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Client: **Neoen**

Project: **Culcairn Solar Farm**

Document: **APA Licence 24 Land Use Change & Encroachment Safety Management Study**

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Document Approval:

Name	Title	Signature	Date

Revision History:

Rev	Date	Details	Changed by
A	18 Sept 2023	Issued for review	Chris Carter
0	22 Sept 2023	Final Issue – Comments incorporated	Chris Carter
1	22 May 2025	Updated with all completed actions	Chris Carter

Contents

1 Introduction

1.1 General

Neoen is working on the pre-construction phase of the Neoen Culcairn solar farm, a 420MWp solar project located approximately 45km north of Albury and 70km south of Wagga Wagga in NSW. Running though the south-east portion of the site is the APA DN450 Culcairn to Barnawatha License 24" high pressure gas pipeline.

A Safety Management Study (SMS) for this land use change and encroachment works is required according to AS/NZS 2885.6-2018. This SMS has included a facilitated validation workshop, as required by the Australian Standard AS/NZS 2885.6-2018.

The scope of this SMS has been to review the overall development and construction works and to identify any additional protection measures or controls required to ensure the works meet AS/NZS 2885 and APA compliance and safety requirements.

Asset Engineering Solutions (AES) has been engaged by Neoen to carry out this Safety Management Study.

1.2 Purpose and Objectives

The purpose and objectives of this SMS according to AS/NZS 2885.6-2018 are:

- To inform the stakeholders of the requirements of the AS/NZS 2885 suite of standards.
- Review proposed development plans to determine Location Classification
- Identify additional protective measures or development modifications, if any, that might be required, to ensure risk remains as low as reasonably practicable (ALARP) with the changed Land Use
- Review construction activities near the pipeline to ensure conformance with AS/NZS 2885 and APA requirements
- Identify all threats and protection measures required so that risk remains ALARP during encroachment works and throughout pipeline life
- Identify effects of the encroachment on the pipeline integrity management activities during encroachment works and throughout pipeline life

1.3 Document Scope

This document presents the outcomes of the Safety Management Study (SMS) which has addressed all aspects of the Culcairn Solar Farm construction and operations with the potential to impact on the APA Licence 24 High Pressure Gas Pipeline.

All actions identified from this SMS (Section 5.3) need to be completed to the satisfaction of all stakeholders to ensure compliance with AS/NZS AS2885.6.

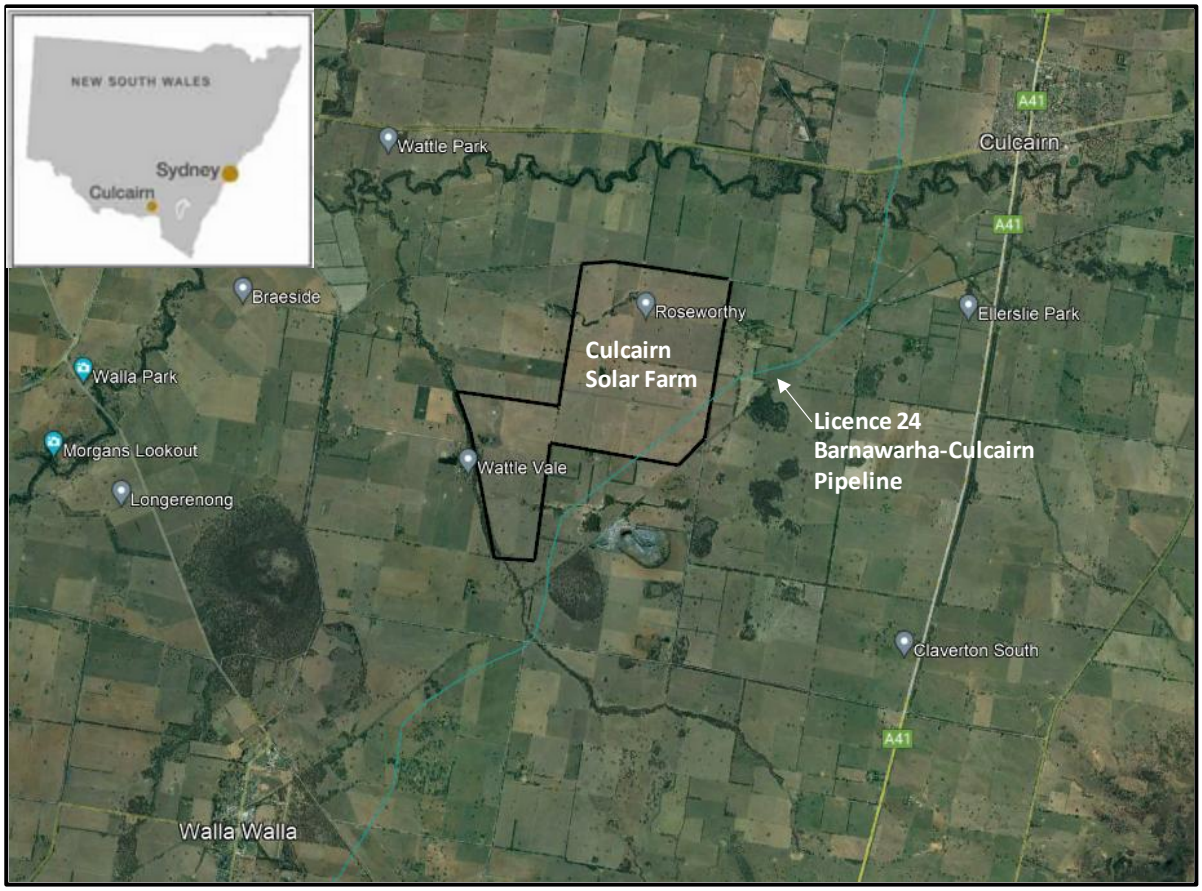
2 Project Description

The following information is a summary of the information provided by workshop participants and presented in the workshop (Appendix 1). Only the works considered relevant to the DN450 Licence 24 pipeline is reported in this section. Details of the works as reviewed in the workshop are provided in Refs [1-3].

2.1 Location

The site is located at Culcairn, approximately 45km north of Albury and 70km south of Wagga Wagga, at approximately KP 224-226 for the APA Licence 24 pipeline. The site location is shown below in Figure 1.

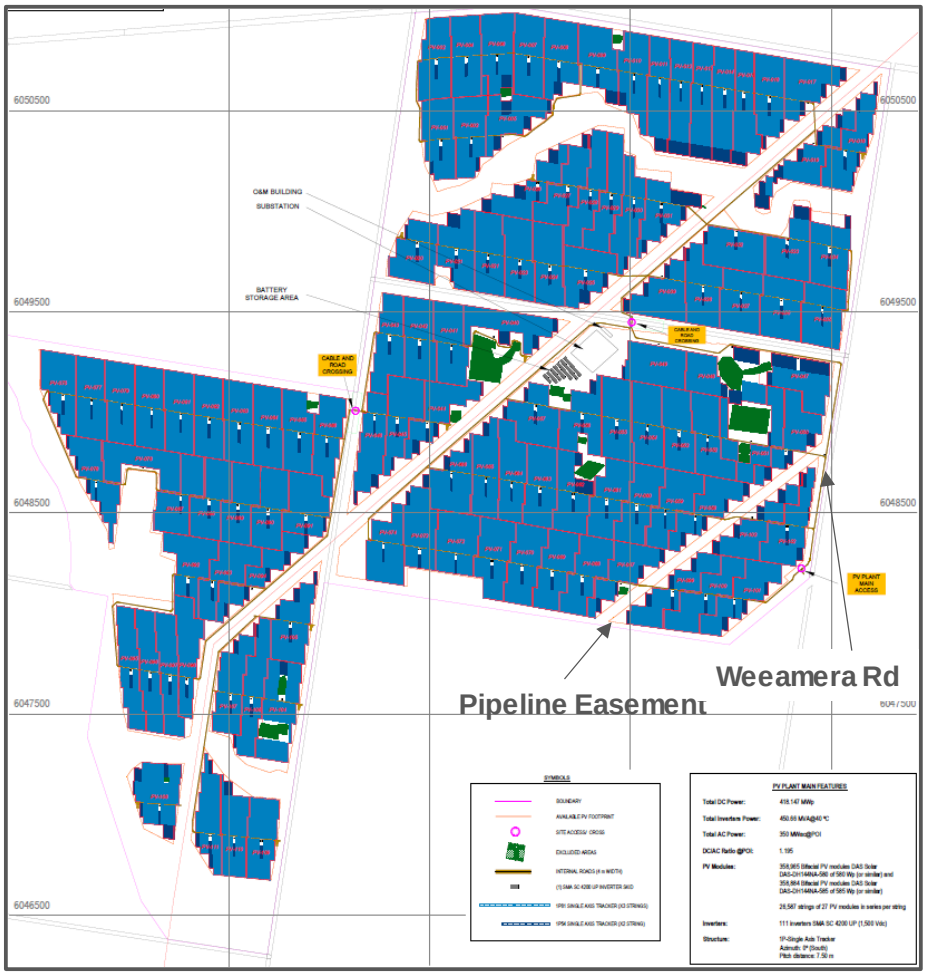
Figure 1: Site Location



2.2 Land Use Descriptions

The solar farm is located on a 900ha rural freehold site, used historically for sheep grazing and agriculture by the two host landowners. The DN450 Licence 24 pipeline within a 24m easement crosses the site at the south-east corner, over a distance of approximately 1.5km, as shown in Figure 2.

Figure 2: Solar Farm Layout



Development details relevant to this SMS are noted below:

- The development consists of solar panel infrastructure connected to a substation which connects directly into the 330kv TransGrid transmission lines which traverses through the centre of the site. The substation is located approximately 1km north-west of the DN450 Licence 24 pipeline
- The solar panels will be mounted on “H” or “I” beam piles driven approximately 2m into the ground. These will be located off the easement, with an estimated offset to the pipeline of minimum 10m (assuming the pipeline is located 8m offset to one easement edge).
- The new infrastructure crossing the pipeline easement will be gravel roads (for construction equipment and future access), and power cables. TransGrid may also need to install Fibre Optic Cables (FOC) over the easement.
- The details regarding the infrastructure installation are still to be defined and are dependent on the selected Construction contractor. The main variation is the number of crossings, ranging from 1 to 4, as shown in the project information in Appendix 1.
- Site drainage will be towards the west - southwest, into the existing creek system.
- The overall site will be permanently fenced with access control during operations. The main entrance to the site will be located at the southern end of the pipeline easement crossing at Weeamera Rd. Access for APA onto the pipeline easement will be provided at the Weeamera Rd easement intersection
- During solar farm operations, the onsite workforce will typically only be approximately 3 – 10 personnel during working days.
- Neoen will carry out an Electrical Hazard Assessment according to AS4853 when the earthing design has been completed. Zero Sequence Earthing may be selected as a contractor to perform this study.

2.3 Encroachment Works

Details of the encroachment works as discussed in the workshop are summarised below:

- Potholing has been carried out at six (6) locations along the pipeline route, including at the four (4) proposed crossing locations. These show that the depth of cover varies from 0.9m at the southern boundary to 1.8m at Weeamera Rd, Ref [2].
- Confirmation potholing will be also carried out immediately prior to the construction works.
- A minimum of 1.2m cover will be provided at all road crossing. Road crossing construction will consist of a geofabric laid on the existing ground, overlayed by approximately 350mm road base, or as required to provide the required cover. Construction vehicle loadings and road details have been provided to APA for confirmation of acceptable pipe stresses and are provided in Appendix 1, Ref [3].
- Power cables and FOC are currently proposed to cross over the DN450 Lic 24 pipeline. A minimum separation of 600mm has been specified in the design, Ref [3] which meets APA minimum requirement of 500mm.
- A steel protection plate has been included above the cables, however it was noted in the workshop that this should be changed to either HDPE or concrete to avoid CP interference.
- It was noted in the workshop that underbores may be used in some cases to install services accross the easement. In this case, it was noted that a 1m separation and witness trenches would be required.
- The solar panel “H” or “I” beam piles will be driven to a depth of approximately 2m. Ground conditions are such that ground vibration is not expected to be an issue on the DN450 Lic 24 pipeline (i.e. exceeding 20mm/s). However, it was noted in the workshop that a similar installation method will be used for the Walla Walla solar farm which is immediately south of Culcairn Solar farm. These works will include vibration monitoring for the DN450 Licencen24 pipeline, hence will provide confirmation or otherwise.

3 Pipeline Description

3.1 Pipeline Details

The following information regarding the APA Licence 24 High Pressure Gas pipeline was made available for this SMS.

Table 1: Pipeline Parameters

Parameter	APA Licence 24 (KP 224-226)
Diameter	457mm
WT	6.8mm
Grade	API 5L X70
MAOP	10,200kPa
Hoop stress @ MAOP	342MPa (71% SMYS)
Critical Defect Length	90mm
Radiation Zones:	
Rupture - 4.7kW/m^2	460m (measurement length)
Rupture - 12.6kW/m^2	280m
50mm Hole - 4.7W/m^2	50m
50mm Hole - 12.6kW/m^2	30m
Location Class	R1

3.2 Penetration Resistance

Penetration analysis show that the 6.8mm wall thicknesses offers effective protection against penetration against the most credible construction equipment (excavators =<30T) equipped with general purpose teeth. However, the pipelines will have limited resistance against penetration for 20T or greater excavators equipped with tiger teeth (single tooth) or penetration teeth.

Defect analysis indicate that gouges would need to be deeper than 4mm and longer than 100mm to cause loss of containment (rupture), which provides a reasonable level of protection. Furthermore, a dent/gouge assessment indicates that equipment of 20T or more could potentially cause a dent / gouge combination causing loss of containment.

4 SMS Review Workshop

4.1 Objectives

The SMS workshop was conducted in accordance with AS/NZS 2885.6 with the objectives as defined in Section 1.2.

In addition, any actions required to mitigate project risks or to clarify requirements were also noted and recorded.

4.2 Attendees

A virtual workshop was held via Microsoft Teams on Thursday 14th Sept 2023. The workshop attendees are listed in Appendix 2.

The participants were considered sufficient to adequately represent the interests of all the stakeholders and provide a robust basis for the threat and risk assessment.

4.3 Methodology

The Workshop was carried out by reviewing the following:

- Overview of the project and associated works;
- Review of existing and revised Location Classification;
- Review of construction works and encroachment to the pipelines;
- Review of pipeline details;
- Review of all threats, controls and associated risks associated with the Solar Farm construction and operational phases.

5 Workshop Findings

5.1 General

The SMS Assessment worksheet reviewed and recorded at the Workshop is presented in Appendix 3.

5.2 Location Classification

The participants agreed that the appropriate Location Classification due to this Land Use Change would be a revision from R1 to R2 – HI, with R2 requirements. The basis for this is noted below;

- The number of personnel on site during operations is estimated to be typically 3-10. Given there will be a presence on site for a reasonable amount of time, but of reasonable low density, a higher Primary classification from the current R1 was deemed appropriate, but not to the extent of a T1 classification. Hence R2 was deemed appropriate.
- A Heavy Industrial (HI) Secondary Classification was deemed appropriate to reflect the presence o the Solar Farm. However, since there would be no issues regarding escalation in event of a pipeline failure (i.e. fire, toxic gases), the R2 requirements where deemed appropriate.

5.3 Threat and Risk Assessment Results

The workshop reviewed in detail the land use change and encroachment works as described in Section 2 and identified credible threats to the DN450 Licence 24 pipeline due to the associated works.

All threats were deemed “Controlled” and acceptable as per AS/NZS AS2885.6, with the proposed controls or subject to the implementation of the additional controls and close out of the actions identified in Section 5.3.

5.4 Summary of Additional Controls / Actions

Table 2 presents the summary of the Additional Controls/Actions identified in the SMS Workshop.

Table 2: Summary of Additional Controls/Actions from SMS Workshop

Action No	Threat No	Threat	Additional Control / Actions	Resp.	Close Out
1	1	Prevailing Primary Land Classification changed from current location classification (R1) increasing risk to unacceptable level (per AS2885) or HCA non-compliance with current controls	APA to check sign posting within Solar Farm to ensure compliance with AS2885.1 as well as threat / risk management considerations.	APA	31/10/2024: APA agreed to close out (actions sit with APA)
2	6,7	Installation of new services (power cables, FOC) crossing pipeline or located within easement resulting in direct impact due to construction equipment and pipeline loss of containment	Construction methodology to include the following: '1) Trenching equipment within easement to be as small as practical but limited to max 20T excavator with blade bucket/GP teeth only. 2) No mechanical trenchers (e.g. chainsaw, bucket wheel) or rippers across easement. 3) If under-bore adopted, requires a 1m separation and witness trench on bore entry side of pipeline (Ref: APA std dwg 530-DWG-L-1004).	Neoen / TransGrid	Relevant Third-Party Works Authorization has been secured. Neon / Trans Grid to confirm all installation activities requiring APA permits are complete. 31/10/2024: APA agreed to close out
3	8	Boundary fence installation. Driven posts and/or excavation equipment striking pipeline and causing pipe damage. Threat includes possible installation of cables for camera power/data.	Construction methodology to include the following: 1) Pipe position/depth to be physically confirmed at fence crossing location prior to positioning fence posts. Posts to be located so that pipeline is at midspan.	Neoen	Relevant Third-Party Works Authorization has been secured. Neon / Trans Grid to confirm all installation activities requiring APA permits are complete. 31/10/2024: APA agreed to close out
4	10	Compaction of new roads or road upgrades over pipelines resulting in overstress (overload/vibration)	Construction methodology to include the following: 1) No vibration compaction in vicinity of pipeline as per Section 4.4 APA Guideline 580-POL-L-0001 2) Compaction equipment within limits defined in Table 7 APA Guideline 580-POL-L-0001	Neoen	Relevant Third-Party Works Authorization has been secured. Neon / Trans Grid to confirm all installation activities requiring APA permits are complete. 31/10/2024: APA agreed to close out
5	13	Installation of surface drainage crossing over pipeline resulting in direct impact due to construction equipment and pipeline loss of containment	Final drainage design to be completed and confirmed. Drainage design to be provided to APA for acceptance.	Neoen	22/05/2025 : APA site visit confirmed acceptable. APA agreed to close out.
	18	Change in flows causing erosion/flooding on pipeline easement			

6	15	Physical damage to existing CP system by construction equipment resulting in loss of protection	Post meeting note: APA provided alignment sheet which confirmed CP test post near Weeamera Rd. CP test post location to be ground truthed and protection incorporated into Construction Methodology, as required. This needs to include buried cabling from CP Test Post to buried pipeline.	Neoen	APA to confirm if this item can be closed. 31/10/2024: APA agreed to close out
7	16	Electrical interference with existing CP system or causing electrical faults (LFI, EPR)	EHA Study be commenced when earthing design completed. Study to specifically consider touch potentials at nearest CP Test Post (for APA employee safety). Completed EHA Study to be provided to APA for acceptance.	Neoen	Refer to outcome of EHA (EPR) study and APA acceptance. 31/10/2024: APA agreed to close out
8	23	Inadequate as-built drawings or loss of construction data/records	APA to provide standard crossing form (as-built data requirements) to Neoen so APA can update as-built database (when works complete)	APA	22/05/2025: As-builts provided. APA agreed to close out

6 Conclusions

The SMS workshop review and conclusions have been based on the proposed development and pipelines details as described in this document. On this basis, participants reviewed the findings and agreed that:

- The threat identification was thorough and adequate in recognising all credible threats, associated controls and consequences associated with the proposed solar farm development.
- The proposed development will result in a change in Location Classification to R2-HI. This change in Location Classification has no detrimental impact on pipeline compliance to AS/NZS 2885 requirements.
- All threats have been assessed to be "Controlled" and are therefore acceptable and in compliance with AS/NZS 2885.6-2018 risk levels based on the proposed controls and/or subject to the implementation of the additional controls listed in Section 5.3.
- To ensure compliance with AS/NZS 2885.6-208, all additional controls and actions identified from this SMS (Section 5.3) need to be implemented to the satisfaction of all stakeholders.

7 Reference Documentation

The following information was provided for the SMS workshop.

Ref	Document Title	Rev / Date
1	Neoen, Culcairn Solar farm General Layout, 123-0021-ING	Rev 2 July 23
2	QEST Infrastructure, Utility Survey, Job No 0829	Rev 0
3	wsp, Culcairn Solar Farm APA Crossings, 204179-WSP-RD-MEM-00002	Rev C
4	APA, Wodonga Wagga Wagga Natural Gas Pipeline, YW-80-1039	Rev 5

8 Terms and Definitions

ALARP	As Low as Reasonably Practicable
BYDA	Before You Dig Australia
CP	Cathodic Protection
FOC	Fibre Optic Cable
KP	Kilometre Point
MAOP	Maximum Allowable Operating Pressure
SMS	Safety Management Study
TP	Test Post
WT	Wall thickness

Appendix 1 SMS Workshop Presentation Material

(inc wsp APA Crossings Memo 204179-WSP-RD-MEM-000002 Rev C)

NEOEN

Culcairn apa Safety Management Study Workshop

September 14th 2023

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1. Quick Round of Introductions
2. Introduction to the SMS [AES Pipelines]
3. Culcairn Solar Farm Project Background [Neoen]
4. Vehicles/Cables Crossings Design Principles [WSP]
5. Threats & Risk Assessment to the Pipeline [All participants]
6. Conclusion

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Culcairn Solar Farm
Land Use Change / Encroachment Safety Management Study

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Neoen Culcairn Solar Farm
Land Use Change / Encroachme

- APA Licence 24 HP Gas

Safety Management Study

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Culcairn Solar Farm
Land Use Change / Encroachment Safety Management Study

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Agenda

9:00 – 9:15	SMS Introduction (Introductions, Scope, Objectives and Process)	C. Carter
9:15 – 9:45	Description and review of Solar Farm Development and construction works	Neoen
9:45 – 12:15	Threat and Risk Assessment : - Identify all changes and threats - Confirm Controls - Likelihood / consequences - Risk levels	All
12:15 – 12:30	Summary and confirmation of findings/actions	C. Carter

Note: Breaks as required

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Culcairn Solar Farm
Land Use Change / Encroachment Safety Management Study

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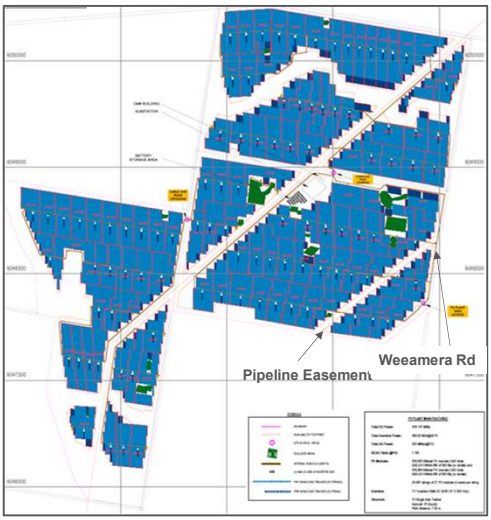
Scope:

Land Use Change and all encroachment works associated with the Culcairn Solar Farm encroaching the APA DN450 Licence 24 Barnawartha to Culcairn High Pressure Gas Pipeline, including:

- Road crossing
- Power cables over pipeline easement
- Solar panel installation
- Operational land use



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Culcairn Solar Farm
Land Use Change / Encroachment Safety Management Study

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Objectives – Land Use Change:

The objectives for a Land Use Change SMS include:

- Informing stakeholders of AS2885 requirements
- Confirm Location Classification and AS2885 Compliance
- Identify any additional protective measures that might be required to ensure risk remains ALARP as per AS2885.6 despite changed surroundings (changed threats and consequences)
- Review development plans to determine if they can be optimised to minimise impact on pipeline safety
- Identify effects of the Land Use change on the pipeline integrity management activities

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Culcairn Solar Farm

Land Use Change / Encroachment Safety Management Study

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Objectives – Encroachment Works:

The objectives for an Encroachment SMS include:

- Generate requirements for works to conform with AS2885.3 & Jemena Requirements
- Identify all threats and protection measures required so that risk remains ALARP during encroachment works and throughout pipeline life
- Review proposed plans and work methods to determine if they should be modified to minimise impacts to the pipeline
- Identify effects of the encroachment on the pipeline integrity management activities during encroachment works and throughout pipeline life

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Culcairn Solar Farm

Land Use Change / Encroachment Safety Management Study

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Pipeline Parameters (KP 224-228)

Parameter	Lic 24
Diameter	457mm
WT	6.8mm
Grade	API 5L X70
MAOP	10,200 kPa
Hoop stress @ MAOP	342MPa (71%S MYS)
Critical Defect Length	90mm
Radiation Zones - Rupture - 50mm Hole	 4.7kW/m^2 = 460m (ML) 12.6kW/m^2 = 280m 4.7kW/m^2 = 50m 12.6kW/m^2 = 30m
Location Class	R1

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Culcairn Solar Farm
Land Use Change / Encroachment Safety Management Study

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Background Documents :

- Neoen, Culcairn Solar farm General Layout, 123-0021-ING Rev 2 July 23
- QEST Infrastructure, Utility Survey, Job No 0829, Rev 0
- wsp, Culcairn Solar Farm APA Crossings, 204179-WSP-RD-MEM-00002 Rev B
- APA, Wodonga Wagga Wagga Natural Gas Pipeline, YW-80-1039 Rev 5

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Encroachment Safety Management Study Process

1. **Identify all credible threats to the pipeline**
2. **Identify and assess effectiveness of relevant controls**
3. **Assess if Failure Event is Credible (Threat Controlled?)**
4. **If not, define:**
   - **Failure mode,**
   - **Severity (Consequence)**
   - **Frequency (Likelihood)**
   - **Residual Risk**
5. **Where residual risk levels are not ALARP, identify and define suitable risk management actions**

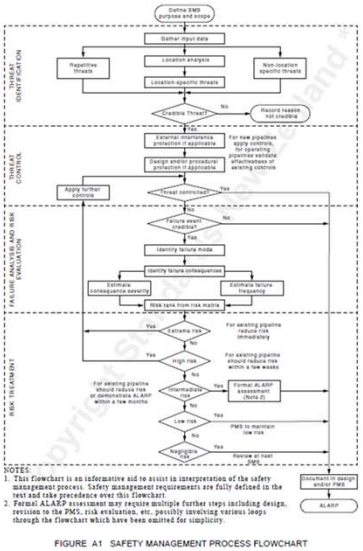

FIGURE A1 SAFETY MANAGEMENT PROCESS FLOWCHART

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Culcairn Solar Farm
Land Use Change / Encroachment Safety Management Study

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Development Review

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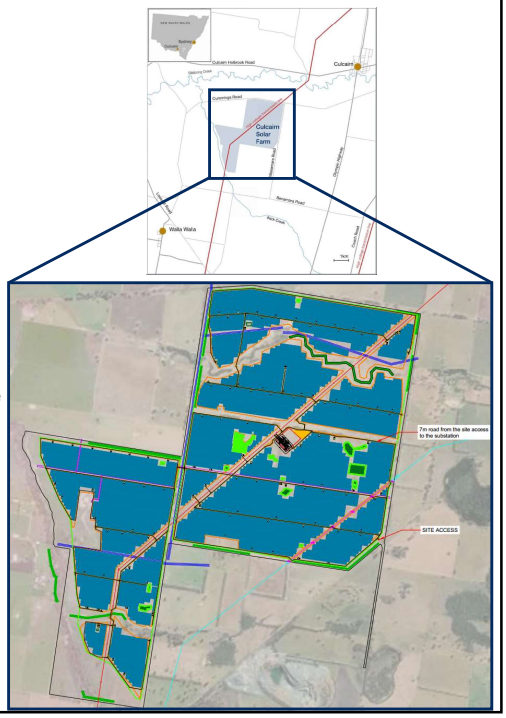
Project Characteristics

- Developed since 2017 and received Development Approval from the Department of Planning & Environment in March 2021 for 350 MWac of PV
- ~ 900 ha of flat rural freehold land, used historically for sheep grazing and agriculture by the two host landowners
- Project location: 45km north of Albury and 70km south of Wagga Wagga
  - 370 km NE of Melbourne
  - 510 km SW of Sydney
- The project will generate ~ 900 GWh of renewable electricity every year for 30+ years
- Project interconnected onsite with the substation connecting directly into the 330kv Transgrid line traversing the site
- APA gas pipeline Culcairn to Barnawatha pipeline traversing the south-east corner of the site across 1500m

Pipeline	Licence	Easement Width	Diameter	Measurement Length
Barnawatha-Culcairn	T99, PL24	24m	450mm	1500m



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Project Timeline

- EPC Request for Proposal is well-underway with Best & Final Offers received September 08th 2023
- Contract negotiation & finalization: September/October 2023
- Notice to Proceed to EPC & Transgrid: November 2023
- Site Access: February/March 2024
- Transgrid works completion: March 2025
- EPC works completion: End 2025

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Summary of APA Engagement

- Regular engagement with the APA third-party projects team since March 2023
- Signing of the Third Party Works Conditions: July 2023
- Potholing Study from Qest: July 2023
- Safety Management Study: September 2023
- Construction Management Plan: November/December 2023
- Electrical Hazard Studies: 2024 once the earthing designs for the switchyard, project substation, and solar farm are finalized

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Potholing Study Results

- Neoen's contractor Qest has performed the under the supervision of APA
- 18 tests have been performed in total across 6 main locations
- Pipeline is deepest at the north of the project site entrance (1.8m), plateauing for most of the pipeline project section to 1.25m before dropping to 0.9m at the south west of the site entrance

Pothole ID	Service	Easting	Northings	AHD	Depth	AHD NS	Diameter	Material	SUI_Quality
1	Gas	498485.090	6048843.484	205.021	1.86	206.881	450	STEEL	A
2	Gas	498481.369	6048840.388	205.179	1.86	207.039	450	STEEL	A
3	Gas	498477.140	6048837.107	205.302	1.69	206.992	450	STEEL	A
4	Gas	498266.234	6048672.443	205.556	1.43	206.986	450	STEEL	A
5	Gas	498262.347	6048669.520	205.526	1.22	206.746	450	STEEL	A
6	Gas	498258.285	6048666.436	205.604	1.18	206.784	450	STEEL	A
7	Gas	498048.360	6048502.358	205.093	1.25	206.343	450	STEEL	A
8	Gas	498044.516	6048499.390	205.088	1.25	206.338	450	STEEL	A
9	Gas	498040.680	6048496.482	205.131	1.20	206.331	450	STEEL	A
10	Gas	497829.249	6048331.115	205.020	1.25	206.270	450	STEEL	A
11	Gas	497825.467	6048328.224	205.003	1.25	206.253	450	STEEL	A
12	Gas	497821.248	6048325.126	204.996	1.25	206.246	450	STEEL	A
13	Gas	497607.243	6048157.705	204.842	1.25	206.092	450	STEEL	A
14	Gas	497603.295	6048154.865	204.834	1.25	206.084	450	STEEL	A
15	Gas	497599.381	6048151.812	204.823	1.25	206.073	450	STEEL	A
16	Gas	497342.009	6047950.615	204.819	1.15	205.969	450	STEEL	A
17	Gas	497338.343	6047947.700	204.805	1.12	205.925	450	STEEL	A
18	Gas	497334.592	6047944.877	204.775	0.93	205.705	450	STEEL	A

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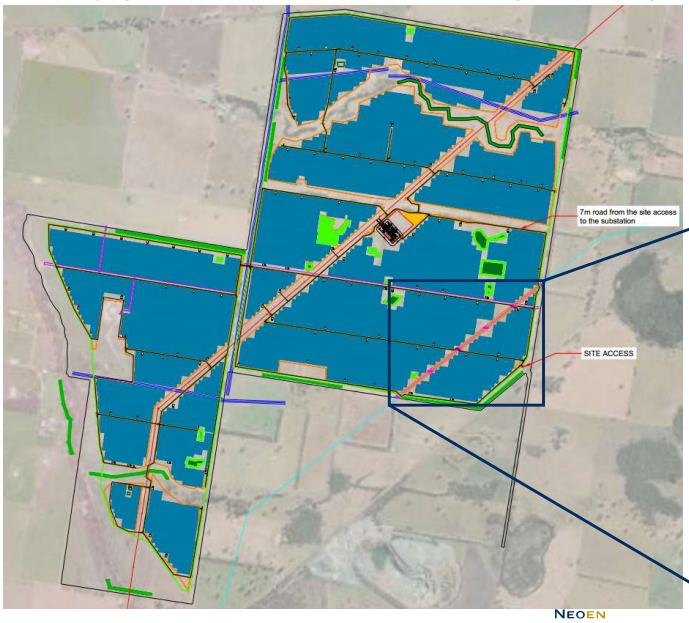
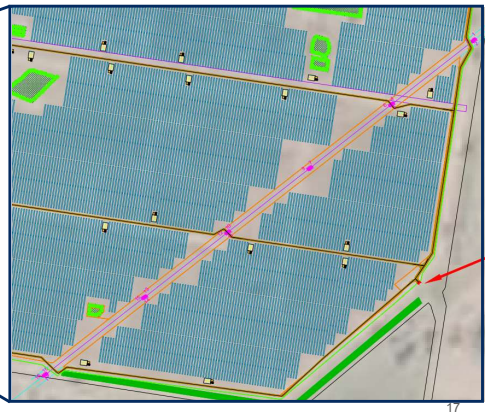
Bouygues Construction (BYCA) Layout



- 4 vehicles/cables crossings with 90° angle, very close to the potholed locations (pipeline will be potholed again before construction)
- Laying of cables above ground to be discussed with APA during the workshop
- One APA access point at Weeamera road entrance



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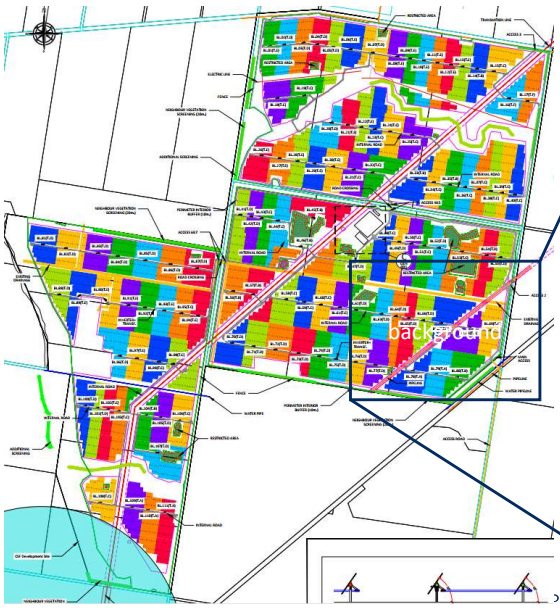
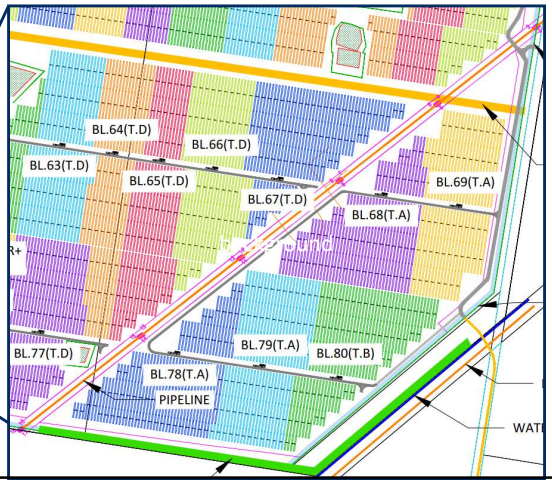
Gransolar (GRS) Layout



- 1 crossing with 90° angle, very close to the potholed locations (pipeline will be potholed again before construction)
- Vehicles/cables crossings co-located
- One APA access point at Weeamera road entrance



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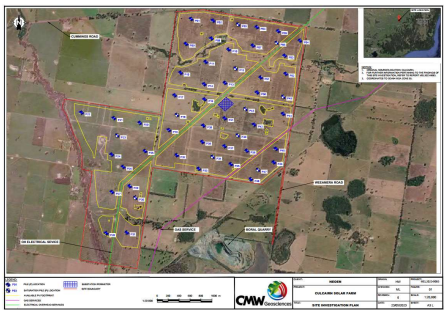
Geotechnical Conditions & Piling Method

- Comprehensive geotechnical campaign performed by SNC Lavallin in 2019
- Comprehensive pile load testing campaign performed by CMW in 2023 at 54 locations across the site
- Soil conditions are optimal for a solar farm construction site
- “I” or “H” beam piles are expected to be driven into the ground at a depth of ~ 2m by an excavator up to 30T
- Pre-drilling / augering is unlikely from the geotech, although it will be an option for the piles closest to the pipeline if monitoring determines the 20mm/s threshold is exceeded (unlikely as per initial feedback from GRS)



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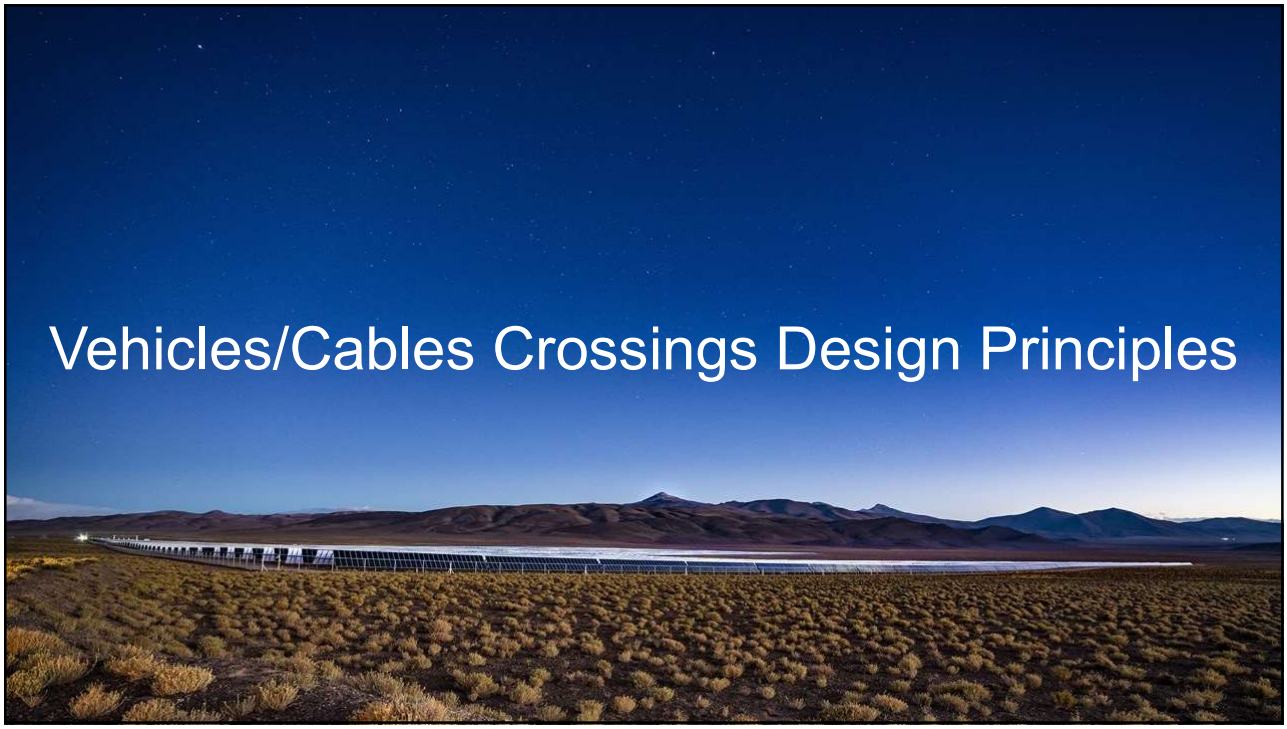

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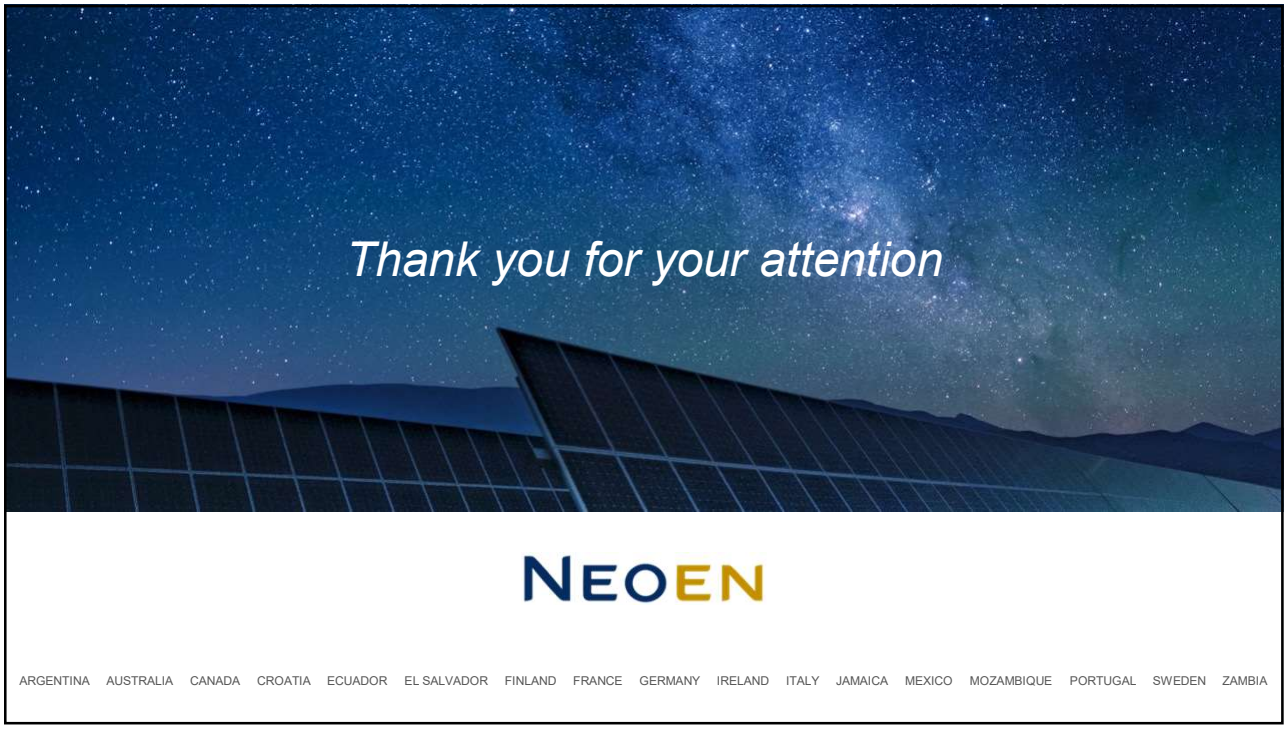
Vibration Monitoring - Walla Walla GRS Feedback

- Pending official vibration monitoring in 10 days with APA, GRS did some monitoring tests in other areas to get some vibration measurements near piling machines.
- These vibrations are much lower than the 20mm/s limit defined in the SMS) so not expecting any issue with this requirement. In addition, Texcel (the company who is providing the monitoring system for this testing) advised that this test shouldn't fail after reviewing the geotechnical report and the testing conditions.
- GRS has considered the 24m easement width in the layout without additional buffer for the tracker installation. The closest piles are around 15-20m from the gas pipeline. If the monitoring scheduled in 10 days fails the vibration test (unlikely), plan-B is pre-drilling/augering these piles (feasible without changing the current layout).

22


Thank you for your attention
NEOEN
ARGENTINA AUSTRALIA CANADA CROATIA ECUADOR EL SALVADOR FINLAND FRANCE GERMANY IRELAND ITALY JAMAICA MEXICO MOZAMBIQUE PORTUGAL SWEDEN ZAMBIA

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Appendices

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Memo

To:	Neoen
From:	WSP Australia
Subject:	**Culcairn Solar Farm APA Crossings**
Our ref:	204179-WSP-RD-MEM-000002 RevC.docx
Authors:	Kelly Yi Nick Foreman
Date:	**21 September 2023**

Project and Design Description

WSP Australia have been engaged to provide the engineering design for the access roads in and around the Culcairn Solar Farm.

The purpose of this memo is to outline the technical specifications relevant to the Safety Management Study undertaken by APA in their approval process for the access road design.

General Design Criteria

Refer Table 1 for the general design criteria related to the project.

Table 1 General Design Criteria

Description	Value	Specification
Pipeline minimum depth of cover	1,200mm	APA Standard 580-POL-L-0001, Table 4
Maximum surface pressure	400kPa directly above the pipeline	APA Standard 580-POL-L-0001, Section 3.8
Easement width	24m	Culcairn Solar Farm online website - "Appendix C.2 - Non-agency Consultation.pdf"
Design Vehicle (Loading)	Assumed that all vehicles crossing will have TfNSW road legal axle loads	Heavy Vehicle National Law and Regulations

Level 27, 680 George Street
Sydney NSW 2000
GPO Box 5394
Sydney NSW 2001

Tel: +61 2 9272 5100
Fax: +61 2 9272 5101
www.wsp.com

Design Vehicle

The loading from construction plant is assumed as shown in Table 2 for the construction of Culcairn Solar Farm. The loading has been assumed using the worst case (e.g. piling rig). As APA requires a maximum allowable load at finished surface level of 400kPa when there is 1.2m. Typical plant and vehicle loads for the construction and ongoing maintenance of the Culcairn Solar Farm will be as per Table 2 below.

Table 2 Typical Working Loads for Solar Farm Construction

Vehicle	Typical Surface Load (kPa)
Piling Rig (40 Tonne rig)	150-200
Heavy Excavator (30 Tonne)	70-100
Truck and Dog (aggregate truck)	750-800
Concrete truck	750-800
Heavy Lift Crane	800-900
Transformer truck/trailer	750-800
Semi/B-Double truck	750-800

As can be seen from the typical loads the vast majority of vehicles that will need to travel over the pipeline will be road going vehicles on defined haul roads. Whilst the truck and trailer that will be bringing the transformer into the site will have a total gross mass of around 290 Tonnes, this load will be very well distributed across all axles and wheels of the trailer. This load distribution will ensure that it is a road legal load which means that this will impart a load similar to that of a Semi-trailer or B-Double.

The loads quoted for the piling rig and heavy excavator in Table 2 (i.e. highest typical loads) would be for those items of construction plant traversing over the pipeline on the internal access roads. These vehicles should only be travelling over the pipeline at 1.2 metres cover so actual exerted pressures will be well below those values quoted.

APA Pipeline – Road Crossing

The pipeline has potholing information as per below (extract from pothole survey drawing).

Figure 1 - Potholing plan

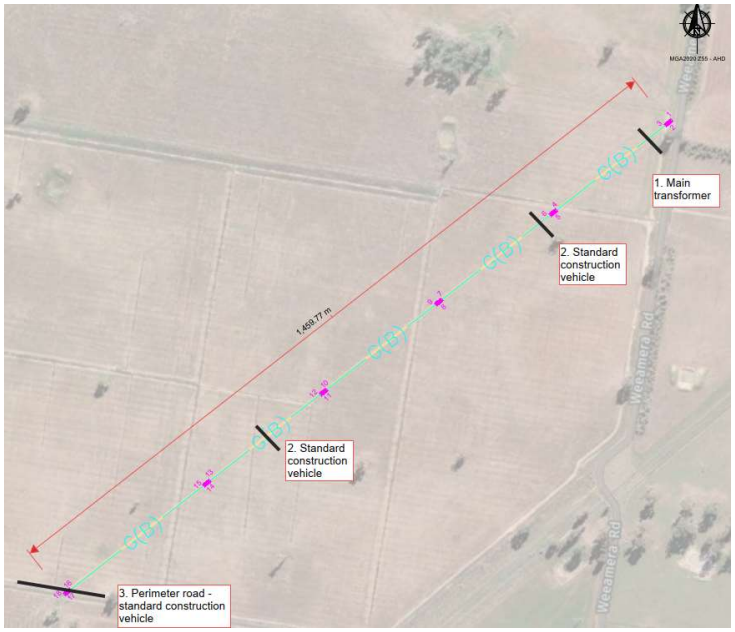


Table 3

Pothole ID	Service	Easting	Northings	AHD	Depth	AHD NS	Diameter	Material	SUI_Quality
1	Gas	498485.090	6048843.484	205.021	1.86	206.881	450	STEEL	A
2	Gas	498481.369	6048840.388	205.179	1.86	207.039	450	STEEL	A
3	Gas	498477.140	6048837.107	205.302	1.69	206.992	450	STEEL	A
4	Gas	498266.234	6048672.443	205.556	1.43	206.986	450	STEEL	A
5	Gas	498262.347	6048669.520	205.526	1.22	206.746	450	STEEL	A
6	Gas	498258.285	6048666.436	205.604	1.18	206.784	450	STEEL	A
7	Gas	498048.360	6048502.358	205.093	1.25	206.343	450	STEEL	A
8	Gas	498044.516	6048499.390	205.088	1.25	206.338	450	STEEL	A
9	Gas	498040.680	6048496.482	205.131	1.20	206.331	450	STEEL	A
10	Gas	497829.249	6048331.115	205.020	1.25	206.270	450	STEEL	A
11	Gas	497825.467	6048328.224	205.003	1.25	206.253	450	STEEL	A
12	Gas	497821.248	6048325.126	204.996	1.25	206.246	450	STEEL	A
13	Gas	497607.243	6048157.705	204.842	1.25	206.092	450	STEEL	A
14	Gas	497603.295	6048154.865	204.834	1.25	206.084	450	STEEL	A
15	Gas	497599.381	6048151.812	204.823	1.25	206.073	450	STEEL	A
16	Gas	497342.009	6047950.615	204.819	1.15	205.969	450	STEEL	A
17	Gas	497338.343	6047947.700	204.805	1.12	205.925	450	STEEL	A
18	Gas	497334.592	6047944.877	204.775	0.93	205.705	450	STEEL	A

The following are recommended for each crossing:

1. Main transformer crossing – north of site entrance
    i. Existing Pipeline depth: ~1.8m
    ii. Types of vehicles: ~200t vehicle carrying the main project transformers (NOTE: the trailer carrying the transformer is a road legal vehicle and standard road legal loads are permitted over the pipeline where cover requirements are achieved. Heavy construction vehicles of similar scale to the transformers, such as a piling rig, will exert the pressures in Table 2
    iii. Road geometry to be designed such that the finish surface level is same as existing surface level.
2. Standard construction vehicle crossing
    i. Existing Pipeline depth: ~1.2m
    ii. Types of vehicles: ~20t standard construction vehicle such as those quoted in Table 2
    iii. Road geometry to be designed such that the finish surface level is 1.5m above the APA gas pipeline.
3. Perimeter road – standard construction vehicle crossing
    i. Existing Pipeline depth: ~1.0m
    ii. Types of vehicles: ~20t standard construction vehicle such as those quoted in Table 2
    iii. Road geometry to be designed such that the finish surface level is min. 1.2m above the APA gas pipeline.

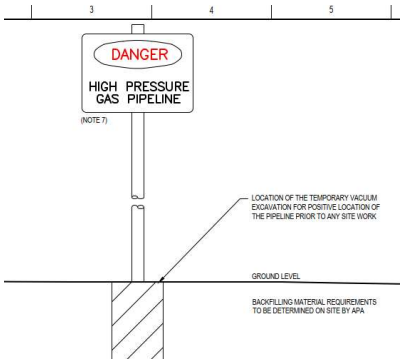
Therefore, the finished surface level of all access road crossings design will need be same as existing surface level or higher to achieve the required minimum 1.2m cover. Refer to the attached drawing for APA road crossing design requirements.

Where the minimum cover requirement of 1.2m cannot be met due to design or other site constraints (drainage or flooding issues, ground improvement works, etc), protective slab must be installed for protecting the pipeline from excessive loads. Refer to 530-DWG-L-1007 from APA for the typical concrete protection slab.

The construction of the access roads must adhere to the protection measures outlined in 580-POL-L-0001 Section 4.10 for excavation, compaction, backfill, etc works near the pipeline. All construction works will require the pipeline to be positively located at the crossing locations prior to construction – this is considered good practice during construction for high-risk item assets for safety. APA will need to be notified and approve the methodology for the locating works. Additionally, no vibration within 3m of the APA gas pipeline when construction works are required within the easement.

It is recommended the sign “DANGER – High Pressure Gas Pipeline” sign beside the road within a safe distance to show where the APA crossings are. See example sign from APA standard drawings below.

Figure 2 - APA Gas Pipeline Sign



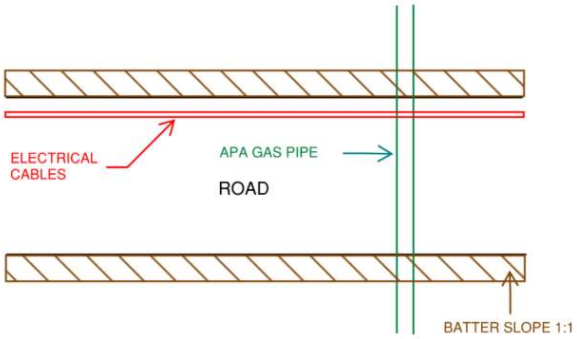
Other Utility Crossing Design

In the national guidelines on the APA website, they prefer to keep the number of road crossings to a minimum and the crossings to be perpendicular to the pipeline. Therefore, any proposed electrical feeder or transmission lines is to be placed within the access road corridor to minimise the number of crossings over the pipeline.

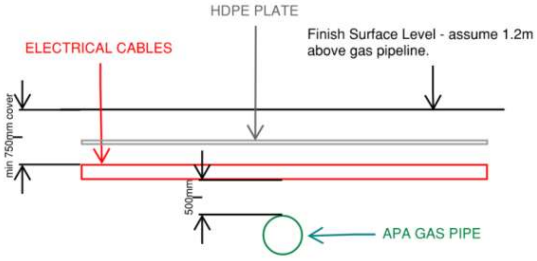
As per 580-POL-L-0001 Section 3.6, the proposed electrical design will need to be assessed in compliance with AS 4853 Electrical Hazards on Metallic Pipeline by a qualified Engineer, with detailed plans and a report to be provided to APA. However, it is noted that perpendicular crossings of the steel pipeline will have minimal effect in comparison to parallel installations as per AS 4853.

Figure 2 shows the requirements for the 33kV DC cables crossing the APA gas pipeline, located around the southern side of the site. The figure has been drawn as per AS 3000 Section 11. NOTE: Implementation of the figure to the design is subject to asset owner approval.

Figure 3 - Electrical Cable Crossing



PLAN VIEW



SECTION VIEW

It is recommended the sign “DANGER – High Pressure Gas Pipeline” sign beside the road within a safe distance to show where the APA crossings are, as per Figure 2. Further, the future designer should place electrical surface markers to show anyone walking past that there is electrical underground as well.

Additionally, no vibration within 3m of the APA gas pipeline when construction works are required within the easement. Trenching equipment within the easement is to be as small as practical but limited to max 20T excavator with blade bucket/GP teeth only. There shall be no mechanical trenches (e.g. chainsaw, bucket wheel)

or rippers across the easement. If there is under-boring, 1m separation is required and witness trench on bore entry side of the pipeline.

Pavement Design

From the geotechnical report, it has been noted that BH 115, TP 120 and BH 102 are close to the APA pipeline. Refer to borehole logs as attachments. The ground is most likely to be silty clay above the pipeline and moisture condition has been identified as moist.

It is recommended that an unsealed gravel/crushed rock pavement be used for the internal access roads to provide sufficient strength during construction that can be repaired/regraded whilst construction takes place. These can then be given a final grading and re-gravelling and will offer a sound pavement for the maintenance phase of the solar farm where much lighter vehicles will be operating. The pavement profile below is recommended for the road crossings and internal access roads and is diagrammatically represented in Figure 3.

- 150 mm base material (CBR>60)
- 200 mm subbase material (CBR>30)
- Geogrid (Tensar TX160 or similar)
- Geofabric on existing ground surface
- Earthworks and subgrade preparations to be in accordance with TfNSW QA Specification R44.

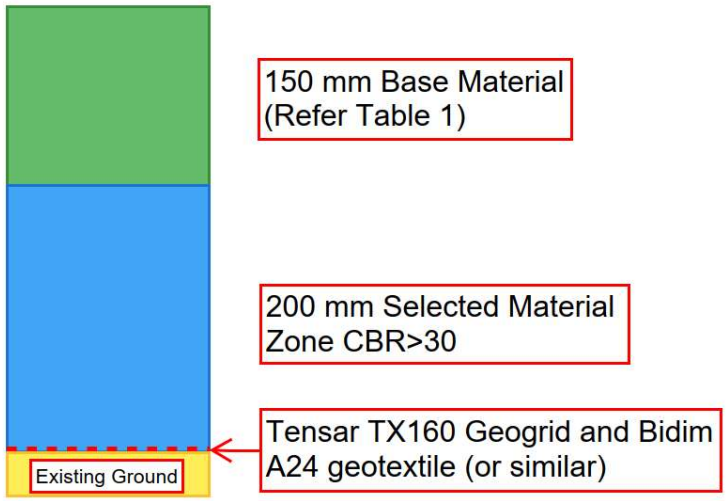


Table 1 - Base Material Properties

SIEVE SIZE (mm)	RECOMMENDED GRADING LIMITS
19.0	100
9.5	92-70
4.75	76-50
2.36	63-35
0.425	40-15
0.075	25-4
PLASTICITY INDEX	4-10%
CBR	Min 60%

Figure 4 Internal Access Road Pavement

This will provide a minimum of 1.2m of cover to the APA pipeline and ensures that the existing surface levels are raised to ensure adequate cover.

Appendix 2 Workshop Attendees

Workshop Attendees

Client:	Neoen
Project:	Culcairn Solar Farm
Pipelines:	APA Licence 24 DN450 Culcairn to Barnawatha
Workshop:	Land Use Change and Encroachment SMS
Workshop Date:	14 Sept 23
Location:	Remote via Teams

Name	Company	Position / Title
Nicholas Fox	Neoen	Senior Project Manager
Alexis Good	Neoen	Project Manager
Laszlo Csanyi	Neoen	Head of Construction, Australia
Joseph Casalegno	APA	Senior Development Engineer
Paul Walters	APA	Senior Pipeline Risk Engineer
Simon Edgerton	APA	Project Technical Officer
Hsuan Chen	APA	Risk Engineer
Chris Yau	wsp	Senior Principal Project Manager
Nick Foreman	wsp	Senior Civil Engineer
Dallas Ko	wsp	Senior Utilities Engineer
Jawad Ahmad	TransGrid	Senior Project Developer, Delivery
John Granger	TransGrid	Project Manager, Delivery
Ben MacKay	TransGrid	Project Engineer, Delivery
Jay Chan	TransGrid	Program Schedule Manager
Chris Carter	AES	Pipeline Consultant – SMS Facilitator

Appendix 3 Safety Management Study Worksheet

(See Also Excel Worksheet)

No	Activity	Threat Type	Threat Description	Comment	Is the threat credible.	Controls		Controls Mitigate Threat?			Additional Controls?		Residual Risk Assessment					Actions Required	Action Type
					Yes/No	Physical Protection	Procedural	Yes/No	If Yes, why?	If No, Failure Mode	Additional Controls?	Threat Controlled?	Severity Class	Severity Comments	Frequency Class	Frequency Comments	Risk Matrix Result		
Location Class - Land Use Change																			
1	NA	Land use change	Prevailing Primary Land Classification changed from current location classification (R1) increasing risk to unacceptable level (per AS2885) or HCA non-compliance with current controls	1) Existing Location Classification is R1 (Rural) 2) Expected personnel on site during solar farm operations is approx. 3 - 10 person during work days/hours	Yes	Primary Location Class due to Solar Farm deemed to be R2 based on 3-10 personnel on-site. Secondary Classification deemed as H, but with R2 requirements since there is no issue regarding escalation of fire, toxic gas releases etc.		Yes	Adequate controls. Also see action		APA to check sign posting within Solar Farm to ensure compliance with AS2885.1 as well as threat / risk management considerations.	Yes					NA		
External Interference - Additional Threats																			
2	New Threats over pipeline life	Overloading	New overloading/overstress long term third party threats or increase in frequency introduced by Solar Farm not currently addressed in Operational SMS during life of pipelines which could increase Failure Event	1) This threat considers overloading due to new roads	Yes	1) Wall thickness 2) Depth of cover 1.2m 3) Permanent road crossing design accepted by APA based on nominated loads and min cover = 1.2m	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) Patrols / APA PI 3) Solar farm operations liaison 4) This will now be a controlled area (fenced security fencing)	Yes	Adequate controls. No additional or escalated threats from current threats.									NA		
3	New Threats over pipeline life	Direct Impact	New direct impact long term third party threats or increase in frequency introduced by Solar Farm not currently addressed in Operational SMS during life of pipelines which could increase Failure Event	1) This threat considers future excavation due to maintenance of services and/or drainage system 2) Also considers possible new services	Yes	1) Wall thickness 2) Depth of cover 1.2m 3) Min. separation of 0.5m to services (power cables / FOC) crossing over pipeline 4) Protection plates e.g. HDPE above service 5) If underbore used, min separation of 1m under gas pipeline	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) Patrols / APA PI 3) Solar farm operations liaison 4) This will now be a controlled area (fenced security fencing)	Yes	Adequate controls. No additional or escalated threats from current threats.									NA		
4	New building works	Direct Impact / vibration	Installation of solar panel support columns causing either direct impact or excessive vibration to pipeline resulting in damage (reduced MAOP) or loss of containment	1) Small H or I beam piles 2) Construction method include driving beam piles 2m into ground	Yes	1) Wall thickness 2) Horizontal separation (No works within 24m easement) 3) Minimum approx.10m separation to pipeline 4) Very unlikely that ground conditions will cause vibration exceeding 20mm/s 5) Vibration monitoring for Walla Walla solar panel beam pile installation will confirm	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) APA PI on site / easement delineated 3) Inductions, SWMS 4) All works in accordance with APA Guideline	Yes	Adequate control to mitigate									NA		
5	New building works	Direct Impact / vibration	Major building works i.e. substation causing either direct impact or excessive vibration to pipeline resulting in damage (reduced MAOP) or loss of containment	1) Substation separation is 1000m	No													NA		
6	Construction works	Direct Impact	Installation of new services (power) crossing pipeline or located within easement resulting in direct impact due to construction equipment and pipeline loss of containment	1) Power Cable Crossings	Yes	1) Wall thickness 2) Depth of cover 3) Min separation 0.5m for crossings over pipeline 4) Min separation of 1m for underbores 5) Pre-construction potholing at crossing locations will verify pipe position and depth	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) APA PI on site 3) Inductions, SWMS 4) All works in accordance with APA Guideline	Yes	Adequate controls pending actions		Construction methodology to include the following: *1) Trenching equipment within easement to be as small as practical but limited to max 20T excavator with blade bucket/GP teeth only. 2) No mechanical trenchers (e.g. chainsaw, bucket wheel) or rippers across easement. 3) If underbore adopted, requires a 1m separation and witness trench on bore entry side of pipeline (Ref APA std dwg 530-DWG-L-1004).	Yes					NA		
7	Construction works	Direct Impact	Installation of other services crossing pipeline or located within easement resulting in direct impact due to construction equipment and pipeline loss of containment	1) Transgrid FOC.	Yes	1) Controls as noted above 2) Noted that excavator would be max 10T or underbore may be used.	1) Controls as noted above	Yes	As above		As Above	Yes					NA		
8	Construction works	Direct Impact	Boundary fence installation. Driven posts and/or excavation equipment striking pipeline and causing pipe damage. Threat includes possible installation of cables for camera power/data.	Post depth to approx. 450mm	Yes	1) Wall thickness 2) Depth of cover 3) Horizontal separation	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) APA PI on site 3) Inductions, SWMS 4) All works in accordance with APA Guideline	Yes	Adequate controls pending actions		Construction methodology to include the following: 1) Pipe position/depth to be physically confirmed at fence crossing location prior to positioning fence posts. Posts to be located so that pipeline is at midspan.	Yes					NA		
9	Construction works	Direct Impact	Excavation for construction of new roads or road upgrades over pipelines resulting in direct impact and pipeline loss of containment or overstress	1)Road crossing does not require excavation above pipeline 2) Geotextile to be used at ground surface, with road base overlay to achieved min cover depth 1.2m	No								Yes					NA		
10	Construction works	Overloading / vibration	Compaction of new roads or road upgrades over pipelines resulting in overstress (overload/vibration)		Yes	1) Wall thickness 2) Depth of cover (existing min + 0.9m)	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) APA PI on site 3) Inductions, SWMS 4) All works in accordance with APA Guideline	Yes	Adequate controls pending actions		Construction methodology to include the following: 1) No vibration compaction in vicinity of pipeline as per Section 4.4 APA Guideline 580-POL-L-0001 2) Compaction equipment within limits defined in Table 7 APA Guideline 580-POL-L-0001	Yes					NA		
11	Construction works	Overloading	Uncontrolled movement of construction equipment or stockpiling on easement during construction causing overloading (overstress)	1) Considers truck access, crane set up, equipment stockpiling, general vehicle movement	Yes	1) Wall thickness 2) Depth of cover (0.9-1.8m) 3) Designated crossing built in initial construction phase 4) 24m easement 5) Easement delineation e.g. bunting	1) APA PI on site 2) Inductions, SWMS 3) All works in accordance with APA Guideline 4) Staging Plan minimises movements	Yes	Adequate controls to mitigate									NA		
12	Construction works	Direct Impact	Regrading / civil works over easement reducing cover and resulting in direct impact to pipeline causing loss of containment	No regrading / civil works on easement.	No													NA		
13	Construction works	Direct Impact	Installation of surface drainage crossing over pipeline resulting in direct impact due to construction equipment and pipeline loss of containment	1) Potentially will be some surface drainage crossing over pipeline. 2) Drainage design is ongoing and is yet to be finalised	Yes	1) Wall thickness 2) Depth of cover (0.9-1.8m) 3) Drainage towards south-west away from pipeline easement. 4) Limited catchment area onto pipeline location	1) BYDA, 3rd Party Works Authorisation to be issued by APA (TPWA) 2) APA PI on site 3) Inductions, SWMS 4) All works in accordance with APA Guideline	Yes	Adequate controls pending actions		Final drainage design to be completed and confirmed. Drainage design to be provided to APA for acceptance.	Yes					NA		
14	Construction works	Direct Impact	Other excavation/boring/piling works not addressed above as part of Solar Farm Construction works	None	No													NA		
Corrosion																			
15	All	Corrosion	Physical damage to existing CP system by construction equipment resulting in loss of protection	1) Believed that a CP test post exists near the Wesamera Road Entrance.	Yes			No	See action		Post meeting note: APA provided alignment sheet which confirmed CP test post near Wesamera Rd. CP test post location to be ground truthed and protection incorporated into Construction Methodology. This include cabling from CP Test Post to buried pipeline.	Yes					NA		
16	All	Corrosion	Electrical interference with existing CP system or causing electrical faults (LFI, EPR)		Yes	1) EHA Study (AS4853) to be completed by Zero Sequence Earthing		Yes	Adequate controls pending actions		EHA Study be commenced when earthing design completed. Study to specifically consider touch potentials at nearest CP Test Post (for APA employee safety). Completed EHA Study to be provided to APA for acceptance.	Yes					NA		
17	All	Corrosion	Corrosion or coating defects existing within work area which could be an integrity issue or will require APA to access site for remedial works during Solar Farm Construction.	1) No pipe or coating defects are known to exist within this area. 2) Next ILI date not confirmed in workshop 3) Expected that pipe and coating is in good condition hence remedial works within timeframe of solar farm construction work not considered credible.	No													NA		
Natural Events																			
18	General	Erosion	Change in flows causing erosion/flooding on pipeline easement	Drainage design ongoing. Drainage to SW, away from pipeline.	Yes	1) Drainage design ongoing 2) All drainage towards south-west away from pipeline 3) Very little catchment onto easement		Yes	Adequate controls pending actions		Final drainage design to be completed and confirmed. Drainage design to be provided to APA for acceptance.	Yes					NA		
19		Flora/Fauna	Introduction of new flora - excessive growth on easement		Yes	Landscaping plan provided to APA and accepted with minor comments. No issues noted.		Yes	Adequate controls to mitigate									NA		
Intentional / Public																			
20	Security	Intentional Damage	None															NA		
Operations and Maintenance																			
21	Maintenance	Lack of access (during and post development)	Inadequate access to pipelines for maintenance/emergency management activities		Yes	1) Access point onto easement to be provide a Wesamera Rd. 2) Gated with daisy chain locks. Available 24hrs to APA		Yes	Adequate controls to mitigate									NA		
Design and Construction																			
22	General	Design change	Inadequate pipe depth/position data - differs from design when on-site		Yes	1) Physical confirmation (potholing) completed for input to design (Ref: QEST Infrastucture Survey) 2) Pre-construction physical confirmation will be carried out at actual crossing points		Yes	Adequate controls to mitigate									NA		

23	General	Lack of as-built	Inadequate as-built drawings or loss of construction data/records		Yes		APA Guideline	Yes	Adequate controls pending actions		APA to provide standard crossing form (as-built data requirements) to Neoen so APA can update as-built database	Yes					NA		
Other																			

Appendix 4 Electrical Hazard Assessment

Neoen Australia Pty Ltd

Culcairn Solar Farm APA Pipeline EPR Assessment Report

Document Record

Prepared For	Nicholas Fox Senior Project Manager Neoen Australia Pty Ltd
Prepared By	Sreejitha Kotteth Sukumaran Electrical Engineer Zero Sequence Earthing
Reviewed By	Akshay Bijarnia Area Manager VIC/SA Zero Sequence Earthing
Issue Date	22 August 2024
Document Number	ZSE23197-01 R0

Revision History

Revision	Issue Date	Description
Revision 0	22 August 2024	Initial Issue

EXECUTIVE SUMMARY

Zero Sequence Earthing (ZSE) has conducted an assessment of Earth Potential Rise (EPR) hazards on the APA Gas pipeline, specifically focusing on the risks posed by single line-to-ground faults due to the proximity of the Solar Farm in Culcairn, NSW. The primary objective of this report is to evaluate the voltage hazard levels on the APA Gas pipeline and to determine if the risk is acceptable according to Australian Standards predominantly AS4853.

Neoen's construction of solar farm & 330/33kV substation does not entail the construction of an overhead or underground transmission (330kV) powerline that run parallel with the APA gas pipeline for a significant distance. Consequently, ZSE's focus will solely be on addressing Earth Potential Rise (EPR) concerns, rendering a Low Frequency Induction (LFI) assessment unnecessary.

The findings indicate that the voltage levels are below the allowable limits specified by the AS4853 standard, which suggests that the risk is minimal. ZSE does not recommend any further mitigation measures for addressing EPR hazards on the valves or any other test points evaluated in this report or in the vicinity of the solar farm.

TABLE OF CONTENTS

1 INTRODUCTION

Neoen Australia Pty Ltd is developing the Culcairn Solar Farm 5km South-west of Culcairn NSW as illustrated in Figure 1-1. Zero Sequence Earthing (ZSE) has been engaged by Neoen to perform a hazard assessment on the APA gas pipeline in the vicinity of the Solar Farm to analyse the potential impacts of faults occurring at the Culcairn Solar Farm and 330/33kV substation.

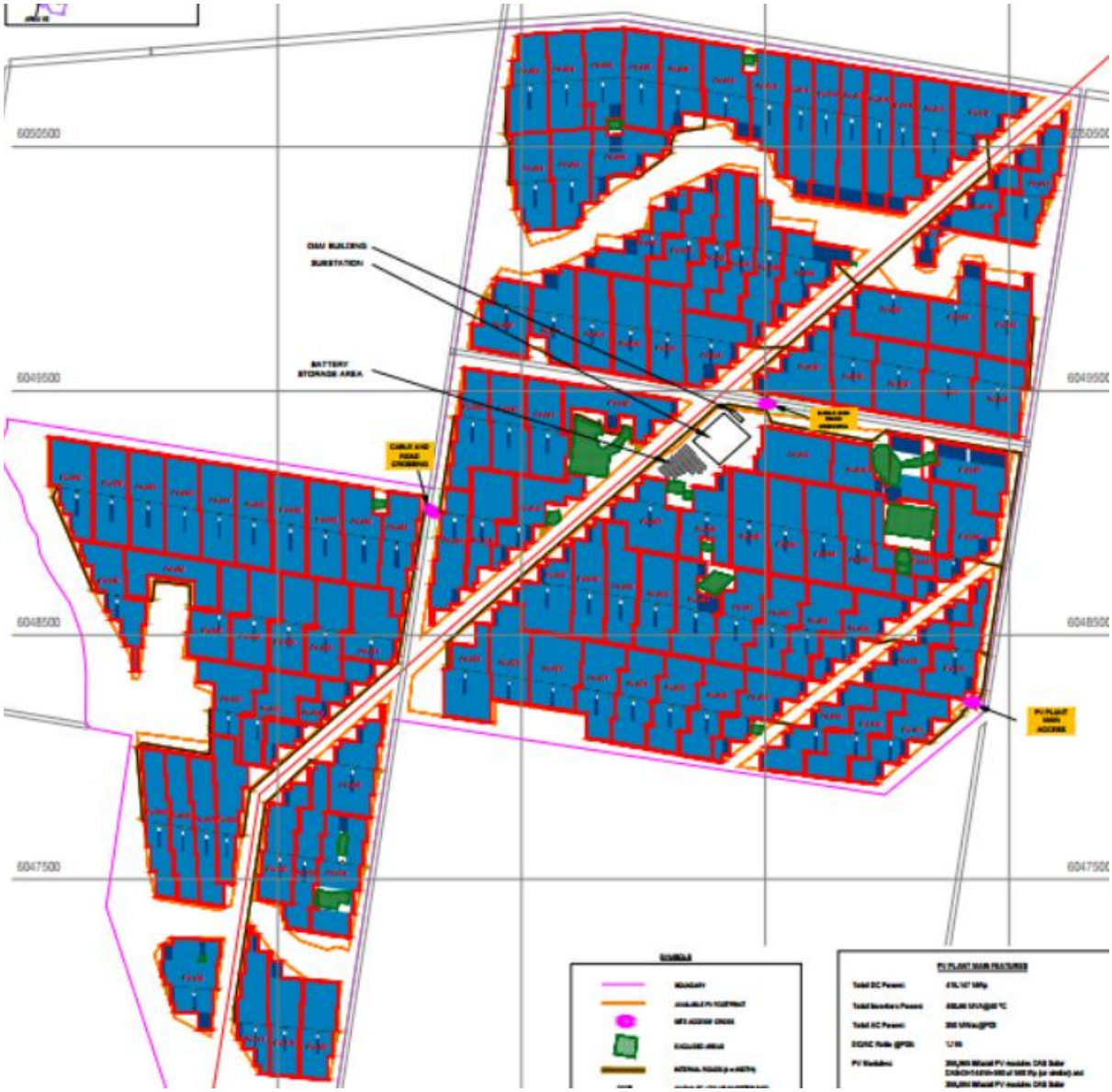


Figure 1-1: Site Layout

Neoen's construction of the Solar Farm and 330/33kV substation does not involve building an overhead or underground 330kV transmission powerline that runs parallel to the APA gas pipeline for a significant distance. Therefore, the report will focus solely on addressing Earth Potential Rise (EPR) concerns and will not include a Low-Frequency Induction (LFI) assessment.

2 DESIGN INPUT DATA

Design information/inputs are based on data supplied by Neoen as listed in section 5 of this report.

2.1 System Configuration

The general layout of Culcairn SF and the APA pipeline in the vicinity is shown in Figure 2-1. Since the APA pipeline is crosses the Solar Farm boundary, EPR assessment is required for the faults occurring both within the SF and at the 330kV substation.

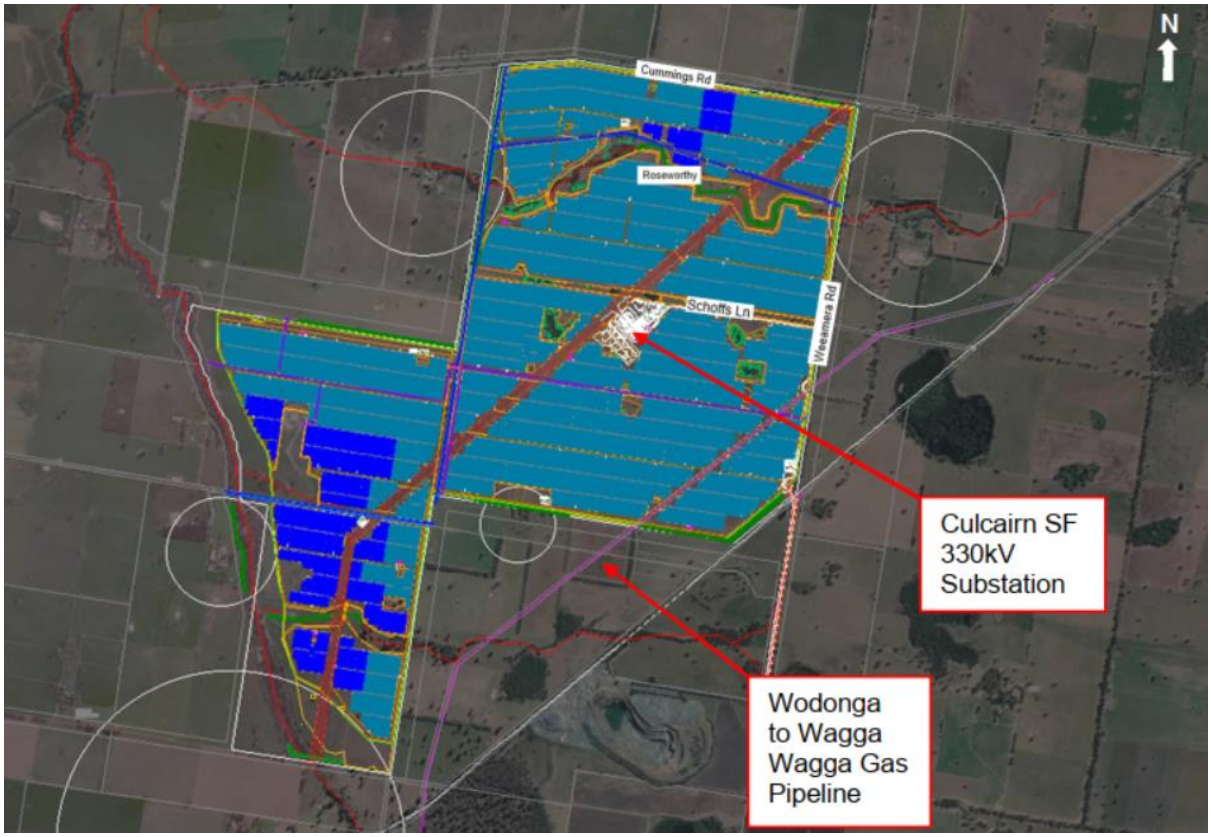


Figure 2-1: Location of Solar Farm and the pipeline

2.2 Pipeline Data

The pipeline data as provided by Neoen is used for the assessment.

Material	API 5L Grade X70 steel
Outside diameter	457mm
Pipeline wall thickness	Standard WT 6.8mm heavy WT 8.1 and 9.7mm in some sections
Pipeline coating	Extruded HDPE
Pipeline thickness	1.2mm

2.3 Fault Level and Clearing Time

The earth fault level data obtained from Neoen Earthing and Lighting protection design Report [2] has been reproduced in Table 2-1.

Table 2-1: Fault level and clearing time.

Fault scenario	Fault level (kA) [1]	Clearing time (s)
330kV Fault at the Substation	50.0	0.1
	11.3	
	13.56	
33kV Fault at the Substation	1	0.55

1. Fault level as obtained from Earthing design report [2]

Table 2-2: Maximum EPR obtained at the Solar Farm and 330kV substation

Fault scenario	EPR
330kV Fault at the Substation	483 V
33kV Fault at the Solar Farm	96 V

According to the Earthing and Lighting protection design Report [2] obtained from Neoen, the maximum EPR is observed during 330kV fault at the substation as shown in Table 2-2. The grid resistance was measured to be 0.035Ω. This value will be used for the assessment as it represents the worst-case scenario.

2.4 Soil Resistivity Information

Soil resistivity testing obtained from the Earthing and Lightning protection report [2] provided by Neoen has been tabulated below in Table 2-3 used for the assessment.

Table 2-3: Soil Resistivity Model

Layer	Resistivity (Ω.m)	Depth (m)
1	58	0.47
2	14	∞
Safety criteria	5[1]	Surface

1. Conservatively applied.

2.5 Applicable Standards and Safety Targets

The allowable safety limits for EPR fault scenarios depend on the likelihood of a fault occurring and the likelihood of contact. AS4853 Level 3 assessment guidelines and the contact frequencies outlined in Table K1-K4 AS4853 [9] form the basis of the EPR safety criteria for metallic pipeline:

2.5.1 330kV EPR Fault Scenario

- 5Ωm soil resistivity, as specified in Section 2.4
- 0.1 Faults per year (conservatively applied)
- 0.1s Clearing time as per Section 2.3
- Standard footwear

Table 2-4: Touch voltage allowable limits for EPR scenario

Scenario	Contact Scenario	Allowable voltage
Public CP/valve	10 contacts,5 s duration	NA[1]
Operator (valve)	250 contacts, 5 s duration	1,153 V
Operator (CP test points)	5 contacts, 5 mins duration	1,085 V

1) No limit as the coincidence probability is < $1x10^{-6}$

2.5.2 33kV EPR Fault Scenario

- 5Ωm soil resistivity, as specified in Section 2.4
- 0.1 Faults per year (conservatively applied)
- 0.55s Clearing time as per Section 2.3
- Standard footwear

Table 2-5: Touch voltage allowable limits for EPR scenario

Scenario	Contact Scenario	Allowable voltage
Public CP/valve	10 contacts,5 s duration	NA[1]
Operator (valve)	250 contacts, 5 s duration	466 V
Operator (CP test points)	5 contacts, 5 mins duration	423 V

1) No limit as the coincidence probability is < $1x10^{-6}$

3 EARTH POTENTIAL RISE ASSESSMENT

The CDEGS Model uses the following input parameters:

- Pipeline details as described in Section 2.2
- Solar Farm layout modelled as per earthing design report [2]

Figure 3-1 shows the CDEGS model diagrams of the Solar Farm and APA pipeline and associated appurtenances in the vicinity.

Figure 3-1: CDEGS model of Culcairn Solar Farm

3.1 Faults causing Earth Potential Rise (EPR)

Earth faults occurring on assets (such as solar farm & substation) near the pipeline can cause an Earth Potential Rise (EPR) at the asset and the surrounding soil. The pipeline sits at a lower voltage relative to the fault location due to the pipeline insulation, and the difference between the pipeline voltage and the soil nearby can result in a touch voltage hazard at pipeline or accessible points on the pipeline.

Table 2-4 presents the calculated allowable pipeline voltages in line AS4853:2012. This report considers fault at both the Culcairn SF and the 330/33kV Substation, with the assessment focusing on the worst-case scenario - fault at the 330kV substation.

Modelling results for the transferred EPR to the APA pipeline during the earth fault condition at the solar farm 330kV substation equipment is shown in Figure 3-2. The maximum pipeline touch voltage is 21V as shown in Figure 3-3 below, which is significantly lower than the AS4853 allowable limits as mentioned in Table 2-4.

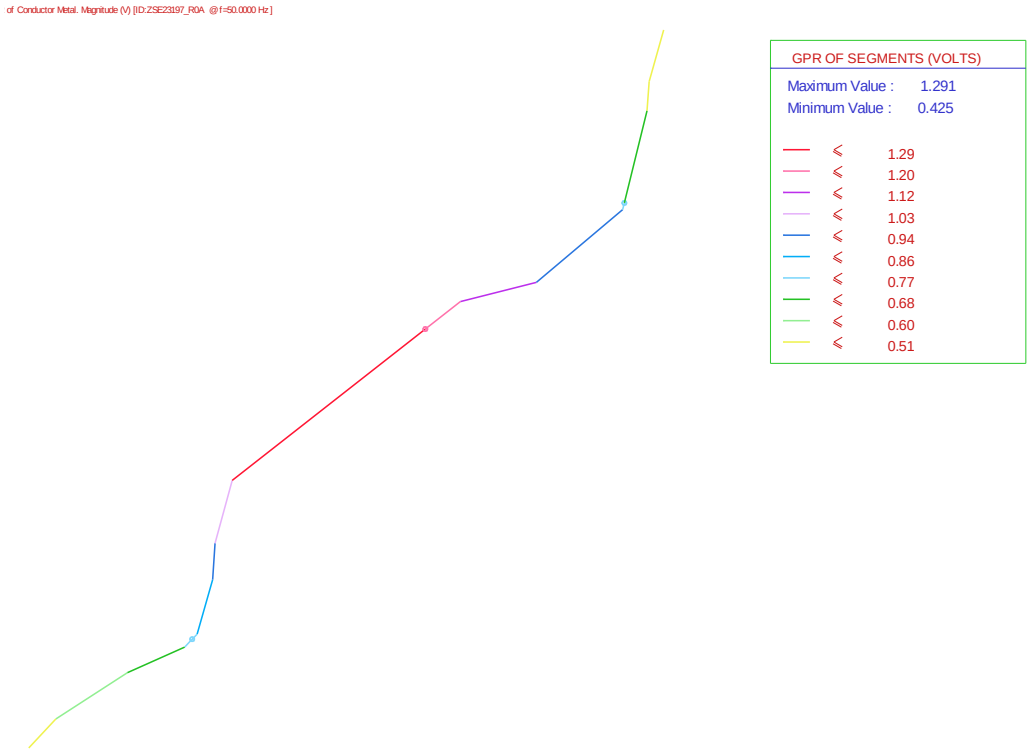


Figure 3-2: 330kV transferred EPR – 330kV fault at SF substation

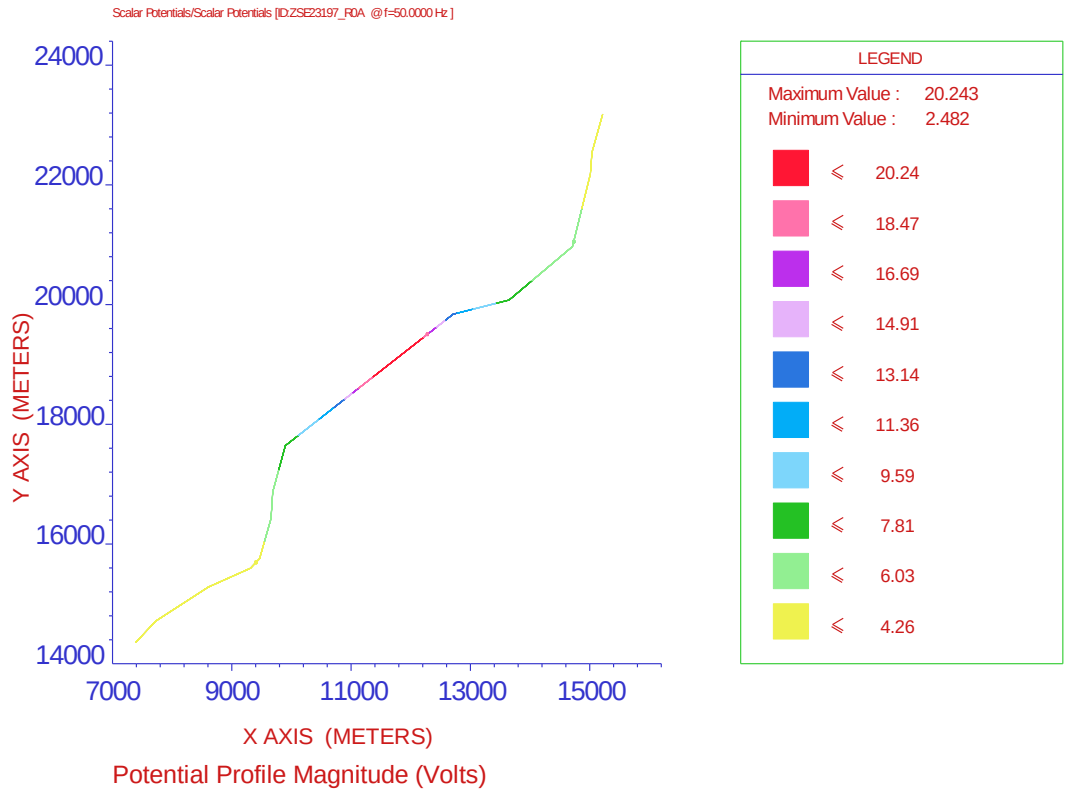


Figure 3-3: Touch Voltage at the pipeline – 330kV fault at SF substation

Figure 3-4, Figure 3-5 and Figure 3-6 displays the touch voltage hazards at the valves/test points for the 330kV earth fault at the Substation.

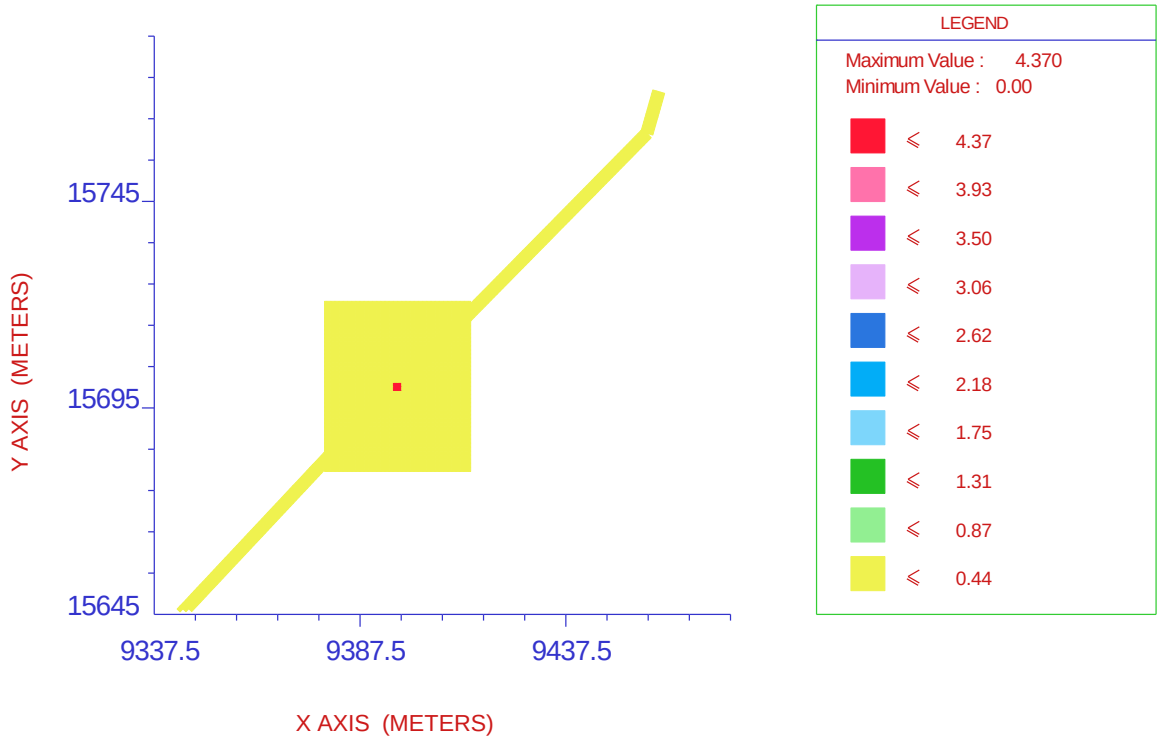


Figure 3-4: Touch Voltage at Valve/TP-1 during 330kV fault at the Substation

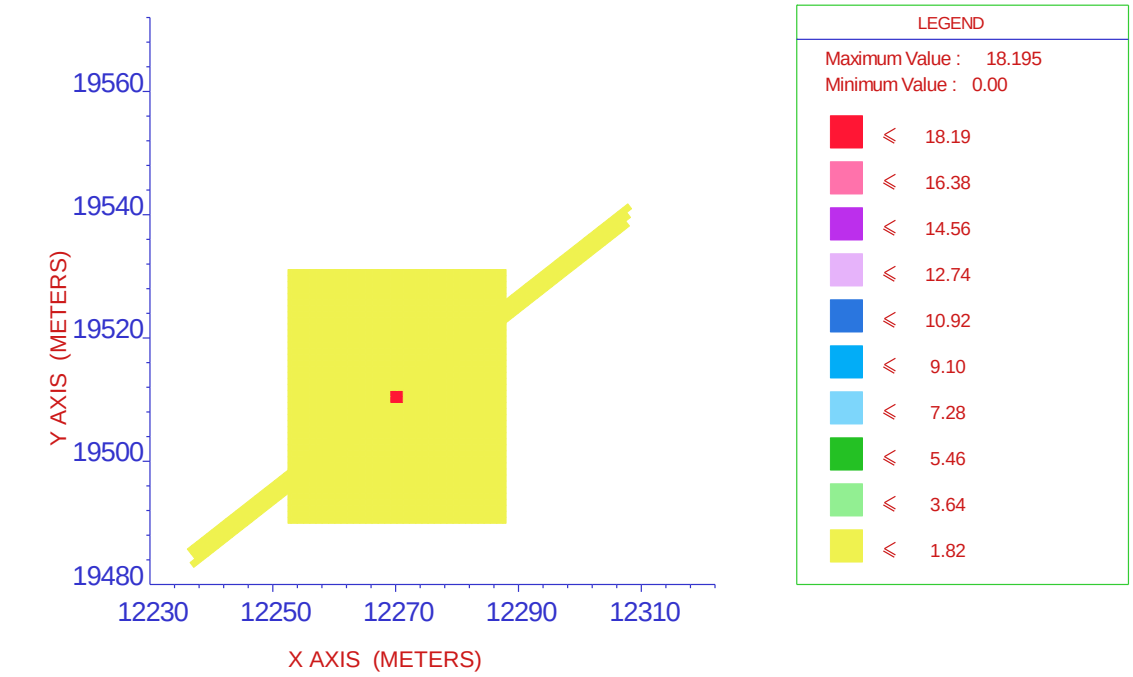


Figure 3-5: Touch Voltage at Valve/TP-2 during 330kV fault at the Substation

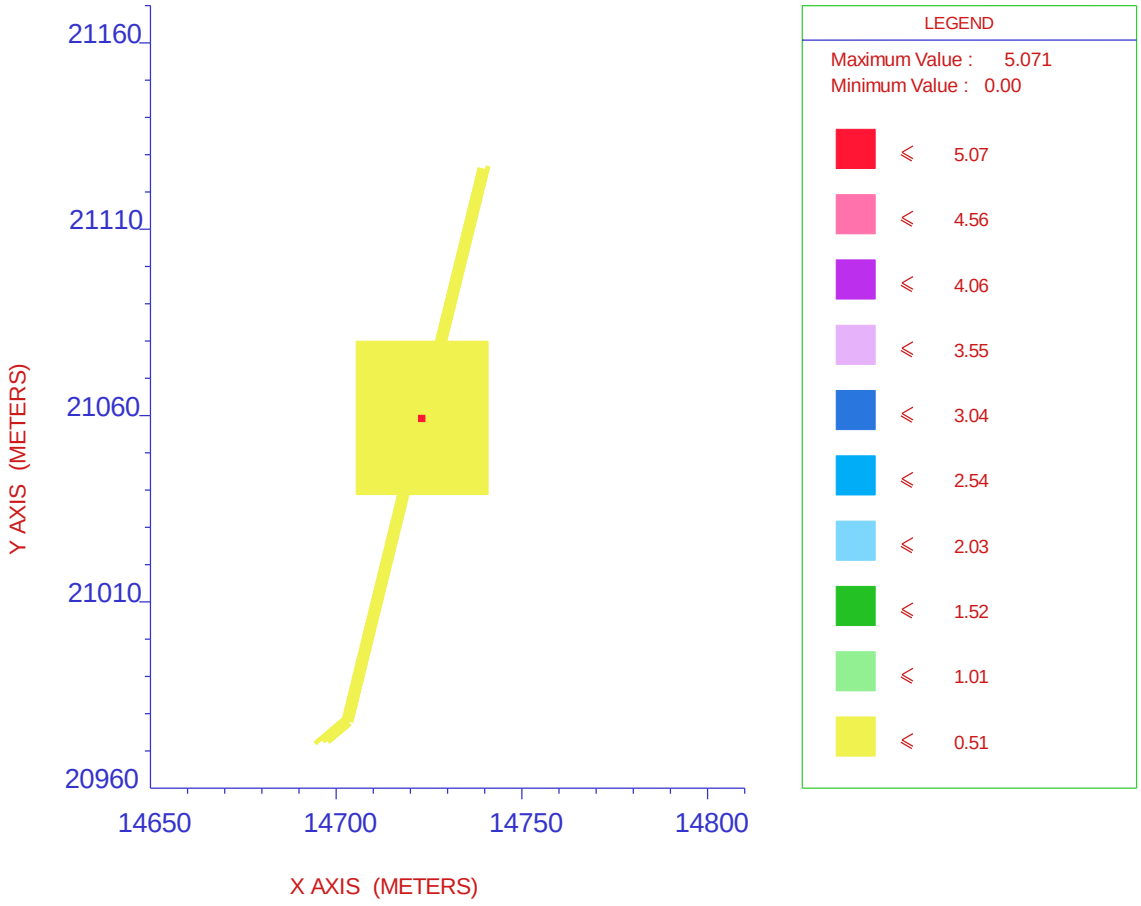


Figure 3-6: Touch Voltage at Valve/TP-3 during 330kV fault at the Substation

Table 3-1 provides a comparison between the calculated touch voltages and the AS4853 safety limits, presenting the percentage of the allowable limits for reference and analysis.

Table 3-1: Calculated touch voltages vs safety limits

Item	Location	Calculated Touch Voltage (V)	Allowable Limit	% Allowable Limit
Maximum Touch Voltage	Valve/TP-1	5	1,085 V	<2%
	Valve/TP-2	19		
	Valve/TP-3	5		

1. Most stringent step voltage limit used.

The touch voltages at all the appurtenances in the vicinity is found to be lower than the maximum thresholds. Overall, the findings suggest compliance with safety standards and relatively low risk levels during the specified fault conditions.

In addition, conducting a fault assessment for a 33kV scenario is deemed unnecessary due to the lower Earth Potential Rise as compared to a 330kV fault scenario. Touch voltages calculated for a 330kV fault consistently remain well below the safety thresholds for 33kV fault scenario, suggesting that touch voltages in a 33kV fault scenario will also be lower and compliant with AS4853 standard.

4 SUMMARY AND RECOMMENDATIONS

Zero Sequence Earthing (ZSE) has assessed Earth Potential Rise (EPR) hazards on the APA Gas pipeline, specifically focusing on the risks posed by single line-to-ground faults due to the proximity of the Solar Farm in Culcairn, NSW.

The findings indicate that the voltage levels are below the AS4853 allowable limits, which suggests that the risk is minimal. ZSE does not recommend any further mitigation measures for addressing EPR hazards on the valves or any other test points evaluated in this report or located in close vicinity to the solar farm.

The table below summarises the results:

Table 4-1: Summary

Location	Measured Touch Voltage (V)	Allowable Limit	% Allowable Limit
Valve/TP-1	5	1,085 V	<2%
Valve/TP-2	19		
Valve/TP-3	5		

5 REFERENCES

Project Information

[1] 450.66 MVA, 418.147 MWdc Culcairn (Australia), DRW-01-Layout-Ed0, Mar 23

[2] NEO-CUSF-6704-EL-CSH-B, Internal Ref: 30019219, Culcairn Sokar Farm, Earthing and Lightning Protection Study Report,8 May 2024

[3] CCN-700006 Culcairn Solar Farm 330kV Switching Station Earthing Design Report, 03 May 2024

Australian Standards and Guidelines

[4] AS 2067:2016 'Substation and high voltage installations exceeding 1kV a.c.'.

[5] ENA EG-0:2022 'Power System Earthing Guide Part 1: Management Principles', Energy Networks Association.

[6] ENA EG-1:2022 'Substation Earthing Guide'. Energy Networks Association.

[7] AS 3000:2018, 'Wiring Rules', Standards Australia.

[8] AS 60479.1:2010 'Effects of Current on Human Beings and Livestock', Standards Australia.

[9] AS 4853:2012, 'Electrical Hazards on Metallic Pipelines'. Standards Australia.

[10] AS 3835:2006 'Earth Potential Rise (EPR) - Coordination of power and telecommunications' Standards Australia.

[11] AS 1768:2021, 'Lightning Protection', Standards Australia

[12] Essential Energy Network Information Portal

[13] CE0M7207.08 Earthing 11/22/33kV O/H to U/G Termination General Arrangement (Timber Pole), 30.07.2004,Essential Energy

International Standards and Guides

[14] IEEE Std 80:2013 'IEEE Guide for Safety in AC Substation Grounding'. The Institute of Electrical and Electronic Engineers, Standards Australia.

Appendix 5 APA Confirmation of Final Close Out

De : Casalegno, Joseph <Joseph.Casalegno@apa.com.au>
Envoyé : vendredi 23 mai 2025 11:18
À : Nicholas Fox <Nicholas.fox@neoen.com>
Cc : APA Third Party Projects <APAThirdPartyProjects@apa.com.au>
Objet : RE: APA 448542; Culcairn; As Built Data

EXTERNAL: Do not click links or open attachments unless you recognize the sender and know the content is safe.

Hello Nicholas,

APA have no objection and agree with the actions closed out and documented in revision 1 of the SMS report.

Regards

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Please note that I work part time and am available Monday, Tuesday and Thursday.

APA Australia's energy infrastructure partner