MBT	Mechanical Biological Treatment



<b>TERM</b>	<b>DEFINITION</b>
<b>NAF</b>	Non-Acid Forming
<b>NAG</b>	Net-Acid Generation
<b>NAPP</b>	Net Acid Production Potential
<b>PAF</b>	Potentially Acid Forming
<b>POEO Act</b>	Protection of the Environment Operations Act 1997
<b>RWRD</b>	Rehabilitated Waste Rock Dam
<b>ROM</b>	Run Of Mine
<b>SEPP</b>	State Environmental Planning Policy
<b>SML20</b>	Special Mining Lease 20
<b>SOP</b>	Standard Operating Procedure
<b>TARP</b>	Trigger Action Response Plan
<b>TDN</b>	Tailings Dam North
<b>TOU</b>	The Odour Unit
<b>TSF4</b>	Tailings Storage Facility 4
<b>Veolia</b>	Woodlawn Bioreactor
<b>VES</b>	Veolia Environmental Services (Australia) Pty Limited
<b>WRMP</b>	Waste Rock Management Plan



### Appendix 3 – Roles and Responsibilities

The following outlines the responsibilities in relation to the compliance to this document.

ROLE	RESPONSIBILITY
<b>Managing Director</b>	<ul style="list-style-type: none"> <li>The <b>Managing Director</b> has overall responsibility for the implementation of the EMS at Woodlawn Mine as well as to review and approve expenditure and resources necessary to effectively implement the EMS and individual management plans.</li> </ul>
<b>Chief Operating Officer</b>	<ul style="list-style-type: none"> <li>The <b>Chief Operating Officer (COO)</b> reports to the Managing Director and is responsible for Project delivery and ultimate development and operation of the Project.</li> </ul>
<b>Project Manager</b>	<ul style="list-style-type: none"> <li>The <b>Project Manager</b> will ensure that the approved management provisions and requirements of the individual Environmental Management Plans and commitments are implemented. The Project Manager will review and evaluate the performance of the EMS program and environmental protection initiatives. This role may be merged with the Mine Manager during the construction period prior to commissioning.</li> </ul>
<b>Construction Manager</b>	<ul style="list-style-type: none"> <li>The <b>Construction Manager</b> will be responsible for the day to day management of the construction workforce, implementation of the Construction EMP and report directly to the Project Manager.</li> </ul>
<b>Mine Manager</b>	<p>The <b>Mine Manager</b> is responsible for the day to day management of the mine and overview role for environmental management systems on site, which will include:</p> <ul style="list-style-type: none"> <li>Ensuring compliance with environmental requirements for the site.</li> <li>Represent the on site contact officer under the Environment Protection Licence and other statutes.</li> <li>Report to the COO on a monthly basis on the environmental performance of mine.</li> <li>Liaise with the Environmental Officer on environmental matters as required.</li> </ul>
<b>Environmental Manager</b>	<p>The <b>Environmental Manager</b> will provide the following assistance with the EMS:</p> <ul style="list-style-type: none"> <li><input type="checkbox"/> Provide technical assistance on environmental matters to the Mine Manager.</li> <li><input type="checkbox"/> Undertake the necessary environmental monitoring program.</li> <li><input type="checkbox"/> Organise external environmental experts as required.</li> <li><input type="checkbox"/> Organise external environmental audits of the site on an annual basis.</li> <li><input type="checkbox"/> Develop Corrective Action Programs in consultation with the Mine Manager and monitor their implementation.</li> </ul> <p>Develop and implement an Environmental Training Package for the Mine.</p>