Lucky Bay Garnet Project
Sand Tailings Stockpile Surface Water Assessment

Prepared for Australian Garnet Pty Ltd

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1. Background

The Lucky Bay Garnet Project (the Project), operated by Australian Garnet Pty Ltd (AGPL), is located in the Shire of Northampton in the Midwest Region, approximately 90 km north northwest of Geraldton and 35 km south of Kalbarri. The location of the Project is shown on Figure 1-1. The Mine Closure Plan (MCP, 2022) reports that the Project is based on the Menari Mineral Sand Deposit located on Mining Lease M 70/1280. The wider Lucky Bay Garnet Project tenure comprises two Mining Leases, one General Purpose Lease and seven Miscellaneous Licences.

The Project is a heavy mineral sands (primarily alluvial garnet) mining and processing operation. It includes an above groundwater moving open pit with a mobile Mining Unit Plant (MUP) that pumps ore feed to a central processing area containing a Wet Concentrator Plant (WCP), dryer and Mineral Separation Plant (MSP), Screening and Bagging Plant (SBP) and associated plant infrastructure and utilities to produce a heavy mineral concentrate of garnet, ilmenite and other final products.

Details for previous approvals can be found in the latest Mining Proposal (MP) (AGPL, 2022b) and Mine Closure Plan (MCP) (AGPL, 2022a).

AGPL previously proposed a temporary stockpiling area for the management of clean sand tails pumped from the WCP, prior to them being returned to the pit. AGPL wish to seek approval for the sand tailings stockpile to remain in place as a permanent stable landform, and the purpose of this Surface Water Assessment (SWA) is to consider potential impacts on the surface water environment.

1.1 Proposed Mining Activity

Stockpiling will occur in designated areas at a maximum rate of 480 tph in order to store and dry slurried sand processed through the WCP. The sand tailings are wet-stacked (20% - 30% moisture) at natural repose using a series of 12 cyclone stackers. The initial dimensions for the sand tailings stockpile (post completion of remedial height reduction activities) will be 250 m wide, 800 m long and 10 m high relative to ground level (25 mAHD) in accordance with the Works Approval conditions (refer Figure 1-1).

The top of the stockpile is constructed in two sections, one with an elevation of 25 mAHD and the other with an elevation of 30 mAHD. The slope between the two sections of the top has a 4° linear gradient. The stockpile top does not contain any crest bunding, and any runoff that is generated on the top surface is able to discharge to the sides. Runoff generated from the uppermost top section (30 mAHD) is also able to discharge to the lower top section (25 mAHD) (Landloch, 2024). The stockpile area includes perimeter bunds and drains to capture runoff and minimise washouts.

Due to operational constraints (site access road to the west and a slurry pipeline services corridor to the east), an interim profile with steeper slopes than the final landform is required. This interim landform will have its slopes stabilised through the application of topsoil and seeded hydromulch through the winter of 2024. Stabilisation is currently achieved through the application of a binding polymer product (DustCheck).

The surface of the stockpile is proposed to be used for the creation of solar drying cells to accommodate clay fraction slimes, a waste product produced from the WCP that includes a chemical additive as a thickener. The final decommissioned landform will have lower slope angles and a wider base to offer greater long term landform stability (Landloch, 2024). Any remaining clay in the solar drying cells will also be excavated and returned to the pit and the cells backfilled with clean sand tails before top soil is spread.

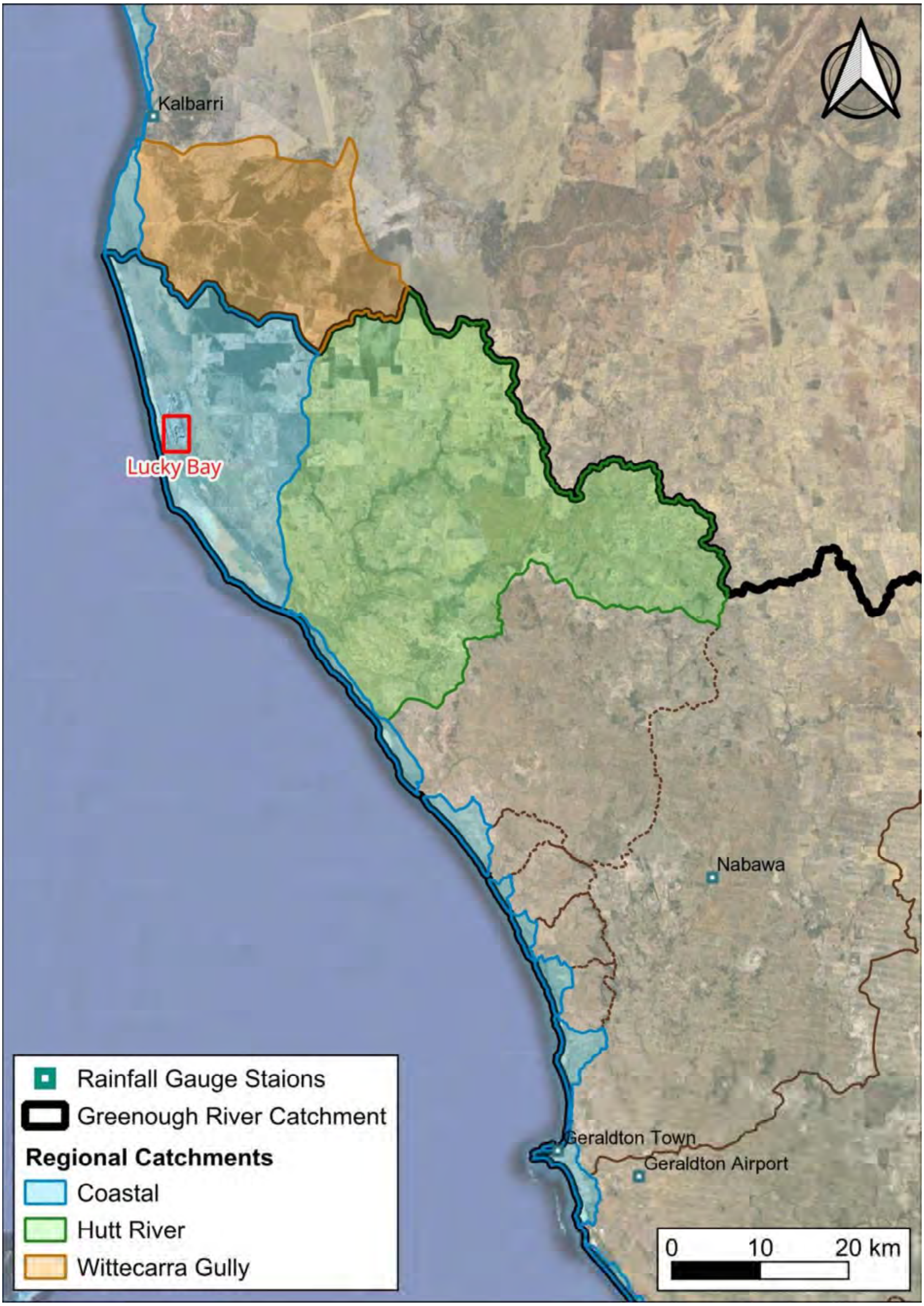

Figure 1-1: Location Plan, Hydrology and Climate Stations

Figure 1-2: Project Layout and Proposed Stockpile Extent

2. Baseline Environment

2.1 Probability Terminology

Australian Rainfall and Runoff (ARR) (Ball, et. al, 2019) recommends the use of Annual Exceedance Probability (AEP) when defining flood probability, so has been adopted throughout this report. AEP is defined as the probability or likelihood of an event occurring or being exceeded within any given year, usually expressed as a percentage. This new terminology supersedes the Annual Recurrence Interval (ARI) terminology adopted in the earlier revision of ARR (Institution of Engineers, Australia, 1987).

The relationship between ARI and AEP is presented in Figure 2-1.

Frequency Descriptor	EY	AEP (%)	AEP (1 in x)	ARI
Very Frequent	12			
	6	99.75	1.002	0.17
	4	98.17	1.02	0.25
	3	95.02	1.05	0.33
	2	86.47	1.16	0.5
	1	63.21	1.58	1
Frequent	0.69	50	2	1.44
	0.5	39.35	2.54	2
	0.22	20	5	4.48
	0.2	18.13	5.52	5
	0.11	10	10	9.49
Rare	0.05	5	20	19.5
	0.02	2	50	49.5
	0.01	1	100	99.5
Very Rare	0.005	0.5	200	199.5
	0.002	0.2	500	499.5
	0.001	0.1	1000	999.5
	0.0005	0.05	2000	1999.5
Extreme	0.0002	0.02	5000	4999.5
			↓	
			PMP/ PMP Flood	

Figure 2-1: ARR Preferred Terminology (Ball, et. al, 2019)

2.2 Regional Climate

The Project region experiences a typically Mediterranean climate with mild wet winters and hot dry summers. The nearest (active) Bureau of Meteorology (BOM) climate stations are located at Kalbarri (about 40 km north), Nabawa (about 80 km southeast) and Geraldton Town (about 90 km south) (refer Figure 1-1). Average daily temperatures recorded at Kalbarri (BOM site 8251) range between a minimum of 9.7ºC in July and a maximum of 34.1ºC in February, as shown in Table 2-1.

Table 2-1: Lucky Bay Climate Statistics

	Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Kalbarri	Mean Maximum Temperature (ºC)	33.2	34.1	32.6	29.5	26.1	23	21.9	22.6	24.1	26.2	28.4	31.2	27.7
	Mean Minimum Temperature (ºC)	46.4	48.1	47.2	39.5	36.2	30.9	30.5	33	38.5	41.2	42.4	46.5	48.1
	Mean Rainfall 1970-2024 (mm)	4.9	8.3	11.6	19.2	52.9	75.6	69.2	48.0	23.3	13.8	6.8	3.6	334.3
Balline	Mean Rainfall 1930-2024 (mm)	5.0	9.7	15.4	25.3	65.9	95.8	84.2	57.0	28.9	16.4	8.9	3.6	417.1

2.2.1 Rainfall and Evaporation

For the period of available record (1970 – 2024), Kalbarri recorded an annual average rainfall of 334 mm. Rainfall is winter-dominant, with over 70% of rainfall occurring between May and August (Table 2-1). A rainfall monitoring site located at Balline (8004), immediately to the east of the Project, is monitored by the farm owner, and has a partially complete record since 1930 (Water Direct, 2021). The long-term average annual rainfall at Balline is approximately 417 mm and monthly averages are higher than those recorded at Kalbarri. Annual rainfall totals are demonstrating a general declining trend, as shown on Figure 2-2.

It has not been possible to obtain recent evaporation data from BOM weather stations. URS (2010) reported that the annual average evaporation measured at Geraldton was 2,450 mm, and that average monthly evaporation exceeded average rainfall in all months of the year. Extrapolation of evaporation data from all Western Australian climate stations with over 10 years of measurements by the BoM indicated that the Project area has an annual evaporation rate of about 2,550 – 2,600 mm.

2.2.2 Intensity-Frequency-Duration (IFD) Data

Intensity-Frequency-Duration (IFD) was extracted from the BoM website for the Project, from the 2016 datasets, which is presented in Table 2-2 and Table 2-3.

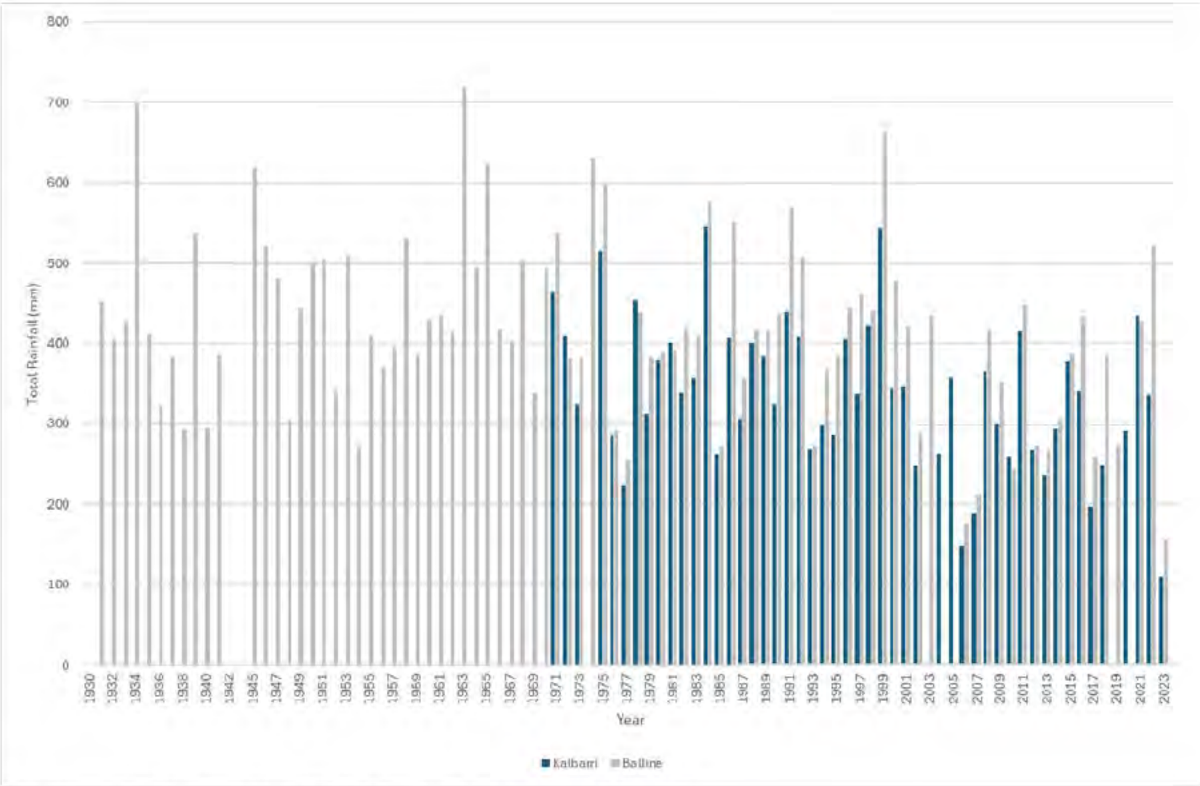

Figure 2-2: Total Annual Rainfall at Kalbarri and Balline

Table 2-2: IFD Data (Rainfall Depths in mm)

Duration	Annual Exceedance Probability (AEP)					
	50%	20%	10%	5%	2%	1%
5 min	5.43	7.52	9.08	10.7	13.1	15.1
10 min	8.60	12.0	14.5	17.2	21.0.	24.3
20 min	12.3	17.1	20.7	24.5	30.0	34.6
30 min	14.6	20.3	24.5	29.0	35.4	40.8
45 min	17.0	23.5	28.4	33.5	40.9	47.1
1 hour	18.8	26.0	31.3	37.0	45.1	51.9
3 hour	27.2	37.5	45.2	53.4	65.3	75.3
6 hour	34.2	47.5	57.6	68.2	83.8	96.7
12 hour	42.4	59.7	72.7	86.7	107	123
24 hour	50.9	72.3	88.5	106	130	149
36 hour	55.5	78.8	96.6	116	141	161
48 hour	58.6	83.0.	101	121	147	167
72 hour	63.0	88.4	108	128	153	173
96 hour	66.5	92.7	112	132	157	177
120 hour	70.1	96.9	116	136	162	182
144 hour	74.0	102	121	141	167	187
168 hour	78.2	107	126	146	173	194

Table 2-3: IFD Data (Rainfall Intensity in mm/hr)

Duration	Annual Exceedance Probability (AEP)					
	50%	20%	10%	5%	2%	1%
5 min	65.2	90.2	109	129	157	181
10 min	51.6	71.8	87.0	103	126	146
20 min	36.9	51.3	62.1	73.6	90.1	104
30 min	29.2	40.5	49.0	57.9	70.8	81.6
45 min	22.7	31.4	37.8	44.7	54.6	62.9
1 hour	18.8	26.0	31.3	37.0	45.1	51.9
3 hour	9.06	12.5	15.1	17.8	21.8	25.1
6 hour	5.69	7.92	9.60	11.4	14.0	16.1
12 hour	3.53	4.97	6.06	7.22	8.88	10.3
24 hour	2.12	3.01	3.69	4.41	5.4	6.21
36 hour	1.54	2.19	2.68	3.21	3.91	4.47
48 hour	1.22	1.73	2.11	2.52	3.06	3.48
72 hour	0.874	1.23	1.49	1.77	2.13	2.41
96 hour	0.693	0.966	1.17	1.38	1.64	1.85
120 hour	0.584	0.808	0.969	1.13	1.35	1.51
144 hour	0.514	0.705	0.840	0.977	1.16	1.30
168 hour	0.465	0.635	0.752	0.868	1.03	1.15

2.3 Vegetation

Baseline vegetation monitoring conducted in October 2021 found that vegetation had been moderately to severely impacted by drought, with crown loss and tree deaths apparent, highly impacted by stock grazing in some areas, and eucalyptus species showed a strong epicormic response to both water stress and cyclone damage (Borger, 2021). Two years of good rainfall and the removal of grazing pressure resulted in an increased in canopy cover and new growth by May 2023, with tree health remaining generally stable during the subsequent 12 months of below average rainfall (Botany Lens, 2024).

Regular monitoring of Groundwater Dependent Vegetation (GDV) is being conducted; however, no mention is made in previous reports of vegetation being dependent on surface water flows other than direct rainfall.

2.4 Hydrology

The Project is located in the coastal subcatchment of the Greenough River basin (Figure 1-1), within the Northampton Coast surface water management area. The catchment, which has an area of 920 km^2 (DWER, 2018), is characterised by numerous small catchments that drain internally to local depressions with no clearly defined drainage lines or connection to other catchments.

The MCP (AGPL, 2022a) and MP (AGPL, 2022b) report that there are no surface watercourses in the Project area and that surface water flow is limited to shallow overland flow during, and immediately after, rare heavy rainfall events, and temporary shallow ponding in local depressions. A limestone ridge located to the northeast of the pit area may generate higher runoff rates than the surrounding sand areas. It was deemed that surface flow will generally infiltrate or evaporate within the catchment, so flood risk is negligible.

A key aspect of the local hydrological regime is likely to be the high infiltration rates associated with the sand and sandy soils present throughout the Project area (URS, 2010). Rates of typical infiltration for sand and sandy loam soils are 13 mm/h and 12 mm/h respectively. Soil infiltration rates near the process plant area are of the order of 11 – 18 m/day based on field testing, confirming the relatively high percentages of water losses that can be expected. Comparing these to the IFD values presented in Table 2-3, a event duration of 4.5 hours or less would be required for a 1% AEP in order to generate runoff, with shorter durations required for higher AEP events.

Surface water is insignificant in the area as a water supply. There are no known dams within the Project area due to the lack of surface water runoff and clay material for the dams. Local landholders rely on groundwater bores to supply their stock with water and direct rainfall for cropping (URS, 2010). Data is not available on surface water quality in the Project as water is so rarely present, but it is expected to be similar to rainwater quality as it is only present briefly after rainfall.

As a result of limited to no surface water within the Project area, no ongoing management of surface water was proposed post closure, other than the general reprofiling of all disturbed surfaces to mimic the surrounding terrain.

3. Surface Water Assessment

3.1 Topographic Data

The following topographic datasets were used in this assessment to produce a combined baseline Digital Elevation Model (DEM) (Figure 3-1):

- 240527 NCSE DEM
- 240226 SW.ei
- 240328 NW.ei
- 240127 Hose1.ei
- 231007 NC tower.ei
- 231123 NE-v1.ei
- Digital Elevation Model (DEM) of Australia derived from STRM with 1 Second Grid - Hydrologically Enforced

It should be noted that the time-stamped surveys provided by AGPL had not been screened to remove vegetation, however the accompanying aerial imagery assisted in their interpretation.

The following designs were provided by AGPL for the sand tailings stockpile, with the final design being added to the baseline DEM to produce a post-development scenario (Figure 3-2):

- cln_sandn_final_des_lwork-v36a
- cln_sandn_rehab_des_lwork-v36a
- cln_sandn_slime_clip-v41d

3.2 Project Catchments

The Project topography ranges from over 100 mAHD at the high point to the east, to below 10 mAHD within depressions to the south and west of the proposed stockpile. The baseline DEM was used to define surface water catchments draining in the vicinity of the proposed stockpile (Figure 3-1); the areas of these are presented in Table 3-1. All of the catchments are internally draining to either bunded locations within the Project, or to depressions within the topography.

The largest catchment, which drains into the pit, is catchment 2, with an area of 2.4 km^2. A bund located to the east of the existing stockpile forms the western boundaries of catchments 1 and 9, as this functions to separate internal and external runoff and provide containment for the pipeline corridor. It has been assumed that runoff from catchment 8 does not drain to the north, based on the available DEM.

These catchments were modified to include the proposed final (operational) design for the stockpile, as the footprint for this is larger than for the rehab (closure) design (Figure 3-2). The most noticeable changes were to catchments 2 and 3, which decreased and increased by 0.1 km^2 respectively as the revised topography increases the area draining to the bunded low point within catchment 3, to the southeast of the stockpile. There is no change to the external boundary of the Project catchments.

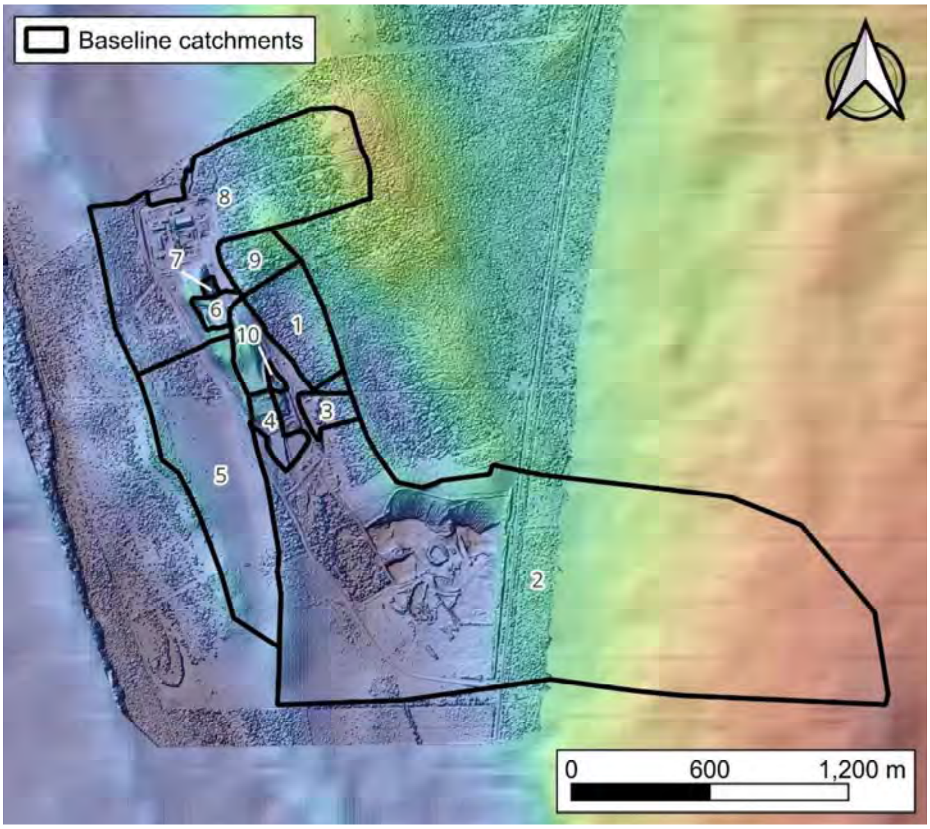

Figure 3-1 Baseline Project Catchments

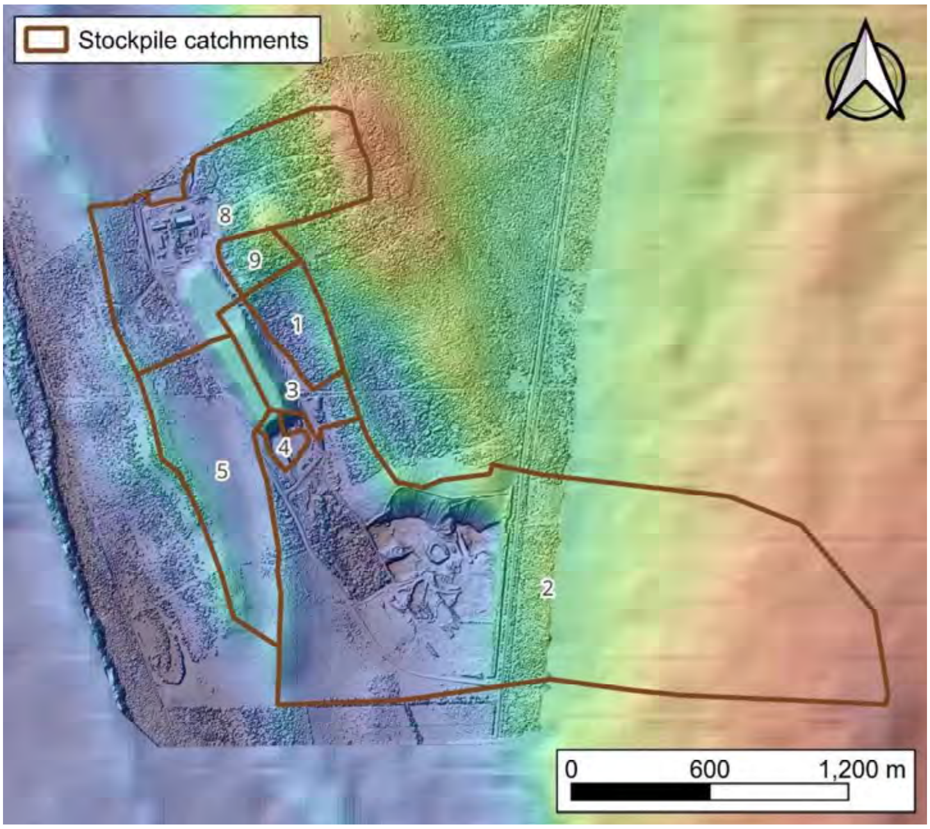

Figure 3-2 Post-Development Project Catchments

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Table 3-1: Project Catchment Characteristics

Catchment	Baseline Area (km^2)	Post-Development Area (km^2)
1	0.12	0.12
2	2.45	2.36
3	0.03	0.13
4	0.04	0.03
5	0.41	0.43
6	0.02	-
7	0.004	-
8	0.63	0.65
9	0.06	0.06
10	0.006	-

3.3 Erosion

Results of structural tests on topsoils from the Project, indicated that the overall risk of dispersion and erosion was low, with it being suitable for use on sloping surfaces (AGPL, 2022b). A draft landform stability assessment looking at the potential for water erosion impacting the proposed stockpile was available (Landloch, 2024) and it established that both soil and sand samples that were tested were structurally stable.

Landloch (2024) found that the effective hydraulic conductivity of the sand was extremely high (150 mm/h), meaning that it will not likely runoff even in extreme rainfall events, and its placement beneath the soil is not likely to produce saturation of the surface soil layer, with the risk of sloughing of the soil being low. Both the soil and sand are prone to rill (the erosion of sediment by concentrated flow) and interrill (a process of soil detachment by the impact of raindrops, transport by shallow sheet flow, and delivery to rill channels) erosion, with the soil being more susceptible than the sand. Modelling indicated that the sand is not prone to erosion by water, but that the soil is likely to erode every 1-2 years in response to rainfall.

The MP (AGPL, 2022b) and MCP (AGPL, 2022a) recommend that landform stability is maintained at all times and actively remediated if erosion occurs, with landforms to be safe, stable and non-polluting. Landloch (2024) recommend that erosion potential will likely be required for the soil to remain erosionally stable in response to surface water flows. Hydromulch is currently planned to be used and will be essential in providing some protection in the short term until vegetation is established. Vegetation will be essential in providing some erosion resistance in the longer term. Use of tree debris is also strongly recommended (along with hydromulching) to provide stabilisation both in the short term while vegetation is establishing, and in the longer term once vegetation is established but groundcover remains low. It would also provide protection in the event that vegetation cover levels decrease due to drought, grazing, or a changing climate.

Due to the Project catchments being internally draining, with areas of bunding separating them from external runoff to the east, it is anticipated that any material that is eroded from the stockpile by surface water would be deposited locally as the water infiltrates. Landloch (2024) also recommends installation of crest bunding around the perimeter of the top of the stockpile, and at the edge of the batter separating the two top sections.

Landloch (2024) indicated that the very high silt and clay content of the slimes (~98% being <0.045 mm (45 µm)) will mean it is likely to have very low permeability. This in turn would lead to very high runoff and erosion potential if this material was present at the surface.

3.4 Water Quality

The proposed stockpile will consist primarily of clean sand tailings from the pit. The MP (AGPL, 2022b) identified that disturbance and stockpiling of the subsoil poses very low risk to the environment, and that topsoils are suitable for re-use as rehabilitation topsoil. Landloch (2024) tested soil and sand samples and found both to have low salinity, negligible net acidity and slightly elevated levels of metals, with pH levels within the sand being slightly elevated, none of which would pose a risk to the environment.

Overall, the leachate quality of the sand (for the elements measured) was similar or better (lower concentrations) than the soil. Given this, it was not anticipated that mobilisation of metals from the sand will lead to increased metal concentrations above those currently being supplied by the soil. For both materials, <5% of the sediment produced will be easily mobilised, likely leading to runoff with low suspended sediment concentrations and low risk of transporting contaminants that may attach to the mobilised sediment.

It is therefore not considered that the relocation of these introduces any risk to the quality of surface water runoff.

The MP (AGPL, 2022b) reports that the slimes are strongly alkaline with a pH of 8.8 with moderate salinity reflected by EC values of 970 µS/cm in the slime decant liquid. The slime is classified as non-acid forming (acid consuming) due to its low sulfur content and high ANC and the slime decant contained low concentrations of metals and metalloids, within livestock drinking water guidelines and non-potable use guidelines. Overall, the slime waste is low risk for Acid Mine Drainage. The slimes consist of very fine particles with 100% of the sample less than 90 µm, and almost 98% less than 45 µm and are not suitable for disposal on slopes due to its tendency to disperse.

AGPL have advised that Aglime of Australia are currently testing the clay fraction slimes that will be stored within the cells on top of the stockpile, to determine their potential for use as an agricultural additive.

3.5 Surface Water Monitoring

The MP (AGPL, 2022b) and MCP (AGPL, 2022a) did not make any recommendations for monitoring of surface water, due to the absence of semi to permanent surface water bodies. Combined with the high infiltration rates at the Project and absence of defined watercourses, we do not propose to introduce any monitoring.

4. Summary and Conclusions

This SWA has consisted of a desktop review of previous studies and reports produced for the Project, including an update to consider the most recently available public and Project data. It is concluded that the proposed conversion of the sand tailings stockpile does not pose a risk to the surface water environment in relation to modification of catchments, erosion potential and water quality. The high infiltration rates reported for the catchment indicate that surface flow will generally infiltrate or evaporate within the catchment, so flood risk is negligible. No recommendations have been made for monitoring of surface water due to the high infiltration rates at the Project and the absence of defined watercourses.

5. References

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