Appendix D: PDP Stormwater Assessment

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Dear Greg

STORMWATER TECHNICAL ASSESSMENT FOR PROPOSED SOLAR FARM DEVELOPMENT, 80 STRUIE ROAD, HORORATA

1.0 Introduction

Rā Tuatahi No 1. Limited (Rā Tuatahi) has engaged Pattle Delamore Partners (PDP) to provide a technical stormwater assessment for the proposed establishment and operation of a solar panel (module) array (i.e. solar array or solar farm) at 80 Struie Road, Hororata, Central Canterbury. This letter has been prepared to support land use and resource consent applications for the proposed development.

The scope of work for the stormwater assessment includes an assessment of the quality and quantity of stormwater runoff from the site in comparison to the receiving water standards, and an analysis of the results from double-ring infiltration tests to address any overland flow issues. A double-ring infiltrometer test was unable to be conducted on the site at the time of the geotechnical investigations due to the presence of forestry slash and tree stumps. Additionally, it was considered that results from this type of surface are unlikely to be representative of the proposed finished grassed surface therefore a test was not conducted. Soil permeability data has been gathered from S-Maps instead.

2.0 Site Description

The proposed development is located at 80 Struie Road, Hororata, which is located on the Canterbury Plains. The proposed solar farm is legally described as Lot 6 DP 66179 with an area of approximately 10.2 ha. The site is shown in Figure 1 below.

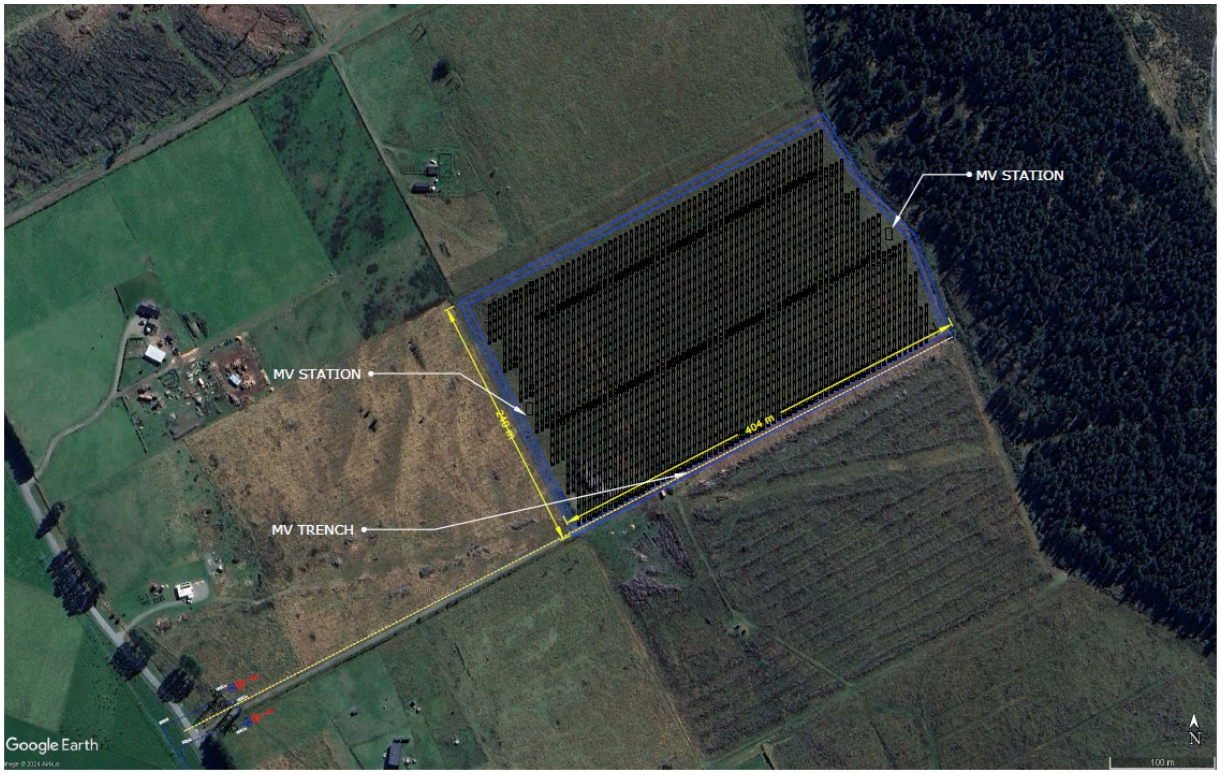

Figure 1: Draft site arrangement provided by Rā Tuatahi on 19 August 2024 (Drawing TT_RT-NO1-SGA_SITE_ARRANGEMENT-19.08.24)

The current site is a grassed paddock with surrounding land use that includes rural residential properties, forestry, and pastoral (sheep) land. The Waikirikiri Selwyn River lies to the east of the site. The site is generally flat and has a gentle slope of approximately 0.006 m/m (1V:170H) towards the southern boundary.

2.1 Groundwater Characteristics

Based on Canterbury Maps, the groundwater is expected to flow from north to south. A bore located south of the site (BX22/0213) showed the depth to groundwater was 8.9 metres below ground level (mbgl) in February 2021. A nearby bore (BX22/0140) which is located approximately 300 m north-east of the site shows long-term monitoring data from 2016 until present with the highest groundwater level recorded at 2.27 mbgl. A review of other nearby bores on Canterbury Maps show there are little to no water quality records for heavy metals.

2.2 Soil Permeability

Double-ring infiltration tests were initially proposed to be undertaken at the site to investigate the soil permeability of the site. However, at the time of undertaking site investigations on site (i.e. in November 2023), part of the site had presence of forestry slash and it was decided at the time that any infiltration testing undertaken on that surface may not be representative of the final grassed surface of the site. Based on that, the proposed double-ring infiltration tests were not completed.

Instead, a desktop assessment using S-Maps was undertaken. S-maps provides basic soil property data for the top 1 m soil profile of the site and is considered suitable for this initial assessment. S-maps indicates that the site is located on two types of soil, Lismore 1a and Lismore 2a. These are both well-drained brown silts. They have similar permeability profiles, with rapid infiltration (> 72 mm/h) in the top 0.2 m, followed by layers of moderate (18-72 mm/h) and moderately slow (4-18 mm/h) permeability until

approximately 0.5 – 0.55 m below ground level (mbgl). Below this, permeability returns to rapid until a depth of 1 mbgl. Based on the S-maps data, it is assumed that the site has moderate permeability.

2.3 Receiving Environment

The site is graded to the south, and as the Waikirikiri Selwyn River is located to the east of the site, there is no direct runoff to surface water. In addition, due to the relatively flat land, the primary receiving environment of the stormwater runoff for this site is likely to be groundwater. The site is located within the Selwyn – Waihora groundwater quality zone under Environment Canterbury's (ECan) Land and Water Regional Plan (LWRP).

3.0 Proposed Activity

3.1 Proposed Development

For the proposed development, 12,012 solar panels are proposed to be installed on site, with each panel having a surface area of approximately 3.1 m^2. This equates to approximately 3.7 ha[1] of solar panels. The solar panels will be arranged in rows (running North to South) and will change angles and tilt on a single axis to track the sun from East to West throughout the day. The development will also include a small medium-voltage station that will contain two units, each made of a transformer and an inverter.

PDP understand that cleaning operations will take place annually or possibly biannually. The land under the panels is proposed to be grassed, and this will be maintained regularly. Little traffic is expected at the site however a gravelled area at the end of the accessway is likely to be established for parking.

The construction and installation of the solar farm may require some of the topsoil to be removed, however this should not cause a significant reduction in the site's infiltration capacity.

3.2 Expected Stormwater Contaminants

Solar Panels

Photovoltaic panels are made with several materials that are known to pose significant health risks. These materials are predominantly metalloids and include aluminium, cadmium, selenium, copper, nickel, lead, and barium. Due to their toxicity and/or abundance in the panels, copper, cadmium and lead pose the largest risk. However, the solar panels will be encased by reinforced glass and polymer film, and insulated with silicone sealant. The panels will be framed and secured with galvanised steel. Literature review[2] has shown that heavy metals concentrations leached from encased solar panels are likely to be minimal, and are likely to be:

- Aluminium = 0.014 mg/L
- Barium = 0.0042 mg/L
- Cadmium = 0.0003 mg/L
- Copper = 0.15 mg/L
- Lead = 0.029 mg/L
- Nickel = 0.016 mg/L
- Selenium = 0.00025 mg/L
- Zinc = 0.056 mg/L

[1] Number of solar modules and dimensions of each solar module were provided by Power Technology on 19 August 2024.
[2] Source: Gao, Q. & Kirisits, M.J., 2021, based on synthetic rainwater.

The leaching for the proposed panels is expected to be lower than the values stated above due to the newer encapsulation technology proposed to be used for the panels.

PDP understand that the panels are expected to be washed once per year (or twice if the year is particularly dry). The water to be used will likely be brought in by a tanker truck although a bore or permanent onsite tanks can also be considered. No chemicals will be used in the washing process. A minimal amount of contaminants may be washed off during this process, such as any atmospherically deposited sediment. This is likely to result in stormwater quality similar to that of a moderate rainfall event.

Medium-voltage Station

The medium-voltage (MV) stations include a galvanised base frame to ensure its robustness in various conditions. The metal surfaces of the transformer and inverter will likely be powder coated, which will reduce heavy metal contaminant leaching into stormwater runoff. The expected stormwater quality from powder coated steel surfaces is expected to be similar to typical painted roof runoff which typically discharges directly to ground with no treatment. Therefore, the main contaminant of concern is sediment via atmospheric deposition. There are no batteries proposed to be onsite.

Remaining Site Cover

The majority of the site is likely to be grassed. The final surface of the accessway and parking area are likely to be gravel, meaning there is a potential for generation of dust and sediment.

4.0 Assessment of Effects

4.1 Discharge Quality Effects

As the site is located within the Selwyn – Waihora groundwater quality zone under the LWRP, the discharge requirements of Section 11 Selwyn – Te Waihora in the LWRP take precedence over any water quality limits set out in Schedule 8 of the LWRP. Both Schedule 8 and Section 11 water quality limits for groundwater require all contaminants of health significance, excluding nitrate, to be less than 50% of the maximum acceptable value (MAV) as described in the Water Services Drinking Water Standards for New Zealand 2022 (DWSNZ).

Schedule 8, Section 11, and DWSNZ do not specify a limit or MAV for total suspended solids. Sediment laden in the stormwater runoff from the solar panels, transformer/inverter and gravelled surfaces are expected to be either captured on the grassed or unsealed gravel surfaces, or captured within the soil matrix through infiltration.

Heavy metals leached in the stormwater runoff from the solar panels, as discussed in Section 3.2, may reach groundwater. Heavy metals such as cadmium, lead, copper and zinc are unlikely to reach groundwater as they can readily adsorb to sediment and sediment are expected to be either captured on the grassed surface, or captured within the soil matrix through infiltration. Additionally, there will be at least approximately 2.2 m of separation between the stormwater discharge and the groundwater table (i.e. highest groundwater at the site is likely to be 2.27 mbgl). This is considered to be sufficient distance to remove most contaminants, via adsorption (i.e. cadmium, lead, copper and zinc) and filtration (sediment), from the stormwater before reaching groundwater. Note that Environment Canterbury's Land and Water Regional Plan (LWRP) discharges to ground rules only require 1 m of separation above the seasonal high water table at a site.

Other potential heavy metals such as barium, selenium, nickel and aluminium do not adsorb to sediment as readily. These contaminants may enter groundwater and have therefore been compared against appropriate groundwater limits as shown in Table 1. The stormwater runoff from the solar panels would

be well below the receiving groundwater limits and considered to have no significant adverse effects on the groundwater quality.

Table 1: Comparison to Groundwater Standards

Metal	Leaching Concentrations (mg/L)	Receiving Groundwater Limits[1]
Aluminium	0.014	0.5
Barium	0.0042	1.5
Nickel	0.016	0.08
Selenium	0.00025	0.04

Notes

1. *50% MAV obtained from Water Services (Drinking Water Standards for New Zealand) Regulations 2022 (Winkleman 2022), in accordance with ECan LWRP Schedule 8 and Section 11.*

4.2 Discharge Quantity Effects

Rainfall landing on the surface area of 3.7 ha of solar panels is expected to result in increased flows and a change in distribution of rainwater reaching the ground, in comparison to the existing grassed paddocks (with forest slash piles). To determine the potential increased stormwater discharge from the solar panels, a hydrological modelling system, HEC-HMS, was used to model runoff flows from the site pre- and post-development. HEC-HMS is considered appropriate to model the runoff as it incorporates soil infiltration, storm hydrographs, and hydrologic routing. The HEC-HMS inputs are:

- Time of concentration of 27 minutes (gives lag time of 16 minutes).
- Design storm of 1 in 10 year, 12-hour nested storm (based on HIRDS v4 data for RCP8.5 2081-2100 scenario).
- Pre-development curve number (CN) of 59 (i.e. silt loams or loams are Group B soils).
- Pre-development initial abstraction (Ia) is 17.7 mm.
- Post-development weighted CN of 73 (i.e. 3.74 ha of CN 98 and remaining area of CN 59).
- Post-development initial abstraction (Ia) is 9.3 mm.

HEC-HMS modelled the pre-development peak runoff from the site to be 240 L/s and post-development peak runoff to be 470 L/s. Across the 400 m length of the southern boundary (down-gradient, runoff exiting the site), the increase in flows of 230 L/s is equivalent to the solar farm development resulting in 0.6 L/s/m of additional runoff from pre-development leaving the site.

The inputs for the post-development model are considered to be very conservative, as it assumes a nested storm and that the entire surface area of the solar panels is 100% impervious. The 100% impervious surface means 3.7 ha of the site is sealed allowing high runoff. However this is not the case as the ground beneath the solar panels will be grassed (i.e. the same as the pre-development site), so there is still chance for stormwater to infiltrate to ground prior to exiting the site. This means the post-development flows are likely to be lower than calculated and may not be too dissimilar from the pre-development flows. Additionally, the flows exiting the site will be into similar grassed paddock surface with minimal infrastructure in place. Based on this, it is considered that the proposed development will unlikely have an adverse effect on the neighbouring property.

If future development is proposed at the southern neighbouring property, an infiltration drain can be installed along the 400 m length of southern boundary to capture and allow stormwater to infiltrate to ground without exiting the site. The location of the infiltration drain will have to be designed such that an appropriate separation distance from the MV trench along the southern boundary is considered.

4.3 Discharge Erosion Effects

As noted above, the solar panels are likely to change the distribution of rainwater reaching the ground. The same quantity of rainwater will reach the ground, but the rain that falls off the surface of the panels (which will be angled to face the sun) will be more concentrated on one side of the panel and this may cause rills (soil erosion) alongside the panels. However, it is expected that the final grassed cover of the site is likely to minimise soil erosion.

5.0 Conclusion

In summary, PDP have undertaken a quality and quantity assessment of the stormwater runoff from the proposed development of a solar farm at 80 Struie Road, Hororata.

The expected contaminants from the stormwater discharge from the solar panels, transformer/inverters, and accessway/parking are sediment and heavy metals (i.e. cadmium, copper, lead, zinc, barium, selenium, aluminium and nickel). Any contaminants not captured within the surfaces (i.e. grassed or unsealed gravel) or within the soil matrix are likely to meet ECAN LWRP Schedule 8 groundwater quality limits (as well as Section 11 and the DWSNZ). Based on this, the development is not expected to result in significant adverse effects on the groundwater quality.

The additional (pre- vs. post-) stormwater runoff that is expected from the developed site was very conservatively estimated to be 0.6 L/s/m. However, due to the ground surface beneath the solar panels being grassed, it is likely the post-development flows are actually lower than calculated and may be similar to the pre-development flows. Additionally, the land use to the south of the site is also grassed paddocks, and it is considered that any minimal additional runoff from the developed site will not have significant adverse effects on the neighbouring property. Mitigations (i.e. infiltration drain) can be installed to capture the additional runoff. The runoff is also not expected to cause significant erosion, based on a combination of moderately permeable soils, a relatively flat site, and final grassed surface.

6.0 References

Gao, Q. & Kirisits, M.J. (2021) *The Effect of Photovoltaic Nanomaterial Roofing on Harvested Rainwater Quality.* Department of Civil, Architectural and Environmental Engineering, The University of Texas.

7.0 Limitations

This report has been prepared by Pattle Delamore Partners Limited (PDP) on the basis of information provided by Rā Tuatahi No 1. Limited and others (not directly contracted by PDP for the work), including Power Technology. PDP has not independently verified the provided information and has relied upon it being accurate and sufficient for use by PDP in preparing the report. PDP accepts no responsibility for errors or omissions in, or the currency or sufficiency of, the provided information.

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Yours faithfully

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