Technical Memorandum

To:	Dion Cowley	**From:**	Charlotte Lockyer
Company:	FRV		**SLR Consulting New Zealand**
cc:	Tim Grace	**Date:**	29 April 2026
		Project No.	810.032031.00001

RE: Rangitīkei Solar Farm
Technical Memorandum for Referral Application
Flooding

1.0 Introduction

FRV propose to construct, operate and maintain, and where necessary decommission, a utility scale solar farm, associated substation and battery energy storage system (BESS), and ancillary activities and infrastructure, including provision for access to the site, to connect and supply electricity to the National Grid near Marton. This technical memorandum has been prepared in relation to a referral application under the Fast-track Approval Act 2024 (FTAA) specifically addressing the flooding hazard to site infrastructure and surrounding properties from fluvial flooding (streams flowing through the site), pluvial flooding (rainfall on the site) and the management of stormwater runoff on-site.

The project is expected to require the following works:

<u>Electricity generating works</u>

Construction, operation, and maintenance, and where necessary decommission of a some 220MW ac solar farm over an approximate development area of 403 ha, including elements such as:

- Solar arrays installed on a single-axis tracking system or fixed-tilt mounts on pile-driven supports. It is anticipated that approximately 300,000 individual monocrystalline photovoltaic panels will be installed within a maximum height envelope of 4.5 metres.
- Inverters and transformers and associated external cabling.
- Underground cabling.
- Provision for construction of some 190 MW BESS (battery energy storage system).
- Construction of a new transmission substation and connection to Transpower’s 220 kV overhead transmission lines which run through the site.
- The proposed development will be delivered as a single-stage construction comprising the solar farm and all ancillary activities and infrastructure. The BESS is the only component that may be constructed separately, after the solar farm has been established and is operational. No further staging is proposed.

<u>Ancillary Infrastructure</u>

Construction of:

- New primary site access from Calico Line and new secondary site access from Colemans Road.

- Any necessary (yet to be determined) road or intersection upgrades, which may include widening of Colemans Road, and / or upgrade to the intersection of State Highway 1 / Colemans Road and / or right turn bay on Calico Line.
- Temporary construction laydown and yard areas and associated temporary construction buildings and facilities.
- Permanent storage and maintenance buildings and site office buildings and associated yard areas.
- Water tanks and other fire prevention, management and mitigation measures, as required.
- Internal access and maintenance roads and parking areas.
- Lighting, fencing and security and monitoring cameras and devices.
- Any necessary (yet to be determined) acoustic barriers.

Earthworks

Completion of earthworks required to construct the solar farm and the ancillary infrastructure, including:

- Construction of new site accesses.
- Completion of road upgrades (as required).
- Formation of temporary construction laydown and yard areas.
- Formation of internal access roads.
- Piling of solar array support posts.
- Construction of platforms for inverters and transformers.
- Trenching of cables.
- Formation of permanent building platforms and yard areas for substation and BESS.

Subdivision

Subdivision to give effect to long-term lease (lease more than 35 years) which at a minimum will result in the creation of new lots over land to be retained by the landowners, and resulting lots containing the solar farm and the associated infrastructure.

Planting

Boundary mitigation planting, riparian planting around streams and wetlands and mid-block mitigation planting around infrastructure.

2.0 Site Background

The proposed site is immediately north-east of Marton bounded by Tūtaenui Road, Colemans Road, Calico Line and State Highway 1 (Figure 1). The site is held on four land holdings and combined this land area totals approximately 507ha.

The site sits on a plateau west of the Rangitīkei River. It is relatively flat with a gentle fall from north to south. The highest point is at the north-eastern boundary at 190m, falling to 165m at the south-western boundary. There are small undulations across the site forming natural drainage channels. These drainage channels are evident in aerial imagery.

There are multiple water courses adjacent to and throughout the site. These include the Tūtaenui Stream, Foley Stream, and tributaries. Tributary channels appear to be ephemeral or intermittent, meaning they only flow in direct response to rainfall, or cease to flow for some periods over the course of a year. The soils have poor drainage so often result in boggy muddy paddocks following wet periods.

The Tūtaenui Stream runs along the western boundary of the site in a north to south direction, then through the township of Marton. The stream poses a flood risk to Marton, consequently water level and flow is monitored at Hammond Street, and the flood hazard through Marton has been previously modelled and mapped by Horizons Regional Council (Horizons).

The Tūtaenui River Scheme (or Tutaenui Catchment Control Scheme) was established in 1976 (completed in 1985) to control flooding and manage the stream channels within the catchment. The design was to manage flows in the Tūtaenui Stream in flood events up to a 5% AEP (equivalent to a 1 in 20-year) (Horizons, 2016). The scheme currently consists of 18 detention dams, stopbanks, grade control structures, a spillway and drainage channels (Horizons, 2020). Detention dam E4 is located within the site along Foley Stream and has a contributing catchment area of approximately 800ha.

Following the major flood event in the Tūtaenui Stream between 19-21 June 2015, in which significant flooding occurred in Marton, the scheme was audited (Horizons, 2016). At the Tūtaenui at Hammond Street gauge, the flow peaked at 70m^3/s, approximately a 1 in 60-year flood. It is understood that during this event, Dam E4 filled to capacity and spilled via the designated spillway. The audit noted that channel clearing works are essential to maintain stream conveyance and the effectiveness of the river scheme, as well as noting several options to enhance the scheme to reduce the risk of flooding to Marton.

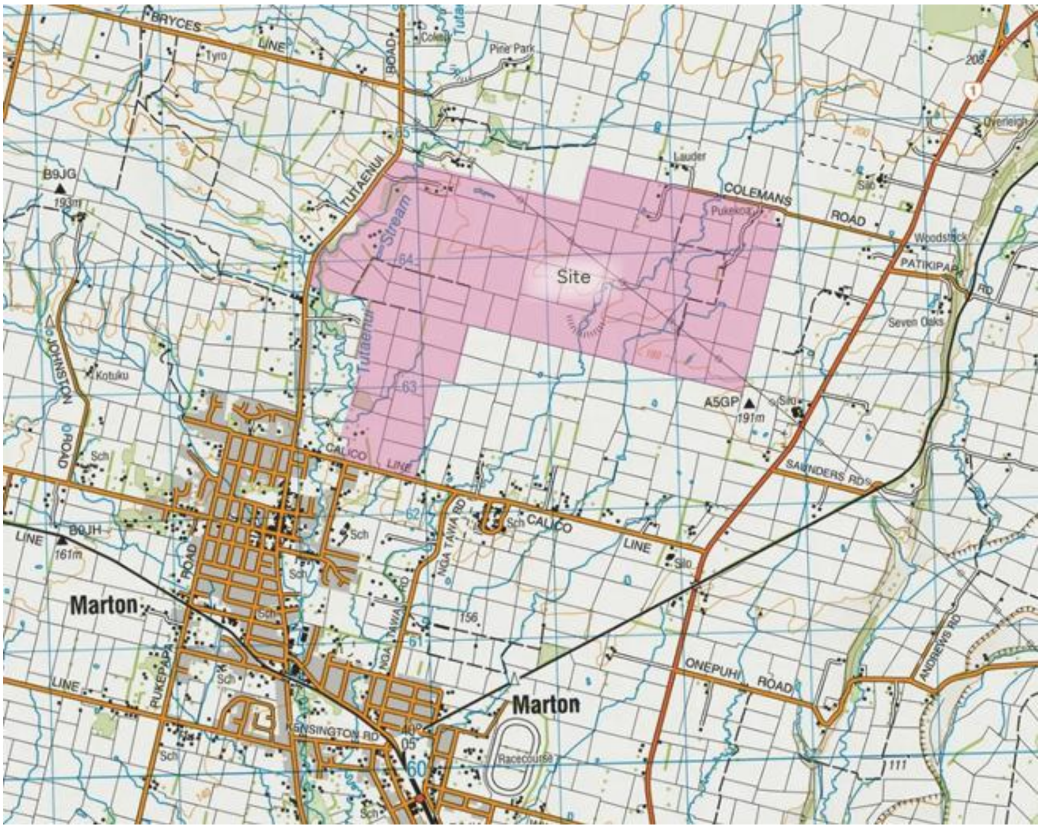

Figure 1 Site location

There is no flood risk from the Rangitīkei River to the east of the site. This river is approximately 100m lower than the plateau upon which the solar farm is located.

The site has a mean annual rainfall total of approximately 1100mm. The nearest rainfall gauges operated by Horizons are north of the site at Tūtaenui at Ribby Farm near Marton Reservoirs and north-east of the site Porewa Catchment at Tututorara.

The site is within the Coastal Rangitīkei (Rang_4d) surface water management zone in Horizons One Plan. The water management zones support the policy framework for surface water allocation, water quality, and activities in the beds or rivers and lakes including flood protection structures (Horizons, 2007).

The site is within the Rangitīkei groundwater management zone (for quantity management). There are four public water bores adjacent to the site to the north-west and south-east of the boundary, noted on Horizons District Advice – Property Enquiry. Three of the four bores have recorded depths of between 11m and 20m. The fourth is a deeper bore at 96m. The site is within catchment zone 3 for drinking water source protection, meaning the catchment contributes water to the intake.

The soil order is classified as Pallic, typified by weak structure and high-density subsurface horizons (Manaaki Whenua Landcare Research, 2023). The soil is characterised as having poor drainage through clay soils/Marton silt loam. The surface horizons are often waterlogged in winter due to slow drainage. The depth to hard soils, rock or gravels is over 1m. The site has low erosion susceptibility.

It is understood that infiltration through the site soils is enhanced through tile drainage. These are constructed sub-surface permeable pipes laid horizontally on a low grade and discharge to a surface water course. They are designed to reduce waterlogged soils and subsequently improve the productivity of land. These have been constructed across the site over generations, so the abundance, location and state of them are unknown.

3.0 Work to date

3.1 Previous studies

SLR has been involved with development of the Rangitīkei solar farm since 2023. Since this time, the site area and land parcels have varied slightly, though the core parcels between Tūtaenui Road, Colemans Road and the Tūtaenui Stream have remained constant. Multiple hydrological studies have been conducted. These are summarised below.

- Flood Assessment (prepared for Solar-Gen Joint Venture, dated 1 December 2023). This was a desktop flood risk assessment to support a site feasibility study. This assessment evaluated the available information and deemed the site as having a low flood risk to solar infrastructure.
- Marton solar farm hydraulic modelling preliminary risk assessment (technical memorandum prepared for FRV Services New Zealand, dated 10 October 2025). Cross-referenced hazardous floodwaters with the location of potential solar infrastructure, provided a flood risk assessment to identify and mitigate the potential risk.
- Hydraulic modelling assessment (prepared for FRV Services New Zealand, dated 16 October 2025). This report documented the hydraulic model build, including hydrological inputs and hydraulic modelling outputs. Depth, velocity and hazard maps were presented, identifying the flood hazard within the site boundary, and upstream and downstream of the proposed development area. The hydraulic modelling preliminary risk assessment was appended to this report.

- Opportunities and Constraints – background review and initial assessment: hydrology (prepared for SLR, dated 18 February 2026). Internal memorandum summarising the opportunities and constraints, risks and mitigations for development of the site.

This memorandum compiles earlier work to describe and evaluate the anticipated and known adverse effects from flooding and the significance of these anticipated and known adverse effects.

3.2 Hydraulic modelling flood hazard

A validated two-dimensional (2D) hydraulic model was constructed using TUFLOW (SLR, 2025). The purpose of this model was to assess the flood risk to the site. Assessment of a range of storm durations, distributed using the HIRDS East of North Island (ENI) temporal pattern, identified a critical storm duration of four hours. The 4-hour storm distribution was applied to design rainfall depths for the 20%, 10%, 5%, 2%, 1%, and 0.5% annual exceedance probability (AEP) events under current climate conditions. These events were routed through the model. The 1% AEP event was also modelled with adjustment for the predicted temperature increase for the RCP-8.5 future climate scenario.

For this assessment, the 0.5% AEP event is considered the critical design event, as it represents the minimum threshold required for resource consent under Rangitīkei District Council's Natural Hazard planning rules for flooding. Depth, velocity and hazard maps are presented in

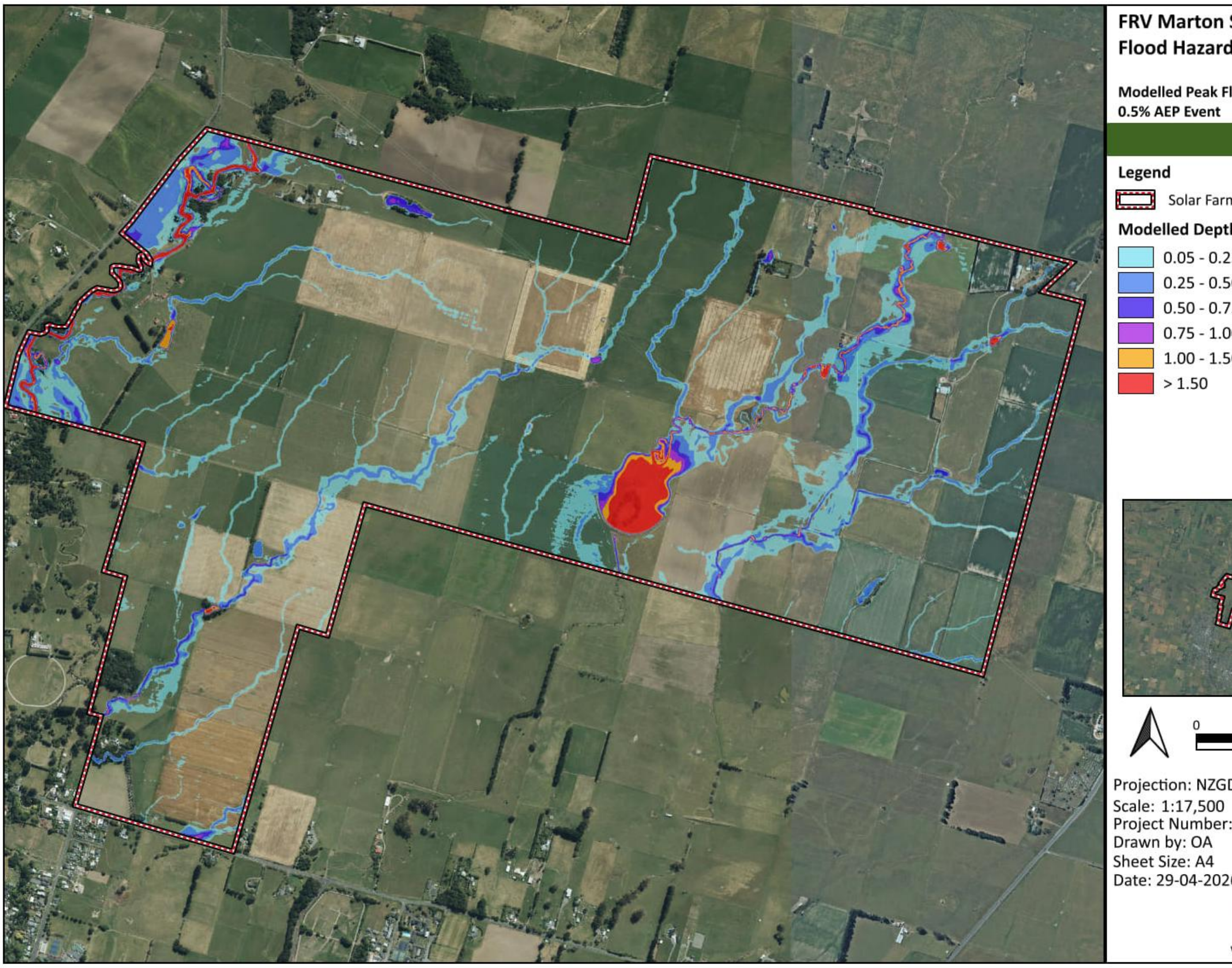

Figure 2 to Figure 4. The hazard criteria used to define high, moderate and low risks is based on the following depth and velocity thresholds:

- High risk – flood depths exceeding 0.5m or velocity greater than 1m/s.
- Moderate risk – flood depth between 0.3 and 0.5m or velocity between 0.5 and 1m/s.
- Low risk – flood depth less than 0.3m or velocity less than 0.5m/s.

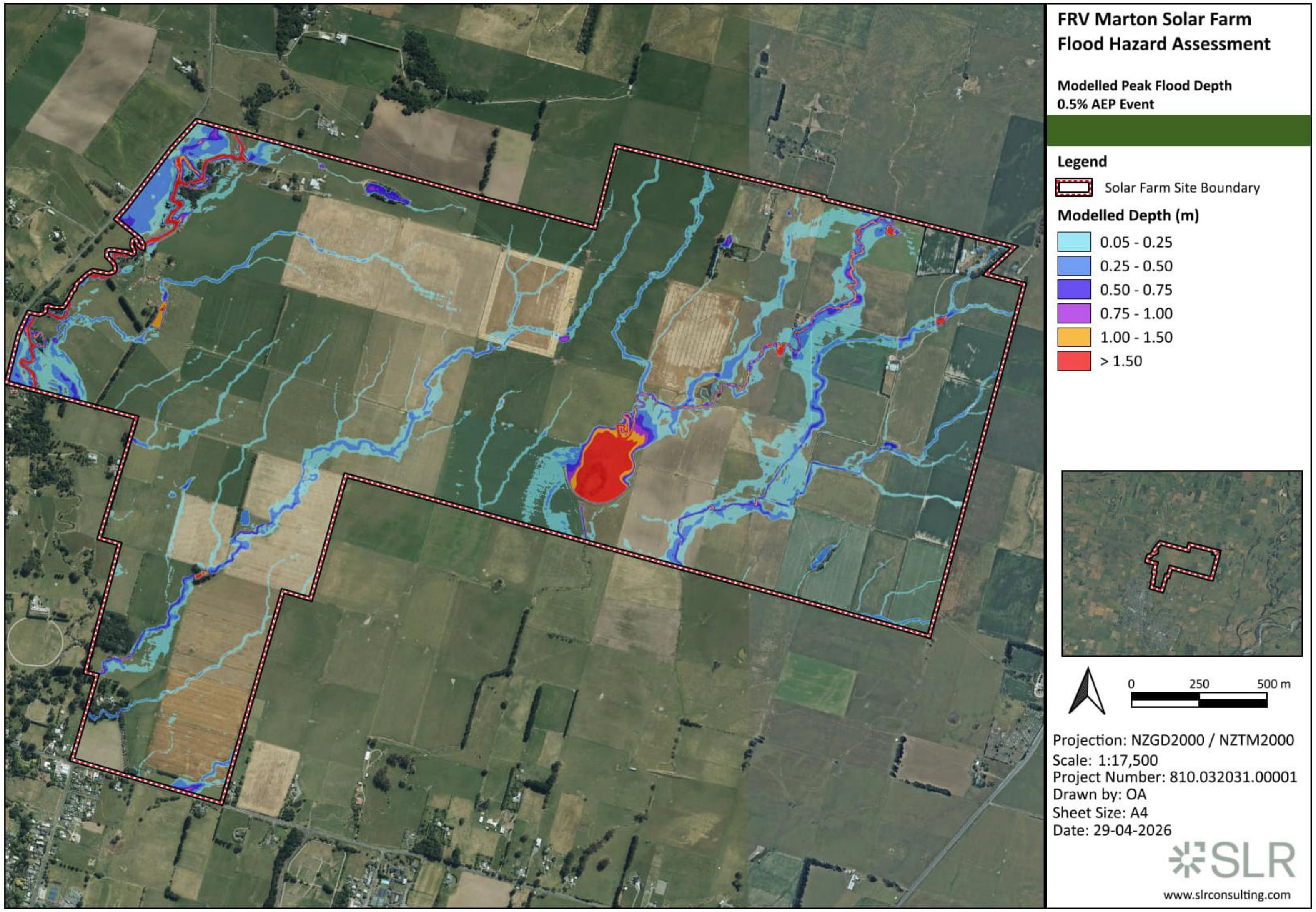

Figure 2 Flood depth map, 0.5% AEP event

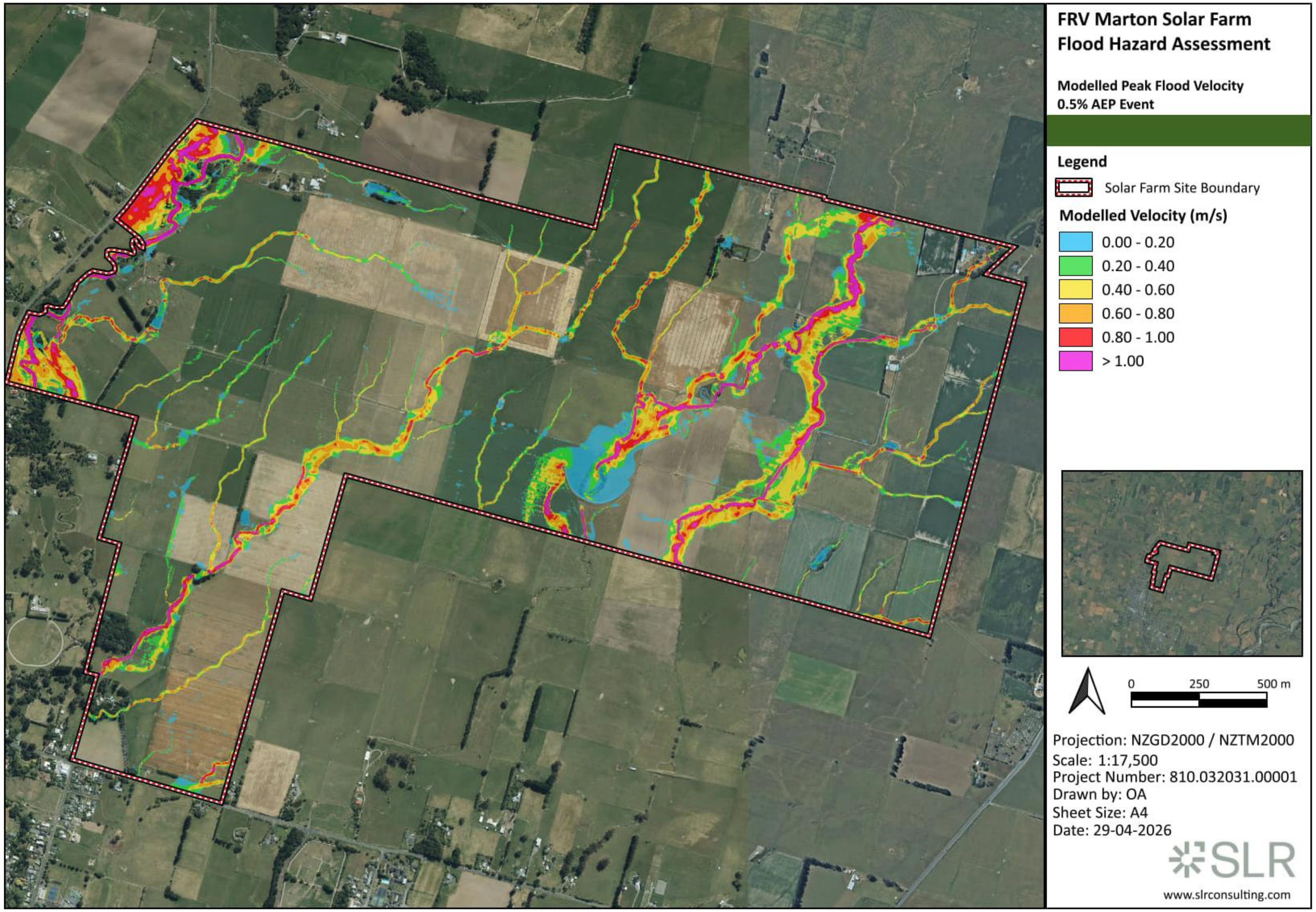

Figure 3 Flood velocity map, 0.5% AEP event

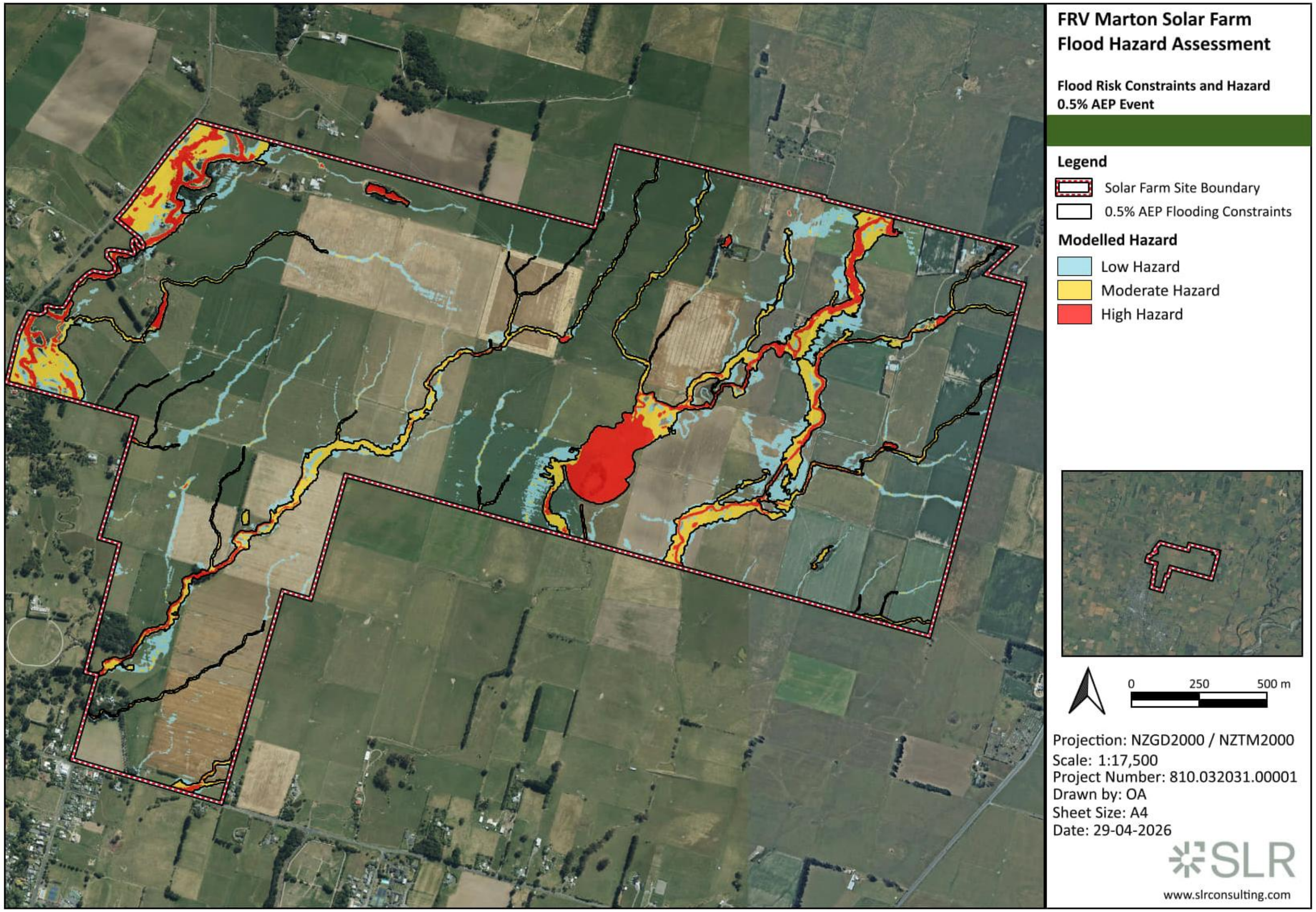

Figure 4 Flood hazard map, 0.5% AEP event

The hazard map in Figure 4 also identifies flooding constraint areas. These are contiguous area with primarily high risk and moderate risk where flooding may pose a constraint on development.

Modelling allowed for the various hydrological features and associated flood risks for the site and wider area to be visualised and quantified. Further details of the model build, including assumptions and limitations, and outputs can be found within the model build report (SLR, 2025).

It is important to note that the modelling did not incorporate the initial design plans. Therefore, the model results only represent the existing conditions to identify flooding constraints and may be subject to change following development of the area.

4.0 Known and anticipated adverse effects and significance

The known and anticipated adverse effects of flooding associated with the proposed development are summarised in Table 1. The significance of each effect has been assessed qualitatively, based on professional judgement of the potential impacts assuming no mitigation measures are implemented. These effects consider construction activities as well as operation of the solar farm.

Within the site, hazardous floodwater (deep and/or high velocity) is generally confined to channels, overland flowpaths, and the detention dam basin. Adverse effects on solar infrastructure are considered to be of very low significance, as any damage would primarily affect FRV assets. Areas of higher flood risk are being addressed in the ongoing design of the solar farm through the inclusion of sufficient buffer zones that exclude development from these locations.

Outside the site boundary, there is greater uncertainty in assessing the significance of potential adverse effects because the proposed site layout has not yet been explicitly modelled. This is due to several factors, including that FRV is still refining site opportunities and constraints, meaning the layout is still being developed and remains subject to change. In addition, hydraulic modelling of solar panels is time-consuming and requires numerous assumptions, such as the length and width of panel arrays, tilt angles, and spacing between panels. This uncertainty is expected to reduce as details are progressed during the design process.

Nonetheless, studies indicate that solar farms constructed on suitable sites, with layouts that promote drainage and well-maintained vegetation cover beneath panels, are unlikely to cause a significant increase in stormwater runoff (Bejehbaj et al., 2024; Cook and McCuen, 2013; Mulla et al., 2024; SLR, 2024). A key performance criterion for a suitable site is the siting of PV panels on relatively flat land. Flatter slopes typically generate a slower runoff response, allowing greater infiltration and resulting in runoff behaviour similar to pre-development conditions.

Table 1 Known and anticipated adverse flooding effects

Anticipated effect	Significance	Justification
Adverse impacts to solar infrastructure resulting from onsite flooding.	Very low	Unlikely to cause adverse effects to persons or property other than FRV and the property owners. Potential impacts would generally be limited to localised erosion or scour, or flood inundation, during low-frequency, high-magnitude flood events.

Anticipated effect	Significance	Justification
		Velocities are typically slow and therefore unlikely to cause widespread damage.
Adverse impacts to people, property, and infrastructure resulting from changes to flow paths and detention storage volume.	Low	There is no intention to change the overland flowpath inflow and outflow locations along the site boundary. Within the site, development within all high-risk areas will be avoided. If runoff from new hardstand areas is not adequately managed, increased runoff volumes may enter the detention reservoir behind Dam E4, potentially reducing flood resilience.
Reduced ability of the flood control scheme to manage the design flood events.	Moderate-low	Changes to Dam E4, the spillway, or inflow conditions could reduce the effectiveness of the structure in mitigating flood hazards to Marton. Detailed design will need to consider how earthworks may change overland flowpaths and catchment boundaries. Care will need to be exhibited to ensure the catchment area draining to Dam E4 does not markedly increase.
Increased runoff resulting from the presence of solar infrastructure across the site.	Moderate	The site is considered suitable for solar development. However, the presence of numerous overland flow paths may increase this risk. As the site is located immediately upstream of Marton, which is already subject to flooding during significant rainfall events, there will be concerns that runoff from the site may increase the flood risk downstream. Refer to 5.0 for discussion on future modelling to better understand this risk and adjustments to the solar farm layout accordingly.
Adverse impacts to downstream environments resulting from contaminated stormwater runoff.	Very low	The risk of stormwater contamination from PV panels is considered low under normal operating conditions, as panels are manufactured as sealed units with cells encapsulated between glass and polymer layers within durable framing. The substation and BESS will be located outside the 0.5% AEP flood extent. Additional protection measures, such as elevating the footprint or bunding, may be implemented to reduce the risk of floodwaters mobilising hazardous substances from these assets during events exceeding the design standard.

5.0 Work required to further understand anticipated effects

As the project progresses further modelling will be undertaken to incorporate the proposed site layout, including representation of PV panels, proposed landscaping and earthworks. This will improve understanding of the known and anticipated adverse effects of flooding to Dam E4 and to Marton. Where the significance of the effect is considered to exceed a moderate-low status, mitigation measures will be evaluated with the objective being to reduce the significance to low or very low. Modelling may be iterative to assess the effectiveness of mitigation measures.

6.0 Potential mitigation measures

There are numerous mitigation measures that could reduce the known and anticipated adverse effects in Table 1 to low or very low significance. The list below is not exhaustive but provides examples of potential measures that could be considered if the further modelling indicates that additional management of downstream flood risks is required.

1. Avoid developing any area within a high-risk hazard zone. The concept design avoids the high-risk hazard zone.
2. Manage development in any moderate risk hazard zone to ensure the conveyance capacity of the overland flowpath is maintained. The flowpath may be diverted within the site to bypass infrastructure if necessary, however, the inflow and outflow location along the site boundary must remain unchanged. This will be addressed through the ongoing design process. It is recommended that inverters are placed outside of moderate-risk zones. The BESS and substation are currently proposed to be located outside of the 0.5% flood risk areas. PV panel pylons located within the low-risk and moderate-risk zones are anticipated to result in little or no noticeable change to the flood hazard.
3. Stormwater retention or detention should be proposed for substantial hardstand areas (i.e., substation, BESS, permanent buildings, etc.) and be appropriately sized to reduce the post-development peak flow to the pre-development peak flow. This will be addressed through the ongoing design process.
4. Channel clearing works within designated streams and culverts are essential to maintaining stream conveyance and the effectiveness of the river scheme. Access to waterways and significant flowpaths for maintenance will be considered as the design progresses. A maintenance programme should be developed prior to construction to ensure conveyance is maintained. This is anticipated to be a condition of consent.
5. Earthwork activities may change the drainage characteristics, including infiltration capacity and flow direction. Care must be exhibited so all site boundary channel and overland flowpath inflow and outflow locations remain unchanged. Design should avoid changing the eastern tributary catchment boundary which may divert greater flow to this reach of the Tūtaenui Stream. This area already has a heightened flood risk and further runoff may worsen flooding to Marton. This will be addressed through the ongoing design process.
6. Avoid earthworks or placement of infrastructure within the Dam E4 designation. The concept design avoids the designation.
7. Minimise hardstand areas. Unsealed gravel roads are preferred as these allow for infiltration. This will be addressed through the ongoing design process.
8. Construction may result in the compaction of site soils and damage to tile drainage. This may worsen soil drainage. Care should be taken during design and construction to minimise the potential impact of damage. This is anticipated to be a condition of consent.
9. Consider PV panel alignment. The following items can be advantageous to reducing stormwater runoff and will be addressed through the ongoing design process:
   a) Allow adequate spacing between panels to support grass growth and lateral infiltration. Current design provides 2m-6m spacing between rows of panels.

   b) Maintain ground cover and prompt remediation of any rills forming beneath panel drip lines.
   c) Provide rows of vegetation buffers perpendicular to the drainage channel either between blocks of arrays or at the boundary to slow sheet flow and encourage infiltration.

10. Possibility of raising access roads to form a minor bund, and/or under-sizing culverts to slow the rate of any surface runoff and encourage minor ponding and infiltration on the upstream side. Culverts will be set at a level consistent with or below the existing stream beds. This will be addressed through the ongoing design process.
11. Provide stormwater treatment for runoff from higher hazard areas (i.e., substation and BESS yard areas).

7.0 Potential adverse effects after mitigation

Where the potential management measures outlined above are considered necessary to avoid or mitigate any adverse flooding effects identified through the subsequent modelling, it is feasible that all anticipated effects from flooding (including from stormwater) can be reduced to low or very low significance (refer to Table 2).

Table 2 Anticipated effects with site mitigation

Anticipated effect	Significance
Adverse impacts to solar infrastructure resulting from onsite flooding.	Very low
Adverse impacts to people, property, and infrastructure resulting from changes to flow paths and detention storage volume.	Very low
Reduced ability of the flood control scheme to manage the design flood events.	Low
Increased runoff resulting from the presence of solar infrastructure across the site.	Low
Adverse impacts to downstream environments resulting from contaminated stormwater runoff.	Very low

SLR Consulting New Zealand

Charlotte Lockyer
Principal Hydrologist

8.0 References

Bejehbaj, R.Y., Cibin, R., Duncan, J. and McPhillips, L.E. 2024. *Quantifying soil moisture and evapotranspiration heterogeneity within a solar farm: implications for stormwater management*. Journal of Hydrology, Vol 638.

https://www.sciencedirect.com/science/article/abs/pii/S0022169424008709

Cook, L.M. and McCuen, R.H. 2013. *Hydrologic response of solar farms.* Journal of Hydrologic Engineering, 18(5), pp.536-541.

https://protecthardysvale.wordpress.com/wp-content/uploads/2021/06/shv-8.-cook-mccuen-hydrologic-response-of-solar-farms.pdf rms

Horizons, 2007. *Development of Water Management Zones in the Manawatu-Wanganui Region: Technical report to support policy development.* Report No: 2006/EXT/733. January 2007. https://www.horizons.govt.nz/HRC/media/Media/One%20Plan%20Documents/Development-of-Water-Management-Zones-in-the-MW-Reg.pdf?ext=.pdf

Horizons, 2016. *Catchment Operations Committee: Tutaenui River Scheme Audit (PRD 05 30)*. Report No. 16-240. 14 December 2016. https://www.horizons.govt.nz/HRC/media/Media/Agenda-Reports/Catchment-Operations-Committee-2016-14-12/16240%20Tuatenui%20River%20Scheme%20Audit%20Report.pdf

Horizons, 2020. *2019-2020 River Management Activity Group: Tutaenui Scheme Meeting*.

https://www.horizons.govt.nz/HRC/media/Media/Flood%20protection/2020-21-Tutaenui-Scheme-Presentation.pdf?ext=.pdf

Manaaki Whenua Landcare Research, 2023. S-map Online. https://smap.landcareresearch.co.nz/maps-and-tools/app/

Mulla, D., Galzki, J., Hanson, A. and Simunek, J. 2024. *Measuring and modelling soil moisture and runoff at solar farms using a disconnected impervious surface approach.* Vadose Zone Journal, Vol 23 (4), July 2024.

https://acsess.onlinelibrary.wiley.com/doi/epdf/10.1002/vzj2.20335

SLR Consulting New Zealand (SLR), 2024. Hydrological Impacts of Solar Farms. November 2024.

SLR Consulting New Zealand (SLR), 2025. Hydraulic modelling assessment – Marton Solar Farm. October 2025.