Surface Water Impact Assessment

Federation Project

Hera Resources Pty Limited

18 November 2021

→ **The Power of Commitment**

GHD Pty Ltd | ABN 39 008 488 373
GHD Tower, Level 3, 24 Honeysuckle Drive
Newcastle, New South Wales 2300, Australia
T 61-2-4979 9999 | **F** 61-2-9475 0725 | **E** ntlmail@ghd.com | **ghd.com**

Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	T Tinkler	S Gray		S Gray		12/11/21
S4	1	T Tinkler	S Gray	SGray	S Gray	SGray	18/11/21

Glossary

Alkalinity	A measure of the ability of an aqueous solution to neutralise acids. Alkalinity of natural waters is due primarily to the presence of hydroxides, bicarbonates and carbonates. It is expressed in units of calcium carbonate ($CaCO_3$).
Alluvial	Deposition from running waters.
Ambient	Pertaining to the surrounding environment or prevailing conditions.
Australian Height Datum	A common national surface level datum approximately corresponding to sea level.
Baseline monitoring	Monitoring conducted over time to collect a body of information to define specific characteristics of an area (e.g. species occurrence or water quality) prior to the commencement of a specific activity.
Bore	Constructed connection between the surface and a groundwater source that enables groundwater to be transferred to the surface either naturally or through artificial means.
Catchment	The land area draining through the main stream, as well as tributary streams, to a particular location.
Clean water	Water that has not come into physical contact with ore material and does not have an elevated sediment load.
Dewatering	The removal or pumping of water from an above or below ground storage, including the mine water within the water collection system of mine workings.
Dirty water	Water that has an elevated sediment load.
Discharge	The quantity of water per unit of time flowing in a stream, for example cubic metres per second or megalitres per day.
Electrical conductivity	A measure of the concentration of dissolved salts in water.
Ephemeral	Stream that is usually dry, but may contain water for rare and irregular periods, usually after significant rain.
Groundwater	Water occurring naturally below ground level.
Guideline value	The concentration or load of physicochemical characteristics of an aquatic ecosystem, below which there exists a low risk that adverse ecological effects will occur. They indicate a potential risk of impact if exceeded and should 'trigger' action to conduct further investigations or to implement management or remedial processes.
Hydrology	The study of rainfall and surface water runoff processes.
Infiltration	Natural flow of surface water through the ground surface and underlying strata during and following rainfall events.
Licensed discharge point	A location where the premises discharge water in accordance with conditions stipulated within the Environment Protection Licence.
Median	The middle value, such that there is an equal number of higher and lower values. Also referred to as the 50th percentile.
Percentile	The value of a variable below which a certain percent of observations fall. For example, the 80th percentile is the value below which 80% of values are found.
pH	The value taken to represent the acidity or alkalinity of an aqueous solution. It is defined as the negative logarithm of the hydrogen ion concentration of the solution.
Potable water	Water of a quality suitable for drinking.
Reach	Defined section of a stream with a uniform character and behaviour.
Riparian	Pertaining to, or situated on, the bank of a watercourse or other water body.
Runoff	The amount of rainfall which actually ends up as streamflow, also known as rainfall excess.
Run of mine	Raw ore production (unprocessed).
Sediment	Soil or other particles that settle to the bottom of lakes, rivers, oceans and other waters.
Stope	An excavation in a mine working or quarry in the form of a step or notch.

Stream order	Stream classification system where order one is for headwater (new) streams at the top of a catchment. Order number increases downstream using a defined methodology related to the branching of streams.
Subsidence	Vertical lowering, sinking or collapse of the ground surface.
Surface water	Water that is derived from precipitation or pumped from underground and may be stored in dams, rivers, creeks and drainage lines.
Topography	The arrangement of the natural and artificial physical features of an area.
Total Kjeldahl nitrogen	The sum of the concentrations of organic nitrogen, ammonia (NH_3) and ammonium (NH_4^+) in water.
Total nitrogen	A measure of organic and inorganic nitrogen forms in water. The sum of concentrations of TKN and nitrite and nitrate as N.
Total phosphorus	A measure of organic and inorganic phosphorus in particulate and soluble forms.
Total suspended solids	A measure of the filterable matter suspended in water.
Tributary	A stream or river that flows into a main river or lake.
Turbidity	A measure of clarity (turbidity) of water. Turbidity in excess of 5 NTU is just noticeable to the average person.
Watercourse	A natural or artificial channel through which water flows.

Abbreviations

AHD	Australian height datum
BOM	Bureau of Meteorology
DEM	Digital elevation model
DGV	Default guideline value
EC	Electrical conductivity
EIS	Environmental impact statement
EP&A Act	*Environmental Planning and Assessment Act 1979*
EPA	Environment Protection Authority
EPL	Environment Protection Licence
GHD	GHD Pty Ltd
ha	Hectare
kL/day	Kilolitre per day
km	Kilometre
LDP	Licensed discharge point
LOR	Limit of reporting
m	Metre
mg/L	Milligram per litre
ML	Megalitre
ML/day	Megalitre per day
ML/year	Megalitre per year
mm	Millimetre
Mt	Million tonnes
Mtpa	Million tonnes per annum
NRAR	Natural Resources Access Regulator
NTU	Nephelometric turbidity unit
POEO Act	*Protection of the Environment Operations Act 1997*
RL	Reduced level
ROM	Run of mine
SEARs	Secretary's environmental assessment requirements
SILO	Scientific Information for Land Owners
SSD	State significant development
SSGV	Site-specific guideline value
SWIA	Surface Water Impact Assessment
TKN	Total Kjeldahl nitrogen
tonne/year	Tonne per year
TSS	Total suspended solids
TARP	Trigger, action, response plan
WAL	Water access licence
WM Act	*Water Management Act 2000*
WSP	Water sharing plan
µS/cm	Microsiemens per centimetre

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1. Introduction

Hera Resources Pty Limited (Hera Resources) is a wholly owned subsidiary of Aurelia Metals Limited (Aurelia). Hera Resources currently own and operate the Hera Mine located approximately 80 km south-east of Cobar and approximately 5 km south of the township of Nymagee in western NSW, as shown in Figure 1.1. Aurelia owns and operates the Peak Gold Mine (PGM) near Cobar in western NSW.

Hera Resources is evaluating the development of the Federation Project (the Project), a proposed underground metalliferous mine development. The Project comprises underground mining activities and surface infrastructure at the Federation Site, amendments at Hera Mine to facilitate processing of ore from the Federation Site, and a Services Corridor connecting the Federation Site with Hera Mine. The Federation Site is located approximately 15 km south of the Nymagee township and 10 km south of the Hera Mine.

Hera Resources engaged GHD Pty Ltd (GHD) to undertake this Surface Water Impact Assessment (SWIA) for the Project. This assessment forms part of an environmental impact statement (EIS) to support a State significant development (SSD) application under Part 4 of the *Environmental Planning and Assessment Act 1979* (EP&A Act) for the Project.

1.1 Project background

Hera Mine has been operational since 2012 and produces gold and silver doré (unrefined bars) and a zinc/lead concentrate. Waste rock and metalliferous ore are extracted using underground open stope mining methods and underground load and haul operations. Hera Mine is approved to process up to 505,000 tonnes of ore on site annually, with lead/zinc concentrate transported to the Hermidale rail siding located approximately 75 km to the north-east. The Hera Mine Project Approval was modified in June 2021 to allow for operations up to 31 December 2025.

In April 2019 high grade lead, zinc and gold mineralisation was discovered at the Federation deposit. Subsequent surface drilling programs have delineated a substantial gold-lead-zinc-copper-silver mineral deposit. Hera Resources is evaluating the development of a satellite underground mine at the Federation Site that leverages established infrastructure at the Hera Mine to minimise environmental impacts and allow for the continuation of mining operations in the Nymagee area. Mining of the Federation deposit will allow for a transition of mining operations from Hera Mine to Federation Mine, as ore from the Federation deposit replaces ore from the Hera Mine.

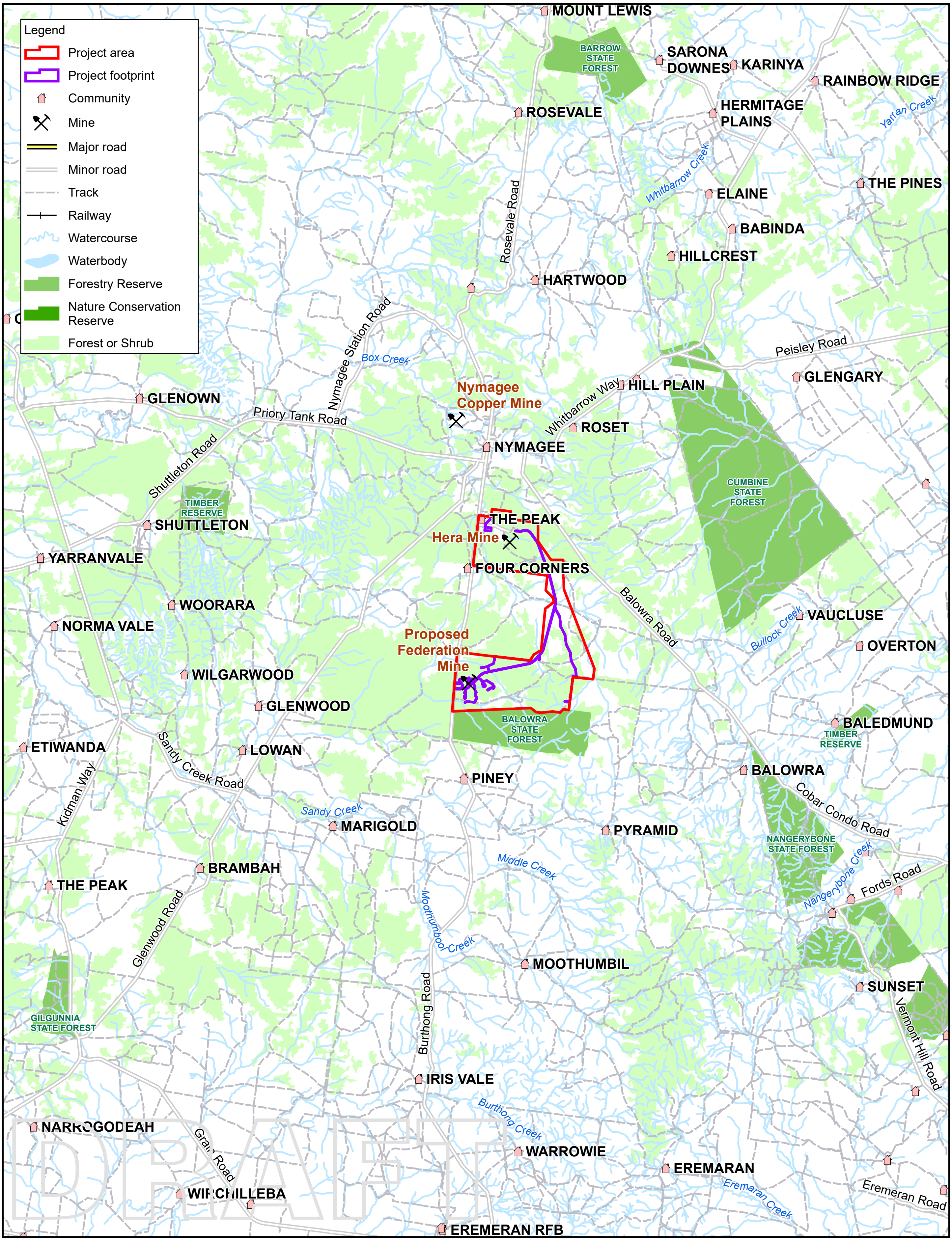
1.2 Project overview

The Project, as shown in Figure 1.2 comprises:

– The establishment and operation of underground gold and metalliferous mining activities, with supporting surface infrastructure, mining approximately 6.95 million tonnes (Mt) of ore over a period of 12 to 14 years, referred to as the Federation Site.
– Amendments at the Hera Mine to facilitate mining and processing of Federation deposit ore, including new process plant and disposal of tailings in the Hera Mine tailings storage facility (TSF).
– Services Corridor between the Federation Site and Hera Mine, including powerline, water pipeline and access track and potentially a tailings pipeline.

Total ore production from the Federation Site is approximately 6.95 Mt over the life of the mine. The majority of ore produced will be sent to Hera Mine for processing. However up to 200 ktpa will be transported to PGM during the initial four years of processing (total of 750 kt over this period), whilst the new processing plant at Hera Mine is being commissioned and ramped up.

Access to the underground mine will be via a portal developed through the base of a box cut. The main decline will be developed to gain access to all production levels, where stopes will be excavated. The loosened ore from the stopes will be brought to the surface via underground truck and placed on the Federation Site Run of Mine (ROM) ore stockpile near the boxcut. Ore will then be transported by surface trucks via Burthong Road to the Hera Mine ROM stockpile at the Hera Mine process plant.



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Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

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Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Project No. 12548432
Revision No. 0
Date 22/10/2021

Locality and site context

Figure 1-1

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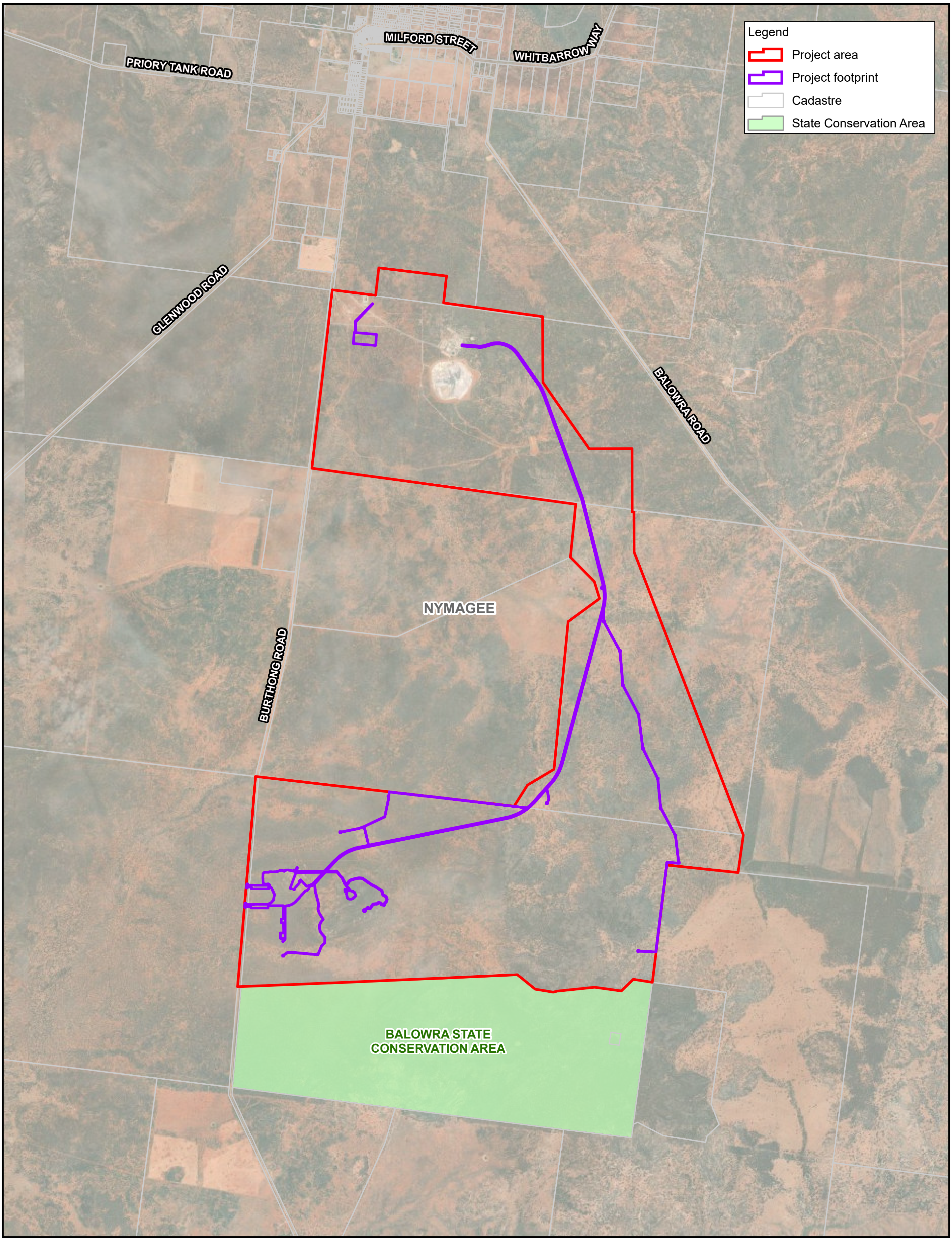
Data source: Resources and Energy: Mining Lease, 2016; Geoscience Australia: 250k Topographic Data Series 3, 2006; LPI: DTDB / DCDB, 2017; . Created by: eibbertson



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GHD

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Project overview

Figure 1-2

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Data source: LPI: DTDB / DCDB, 2017; NSW DPI: Seamless geology, 2020.World Imagery: Earthstar Geographics. Created by: Tmorton,eibbertson

Hera Mine infrastructure is proposed to be modified to facilitate the Project including a new 750 ktpa processing plant and solar farm. The existing processing plant will continue to operate at Hera Mine until the commissioning of the new plant. The new plant will be within the existing approved footprint of Hera Mine. The new processing plant will produce silver and gold doré and separate lead, zinc and copper concentrates.

A total of 5.8 Mt of tailings will be generated from the processing of the ore from the Federation deposit. Of this approximately 5.2 Mt will be produced at Hera Mine, with the remaining 0.6 Mt at PGM. Approximately 60% of total tailings produced will be returned to Federation Site to backfill underground stopes.

Hera Mine and Federation Site will be connected by a Services Corridor. The nominated width of the corridor is 23 m with an approximate length of 14.3 km. Clearing of existing vegetation will be required to install the proposed services infrastructure, including a power transmission line, water pipeline, access track and potentially a tailings slurry pipeline. The access track will be used for maintenance and inspection requirements and will not be used for haulage or ore.

Concentrate from Hera Mine will be trucked to the Hermidale rail siding for transport, as per the current concentrate transport methods and truck sizing. Concentrate from PGM will be transported to Hermidale or Dubbo rail sidings, as per the current concentrate transport methods and truck sizing.

1.2.1 Transitional period

It is anticipated that approval for the Project will be obtained in early 2023. Prior to the construction and operation of the Federation Project, an Exploration Decline Program will be undertaken. This activity will be undertaken under a separate approval to that being sought for the Project. The main objectives of the Exploration Decline Program are to further define the mineral resources associated with the Federation deposit, including permitting drilling of exploration drill holes from underground.

Key components of the Exploration Decline Program include:

- Establishment of a Surface Infrastructure Area required to support the exploration decline.
- Development of a box cut, portal, exploration decline, two ventilation rises and one escapeway.
- Transportation to and storage of waste rock within the Surface Infrastructure Area, with subsequent transport of waste rock to Hera Mine.
- Establishment and use of an approximately 14.8 km surface pipeline to transfer water from the exploration decline to Hera Mine.
- Exploration drilling from the exploration decline.
- Extraction of one or more bulk samples together totalling no more than 20,000 t and transportation of that material to Hera Mine processing plant via Burthong Road.

It is anticipated that the Exploration Decline Program will commence in November 2021 with the Surface Infrastructure Area established and waste rock being generated from the decline. It is anticipated that ore from the bulk sample will be extracted and processed between the third quarter of 2022 and first quarter of 2023. Based on the current schedule for the Project, there will be a transitional period between Exploration Decline Program activities, mining operations at Hera Mine, and Project construction and operations. Following approval of the Project:

- Construction of Project infrastructure (including the new process plant) will commence in the first half of 2023
- Exploration Decline Program activities will transition into mining operations at the Federation Site
- Hera Mine operations may continue over a period of 6 to 12 months

From early 2024, it is anticipated that all activities will be related to the Project operations. The operational workforce numbers will be transitioned from Hera Mine operations to Project operations.

1.2.2 Federation Project detailed overview

A detailed overview of the aspects of the project relevant to surface water are summarised in Table 1.1.

Table 1.1 Detailed Project Overview

Project Aspect	Project Details
Tenements	Hera Mine and Federation Projects Mining Lease 1686 Mining Lease 1746 Exploration Licence 6162 Exploration Licence 7447
Current Approvals	Hera Mine Major Project Approval – (PA) 10_0191 Environment Protection Licence – 20179 Hera Mine Accommodation Village Development Consent 2012/LD-0004 Development Consent 2021/LD-00010
Federation Deposit	The total potential mineralisation is 7 Mt.
Mining Method	Underground mine stoping method. Access to the underground mine will be via a portal developed through the base of a box cut and decline. The proposed mining method requires excavation via drilling to a depth of approximately 530 m to access areas of economically viable mineral resource deposits. Once the mineral deposit is accessed, stopes will be excavated via drilling and blasting. Tailings from Hera Mine will either be placed within the approved Hera Mine tailings storage facility (TSF) or and returned to the Federation Site where they will be processed by a pastefill plant for underground backfilling of mined stopes.
Processing	A new 750 ktpa process plant design is proposed to be commissioned at Hera Mine. The existing processing plant will continue to operate at Hera until the completion of the new plant. The new plant will be within the existing approved footprint of Hera Mine. The new processing plant involves: – Three stages of crushing followed by ball milling with hydrocyclone classification – Gravity separation to recover gold from the milling circuit recirculating load, followed by cyanide leaching of the gravity concentrate – Sequential flotation to produce separate copper, lead and zinc concentrates – Concentrate thickening and filtration – Tailings thickening and disposal by underground backfill placement in the stopes at the Federation Site and surface storage in the Hera Mine TSF The primary difference between the proposed plant and the current plant, is that each concentrate (e.g. zinc concentrate) will be produced through dedicated processing circuits.
Waste Rock Management	Two waste rock stockpiles will be located at the Federation Site to store waste rock generated from the development of the boxcut, decline and the lateral and vertical development. One stockpile will be for the storage of potential acid forming (PAF) materials and the other for mixed non-acid forming (NAF) and PAF materials. Should a greater proportion of waste rock be identified as PAF material, all or part of the NAF waste rock stockpile area will be managed as a PAF waste rock stockpile. PAF waste rock will be stored on surface with drainage to a lined leachate pond and used as backfill underground during or post mine life. NAF waste rock will be stored on surface for later use in rehabilitation, such as backfilling the box cut.
Ore Transport	Ore from the Federation deposit, that will be processed at Hera Mine, is proposed to be transported approximately 11 km along Burthong Rd. Ore proposed for processing at PGM will be transported along Burthong Rd, Priory Tank Rd and Kidman Way (the same as the currently approved alternate concentrate haulage route). Ore will be transported in trucks with an approximate 50 t payload.
Tailings Storage	The approved Hera Mine TSF will continue to be used to store tailings from the Hera processing plant which will process ore from the Federation Site. It is estimated over the life of the Project 5.2 Mt of tailings will be produced from Federation, of which 3.5 Mt will be returned to the Federation Site to be used as backfill. The remaining 1.7 Mt will be placed into the approved TSF.

Project Aspect	Project Details
Surface Infrastructure – Federation Site	Site roads, laydown and access control Explosives magazines x 2 Mobile equipment maintenance workshop and warehouse Hydrocarbon storage Heavy and light vehicle washdown facilities Administration building Change house and laundry Sewerage treatment plant Potable Water Treatment Plant Substation Soil stockpiles Pastefill Plant Batch Plant Communications Tower Quarry
Water Supply	Water will primarily be supplied from dewatering of the underground workings. As part of the mine development, a new borefield will be established for the supply of water from production bores. There are existing water supply bores supplying water to Hera Mine, which will continue to operate. Aurelia holds WAL 43173, which permits the extraction of 543 ML of water annually. There is no planned increase to this limit as part of the Project.
On-site water management	The Project will have an integrated water management system across the Federation Site and Hera Mine. A water pipeline within the Services Corridor, and pumps at the Federation Site and Hera Mine, will allow for transfer of water. Water management infrastructure to be constructed at the Federation Site includes: – Mine water dam for dewatering the underground workings with approximate dimensions of 50 m x 50 m with a capacity of 10 ML. – Leachate ponds for collection of runoff from waste rock pads and ROM pad. Water from the leachate ponds will be pumped to the mine water dam. – Stormwater retention pond designed to collect runoff from disturbed areas that do not contain contaminants. The dam has been sized to collect a 1% AEP 72-hour design rainfall event. – Potentially other minor sediment dams, which would flow to the primary sediment dam. – Drainage infrastructure to separate clean water, sediment water and potentially contaminated water. The catchment areas, which store potentially contaminating materials such as the fuel, hydrocarbons or PAF waste rock will have their own contained catchments and have been limited in extent to minimise the generation of contaminated surface run-off.
Concentrate Transport	Concentrate from Hera Mine will be trucked to the Hermidale rail siding for transport, as per the current concentrate transport methods and truck sizing (50 tonne payload). Concentrate from PGM will be transported to Hermidale or Dubbo rail sidings, as per the current concentrate transport methods and truck sizing.
Hours of Operation	Construction activities will be undertaken 7 days per week during daylight hours, unless a particular aspect of construction requires 24/7 activities. Transport of ore along Burthong Road will be undertaken during daylight hours. Operations at the Federation Site and Hera Mine will be 24 hours per day 7 days per week.
Workforce	It is estimated that a workforce of approximately 100 people will be employed during construction, with a workforce of 200 - 250 for Project operations, depending on the mining and processing production rates. There is a workforce of approximately 150 people for the current Hera Mine operations. Other than the 12 month construction phase, the Project maintains a reasonably consistent workforce, with some increases in the transition from Hera Mine to the Project.

Project Aspect	Project Details
Mining Equipment	Twin boom jumbo Production drill rig 50 t trucks 17 t loaders Shotcrete sprayer Shotcrete agitator Explosives charging unit Integrated toolcarrier (IT) Service truck Grader Water truck Truck and Loader
Decommissioning and Rehabilitation	Rehabilitation and decommissioning of the Project, including the Hera Mine site, would be undertaken on completion of extraction of the Federation deposit, with underground exploration and water extraction continuing at Hera Mine during extraction from the Federation deposit. Backfilling of the stope voids will occur throughout operations. A Rehabilitation Management Plan will be developed for the Project which will outline the rehabilitation objectives and final landform for the project.

1.3 Objectives of the surface water impact assessment

The key objective of the SWIA is to identify and determine the potential impacts of the Project on the surface water environment by addressing the Secretary's environmental assessment requirements (SEARs) for the Project and relevant government agency requirements. The SEARs and additional requirements are presented in Table 2.1, along with a reference to where each has been addressed in the SWIA.

The scope of work for the SWIA includes:

- Review existing assessments and data relevant to the Project
- Review relevant statutory requirements
- Establish the existing and/or approved conditions for the surface water systems
- Determine the water management requirements for the Project
- Undertake an assessment of the potential impacts of the Project on:
  - Water balance
  - Surface water flow
  - Surface water quality
  - Downstream water users, including licensed water users and basic landholder rights
- Undertake an assessment of the cumulative impacts of the Project in association with other operations in the region
- Identify licensing requirements
- Develop measures to avoid, minimise and mitigate potential impacts of the Project and provide recommended management, monitoring and reporting requirements

1.4 Scope and limitations

This report: has been prepared by GHD for Hera Resources Pty Ltd and may only be used and relied on by Hera Resources Pty Ltd for the purpose agreed between GHD and Hera Resources Pty Ltd as set out in Section 1.3 of this report.

GHD otherwise disclaims responsibility to any person other than Hera Resources Pty Ltd arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Hera Resources and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Regulatory context

2.1 Legislation

2.1.1 Environmental Planning and Assessment Act 1979

The EP&A Act is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

The SWIA has been developed to address the surface water components of the SEARs and accompanying government agency requirements for the Project, which are reproduced in Table 2.1, along with a reference to where each requirement has been addressed within this report.

Table 2.1 Secretary's Environmental Assessment requirements

Assessment requirement	Where addressed
The EIS must address the following specific issues with the level of assessment of likely impacts proportionate to the significance of, or degree, of impact on, the issue, within the context of the project location and the surrounding environment and having regard to applicable NSW Government policies and guidelines. **Water** – including:	
An assessment of the likely impacts of the development on the quantity and quality of surface, and groundwater resources, having regard to the *NSW Aquifer Interference Policy*;	Section 6, Section 7, Section 8.2, Section 8.3 Refer to Groundwater Impact Assessment (GIA) (GHD, 2021) for groundwater resources
An assessment of the hydrological characteristics of the site and downstream;	Section 6
An assessment of the likely impacts of the development on aquifers, watercourses, riparian land, water-related infrastructure and systems and other water users, including impacts to water supply from dams, and riparian and licensed water users;	Section 8 Refer to GIA (GHD 2021) for aquifers
A detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply and transfer infrastructure and water storage structures, and measures to minimise water use;	Section 5
Demonstration that water for the construction and operation of the development, for the life of the project, can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant *Water Sharing Plan* (WSP), and include an assessment of the current market depth where water entitlement is required to be purchased;	Section 8.6.1
A description of the measures proposed, including monitoring activities and methodologies, to ensure the development can operate in accordance with the requirements of any relevant WSP or water source embargo;	Section 9
A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate surface and groundwater impacts;	Section 4, Section 9.3
An assessment of the potential flooding impacts of the project;	Section 6

2.1.2 Protection of the Environment Operations Act 1997

The *Protection of the Environment Operations Act 1997* (POEO Act) is administered by the Environment Protection Authority (EPA), which is an independent statutory authority and the primary environmental regulator for NSW. The objectives of the POEO Act are to protect, restore and enhance the quality of the environment, by mechanisms including programs to reduce pollution at the source and monitoring and reporting on environmental quality. The POEO Act regulates and requires licensing for environment protection, including for waste generation and disposal and for water, air, land and noise pollution.

Under the POEO Act, an Environment Protection Licence (EPL) is required for premises at which a 'scheduled activity' is conducted. Schedule 1 of the POEO Act lists activities that are scheduled activities for the purpose of the Act. Licence conditions relate to pollution prevention and monitoring and can control the air, noise, water and waste impacts of an activity.

Hera Resources holds EPL 20179 for the premises at Hera Mine, which includes specific monitoring requirements for surface water, including locations, parameters, frequency, sampling method, and concentration limits for specific pollutants at each licensed discharge point, summarised in Section 4.1.

Changes to EPL 20179 are recommended in Section 8.6.3.

2.1.3 Water Management Act 2000

The aim of the *Water Management Act 2000* (WM Act) is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

Historically, the Water Act 1912 was the main legislation for managing water resources in NSW; however, this Act has been progressively phased out and replaced by water sharing plans (WSPs) under the WM Act. Once a WSP commenced, existing licences under the Water Act 1912 were converted to water access licences (WALs), water supply works and use approvals (controlled activity approvals) under the WM Act. All new WALs and controlled activity approvals are also issued under the WM Act.

Section 4.41 of EP&A Act details that a water use approval under Section 89, a water management work approval under Section 90 or an activity approval (other than an aquifer interference approval) under Section 91 of the Water Management Act 2000 is not required where an SSD approval is given. A water management work approval includes a water supply works approval, drainage work approval and flood work approval. An activity approval includes a controlled activity approval and an aquifer interference approval.

2.1.3.1 Water sharing plans

Fresh water sources throughout NSW are managed via WSPs under the WM Act. Provisions within WSPs provide water to support the ecological processes and environmental needs of groundwater dependent ecosystems (GDEs) and waterways. WSPs also regulate how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

For surface water, the Project is covered by the Yanda Creek Water Source under the WSP for the Intersecting Streams Unregulated and Alluvial Water Sources (2011).

For groundwater, the Project is covered by the porous and fractured groundwater sources of the Lachlan Fold Belt Murray Darling Basin (MDB) groundwater source, a sub-area of the WSP for the NSW MDB Fractured Rock Groundwater Sources.

There are no surface water access licences or works approvals related to the Project. Surface water storages that form part of the water management system are exempt from consideration under water access licensing and harvestable rights, as they are dams solely for the capture, containment and recirculation of drainage, consistent with best management practice to prevent the contamination of a water source.

Aurelia holds a groundwater WAL for the Lachlan Fold Belt MDB groundwater source, which includes works approvals for Hera Mine and Nymagee Mine, as summarised in Table 2.2. The excavation in Table 2.2 refers to the underground workings at Hera Mine.

Table 2.2 Hera Mine groundwater approvals and licences

Works approval	Details	Location	Water Access Licence (WAL)	Share components (ML/year)
85WA752586	10 bores 1 excavation	Lot 664, DP 761702	WAL 43173	543
85WA752816	1 bore	Lot 1, DP 665073		

The security water supply for the Project is assessed in Section 8.6.2.

2.1.3.2 Basic landholder rights

Under the WM Act, extraction of water for basic landholder rights is protected by allocating and prioritising water for basic landholder rights. There are three types of basic landholder rights in NSW under the WM Act:

- Domestic and stock rights: Landholders are entitled to take water from a river, estuary or lake which fronts their land or from an aquifer which is underlying their land for domestic consumption and stock watering, without the need for a licence. However, a water supply work approval is required to construct a dam or a groundwater bore.
- Native title rights: Anyone who holds native title with respect to water, as determined by the *Native Title Act 1993,* can take and use water for a range of purposes, including personal, domestic and non-commercial communal purposes. There are no native holder rights identified in the water sources covering the Project.
- Harvestable rights: Landholders are entitled to collect runoff from their property and store it in one or more dams up to a certain capacity that are located on minor streams. This entitlement is known as a 'harvestable right' and is determined from the total contiguous area of land ownership. In the Western Division of NSW (where the Project is located), landholders may capture and use for any purpose all runoff for their property in dams that are located on minor stream without requiring an approval or licence under the WM Act.

The Project is assessed in terms of basic landholder rights in Section 8.6.1.

2.1.3.3 Controlled activity approval

Section 91 of the WM Act details the requirements for controlled activity approval to carry out work on waterfront land, which includes the bed of any river, lake or estuary and any land within 40 m of its highest bank. SSDs and activities within a mining lease do not require controlled activity approvals. As the Project is an SSD and regulated under a mining lease, no controlled activity approvals are required. However, it remains an offence to harm waterfront land when carrying out an exempt controlled activity.

The Federation Site is located greater than 40 m from any mapped watercourse. The potential impacts of disturbance of watercourses by the construction of the Services Corridor is expected to be mitigated as described in Section 9.3.2.

2.2 Policies

2.2.1 NSW State Rivers and Estuary Policy

The NSW State Rivers and Estuaries Policy (NSW Water Resources Council 1993) provides objectives and principles to achieve sustainable management of rivers and estuaries in NSW to ensure resource use is consistent with the long-term biological and physical function of the natural system. The objectives of the policy are "To manage the rivers and estuaries in NSW in ways which: slow, halt or reverse the overall rate of degradation in their systems; ensure the long-term sustainability of their essential biophysical functions; and maintain the beneficial use of these resources". The policy details guiding principles for sustainable management of rivers and estuaries.

2.3 Guidelines

2.3.1 Australian and New Zealand Guidelines for Fresh and Marine Water Quality

The Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) provide guidance for assessing and managing ambient water quality in a wide range of water resource types and according to specified environmental values, such as aquatic ecosystems, primary industries, recreation and drinking water. The revised Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018) were published in 2018 following scientific review of the ANZECC (2000) guidelines. The Water Quality Management Framework (ANZG 2018) provides the key requirements for determining appropriate guideline values or performance criteria to evaluate the results of water quality monitoring programs.

The ANZG (2018) guidelines adopt a risk-based approach to assessing ambient water quality by providing the framework to tailor water quality guidelines to local environmental conditions. Guideline values provided by ANZG (2018) can be modified into regional, local or site-specific guideline values (SSGVs) by taking into account factors such as the level of modification of the ecosystem, natural variability in water quality at reference sites, and water hardness. Guideline values are applied to the receiving environment at the edge of the mixing zone and do not apply to mine water at the point of discharge.

2.3.2 NSW Water Quality and River Flow Objectives

The NSW Water Quality and River Flow Objectives (DECCW 2006) are the agreed environmental values and long-term goals for each catchment in NSW. The objectives are intended to be considered in assessing and managing the potential impacts of activities on waterways.

Water quality objectives for uncontrolled streams in the Barwon-Darling and Far Western catchment are for the protection of aquatic ecosystems; visual amenity; primary and secondary contact recreation; livestock, homestead water supply and aquatic foods (cooked). The water quality objectives are consistent with the national framework for assessing water quality provided by ANZG (2018) and have been considered in the assessment of surface water quality, discussed in Section 7.

The river flow objectives are to: protect pools in dry times; protect natural low flows; protect important rises in water levels; maintain wetland and floodplain inundation; mimic natural drying in temporary waterways; maintain natural flow variability; maintain natural rates of change in water levels; manage groundwater for ecosystems; minimise effects of weirs and other structures; minimise effects of dams on water quality; make water available for unforeseen events; and maintain or rehabilitate estuarine processes and habitats. The river flow objectives have been considered in the assessment of surface water flow discussed in Section 6.

2.3.3 Using the ANZECC Guidelines and Water Quality Objectives in NSW

The document Using the ANZECC Guidelines and Water Quality Objectives in NSW (DEC 2006) provides guidance on applying the ANZECC (2000a; revised by ANZG 2018) framework for assessing water quality, including the use of water quality objectives for NSW, which is considered in the methodology for assessing water quality in Section 7.

2.3.4 Australian Guidelines for Water Quality Monitoring and Reporting

The Australian Guidelines for Water Quality Monitoring and Reporting (ANZECC 2000b) sets out a framework and guidance for the monitoring and reporting of fresh and marine surface water and groundwater. ANZECC (2000b) provides information for all aspects of a water quality monitoring program, including setting objectives, designing monitoring and sampling programs, laboratory analyses, data analysis and interpretation and reporting of results and conclusions.

The recommendations for water quality monitoring, presented in Section 9, for the Project were made in accordance with the framework presented by ANZECC (2000b).

2.3.5 Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales

The document Approved Methods for the Sampling and Analysis of Water Pollutants in New South Wales (DEC 2004) lists the sampling and analysis methods to be used when sampling water quality for compliance with environmental protection legislation, a relevant licence or relevant notice. All sample collection, handling and analyses undertaken for the purpose of this SWIA is understood to have been undertaken in accordance with the requirements outlined by DEC (2004).

2.3.6 Managing Urban Stormwater: Soils and Construction

Managing Urban Stormwater: Soils and Construction – Volume 1 (the 'Blue Book'; Landcom 2004) outlines the basic principles for the design, construction and implementation of sediment and erosion control measures to improve stormwater management and mitigate the impacts of land disturbance activities on soils and receiving waters. This document relates particularly to urban development sites; however, it is relevant to the Project as it provides guidance on the configuration of erosion and sedimentation controls, which may be necessary during construction and operation of the Project.

Managing Urban Stormwater: Soils and Construction – Volume 2E Mines and Quarries (DECC 2008) provides specific guidelines, principles and minimum design standards for good management practice in erosion and sediment control during the construction and operation of mines and quarries. This document relates specifically to this Project as a mine site.

2.3.7 Guidelines for controlled activities on waterfront land

The Natural Resources Access Regulator (NRAR) has published a number of guidelines on types of controlled activities and the protection of waterfront land. Waterfront land includes the bed and bank of a river, lake or estuary, and all land within 40 m of the highest bank of the river, lake or estuary.

The guidelines provide recommendations for the design and construction of instream works and an indication of the width of riparian zones to be considered. The guidelines (NRAR 2018) focus on the following key requirements:

- Maintaining the natural geomorphic processes through the accommodation of the existing watercourse, allow for the natural movement of sediment, woody debris and not allowing for an increase or the construction of scour and erosion within the existing watercourse
- Maintaining the existing watercourse hydrologic function through accommodation of low flows and not altering the natural bank full or flood flows
- The use of scour protection when required for the protection of existing banks, using placed rock
- Visual inspections and maintenance on the watercourse during the works

As discussed in Section 2.1.1, the Project is an SSD and as such does not require any controlled activity approvals. Despite this, the assessment of potential impacts of the Project on surface water has considered the guidelines for waterfront land and riparian corridors.

3. Existing environment

3.1 Climate

Climate record was obtained from SILO[1] for the Nymagee (Balowra) (station 49117), which is located approximately 17 km east-south-east of the Federation Site for the period from 1 January 1889 to 1 January 2021.

The cumulative frequency of annual total rainfall and evaporation from SILO dataset between 1889 and 2020 are compared in Figure 3.1. In addition, the figure compares SILO rainfall to site based rainfall recorded from 2015 to 2020 at the Hera Resources Weather Station, located at Hera Mine.

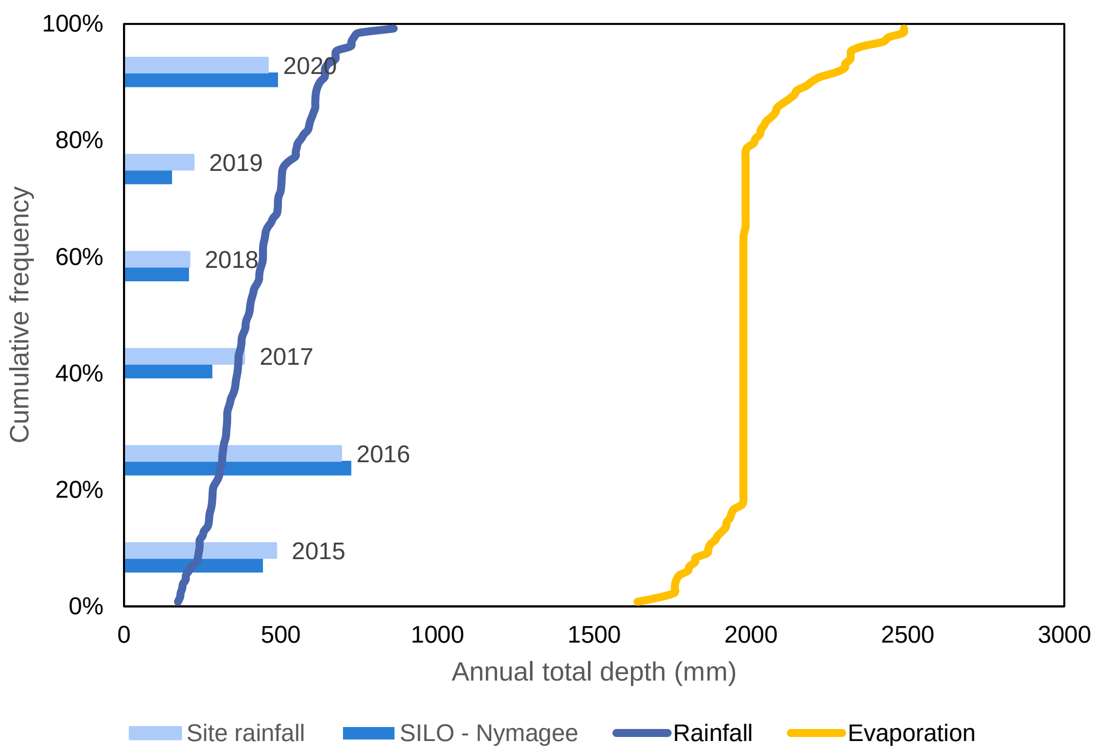


Figure 3.1 Comparison of annual rainfall depths

The statistics of annual totals of the historical rainfall record were:

- Minimum 153 mm (2019)
- Maximum of 902 mm (1956)
- Median of 396 mm

Annual evaporation totals have an average of 2001 mm, corresponding to an average annual moisture deficit (the difference between rainfall and evaporation) of 1575 mm.

The comparison of annual rainfall totals observed at the Hera Resources Weather Station against the SILO dataset is presented in the left side of Figure 3.1 and shows that SILO dataset can provide adequate representation of the potential rainfall variability at the Federation Site.

A plot of average monthly pan evaporation, obtained from the Cobar BOM station, is compared to average monthly rainfall from the historical record in Figure 3.2.

[1] SILO refers to patched point data set from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Science, Information Technology and Innovation (DSITI). SILO patched point data is based on observed historical data from a particular Bureau of Meteorology (BOM) station with missing data 'patched in' by interpolating with data from nearby stations (DSITI, 2021).

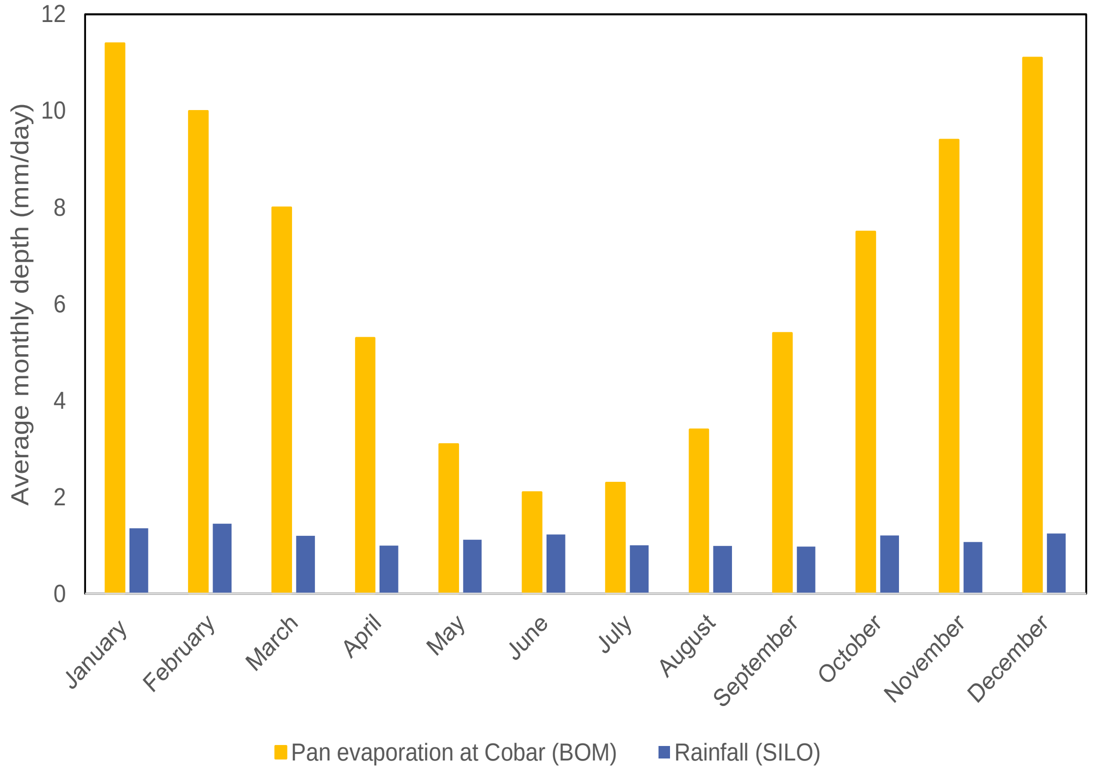


Figure 3.2 Monthly evaporation recorded at BOM station Cobar MO

Figure 3.2 show that evaporation varies seasonally, having higher records in summer compared in winter. The site has an average monthly net rainfall deficit in all parts of the year.

3.2 Topography and hydrology

Elevation near Hera Mine site varies from approximately 360 m AHD to approximately 305 m AHD. Elevated areas lie to the north and to the east of the pit top area and TSF and to the south of the Back Dam East and Back Dam. From this ridgeline elevations dip to the northeast and to the west.

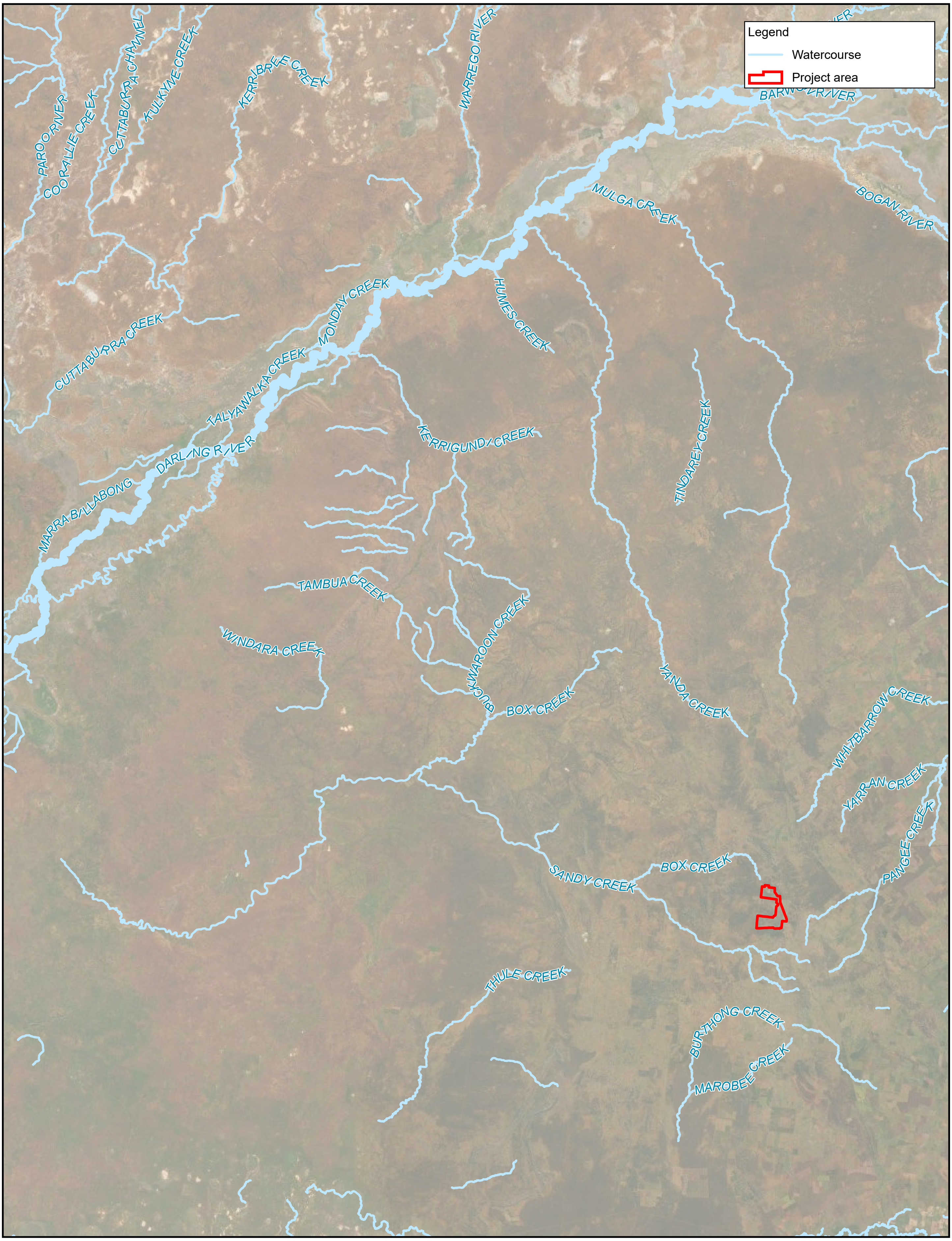
The topography of the Federation Site is generally flat. Local relief within the Federation Site ranges from approximately 315 to 320 m AHD. The elevation rises to the east of the Federation Site to over 380 m AHD.

The Project is located in the Murray Darling Basin. The Project is located within the catchment area of Sandy Creek. The main creek systems in the vicinity of the Project are westerly flowing ephemeral streams that ultimately drain to the Darling River, and include Box Creek to the north, and Sandy Creek to the south. Regional watercourse locations are shown in Figure 3.4. Due to their position in the upper catchment and highly ephemeral nature, there are no data regarding creek water levels and flow in the vicinity of the Project.

An analysis of catchments is presented in Section 6.

Watercourses were classified in terms of stream ordering following the Strahler stream classification system where waterways are given an ‘order’ according to the number of additional tributaries associated with each waterway (Strahler 1952). Figure 3.5 demonstrates the Strahler stream ordering process for a generic catchment. Numbering begins at the top of a catchment with headwater (‘new’) flow paths being assigned as first order. Where two flow paths of order one join, the section downstream of the junction is referred to as a second order stream. Where two second order streams join, the waterway downstream of the junction is referred to as a third order stream, and so on. Where a lower order stream (e.g. first order) joins a higher order stream (e.g. third order), the reach downstream of the junction will retain the higher stream order.

Watercourses that are local to the Project Area were classified by stream order and are shown in Figure 3.4. The tributaries of Box Creek are second and third order stream near Hera Mine and tributaries of Sandy Creek are first and second order near the Federation Site.



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Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
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Federation Project
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Revision No. **0**
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Regional hydrology

Figure 3-3

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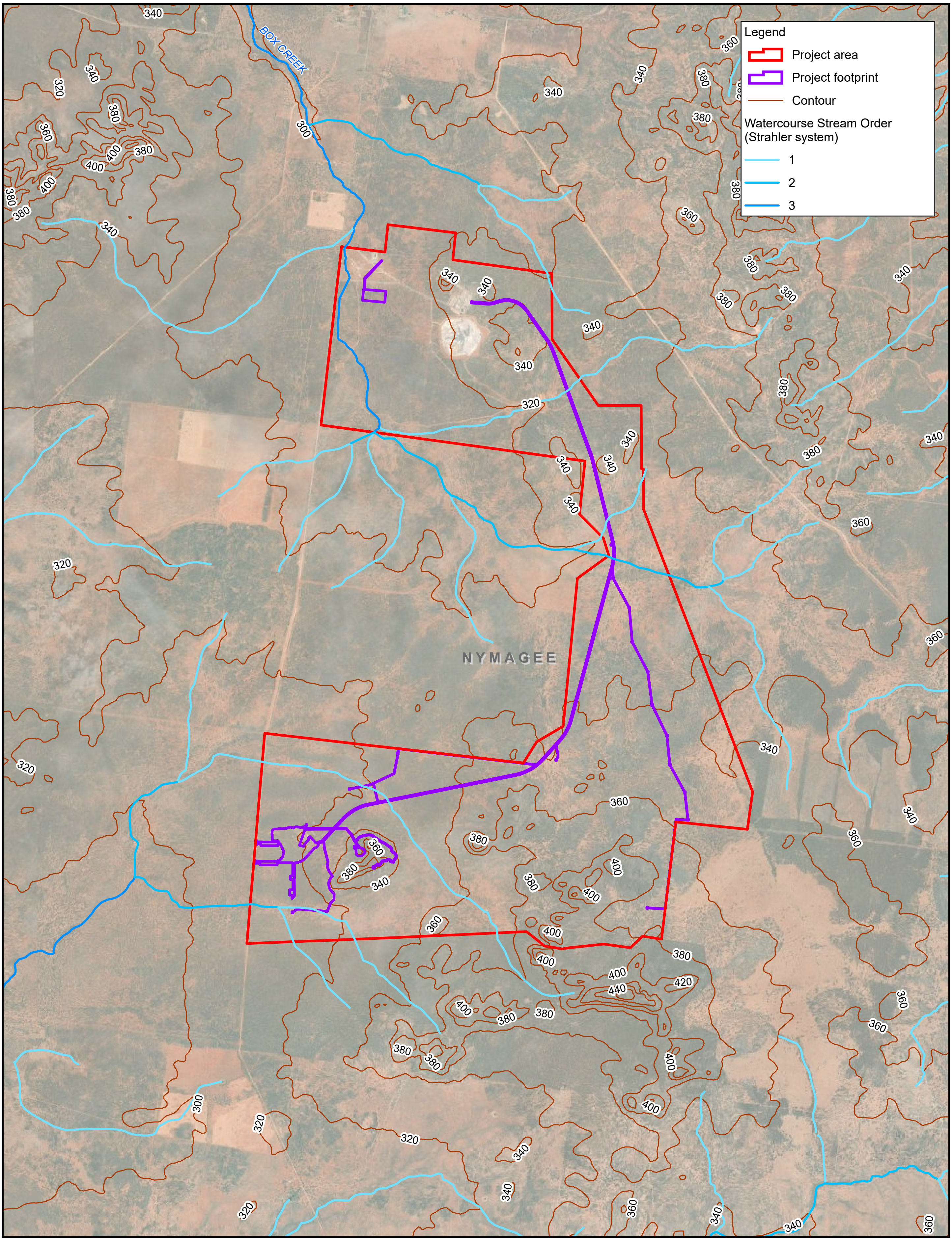
Data source: LPI: DTDB / DCDB, 2017; NSW DPI: Seamless geology, 2020.World Imagery: Earthstar Geographics. Created by: Tmorton,eibbertson



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Topography and watercourses

Figure 3-4

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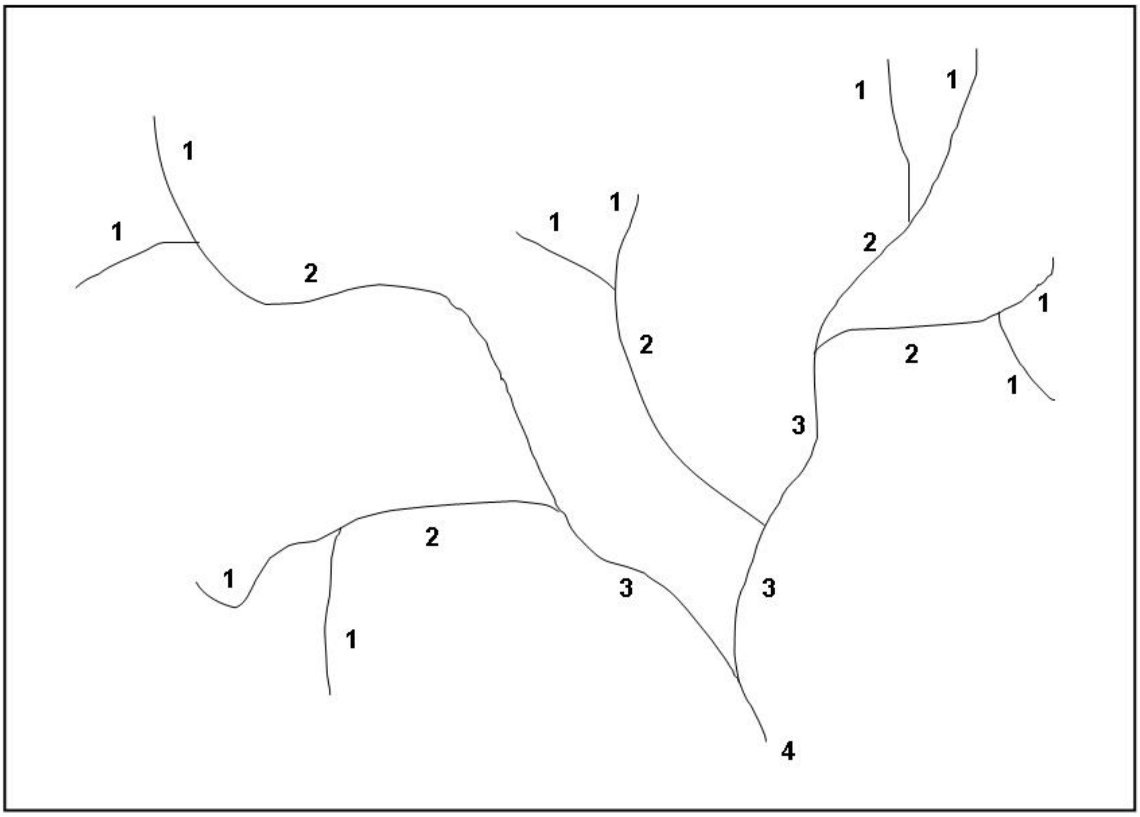


Figure 3.5 *Generic stream order (after Strahler, 1952)*

3.3 Geology and soils

Hera Mine is located on the eastern margin of the Devonian Cobar Basin. Basement rocks (the thick layer of foundation rock) are generally overlain by a layer of weathered regolith. Through the weathering of the basement rocks and the associated chemical changes, metals have mobilised in the regolith. Soil testing has identified elevated levels of lead, silver, arsenic, gold, bismuth, cobalt, copper, manganese, antimony and zinc (Cooper n.d.).

Near the Hera Mine site the regolith is generally overlain by alluvium or colluvium. The known areas of alluvium include one channel that runs from the Three Gates Dam northwards about 200 m west of the Hera deposit and a channel than runs north under both Pete's Dam and the House Dam (Cooper n.d.).

Soil investigations by SEEC (2011) identified very gravelly quartz-rich shallow soils (Lithosols) over most of the Hera Mine Surface Facilities Area and deeper uniform Red Earths without coarse fragments were encountered on the surrounding slopes and plains. Soil erodibility values (K factors) for the site are moderate to high at 0.03 to 0.05 (SEEC, 2011).

A Land and Soil Capability Assessment was undertaken for the Project (SSM 2021). The assessment found that surface soil properties were consistent across the Project footprint. The majority of topsoil layers were described as dark reddish brown sandy clay loam with subangular blocky structure.

3.4 Downstream licensed water users

Licensed surface water users were identified by searching the NSW Water Register (WaterNSW 2021) for licences and works approvals within 10 km of the Sandy Creek downstream of Federation Site and Box Creek downstream of Hera Mine to the confluence with the downstream regulated Darling River (refer to Figure 3.3). No licensed surface water users were identified downstream of the Project.

4. Water management system

The water management system for the Project would comprise the continued operation of the existing Hera Mine (refer to Section 4.1) and the proposed water management system at the Federation Site (refer to Section 4.2). The two locations would be connected by a pipeline along the Services Corridor that would generally convey excess water from Federation Site to Hera Mine. As part of the Project, additional production bores are expected to be constructed as required within the Project area. Although not expected to be required, the Project will also continue to include contingency water supplies including:

– Transfer of water from nearby Nymagee Mine, as approved by works approval 85WA752816
– Recycling of treated wastewater

The water management system at Hera Mine and the proposed Federation Site is generally focused on providing reliable water supply for operations and containing potentially contaminated water to minimise potential for offsite discharge. Sources of water include rainfall, runoff, production bores and groundwater inflow into the underground mine workings. Water demands include for ore processing, underground mining operations, dust suppression and staff amenities.

The water management system is classified into clean, dirty, raw and contaminated water elements:

– Clean water is surface runoff from undisturbed catchment areas within and upslope of the disturbance area. Clean water may be diverted around and discharged off site without treatment or licensing. Clean water collected in clean water storages may be harvested. No additional clean water harvesting under the WM Act is proposed, and in any case would not require approval as part of the Project.
– Dirty water is runoff from disturbed catchments that is potentially sediment laden, due to disturbance from construction activities.
– Raw water is groundwater sourced from production bores that is not contaminated. Raw water is a scarce resource that is extracted from production bores as required to satisfied specific site demands.
– Contaminated (or process) water is categorised by the increased likelihood of elevated concentrations of dissolved metals from contact with ore and waste rock. Contaminated water also includes water that is potentially contaminated with cyanide from the ore extraction process or hydrocarbons

4.1 Hera Mine

The water management system at Hera Mine includes the diversion of clean water runoff around upslope areas of the site, the collection of water from disturbed areas and the discharge of water to Box Creek. The catchments and clean and dirty water drainage are presented in Figure 4.1. The water management system includes:

– Clean water runoff from undisturbed catchment areas within and upslope of the site. These flows may be diverted and discharged off site without treatment or licensing.
– The dirty water management system which consist of a series of dirty water drains. Sediment Basin 1 and Sediment Basin 2 were used as dirty water storages during construction and have since been combined into a larger contaminated water storage which collects runoff from the processing plant area.
– Raw water system supplied from production bores around the site. The production bores transfer water to the Back Tank (located beside Back Dam). Water from the Back Tank is transferred to the Feed Water Tank. The House Dam receives surface water from the clean water catchment and the House Bore (production bore).

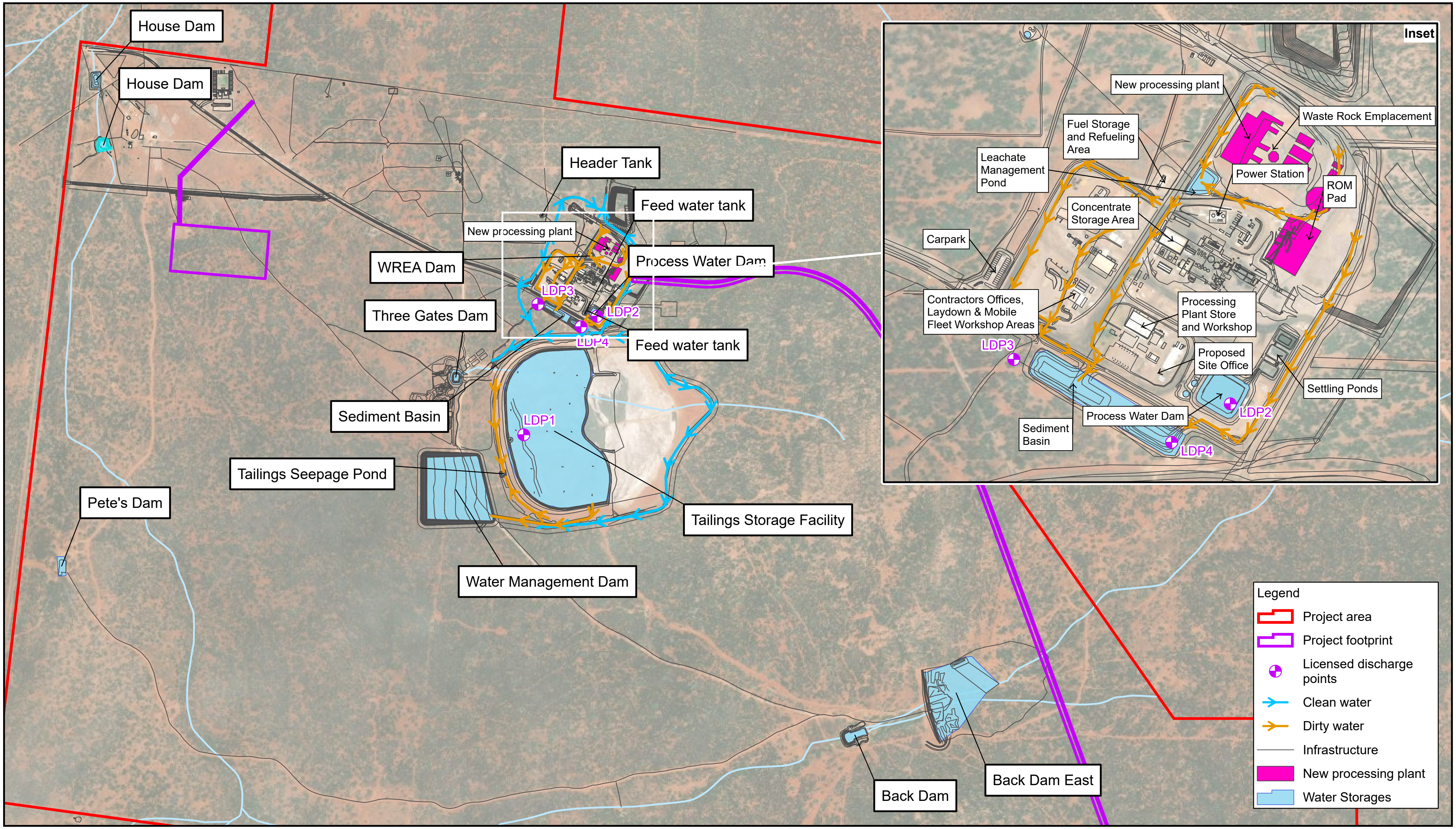
Contaminated water system, which includes Process Water Dam (PWD), TSF (within which is formed a Tailings Decant Pond), Tailings Seepage Pond, WREA Leachate Management Pond, and Sediment Basin. There is no active treatment of this water with all captured volume reused in processing. The construction of an additional contaminated water storage, the Water Management Dam, is approved at Hera Mine. The Water Management Dam is connected to the TSF by a spillway that is represented as a dirty water flow path in Figure 4.1. The Tailings Seepage Pond is intended to collect potential seepage from the TSF. No seepage from the TSF has been identified to date and the seepage pond is effectively a clean water storage collecting runoff from the downstream embankment of the TSF. Following construction of the approved Water Management Dam, overflow from the Tailings Seepage would report to the Water Management Dam.

EPL 20179 currently allows discharges from the site to occur from two locations, Sediment Basin 1 (referred to as LDP3) and Sediment Basin 2 (referred to as LDP4), which were located at the outlet of the former Sediment Basin 1 and Sediment Basin 2 respectively. Following the expansion of the Sediment Basin, an application to the EPA was made in November 2017 to remove LDP3 and LDP4. No response has been received to date. Two internal discharge points also exist for the TSF (LDP1) and PWD (LDP2). The location of the LDPs is included in Figure 4.1.

Discharge from LDP1, LDP2, LDP3 and LDP4 are permitted subject to the concentration limits summarised in Table 4.1. There are no volumetric discharge limits at Hera Mine.

Table 4.1 EPL 20179 pollutant concentration limits

Pollutant	EPL Concentration Limits	
	90% concentration	100% concentration
EPA Point 1		
Cyanide (WAD) (mg/L)		10
EPA Point 2		
Cyanide (WAD) (mg/L)	20	30
EPA Point 3 and EPA Point 4		
Aluminium (mg/L)	-	0.055
Arsenic (mg/L)	-	0.024
Boron (mg/L)	-	0.370
Cadmium (mg/L)	-	0.0002
Copper (mg/L)	-	0.0014
Cyanide (WAD) (mg/L)	-	0.007
Electrical conductivity (µS/cm)	-	1000
Lead (mg/L)	-	0.0034
Manganese (mg/L)	-	1.90
Nickel (mg/L)	-	0.011
Nitrogen (total) (mg/L)	-	0.5
Oil and Grease (mg/L)	-	10
pH (pH units)	-	6.5-8.5
Phosphorus (total) (mg/L)	-	0.025
Silver (mg/L)	-	0.00005
Total suspended solids (mg/L)	-	50
Zinc (mg/L)	-	0.008



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Water management system - Hera Mine

Figure 4-1

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Data source: NSW Trade & Investment Resources and Energy: Mining Lease, 2016; LPI: DTDB / DCDB, 2017 World Imagery: Maxar. Created by: eibbertson

4.2 Federation Site

The proposed water management system at Federation Site is similar to that at Hera Mine, with the absence of a processing plant and TSF. Water management is proposed to include the diversion of clean water runoff around the site, the collection of water from disturbed areas and the collection of underground water. The catchments and clean and dirty water drainage components within Federation Site are presented in Figure 4.2.

The water management system at Federation Site includes the following specific elements:

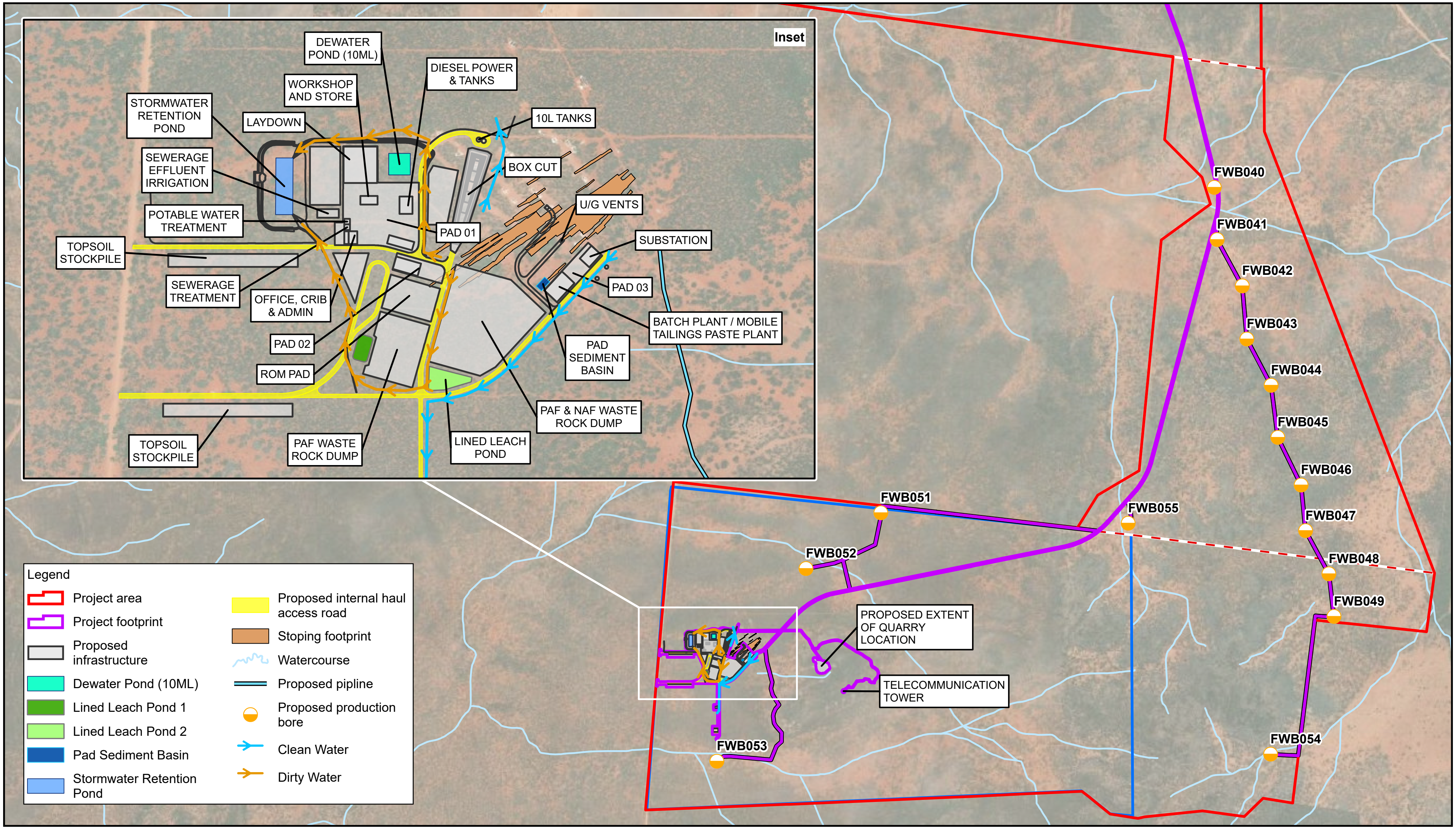
- Clean water from undisturbed catchment upslope of proposed Federation Site would be diverted around the disturbed areas of the site by open drains.
- Dirty water from the disturbed catchment of Federation Site during construction would be captured by dirty water cut off drains and conveyed to a sediment basin within the footprint of the Stormwater Retention Pond.
- Runoff from the PAF waste rock dumps would report to lined leach ponds: Lined Leach Pond 1 and Lined Leach Pond 2. Localised areas of potential contamination (e.g. areas with hydrocarbons) will have their own localised catchments (or be undercover) and be pumped out to the Dewater Pond.
- Runoff from the box cut would report down the decline and be dewatered as part of the underground dewatering system to the Dewater Pond.
- Water contained in the lined leach ponds, Stormwater Retention Pond and Dewater Pond would be recirculated for reuse with the Hera Mine water management system by the proposed water pipeline between Federation Site and Hera Mine.
- Potable water will be provided to the Federation Site by a reverse osmosis (RO) unit taking off from the raw water stream and wastewater will be treated and disposed of by irrigation.

The water management system at Federation Site has been designed to minimise to the potential for off-site discharge of potentially contaminated water to less than 1% annual exceedance probability. The specific design measures include:

- Hydraulic capacity for clean water diversion drains and dirty water captures drains to convey the peak flow from the 1% AEP design rainfall event.
- Water storage capacity to contain the runoff estimated from the 1% AEP 72 hour duration design rainfall event.
- The Dewater Pond has a nominal capacity of 10 ML for operational purposes.

The design criteria for Lined Leach Pond 1 and Lined Leach Pond 2 will be finalised as part of the detailed design of the Federation Site. These storages would overflow internally to the water management system and report to the Stormwater Retention Pond. The overarching criteria to minimise the potential for off-site discharge would remain.

The expected effectiveness of the water management system at Federation Site to minimise the potential for off-site discharges is assessed using the site water balance model in Section 5.6.



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Water management system - Federation Mine

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Figure 4-2

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Data source: NSW Trade & Investment Resources and Energy: Mining Lease, 2016; LPI: DTDB / DCDB, 2017 World Imagery: Earthstar Geographics
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5. Site water balance

The Project is likely to affect the site water balance of Hera Mine. A site water balance model was developed to quantify the potential impacts under a range of rainfall conditions. The methodology and data of the modelling are detailed in Appendix A. The purpose of this section is to provide a summary of the key inputs and assumptions and to assess the potential impacts of the Project based on the modelling results.

5.1 Modelling methodology

The site water balance for the Project was modelled as a semi-distributed mass balance, implemented in the modelling software GoldSim. The site water management system described in Section 4 were conceptualised into a series water cycle components that were linked together to simulate rainfall, runoff, evaporation, overflows pumped transfers, and operations over the life of the Project. The site water balance conceptualisation is presented schematically in Figure 5.2 and Figure 5.3.

For the purpose of this assessment, the results are statistically summarised under two conditions:

– **Existing conditions**: this represents the existing operations at Hera Mine, nominally for calendar year 2021. This does not represent actual conditions in the calendar year 2021, but rather representative of approved operations. This scenario adopted the predicted groundwater inflows into Hera Mine underground workings for 2021 based on the GIA (GHD 2021) as discussed in Section 5.2.

– **Proposed conditions**: this represents the proposed operations as part of the Project, including the proposed water transfers from Federation Site and adopted groundwater flows predictions for Federation underground workings as discussed in Section 5.2. The year 2028 was selected for the purpose of comparison between existing and proposed conditions, as this corresponded to peak in annual total groundwater inflows and therefore represents the proposed operation of the Project that is expected to be most different relative to existing conditions.[2] It was assumed that the approved Water Management Dam at Hera Mine was constructed prior to 2028.

The model considered rainfall variability characterised by the historical record. The model was simulated using a historical time series of daily rainfall data extending over 132 years, from January 1889 to January 2021. A total of 132 realisations were applied, with each realisation modelling a different rainfall pattern from the record.

5.2 Groundwater inflows

The GIA (GHD 2021) details the methodology, calibration and predictive groundwater modelling. Predictive modelling is to predict future groundwater conditions on and surrounding the Project, including inflow rates into the mine. The calibrated model achieved a moderate to high confidence, however it was identified that the model was overestimating current inflows into Hera Mine. The model forecasts that inflows at Hera Mine will remain relatively constant for as long as dewatering of workings continues over the life of the Project, however the actual inflows are likely to be similar to the currently observed inflow volumes than the forecasts of the groundwater model.

For the purpose of this assessment, it was assumed that:

– Inflows required to dewatered from Hera Mine underground workings remained similar to currently observed conditions of approximately 100 m^3/day until mining ceases at Hera Mine in last quarter of 2022. Continued dewatering of the Hera Mine underground workings may continue after this period, however, as this would be for the purpose of ongoing water supply for the Project, this is considered equivalent to extraction of the same volume of water from production bores for the purpose of this assessment (and therefore provides a conservative over-estimate of the requirement for water supply from production bores but is equivalent in terms of total groundwater take). The potential impacts on the groundwater environment of continued dewatering of the Hera Mine underground workings (in combination with production bores and Federation Mine underground workings) are assessed in the GIA (GHD 2021).

[2] There is an instantaneous peak in the predicted groundwater inflows in 2023, however this peak annual total for any calendar year in 2028.

– Dewatering from Federation Mine underground workings will cease in the second quarter of 2034 when forecast ore production falls under 20 000 tonne/month.

The groundwater inflows requiring dewatering from the Hera Mine and Federation Mine underground workings adopted for the purpose of this assessment are presented in Figure 5.1.

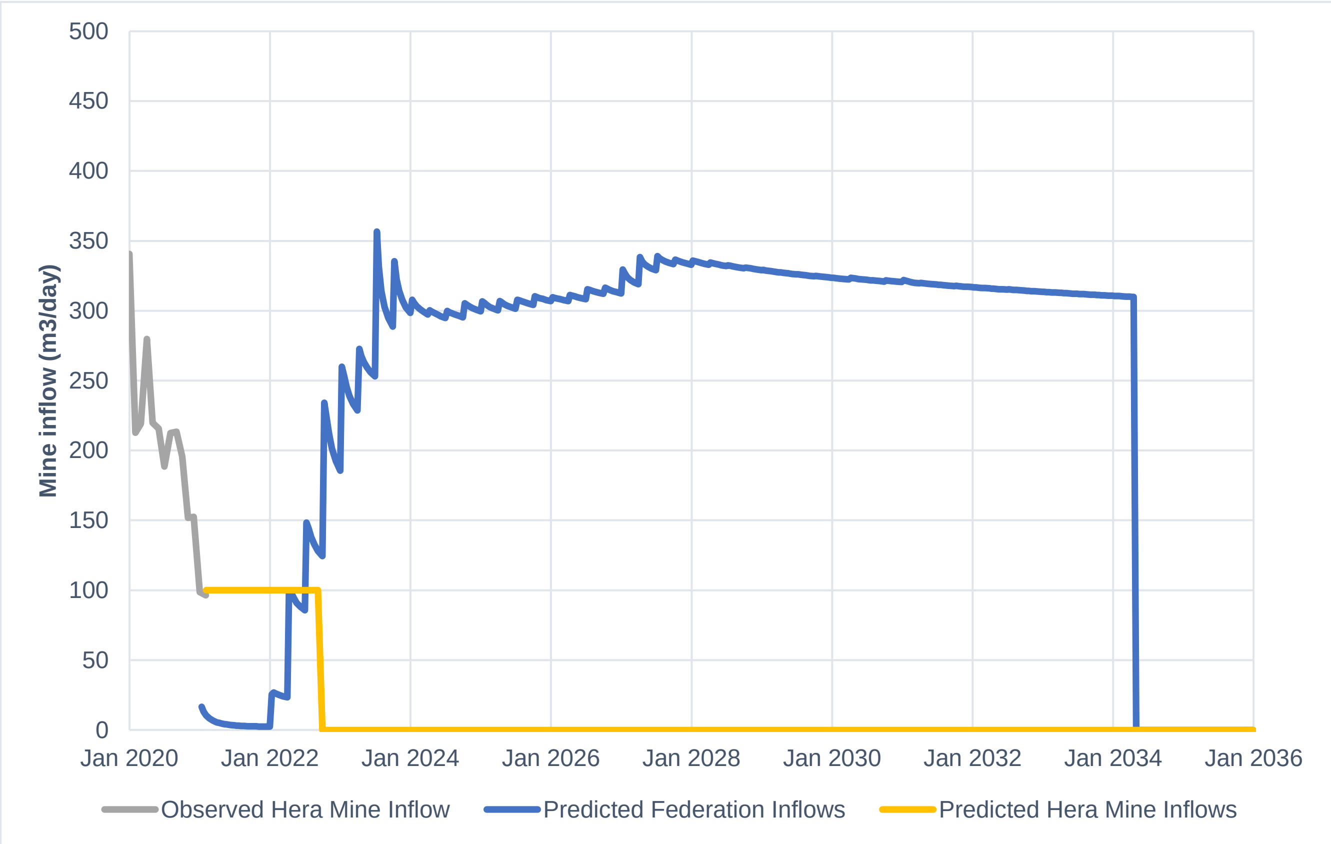
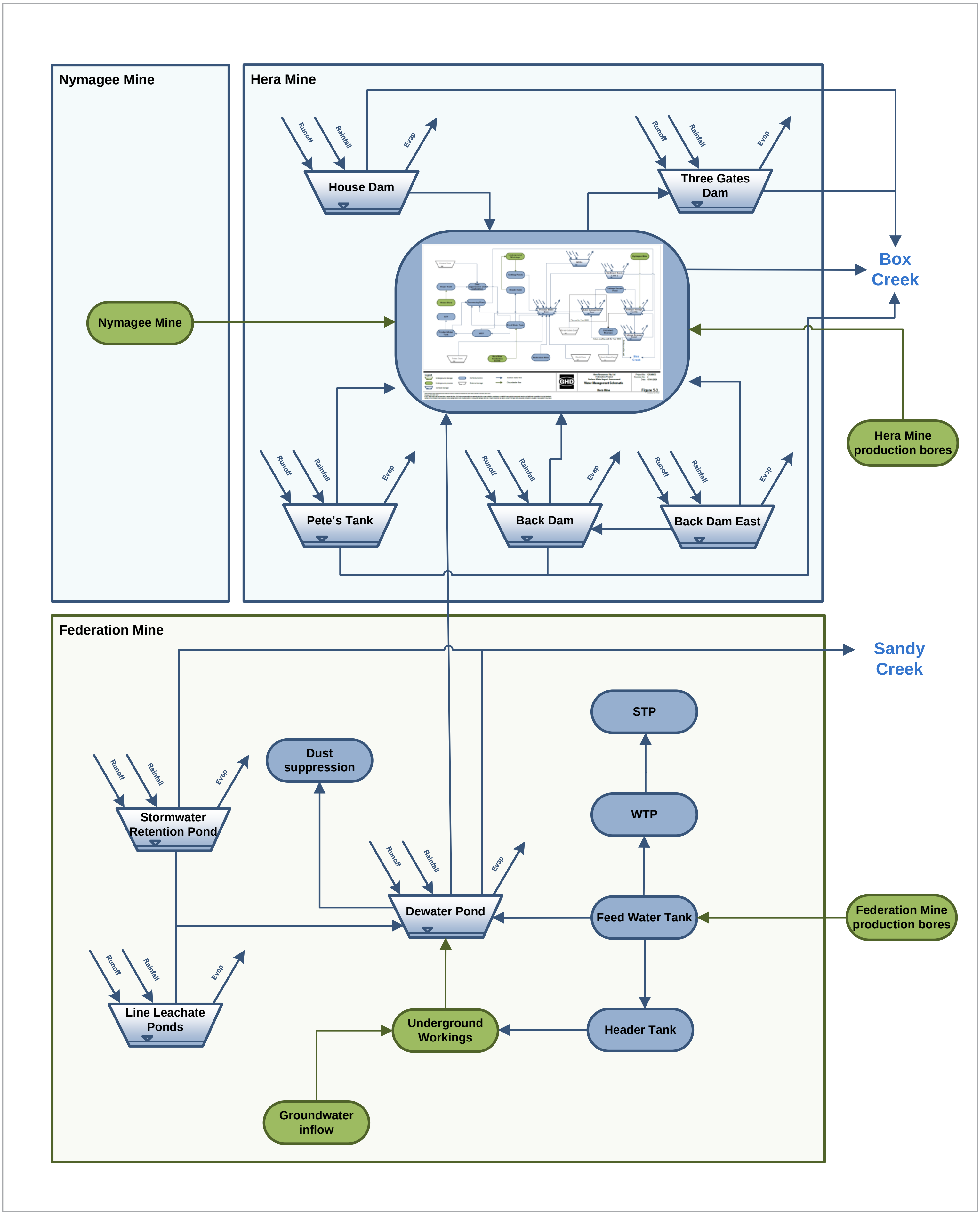


Figure 5.1 Predicted groundwater inflows



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Groundwater flow
- Surface water flow

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment
Water management schematic

Federation Project

Project No. 12548432
Revision No. 2
Date 15/11/2021

Figure 5-2

Created by: Tyler Tinkler

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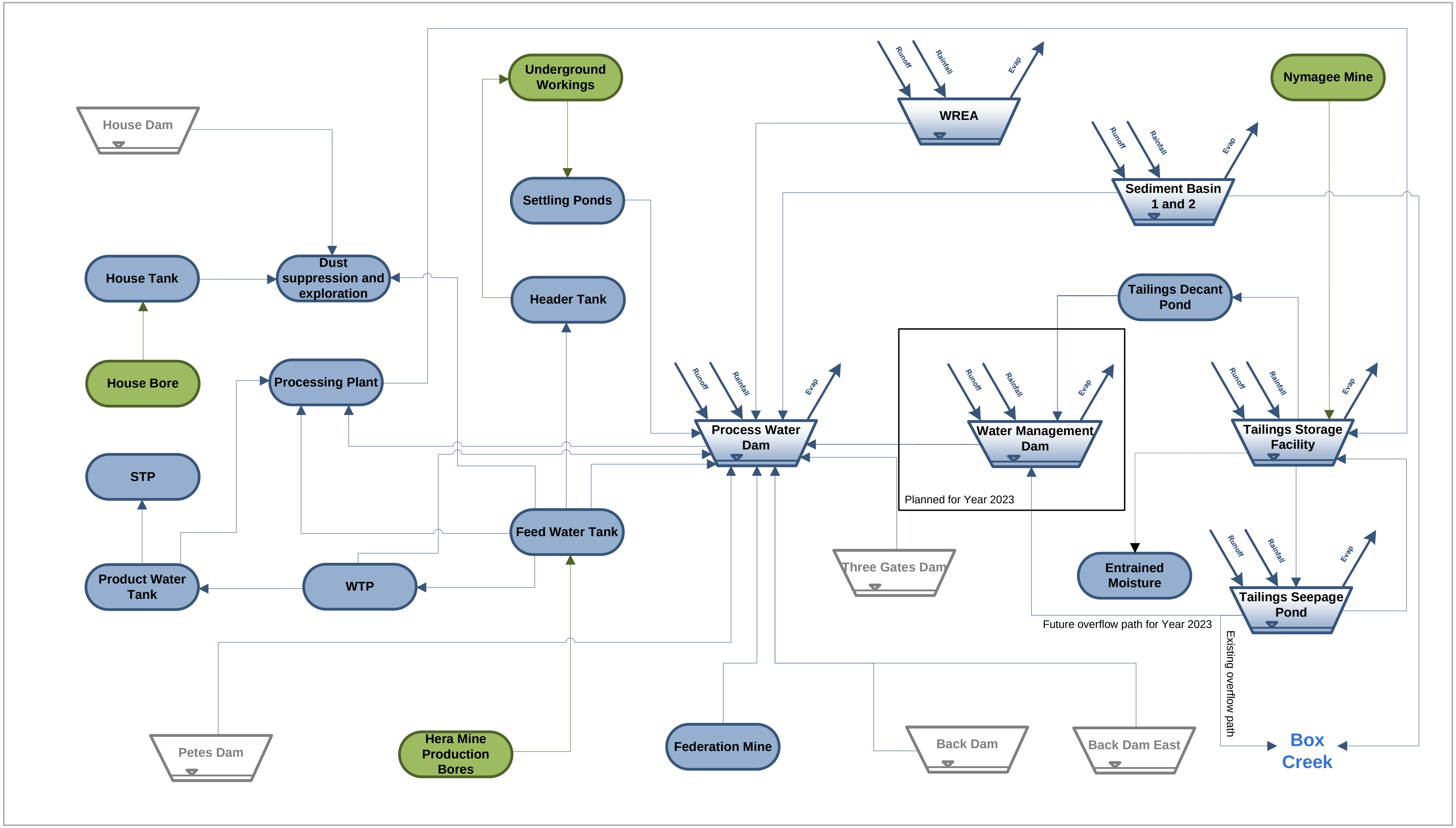

Legend

	Underground storage		Surface process		Surface water flow
	Underground process		External storage		Groundwater flow
	Surface storage				

GHD

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Water Management Schematic

Hera Mine

Project No. 12548432
Revision No. 2
Date 15/11/2021

Figure 5-3

Created by: Tyler Tinkler

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5.3 Modelling results

The annual forecast water transfers for the Project under existing and proposed conditions are shown in Figure 5.4, Figure 5.5, Figure 5.6 and Figure 5.7. The average annual water balance is summarised in Table 5.1.

Table 5.1 Annual average water balance

Water management element	Existing conditions (2021) (ML/year)	Proposed conditions (2028) (ML/year)
INPUTS		
Direct Rainfall	15	44
Catchment runoff	109	164
Groundwater inflows	35	122
Extraction from production bores	176	338
Import from Nymagee Mine	0	0
TOTAL INPUTS	**335**	**668**
OUTPUTS		
Evaporation	49	122
Water entrained in tailings	289	469
Dust suppression	12	48
Wastewater irrigation	21	33
Discharge to Box Creek	0	0
Discharge to Sandy Creek	0	0
TOTAL OUTPUTS	**370**	**672**
CHANGE IN STORAGE		
Surface water storages	-35	-5
Underground Storage	0	0
TOTAL CHANGE IN STORAGE	**-35**	**-5**
BALANCE		
Inputs – outputs – change in storage	0	0

Direct rainfall, runoff and evaporation

Direct rainfall, catchment runoff and evaporation are expected to increase in proposed conditions as a result of the Project. This reflects the additional catchment area of the Federation Site within the water management system and a slight increase due to the assumed construction of the approved Water Management Dam at Hera Mine.

Groundwater inflows

The site water balance modelling results reflect the adopted groundwater inflows discussed in Section 5.2.

Extraction from production bores

Total extraction from production bores for both Hera Mine and Federation Site are simulated to increase under proposed conditions reflecting the increase in water demand for ore processing production rate for year 2028. Water security is assessed in Section 5.4.

Import from Nymagee Mine

No change to the expected volume of water imported from Nymagee Mine is expected as a result of the Project. However, Nymagee Mine remains a contingency source of water for the Project.

Water entrained in tailings

Losses due to water entrained in tailings are simulated to increase in proposed conditions as a result of the Project reflecting the increase in planned production rate in proposed conditions compared to existing conditions from an average of 40,000 tonne/month to approximately 60,000 tonne/month.

Dust suppression

Dust suppression demands is expected to increase in proposed conditions as a result of the Project reflecting the additional surface area at Federation Site requiring dust suppression.

Wastewater irrigation

Wastewater irrigation is expected to increase in proposed conditions reflecting the additional personnel compared to existing conditions as a result of the Project

Discharge to Box Creek

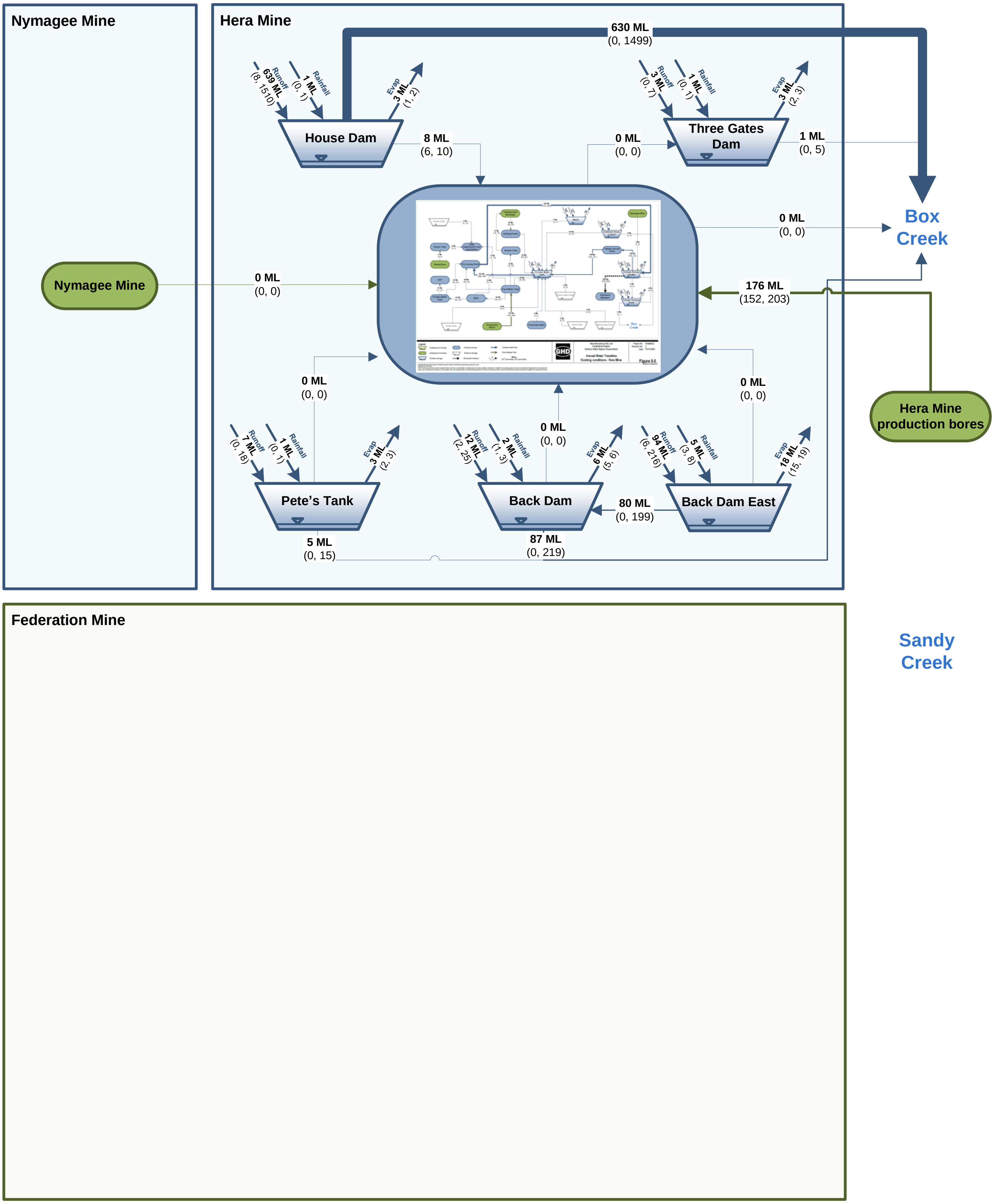
No change in potential off-site discharges to Box Creek is expected as a result of the Project. The average annual modelling results shown in Table 5.1 is rounded to 0 ML/year, which reflects that discharges would only occur due to rare to extreme rainfall events, discussed further in Section 5.6.

Discharge to Sandy Creek

No discharges to Sandy Creek are simulated by the site water balance modelling over the life of the Project. However there remains the potential for discharge to Sandy Creek due to a rare to extreme rainfall event that exceeds the design criteria of the water management system.

Change in storage

As the model is simulated continuously over the Project life, small average changes in the volume of water stored in water storages within the water management system are expected. The change presented in Table 5.1 reflect the average of simulated changes in the volume of water between the beginning and end of a calendar year. These simulated changes are small compared to the overall site water balance and the likely variability with rainfall and are not considered significant. The forecast contaminated water inventory over the Project life is discussed in Section 5.5.



Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Groundwater flow
- Surface water flow

GHD

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Annual Water Transfers
Existing conditions - Federation Project

Project No. 12548432
Revision No. 3
Date 15/11/2021

Figure 5-4

Created by: Jean Macatanong

\\ghdnet\ghd\AU\Newcastle\Projects\22\12548432\Tech\Visio\12548432-VIS-Hera-Federation_Mine-Water_transfers-Regional-2021_SWIA.vsdm
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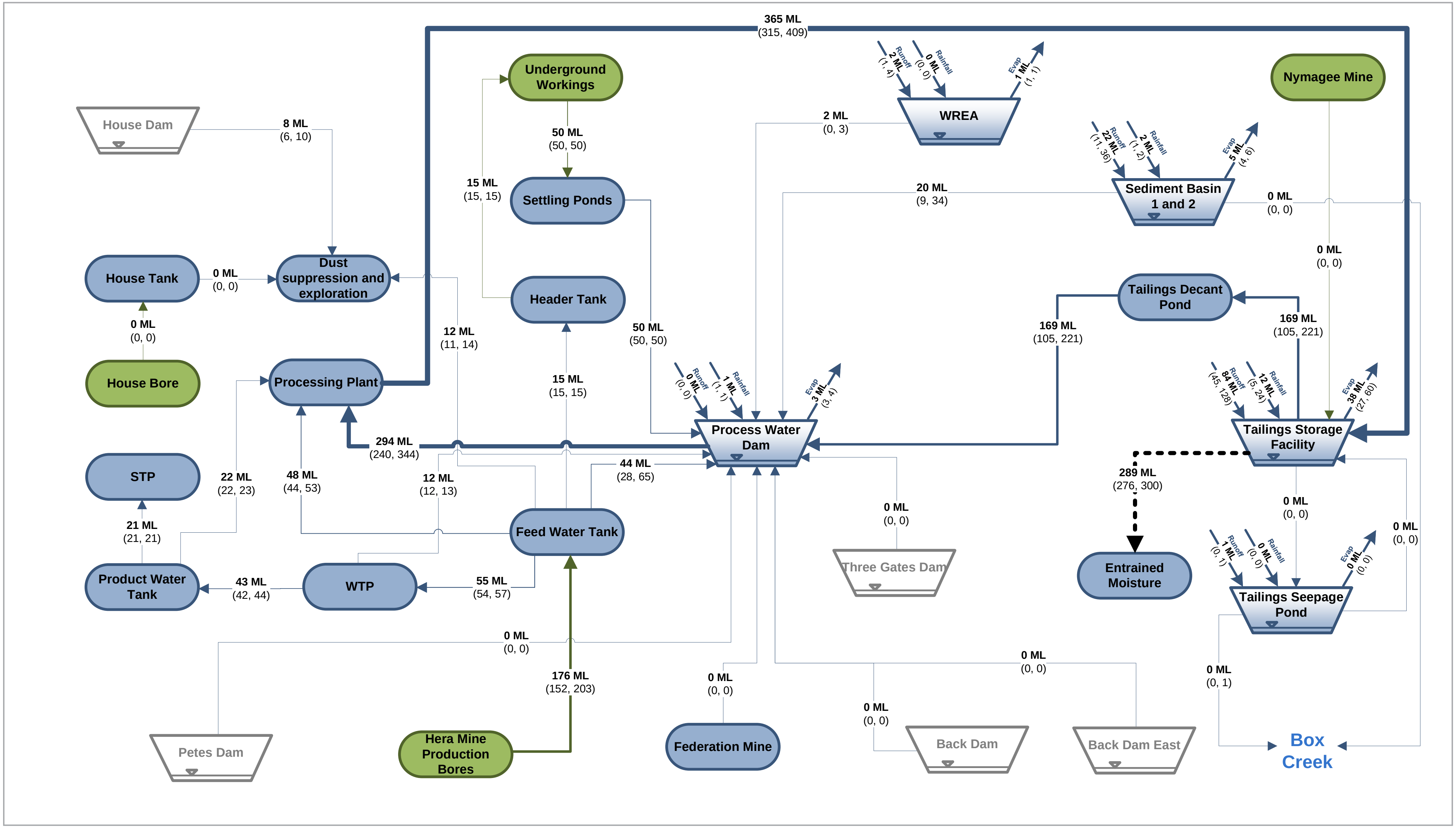

Legend

Underground storage

Underground process

Surface storage

Surface process

External storage

Entrained moisture

Surface water flow

Groundwater flow

X
(X, X)

Mean
(10th percentile, 90th percentile)

GHD

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Annual Water Transfers
Existing conditions - Hera Mine

Project No. 12548432
Revision No. 3
Date 16/11/2021

Figure 5-5

Created by:Jean Macatanong

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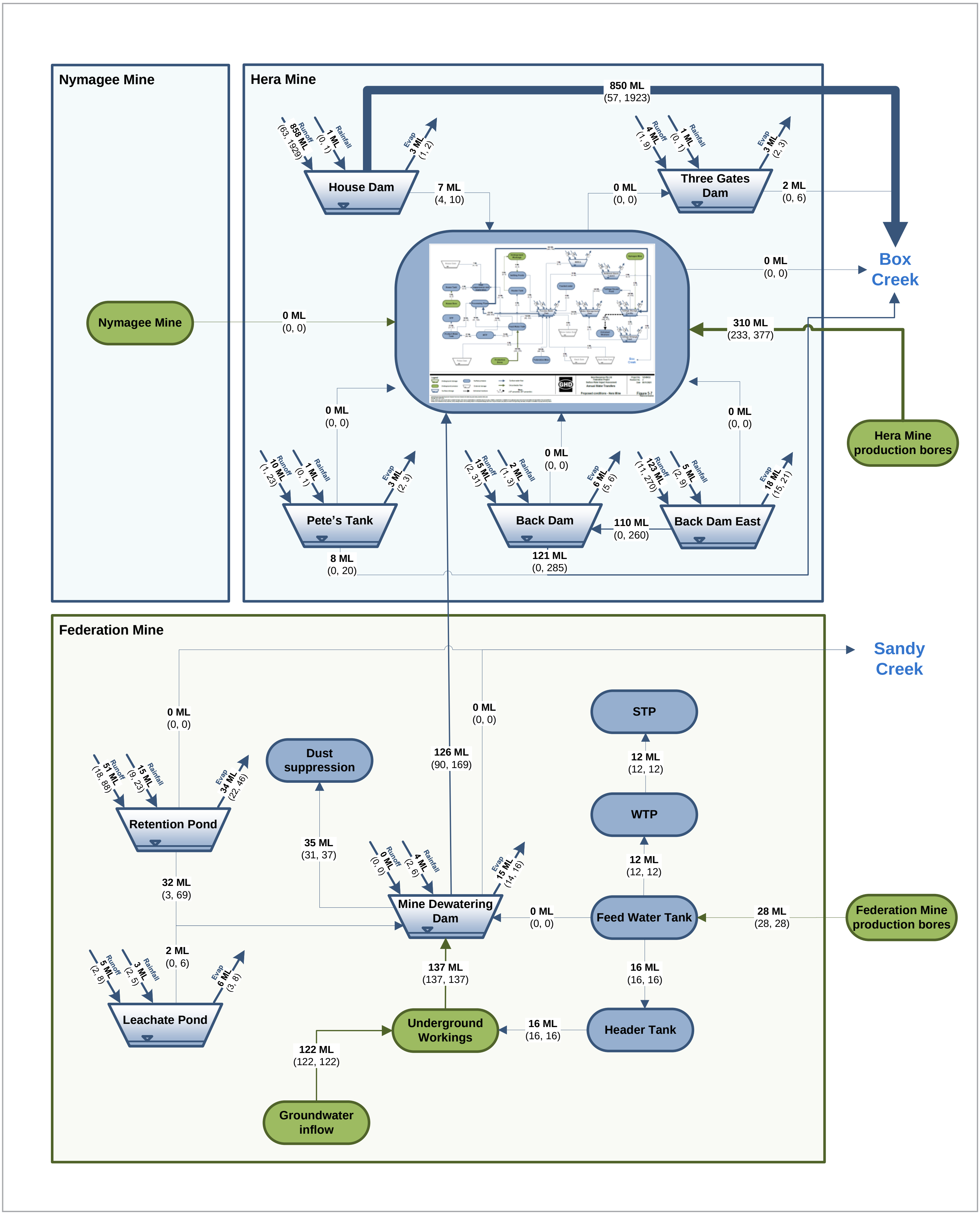

Legend

- Underground storage
- Underground process
- Surface storage
- Surface process
- Licensed discharge point
- Groundwater flow
- Surface water flow

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Annual Water Transfers
Proposed conditions - Federation Project

Project No. 12548432
Revision No. 3
Date 05/11/2021

Figure 5-6

Created by: Jean Macatanong

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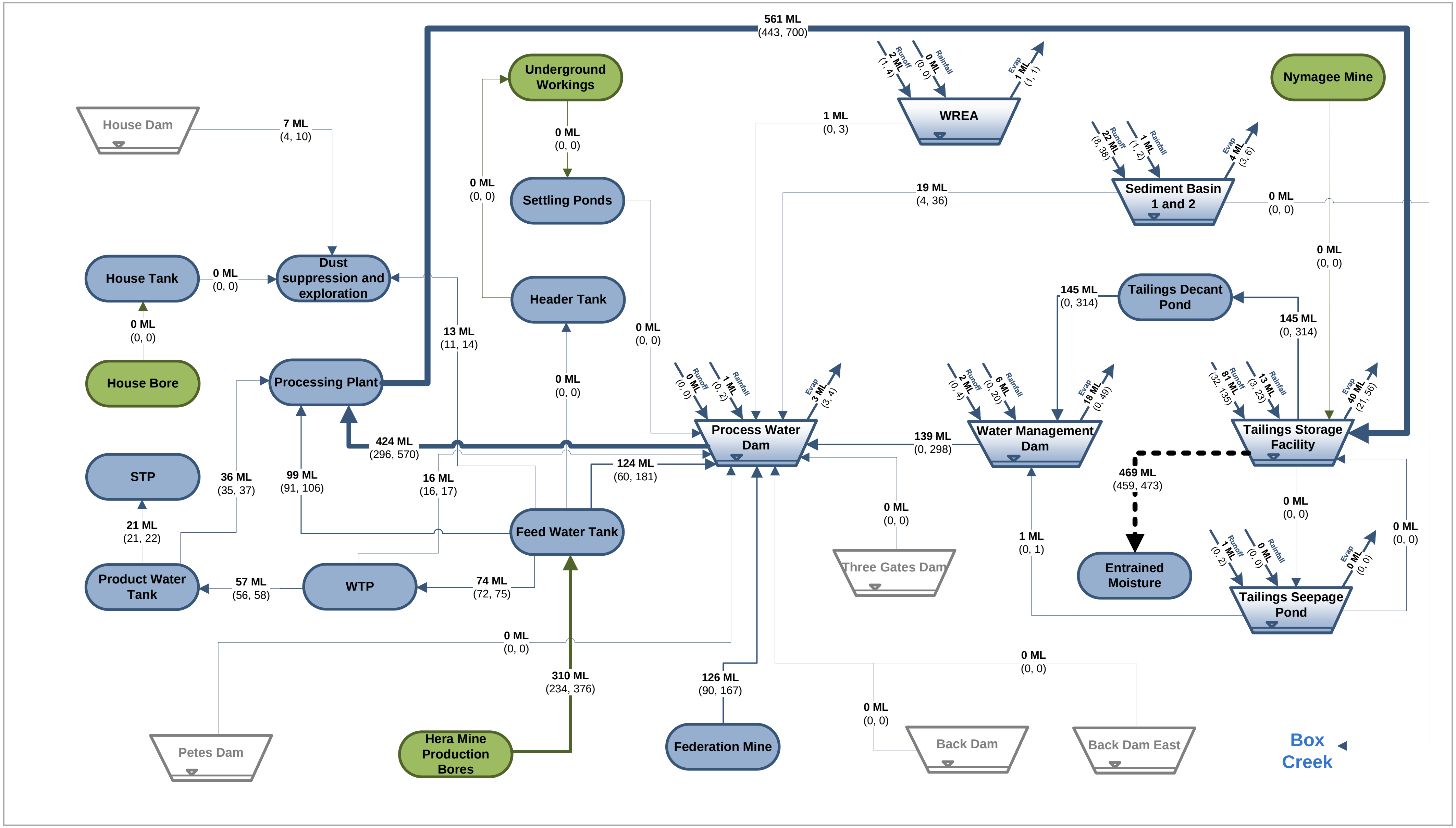

Legend

Underground storage

Underground process

Surface storage

Surface process

External storage

Entrained moisture

Surface water flow

Groundwater flow

X
(X, X)

Mean
(10th percentile, 90th percentile)

GHD

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Annual Water Transfers
Proposed conditions - Hera Mine

Project No. 12548432
Revision No. 3
Date 16/11/2021

Figure 5-7

Created by:Jean Macatanong

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5.4 Water security

The site water balance model simulated the range of annual extraction from all production bore for the Project for proposed conditions, as shown in the cumulative probability distribution in Figure 5.8. Proposed conditions are representative of the peak water demand during the Project, which simulate ore production at the peak of approximately 60,000 tonnes per month. The simulated extraction from production bores includes potential extraction from the Hera Mine underground workings following the completion of mining at Hera Mine, which is assessed in the GIA (GHD 2021), thereby conservatively over-estimating the potential extraction from production bores required.

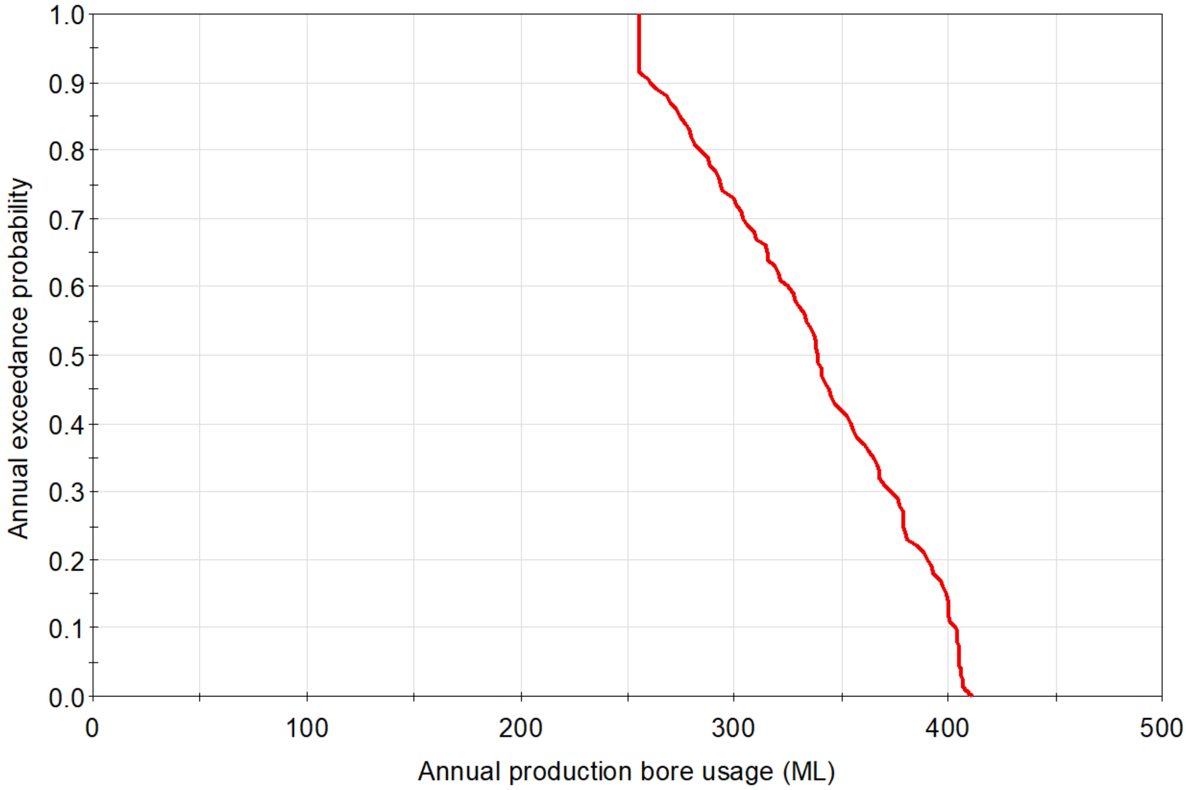


Figure 5.8 Annual production bore usage

Figure 5.8 indicates that total production bore usage to satisfy operational requirements for both Hera Mine and Federation Site over proposed conditions is expected to range from 250 ML to 408 ML. Considered in combination with the forecast groundwater inflows in that year of 122 ML/year, the maximum groundwater extraction forecast by the site water balance model is 530 ML/year. This is within the groundwater entitlement held by Aurelia for the Project under WAL 43173 equivalent to 543 ML/year. Therefore, Aurelia holds sufficient WAL entitlement for the Project.

The maximum groundwater extraction forecast by the site water balance model of 530 ML/year differs slightly from the maximum modelling groundwater inflow modelled as presented in the GIA (GHD 2021) of 536 ML/year. This reflects slightly different modelling assumptions and rounding and these are considered equivalent for the purpose of this assessment.

In reality, take from production bores will vary in response to actual groundwater inflows. Extractions from production bores will be higher if mine inflows are lower than predicted; and extraction from production bores will be lower if mine inflows are higher than predicted. However, in any case, the total extraction is expected to remain within the groundwater entitlement held by Aurelia for the Project under WAL 43173 equivalent to 543 ML/year.

5.5 Contaminated water inventory

The effectiveness of the water management system in minimising the potential for off-site discharge of contaminated water relies in part on capacity for storage of contaminated water during above average rainfall conditions. The volume of water within the TSF decant pond was simulated over the Project life, assuming that contaminated water storages were dewatered following rainfall events and that the approved Water Management Dam was constructed at Hera Mine by mid-2022. Forecast TSF decant pond storage volume over the Project life shown in Figure 5.9.

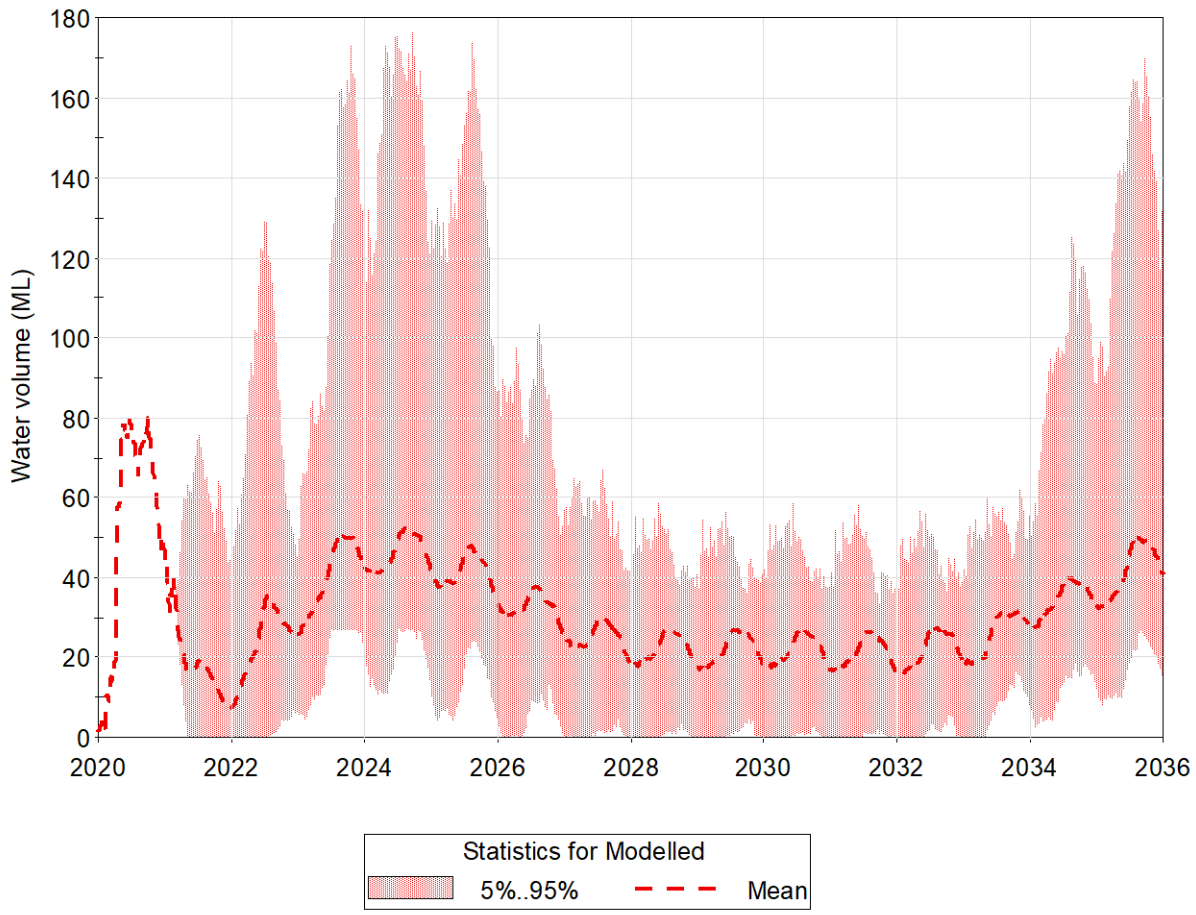


Figure 5.9 Forecast water volume stored in TSF decant pond

Figure 5.9 shows that the water balance model forecasts that water volume at TSF decant pond has a 5% change of exceeding approximately 170 ML in winter of 2023, 2024, 2025 and 2035. These periods correspond to lower forecast ore production compared to the period from 2026 and approximately 2034, where the model forecasts a 5% likelihood of exceeding approximately 50 ML in the TSF decant pond during winter.

In reality, the actual volumes of water in the TSF decant pond will depend on rainfall, groundwater inflows to the underground workings and actual ore processing rates. The timing of approved lifts of the TSF will consider the potential water volumes that may be required to be stored.

5.6 Off-site discharge

The site water balance model was used to estimate the likelihood of off-discharge from the Sediment Basin 1 and 2 at Hera Mine and the Stormwater Retention Pond at Federation Site. The water balance modelling assumes that water management system is constructed as designed and therefore effective in diverting clean water, capturing and containing dirty and potentially contaminated water.

The annual average water balance results presented in Section 5.3 represents the average (mean) conditions and indicates the potential for discharge of about 0.19 ML/day (8% AEP) from the Sediment Basin 1 and 2 at Hera Mine to Box Creek. This potential is unchanged by the Project. This potential discharge would occur as a result of above average or rare rainfall events and does not represent a regular off-site discharge of water. Consistent with the design criteria of the water management system at the Federation Site (refer to Section 4.2), no off-site discharge is forecast by the water balance model from the Stormwater Retention Pond at the Federation Site.

The estimated likelihood of off-discharge from the Sediment Basin 1 and 2 at Hera Mine and the Stormwater Retention Pond at Federation Site based on the site water balance modelling is summarised in Table 5.2.

Table 5.2 Forecast likelihood of off-site discharge

	Forecast likelihood of off-site discharge Existing conditions	Forecast likelihood of off-site discharge proposed conditions
Hera Mine – Sediment Basin	8% AEP	8% AEP
Federation Mine – Stormwater Retention Pond	NA	0% (equivalent to rarer than 1% AEP)

Table 5.2The site water balance modelling considers potential rainfall variability characterised by a historical record, but does not necessarily reflect the potential for off-site discharges due to rare rainfall events that exceeds the design capacity of the water management system. The length of daily historical rainfall record used in the site water balance is longer than 100 years, and therefore water balance modelling results are approximately equivalent, but not directly comparable to, the design criteria with the design criteria of the water management system at the Federation Site (refer to Section 4.2).

6. Surface water flow

Mining operations have the potential to impact on flow regimes in watercourses due to changes to surface water runoff and baseflow contributions. The Project will change the catchment of Sandy Creek due to excision of the catchment within the proposed water management system at Federation Site. Box Creek, a tributary of Sandy Creek, already has a small part of its catchment excised by the existing Hera Mine. These small changes in catchment are assessed cumulatively.

The GIA (2021) concludes that is it highly unlikely that the Project will affect any groundwater baseflow of Box Creek or Sandy Creek. A review of broad scale mapping did not identify any known GDEs within 20 km of the Federation deposit. There are potential terrestrial GDEs in the vicinity of Federation Site, however, given the deep water levels it is considered unlikely that these vegetative communities are GDEs. The deep water levels (>45 m) in the Palaeozoic sediments are beyond the reasonable limit of tree rooting depths. It is considered unlikely that a perched aquifer is present considering that exploration drilling has consistently indicated that the shallow strata is dry.

6.1 Change in catchments

Potential impacts on flow regimes in Box Creek and Sandy Creek have been assessed by comparing total catchment areas for each reporting location per scenario. Three scenarios were considered:

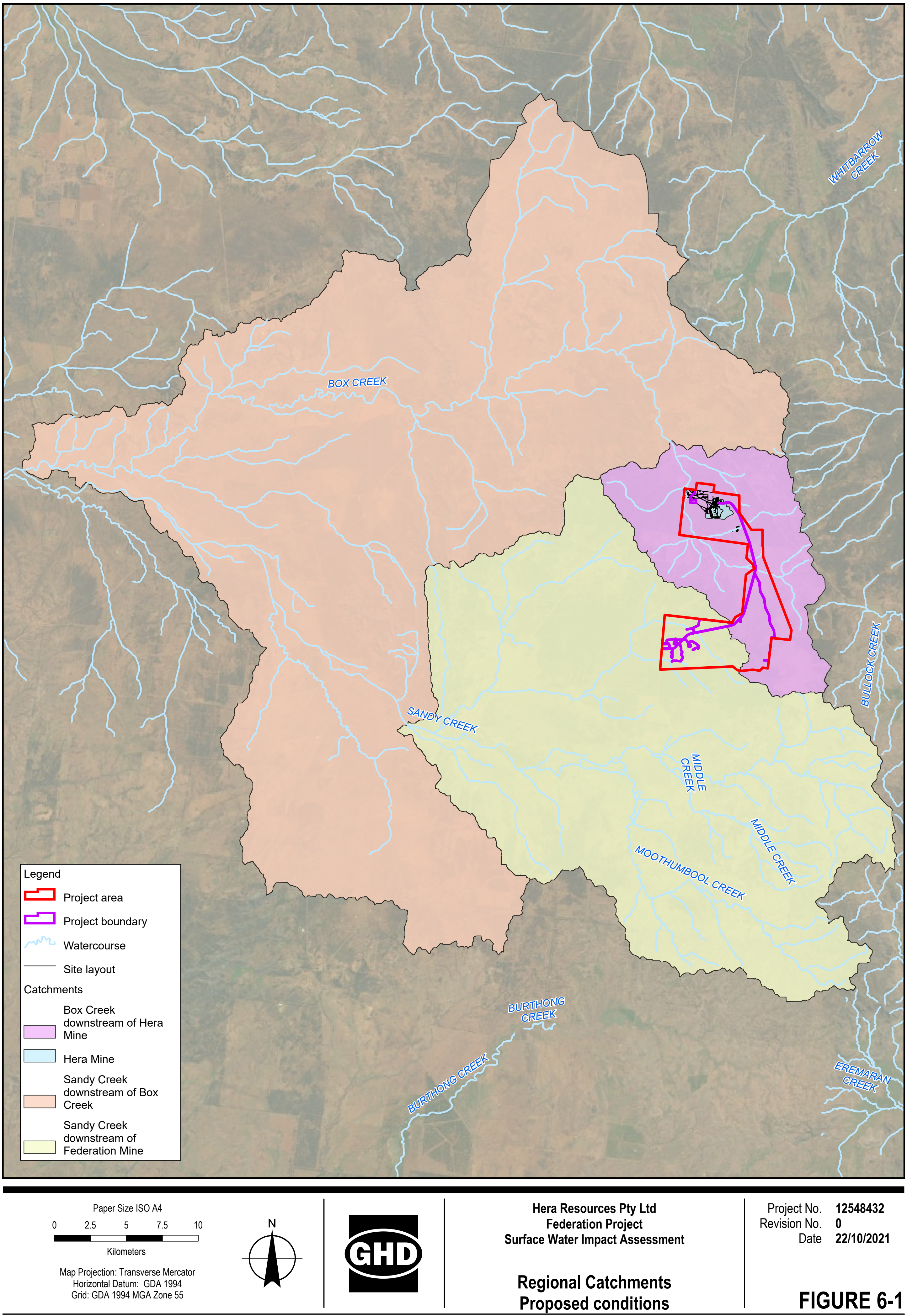
– Pre-development conditions – all catchments are undisturbed prior to Hera Mine. This is for the purpose of cumulative assessment.
– Existing conditions - reflects the existing approved water management system at Hera Mine.
– Proposed conditions – reflects the existing and proposed water management system for the Project.

The catchment areas of the reporting locations are summarised on Table 6.1. The catchments for proposed conditions are shown in Figure 6.1.

Table 6.1 Change in catchment area

Catchment	Pre development catchment area (km^2)	Existing catchment area (km^2)	Proposed catchment area (km^2)
Box Creek downstream of Hera Mine	155.4	153.7	153.7
Sandy Creek downstream of Federation Site	699.9	699.9	699.6
Sandy Creek downstream of Box Creek	1198.5	1196.8	1196.5
Hera Mine – water management system catchment	0	1.7	1.7
Federation Site – water management system catchment	0	0	0.3

Table 6.1 shows that currently the catchment of Box Creek downstream of Hera Mine and combined Sandy Creek and Box Creek downstream of both sites are reduced by around 1.1% and 0.1% of pre-development catchment, respectively. The Project is expected to reduce catchments of Sandy Creek downstream of Federation Site and combined Sandy Creek and Box Creek downstream of both sites by less than 1% of its respective pre-development catchments. This reflects the relatively small disturbance areas and the clean water diversions surrounding both Hera Mine and the proposed Federation Site.



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

GHD

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Regional Catchments
Proposed conditions

Project No. 12548432
Revision No. 0
Date 22/10/2021

FIGURE 6-1

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Data source: World Imagery: Source: Esri, Maxar, GeoEye, Earthstar Geographics, CNES/Airbus DS, USDA, USGS, AeroGRID, IGN, and the GIS User Community. Created by: ttinkler

6.2 Flooding

The proposed Federation Site has the potential to result in localised changes to flow patterns. No changes to the catchment of Hera Mine are proposed.

The change in catchments as discussed in Section 6.1 shows that the proposed Federation Site has a relatively small catchment area compared to the catchment of immediate downstream named watercourse, Sandy Creek. These changes may be considered minor and are not expected to have a significant impact on the extent and depth of flooding.

Overall, there is no expected significant change to the extent of flooding and the stability of downstream water courses, through changes to catchment area as a result of the Project.

Due to the elevated topography of the Federation Site and the inclusion of clean water diversion drains designed to convey the 1% AEP design flow from the upslope catchment around the site, the Federation Site is not expected to be subject to regional or localised flooding.

7. Surface water quality

7.1 Monitoring program

Surface water samples from existing farm dams upstream of Federation Site were collected from two sampling locations on 10 May 2021 by Hera Resources. Sites sampled for water quality are summarised in Table 7.1 and shown in Figure 7.1.

No surface water monitoring of water quality in watercourses has been undertaken at Hera Mine due to lack of flow over the operation of the Project Mine.

These sampling locations are both farm dams, located approximately 350 metres north of the Balowra State Conservation Area. The sampling locations are located upstream of the Federation Site.

Table 7.1 Baseline water quality sampling locations

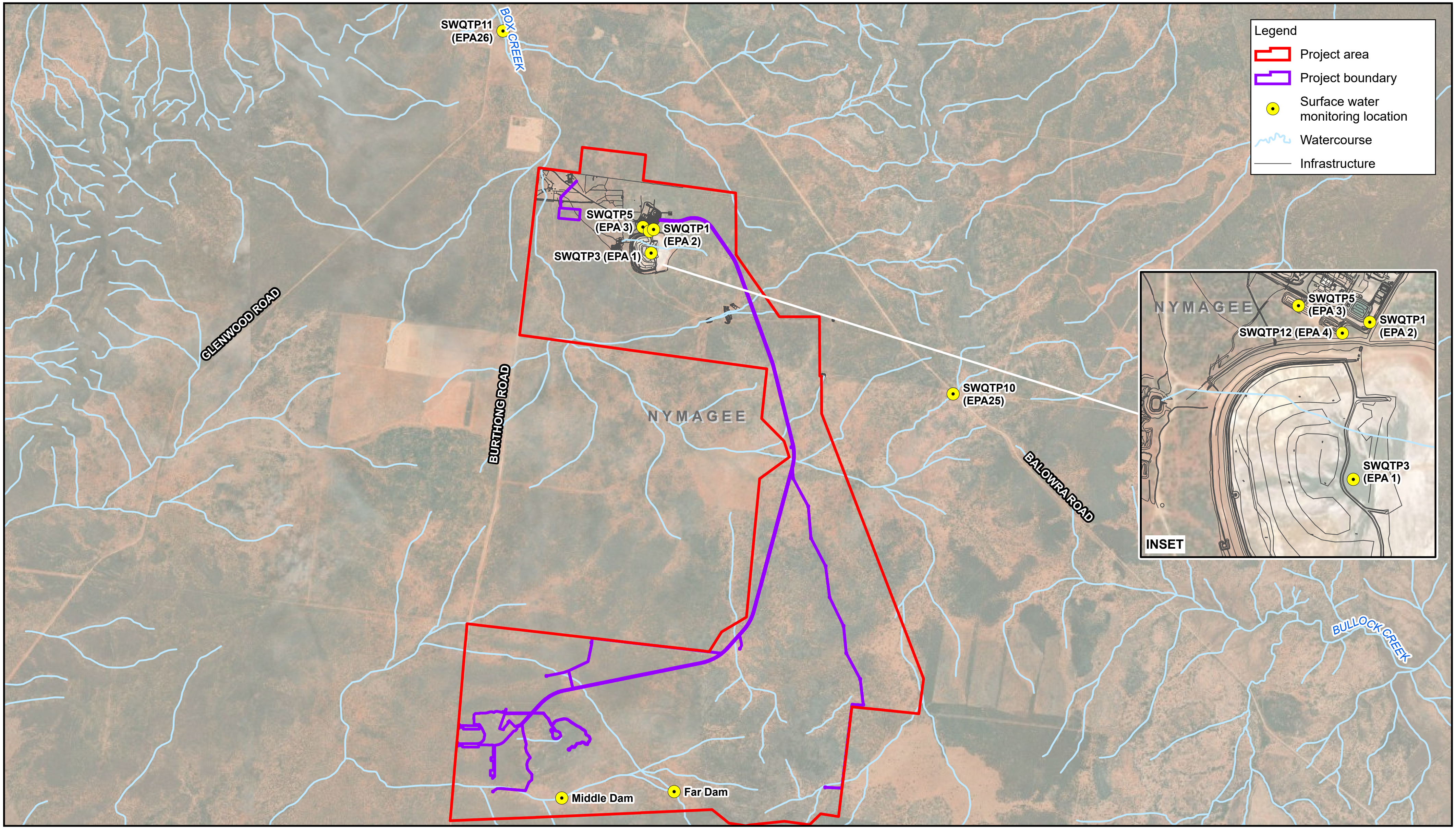
Site name	Easting (MGA94z55)	Northing (MGA94z55)	Site description
Middle Dam	435260	6435565	Dam located approximately 1.7 km southeast of the proposed Federation Site surface infrastructure.
Far Dam	437428	6435688	Dam located approximately 3.4 km east-south-east of the proposed Federation Site surface infrastructure.

Water samples were analysed for the parameters listed in Table 7.2. Analyses were performed by a National Association of Testing Authorities (NATA) accredited laboratory.

Table 7.2 Laboratory analytical suite

Suite	Analytes
Physicochemical parameters	EC, pH, salinity, total suspended solids (TSS), total hardness, turbidity
Metals (dissolved and total)	Arsenic, barium, beryllium, boron, cadmium, chromium, cobalt, copper, lead, manganese, mercury, nickel, selenium, silver (dissolved only), vanadium, zinc
Nutrients	Total nitrogen (TN), nitrate and nitrite (NO_x), total Kjeldahl nitrogen (TKN), total phosphorus (TP)
Other analytes	Free cyanide, total cyanide, weak acid dissociable cyanide, biochemical oxygen demand (BOD), oil & grease

It is acknowledged that the single water sample collected from each of the two sampling locations may not be an accurate representation of the usual condition of the sites. Additional data collected during a range of seasons would be required to gain a more robust assessment of the water quality of these sites. However this is not considered practical given the low frequency of streamflow at the site. As the sites are farm dams, the impounded nature means that conditions are unlikely to be reflective of naturally observed conditions in the area.



Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

GHD

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Surface water quality monitoring locations

Project No. 12548432
Revision No. 0
Date 22/10/2021

Figure 7-1

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Data source: NSW Trade & Investment Resources and Energy: Mining Lease, 2016; LPI: DTDB / DCDB, 2017 World Imagery: Earthstar Geographics
World Imagery: Maxar.
Created by: eibbertson

7.2 Surface water quality guideline values

Water quality results were compared to the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018). Where guideline values have not been updated, ANZG (2018) refers to, but does not reproduce, the guideline values from ANZECC (2000). The following default guideline values (DGVs) were used to assess water quality:

– DGV ranges for physical and chemical stressors for South-east Australia upland rivers (altitude > 150 m), as outlined in Table 3.3.2 of the ANZECC (2000) guidelines.
– DGV ranges for conductivity (EC) and turbidity for South-east Australia upland rivers, as outlined in Table 3.3.3 of the ANZECC (2000) guidelines.
– Toxicant DGVs for protection of 95 percent of freshwater species in slightly-moderately disturbed systems, as outlined in ANZG (2018).

These DGVs are presented in Table 7.3.

Dissolved metal and metalloid concentrations are more applicable for comparison to the water quality DGVs than total metals, as they are more representative of the bioavailable fractions of metals and metalloids within the water. Therefore, only dissolved metal concentrations have been assessed against the water quality DGVs.

Table 7.3 DGVs applicable to water quality samples

Analyte	Unit	DGV
Physico-chemical parameters		
pH	pH unit	6.5-8.0
EC	µS/cm	30-350
Turbidity	NTU	2-25
Dissolved metals		
Arsenic	mg/L	0.013
Beryllium	mg/L	NA
Boron	mg/L	0.94
Cadmium	mg/L	0.0002
Chromium	mg/L	0.001
Cobalt	mg/L	NA
Copper	mg/L	0.0014
Lead	mg/L	0.0034
Manganese	mg/L	1.9
Mercury	mg/L	0.0006
Nickel	mg/L	0.011
Selenium	mg/L	0.011
Silver	mg/L	0.00005
Vanadium	mg/L	NA
Zinc	mg/L	0.008
Nutrients		
Nitrite + nitrate	mg/L	0.015
TKN	mg/L	NA
TN	mg/L	0.25
TP	mg/L	0.02
Other parameters		
Cyanide	mg/L	0.007

7.3 Existing surface water quality

Results of laboratory analyses for water samples collected on 10 May 2021 are presented in Table 7.4.

Water collected from both Middle Dam and Far Dam was neutral and soft, with low EC/salinity. Water from Far Dam was notably more turbid than that collected from Middle Dam.

Concentrations of all dissolved metals were below the laboratory limit of reporting (LOR) at Far Dam, with the exception of dissolved barium, for which no DGV exists. In Middle Dam, only dissolved barium and manganese were observed in concentrations above the LOR, though no exceedances of the DGVs were recorded.

As with dissolved metals, concentrations of the majority of total metals were also low, though copper, lead and zinc were present in both samples as particulate matter not observed in the dissolved samples. Concentrations of all total metals observed in concentrations higher than the LOR were highest in the Far Dam sample.

Nutrients were elevated at both sites, with NO_x, TN and TP exceeding the respective DGVs. All nutrient concentrations were highest in the Far Dam sample. Elevated nutrient concentrations are expected to occur in farm dams such as these, as animals wastes and other organic materials enter the dams in runoff during periods of high rainfall, and become concentrated during dry conditions.

Concentrations of oil and grease, BOD and all forms of cyanide were low at both sites, with all results at or below the LOR. Although no silver above the LOR was detection, the LOR of the test used exceeded the DGV and therefore it cannot be verified that the concentration was below the DGV.

Table 7.4 Water quality results, 10 May 2021

Analyte	Unit	LOR	Middle Dam	Far Dam	DGV
Physico-chemical parameters					
pH	pH unit	0.01	6.89	6.83	6.5-8.0
EC	µS/cm	1	64	88	30-350
Salinity	g/kg	0.01	0.04	0.05	NA
TSS	mg/L	5	7	20	NA
Turbidity	NTU	0.1	6.6	**69.5**	2-25
Total hardness	mg/L	1	25	18	NA
Dissolved metals					
Arsenic	mg/L	0.001	<0.001	<0.001	0.013
Barium	mg/L	0.001	0.013	0.010	NA
Beryllium	mg/L	0.001	<0.001	<0.001	NA
Boron	mg/L	0.05	<0.05	<0.05	0.37
Cadmium	mg/L	0.0001	<0.0001	<0.0001	0.0002
Chromium	mg/L	0.001	<0.001	<0.001	0.001
Cobalt	mg/L	0.001	<0.001	<0.001	NA
Copper	mg/L	0.001	<0.001	<0.001	0.0014
Lead	mg/L	0.001	<0.001	<0.001	0.0034
Manganese	mg/L	0.001	0.012	<0.001	1.9
Mercury	mg/L	0.0001	<0.0001	<0.0001	0.0006
Nickel	mg/L	0.001	<0.001	<0.001	0.011
Selenium	mg/L	0.01	<0.01	<0.01	0.011
Silver	mg/L	0.01	<0.01	<0.01	0.00005
Vanadium	mg/L	0.01	<0.01	<0.01	NA
Zinc	mg/L	0.005	<0.005	<0.005	0.008

Analyte	Unit	LOR	Middle Dam	Far Dam	DGV
Total metals					
Arsenic	mg/L	0.001	<0.001	0.001	NA
Barium	mg/L	0.001	0.014	0.020	NA
Beryllium	mg/L	0.001	<0.001	<0.001	NA
Boron	mg/L	0.05	<0.05	<0.05	NA
Cadmium	mg/L	0.0001	<0.0001	<0.0001	NA
Chromium	mg/L	0.001	<0.001	0.003	NA
Cobalt	mg/L	0.001	<0.001	<0.001	NA
Copper	mg/L	0.001	0.002	0.006	NA
Lead	mg/L	0.001	0.007	0.016	NA
Manganese	mg/L	0.001	0.035	0.086	NA
Mercury	mg/L	0.0001	<0.0001	<0.0001	NA
Nickel	mg/L	0.001	<0.001	0.003	NA
Selenium	mg/L	0.01	<0.01	<0.01	NA
Vanadium	mg/L	0.01	<0.01	<0.01	NA
Zinc	mg/L	0.005	0.018	0.037	NA
Nutrients					
Nitrite + nitrate	mg/L	0.01	**0.06**	**0.15**	0.015
TKN	mg/L	0.1	0.8	0.8	NA
TN	mg/L	0.1	**0.9**	**1.0**	0.25
TP	mg/L	0.01	**0.04**	**0.07**	0.02
Other parameters					
Oil and grease	mg/L	5	<5	<5	NA
Biochemical oxygen demand	mg/L	2	2	2	NA
Free cyanide	mg/L	0.004	<0.004	<0.004	0.007
Total cyanide	mg/L	0.004	<0.004	<0.004	0.007
Weak acid dissociable cyanide	mg/L	0.004	<0.004	<0.004	0.007

Notes: Values in **blue** indicate exceedances of the relevant DGV.
NA = no guideline value applies

8. Impact assessment

8.1 Site water management

As part of the Project, the approved water management system at Hera Mine will remain essentially unchanged. The water management system will be extended to the Federation Site and linked to Hera Mine by a water pipeline and potentially a tailings pipeline. The water management at the Federation Site will mirror the existing water management system at Hera Mine with:

- Drains, dams and pumps to capture, contain and recirculate potentially contaminated runoff.
- Inflows of groundwater intercepted by the Hera Mine underground workings replaced by inflows of groundwater intercepted by the Federation underground workings. Dewatering of Hera Mine may continue.
- Similar to Hera Mine, potable water will be provided to the Federation Site by a reverse osmosis (RO) unit taking off from the raw or contaminated water stream and wastewater will be treated and disposed of by irrigation.

The integrated water management system for the Project will retain the ability to access contingency water sources, including:

- Water transferred from the nearby Nymagee Mine via an existing pipeline, as approved
- Reuse of treated wastewater into the contaminated water stream
- Dewatering of the Hera Mine workings after mining has ceased

8.2 Hydrology and flow regimes

There is no expected significant reduction in streamflow due to the Project as the project area is significantly small compared to the catchment area of immediately downstream watercourse, Sandy Creek (refer to Section 6.1). This reflects the design of the proposed surface water management system that considers diversion of the clean water from undisturbed catchment upslope of Federation Site around the disturbed areas of the site by open drains.

The watercourses downstream of the Project are ephemeral and off-site discharges are only expected in the unlikely event of a rare rainfall event that exceeds the relevant design criteria of the water management system. The incremental changes in flow regime during a rare rainfall event due to off-site discharges are expected to be negligible. Therefore, baseline and ongoing monitoring of streamflow in potentially affected watercourses are not required.

8.3 Surface water quality

The Project has been designed to minimise the potential for to changes to the surface water quality in downstream watercourses. The water management system has been designed to divert clean water around mining operations (where practical) and capture, contain and recirculate dirty and potentially contaminated water up to the nominated design criteria to minimise adverse effects on water quality from operations to downstream waterways.

A surface water quality monitoring program is recommended in Section 9.2.

8.4 Downstream surface water users

No surface water users were identified downstream of the Project.

8.5 Cumulative impacts

The ongoing operation of Hera Mine forms part of the Project and has been assessed. There are no other potential surface water impacts identified in the Project boundary. No potential cumulative surface water impacts have been identified as part of this assessment.

8.6 Licensing requirements

8.6.1 Harvestable rights

There is no additional interception of clean water by means of a dam on a first or second order stream proposed as part of the Project. Existing and proposed dirty and contaminated water management structures for the capture, containment and recirculation of water to prevent contamination of downstream watercourses will continue to be exempt from licensing consideration under pollution control exemptions.

Notwithstanding, as the Project is located in the Western Division, the proponent, as the landholder, may construct additional water storage on first and second order streams to harvest runoff at any time and use that harvested surface water for any purpose.

8.6.2 Water licencing

No extraction of water surface water from third order watercourses is proposed as part of the Project.

The hydrogeological conceptualisation presented in the GIA (GHD 2021a) indicates that the Project will not have any incremental drawdown impacts on a shallow water table (which does not exist as the water table is between 45 and 90 metres below ground level) and there will be no impacts to baseflow in creeks.

Overall, there are no surface water entitlements expected to be required as a result of the Project.

The GIA (GHD 2021) concluded that the WAL volume held by Hera Resources is sufficient volume for encountered groundwater.

8.6.3 Environment protection licence

The proposed water management system for the Project includes the existing LDPs at Hera Mine (under EPL 20179).

Although the water management system at the Federation Site has been designed as a zero off-site discharge system, in the unlikely event of a rare rainfall event that exceeds the design capacity of the system, off-site discharge may occur.

Therefore, it is recommended that an additional LDP be established for the premises at the invert of the crest of the spillway of the Stormwater Retention Pond. The location of the recommended LDP is labelled SWQTP32 in Figure 9.1.

No other changes to EPL 20179, as relevant to surface waters, are required for the Project.

9. Mitigation, monitoring and management

9.1 Surface water quantity

As discussed in Section 8.2, no monitoring of streamflow in watercourses is required.

Monitoring requirements for groundwater extraction are discussed in the GIA (GHD 2021a).

For the purpose of validating the site water balance model, it is recommended that flow meters be installed at the following locations at the Federation Site:

– Transfer from the leachate ponds to the Mine Dewatering Dam
– Transfer from the Stormwater Retention Pond to the Mine Dewatering Dam
– Transfer from the Mine Dewatering Dam to Hera Mine

It is also recommended that level sensors measuring the water level in the Stormwater Retention Pond water storage be installed to estimate discharge quantities in the unlikely event of discharge.

If practical, the flow meters and level sensors should record data continuously and report to the site Supervisory Control and Data Acquisition (SCADA) system.

9.2 Surface water quality

Surface water quality at Hera Mine will continue to be monitored in accordance with the approved Hera Mine Water Management Plan.

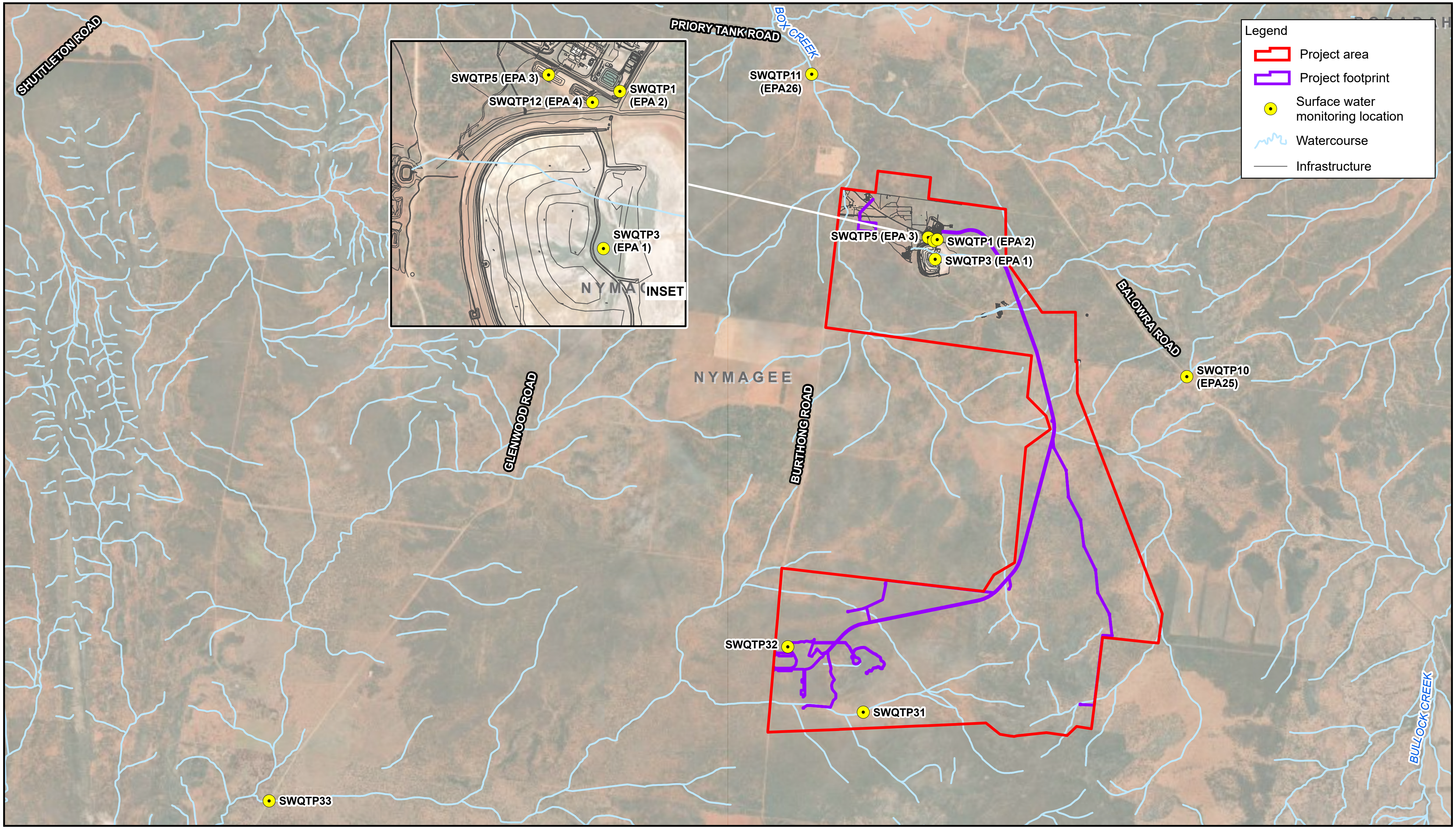
It is recommended that two additional (one upstream and one downstream) surface water quality monitoring locations be nominated for the Federation Site and be added to the surface water quality monitoring program. These two locations are located on watercourses and would only be sampled during rainfall events sufficient to case runoff. These locations are not the two farm dams sampled for the purpose of the baseline surface water quality assessment in Section 7.3.

The consolidated surface water quality monitoring program including the existing surface water monitoring locations for Hera Mine and the recommended additional locations for the Project are summarised in Table 9.1.

Table 9.1 Recommended surface water quality monitoring program

EPA Point, Location	Frequency	Parameters
SWQTP3 Discharge to TSF SWQTP1 Discharge to PWD	Daily during any discharge	Cyanide (weak acid dissociable)
SWQTP5 / SWQTP12 [A]	Daily during discharge	EC, pH, TSS, Cyanide (weak acid dissociable), Al, As, B, Cd, Cu, Pb, Mn, Ni, N (total), Oil and grease, Ag, Total P (filtered), Zn
SWQTP10 Surface Quality Monitoring Point Upstream SWQTP11 Surface Quality Monitoring Point Downstream		
SWQTP31 Federation upstream SWQTP32 Stormwater Retention Pond discharge SWQTP33 Federation downstream		

Recommended surface water monitoring locations are presented in Figure 9.1.



Paper Size ISO A4

0 1 2 3

Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA 1994
Grid: GDA 1994 MGA Zone 55

N

Hera Resources Pty Ltd
Federation Project
Surface Water Impact Assessment

Recommended surface water quality monitoring locations

Project No. 12548432
Revision No. 0
Date 22/10/2021

Figure 9-1

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Print date: 12 Nov 2021 - 09:25

Data source: NSW Trade & Investment Resources and Energy: Mining Lease, 2016; LPI: DTDB / DCDB, 2017 World Imagery: Earthstar Geographics
World Imagery: Maxar.
Created by: ttinkler

9.3 Management plans

9.3.1 Water management plan

The existing Water Management Plan ensures that Hera Mine, with respect to water, meets all relevant regulatory requirements. The site-specific water management plan for the Project will include the water management requirements of the Project, including Hera Mine. The updated Water Management Plan should be reviewed at a minimum every three years or as a result of any regulatory requirements, any significant changes to water management practices.

TARPs are provided in the site-specific water management plans. Modification and, if required, additional TARPs will be developed as required to provide guidance on the immediate actions that should be taken in response to any impacts of the Project identified as part of the monitoring program within the relevant water management plan. Generally, responses include investigation and monitoring, determination of the risk of impact and remedial measures to be implemented.

9.3.2 Erosion and sediment control plan

Permanent erosion and sediment control will continue to be undertaken in accordance with the erosion and sediment control framework outlined in the Hera Mine water management plan. Any construction activities associated with the Project will have a detailed Erosion and Sediment Control Plan (ESCP) prepared based on specific construction methodologies. The objective of the ESCP is to ensure that appropriate structures and programs of work are in place to:

- Identify activities that could cause erosion and generate sediment.
- Describe the location, function and capacity of erosion and sediment control structures required to minimise soil erosion and the potential for transport of sediment downstream.
- Ensure erosion and sediment control structures are appropriately maintained.
- Fulfil the statutory conditions of the project approval.
- Consider industry standard practice, specifically:
  - Landcom 2004. Managing Urban Stormwater – Soils and Construction, Volume 1, 4th Edition.
  - Department of Environment and Climate Change (DECC) 2008. Managing Urban Stormwater – Soils and Construction, Volume 2E – Mines and Quarries.

9.4 Water balance model

The water balance model should be reviewed and revised annually. The average predicted water balance for the Project will be included in the water management plan and the results for each year will be reported in the Annual Review for the Project.

10. Summary

The SWIA considers the potential impacts of the Project on the surface water environment under the proposed conditions. The assessment of potential impacts associated with the Project considered the following:

– Water balance and water security
– Surface water flow
– Surface water quality
– Downstream water users, including licensed water users and basic landholder rights
– Cumulative impacts of the Project in association with other operations in the region

A summary of the existing conditions and potential impacts as a result of the Project is outlined in Table 10.1.

Table 10.1 Summary of potential impacts

Component	Existing conditions	Potential impacts
Water balance	Operations at Hera Mine primarily sources water from groundwater sources within existing entitlements.	The water requirements of the Project are expected to meet within the entitlements already held for Hera Mine.
Surface water flow	The additional disturbance area of the Project is within the catchment of the ephemeral Sandy Creek. Existing water management system at Hera Mine within the Box Creek catchment uses clean water diversion and captures and contains potentially impacted water to minimise changes to flow regimes and hydrology.	No change to flow regime in Box Creek or Sandy Creek.
Surface water quality	Existing water management system at Hera Mine within the Box Creek catchment uses drains and storages to capture and contain potentially contaminated water to minimise potential surface water quality impacts within the relevant design criteria.	The potential surface water quality impacts of Project are expected to be similar to the existing Hera Mine. The water balance modelling forecasts no adverse change in the likelihood, frequency or volume of off-site discharges from Hera Mine or Federation Site.
Downstream water users	No surface water users were identified downstream of the Project.	No impacts to downstream water users predicted.
Cumulative impacts	No existing cumulative impact identified in downstream watercourses.	No change in cumulative impacts.

11. References

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SEEC (2011a) *Hera Project Soils Assessment*, prepared for YTC Resources Limited

SSM (2021) Federation Project Land and Soil Capability Assessment. Report prepared for Hera Resources Pty Ltd.

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Appendix A

Site Water Balance Modelling

Site Water Balance Modelling

Federation Project

Hera Resources Pty Ltd

12 November 2021

→ **The Power of Commitment**

GHD Pty Ltd | ABN 39 008 488 373

GHD Tower, Level 3, 24 Honeysuckle Drive

Newcastle, New South Wales 2300, Australia

T 61-2-4979 9999 | **F** 61-2-9475 0725 | **E** ntlmail@ghd.com | **ghd.com**

Document status

Status Code	Revision	Author	Reviewer		Approved for issue		
			Name	Signature	Name	Signature	Date
S4	0	J M Macatanong	T Tinkler	T.G.Till	S Gray		12/11/21

The Power of Commitment

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1. Introduction

GHD Pty Ltd (GHD) was engaged by Hera Resources Pty Ltd (Hera Resources), a subsidiary of the publicly listed Aurelia Metals Ltd, to prepare a Surface Water Impact Assessment (SWIA) for the proposed consolidation of the existing Hera Mine and proposed Federation Mine (the Project) and to provide for ongoing production from Hera Resources assets through 2035 (end of mining).

1.1 Purpose of this report

This report has been prepared only as technical appendix to support SWIA and must be read only as part of SWIA. The objective of the water balance is to quantify the water balance of the Project, including inflows, outflows and net change in storage.

1.2 Scope and limitations

The scope of work for the site water balance is as follows:

– Collation and review of data relating to Hera Mine and Federation Mine.
– Develop a GoldSim site water balance model for the mine to reflect existing and proposed site conditions, including transfer and discharge rates.

This report: has been prepared by GHD for Hera Resources and may only be used and relied on by Hera Resources for the purpose agreed between GHD and Hera Resources as set out in Section 1.1 of this report.

GHD otherwise disclaims responsibility to any person other than Hera Resources arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

GHD has prepared this report on the basis of information provided by Hera Resources and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

2. Data

The development of the site water balance model for existing and proposed operations at Hera and Federation Mine involved the collation and interpretation of data and operational processes from various sources. The purpose of this section is to outline the data and assumptions used in developing the site water balance model. The sources of data for the water balance are summarised in Table 2.1.

Table 2.1 Data sources

Source	Item
Provided by Hera Resources	Observed meter readings
	ROM production rates
	Observed daily rainfall
Derived from information provided by Hera Resources	Areas of surface water storages
	Catchment areas
	Surface storage capacities
	Water storage operation and management rules
Department of Lands	Topographic information
Bureau of Meteorology	Daily rainfall and evaporation
GHD (2021)	Forecast groundwater inflows

2.1 Climate data

Hera Mine has a site weather station, which has operated since 17 January 2013. A longer historical climate record was obtained from SILO[1] for the Nymagee (Balowra) (station 49117), which is located approximately 17 km south east of the site for the period from 1 January 1889 to 1 January 2021.

The cumulative frequency of annual total rainfall and evaporation from SILO dataset between 1889 and 2019 are compared in Figure 2.1. In addition, the figure compares SILO rainfall to site based rainfall recorded from 2015 to 2020.

[1] SILO refers to patched point data set from the Scientific Information for Land Owners (SILO) database operated by the Queensland Department of Science, Information Technology and Innovation (DSITI). SILO patched point data is based on observed historical data from a particular Bureau of Meteorology (BOM) station with missing data ‘patched in’ by interpolating with data from nearby stations (DSITI, 2021).

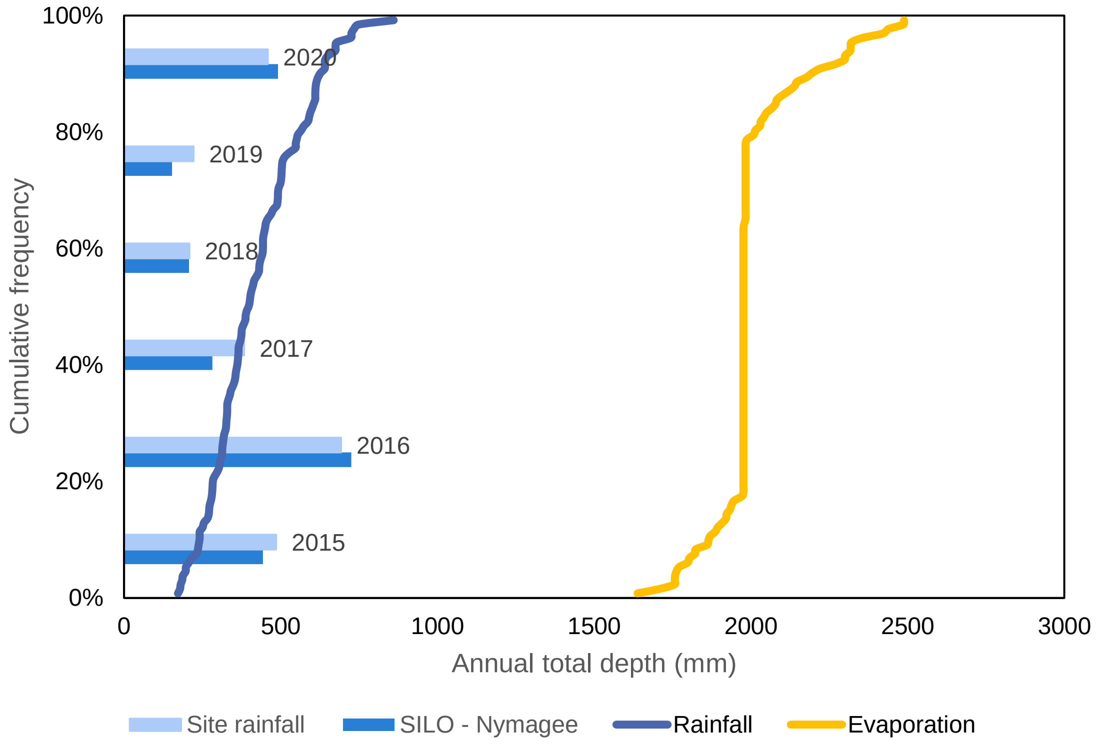

Figure 2.1 ***Comparison of daily rainfall depths***

Figure 2.1 shows that the statistics of annual totals of the historical rainfall record were:

- minimum 153.2 mm (2019)
- maximum of 902.6 mm (1956)
- median of 396.7 mm

Annual evaporation totals have an average of 2001.6 mm, corresponding to an average annual moisture deficit (the difference between rainfall and evaporation) of 1575 mm.

The comparison of annual rainfall totals observed at the site weather station against the SILO dataset is presented in the left side of Figure 2.1 and shows that SILO dataset can provide adequate representation of the potential rainfall variability at the site.

Plot of average monthly pan evaporation is compared to average monthly rainfall from the historical record in Figure 2.2.

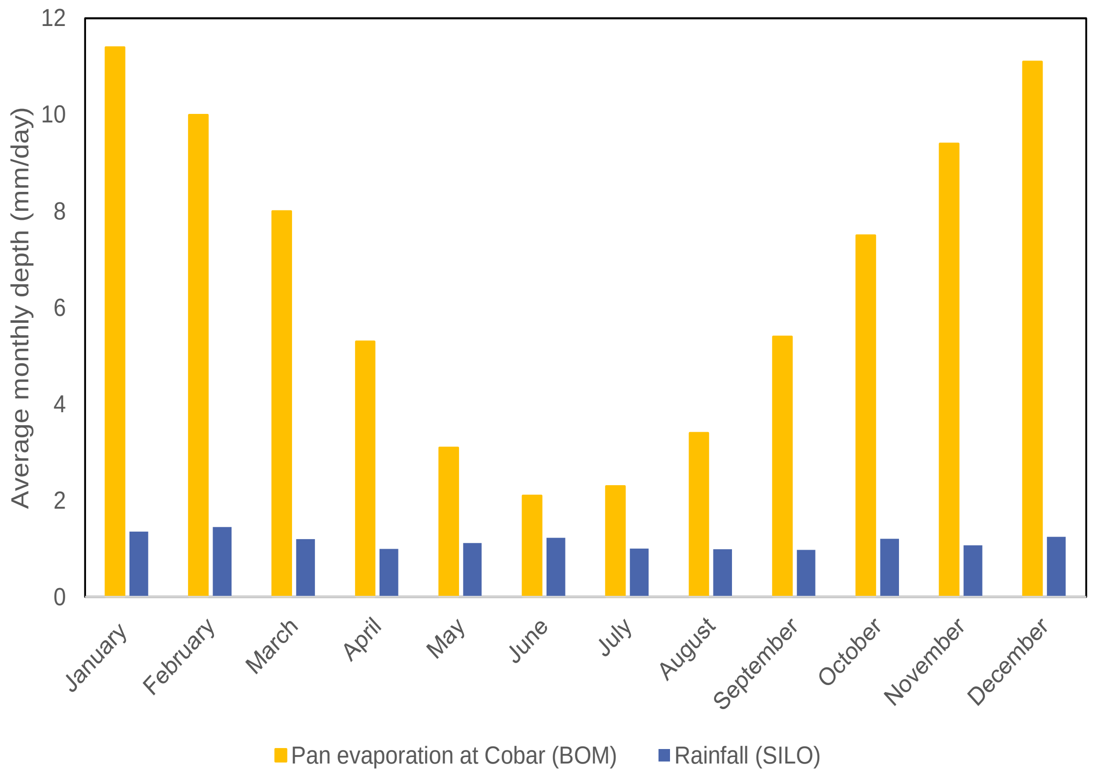

Figure 2.2 Monthly evaporation recorded at BOM station Cobar MO

Figure 2.2 show that evaporation varies seasonally, having higher records in summer compared in winter. The site has an average monthly net rainfall deficit in all parts of the year.

2.2 General operational data

Operational data and site infrastructure information relating to water management at Hera Mine was used to develop the site water balance model. The site-specific information was used as input to the model (i.e. modelling parameters) and is listed in Table 2.2.

Table 2.2 Modelling parameters

Category	Parameter	Input
Operational data	ROM extraction rate	Based on planned production schedule from Hera Resources, refer to Section 2.4.
	Gross processing demand	750 L/tonne
	Dust suppression demand	Net daily evaporation deficit
	Dust suppression application area – Hera Mine	2 ha
	Dust suppression application area – Federation Site	5 ha
	Average domestic water usage per person	655 L/person/day
	Average RO demand at processing plant	50 L/tonne
	RO plant brine stream fraction (%)	30%
	Gland water demand	180 L/tonne
	Moisture left in tailings (%)	84%

Category	Parameter	Input
Mining support operations	Diamond drill rigs pump (L/s)	2 L/s @ 70% utilisation
	Grouting pump (L/s)	0.5 L/s @ 4% utilisation
	Jumbo pump (L/s	3.2 L/s @ 40% utilisation
	Longhole drill pump (L/s)	3 L/s @ 60% utilisation
	Watering down development face pump (L/s)	0.5 L/s @ 4% utilisation
	Watering down slope dirt pump (L/s)	0.5 L/s @ 90% utilisation
	Shotcrete mixing demand (L/s)	2.24 L/s
	Shotcrete mixing recycling factor (%)	90%
	Underground makeup water demand (ML/day)	0.043 ML/day
	UG thickener underflow fraction (%)	40%

Catchment and water storage information input into the model are presented in Table 2.3.

Table 2.3 Catchment area data

Storage	Capacity (ML)	Catchment area (ha)	Catchment type
Hera Mine			
Pete's Dam	3.2	103.8	100% Vegetated
Back Dam East	107.5	1181.0	99.7% Vegetated, 0.3% Hardstand
Back Dam	6.5	123.4	99% Vegetated, 1% Hardstand
Three Gates Dam	3.6	34.6	99.9% Vegetated, 0.1% Hardstand
House Dam	2.0	8474.6	100% Vegetated
PWD	5.4	0	100% Vegetated
TSF	140.0	43.9	100% Tailings
Tailings Seepage Pond	0.05	7.0	100% Tailings
WREA Dam	0.9	1.2	100% Hardstand
Water Management Dam (design)	168	18..7	100% Vegetated
Sediment Basin 1 and 2	7.9	14.8	23% Vegetated, 77% Hardstand
Federation Mine			
Leachate Ponds	7.7	3.3	100% Hardstand
Stormwater Retention Pond	35.9	29.6	100% Hardstand
Dewater Pond	10.0	0	-

2.3 Groundwater inflows

The results of hydrogeological modelling undertaken for the Groundwater Impact Assessment (GHD 2021) were used to estimate the future ground water inflows into Hera Mine and Federation Mine, as shown in Figure 2.3. Refer to the SWIA for a detailed discussion of groundwater inflows adopted for the purpose of this assessment.

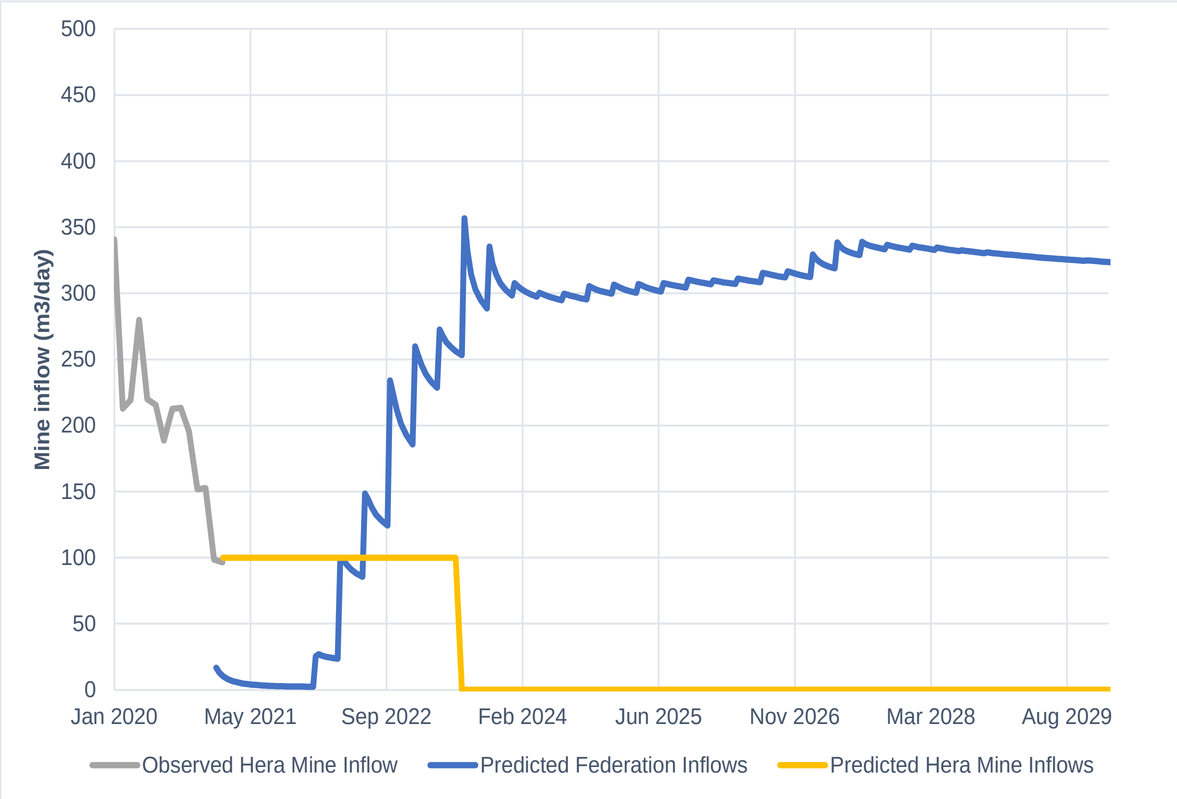

Figure 2.3 Predicted groundwater inflows

2.4 Production

The modelled production rates was developed from observed data for existing Hera Mine and planned production schedule for the proposed Federation Mine. Monthly production rates are presented in Figure 2.4.

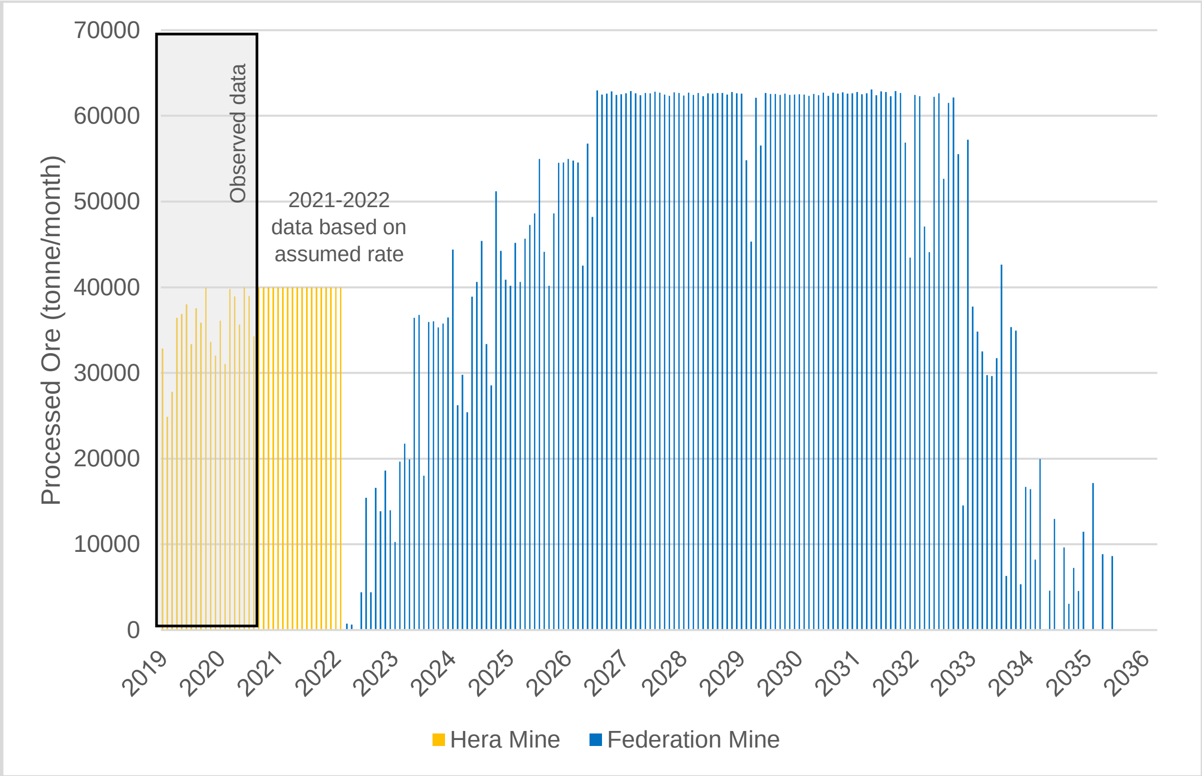

Figure 2.4 Processed ore schedule

2.5 Water management features

The existing and proposed water management system at Hera and Federation Mine were conceptualised as a network of water management features representing surface water storages, operational processes, discharged points and receiving waters. Each water management feature was defined by its connection to the other water management features by inflows and outflows of water. The water management features considered are summarised in Table 2.4. All surface water storages receive direct rainfall and catchment runoff and lose water by evaporation, which, for brevity, is not included in Table 2.4.

The model did not include the backfilling of underground stopes, which was considered equivalent to emplacement in the TSF for the purpose of the site water balance modelling.

Table 2.4 Water management features

Feature	Water storage	Surface water catchments	Inflows	Outflows
Hera Mine				
Pete's Dam	Yes	Yes		Transfers to PWD as required
Back Dam East	Yes	Yes		Transfers to PWD as required Overflows to Back Dam
Back Dam	Yes	Yes	Overflows from Back Dam East	Transfers to PWD as required
Three Gates Dam	Yes	Yes		Transfers to PWD as required Overflows to Box Creek
House Dam	Yes	Yes	Catchment runoff from undisturbed upslope catchments	Used predominately for exploration drilling, dust suppression and transfer to the PWD as required. Overflows to Box Creek
Feed Water Tank	No	No	Receives water from Hera production bores	Transfers to WTP Transfers to Underground Header Tank Transfers to PWD Transfers to Processing Plant (gland water)
Header Tank	No	No	Transfers from Feed Water Tank Dewatering from underground	Transfers to underground workings
Process Water Dam (PWD)	Yes	No	Transfers from Underground Header Tank Transfers from Water Management Dam Transfers from Back Dam East Transfers from Pete's Dam Transfers from Back Dam Transfers from Three Gates Dam Transfers from WTP Transfers from Feed Water Tank Transfers from Sediment Basin Transfers from trucked water Transfers from WREA Leachate Dam Transfers from Federation Mine	Transfers to Processing Plant

Feature	Water storage	Surface water catchments	Inflows	Outflows
Processing Plant	No	No	Transfers from PWD Transfers from Feed Water Tank (gland water)	Pumps tailings to TSF
Tailings Storage Facility (TSF) and Tailings Decant Pond	Yes	Yes	Received tailings from Processing Plant Transfers from Nymagee bore Transfers from WREA	Transfers to TSF sprinklers Losses due to water retained in tailings Transfers to Tailings Seepage Pond
Tailings Seepage Pond	Yes	Yes		Intercepts any potential seepage. Intercepted water is pumped to the TSF as required. Overflows to Water Management Dam (once constructed)
WREA Dam	Yes	Yes	Collection of seepage from WREA.	Transfers to PWD Overflows to Sediment Basin 1 and 2
Water Management Dam (design)	Yes	Yes	Decant from Tailings Decant Pond	Transfers to PWD Overflows to Box Creek
Sediment Basin 1 and 2	Yes	Yes		Transfers to PWD Overflows to Three Gates Dam
Underground workings				
Underground Storage	Yes	No	Groundwater intercepted by underground workings Transfers from Underground Header Tank	Dewaters to PWD
Federation Mine				
Feed Water Tank	No	No	Receives water from Federation production bores	Transfers to Mine Dewatering Dam
Underground Header Tank	No	No	Transfers from Feed Water Tank	Transfers to underground workings Transfers to Wastewater Treatment Plant (WTP)
Leachate Pond	Yes	Yes		Pump to Mine Dewatering Dam Overflows to Retention Pond
Retention Pond	Yes	Yes		Pump to Mine Dewatering Dam Overflows to Sandy Creek

Feature	Water storage	Surface water catchments	Inflows	Outflows
Mine Dewatering Dam	Yes	Yes	Dewatering from underground Transfers from Feed Water Tank	Transfers to Hera Mine Dust suppression demand
Underground workings				
Underground Storage	Yes	No	Groundwater intercepted by underground workings Transfers from Underground Header Tank	Dewaters to Mine Dewatering Dam

3. Model methodology

The site water balance for the Project was modelled as a semi-distributed mass balance, implemented in GoldSim (refer to Section 3.4). The site water management features described in Section 2.5 were linked together to simulate rainfall, runoff, evaporation, overflows pumped transfers, and operations over time. The estimation of catchment runoff, based on rainfall and potential evaporation is itself simulated by the Australian Water Balance Model, described in Section 3.3.

3.1 Site water balance

The water balance for the project was modelled as a semi-distributed mass balance, considering the existing and proposed water management features, as described in Section 2.5. A site-specific water balance equation was derived from the catchment scale water balance equation described by Ladson (2008). The water balance equation applies conservation of mass to derive an ordinary differential equation that describes how the volume of water V changes over time t:

$$\frac{dV}{dt} = R + C + G_{in} + P_{in} + Q_{in} - E - G_{out} - P_{out} - Q_{out}$$

The water balance considered the inflows into each storage:

– Direct rainfall R, estimated from the simulated water surface area of the storage and the simulated rainfall intensity.
– Catchment runoff C, using the Australian Water Balance model (AWBM) (Boughton & Chiew, 2003) and accounting for the change in simulated water surface area.
– Groundwater inflows G_{in}, as described in Section 2.3.

The water balance considered the outflows from each storage:

– Evaporation E, estimated from the simulated water surface area of the storage. A pan factor of 0.8 was adopted to the observed pan evaporation to estimate both potential evaporation and potential evapotranspiration from simulated pan evaporation.

The water balance considered transfers between storages:

– Pumped transfers P_{in} and P_{out}, according to site-specific operating rules and pump rates, as described in Section 2.5
– Overland channel and gravity pipe flow Q_{in} and Q_{out}, due to overflows from one storage to another.

3.2 Rainfall variability

Rainfall variability was considered in the site water and salt balance by sampling simulated rainfall from the historical rainfall record (refer to Section 2.1). A series of simulations were performed, each beginning in a different year of the historical rainfall record and proceeding consecutively through the record (and looped where required).

This approach assumes that the historical rainfall record is characteristic of future rainfall variability and does not consider inter-annual climate patterns such as the El Niño Southern Oscillation.

3.3 Hydrologic model

To estimate the runoff contributing to the surface water storages at Federation Mine and Hera Mine, the Australian Water Balance Model (AWBM) was incorporated into the wider water balance model. The AWBM was adopted as the most suitable model as it is widely used throughout Australia in mine water balances, has been verified through comparison with large amounts of recorded streamflow data and literature is available to assist in estimating input parameters based on recorded streamflow data (Boughton and Chiew, 2003). Another advantage of the AWBM is the consideration of soil moisture retention when determining runoff.

The AWBM is a catchment water balance model that calculates runoff from rainfall after allowing for relevant losses and storage. As seen in Figure 3.1, the model consists of three storages (with surface areas A_1, A_2 and A_3) representing elements such as infiltration into the soil. Rainfall initially enters these storages and once a storage element is full, any additional rainfall is considered to be excess rainfall. Of this excess rainfall, a proportion is routed to the groundwater/baseflow storage (BS) while the remainder is routed to the surface storage (SS). The discharge from the groundwater storage and surface storage is estimated as a proportion of the volume of the storages at the end of each day. The total daily runoff is equal to the combined volume of water discharged from these two storages. The definition of AWBM parameters is provided in Table 3.1.

Table 3.1 Description of Australian Water Balance Model parameters

Parameter	Description
A1, A2, A3	The partial areas of the overall catchment contributing to storages 1, 2 and 3 respectively.
C1, C2, C3	The capacity of storages 1, 2 and 3 respectively.
BFI	The proportion of excess rainfall flowing to the baseflow.
Kb	The proportion of the volume of the baseflow storage remaining in the storage at the end of each day. Not applicable for this water balance model as there is no baseflow component.
Ks	The proportion of the surface storage remaining in the storage at the end of each day.
Excess	Excess from storages C1, C2 and C3.
SS	Surface storage recharge.
BS	Baseflow storage recharge.

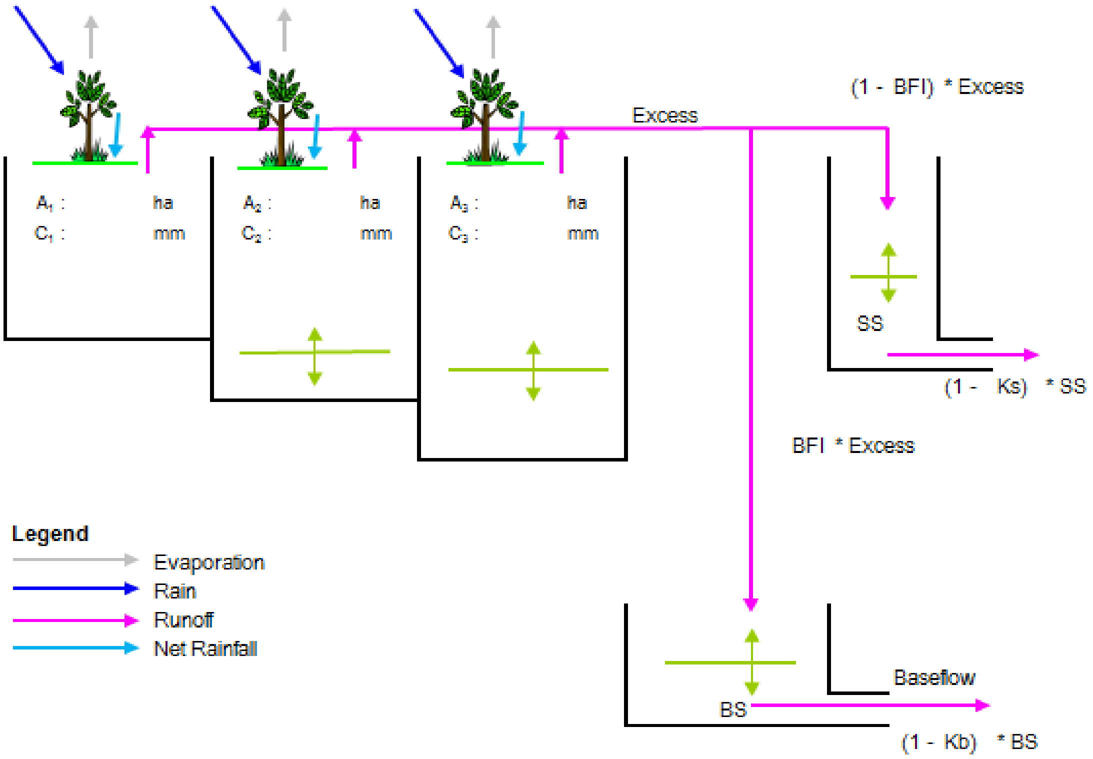

Figure 3.1 Australian Water Balance Model representation

Site catchments were divided into land uses representing bushland/vegetation and impervious areas. Each land use was assigned an AWBM parameter set, which are presented in Table 3.2.

The parameters for bushland/vegetated areas were determined based industry experience and previous water balance modelling undertaken for Hera Mine. The recommended parameters relating to baseflow were adjusted to reflect the ephemeral nature of drainage lines within the site.

The impervious areas were modelled without infiltration into the soil and without surface storage or baseflow storage. Only one storage (A1 in Figure 3.1) was assigned a non-zero capacity. This storage represents depression storage of 5 mm for impervious areas.

The adoption of regional and industry standard runoff parameters were considered reasonable given the lack of site-specific flow gauging data.

Table 3.2 Australian Water Balance Model parameters adopted

Parameter	Bushland/vegetation areas	Impervious areas	Tailings
A1, A2, A3	0.134, 0.433, 0.433	1.0, 0.0, 0.0	0.134, 0.433, 0.433
C1, C2, C3	26.87, 274.37, 548.73	5.0, 0.0, 0.0	0.38, 3.81, 7.62
BFI	0.0	0.0	0.0
Kb	N/A	N/A	N/A
Ks	0.5	0.5	0.5
Average annual runoff coefficient (%)	1.8	42.2	43
Average annual runoff yield (ML/ha/year)	0.1	1.8	1.8

3.4 Numerical implementation

The operation of the water cycle for site conditions was modelled in GoldSim (version 12.1). This software is a graphical object orientated system for simulating either static or dynamic systems. It is like a ‘visual spreadsheet’ that allows the visual creation and manipulation of data and equations representing system behaviour.

GoldSim solves the mass conservation equations using an explicit scheme. A daily time step was used, consistent with the daily rainfall data, with shorter time steps dynamically inserted as required. The following simplifications were used:

– Transfer rates were modelled using daily time steps. In reality, transfer rates are determined during the day on an ‘as needs basis’ and may operate over periods smaller than a day.
– The rate of delivery of potable water to surface facilities and underground potable demand were input at constant rates. This was determined from average annual data obtained from Hera Mine. In reality the demand for the surface facilities and varies daily.
– Idealised operating conditions were established within the model in accordance with advice from the Hera Mine personnel.
– Rainfall and runoff are represented in daily time steps and therefore short duration, high intensity events are not accurately represented by the model. In reality, more overflows from surface water storages may occur than represented by the water balance model.

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