TSF4 Seepage Assessment: Woljenup Creek Hydrological Assessment

02 October 2023

[redacted]

1. Introduction

1.1 Background

Talison Lithium Pty Ltd (Talison) is constructing Tailings Storage Facility # 4 (TSF4) to facilitate ongoing operation of their Greenbushes Mine in Western Australia. The Department of Mines, Industry Regulation and Safety (DMIRS) and Department of Environment and Regulation (DWER) has approved the respective Mining Proposal (MP Reg ID 92728) and Works Approval (WA W6618) to allow construction of TSF4, subject to certain conditions and requests for information. A list of these conditions and requests is presented in **Table 1**.

Table 1: Issues Raised by DMIRS and DWER

Item	Source of request	Agency	Request and information required
1A	Schedule 1: Areas of the Mine Closure Plan that require further development in the next revision.	DMIRS	Update the MCP with the hydrogeological information gained from the non-standard tenement condition requiring an assessment of water recharge to stock water dams 1 and 2 south of TSF4
1B			The MCP is to provide updated information on the expected timeframe for seepage water from TSF4 to reach an acceptable quality such that active management of seepage is no longer required post closure of the facility. This should include details of the test work completed to date, to determine the changes in seepage water quality over time.
2	Schedule 2: Recommended further conditions	DMIRS	Prior to 1 December 2022, the tenement holder shall undertake a hydrological and hydrogeological assessment to confirm there will be no significant reduction in the quantity of water recharge to stock water dams 1 and 2 south of the TSF4.
3A	Schedule 3: Table 11-8: Baseline Environmental Data Gaps	DMIRS	A subset of the recently identified (GHD 2020f) CoPC was analysed for the first time in 2020 and do not have published guidelines (antimony, caesium, rubidium, thallium)
3B			Time for TSF4 to drain and seepage to cease after tailings deposition ceases has not yet been modelled.
3C			Further information is needed on the tailings slurry water quality during operations.
4A	TSF4 Works Approval Condition 4(f)	DWER	Updated hydrogeological conceptual model incorporating: i) additional permeability testing of the saprolitic profile beneath the TSF4 footprint
4B			Updated hydrogeological conceptual model incorporating: ii) confirmation of the permeability, lateral continuity and expected seepage and migration rates from TSF4

Item	Source of request	Agency	Request and information required
5A	TSF4 Works Approval Condition 16(e)	DWER	(i) updated seepage management plan, including an updated seepage model reflecting actual data collected from additional hydrogeological studies and actual tailings characteristics
5B			(ii) Trigger values for groundwater and surface water monitoring to identify potential impacts from seepage from TSF4, and actions undertaken to respond to potential seepage impacts
6	TSF4 Works Approval Condition 16(h)	DWER	(h) a groundwater monitoring report demonstrating their compliance with conditions 10, 11 and 12 for the time limited operations period....”

GHD Pty Ltd (GHD) was appointed by Talison to assess the seepage from TSF4 (the Study) in response to the issues raised. The scope of the Study will culminate in a suite of reports that will be submitted to DMIRS and/or DWER in response to the various conditions and requests. Given the nature of these conditions and requests, some have been addressed across several reports detailing separate, but related, subject matter, and others have been addressed partly within a single report. A summary of the Study reporting structure is provided in **Table 2** and is depicted schematically in **Figure 1**. This report represents one component of the overall Study and provides an overview of the hydrology of Woljenup Creek.

Table 2: Reporting Structure to Address the DMIRS and DWER Requests and Conditions

Report	Description	Item(s) Addressed in Table 1-1
Tailings Leach Testing (GHD, 2023a)	The Testing of the tailings (in-situ TSF1/TSF2 material and fresh tailings) characterises the leaching of Contaminants of Potential Concern (CoPCs) from tailings material for the modelling work and risk assessment.	1B, 3B
Sub-surface Clays Attenuation Capacity Testing (GHD, 2023b)	The Testing of the clays beneath TSF4 derived the attenuation factors for key CoPCs within clays for the seepage modelling and risk assessment.	1A, 2
Baseline Monitoring Report (GHD, 2023c)	The Report summarises the quarterly sampling and monitoring of the surface and groundwater monitoring of quality, levels and reporting to provide a pre-construction baseline.	6
Conceptual Hydrogeological Model of TSF4 (GHD, 2023d)	The Conceptual Model is a collation of drilling, hydraulic and monitoring information, to present aquifer and clays continuity, groundwater flow directions and groundwater discharge locations and surface water flows.	2, 4A, 4B
Site-Specific Water Quality Criteria (GHD, 2023e)	The Criteria have been derived for site specific conditions and form the basis for tolerable mine discharges to off-site environments. A summary of all previous guideline derivation work is included. Determined As, Li and Rb are the key CoPCs	1B, 3A, 3B, 4B
Woljenup Creek Hydrological Assessment (this report)	The Assessment involves the determination of the dilution effect on any released CoPCs in the downstream creeks and estimates the total load on the Blackwood River.	Required for Risk Assessment
Site Wide Seepage Modelling (GHD, 2023f)	The Modelling provides predictions for the fate and transport of impacted seepage within the groundwater system from facilities, including TSF1, TSF2, TSF4 and Floyds Waste Rock Landform (cumulative impacts for TSF4).	1A, 2, 4A, 4B
	The Modelling provides preliminary predictions of the timeframe for TSF4 to drain, the quality of the drainage waters, and an indication of how long drainage will continue after closure of TSF4.	1B, 3B, 3C
Risk Assessment (GHD, 2023g)	Assessment of risks to human health and the environment from mine site seepage and discharge, supported by the various technical studies (herein).	-
Seepage Management Plan (GHD, 2023h)	The Plan details a monitoring plan and schedule for surface and groundwater, associated trigger criteria, and actions that should be undertaken should seepage be detected above the trigger levels.	5A and 5B

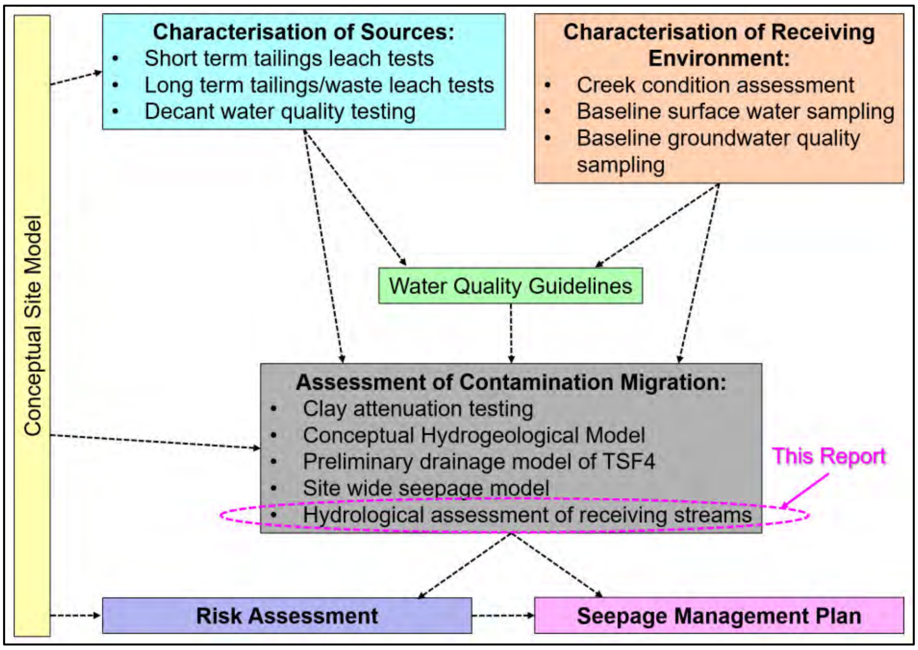


Figure 1: Reporting Structure for TSF4 Seepage Assessment

The key focus of the Study was to identify any Contaminants of Potential Concern (CoPCs) released from TSF4, quantify their rates of release, as well as to evaluate their potential risks to the health of downstream water users and the waterways environment. The hydrological assessment of the Woljenup Creek catchment has been undertaken as part of the Study.

1.2 Purpose of This Report

This report documents the approach and outcomes of the hydrological assessment that was undertaken for the Woljenup Creek catchment. The purpose of this assessment was to:

- Assess the dilution of any CoPCs released downstream of TSF4 to the Woljenup Creek; and
- Assess potential hydrological impact on Jones Farm Dam (SW20-02).

The information contained herein supports the overarching seepage assessment and preparation of a seepage management plan for TSF4.

2. Scope and Limitations

2.1 Scope of Work

The scope of the hydrological assessment entailed the delineation of hydrological catchments and estimation of catchment discharges thereof, and the derivation of dilution factors to support estimation of CoPC concentrations following instream dilution by catchment discharges in the creek. The model domain covers the entire the Woljenup Creek catchment up to its confluence with the Blackwood River.

2.2 Limitations

This report has been prepared by GHD for Talison and may only be used and relied on by Talison for the purpose agreed between GHD and Talison as set out in **Section 1.2** of this report.

GHD otherwise disclaims responsibility to any person other than Talison 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 Talison 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.

The opinions, conclusions and any recommendations in this report are based on information obtained from, and testing undertaken at or in connection with, specific sample points. Site conditions at other parts of the site may be different from the site conditions found at the specific sample points.

Investigations undertaken in respect of this report are constrained by the particular site conditions, such as the location of buildings, services and vegetation. As a result, not all relevant site features and conditions may have been identified in this report.

3. Catchment Hydrology

3.1 Overview

Woljenup Creek is a tributary of Blackwood River and flows in a southerly direction, with the proposed TSF4 located on the upper reaches of the said creek. **Figure 2** shows the alignment of the creek's main channel and the extents of its contributing catchment. The same figure also denotes the four sites where GHD undertook water quality sampling on 13 July 2022.

3.2 Catchment Areas

A catchment analysis has been undertaken to determine the contributing catchment area along Woljenup Creek. The analysis was carried out using the following information:

– 2 m LiDAR data over the mine site dated May 2022;
– Regional 1 m contours from past projects (of unknown date and quality); and
– Detailed design outputs (as of February 2023) from GHD for the TSF4 embankments.

The increasing catchment area with reach along the creek is depicted in **Figure 3**. Stepped increases in catchment area occur where tributaries of the creek connect into the main channel. The total catchment area of Woljenup Creek at its confluence with the Blackwood River (at Chainage ~5,270) is ~1,220 ha.

Jones Dam is a farm dam located on the main channel of Woljenup Creek at Chainage ~770. The dam is one of the surface water monitoring locations (i.e., location ID SW20/02) stipulated by the DWER in Works Approval No. W6618/2021/1. As depicted in **Figure 4**, construction of TSF4 will reduce the dam's contributing catchment area by ~47% (from 256 ha to 135 ha).

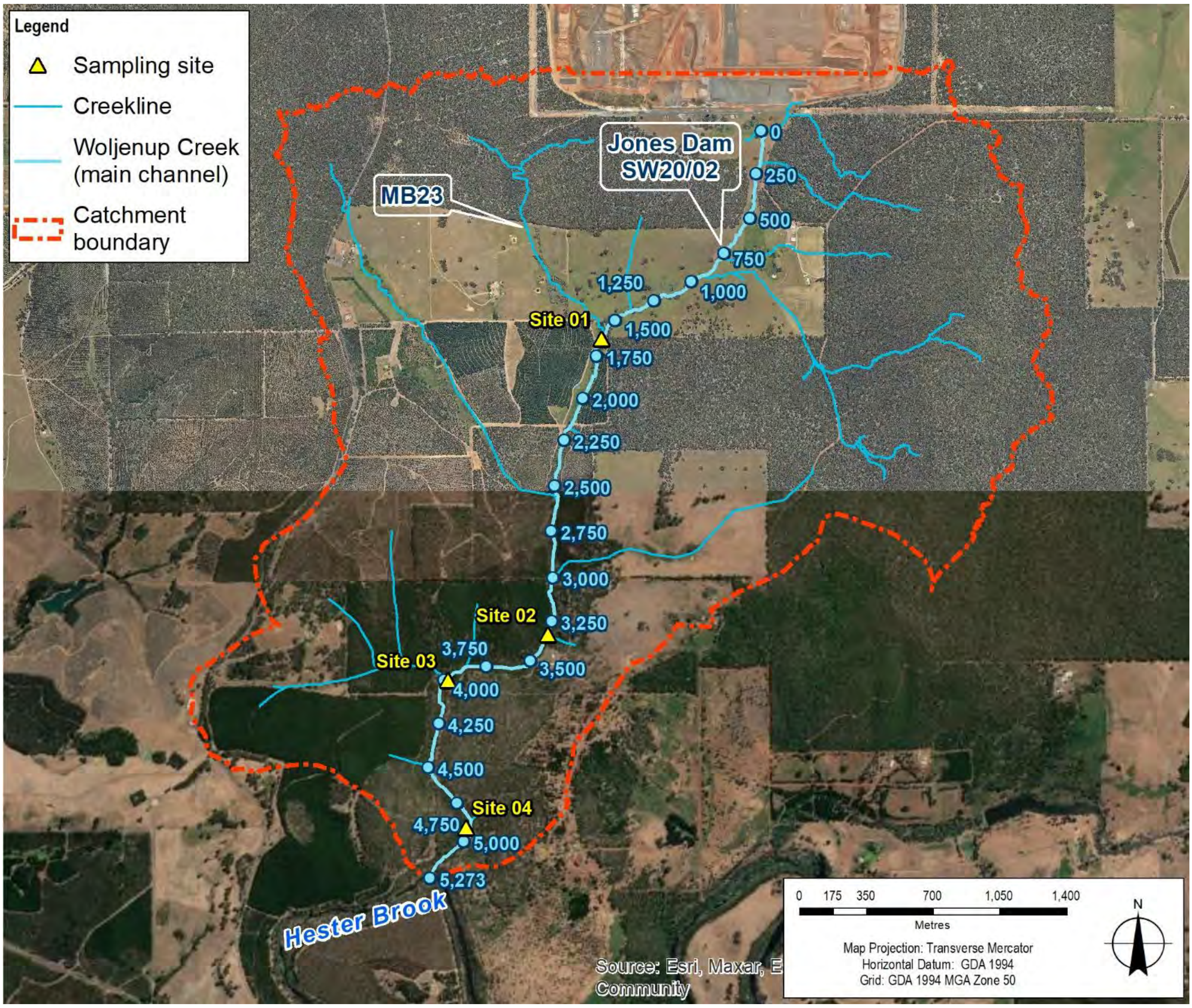


Figure 2: Woljenup Creek alignment and overall catchment boundary

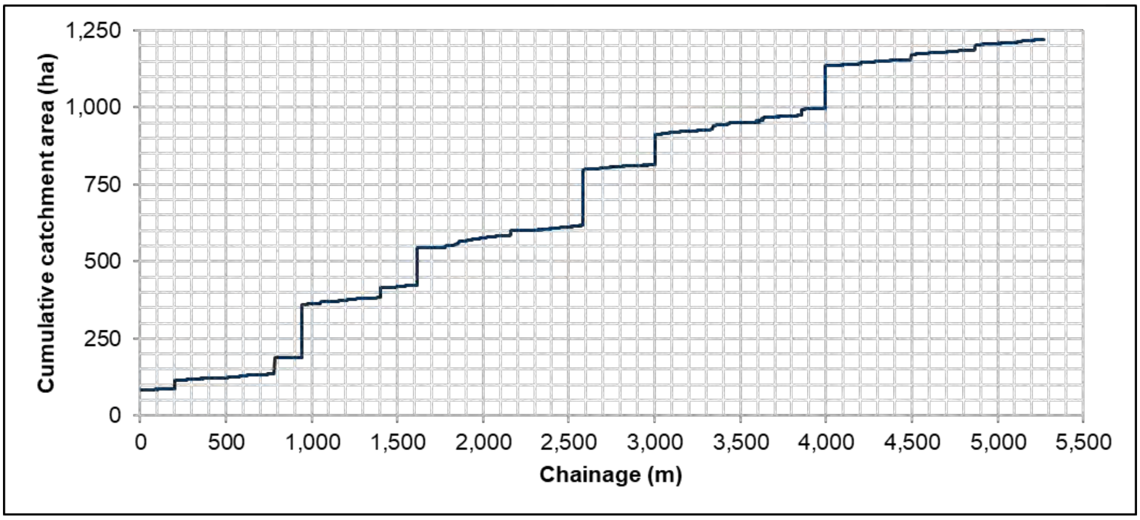


Figure 3: Cumulative catchment area along Woljenup Creek

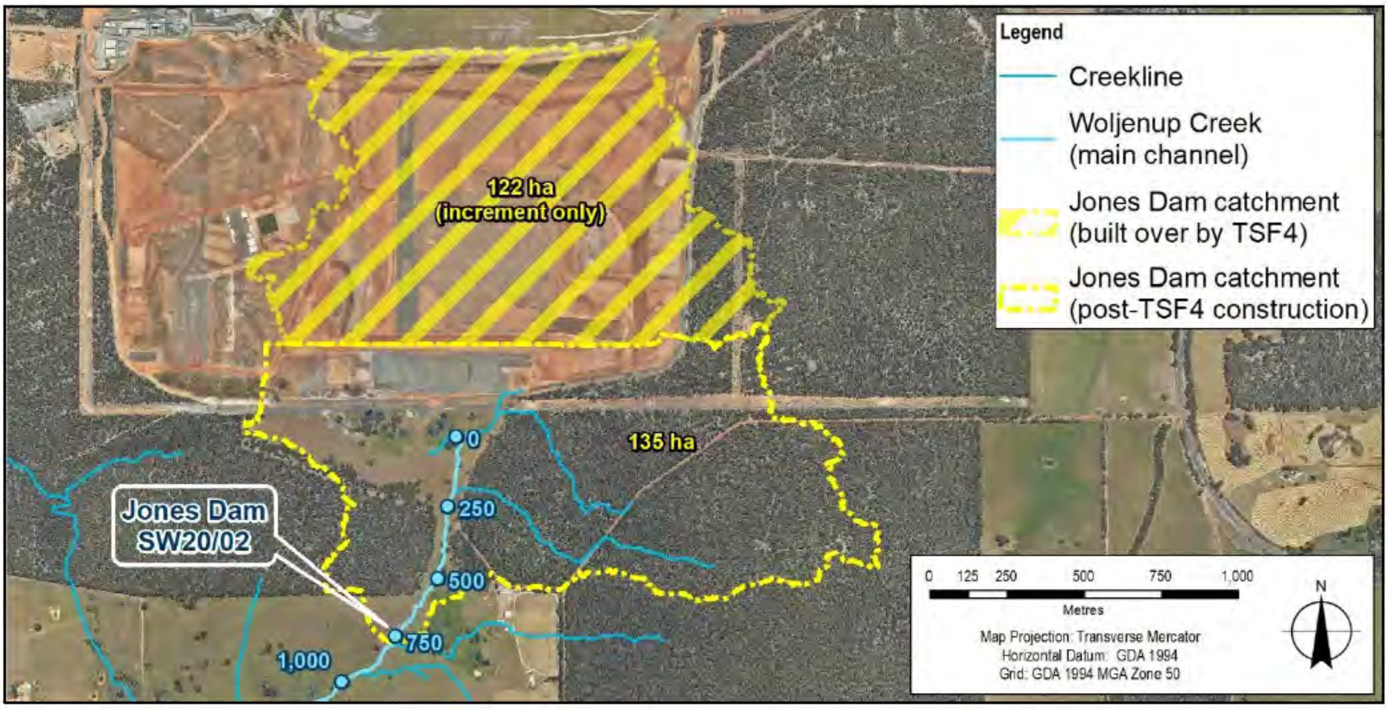


Figure 4: Jones Dam catchment extents pre and post-construction of TSF4

3.3 Rainfall-Runoff Model Calibration

Discharge from each catchment was estimated using the Australian Water Balance Model (AWBM), which is the same rainfall-runoff model adopted in all previous water balance work undertaken by GHD for the Talison mine site. Considering that baseflow is observed within Woljenup Creek throughout summer, adoption of AWBM parameters from previous work, which mainly focused on the mine site, was deemed inappropriate.

Consequently, the AWBM parameters for the Woljenup Creek catchment were determined via calibration against the streamflow records collected at the nearest gauging site of Hester Hill (Site Ref. 609016) in the neighbouring Hester Brook catchment. This site was in operation for about 22 years from March 1983 to July 2005. The calibrated AWBM parameters are summarised in **Table 3**.

Table 3: Adopted AWBM parameters for the Woljenup Creek catchment

AWBM parameter	Adopted values
Partial surface store areas[1] A_1 / A_2 / A_3	0.141 / 0.394 / 0.466
Surface store capacities C_1 / C_2 / C_3 (mm)	6.19 / 188.27 / 475.60
Baseflow index BFI (i.e., ratio of baseflow to total streamflow)	0.558
Baseflow recession constant K_b (i.e., proportion of moisture depth remaining in the baseflow store)	0.964
Surface flow recession constant K_s (i.e., proportion of moisture depth remaining in the surface runoff routing storage)	0.489

Caution should be applied when assessing the streamflow simulated with the above parameters due to:

– Differences in scale of area and land use between the catchments of Woljenup Creek and Hester Brook. The catchment of Hester Brook is about 15 times larger than that for the Woljenup Creek.
– Changes in land use that have occurred since streamflow records ceased (in 2005). There is no available information pertaining to the state of land use when stream gauging was in operation.

Nevertheless, in the absence of any other site-specific information, adoption of the Hester Brook catchment parameters is considered a reasonable approach for the purposes of this assessment. This approach is also

[1] Areas are conceptual only and do not correlate to any actual areas in the catchment.

considered conservative (i.e., results in lower discharges) since calibration was undertaken over a period when the catchment was more forested and had less clearing. A recent CSIRO study of the Donnelly River catchment (about 50 km south of Woljenup Creek) found that discharge from forested areas is likely to decrease more rapidly than cleared areas as the climate becomes drier (Hughes & Wang, 2022).

Figure 5 compares the measured discharge at the Hester Hill gauging site against values simulated using the calibrated parameters (in **Table 3**).

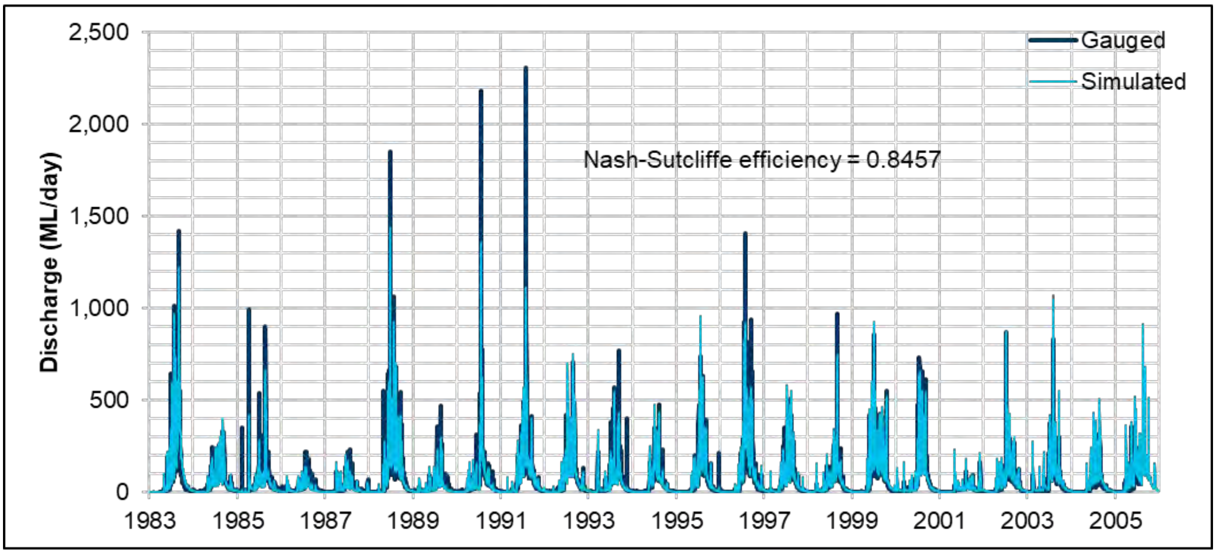


Figure 5: Comparison of gauged and simulated discharges from the Hester Brook catchment

3.4 Validation of Model Parameters

The calibrated baseflow index (BFI) as detailed in **Table 3** indicates that the proportion of baseflow to the overall catchment discharge is approximately 56%. This is somewhat corroborated through onsite observations made by Talison personnel near Site 1 (at Chainage ~1600) on 28 February 2023. A shallow but continuous streamflow was observed upstream of Site 1 (see **Figure 6**). However, flow was also noted to quickly dissipate when passing through the wetland immediately downstream of Site 1 (see **Figure 7**).

Figure 6: Woljenup Creek bed at Site 1 facing upstream

Figure 7: Woljenup Creek bed at Site 1 facing downstream

These observations suggest that:

– Streamflow is likely persistent throughout the year, considering that February 2023 is the driest month over the preceding 12 months, according to the nearby Bridgetown weather station (station no. 009617).

– Streamflow may occur subsurface (as baseflow) or express onto the creek bed (as surface flow) depending on topography and geology (i.e., groundwater discharge as evinced at MB23 monitoring bore where artesian conditions are noted).

Considering the findings above, adoption of the calibrated parameters (in **Table 3**) for the Woljenup Creek catchment was considered appropriate.

3.5 Catchment Discharge Estimation

Using the parameters listed in **Table 3**, the AWBM model simulated flows for the entire Woljenup Creek catchment through ensembles of sixteen future climate sequences over the period following mine closure (i.e., start of 2044) up to the end of the century (i.e., end of 2099) at a daily time step. These sequences were extracted from the Bureau of Meteorology's National Hydrological Projections, from which ensembles for two Representative Concentration Pathways (RCP), or greenhouse gas scenarios, are available. The simulation results were subsequently aggregated to produce the annual (unit area) discharge totals shown in **Figure 8** and **Figure 9**.

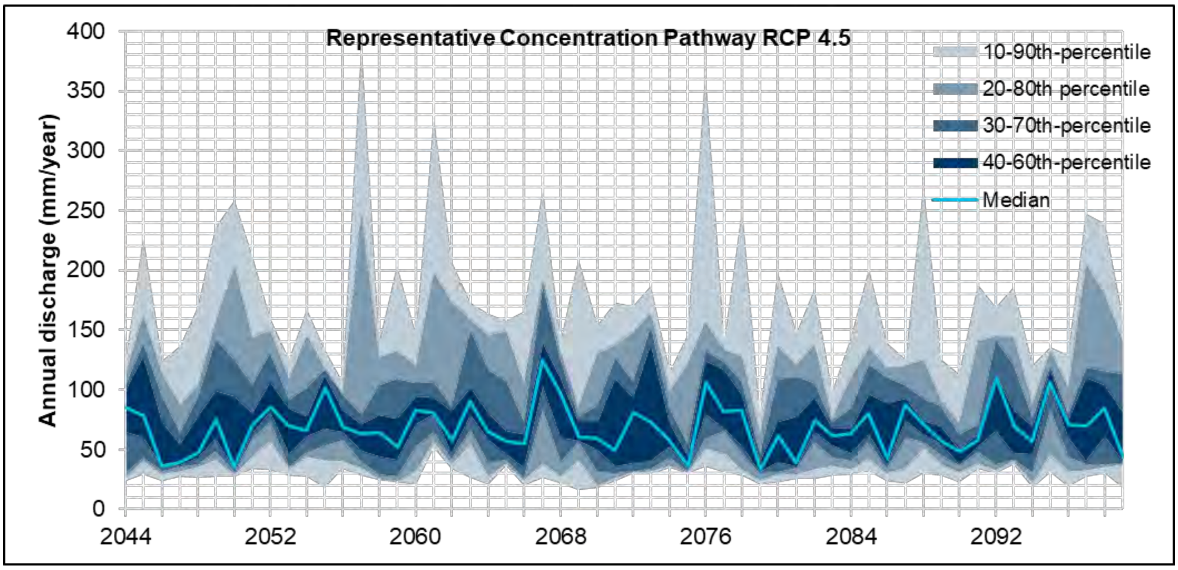


Figure 8: Simulated annual catchment discharge rates for the RCP 4.5 scenario

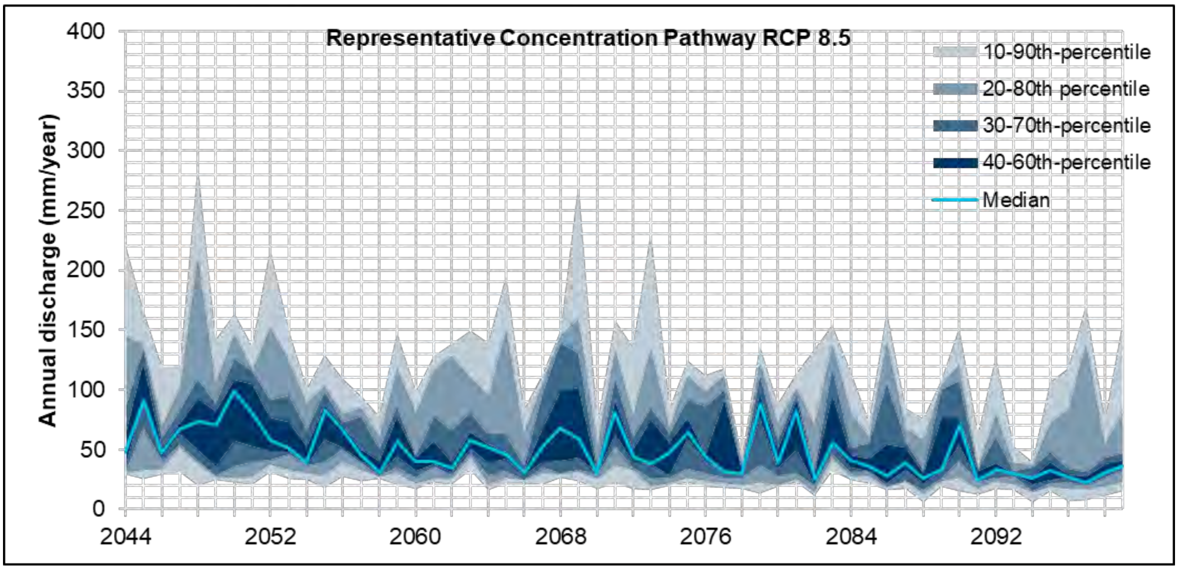


Figure 9: Simulated annual catchment discharge rates for the RCP 8.5 scenario

The simulated results for the RCP 4.5 scenario displayed a median average annual discharge of about 68 mm/year with a relatively flat long-term trend over the simulation period. In contrast, the annual discharges in the RCP 8.5 scenario are noticeably lower (with a median average of about 49 mm/year) and exhibit a gradual decreasing trend over the same period.

Figure 10 compares the median discharges of the two scenarios at a daily timescale. Similar to the annual rates, daily discharge in the RCP 8.5 scenario is generally lower than that in the RCP 4.5 scenario for a given day, although the opposite may be observed during extreme events. Further, the daily rates indicate that streamflow within the Woljenup Creek is highly seasonal, with peak flow occurring in winter and orders of magnitude larger than summer flow. The simulated flows approach zero during late summer in most cases.

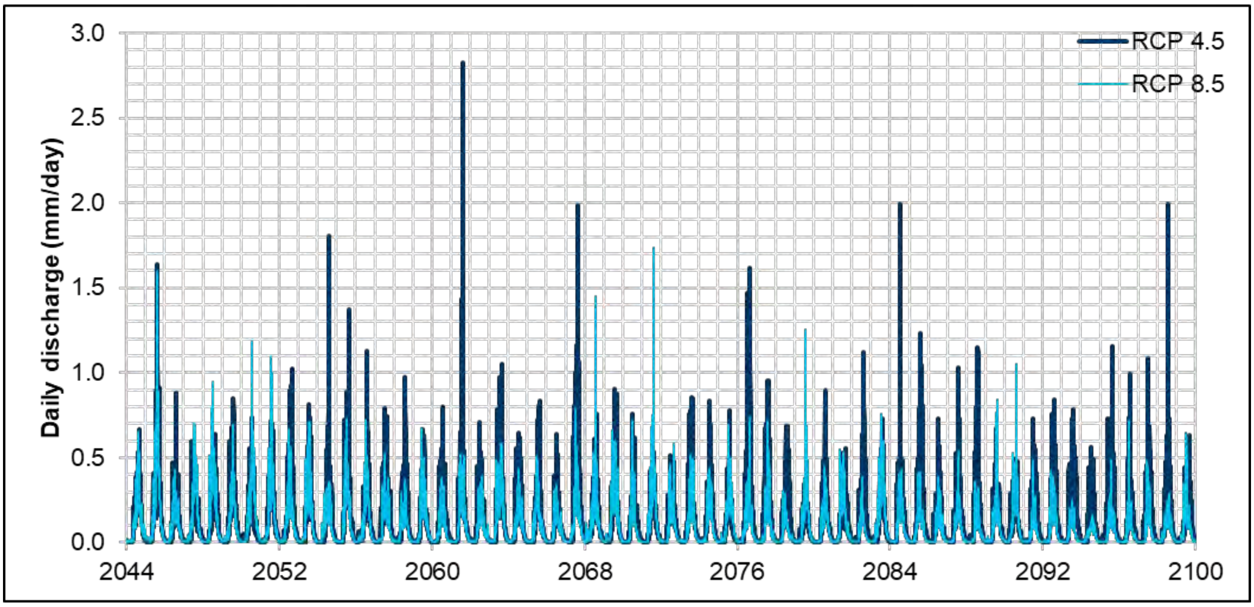


Figure 10: Comparison of simulated median daily catchment discharge rates

3.6 Jones Dam

A summary of the simulated streamflow reduction to Jones Dam is provided in **Table 4**, which assumes median climate conditions across the simulated period. The reduction in catchment area is expected to result in a corresponding reduction in annual discharges to the Jones Dam by an average of about 59 ML/year in the RCP 4.5 scenario and 41 ML/year in the RCP8.5 scenario. The simulated annual discharges pre and post-construction of TSF4 are given in both **Figure 11** and **Figure 12** respectively. The reduction in annual streamflow over the simulated period under the RCP8.5 scenario is evident in **Figure 12**.

Table 4: Summary of Median Simulated Annual Streamflow (ML/yr)

	Catchment Area (Ha)	RCP 4.5	RCP 8.5
Pre-TSF4 Streamflow	256	124	85
Post-TSF4 Streamflow	135	65	44
Difference	121	59	41

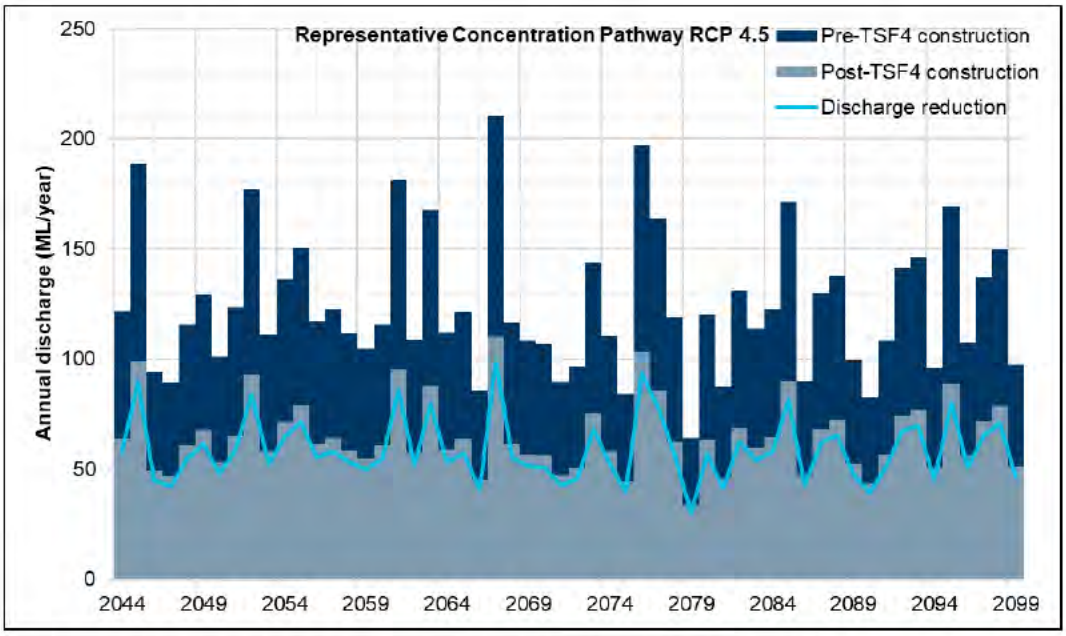


Figure 11: Estimated annual discharge medians at Jones Dam (SW20/02) in the RCP 4.5 scenario

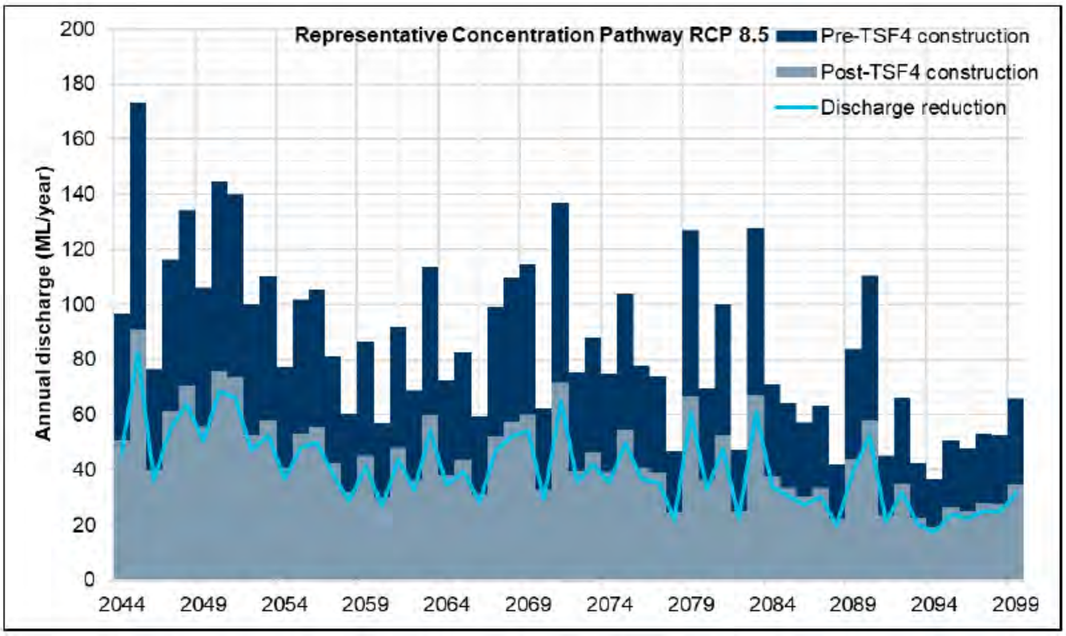


Figure 12: Estimated annual discharge medians at Jones Dam (SW20/02) in the RCP 8.5 scenario

An assessment of the storage capacity of Jones Dam was made based on dimensions derived from recent aerial photography, the May 2022 LiDAR dataset, and typical farm dam design criteria. The basic dimensions of the impoundment behind Jones Dam are depicted in **Figure 13**. Estimates of the embankment dimensions are as follows:

- Embankment length ~35 m.
- Dam reach ~60 m.
- Upstream bank slope ~45%.
- Downstream bank slope ~10%.
- Spillway level ~RL 219.6.
- Assuming the lowest point corresponds with the middle of the embankment, the embankment height is ~2.9 m.

Assuming that the dam reservoir geometry is equivalent to a triangular pyramid, the dam impoundment capacity at crest level is therefore ~1,000 m^3, or 1 ML, and that at spillway level is 650 m^3, or 0.65 ML. It is also noted that the lowest water level measured in the dam using historical LiDAR data is ~RL 218.9, which indicates that the dam is often at or near capacity.

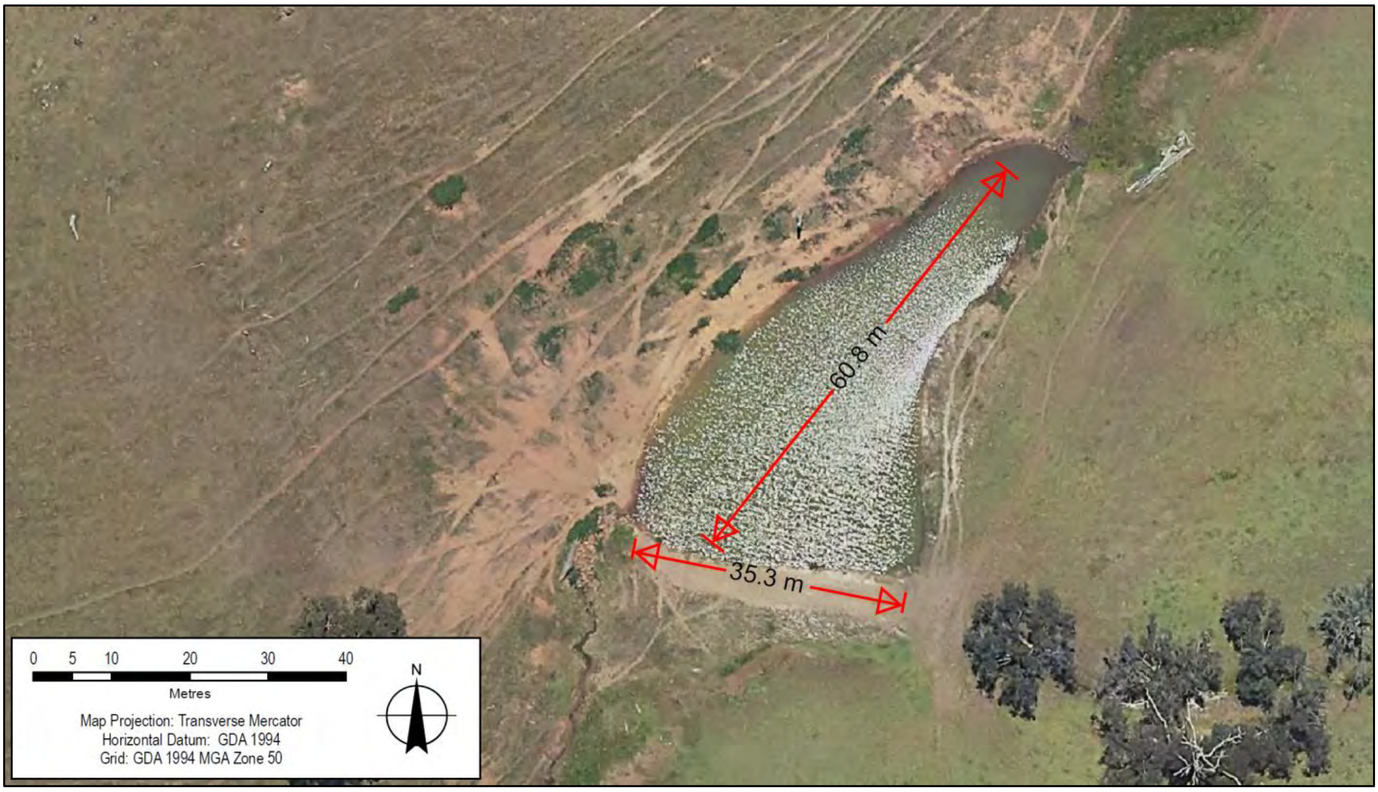


Figure 13: Indicative Dimensions of Jones Dam

Comparison of the estimated dam capacity of Jones Dam of 0.65 ML to the simulated streamflows in **Table 4** indicates that the capacity will be 1.5% of the median annual streamflow of 44 ML/yr under the worst-case RCP 8.5 scenario. This indicates that the dam will remain at, or near, capacity for most of the time with possible drawdowns during very dry periods. It should be noted that, based on the conceptual hydrogeological model (GHD, 2023d), the dam is located in an area where groundwater is inferred to discharge and the reduction in catchment area is not expected to impact this baseflow.

4. Water Quality

4.1 CoPC Dilution

According to the *TSF4 Seepage Assessment – Groundwater Model Update and Site Assessment* report (GHD, 2023f), ~80% of the seepage from TSF4 is expected to migrate southwards and be collected by Sump A, which is immediately adjacent to TSF4's southern embankment. Without continuous pump back to the mine water circuit, seepage collected at the sump would overflow directly into the upper reaches of Woljenup Creek. It should be noted that recirculation back into the mine water circuit will continue after closure until the water is of suitable quality to be released to the environment. The predicted flows from Sump A from 2044 (a nominal date of 5 years after closure when discharge to Woljenup Creek via passive management will commence) are shown in **Figure 14**.

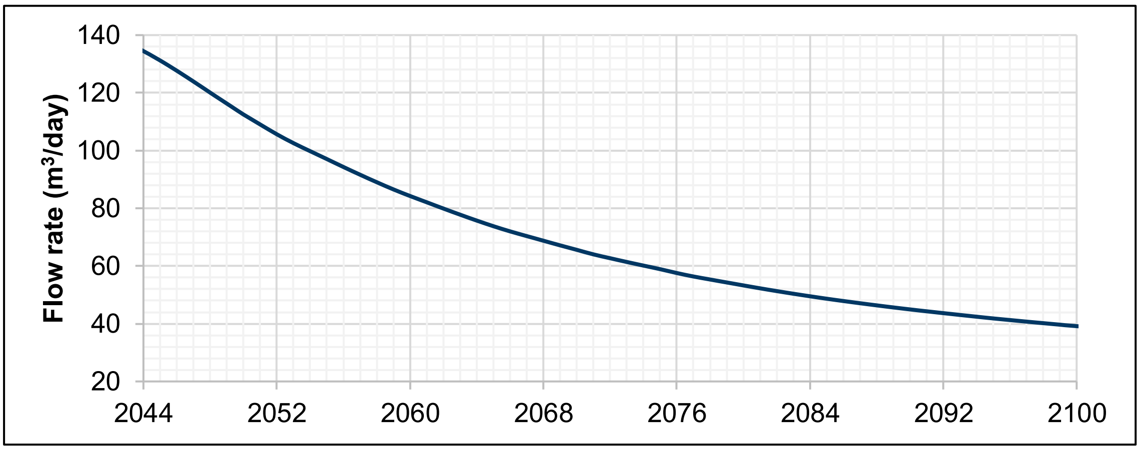


Figure 14: Predicted TSF4 Sump A flow releases

The potential impacts of CoPCs contained within the flow releases from Sump A is the focus of this assessment and could be mitigated to a reasonable degree through natural dilution processes. To assess the effects of dilution, dilution factors at key points along Woljenup Creek were determined as follows:

$$\text{Dilution factor} = \frac{\text{Catchment discharge (see } \textbf{Figure 10}\text{) + Sump A flow releases (see } \textbf{Figure 14}\text{)}}{\text{Sump A flow releases (see } \textbf{Figure 14}\text{)}}$$

Calculation of the dilution factors assumed the following:

– Dilution of the released seepage flows (from Sump A) by catchment discharge occurs instantaneously and the resultant diluted flow in the creek is fully mixed at both subsurface and surface.

– Discharges from Sump A are not subject to any losses or attenuation whilst flowing down Woljenup Creek (which is unlikely given the site observations detailed in **Section 3.4**).

– CoPCs are conservative species that do not decay nor react to any external environmental, chemical or biological factors.

– Streamflow from the Woljenup Creek catchment is free of CoPCs.

The dilution factors under median catchment discharge flow conditions were calculated at Site 01 (see **Figure 2**) and at the confluence of Blackwood River and Woljenup Creek. The calculated factors are presented in **Figure 15** and **Figure 16** for the RCP 4.5 and RCP 8.5 scenarios respectively. Note that a dilution factor of 1.0 indicates that there is no dilution due to zero catchment discharge, and a dilution factor of 2.0 indicates that the catchment runoff is equal to the sump discharge.

Figure 17 to **Figure 20** presents the monthly dilution factor averages at Site 01 and the confluence of Blackwood River and Woljenup Creek. The following observations are noted from the figures:

– Dilution factors peak in the winter months of June to September and are lowest in the summer months of January to March.

– On average, the RCP 4.5 scenario generates dilution factors that are 40-50% higher than those in the RCP 8.5 scenario.

– Dilution factors generally increased with each passing decade in both RCP scenarios.

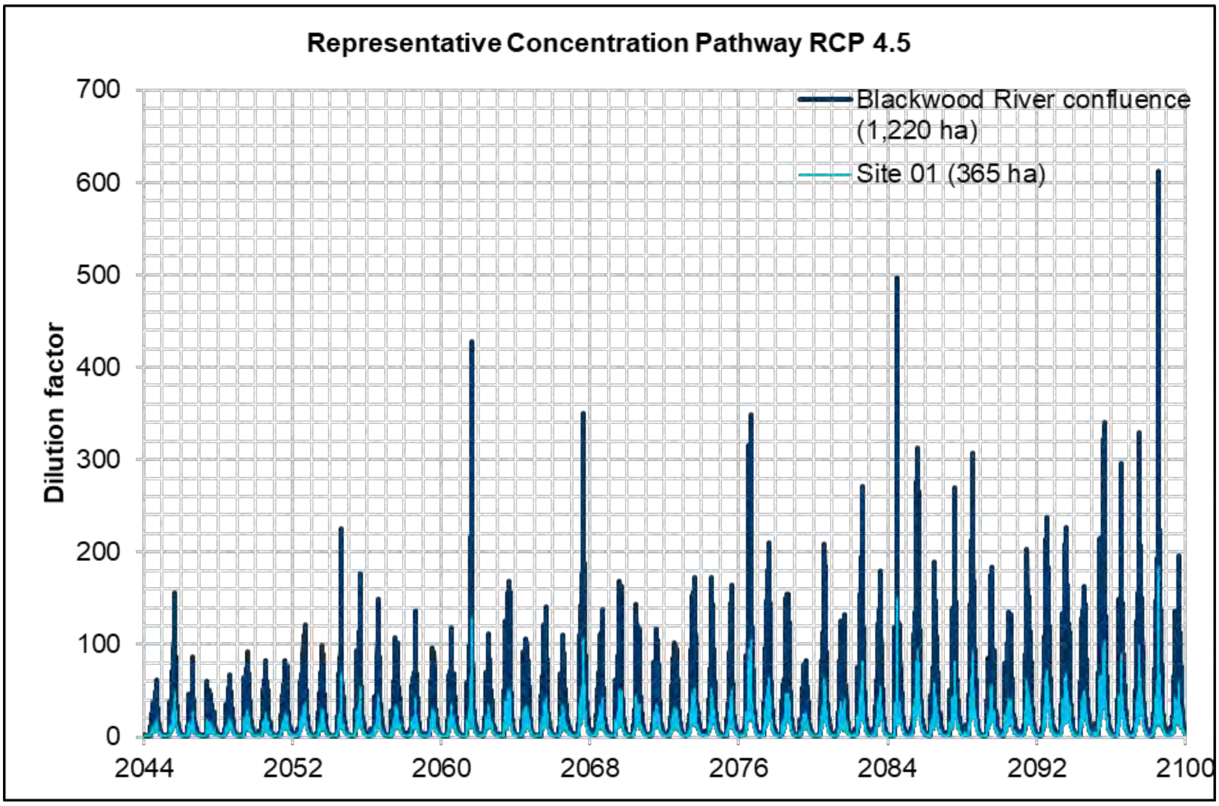


Figure 15: Dilution factors at selected locations along Woljenup Creek under the RCP 4.5 scenario

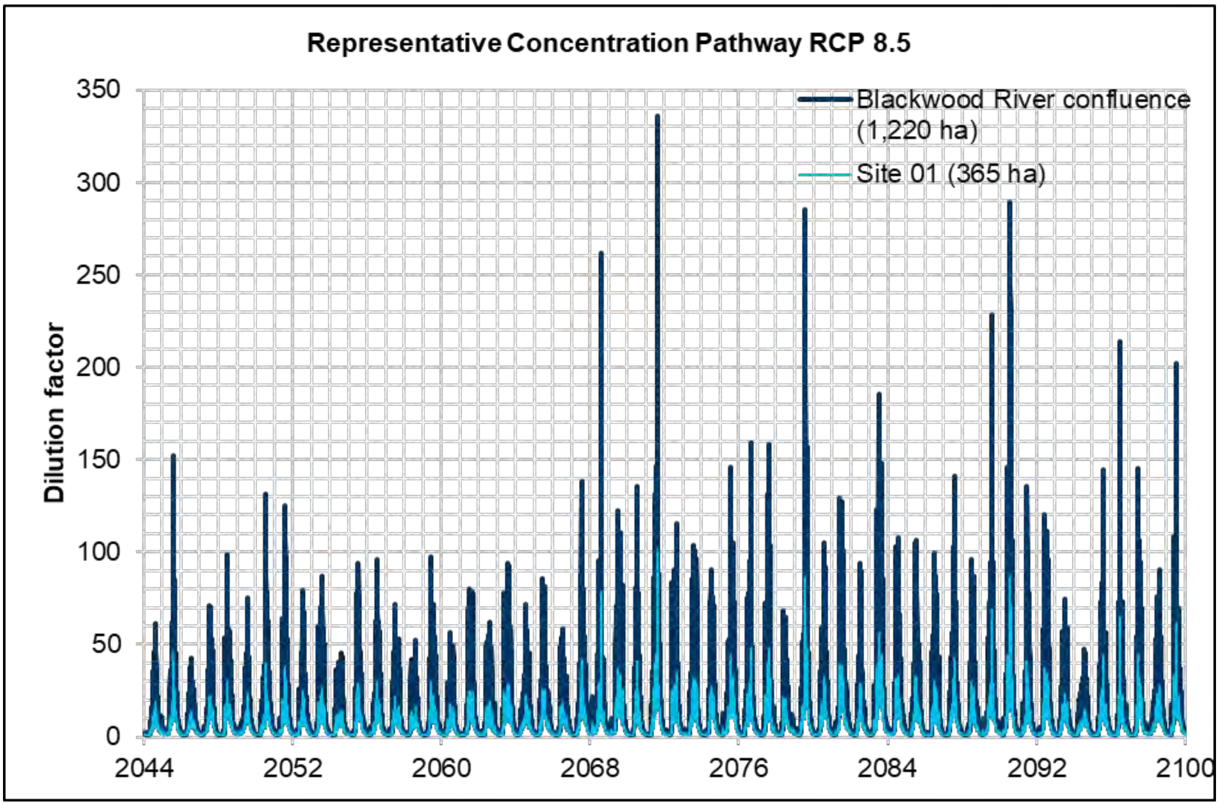
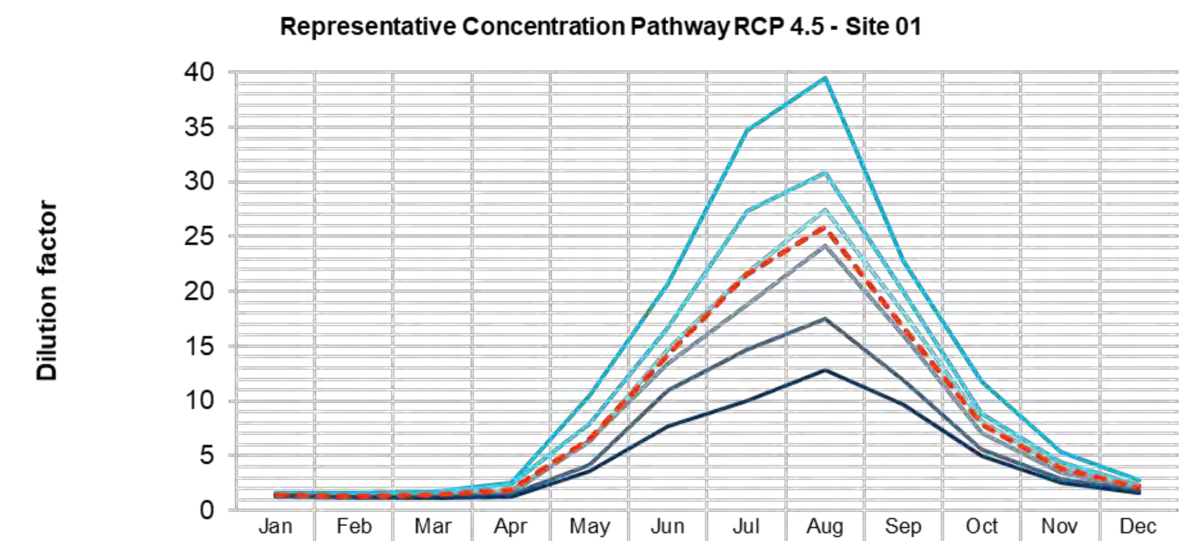
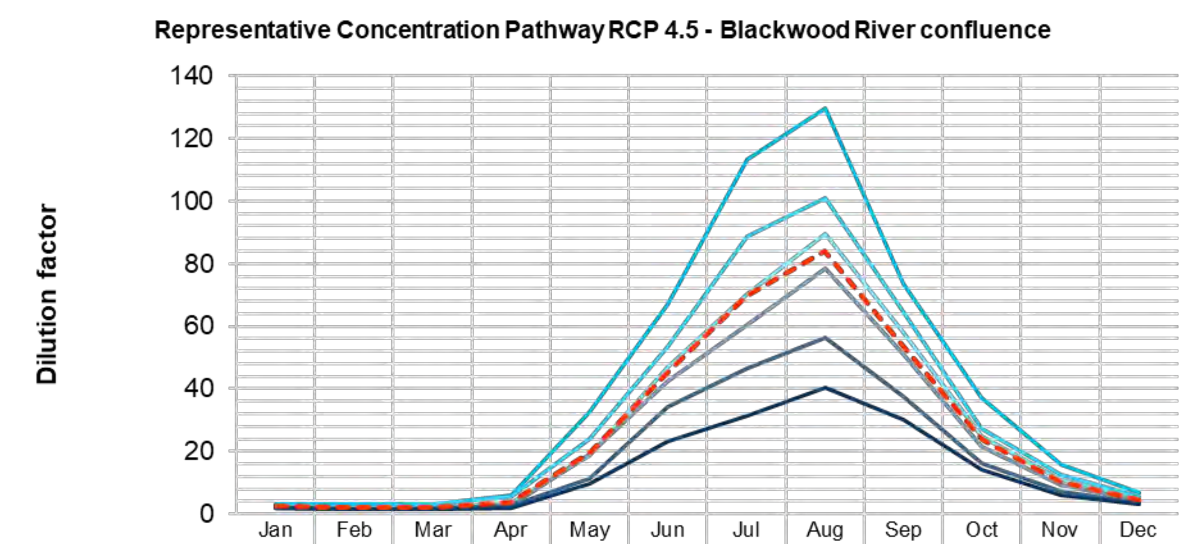


Figure 16: Dilution factors at selected locations along Woljenup Creek under the RCP 8.5 scenario



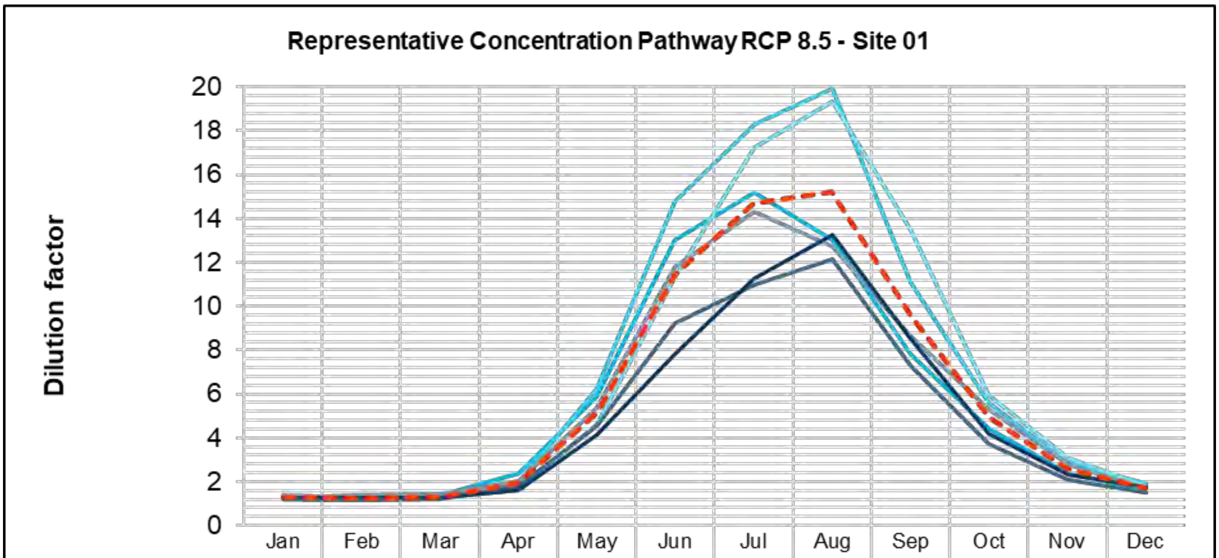
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2091-2099	1.655	1.581	1.683	2.523	10.515	20.719	34.659	39.463	22.780	11.811	5.400	2.757
2081-2090	1.527	1.368	1.643	2.365	7.948	16.687	27.307	30.882	20.008	8.838	4.449	2.332
2071-2080	1.410	1.291	1.291	1.814	6.265	14.749	21.755	27.484	18.121	8.126	3.956	2.140
2061-2070	1.442	1.265	1.207	1.559	6.421	13.446	18.803	24.156	15.965	7.107	3.518	2.003
2051-2060	1.244	1.136	1.247	1.476	4.146	11.006	14.685	17.551	11.896	5.549	2.901	1.785
2044-2050	1.332	1.195	1.153	1.223	3.542	7.681	10.063	12.829	9.670	5.008	2.535	1.649
Average	1.437	1.307	1.377	1.847	6.558	14.270	21.569	25.816	16.654	7.813	3.832	2.124

Figure 17: Monthly dilution factor averages at Site 01 by decade under the RCP 4.5 scenario



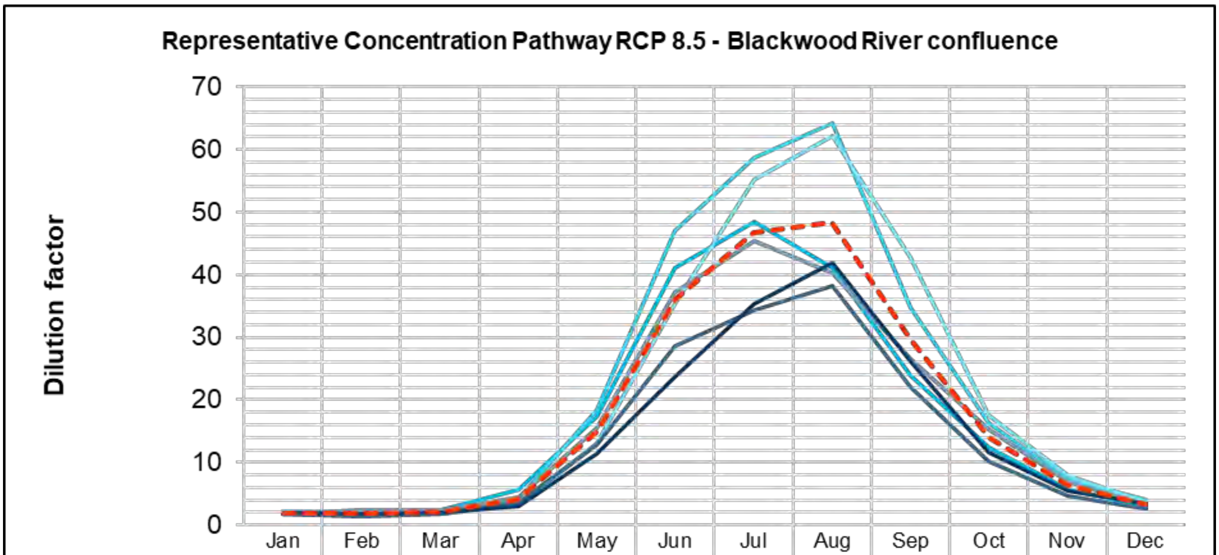
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2091-2099	3.189	2.942	3.282	6.087	32.785	66.867	113.432	129.480	73.752	37.112	15.697	6.870
2081-2090	2.762	2.230	3.149	5.560	24.210	53.399	88.877	100.816	64.495	27.182	12.521	5.451
2071-2080	2.369	1.973	1.973	3.720	18.589	46.928	70.331	89.468	58.192	24.802	10.874	4.808
2061-2070	2.477	1.884	1.692	2.867	19.109	42.575	60.469	78.349	50.990	21.400	9.411	4.351
2051-2060	1.815	1.456	1.827	2.591	11.510	34.424	46.712	56.288	37.396	16.194	7.350	3.621
2044-2050	2.110	1.651	1.512	1.743	9.491	23.318	31.274	40.514	29.962	14.387	6.128	3.169
Average	2.459	2.026	2.260	3.828	19.566	45.327	69.709	83.895	53.290	23.759	10.459	4.756

Figure 18: Monthly dilution factor averages at the Blackwood River confluence by decade under the RCP 4.5 scenario



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2091-2099	1.222	1.162	1.399	2.401	5.888	12.995	15.186	13.018	7.838	4.399	2.407	1.609
2081-2090	1.342	1.246	1.317	1.996	6.218	14.776	18.280	19.927	11.106	5.613	2.858	1.886
2071-2080	1.370	1.287	1.253	1.643	4.619	11.303	17.240	19.313	13.517	5.920	3.075	1.797
2061-2070	1.260	1.386	1.435	2.047	5.355	11.820	14.311	12.747	8.618	5.296	2.788	1.666
2051-2060	1.232	1.126	1.231	1.798	4.518	9.248	10.981	12.139	7.274	3.728	2.098	1.473
2044-2050	1.275	1.244	1.273	1.595	4.115	7.810	11.261	13.234	8.534	4.181	2.342	1.727
Average	1.285	1.243	1.319	1.922	5.159	11.484	14.708	15.198	9.561	4.901	2.612	1.693

Figure 19: Monthly dilution factor averages at Site 01 by decade under the RCP 8.5 scenario



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2091-2099	1.742	1.541	2.332	5.681	17.328	41.068	48.388	41.146	23.842	12.355	5.699	3.036
2081-2090	2.141	1.822	2.060	4.327	18.429	47.017	58.721	64.222	34.758	16.408	7.206	3.959
2071-2080	2.236	1.957	1.845	3.147	13.088	35.415	55.249	62.173	42.810	17.435	7.931	3.662
2061-2070	1.869	2.290	2.452	4.497	15.547	37.144	45.463	40.241	26.447	15.351	6.974	3.225
2051-2060	1.773	1.420	1.770	3.667	12.751	28.550	34.339	38.208	21.959	10.113	4.668	2.578
2044-2050	1.919	1.815	1.913	2.988	11.404	23.747	35.276	41.865	26.165	11.626	5.483	3.427
Average	1.952	1.812	2.065	4.079	14.892	36.020	46.788	48.425	29.598	14.029	6.383	3.313

Figure 20: Monthly dilution factor averages at the Blackwood River confluence by decade under the RCP 8.5 scenario

4.2 Jones Dam

Monitoring the water quality of Jones Dam has been undertaken since May 2022 as a condition of the TSF4 Works Approval (W6618/2021/1), details of which are appended hereto at **Attachment 1**. It is noted from these results that:

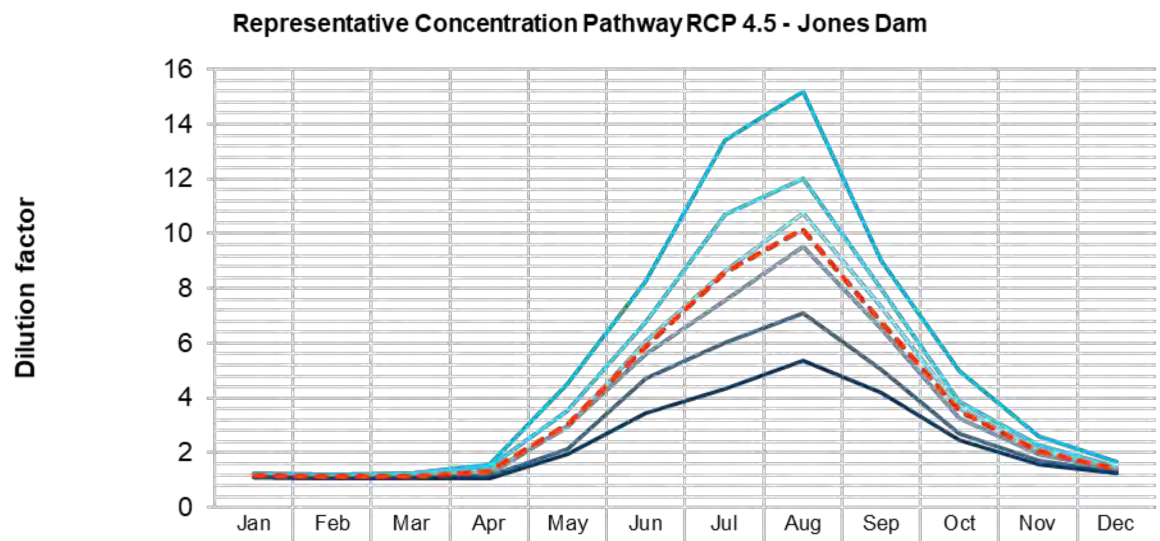
- Aluminium concentrations exceeded the ecological and drinking water site specific guidelines (GHD, 2023e).
- Copper concentrations exceeded the ecological site specific guidelines.
- Manganese concentrations exceeded the drinking water and irrigation site specific guidelines.

Aluminium and manganese are considered CoPCs sourced from the tailings decant and leach, however, copper is not.

Figure 21 and **Figure 22** presents the monthly dilution factor averages at Jones Dam for RCP 4.5 and RCP 8.5 respectively. The following observations are noted from the figures:

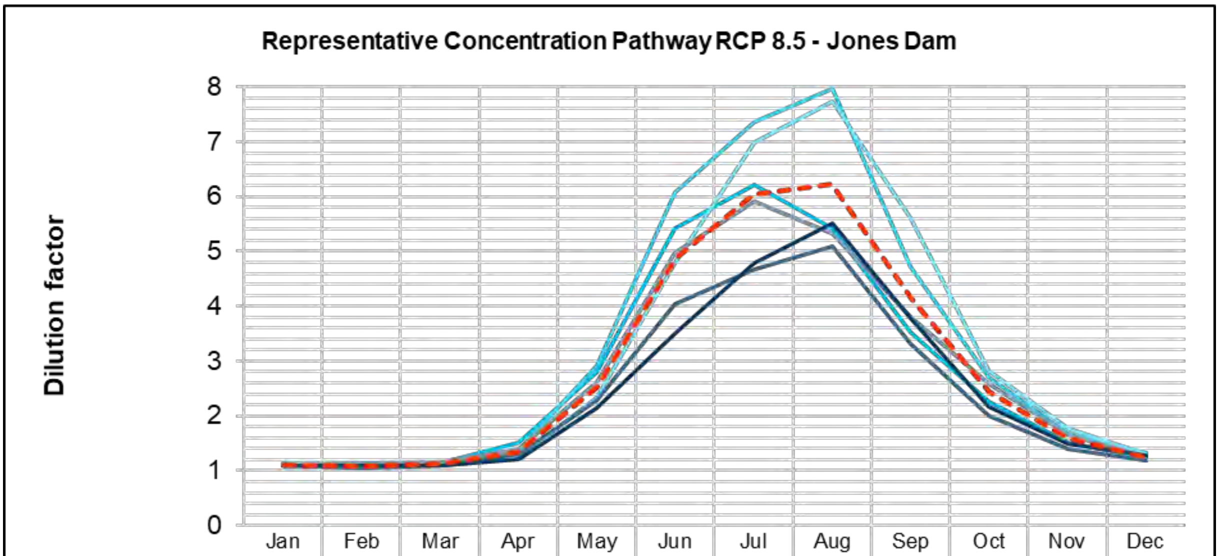
- Dilution factors during the summer months (i.e., December to April) are less than 2.0 indicating the Sump A discharge is greater than the catchment runoff.
- Dilution factors in February often drop to near 1.0 indicating that the flows are predominantly from Sump A.

Given the low levels of dilution of sump discharges into Jones Dam during summer, management measures for the discharge of TSF4 impacted water from Sump A following closure will need to consider the water quality requirements of this user and/or possibly provide an alternative source of water. The drainage into Sump A will continue to be returned to the MWC after closure until such time as the water is of suitable quality and quantity to accommodate implementation of appropriate management strategies to attenuate this discharge. Such measures could include a constructed wetland, infiltration pits or similar, further details of which are provided in the Seepage Management Plan (GHD, 2023h).



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2091-2099	1.241	1.214	1.252	1.561	4.506	8.265	13.401	15.171	9.025	4.983	2.621	1.647
2081-2090	1.194	1.136	1.237	1.503	3.560	6.780	10.693	12.010	8.003	3.888	2.271	1.491
2071-2080	1.151	1.107	1.107	1.300	2.940	6.066	8.647	10.758	7.308	3.625	2.089	1.420
2061-2070	1.163	1.097	1.076	1.206	2.997	5.586	7.559	9.532	6.514	3.250	1.928	1.370
2051-2060	1.090	1.050	1.091	1.175	2.159	4.687	6.042	7.098	5.014	2.676	1.700	1.289
2044-2050	1.122	1.072	1.056	1.082	1.937	3.462	4.339	5.358	4.195	2.477	1.566	1.239
Average	1.161	1.113	1.139	1.312	3.048	5.889	8.579	10.143	6.768	3.510	2.043	1.414

Figure 21: Monthly dilution factor averages at Jones Dam by decade under the RCP 4.5 scenario



	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
2091-2099	1.082	1.060	1.147	1.516	2.801	5.419	6.227	5.428	3.519	2.252	1.518	1.225
2081-2090	1.126	1.091	1.117	1.367	2.922	6.076	7.367	7.973	4.724	2.700	1.684	1.326
2071-2080	1.136	1.106	1.093	1.237	2.333	4.796	6.984	7.747	5.612	2.813	1.765	1.294
2061-2070	1.096	1.142	1.160	1.386	2.605	4.987	5.904	5.328	3.807	2.583	1.659	1.245
2051-2060	1.085	1.046	1.085	1.294	2.296	4.039	4.677	5.104	3.312	2.005	1.405	1.174
2044-2050	1.101	1.090	1.101	1.219	2.148	3.509	4.781	5.507	3.776	2.172	1.494	1.268
Average	1.105	1.090	1.118	1.340	2.532	4.863	6.050	6.231	4.154	2.437	1.594	1.255

Figure 22 ***Monthly dilution factor averages at Jones Dam by decade under the RCP 8.5 scenario***

5. References

1. GHD. (2022). *TSF4 Seepage Assessment: Receiving Environment Water Quality Sampling.* Perth: GHD.
2. GHD. (2023). *TSF4 Seepage Assessment - Groundwater Model Update and Site Assessment.* Perth: GHD.
3. GHD. (2023a). *TSF4 Seepage Assessment: Tailings LEAF Leach Testing. Report prepared for Talison Lithium Pty Ltd. February 2023, Ref 12575610.*
4. GHD. (2023b). *TSF4 Seepage Assessment: Sub-surface Clays Attenuation Capacity Testing. Report prepared for Talison Lithium Pty Ltd. February 2023, Ref. 12575610.*
5. GHD. (2023c). *TSF4 Seepage Assessment: Baseline Monitoring Report. Draft report prepared for Talison Lithium Pty Ltd. June 2023, Ref. 12575610.*
6. GHD. (2023d). *TSF4 Seepage Assessment: Conceptual Hydrogeological Model of TSF4. Final report prepared for Talison Lithium Pty Ltd. February 2023, Ref. 12575610.*
7. GHD. (2023e). *TSF4 Seepage Assessment: Site-Specific Water Quality Guidelines, Repport prepared for Talison Lithium Pty Ltd, March 2023, Ref 12575610.*
8. GHD. (2023f). *TSF4 Seepage Assessment: Groundwater Model Update and Site Assessment, April 2023, Ref 12575610.*
9. GHD. (2023g). *TSF4 Seepage Assessment: Woljenup Creek Hydrological Assessment. Report prepared fro Talison Lithiu,m Pty Ltd. (report in draft).*
10. GHD. (2023h). *TSF4 Seepage Assessment: Seepage Management Plan. Draft report for Talison Lithium Pty Ltd. August 2023. Ref 12575610.*
11. Hughes, J., & Wang, B. (2022). *Future climate streamflow estimation in the Donnelly River catchment.* Canberra: CSIRO Land and Water.

Attachment 1

Jones Dam Water Quality Monitoring Results

			Inorganics			Acidity & Alkalinity							Major Ions									
			pH (Lab)	Electrical conductivity (lab)	Total Dissolved Solids	Alkalinity (Carbonate as CaCO3)	Alkalinity (Bicarbonate as CaCO3)	Alkalinity (Hydroxide as CaCO3)	Alkalinity (total as CaCO3)	Hardness as CaCO3	Hardness as CaCO3 (filtered)	Calcium (filtered)	Magnesium (filtered)	Potassium (filtered)	Sodium (filtered)	Chloride	Sulfate (filtered)	Fluoride	Cations Total	Anions Total	Ionic Balance
UNIT			pH units	µS/cm	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	meq/L	meq/L	%
EQL			0.01	1	10	1	1	1	1	1	1	1	1	1	1	1	1	0.1	0.01	0.01	0.01
Talison Greenbushes Site-specific WQG, Drinking Water																	250				
Talison Greenbushes Site-specific WQG, Freshwater Ecological																	429				
Talison Greenbushes Site-specific WQG, Irrigation																					
Talison Greenbushes Site-specific WQG, Livestock																	1,000				
Talison Greenbushes Site-specific WQG, Recreational																					
Loc. Type	**Field ID**	**Date**																			
		12/05/2022	8.16	891	496	<1	132	<1	132	-	-	30	26	7	105	208	16	0.1	8.38	8.84	2.64
		5/07/2022	7.68	516	289	<1	50	<1	50	-	104	17	15	4	64	126	24	<0.1	4.97	5.05	0.84
	SW20/02	5/10/2022	7.43	286	152	<1	28	<1	28	60	-	9	9	2	36	74	12	<0.1	2.81	2.9	1.58
		30/03/2023	8.25	1,250	612	<1	184	<1	184	-	-	42	32	10	131	267	9	0.2	10.7	11.4	3.22
		26/06/2023	7.93	968	594	<1	103	<1	103	-	-	32	25	7	116	238	32	<0.1	8.88	9.44	3.05

Comments

1. Reported Analyte LOR is higher than Requeste

Comments

1. Reported Analyte LOR is higher than Requested Analyte LOR

			Minor Ions	Nutrients		Organic Indicators	Metals																
			Silicon as SiO2 (filtered)	Nitrite (as N)	Nitrogen (Total Oxidised) (as N)	Sulfur as S	Aluminium	Aluminium (filtered)	Antimony	Antimony (filtered)	Arsenic	Arsenic (filtered)	Barium	Barium (filtered)	Boron	Boron (filtered)	Caesium	Caesium (filtered)	Cobalt	Cobalt (filtered)	Copper	Copper (filtered)	Iron
UNIT			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.1	0.01	0.01	1	0.01	0.01	0.001	0.001	0.001	0.001	0.001	0.001	0.05	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.05
Talison Greenbushes Site-specific WQG, Drinking Water							0.2	0.2		0.003		0.01						0.08			2	2	
Talison Greenbushes Site-specific WQG, Freshwater Ecol							0.055	0.055		0.09		0.013						0.1			0.0014	0.0014	
Talison Greenbushes Site-specific WQG, Irrigation							5	5				0.1									0.2	0.2	
Talison Greenbushes Site-specific WQG, Livestock							5	5		0.15		0.5						2			0.5	0.5	
Talison Greenbushes Site-specific WQG, Recreational										0.06		0.2						1.6			40	40	
Loc. Type	**Field ID**	**Date**																					
	SW20/02	12/05/2022	12.0	0.02	0.27	6	1.60	0.04	<0.001	<0.001	0.001	<0.001	0.116	0.104	<0.05	<0.05	<0.001	<0.001	0.004	0.003	0.002	<0.001	1.28
	SW20/02	5/07/2022	8.3	0.02	1.69	8	1.50	0.01	<0.001	<0.001	0.001	<0.001	0.044	0.052	<0.05	<0.05	<0.001	<0.001	0.003	0.001	0.002	0.005	0.93
	SW20/02	5/10/2022	3.9	<0.01	0.12	4	0.13	0.02	<0.001	<0.001	<0.001	<0.001	0.011	0.009	<0.05	<0.05	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	0.11
	SW20/02	30/03/2023	8.9	<0.01	0.03	3	0.68	0.03	<0.001	<0.001	0.002	<0.001	0.142	0.146	<0.05	<0.05	<0.001	<0.001	0.005	0.003	0.001	0.002	0.76
	SW20/02	26/06/2023	13.0	0.02	0.92	12	1.13	<0.01	<0.001	<0.001	<0.001	<0.001	0.082	0.078	<0.05	<0.05	<0.001	<0.001	0.002	0.002	0.002	0.001	0.79

Comments **Comments**

1. Reported Analyte LOR is higher than Requeste 1. Reported Analyte L(

			Metals																			
			Iron (filtered)	Lithium	Lithium (filtered)	Manganese	Manganese (filtered)	Molybdenum	Molybdenum (filtered)	Nickel	Nickel (filtered)	Rubidium	Rubidium (filtered)	Silicon (filtered)	Strontium	Strontium (filtered)	Thorium	Thorium (filtered)	Thallium	Thallium (filtered)	Uranium	Uranium (filtered)
UNIT			mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L
EQL			0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.05	0.001	0.001	0.001	0.001	0.001	0.001	0.001	0.001
Talison Greenbushes Site-specific WQG, Drinking Water					0.007	0.5	0.5		0.05		0.002		0.014							0.00004		0.017
Talison Greenbushes Site-specific WQG, Freshwater Ecol(					2	1.9	1.9		0.034		0.08		0.017							0.00003		0.0005
Talison Greenbushes Site-specific WQG, Irrigation					2.5	0.2	0.2		0.01		0.2									0.001		0.01
Talison Greenbushes Site-specific WQG, Livestock					0.82	10	10		0.15		1		0.39							0.13		0.2
Talison Greenbushes Site-specific WQG, Recreational					0.14	10	10		1		0.4		0.28							0.0008		0.34
Loc. Type	**Field ID**	**Date**																				
	SW20/02	12/05/2022	<0.05	0.005	0.005	1.18	1.10	<0.001	<0.001	0.002	<0.001	0.010	0.009	5.61	0.135	0.133	0.002	<0.001	-	-	<0.001	<0.001
	SW20/02	5/07/2022	<0.05	0.007	0.005	0.267	0.242	<0.001	<0.001	0.001	<0.001	0.006	0.004	3.86	0.075	0.073	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SW20/02	5/10/2022	<0.05	0.003	0.004	0.006	0.004	<0.001	<0.001	<0.001	<0.001	0.003	0.003	1.81	0.055	0.049	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SW20/02	30/03/2023	<0.05	0.006	0.004	1.65	1.56	0.001	<0.001	<0.001	<0.001	0.010	0.011	4.16	0.154	0.160	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
	SW20/02	26/06/2023	<0.05	0.006	0.006	0.339	0.325	<0.001	<0.001	0.002	<0.001	0.007	0.006	6.05	0.118	0.116	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001

Comments **Comments**

1. Reported Analyte LOR is higher than Requeste 1. Reported Analyte L(

Project name	Talison TSF4 Seepage Risk Assessment and Supporting Studies						
Document title	TSF4 Seepage Assessment: Woljenup Creek Hydrological Assessment | Woljenup Creek Hydrological Assessment						
Project number	12575610						
File name	12575610-REP-2_Woljenup Creek Hydrological Assessment.docx						
Status Code	**Revision**	**Author**	**Reviewer**		**Approved for issue**		
			Name	**Signature**	**Name**	**Signature**	**Date**

[redacted]

GHD Pty Ltd | ABN 39 008 488 373

999 Hay Street, Level 10

Perth, Western Australia 6000, Australia

T +61 8 6222 8222 | **F** +61 8 6222 8555 | **E** permail@ghd.com | **ghd.com**