HYDRO GEOCHEM GROUP
GREENROAD GROUP

5 Sir William Pickering Drive, Burnside,
Christchurch 8053, New Zealand

T. +64 3 242 0221
E. admin@hydrogeochem.com.au

MEMORANDUM

Recipient:	Mary Askey – Santana Minerals Ltd
From:	Jim Griffiths
Date:	22 June 2026
Cc:	Robyn Simcock – New Zealand Institute for Bioeconomy Science; Jeroen Lurling – RMA Ecology
Document Number:	J-H-NZ0238-005-M-Rev0
Document Title:	BOGP Wetland Hydrology Analysis

INTRODUCTION

Hydro Geochem Group Limited (HGG) was engaged by Matakanui Gold Limited (MGL) to provide hydrological advice for proposed constructed wetlands at the Bendigo Ophir Gold Project (BOGP). The two proposed constructed wetlands are:

- Lower Shepherds Wetland.
- Shepherds Tailings Storage Facility (TSF) Wetland.

Location of each wetland within the BOGP are shown as an attachment.

The scope of this hydrological assessment was to evaluate if sufficient surface water would be available to construct and maintain these wetland systems.

The Lower Shepherds Wetland was evaluated conceptually given the downstream location provides for sufficient upstream catchment area to generate sufficient flow to maintain wetland hydrology. In contrast, the Shepherds TSF Wetland will be situated higher in the catchment with less catchment area and runoff reporting to that location. As such, a water balance model was developed to evaluate potential for maintaining the Shepherds TSF Wetland.

CLIMATE CONDITIONS

MWM (2025) describe the climate setting for the BOGP, with monthly data shown in Figure 1. They make the following observations:

- Based on the Köppen-Geiger classification, the climate can be characterised as temperate, without a dry season, and as having a warm summer (Cfb). Mean annual air temperature is 8 °C.
- On an annual basis, precipitation (P) is approximately 510 mm while potential evaporation (PE) is approximately 815 mm.

- The climate is relatively dry, with a strong energy surplus (PE>P) present between September through March, and an energy deficit (PE<P) over the remainder of the year, most notably over winter.

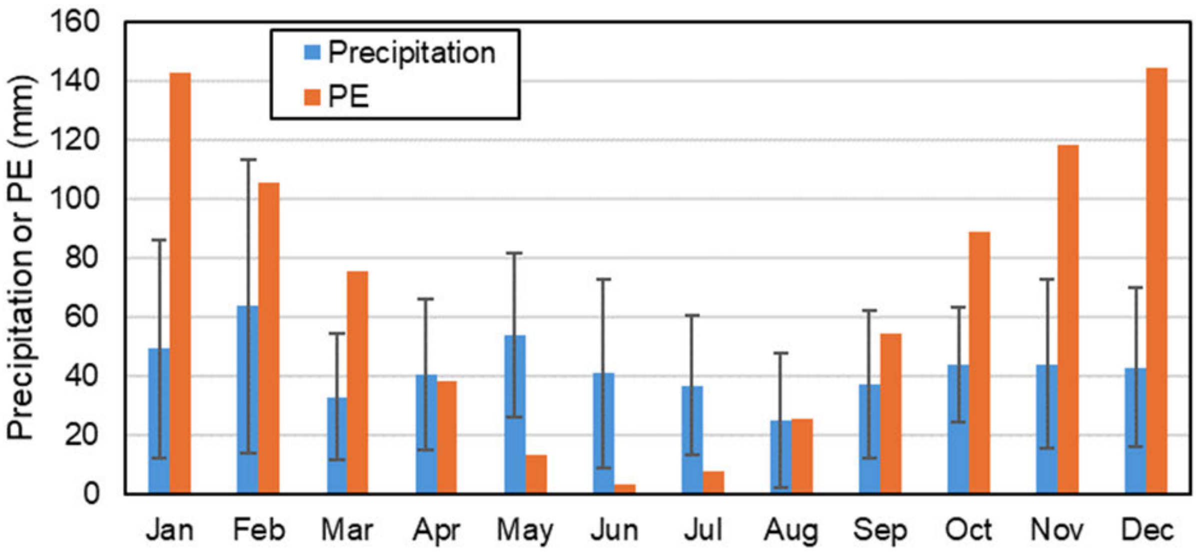

Figure 1: Monthly precipitation and PE summary.

PE=Potential Evaporation. Bars show monthly averages while error bars show rainfall standard deviation over the period of record.

Source: MWM (2025).

<u>LOWER SHEPHERDS CREEK WETLAND</u>

The Lower Shepherds Creek Wetland is proposed to be located within the Shepherds Creek valley bottom, as shown in (Figure 2), with an area of 1 Hecate (ha). This location is approximately 250 m upstream of the water monitoring site SC01, which has a catchment area of approximately 1,200 ha. The wetland will be constructed at the start of mining. It is noteworthy that wetland already exist near this location.

During the operational phase of the BOGP, creek flows at SC01 were forecast to be reduced by 17% on average (MWM, 2025) without mitigation. To maintain flows at SC01 during operations, MGL propose to augment Shepherds Creek flow such that pre-mining flows are maintained (HGG, 2025). For reference, recorded flows at SC01 were 15.6 L/s on average (KSL, 2025).Post-closure, the release of treated water means the surface water flow reporting to SC01 are forecast to increase by approximately 60% on average (MWM, 2025).It is therefore considered reasonable to expect sufficient water to be available to construct and maintain the Lower Shepherds Creek Wetland given the pre-ming flows will be maintained during operations and flow rates are projected to increase post-closure.

The upstream and downstream flows into and out of the existing wetland at the proposed site should be monitored to allow development of a site water balance. In addition, several shallow piezometers should be strategically placed within the wetland or near its boundaries where is suspected that sub-surface groundwater is contributing to site. Data from the piezometers can also be used to describe the annual fluctuation of subsurface water in response to surface water influx and precipitation. Analysis of data from the existing site will be used to inform the water demand of the proposed upstream extension of the wetland.

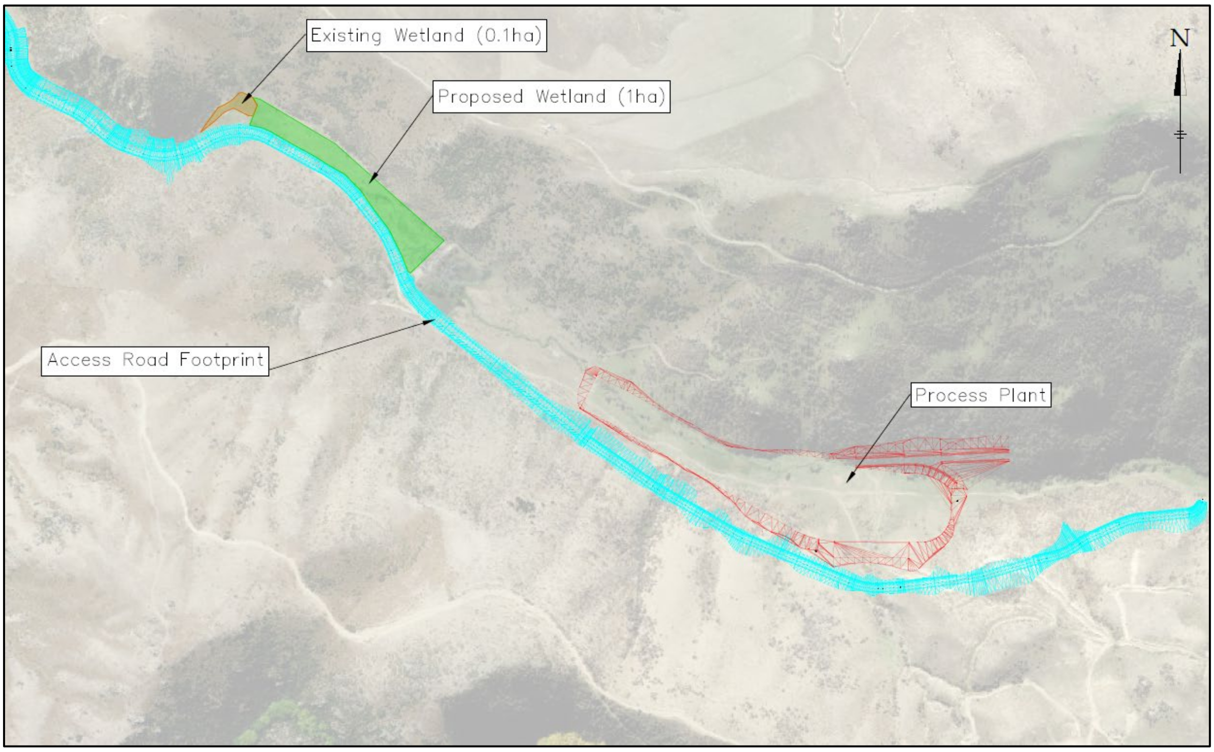

Figure 2 Location of proposed Lower Shepherds Creek Wetland.

SHEPHERDS TSF WETLAND

The Shepherds TSF Wetland is proposed to be constructed atop the Shepherds TSF following rehabilitation of this landform (see attached location map). The wetland will include the following elements:

- 0.5 ha of open water aquatic habitat.
- 1.5 ha permanently inundated vegetated swamp.
- 4.5 ha of seasonally inundated swamp/marsh.

Table 1 provides inundation requirements for the wetland[1]. The standing water will be controlled by constructing a bund with a weir and spillway. The wetland will be constructed above the tailings material such that there is a physical separate between the two.

Model Objectives

Model objectives included addressing the following questions:

1. How a weir or similar overflow structure can be managed during construction and then post-closure phase of wetland (i.e. what range of water depths will need to be managed).
2. Can a minimum area of permanent water be maintained and what mitigation strategies (at the time of construction, and then once constructed) can be used.
3. What testing/verification can be done before planting (for example permeability of the tailings).

[1] *Personal communication with J. Lurling (Ecology Expert) via email dated 18 June 2025.*

4. How can large rainfall events (and associated volume of water) be managed, (and is it part of post-closure ongoing management?).

Table 1: Ecological inundation requirements for the TSF wetland

WETLAND TYPE	AREA (HA)	TARGET WATER DEPTH DURING INUNDATION	DRY YEAR (MIN PERIODS)	AVERAGE YEAR	WET YEAR (MAX PERIODS)
Open water aquatic habitat	0.5	1.0–2.0 m (minimum >0.5 m)	0.5 ha inundated for 12 months	0.5 ha inundated for 12 months	0.5 ha inundated for 12 months
Permanently inundated vegetated swamp	1.5	0.1–0.5 m	≥1.5 ha inundated for 8–10 months at 0.1–0.5 m depth.	≥1.5 ha inundated for 10–12 months at 0.1–0.5 m depth.	≥1.5 ha inundated for 12 months at 0.1–0.5 m depth. Temporary increases to 0.5–0.75 m depth are acceptable during high rainfall periods.
Seasonally inundated swamp/marsh	4.5	0.05–0.30 m (local hollows to 0.5 m)	Marsh areas: 1–2 months inundation at min. 0.05 m depth. Swamp areas: 1–3 months inundation at min. 0.05 m depth.	Marsh areas: 2–4 months inundation. Swamp areas: 3–8 months inundation.	Marsh areas: 4–6 months inundation at up to 0.3 m depth. Swamp areas: 6–9 months inundation up to 0.3 m depth. Local hollows may remain inundated at up to 0.5 m depth for longer periods.

Model and Assumptions

The developed model assumes that the wetland will consist of a central pond that will vary in area, volume and depth according to dimensions supplied by EGL (Table 2). The model was structured to calculate the volume of water stored in the wetland in response to precipitation, evaporation, seepage and rainfall runoff. The water-level in the wetland will be controlled by two weir control structures (Table 2 and Figure 3). The lower weir will be sited just above the elevation of minimum pond depth required (0.3 m above the surface of the TSF) to provide 2 ha of permanent water pond. A second weir will be sited at 0.7 m above the TSF surface and will be used to spill potential peak flood flows from the wetland.

The model was developed in GoldSim and run at daily timesteps, for a period of 100 years using rainfall and potential evapotranspiration timeseries reported in MWM (2025). Inflow terms to the wetland included:

- Rain falling directly onto the ponded area.
- Runoff from the rehabilitated TSF area that is not inundated by the pond.
- Runoff from undisturbed areas upstream of the TSF.

Outflow terms were:

- Evaporation from pond water surface.
- Vertical seepage of pond water into the TSF.
- Outflow via weir and spillway.

- The flow of water into and out of the wetland are described by the processes shown in Table 3.

Table 2: TSF wetland volume-area-height relationships.

	Height	Delta height	Volume to height	Delta volume	Plan area	Delta plan	Slope area	Delta slope	Depth	Area	
Flood spillway	684	0.1	26850	9159.46	100732	18275	100738	18276	0.708	10 Ha	water
	683.9	0.1	17691	7339.47	82457	18458	82462	18459	0.608		
Bund Crest	683.8	0.1	10351	5185.78	63999	24154	64002	24155	0.508	6 Ha	Ehphemeral water
	683.7	0.1	5165.4	2969.16	39846	19847	39848	19848	0.408		
Weir Invert	683.6	0.1	2196.3	1424.6	19999	10438	20000	10439	0.308	2 Ha	Permanent water
	683.5	0.1	771.66	630.746	9560.2	6131.4	9560.7	6131.7	0.208		
	683.4	0.1	140.92	140.842	3428.8	3396.9	3429	3397	0.108		
	683.3	0.008	0.073	0.073	31.97	31.97	31.972	31.972	0.008		
Min height	683.292	1	0	0	0	0	0	0	0		
	682.292	-	0	-	0	-	0	-			

Source: EGL[2]

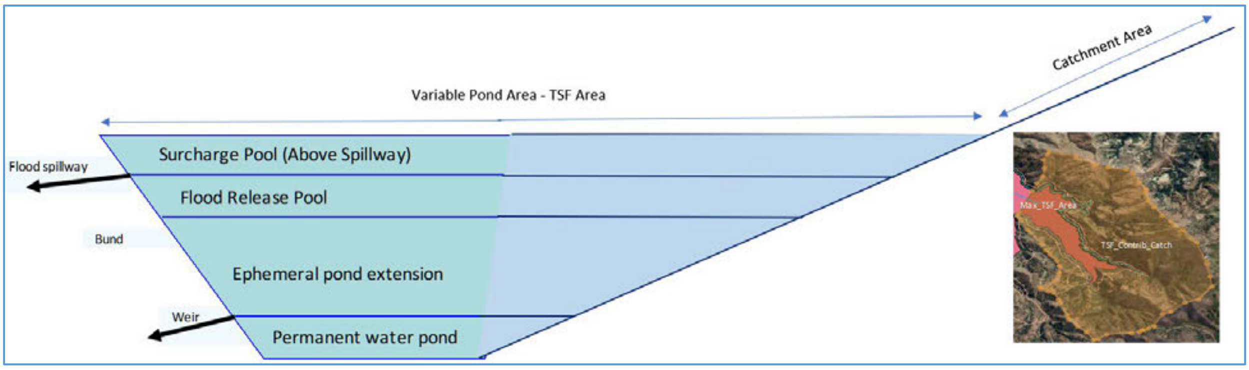

Figure 3: TSF wetland conceptual model illustrating varying pond area, thresholds, and upper catchment.

Table 3: Inputs and outputs to the wetland.

TYPE	SOURCE	CALCULATION METHOD	REFERENCE
Input	Precipitation	Total precipitation falling on pond area.	(MWM, 2025)
Input	Runoff from rehabilitated TSF surface (area varies inversely with pond size)	Runoff from non-wetted rehabilitated TSF surface calculated using assumptions for rehabilitated ground in the BOGP closure water and load balance model.	(MWM, 2025)
Input	Runoff from surrounding catchment (area = 5.8 km^2)	Runoff from surrounding catchment calculated using assumptions for undisturbed ground in the BOGP closure water and load balance model.	(MWM, 2025)
Output	Evaporation from pond water surface	Assumed to be 1.05 x PET estimated for this region, consistent with the BOGP closure water and load balance model.	(MWM, 2025)
Output	Seepage water	Saturated conductivity of the sub-surface assumed to be $5x10^{-8}$ m/s[3], assumes a unit gradient beneath open water pond.	-

[2] *Email from J. Zou dated 11 June 2026.*

[3] *Higher values were initially used, but lower values were required to achieve minimum ponded area criteria. Exact value to be used will be refined design advances.*

Output	Outflow via lower weir	Dependent on the water level within the wetland pond and calculated using equation for flow over uncontrolled weir ($Q = C\ L\ H^{1.5}$). Weir length (L) = 0.5 m	-
Output	Outflow via flood spillway	Dependent on the water level within the wetland pond and calculated using equation for flow over uncontrolled weir ($Q = C\ L\ H^{1.5}$). Weir length (L) = 2 m	-

Model Results

The model was initially set-up with the parameters indicated within Table 3. The model was first run for a period of 1, 5 and 100 years to allow illustration of short term variation and confirmation that such patterns are replicated over a longer period.

The modelled flows into and out of the TSF wetland can be divided into two groups (illustrated for the period 2025 to 2026 in Figure 4). Smaller magnitude flows include precipitation to the wetland pond (mean[4] = 47.5 m^3/day or 0.5 L/s), evaporation from the wetland pond (mean = 83.2 m^3/day or 1 L/s), and seepage from the TSF wetted area (mean = 143 m^3/day or 1.6 L/s). Larger magnitude flows include runoff from the surrounding undisturbed catchment (mean = 749 m^3/day or 8.7 L/s), runoff generated within the non-wetted area of the TSF (mean = 7.7 m^3/day or 0.1 L/s), and flow across the permanent pond weir (mean = 624 m^3/day or 7.2 L/s). It is noted that catchment flows into the wetland approximate outflows through the spillway (8.6 L/s and 7.2 L/s respectively).

Modelled variation of water depth in the TSF wetland pond for the two-year simulation period (2025-2026) is shown in Figure 5 relative to the lower weir threshold (permanent water pond), bund threshold (nominal ephemeral wetland area), and flood spillway threshold. The water level dips below the preferred permanent inundation level (weir level) for two periods (46 days from February to April 2025, and 53 days from March to May 2026).

Figure 6 illustrates modelled pond area for the same period and where the equivalent permanent pond threshold area is 2 ha. For the same two dry periods, the pond area decreases to 0.8 ha at its most extreme (excluding the 6-day start-up period). Over an extended period of five years (Figure 7) there is only one more dry period in which the water level falls below 1 ha for 9 days. Over a 100 year period (Figure 8) there is a total of 193 days below 1 ha.

To reduce the amount of drainage from the pond in dry periods the wetland was modelled without the lower weir (Figure 9). This resulted in a higher mean water area (7.9 ha compared to 3.3 ha with the weir), and just 100 days in which the pond fell below 1 ha.

[4] *Means calculated for simulation period 2025 to 2124.*

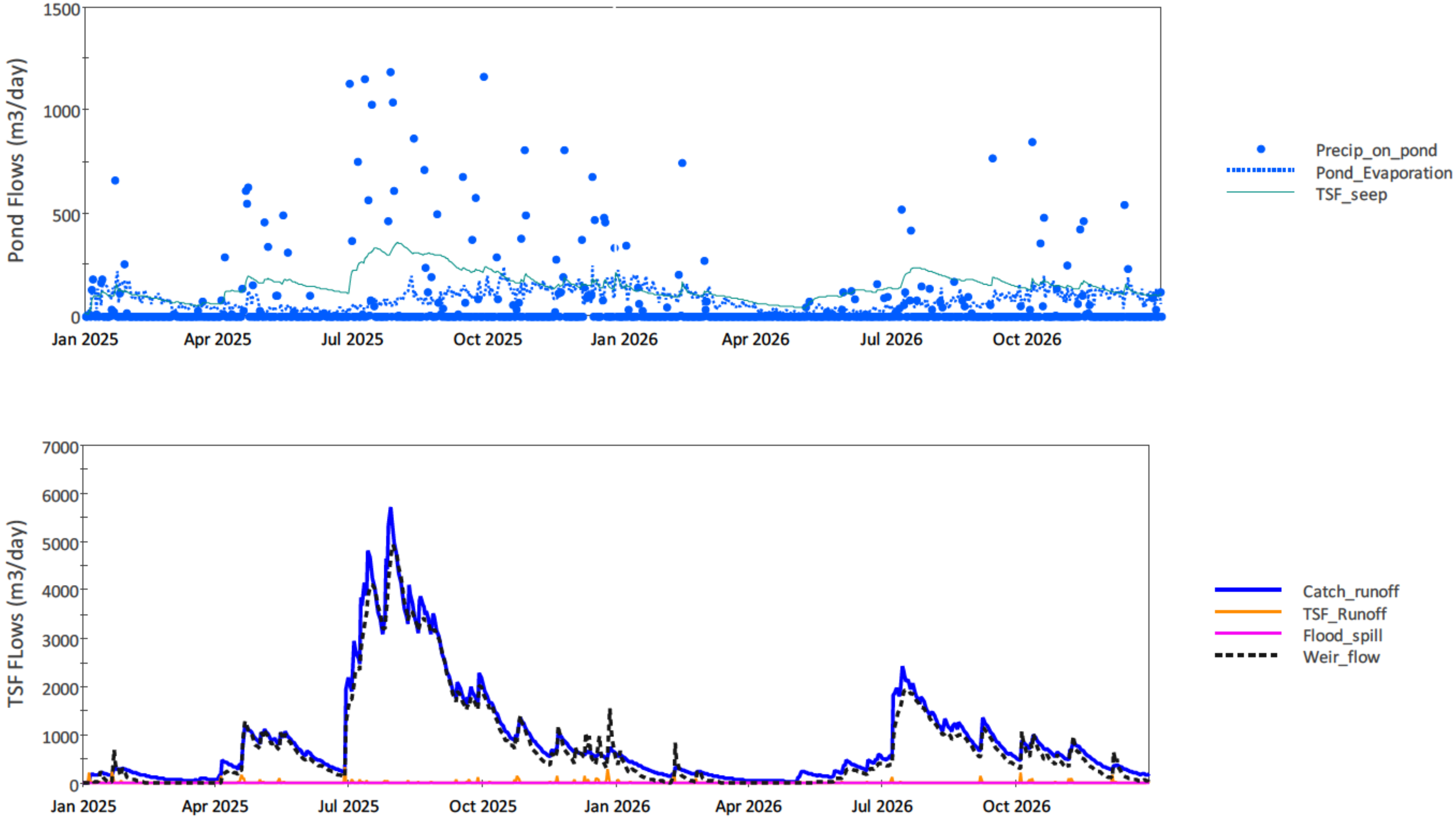

Figure 4: Modelled inputs and outputs to the TSF wetland pond (upper) and wider catchment (bottom) for period from January 2025 to December 2026.

Figure 5: Modelled TSF wetland pond depth (m) from January 2025 to December 2026 (0.5 m weir, 2 m flood spillway).

Figure 6: Modelled TSF wetland pond area (ha) from January 2025 to December 2026 (0.5 m weir, 2 m flood spillway).

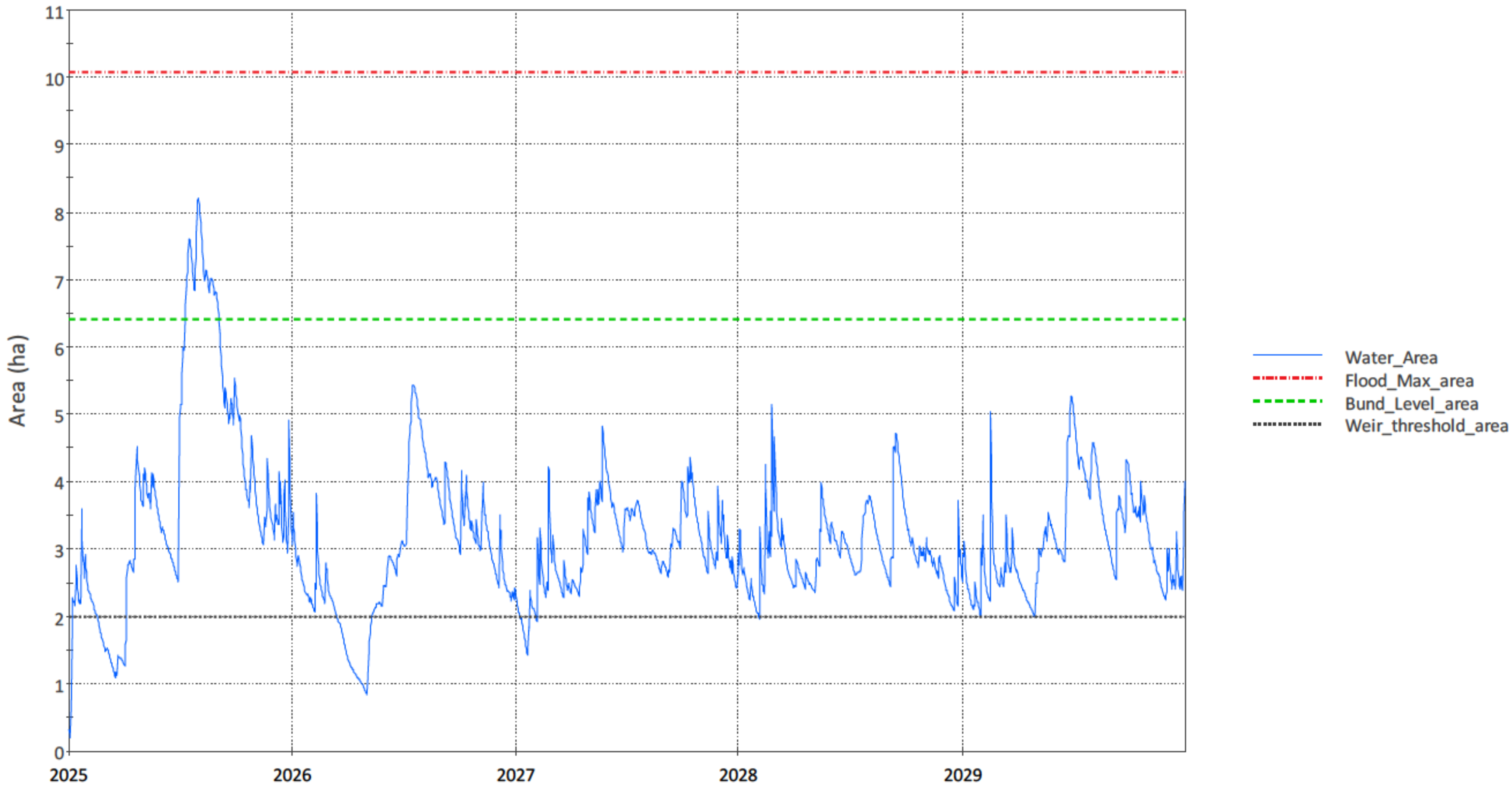

Figure 7: Modelled TSF wetland pond area (ha) from January 2025 to December 2029 (0.5 m weir, 2 m flood spillway).

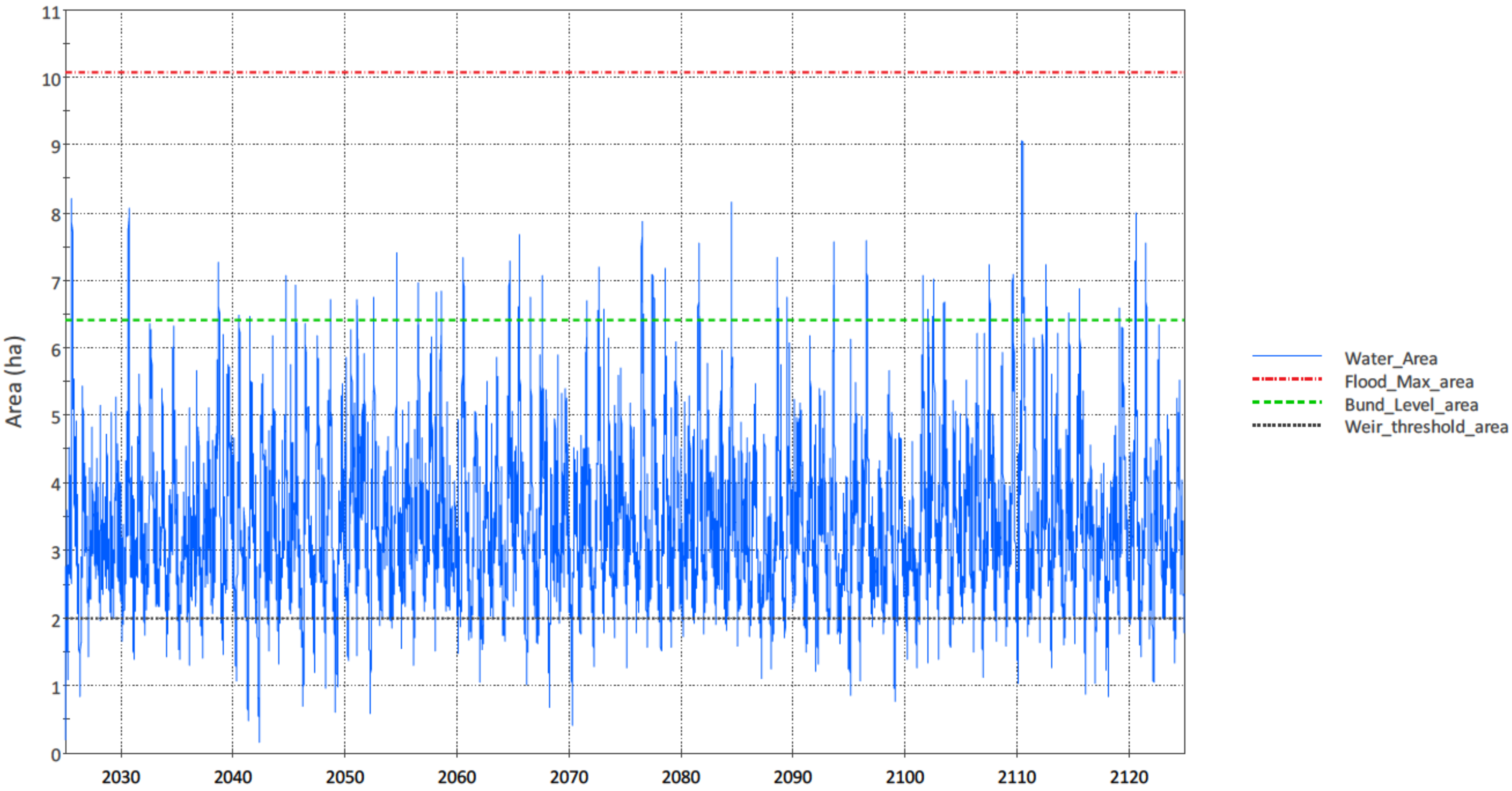

Figure 8: Modelled TSF wetland pond area (ha) from January 2025 to December 2124 (0.5 m weir, 2 m flood spillway).

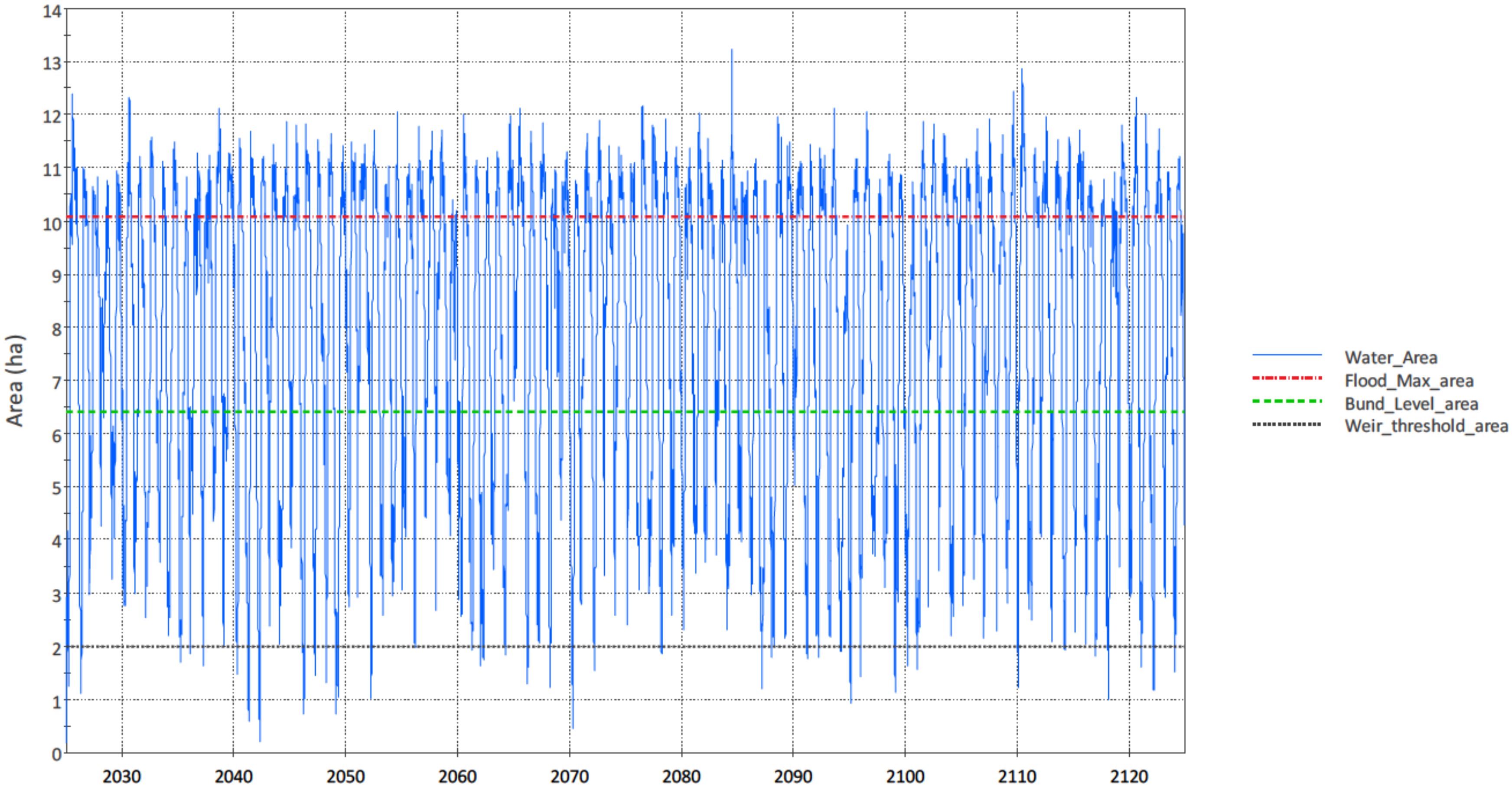

Figure 9: Modelled TSF wetland pond area (ha) from January 2025 to December 2026 (no weir, 2 m flood spillway).

Discussion

The presented model is a relatively simplistic water balance of the proposed TSF wetland. However, it allows analysis of the combined wetland inputs (precipitation and runoff) relative to nett losses (seepage, evaporation and weir spills) from the proposed wetland area. The model also allows assessment of how the wetland will respond to changes in design and management parameters (e.g., the wetland depth-area-volume specifications, and proposed wier/spill thresholds). Finally, the model can be used to inform the questions related to model objectives:

1. *How can a weir or similar overflow structure be managed during construction and then post-closure phase of the wetland (i.e. what range of water depths will need to be managed).*

Whilst the answer to this question will be influenced by the initial volume-area-depth relationships of the wetland design, it was noted from model simulations that catchment runoff (i.e., runoff generated from the catchment upstream of the TSF location) is the main control of the volume of water delivered to the wetland pond (see Figure 4). It is therefore suggested that the construction phase of the wetland occurs in the dry period that most frequently occurs at the end of summer and start of autumn. This would allow the wetland to fill in the first winter rainfall season (assuming it is an average rainfall year). Any weir or overflow system would be kept closed until the minimum required capacity of the wetland pond was reached. Continued closure of the weir to achieve additional volume would be advisable as simulations suggest that water level is more resilient to any subsequent dry periods.

2. *Can a minimum area of permanent water be maintained and what mitigation strategies (at the time of construction, and then once constructed) can be used.*

Model simulations suggest that the lower the 0.3 m water-level threshold was exceeded on 105 days in the 2-year simulation period from 2025-2026 (using a 0.5 m long weir drainage structure). If the weir was removed, the minimum threshold exceedance fell to 69 times in the same 2-year period. This suggests that the permanent water level can be better maintained using the wetland drainage structure. Other factors that will decrease the sensitivity of the wetland water level to climate fluctuations (particularly a lack of rainfall) include:

- decreasing seepage losses from the wetland by decreasing the permeability of the under-surface
- increasing the minimum water level height threshold of the wetland (high volume of stored water will improve water level resilience to dry periods)
- changing the volume-area-depth profile of the wetland design to reduce evaporative losses (as smaller area deeper wetland ponds would exhibit lower ET losses than a shall large area pond). It has also been noted that there is some flexibility in TSF design which can be shaped to provide a shallower (larger area), or deeper (smaller area) wetland footprint so as to meet ecological closure requirements (as long as engineering design objectives (i.e., retain tailing quantity and graded to spillway and culvert outlets).

The sensitivity of the wetland water-level and area can be further investigated using the model if required. However, given the ecological inundation requirements for the TSF wetland (Table 1), the model simulations suggest that the criteria to maintain a minimum open water aquatic habitat area of at least 0.5 ha can be achieved in all but the most extreme year (18 days in May 2042) within the 100-

year modelled scenarios. To reduce the risk of this happening, seepage losses through the TSF wetland could be reduced by decreasing the design surface permeability. Alternatively, strategies to augment flow into the wetland under extreme conditions could be investigated.

3. *What testing/verification can be done before planting (for example permeability of the tailings).*

The model results suggest flow from the upstream undisturbed catchment are the largest water balance contribution. Flow monitoring for catchment area reporting to this wetland undertaken to confirm model results are representative. The Northern Diversion Channel should be considered for installation of a monitoring system.

Model results suggest maintaining a pond area is sensitive to the quantum of seepage losses. Permeability of (i) underlying tailings and (ii) rehabilitation material should be verified by in situ (i.e., field) testing.

The Lower Shepherds Creek Wetland, if appropriately instrumented, may provide a useful analogue and knowledge base for designing the TSF Wetland. In addition, provided suitable space is available on the operational TSF, a field trial TSF wetland built prior to closure would enhance confidence in the expected performance of the constructed wetland.

A more detailed description of TSF wetland design (design topography) will help improve the model resolution to predict inundation for different vegetation assemblages (related to wetland height). Data relating to the runoff regime in the upper catchment will be needed validate catchment flows into the TSF wetland.

4. *How can large rainfall events (and associated volume of water) be managed, (and is it part of post-closure ongoing management?).*

Rainfall and runoff flux into the wetland were simulated based on the synthetic 100-year precipitation and evaporation timeseries. The upper flood spillway weir was set to 2 m in length for all model simulations and was able to drain 24-hour rainfall totals of up to 109 mm (which produced 7,219 m^3 of catchment runoff and 2,026 m^3 of runoff from the TSF surface). The maximum flow through the flood spillway was 100 L/s when the lower weir was closed to increase mean wetland water level. For comparison, the maximum flow through the lower weir (0.5 m crest) was 70 L/s. Notably, there were no flows through the flood spillway when the lower weir was operational.

CLOSING REMARKS

In summary, analysis suggest there will be sufficient water available for either wetland. The TSF wetland model suggests that if the wetland is designed with no lower weir, the pond will be deeper and larger and will be more resilient to all but the driest periods. Use of a lower weir (with crest of 0.5 m), whilst allowing flow through the wetland, will increase the risk of the pond falling below the minimum required threshold in drier periods. Water conservation in the pond could be improved in both the above situations by reducing seepage from the pond.

Please do not hesitate to contact [redacted] should you wish to discuss our memorandum in greater detail.

REFERENCES

Martinec, J., Rango, A., and Roberts, R., 2008. Snowmelt Runoff Model (SRM) User's Manual. Version 1.11. USDA Jornada Experimental Range, New Mexico State University.

Hydro Geochem Group (HGG) 2025. BOGP Flow Augmentation Strategy, Report No. J-NZ0235-002-R-Rev0.

Kōmanawa Solutions Ltd (KSL), 2025. Rise & Shine Gold Project – Surface Water & Catchment Existing Environment & Effects Assessment. Report for Matakanui Gold Limited. RN: Z24002BOG2-Rev2. Dated 19 August 2025.

Mine Waste Management (MWM) 2025. BOGP Water and Load Balance Model Report, Report No. J-NZ0233-016-R-Rev1.

ATTACHEMENTS

LANDSCAPE CLOSURE PLAN