NZ CLEAN ENERGY

APPENDIX 14 STORMWATER MANAGEMENT PLAN

Planning | Surveying | Engineering | Environmental

Stormwater Management Plan

NZ Clean Energy Ltd

3954A State Highway 2, Masterton

Document Information

Client	**NZ Clean Energy Ltd**
Site Location	3954A State Highway 2, Masterton
Legal Description	
CKL Reference	B23067
Office of Origin	Hamilton

Author	Mostafa Baghersad		
Signed		**Date**	20/11/2023

Reviewed By	Andy Dow		
Signed		**Date**	20/11/2023

Authorised By	Bronwyn Rhynd		
Signed		**Date**	21/11/2023

Revision	Status	Date	Author	Reviewed By	Authorised By
01	Approved	1/12/2023	MB	BR	BR
02	Approved	1/03/2024	MB	BR	BR

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1 Introduction

This report outlines a stormwater management plan prepared by CKL NZ Ltd (CKL) in support of a resource consent application for the proposed solar farm at 3290 & 3954A State Highway 2, Masterton. This assessment has been undertaken based on information from the following sources:

- Masterton District Council (MDC) Online Map – Wairarapa Maps (accessed November 2023)
- Carterton District Council, Code of Practice – Guidelines for Water Race Property Owners, January 2022
- Land, Air, Water Aotearoa (LAWA), accessed October 2023
- Proposed site Plan, prepared by NZ Clean Energy (NZCE), dated October 2023 (Appendix 1).

2 Existing Site Conditions

The MDC indicates that the 147.3 Ha site is situated in a Special Rural Zone. Currently, the land is primarily grassland with some trees and is intersected by a Council Water Race running from north to south. Currently most of the land is used for stock grazing. Close to State Highway 2, there are two houses and several farm-related structures. The land is predominantly flat with a slight incline towards the south, showing an approximately 7m elevation difference between the northern and southern boundaries. The distance from the site's northern to southern extents is approximately 1700m. The site location and surrounding area are shown in Figure 1.

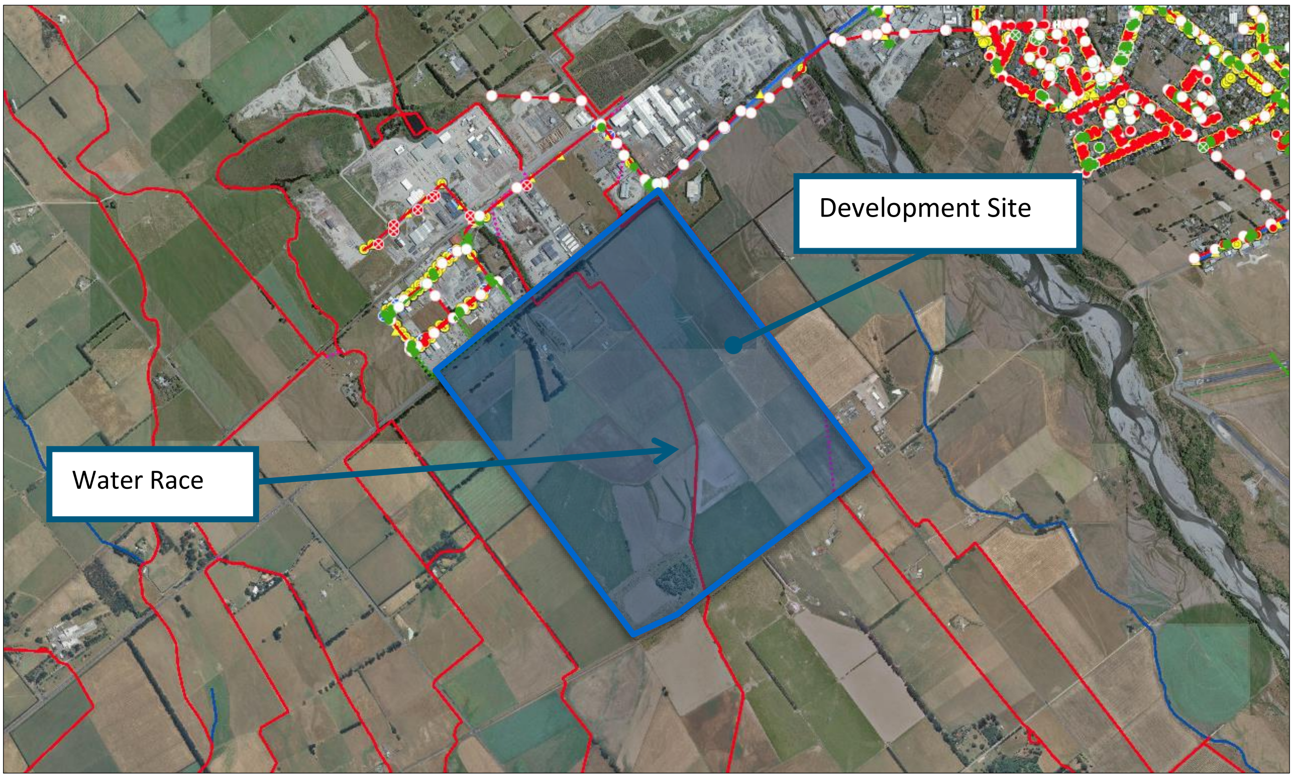


Figure 1: Existing development layout within the site[1]

3 Proposed Development

The proposal entails the establish an approximately 138ha agrivoltaic development, also known as a solar farm, within the subject site. This project will include erecting solar panels (photovoltaic modules), inverters, transformers, battery energy storage system (BESS), a substation, and a site office.

The site devleopment will include the construction of internal access routes, a designated site parking, and a laydown area. Furthermore, it is proposed to build hardstand areas specifically for the substation and BESS units. The proposal includes the construction of two new internal culvert crossings, along with the upgrading of an existing culvert crossing. A new site entrance is to be constructed from Cornwall Road, as per the site plan shown in Figure 2. The proposed site plan is attached in Appendix 1.

[1] Wairarapa Maps, assessed October 2023

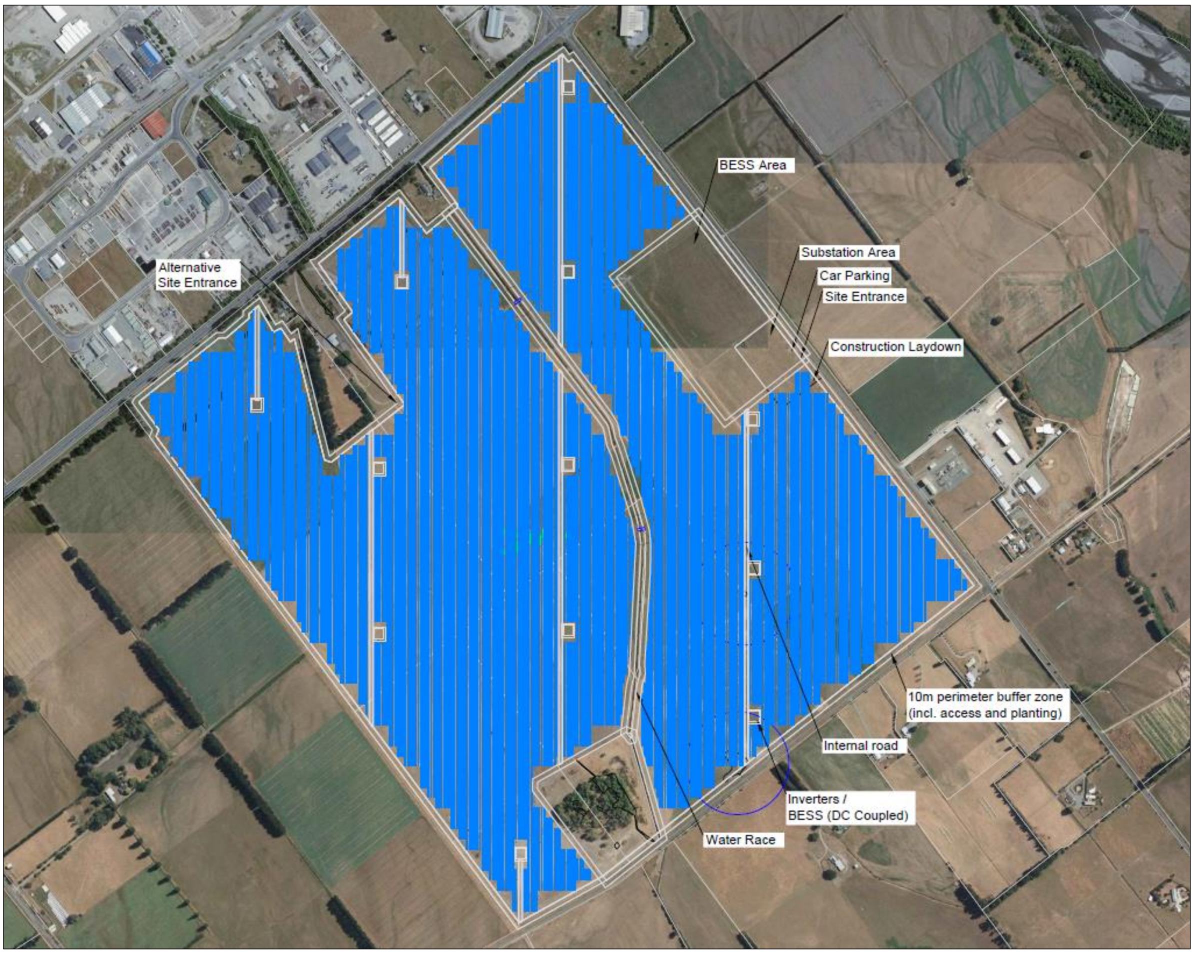


Figure 2: Proposed site plan[2]

The project encompasses not only the photovoltaic arrays (solar panels) but also the essential supporting infrastructure, such as substations, inverters, and service paths. For visual reference, Figure 3 showcases a photograph of a comparable operational solar farm, while Figure 4 provides a detailed schematic representation of the planned solar facility.

[2] NZ Clean Energy (NZCE), dated October 2023

Figure 3: Example photograph of ground-mounted solar arrays

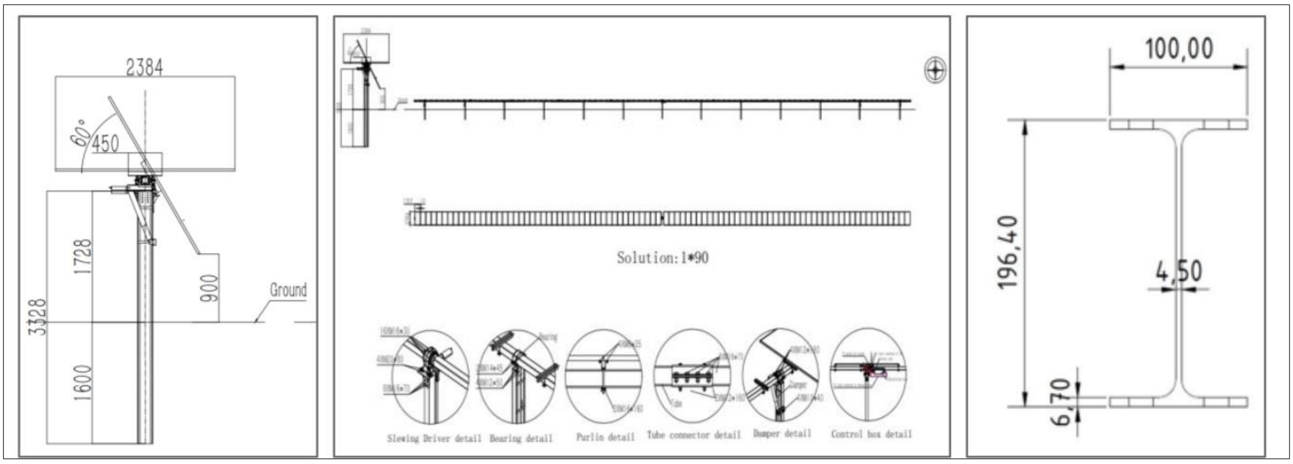


Figure 4: Example solar panel drawing (left and middle) & support pile cross-section (right)

A noteworthy feature of the (panel) design is the inclusion of adjustable mounting frames, which will enable the solar panels to pivot for optimal solar engagement throughout the day.

4 Stormwater Management Plan

The primary objective of a stormwater management plan is to manage stormwater runoff in such a way as to minimise flood damage and adverse effects on both the built and natural environments. The site is located under the Carterton District Council territorial authority and development with respect to stormwater in this area is guided by the following documents and standards:

- Carterton District Council, Code of Practice – Guidelines for Water Race Property Owners, January 2022
- NZS 4404:2010 Land development and subdivision infrastructure
- Acceptable Solutions and Verification Methods for New Zealand Building Code Clause E1 Surface Water, 1st Edition, amendment 11, dated 5 November 2020.

4.1 Existing Site Assessment

The existing site assessment includes an assessment of flow discharge from the Taratahi race to the site and the catchment response from the upstream catchment to the site as detailed in following sub-sections.

4.1.1 Flow from the Taratahi race

The Taratahi race bisects the site from north to south. Based on Carterton District Council information, the Taratahi race (270km long) takes 800 litres per second (l/s) from the Waingawa River when the river exceeds 3500 l/s at the gauging site, 480 l/s when the flow is between 1900-3500 l/s, 410 l/s when the flow is between 1700-1900l/s, and 337 l/s when the level at the gauging site is less than 1700 l/s.

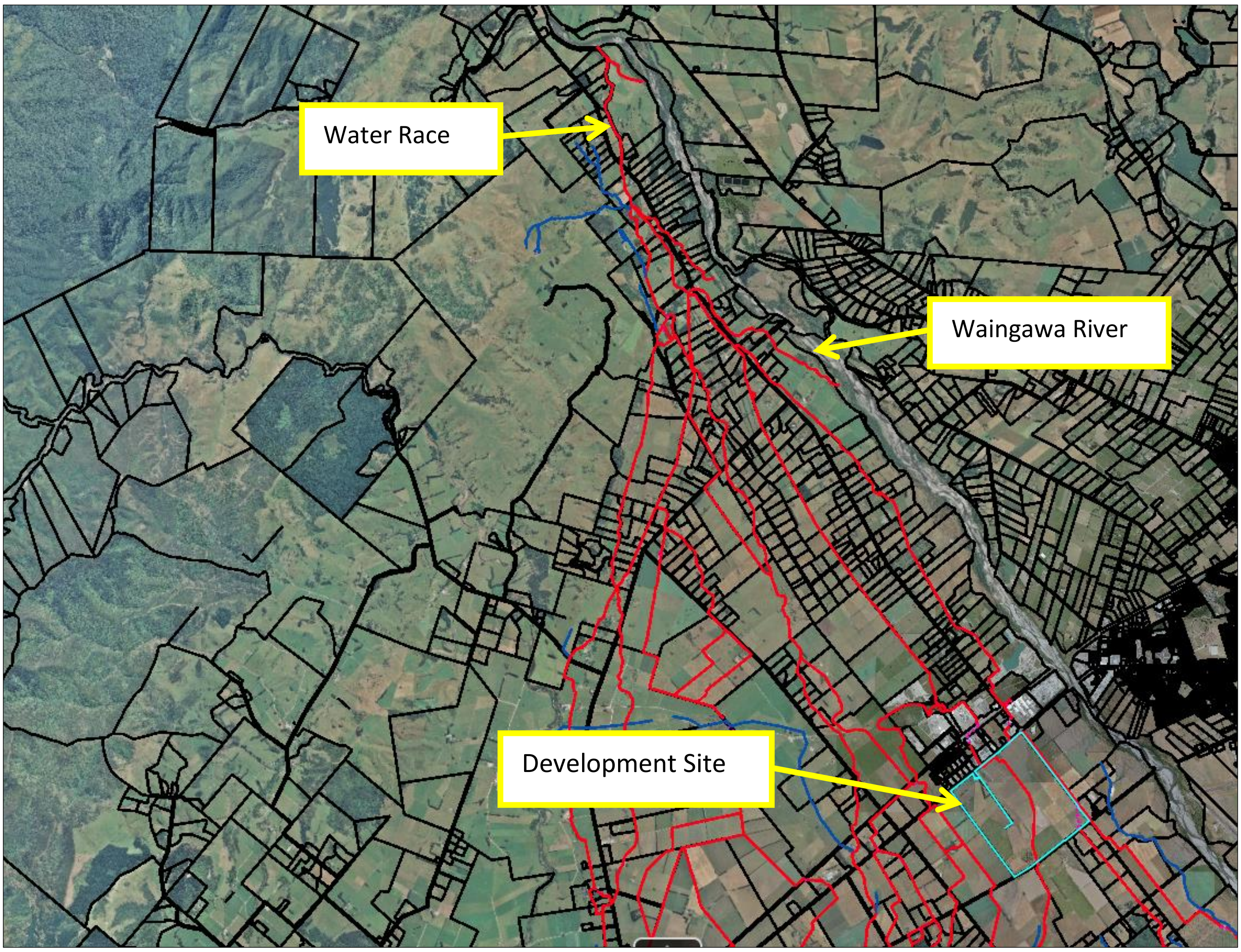


Figure 5: Taratahi race[3]

A site visit was conducted by CKL staff on 20th September. Based on the Land, Air, Water Aotearoa (LAWA) website, the flow rate of the Waingawa River at the time of the site visit was 11.2 m^3/s (refer to Figure 6), which means the river flow exceeded 3500L/s (3.5 m^3/s) at the time of the site visit. Therefore, 800L/s would have been entering the Taratahi Race on this day. Moreover, reviewing rainfall data (refer to Figure 7) confirms that there is minimal catchment response from rainfall at the time of the site visit as such the flow within the race would have been generated from the Waingawa River take.

[3] Wairarapa Maps- Water Services, assessed October 2023

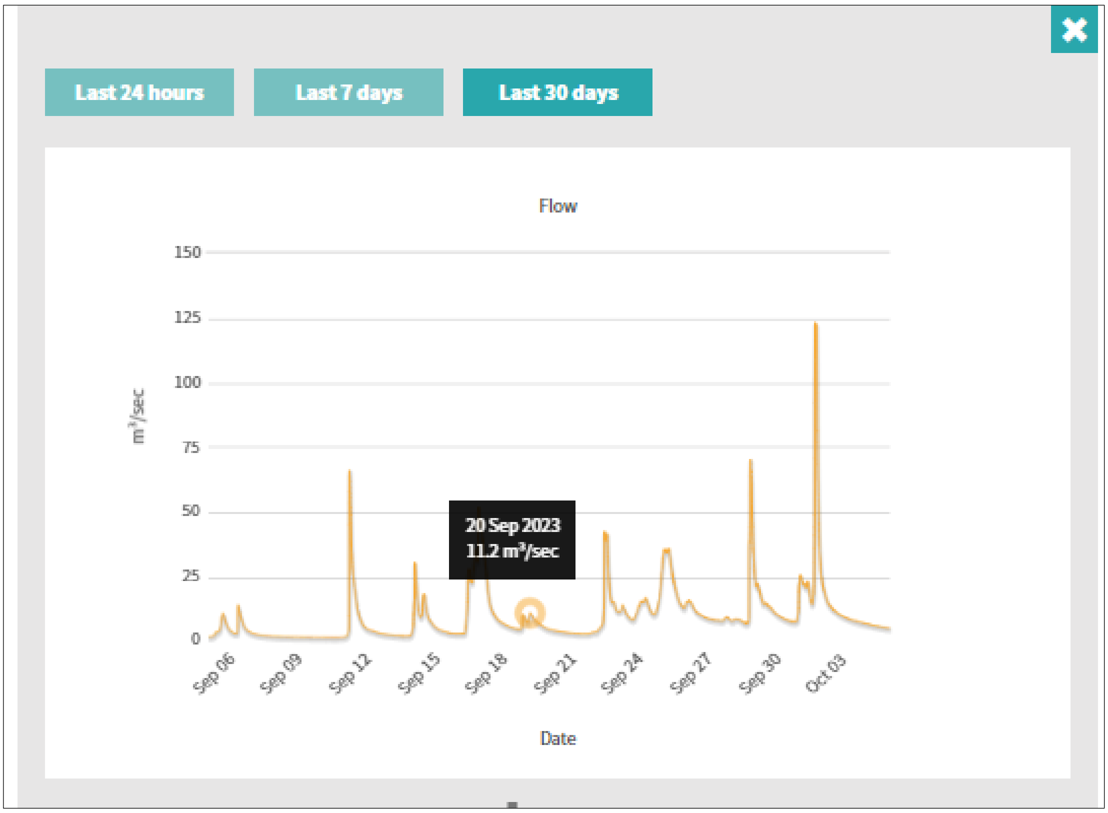


Figure 6: Flow rate at the time of CKL site visit[4]

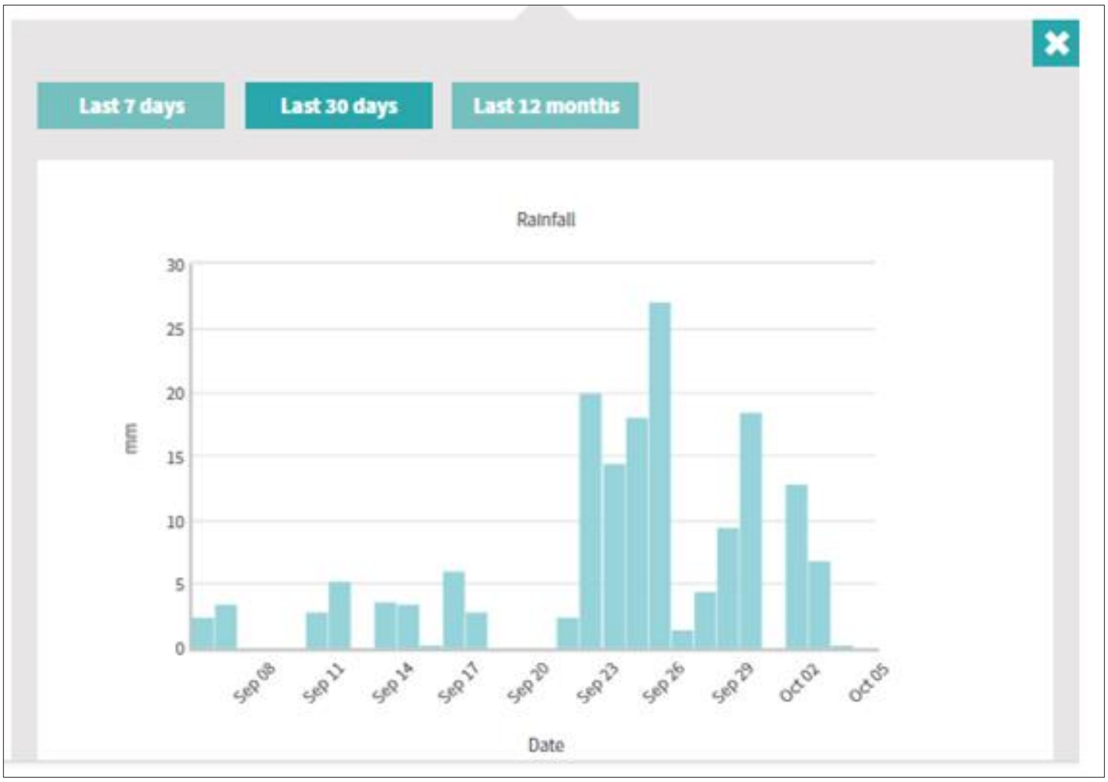


Figure 7: Rainfall depth at the time of CKL site visit[5]

[4] Source: www.lawa.org.nz, Flow Data, accessed in October 2023
[5] Source: www.lawa.org.nz, Rainfall Data, accessed in October 2023

4.1.2 Estimated flows within the site

The site includes several existing culverts that facilitate access for agricultural activities by traversing the established water race. This water race, traversing the property, has a 450mm diameter culverts at entry and exit points, with several internal culverts measuring 600mm in diameter. Within one of these 600mm internal culverts, the water depth has been recorded at 280mm up to the obvert level, indicating that the culvert is filled to 53% of its total height. This measurement allows for extrapolation to an estimated flow rate of 442L/s, which is exclusively derived from the Waingawa River take. This concludes that when the Taratahi Race receives 800L/s at its head, 442 L/s is measured within the site. Detailed calculations supporting this estimation can be found in Appendix 2.

4.1.3 Catchment response

A catchment analysis was conducted using the following background information:

- LINZ Wellington LiDAR 1m DEM (2013-2014),
- Wairarapa Maps; and
- Site visit photos.

Ten (10) sub-catchments were delineated for the OLFPs potentially affecting the site (referred to as sub-catchment 1, to sub-catchment 10). Figure 8 shows the OLFPs alignment and delineation of the sub-catchment areas.

Figure 8: Contributing catchment areas of OLFPs affecting the subject site

The outcome of the catchment delineation process reveals that Overland Flow Paths (OLFPs) associated with the sub-catchments labelled C1 through C3 are integral to the flow contribution toward the water race. In contrast, the OLFPs associated with sub-catchments C4 through C10 are directed away from the site, hence they do not feed into the water race's flow. Consequently, for the purposes of this assessment, only the sub-catchments C1 to C3 are taken into account.

Table 1 summarises the OLFP's characteristics, including the contributing catchment areas and the associated peak flow during 100yrCC rainfall events, taking into consideration the Maximum Probable Development (MPD) of the catchments. Supporting calculations are appended for reference (Appendix 2).

Table 1: OLFPs characteristics

OLFPs	Catchment Area (ha)	Zone	Impervious area (%) (MPD-assumed)	Peak Flow (100yrcc) (m^3/s)
Catchment of OLFP 1	13.63	Industrial	90	1.54
Catchment of OLFP 2	7.71	Industrial	90	0.87
Catchment of OLFP 3	38.26	Special Rural	15	2.01

4.1.4 Culvert capacity check

The above analysis indicates that during the extraction of 800 litres per second from the Waingawa River, the culvert is observed to operate above fifty per cent capacity.

Assessing the conveyance capacity of the 600mm diameter culvert reveals insufficient capacity even for a $2yr_{CC}$ ARI rainfall event for the upstream sub-catchments (C1 to C3) runoff. Consequently, the culvert will be overtopped during this rainfall event.

The overtopping of the culverts is likely to result in wide and shallow sheet flow. Detailed supportive calculations for this finding are provided in Appendix 2 for reference.

4.2 Proposed rainfall runoff regime – solar panels

The proposed site solar panel installation will alter the rainfall pattern prior to the runoff entering the site ground surface. As such whilst there is an alteration in the runoff arriving to the site the runoff regime across the surface itself remains the same as exiting. This is discussed further in the following subsection.

4.2.1 Runoff to the existing grassed areas

Whilst the panels themselves are considered impermeable, the ground below remains vegetated and permeable. Rain (stormwater) will runoff from the panels and fall to the ground, where it will either infiltrate into the soil or runoff as overland flow when the soils infiltration capacity is exceeded, or the soils are saturated.

An example photograph of one of the applicants existing solar farms is presented in Figure 4. This shows the gaps between solar panel arrays allow the water to runoff onto the ground, and that the natural groundcover can remain. Based on current estimates provided by the applicant, it is anticipated the spacing between solar panel arrays will be approximately 2.8 m.

Only minor earthworks associated with the access tracks are proposed for the development. No major grading or contouring of the site is proposed.

The solar panel tables will be raised above the ground, there will be no significant change in impermeable surface cover across the site, and the existing site water race will remain untouched. Therefore, the increase in stormwater generation will be no more than minor.

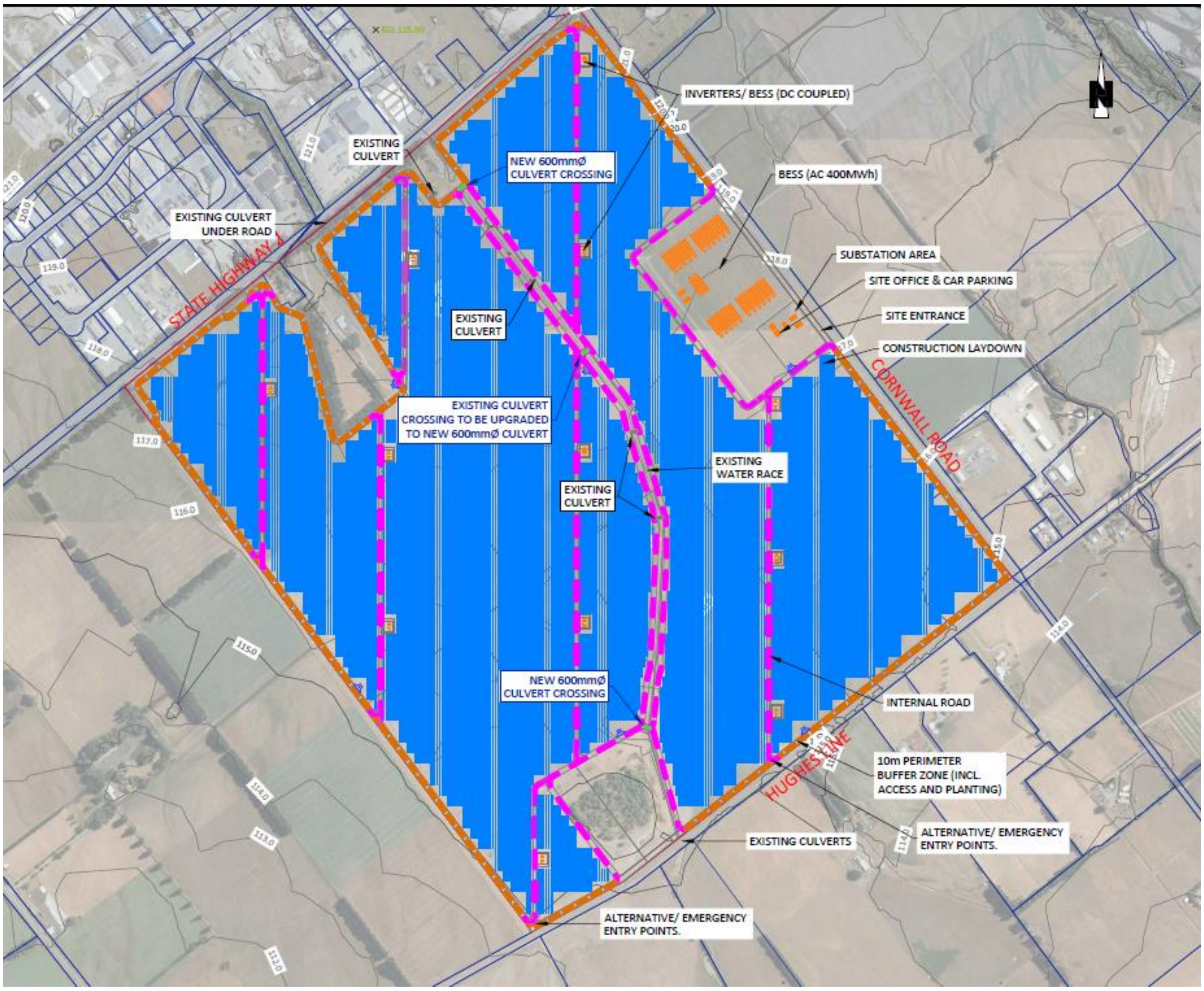


Figure 9: Overall layout access routes[6]

4.3 Amenity areas

An options assessment is completed below, taking into account the potential for connection to a public drainage network, the feasibility of soakage devices and the management of sheet flow discharge for the amenities associated with the project.

As indicated in the proposed site plan, the proposed development includes the construction of a site office, carparks and layout down area, and hard stand areas for substation and BESS units. An assessment has been conducted to size the soakage device. The size of the device for t per 1000m^2 of impervious area Table 2.

[6] Overall Layout, access routes, CKL, DWG No: 3000, Rev 3, dated 15/11/23.

Table 2: Soakage size per 1000m² of impervious area

Location	Contributing Catchment	Number of soakage trenches	Trench Base Area (m^2)	Soakage Trench Depth (m^2)	Drainage Metal Void Ratio (%)
Amenity areas (hardstand/roof etc) *	1000 m^2	1	50 m^2	1 m^2	38%

*Anti-clogging measures such as sediment chambers, catchpits, litter traps or leaf separators should be incorporated in the design of all soakage devices to minimise maintenance requirements and ensure the long-term operation of soakage devices.

The review of soil drainage characteristics using the S-Map Online resource reveals that the site features a heterogeneous mix of soil types, including well-drained, moderately well-drained, and poorly drained areas, as detailed in Figure 10. It is important to note that no onsite soakage tests have been performed; thus, the assessment relies on a presumed soakage rate of 500 mm/hour. It is strongly advised to conduct actual soakage testing to verify these assumptions and, if necessary, to recalibrate the assessment accordingly. In the event that the soakage capacity is found to be inadequate, the investigation of alternative discharge methods will be needed.

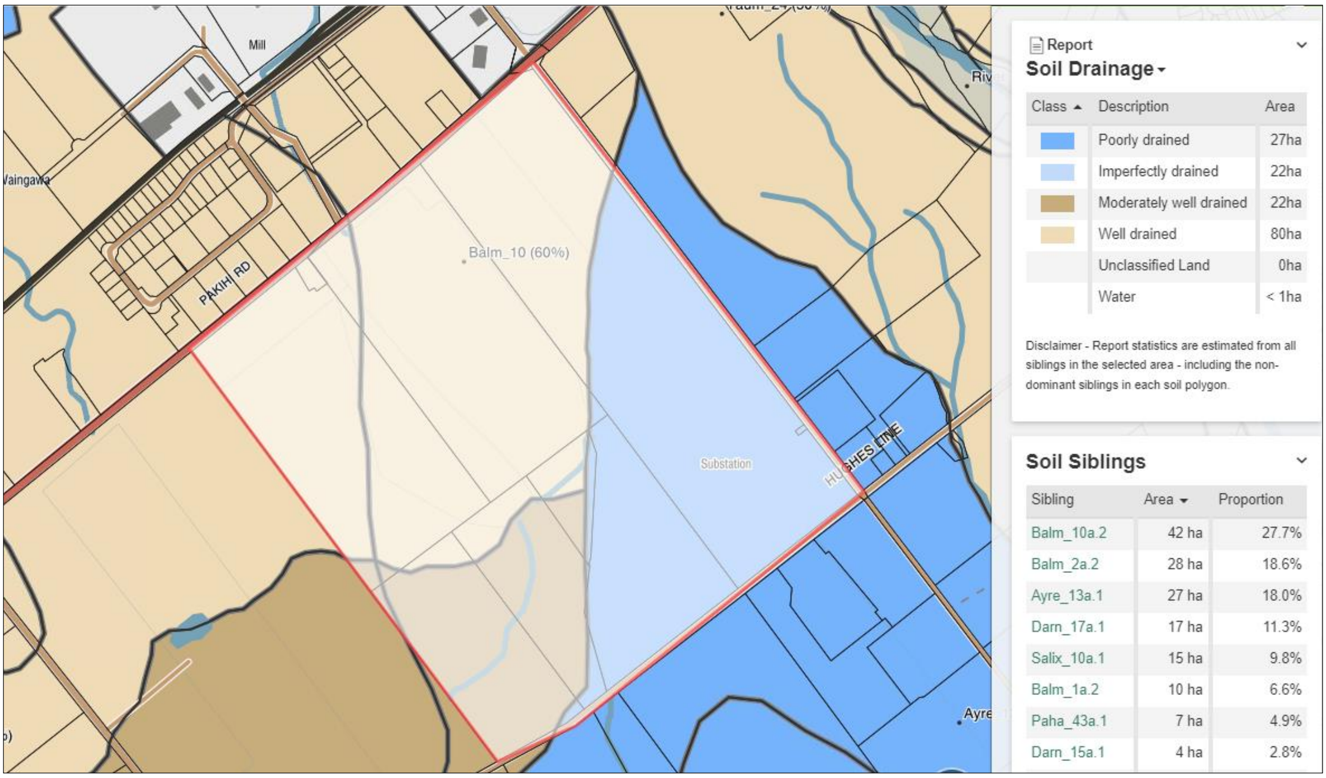


Figure 10: S-MAP Online[7]

[7] Accessed November 2023

4.4 Stormwater Treatment Assessment

The surface runoff that could potentially require treatment due to contaminant generation is the runoff from amenity areas. The proposed site office cladding (for roof and walls) is to be non-contaminate generating material. As a result, the total site office is considered as a low contaminant generating area/activity and as such the standard cesspit collection and cladding choice will provide sufficient treatment mitigation for this site.

The impervious areas of the carparks were not confirmed at the time of this investigation. However, parking areas are considered as low traffic volume areas and no additional treatment devices are proposed for parking areas. Anti-clogging measures such as sediment chambers and catchpits is sufficient to minimise maintenance requirements and ensure long-term operation of the soakage device.

4.5 Proposed site development within potential contaminated zone

An analysis of the online resources provided by the MDC – District Plans reveals that the proposed location for the solar panel installation partially overlaps with an area designated as contaminated, as detailed in Figure 11. Further investigation is necessary to ascertain the specific nature of the contamination. Despite this, it is pertinent to mention that the installation of the solar panels, which will be mounted on piles, is not expected to expand the impervious surface of the site. Consequently, the development of the solar panel facility is unlikely to exacerbate any adverse environmental impacts on the downstream regions stemming from the contamination site.

Figure 11: Contaminated site[8]

[8] Wairarapa Maps- District Plan, assessed October 2023

5 Culvert crossings: assessment against NES:F

The proposed culvert crossings are designed to facilitate fish passage while maintaining the existing flow dynamics, without causing erosion or scour.

An evaluation based on the NES-F[9] standard, specifically Clause 70, was conducted. According to this standard, the diameter of the culvert should be 1.3 times the stream bed width to meet the criteria for permitted activities. Whilst this can be accommodated where the stream banks are laid back, within the majority of the site a water race with steep sides is present. Therefore, the possibility of accommodating this permitted activity threshold is no present. Consequently, the most practical and environmentally responsible approach is to adhere to the initially stated design criteria, which aims to prevent any adverse environmental impacts.

6 Best Practicable Stormwater Management Option

Based on the options assessment, the best practicable options to manage stormwater runoff from the site are presented in Figure 12 below.

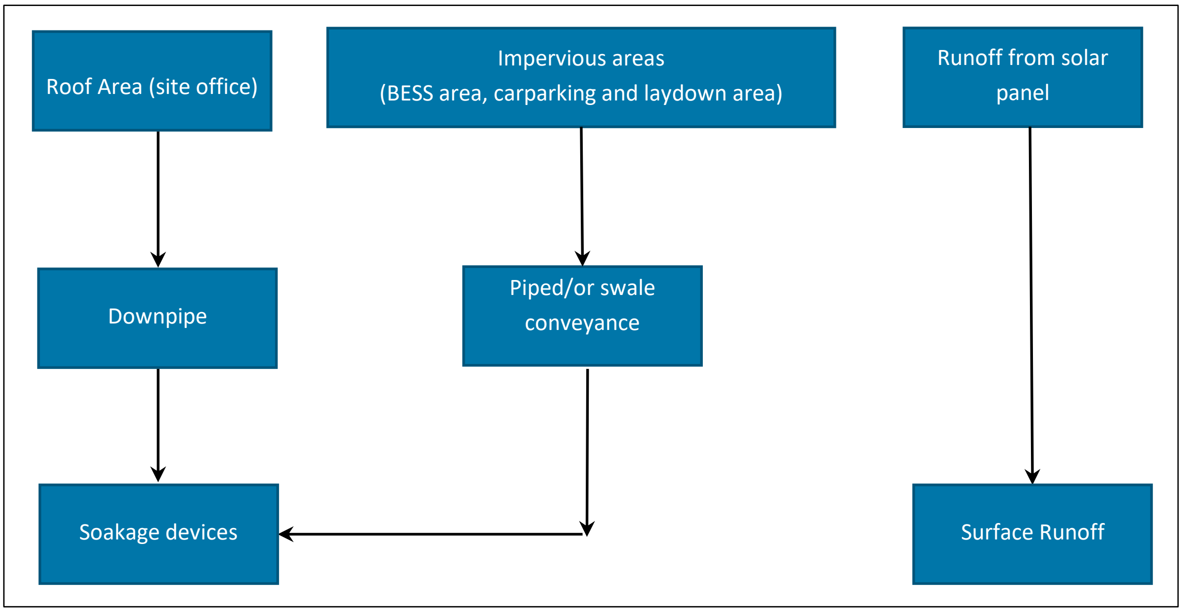


Figure 12: Best Practicable stormwater management option

[9] National Environmental Standards for Freshwater, Version as at 21 September 2023

7 Flood Risk Assessment

No specific flood modelling has been conducted for the site. However, a review of the Masterton District Council's Flood Zones maps available online suggests that the subject site does not fall within the 50-year flood zones of the Wairarapa Zones, as illustrated in Figure 4.

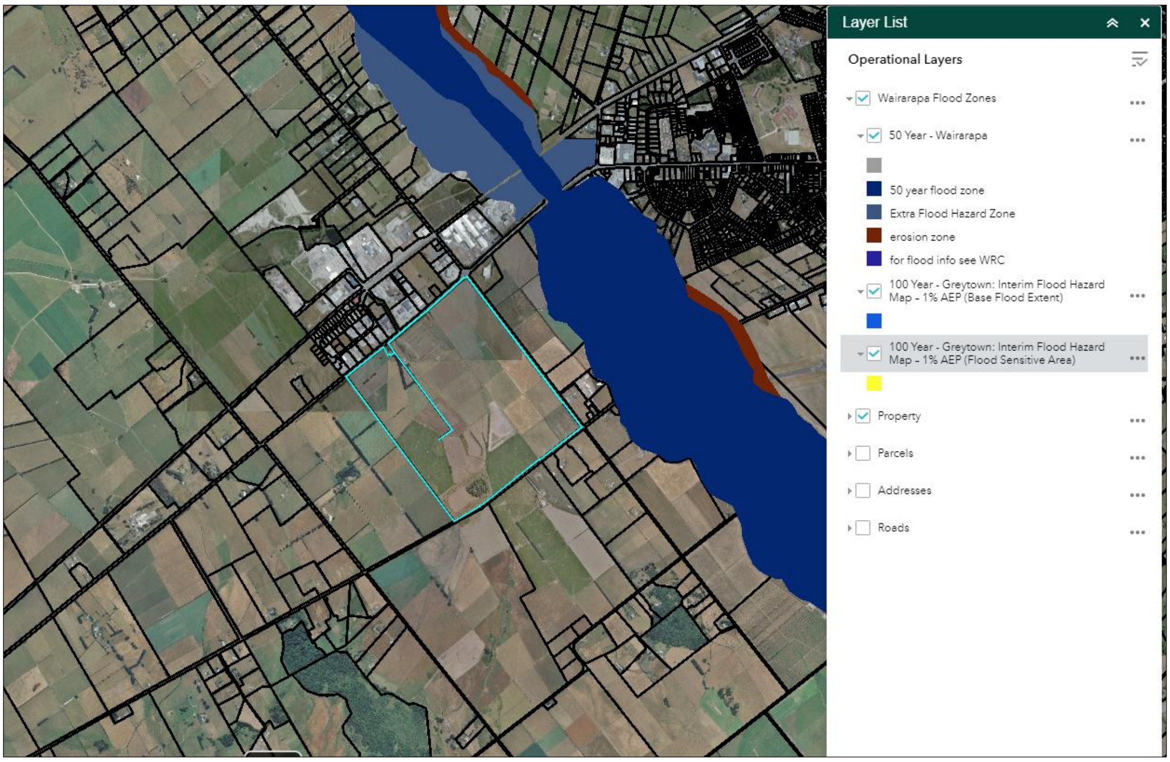


Figure 13: Flood Zones[10]

7.1 Flood Hazard Assessment

The assessment indicates that the currently existing 600mm internal culvert will be overtopped during 2yrCC rainfall events. While the proposal suggests upgrading the existing northern and southern culverts along the north/south water race with new pipes—as detailed in the infrastructure report—to bolster the crossing points for heavy vehicle traffic, it is important to note that this measure will not address the current flooding concerns associated with the internal culverts. These issues remain unaltered in the proposed condition.

The effect of overtopping/undersized culverts can be mitigated by appropriate culvert design, including headwalls.

[10] Wairarapa Maps- Flood Zones, assessed October 2023

8 Summary

This report, prepared by CKL NZ Ltd, supports a resource consent application for a proposed solar farm at Masterton and includes a stormwater management plan. The site is 147.3 hectares in a Special Rural Zone, currently used for stock grazing, and features a water race and minimal structures. The proposed 138ha agrivoltaic development, also known as a solar farm, will have a 91,758 kW DC capacity with essential infrastructure and adjustable solar panels.

Stormwater management strategy has the overarching aim to minimise adverse environmental effects. The site's stormwater runoff is managed by existing culverts, but the capacity is insufficient for conveyance of flow during a $2yr_{CC}$ rainfall event, posing surface flow and potential flood risks. Soakage devices are considered for managing stormwater, with the design including anti-clogging measures and soil infiltration evaluation, although actual onsite testing is recommended, associated with the amenity facilities such as roof areas and carparks.

The solar panels, whilst interrupting the rainfall deposition to the ground surface, does not result in the change in surface flow patterns of the runoff. As such the runoff crosses the ground surface and results in minimal change in runoff volume to the receiving environment, which it will either infiltrate into the soil or runoff as overland flow when the soils infiltration capacity is exceeded, or the soils are saturated. The solar panel tables will be raised above the ground, there will be no significant change in impermeable surface cover across the site, and the existing site water race will remain untouched. Therefore, the increase in stormwater generation will be no more than minor.

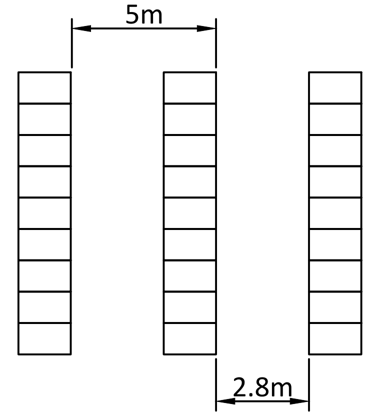
The site office's cladding will be non-contaminant generating, and parking areas are considered low traffic, requiring no additional treatment devices. A contaminated site overlap requires further investigation, but solar panel installation is unlikely to exacerbate adverse impacts. Flood risk assessment indicates the site does not fall within a 50-year flood zone, but existing culverts will likely be overtopped during $2yr_{CC}$ events, suggesting a need for a culvert redesign to mitigate flood risks.

9 Limitations

This report has been prepared solely for the benefit of our client with respect to the particular brief and it may not be relied upon in other contexts for any other purpose without the express approval by CKL. Neither CKL nor any employee or sub-consultant accepts any responsibility with respect to its use, either in full or in part, by any other person or entity. This disclaimer shall apply notwithstanding that the report may be made available to other persons including Council for an application for consent, approval or to fulfil a legal requirement.

Appendix 1 Drawings

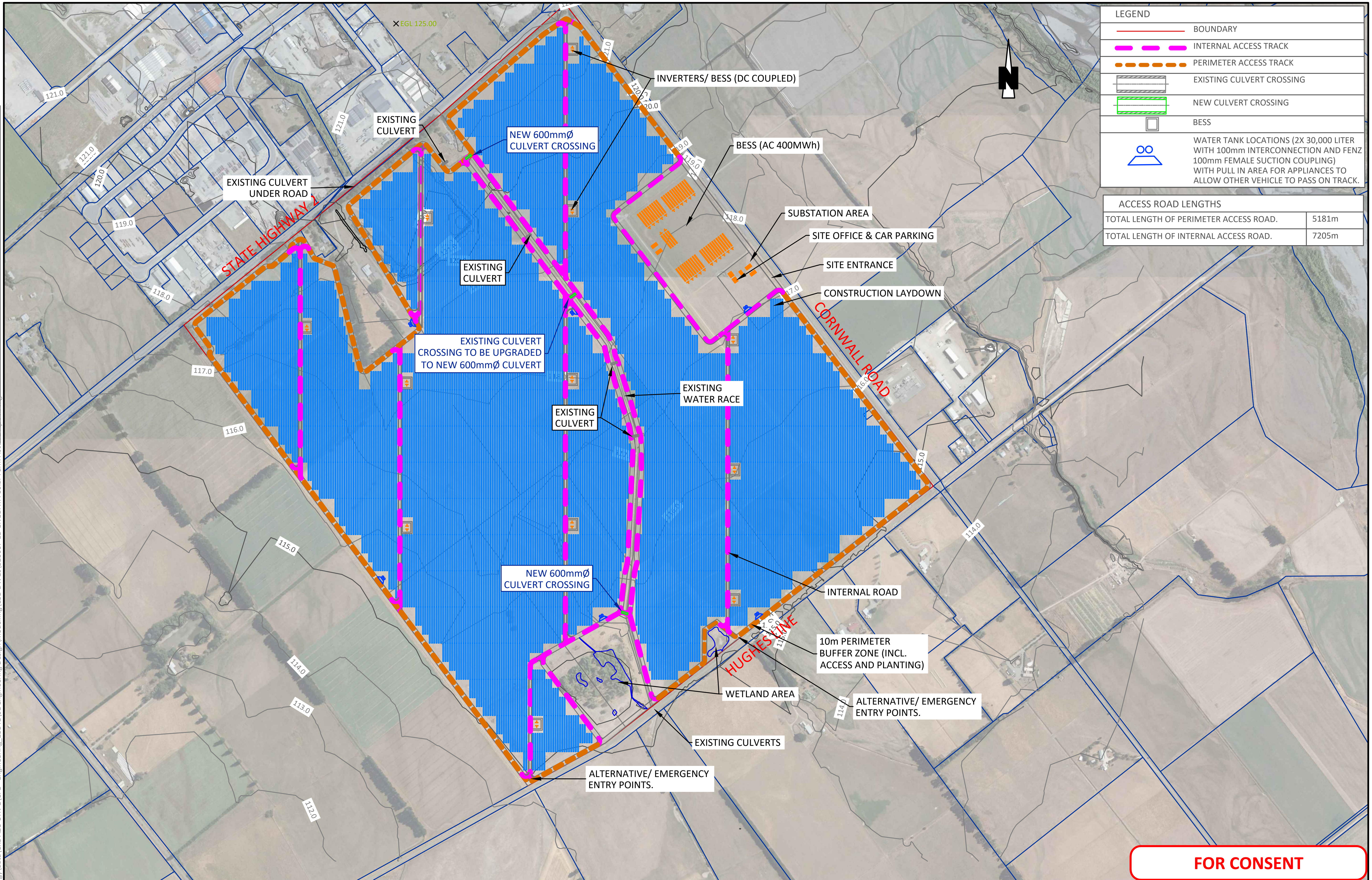
Panel Frame Layout



Title	Plot Plan
Project	Masterton
Location	Cornwall Road Masterton New Zealand
DC Capacity	95,090 kW
-	-

NZ Clean Energy
Email: projects@nzcleanenergy.nz
Web: www.nzcleanenergy.nz

Drawing prepared by Project Delivery Services



LEGEND

- BOUNDARY
- INTERNAL ACCESS TRACK
- PERIMETER ACCESS TRACK
- EXISTING CULVERT CROSSING
- NEW CULVERT CROSSING
- BESS
- WATER TANK LOCATIONS (2X 30,000 LITER WITH 100mm INTERCONNECTION AND FENZ 100mm FEMALE SUCTION COUPLING) WITH PULL IN AREA FOR APPLIANCES TO ALLOW OTHER VEHICLE TO PASS ON TRACK.

ACCESS ROAD LENGTHS	
TOTAL LENGTH OF PERIMETER ACCESS ROAD.	5181m
TOTAL LENGTH OF INTERNAL ACCESS ROAD.	7205m

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CORNWALL ROAD, MASTERTON

OVERALL LAYOUT ACCESS ROUTES

Issue	Description	Checked	Date
1	Culverts amended	GCW	13.10.23
2	Revised Layout	GCW	06.11.23
3	Revised Layout	GCW	08.11.23
4	Culverts amended	GCW	14.11.23
5	Track amended around Wetland	GCW	29.11.23

		Date
Designed:	RRC	09.10.23
Drawn:	RRC	09.10.23
Checked:	GCW	09.10.23

Scale: 1:7500 (A3 Original)

Job No: B23067 Dwg No: 3000 Rev: 5

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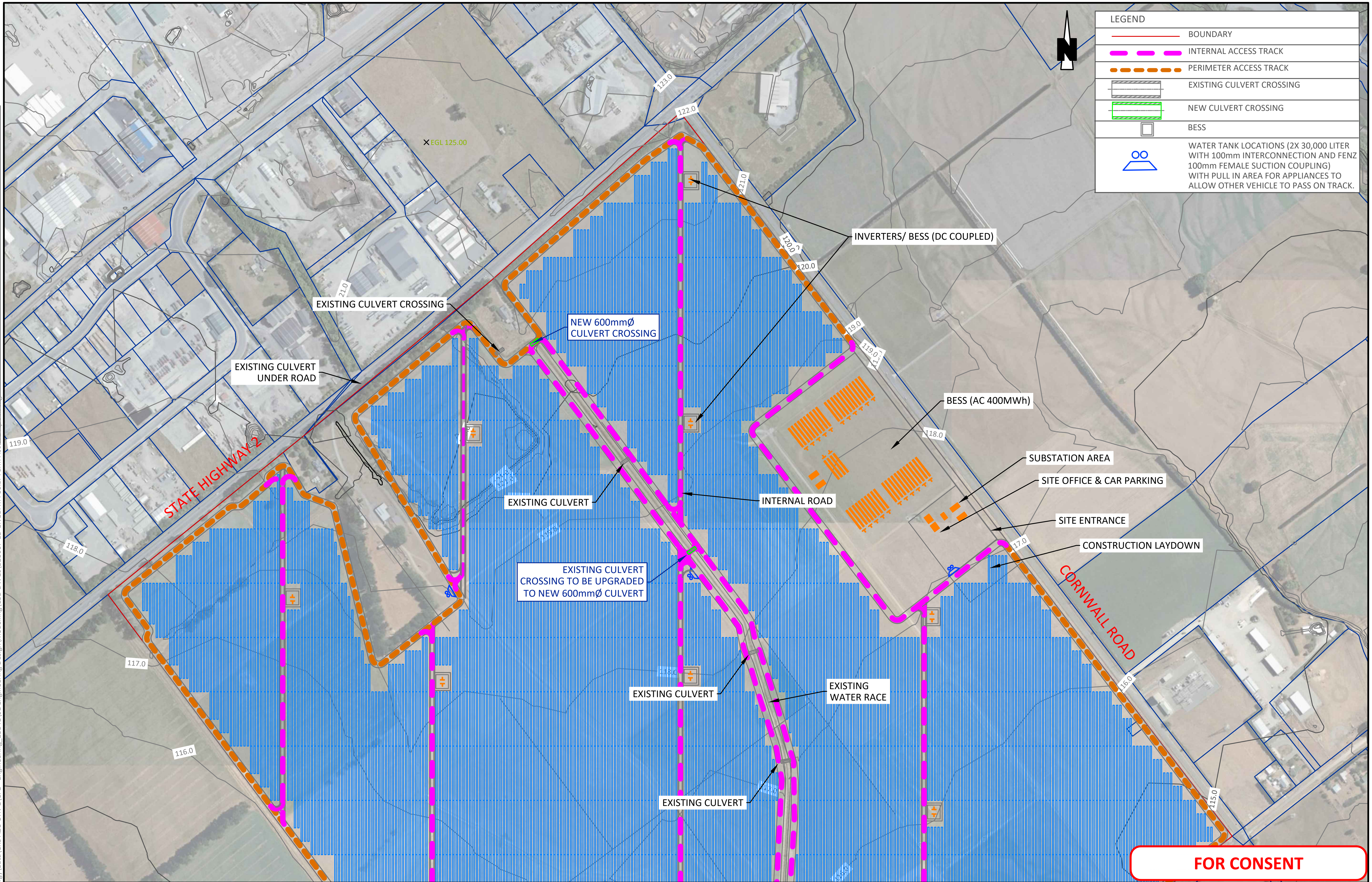

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SITE LAYOUT SHEET 1
ACCESS ROUTES

Issue	Description	Checked	Date
1	Culverts amended	GCW	13.10.23
2	Revised Layout	GCW	06.11.23
3	Revised Layout	GCW	08.11.23
4	Culverts amended	GCW	15.11.23

		Date
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Checked:	GCW	09.10.23

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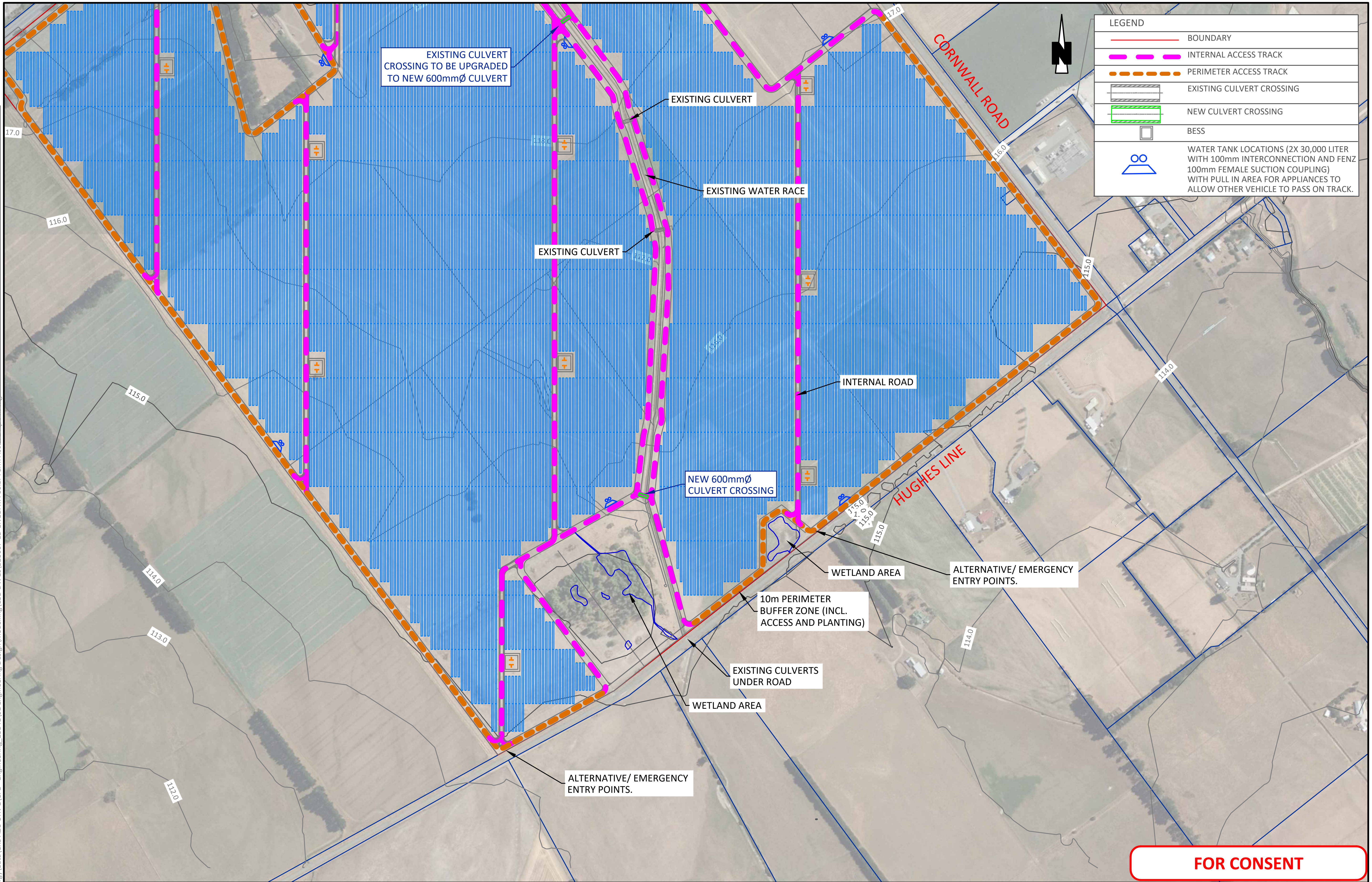
Job No:	Dwg No:	Rev:
B23067	3001	4



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SITE LAYOUT SHEET 2
ACCESS ROUTES

Issue	Description	Checked	Date
1	Culverts amended	GCW	13.10.23
2	Revised Layout	GCW	06.11.23
3	Revised Layouts	GCW	18.11.2023
4	Culverts amended	GCW	15.11.23
5	Track amended around wetland	GCW	29.11.23

		Date
Designed:	RRC	09.10.23
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Checked:	GCW	09.10.23

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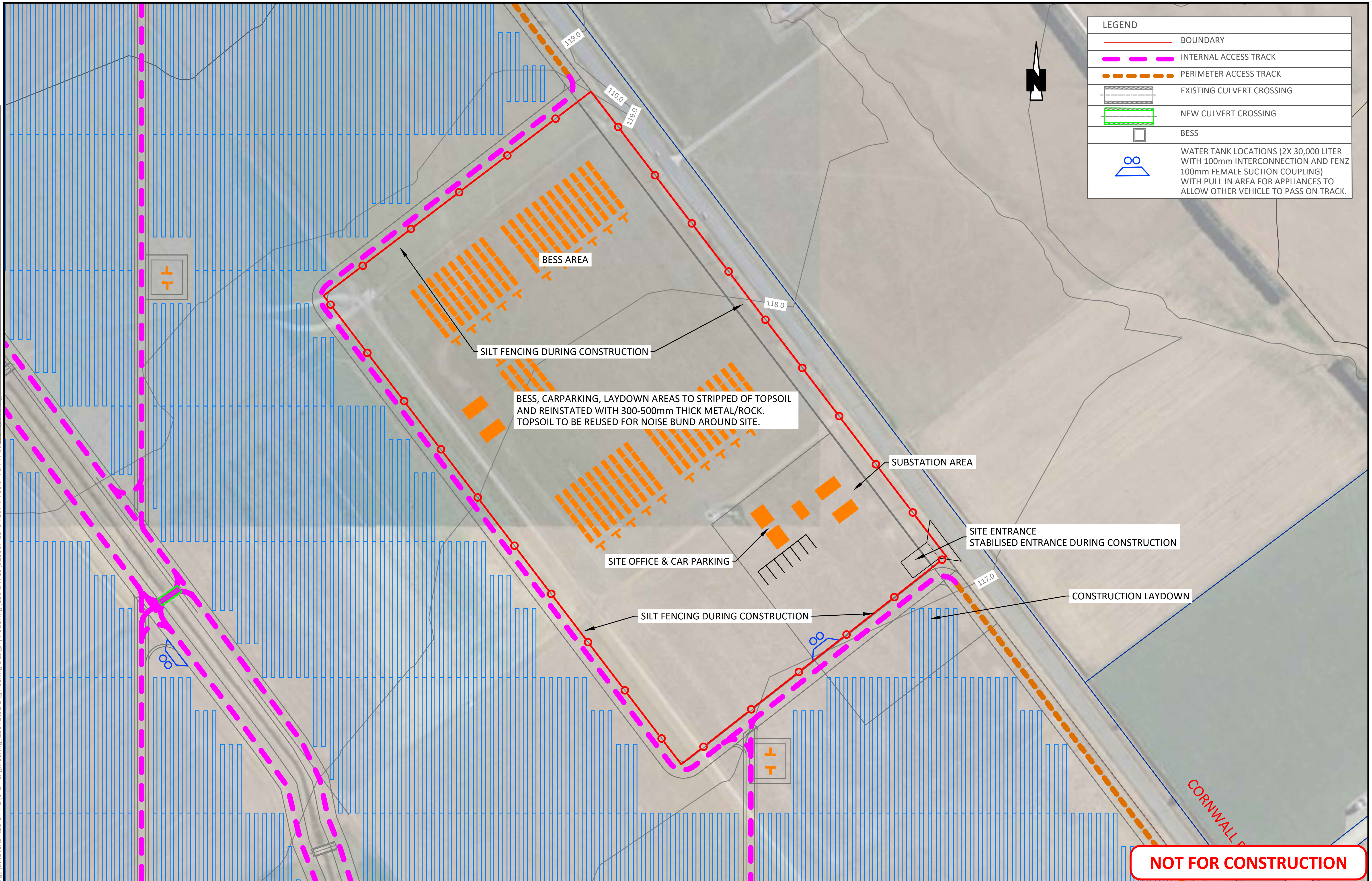
Job No: B23067 | Dwg No: 3002 | Rev: 5



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SITE LAYOUT SHEET 3
ACCESS ROUTES
OFFICE/ CAR PARK AREA

Issue	Description	Checked	Date
1	Revised Layout	GCW	06.11.23
2	Revised Layout	GCW	08.11.23
3	Culverts amended	GCW	15.11.23

		Date
Designed:	RRC	09.10.23
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Checked:	GCW	09.10.23

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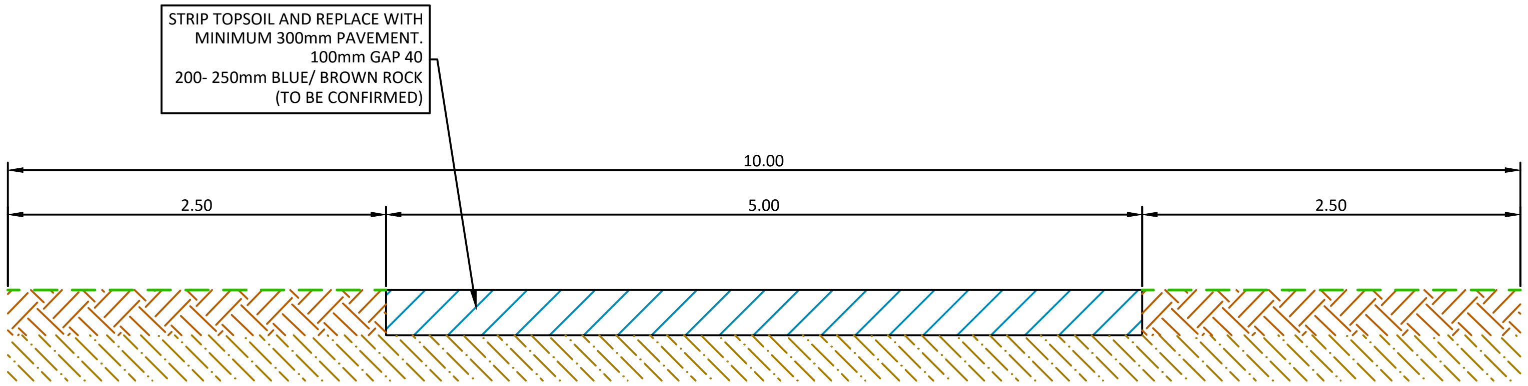
Job No: B23067 | Dwg No: 3003 | Rev: 3



INTERNAL SERVICE/ ACCESS TRACK
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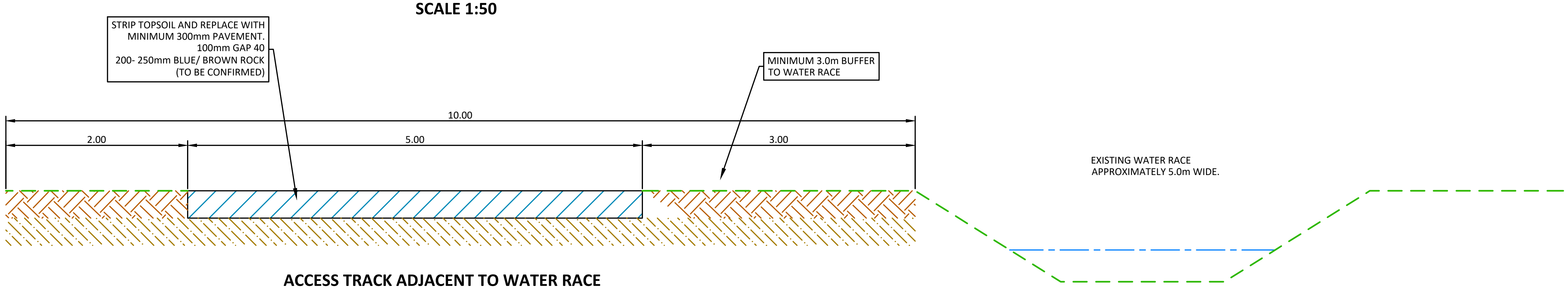
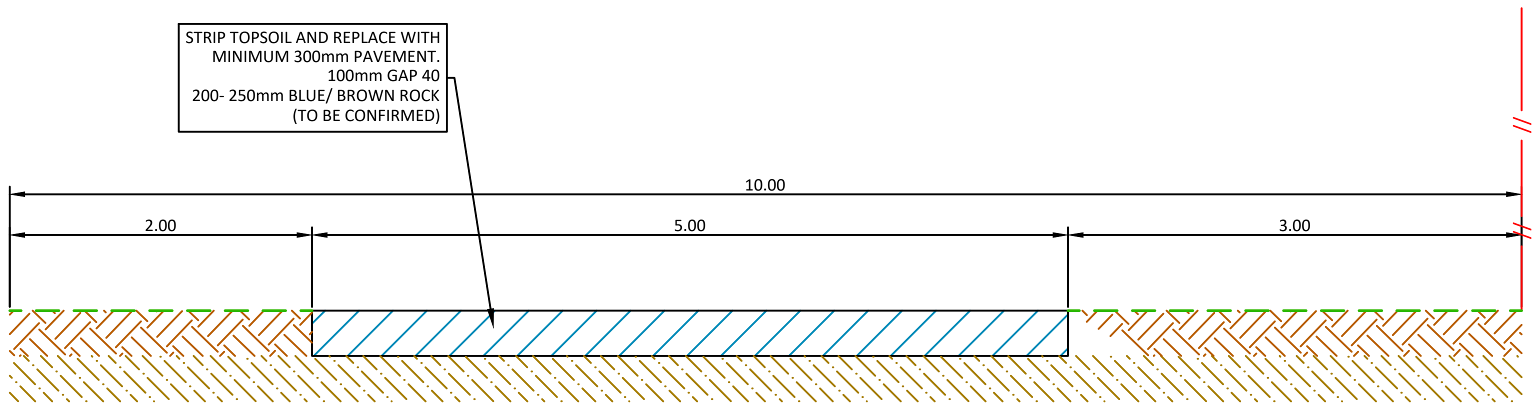


ACCESS TRACK ADJACENT TO WATER RACE
SCALE 1:50



PERIMETER SERVICE/ ACCESS TRACK
SCALE 1:50

FOR COSENT

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TYPICAL SECTIONS
ACCESS ROUTES

Issue	Description	Checked	Date
1	Additional section added	GCW	13.10.23

		Date
Designed:	RRC	09.10.23
Drawn:	RRC	09.10.23
Checked:	GCW	09.10.23

Scale: **1:50** (A3 Original)

Job No:	Dwg No:	Rev:
B23067	**3004**	**1**

Appendix 2 Calculation Summary

Client : **NZ Clean Energy Ltd**
Site address : **3954A State Highway 2, Masterton**
Job name : **HN - Engineering - Civil Design - Masterton**
Job number : **B23067**

File Name B23067-EV- -Pipe capacity check.xlsx
Sheet Name Pipe Network Capacity

Date 2/11/2023
By MB

Checked KW

Catchment Breakdowns and Peak Flow Calculation for Existing Pipe Network

Assumptions:

Runoff Coefficient (c): c=0.95 for roof
c=0.9 for driveway
c=0.3 for permeable surafces

Roughness factor (k): k = 0.6 (conservative value for existing concrete & plastic pipes)
See NZS4404 Table 4.2 for more details

Design rainfall: 2yr 10min +CC 49 mm/hr
Design rainfall: 10yr 10min +CC 81 mm/hr

Colebrook-White Equation for Pipe Velocity

$$V = -2\sqrt{2g \cdot D \cdot S_f} \cdot log\left(\frac{k_s}{3,70 \cdot D} + \frac{2,51 \cdot \upsilon}{D\sqrt{2g \cdot D \cdot S_f}}\right)$$

with $S_f = \frac{h_f}{L}$

V =	mean velocity	[m/s]
D =	Hydraulic Diameter	[m]
k_s =	surface roughness	[m]
υ =	Kinematic viscosity water, 20°C= $1,00 \cdot 10^{-6}$	[kg/ms]
S_f =	slope of hydraulic gradient	[-]
h_f =	frictional head loss	[m]
L =	Length between the Head Loss	[m]
g =	earths gravity	[m/s^2]

Catchment Details - 2yr 10min +CC

Catchment	Description	Area	% Impervious	% Pervious	Weighted "c"	Peak Flow from Catchment (L/s)	
C1	Industrial Zone	136301	90%	10%	0.84	1543.71	13.63
C2	Industrial Zone	77144	90%	10%	0.84	873.71	7.71
C3	Special Rural zone	382649	15%	85%	0.39	2012.11	38.26
						4429.53	

Catchment Details - 10yr 10min +CC

C1	Industrial Zone	136301	90%	10%	0.84	2571.78
C2	Industrial Zone	77144	90%	10%	0.84	1455.59
C3	Special Rural zone	382649	15%	85%	0.39	3352.13
						7379.50

Pipe Capacity

Pipe	Roughness Factor	Pipe size(mm)	Pipe Slope (%)	Velocity (m/sec)	Capacity (Q = VA)	Peak Flow from Catchment (L/s)	Does pipe have sufficient capacity?
A- 2yr 10min +CC	1.5	600	1.82	**2.93**	**827.5**	**4429.5**	**NO**
A- 10yr 10min +CC	1.5	600	1.82	**2.93**	**827.5**	**7379.5**	**NO**

HIRDS V4 Intensity-Duration-Frequency Results

Sitename: Custom Location

Coordinate system: WGS84

Longitude: 175.6004

Latitude: -40.974

DDF Model Parameters		c	d	e	f	g	h	i
	Values:	-0.00756	0.474824	0.022709	-0.0065	0.272862	-0.00957	2.45292
	Example:	Duration (hrs)	ARI (yrs)	x	y	Rainfall Rate (mm/hr)		
		24	100	3.178054	4.600149	5.73577		

Rainfall intensities (mm/hr) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	33.2	21.4	16.9	11.6	8.14	4.7	3.28	2.23	1.47	1.12	0.914	0.775
2	0.5	36.9	23.8	18.7	12.8	8.98	5.16	3.6	2.45	1.6	1.22	0.997	0.845
5	0.2	50	32	25.2	17.1	11.9	6.79	4.7	3.18	2.07	1.57	1.28	1.08
10	0.1	60.4	38.5	30.2	20.5	14.2	8.02	5.54	3.73	2.42	1.83	1.49	1.26
20	0.05	71.6	45.4	35.6	24	16.6	9.33	6.41	4.3	2.78	2.1	1.71	1.44
30	0.033	78.6	49.8	38.9	26.2	18.1	10.1	6.95	4.65	3	2.27	1.84	1.55
40	0.025	83.7	53	41.4	27.8	19.1	10.7	7.34	4.9	3.16	2.38	1.93	1.63
50	0.02	87.9	55.5	43.4	29.1	20	11.2	7.64	5.1	3.28	2.48	2	1.69
60	0.017	91.3	57.7	45	30.2	20.7	11.6	7.9	5.27	3.38	2.55	2.06	1.74
80	0.013	96.9	61.1	47.6	31.9	21.9	12.2	8.31	5.53	3.55	2.67	2.16	1.82
100	0.01	101	63.9	49.7	33.3	22.8	12.7	8.62	5.74	3.67	2.77	2.24	1.88
250	0.004	121	75.6	58.8	39.1	26.7	14.7	9.97	6.6	4.2	3.16	2.55	2.14

Intensity standard error (mm/hr) :: Historical Data

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	0.91	1.6	1.2	0.72	0.43	0.31	0.28	0.064	0.083	0.082	0.067	0.036
2	0.5	0.73	1.7	1.3	0.77	0.46	0.34	0.31	0.065	0.09	0.091	0.073	0.038
5	0.2	2.5	2.8	2.2	1.2	0.74	0.49	0.43	0.13	0.13	0.13	0.1	0.058
10	0.1	4.6	4.3	3.3	1.9	1.1	0.68	0.56	0.2	0.17	0.17	0.13	0.081
20	0.05	7.5	6.5	4.8	2.8	1.7	0.95	0.74	0.3	0.23	0.22	0.17	0.11
30	0.033	9.7	8.2	6	3.4	2.1	1.2	0.87	0.38	0.27	0.25	0.2	0.13
40	0.025	11	9.5	7	4	2.5	1.3	0.98	0.43	0.3	0.28	0.22	0.15

50	0.02	13	11	7.8	4.5	2.8	1.5	1.1	0.48	0.33	0.3	0.24	0.16
60	0.017	14	12	8.6	4.9	3.1	1.6	1.1	0.52	0.36	0.32	0.26	0.18
80	0.013	17	14	9.9	5.7	3.6	1.8	1.3	0.59	0.4	0.36	0.28	0.2
100	0.01	19	15	11	6.4	4	2	1.4	0.65	0.43	0.38	0.31	0.22
250	0.004	29	24	17	9.9	6.3	2.9	2	0.94	0.61	0.52	0.42	0.3

Rainfall intensities (mm/hr) :: RCP2.6 for the period 2031-2050

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	35.6	22.9	18.1	12.4	8.68	4.96	3.43	2.33	1.52	1.15	0.94	0.796
2	0.5	39.5	25.5	20.1	13.8	9.59	5.46	3.78	2.55	1.66	1.26	1.03	0.869
5	0.2	53.8	34.4	27.1	18.4	12.8	7.21	4.96	3.32	2.15	1.63	1.32	1.12
10	0.1	65	41.5	32.5	22	15.2	8.54	5.85	3.91	2.52	1.9	1.54	1.3
20	0.05	77.2	49	38.4	25.9	17.8	9.94	6.78	4.51	2.9	2.19	1.77	1.49
30	0.033	84.8	53.7	42	28.3	19.4	10.8	7.35	4.88	3.13	2.36	1.9	1.6
40	0.025	90.4	57.2	44.7	30	20.6	11.4	7.77	5.15	3.29	2.48	2	1.68
50	0.02	94.9	60	46.8	31.5	21.5	11.9	8.09	5.36	3.42	2.58	2.08	1.75
60	0.017	98.6	62.3	48.6	32.6	22.3	12.3	8.36	5.53	3.53	2.66	2.14	1.8
80	0.013	105	66	51.5	34.5	23.6	13	8.8	5.81	3.7	2.78	2.24	1.88
100	0.01	110	69	53.7	36	24.5	13.5	9.14	6.03	3.84	2.88	2.32	1.95
250	0.004	130	81.7	63.5	42.3	28.7	15.7	10.6	6.93	4.39	3.29	2.64	2.22

Rainfall intensities (mm/hr) :: RCP2.6 for the period 2081-2100

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	35.6	22.9	18.1	12.4	8.68	4.96	3.43	2.33	1.52	1.15	0.94	0.796
2	0.5	39.5	25.5	20.1	13.8	9.59	5.46	3.78	2.55	1.66	1.26	1.03	0.869
5	0.2	53.8	34.4	27.1	18.4	12.8	7.21	4.96	3.32	2.15	1.63	1.32	1.12
10	0.1	65	41.5	32.5	22	15.2	8.54	5.85	3.91	2.52	1.9	1.54	1.3
20	0.05	77.2	49	38.4	25.9	17.8	9.94	6.78	4.51	2.9	2.19	1.77	1.49
30	0.033	84.8	53.7	42	28.3	19.4	10.8	7.35	4.88	3.13	2.36	1.9	1.6
40	0.025	90.4	57.2	44.7	30	20.6	11.4	7.77	5.15	3.29	2.48	2	1.68
50	0.02	94.9	60	46.8	31.5	21.5	11.9	8.09	5.36	3.42	2.58	2.08	1.75
60	0.017	98.6	62.3	48.6	32.6	22.3	12.3	8.36	5.53	3.53	2.66	2.14	1.8
80	0.013	105	66	51.5	34.5	23.6	13	8.8	5.81	3.7	2.78	2.24	1.88
100	0.01	110	69	53.7	36	24.5	13.5	9.14	6.03	3.84	2.88	2.32	1.95
250	0.004	130	81.7	63.5	42.3	28.7	15.7	10.6	6.93	4.39	3.29	2.64	2.22

Rainfall intensities (mm/hr) :: RCP4.5 for the period 2031-2050

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	36.2	23.3	18.4	12.6	8.82	5.02	3.47	2.35	1.53	1.16	0.946	0.801
2	0.5	40.2	25.9	20.4	14	9.75	5.54	3.82	2.58	1.67	1.27	1.03	0.875
5	0.2	54.7	35	27.6	18.7	13	7.31	5.02	3.36	2.17	1.65	1.33	1.13
10	0.1	66.2	42.2	33.1	22.4	15.5	8.67	5.93	3.95	2.54	1.92	1.56	1.31
20	0.05	78.6	49.9	39.1	26.4	18.1	10.1	6.88	4.56	2.93	2.21	1.78	1.5
30	0.033	86.3	54.7	42.8	28.8	19.8	11	7.45	4.94	3.16	2.38	1.92	1.62
40	0.025	92	58.2	45.5	30.6	21	11.6	7.88	5.21	3.33	2.5	2.02	1.7
50	0.02	96.7	61.1	47.7	32	21.9	12.1	8.2	5.42	3.46	2.6	2.1	1.76
60	0.017	100	63.4	49.5	33.2	22.7	12.5	8.48	5.6	3.57	2.68	2.16	1.82
80	0.013	107	67.3	52.4	35.1	24	13.2	8.92	5.88	3.74	2.81	2.26	1.9
100	0.01	112	70.3	54.7	36.6	25	13.7	9.27	6.1	3.88	2.91	2.34	1.97
250	0.004	133	83.3	64.7	43.1	29.2	15.9	10.7	7.02	4.44	3.32	2.67	2.24

Rainfall intensities (mm/hr) :: RCP4.5 for the period 2081-2100

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	38	24.5	19.4	13.3	9.25	5.23	3.6	2.42	1.57	1.19	0.966	0.817
2	0.5	42.3	27.3	21.5	14.7	10.2	5.77	3.97	2.66	1.72	1.3	1.06	0.894
5	0.2	57.8	37	29.1	19.8	13.7	7.65	5.23	3.48	2.24	1.69	1.37	1.15
10	0.1	69.9	44.6	35	23.7	16.3	9.07	6.17	4.09	2.62	1.98	1.6	1.35
20	0.05	83.1	52.8	41.3	27.9	19.1	10.6	7.17	4.73	3.02	2.27	1.83	1.54
30	0.033	91.3	57.9	45.2	30.5	20.9	11.5	7.77	5.12	3.26	2.45	1.98	1.66
40	0.025	97.3	61.6	48.1	32.4	22.1	12.2	8.22	5.4	3.43	2.58	2.08	1.74
50	0.02	102	64.6	50.4	33.9	23.2	12.7	8.56	5.62	3.57	2.68	2.16	1.81
60	0.017	106	67.1	52.3	35.1	24	13.1	8.85	5.81	3.69	2.76	2.22	1.86
80	0.013	113	71.2	55.5	37.2	25.3	13.8	9.31	6.1	3.87	2.9	2.33	1.95
100	0.01	118	74.4	57.9	38.8	26.4	14.4	9.68	6.33	4.01	3	2.41	2.02
250	0.004	141	88.1	68.4	45.6	30.9	16.7	11.2	7.28	4.59	3.42	2.75	2.3

Rainfall intensities (mm/hr) :: RCP6.0 for the period 2031-2050

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	35.9	23.2	18.3	12.6	8.76	5	3.46	2.34	1.52	1.16	0.943	0.799
2	0.5	39.9	25.7	20.3	13.9	9.69	5.51	3.81	2.57	1.67	1.27	1.03	0.872
5	0.2	54.4	34.8	27.4	18.6	12.9	7.27	5	3.35	2.16	1.64	1.33	1.12

10	0.1	65.7	41.9	32.9	22.3	15.4	8.61	5.9	3.93	2.53	1.92	1.55	1.31
20	0.05	78	49.6	38.8	26.2	18	10	6.84	4.54	2.92	2.2	1.78	1.5
30	0.033	85.7	54.3	42.5	28.6	19.6	10.9	7.41	4.91	3.15	2.37	1.92	1.61
40	0.025	91.4	57.8	45.2	30.4	20.8	11.5	7.83	5.18	3.31	2.49	2.01	1.69
50	0.02	95.9	60.6	47.3	31.8	21.8	12	8.16	5.39	3.45	2.59	2.09	1.76
60	0.017	99.7	63	49.1	33	22.6	12.5	8.44	5.57	3.55	2.67	2.15	1.81
80	0.013	106	66.8	52	34.9	23.8	13.1	8.87	5.85	3.73	2.8	2.26	1.89
100	0.01	111	69.8	54.3	36.4	24.8	13.6	9.22	6.07	3.86	2.9	2.34	1.96
250	0.004	132	82.6	64.2	42.8	29	15.8	10.6	6.98	4.42	3.31	2.66	2.23

Rainfall intensities (mm/hr) :: RCP6.0 for the period 2081-2100

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	39.7	25.6	20.2	13.9	9.63	5.42	3.71	2.49	1.6	1.21	0.984	0.832
2	0.5	44.2	28.5	22.5	15.4	10.7	5.99	4.1	2.73	1.76	1.33	1.08	0.911
5	0.2	60.4	38.7	30.4	20.7	14.3	7.95	5.41	3.58	2.29	1.73	1.4	1.18
10	0.1	73.2	46.7	36.6	24.8	17.1	9.44	6.4	4.22	2.69	2.03	1.64	1.38
20	0.05	87.1	55.3	43.3	29.2	20	11	7.43	4.88	3.11	2.33	1.88	1.58
30	0.033	95.7	60.7	47.4	32	21.9	12	8.06	5.28	3.35	2.51	2.03	1.7
40	0.025	102	64.6	50.4	33.9	23.2	12.7	8.52	5.58	3.53	2.65	2.13	1.79
50	0.02	107	67.8	52.9	35.5	24.2	13.2	8.88	5.8	3.68	2.75	2.21	1.85
60	0.017	111	70.4	54.9	36.9	25.1	13.7	9.19	6	3.79	2.84	2.28	1.91
80	0.013	118	74.7	58.2	39	26.5	14.4	9.66	6.3	3.98	2.97	2.39	2
100	0.01	124	78	60.8	40.7	27.7	15	10	6.54	4.12	3.08	2.47	2.07
250	0.004	147	92.4	71.8	47.8	32.4	17.4	11.6	7.52	4.72	3.51	2.82	2.35

Rainfall intensities (mm/hr) :: RCP8.5 for the period 2031-2050

ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	36.6	23.6	18.6	12.8	8.92	5.07	3.5	2.37	1.54	1.17	0.951	0.805
2	0.5	40.7	26.2	20.7	14.2	9.87	5.59	3.86	2.6	1.68	1.28	1.04	0.879
5	0.2	55.5	35.5	27.9	19	13.2	7.39	5.07	3.39	2.19	1.66	1.34	1.13
10	0.1	67.1	42.8	33.5	22.7	15.7	8.76	5.99	3.99	2.56	1.94	1.57	1.32
20	0.05	79.6	50.6	39.6	26.7	18.4	10.2	6.94	4.6	2.95	2.22	1.8	1.51
30	0.033	87.5	55.5	43.4	29.2	20	11.1	7.53	4.98	3.18	2.4	1.93	1.63
40	0.025	93.3	59	46.1	31	21.2	11.7	7.96	5.25	3.35	2.52	2.03	1.71
50	0.02	98	61.9	48.3	32.5	22.2	12.2	8.29	5.47	3.49	2.62	2.11	1.77

60	0.017	102	64.3	50.2	33.7	23	12.7	8.57	5.65	3.6	2.7	2.18	1.83
80	0.013	108	68.2	53.1	35.6	24.3	13.3	9.01	5.93	3.77	2.83	2.28	1.91
100	0.01	113	71.2	55.5	37.1	25.3	13.9	9.36	6.16	3.91	2.93	2.36	1.98
250	0.004	135	84.4	65.5	43.7	29.6	16.1	10.8	7.08	4.47	3.34	2.69	2.25

Rainfall intensities (mm/hr) :: RCP8.5 for the period 2081-2100

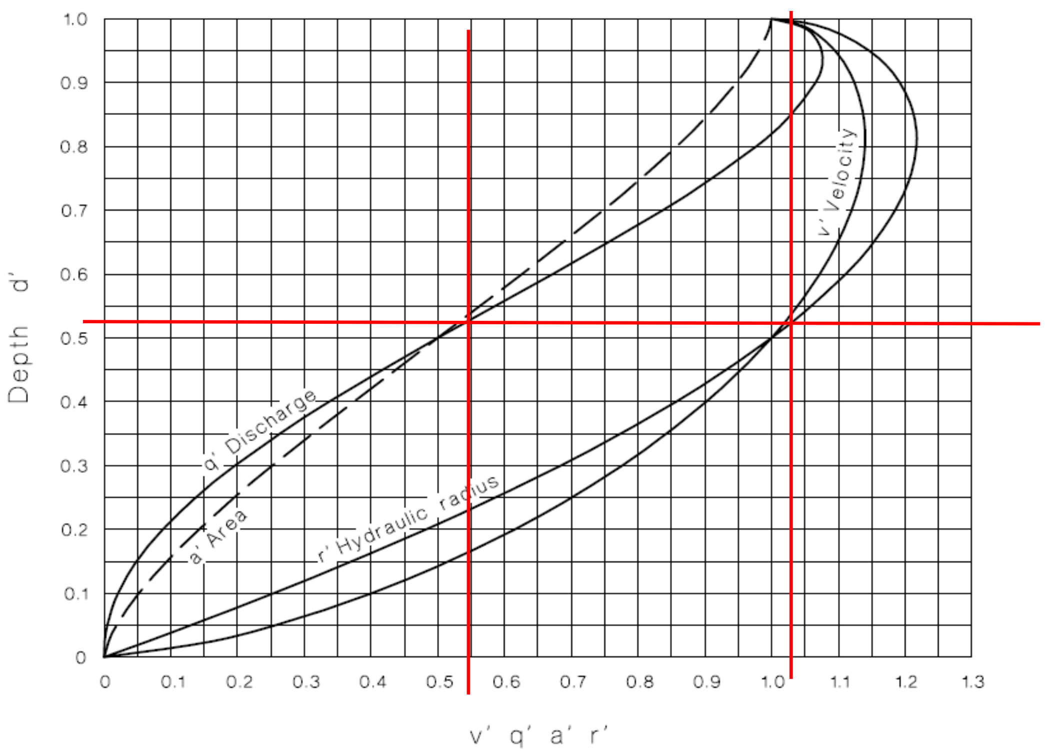
ARI	AEP	10m	20m	30m	1h	2h	6h	12h	24h	48h	72h	96h	120h
1.58	0.633	43.4	28	22.1	15.2	10.5	5.84	3.96	2.64	1.69	1.27	1.03	0.865
2	0.5	48.5	31.2	24.6	16.9	11.7	6.47	4.39	2.9	1.85	1.4	1.13	0.949
5	0.2	66.5	42.6	33.5	22.8	15.7	8.62	5.82	3.82	2.43	1.82	1.47	1.23
10	0.1	80.8	51.5	40.4	27.4	18.8	10.3	6.9	4.51	2.85	2.14	1.72	1.44
20	0.05	96.1	61	47.8	32.3	22.1	12	8.02	5.21	3.3	2.46	1.98	1.66
30	0.033	106	67	52.4	35.3	24.1	13.1	8.71	5.65	3.56	2.66	2.14	1.78
40	0.025	113	71.3	55.7	37.5	25.5	13.8	9.21	5.97	3.75	2.8	2.24	1.88
50	0.02	118	74.9	58.5	39.3	26.7	14.4	9.6	6.21	3.91	2.91	2.33	1.95
60	0.017	123	77.8	60.7	40.7	27.7	15	9.94	6.42	4.03	3.01	2.41	2.01
80	0.013	131	82.6	64.4	43.1	29.3	15.7	10.4	6.74	4.23	3.15	2.52	2.11
100	0.01	137	86.3	67.2	45	30.5	16.4	10.9	7.01	4.38	3.26	2.61	2.18
250	0.004	163	102	79.4	52.9	35.7	19	12.6	8.06	5.02	3.72	2.97	2.48

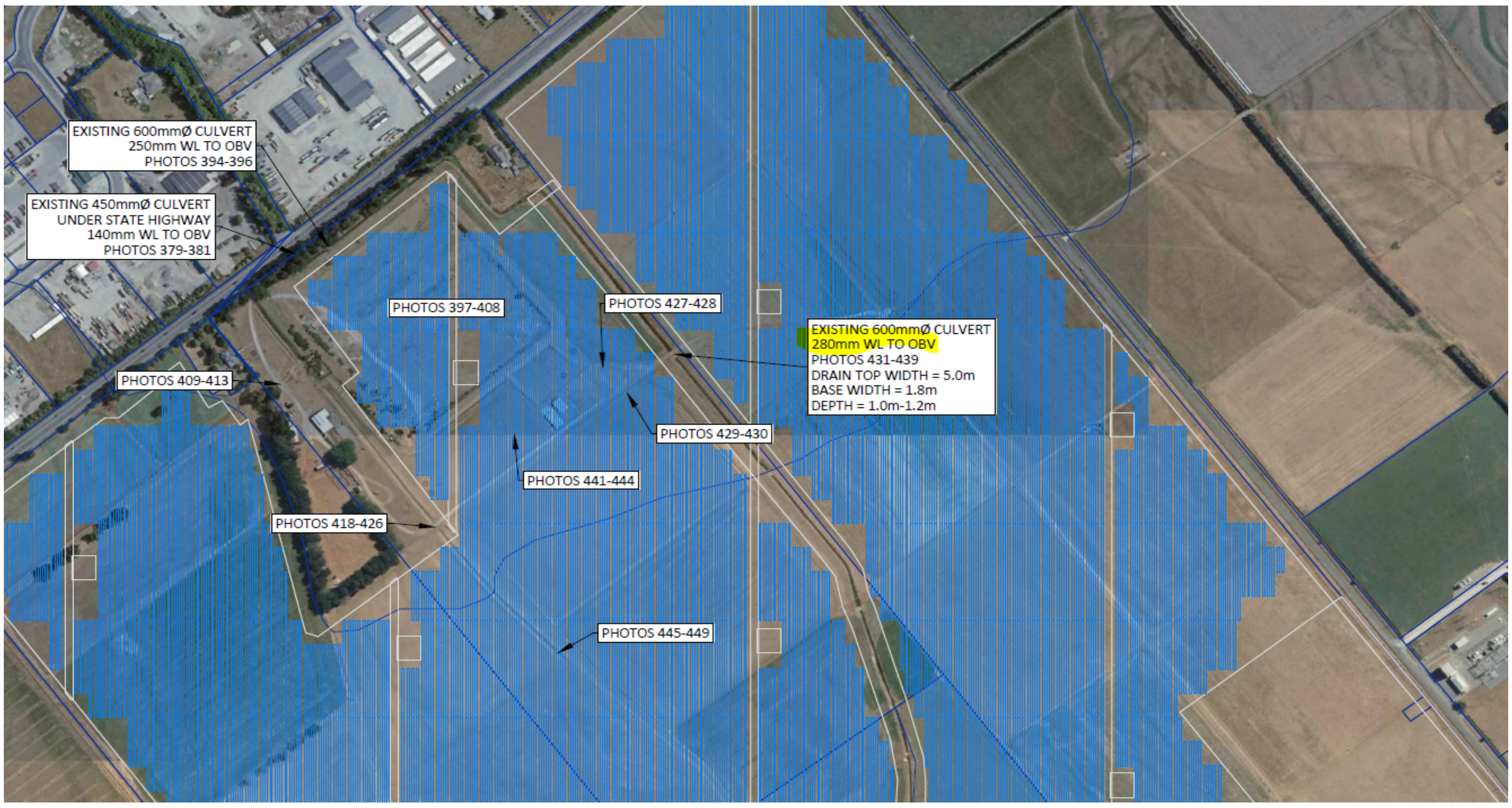
Job name	3954A State Highway 2, Masterton	File Name	
Job No.	B23067	Path	
Date	2/11/2023	Sheet Name	
Designed by	MB	Checked by	KW

Reference: Colebrook-White Formula

Roughness factor (k):	Roughness Factor	Pipe size(mm)	Grade(1 in)	%
k = 0.6 for pipe diameter > 1000mm k = 1.5 for pipe diameter < 1000mm	1.5	600	54.95	1.82
VELOCITY (m/sec)		2.93	m/s	
CAPACITY (Q = VA)		827.9	L/s	
d'		0.53	m	**From site visit**
q'		0.55	L/s	
v'		1.04	m/s	
v		3.05	m/s	
q		441.56	L/s	

Appendix 9: Part Full Pipe Flow Nomograph





Client :
Site address :
Job name :
Job number :

File Name	B23067-EV- -Soakage Design.xlsx
Sheet Name	Soakage Trench E1 (2)

Date	2/11/2023		
By	MB	Checked	KW

AIM: To determine soakage trench design and corresponding storage requirements in Hamilton

Design based on Hamilton Infrastructure Technical Specifications Section 4.2.15 and New Zealand Building Code E1/VM1

Design Parameters

Design Storm Event	10 Year ARI		
1 hour duration of rainfall intensity (Including Climate Change)	34.4	mm/hr	
Soakage Rate	500	mm/hour	Assumed
Soakage Rate Reduction	50%		
Design Soakage Rate (S_r)	250	mm/hour	

Post-Development Flow

Soakage Flow: $R_C = \frac{CiA}{1000}$ (NZBC E1/VM1)

Contributing Catchment	C	A (m^2)	CA (m^2)	Rc (m^3)
Impervious area	0.90	1000	900	31.0
Total		1000	900	31.0

Soakage Trench Design

$$V_{stor} = R_c - V_{soak}$$

where $V_{soak} = (A_{sp} \times S_r)/1000$ (NZBC E1/VM1)

Run-off into soak pit in one hour	30.96	m^3	(R_c)
Soakage released in one hour	12.50	m^3	(V_{soak})
Storage Required	18.46	m^3	(V_{stor})

Number of soakage trenches	1	
Trench Base Area (A_{sp})	50.00	m^2
Soakage Trench Depth	1.00	m
Drainage Metal Void Ratio	38%	(NZBC E1/VM1)
Total Available Trench Volume	19.00	m^3
Soakage Pit Empties in	1.5	Hrs

Client :	
Site address :	
Job name :	
Job number :	

		File Name	B23067-EV- -Soakage Design.xlsx
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Design Parameters

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Soakage Rate	500	mm/hour	Assumed
Soakage Rate Reduction	50%		
Design Soakage Rate (S_r)	250	mm/hour	

Post-Development Flow

Soakage Flow: $R_C = \frac{CiA}{1000}$ (NZBC E1/VM1)

Contributing Catchment	C	A (m^2)	CA (m²)	Rc (m^3)
Impervious area	0.90	81380	73242	2519.5
Total		81380	73242	2519.5

Soakage Trench Design

$$V_{stor} = R_c - V_{soak}$$

where $V_{soak} = (A_{sp} \times S_r)/1000$ (NZBC E1/VM1)

Run-off into soak pit in one hour	2519.52	m^3	(R_c)
Soakage released in one hour	1000.00	m^3	(V_{soak})
Storage Required	1519.52	m^3	(V_{stor})

Number of soakage trenches	1	
Trench Base Area (A_{sp})	4000.00	m^2
Soakage Trench Depth	1.00	m
Drainage Metal Void Ratio	38%	(NZBC E1/VM1)
Total Available Trench Volume	1520.00	m^3
Soakage Pit Empties in	1.5	Hrs