

RiIO T3 Transformer Replacement Programme - OFGEM Justification Paper	
Name of Scheme/Programme	RiIO T3 Transformer Replacement Programme
Primary Investment Driver	Asset Health (Lead asset – Transformer)
Scheme reference/mechanism or category	SPNLT 2042 / Transformer SPNLT2044 / Transformer SPNLT2045 / Transformer
Output references/type	NLRT2SP2042 – 2044 - 2045 (275kV Transformer)
Cost	Total cost: £ 10.75 m (RiIO T2 spend: £0.12 m / RiIO T3 spend: £ 10.63 m) SPNLT 2042 - £ 4.13 m (RiIO T2 spend: £ 0.09 m / RiIO T3: £ 4.04 m) SPNLT 2044 - £ 3.03 m (RiIO T2 spend: £ 0.03 m / RiIO T3: £ 3.00 m) SPNLT 2045 - £ 3.59 m (RiIO T2 spend: £ 0.002 m / RiIO T3: £ 3.59 m)
Delivery Year	SPNLT 2042 / Transformer - 2028 SPNLT2044 / Transformer - 2028 SPN:T2045 / Transformer - 2029
Reporting Table	C0.7 / C2.2a_AP / C2.2a_CI / C2.3 / C2.4b / C2.5 / C2.5a
Outputs included in RiIO T1 Business Plan	No

Issue Date	Issue no.	Amendment details
23/07/2020	1	First issue of document



	OFGEM RIIO-T2 justification paper: RIIO T3 Transformer replacement programme (Strathaven SGT1, Cockenzie SGT1 and Kaimes SGT2 275/33kV 120MVA units)	Issue 1
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1 Introduction

In 2015 a condition assessment of the in-service Bruce Peebles 120MVA 275/33kV transformers of a specific design was commissioned by SP Transmission as a result of previous post mortem investigations that had identified a thermally degraded soldered connection in the LV delta circuit. The condition assessment based on TRAN-02-002¹ established the likelihood of the presence of this particular defect in the remaining operational transformer fleet. The investigation also identified assets at or approaching end of life, particularly those with high Dissolved Gas Analysis (DGA) readings and poor site specific condition.

The analysis was carried out based on the oil diagnostic data sampled and analysed internally by SP Transmission and highlighted that, of the transformers in the fleet, a total of 12 transformers were suspected of having this type fault.

The transformers were ranked in order of condition with those showing the worst signs of distress being included in the RIIO T1 business plan and programmed for replacement allowing the remaining to be monitored and scheduled for replacement in subsequent price control periods.

The units at Strathaven (SGT1), Cockenzie (SGT1) and Kaimes (SGT2) were identified for continual DGA monitoring having been assigned a lower priority at that time and now are being scheduled for replacement during the RIIO T3 period.

In line with the above, the proposed lead asset outputs for the selected option are:

- 275kV Transformer disposal – 3 units
- 275kV Transformer addition – 3 units

The transformers are planned to be replaced under the following schemes in RIIO T3 period:

- SPNLT 2042 – Cockenzie 275/33kV 120MVA SGT1 replacement (Delivery year 2028)
- SPNLT 2044 – Strathaven 275/33kV 120MVA SGT1 replacement (Delivery year 2028)
- SPNLT 2045 – Kaimes 275/33kV 120MVA SGT2 replacement (Delivery year 2029)

The delivery of each of the above projects would be over 1 outage season with respective non-lead assets also proposed to be replaced in the same year.

A full CBA and refresh of the scope of works will be carried out in the preparation of the RIIO-T3 business plan. This paper demonstrates that the feasible options have been considered and that the funding required in RIIO-T2 is essential to enable timely and efficient delivery of the outputs in RIIO-T3. It is considered that these costs will contribute to the RIIO-T2/T3 fixed pot bridging fund as indicated in the draft determination.

¹ Assessment of Operational Adequacy of Transformers & Reactors (33kV & Above)

2 Background Information

Based on the values determined in accordance with the NOMS methodology, the transformers identified for replacement each have an EoL modifier score of 8.00, and considering the inherent type fault, have been identified accordingly for replacement during the RIIO-T3 period. Accordingly this paper supports a proposal to replace the existing 275/33kV 120MVA units at Strathaven (SGT1), Kaimes (SGT2) and Cockenzie (SGT1) on a like for like basis with new 275/33kV 120MVA units.

This is also in line with the SP Transmission investment strategy for transformers to replace assets at or approaching end of life, particularly those with high Dissolved Gas Analysis (DGA) readings and poor site specific, condition-based assessment ranked through our type based operational adequacy methodology TRAN-02-002².

Please find details of the lead assets proposed to be replaced:

Asset Description	Manufacturer	Year of Manufacture	<u>EoL (Transformer)</u> <u>(End of RIIO T2)</u>	Monetised risk
STHA275TRXSGT1	PARSONS PEEBLES	1966	8.00	£ 405,069.46
KAIM275TRXSGT2	BRUCE PEEBLES	1964	8.00	£ 742,967.97
COCK275TRXSGT1	BRUCE PEEBLES	1965	8.00	£ 449,451.73

A detailed site review and technical assessment of the condition of the non-lead assets at these sites has been carried out by SP Transmission as part of the project's development.


Condition assessment of the associated 275kV disconnectors at Kaimes and Strathaven substation have shown that the mechanical components are at a level of deterioration where intervention is required and the electrical components are at the end of their serviceable life.

The recommendation for the 275kV disconnectors is that it would be possible to refurbish them and make them operational for the expected design life of refurbished bays (40 years). However for refurbishing and reusing existing disconnectors, a substantial amount of work is required to be carried out by a specialist contractor. This involves rebuilding main contacts, sand blasting arcing rings, painting, replacing earth cables, rewiring and painting mechanism boxes, replacing contactors, relays, fuses, heaters and mechanism boxes to be tested in workshops. There is an element of added cost and time for refurbishment that needs to be reflected in the overall project timescales and costs. The costs and timescales to refurbish the disconnectors and mechanism boxes when compared with the costs and timescales to replace them indicate that replacement is the most economic option.

Accordingly the 275kV disconnectors in Kaimes SGT2 and Strathaven SGT1 bay are being proposed for replacement in this project.

Specific scope of works for each site are as below:

² Assessment of Operational Adequacy of Transformers & Reactors (33kV & Above)

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2.1 Cockenzie SGT1 bay:

It is proposed to replace SGT1, 275/33kV, 120MVA, transformer at Cockenzie 275kV substation along with its associated transformer bay equipment which includes; liquid filled neutral earthing resistors, auxiliary/earthing transformers, 275kV and 33kV surge arresters, oil containment system together with a new oil/water separator, other associated transformer bay civil works including a fire/noise enclosure, 33kV cable tails as well as modifications to the existing SGT1 protection equipment. The project will be an online build although the bund for the new transformer will be constructed off-line and used as a skid way to facilitate the removal of the existing transformer. There is also adequate interconnection of the 33kV network to support the demand required of the Cockenzie GSP in the event of a fault on SGT2 during the works to replace SGT1.

2.2 Kaimes SGT2 bay:

It is proposed to replace SGT2, 275/33kV, 120MVA, transformer at Kaimes 275kV substation along with its associated transformer bay equipment which includes; liquid filled neutral earthing resistors, auxiliary/earthing transformers, 275kV and 33kV surge arresters, oil containment system together with a new oil/water separator, other associated transformer bay civil works, modification of the 33kV cable tails as well as modifications to the existing SGT2 protection equipment.

A fire/noise enclosure has been considered during the initial concept to comply with SUB-01-0123 but sufficient electrical clearance can be achieved to the adjacent HV busbars by installing the enclosure. It has therefore been suggested that the use of a MIDEL filled transformer, to reduce the fire risk, should be considered.


2.3 Strathaven SGT1 bay:

It is proposed to replace SGT1, 275/33kV, 120MVA, transformer at Strathaven 275kV substation along with its associated transformer bay equipment which includes; liquid filled neutral earthing resistors, auxiliary/earthing transformers, 275kV and 33kV surge arresters, oil containment system together with a new oil/water separator, other associated transformer bay civil works including a fire/noise enclosure, 33kV cable tails as well as modifications to the existing SGT1 protection equipment.

Road upgrades and general infrastructure upgrades will be completed off-line in order to keep the outage to a minimum. Modification to the bund arrangements to suit the new transformer cannot take place until the existing transformer is removed therefore will be constructed during the outage for associated with the replacement.

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³ Substation Fire Protection Policy


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3 Optioneering

The following is a summary of the options considered for these schemes. The respective associated drawings for the proposed option are available for review if required.

	Option	Status	Reason for rejection
	Do Nothing	Rejected	This option was considered but due to the nature of the type fault and the dissolved gas analysis results showing an increasing trend in the presence of ethylene, carbon monoxide and 2FAL levels it was discounted and the options to intervene have been taken forward for further consideration.
1	Refurbishment	Rejected	A refurbishment option for the transformer was considered but given the drivers for intervention, type fault and deteriorating DGA results, the decision was made that refurbishment was not the preferred option.
2	Replacement in RIIO T2	Rejected	Detailed condition assessment carried out by SP Energy Networks on these type of transformer units and further DGA analysis of these units have shown that intervention is not required immediately and can wait until the next price control period. The results from the analysis proves any intervention in RIIO T2 period to be neither technically or commercially viable.
3	Replacement in RIIO T3 (on a like for like basis)	Proposed	-
4	Removal of transformers	Rejected	The transformer rating has been reviewed against the SP Transmission demand and generation scenarios and it has been confirmed that the replacement with a transformer as specified is appropriate.

Based on engineering design studies to determine the costs of the options identified as addressing the asset condition issues, the option to replace the units on a like for like basis in RIIO T3 was considered for further review.

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4 Detailed analysis

The units considered had been identified as having the known type fault and therefore the option which has been determined to be feasible and progressed for detailed consideration are to replace the transformer on asset health grounds.


No CBA or sensitivity analysis has been carried out for the options described as no alternative options have been considered technically or commercially feasible at the moment.

The project costs have been built up from individual costs for each element and included in a bill of quantities. The bill of quantities has been engineered from the design layouts developed for each option. The basis of individual unit costs has been the SP Energy Networks MoSC (Manual of Standard Costs) tool which makes reference to costs incurred during previous similar projects. Site contractor costs have been derived from contract costs from previously executed similar projects by SP Energy Networks in the RIIO T1 period.

5 Specific factors contributing to additional cost

The following factors were identified specifically project which resulted in additional cost:

- Remedial measures for ground contamination from oil leaks below the transformer bunds.
- Use of Midel transformer for SGT2 at Kaimes 275kV substation.
- Building modification works required at Cockenzie for decommissioning/removal of existing SGT1, while replacement of new SGT1 unit.
- Road upgrades at Strathaven 275kV substation to provide suitable access to the new Transformer location.

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5.1 Selected option

Please find below a cost and construction timescale summary of the preferred option:

	Option 3: Replacement in RIIO T3 on a like for like basis		
	Cockenzie SGT1	Kaimes SGT2	Strathaven SGT1
Cost (£m)	£ 4.13 m	£ 3.59 m	£ 3.03 m
Construction timescale	1 outage season		

5.2 Environment & Sustainability

In line with company's objective of reducing the company's carbon footprint, the selected option considers reuse of existing civil concrete foundations at site where possible. This is subject to further concrete testing of the existing civil assets at project delivery stage.

Use of a Midel filled power transformer at Kaimes SGT2 has also been considered as part of this project's review.

6 Conclusion


The option proposed has been reviewed in terms of scope, costs, timescales, construction risk, and sustainability requirements and have been found to be deliverable.

It also achieves the main objective of reducing the network risks due to existing 275/33kV 120MVA unit and so are acceptable.

The overall costs based on the recommended investments for each scheme is summarised below.

Overall recommendations and cost				
Project	Proposal	T2 Cost (£ m)	T3 Cost (£ m)	Asset
Cockenzie SGT1	Replacement in RIIO T3	£ 0.09	£ 4.04	Transformer
Kaimes SGT2	Replacement in RIIO T3	£ 0.002	£ 3.59	Transformer
Strathaven SGT1	Replacement in RIIO T3	£ 0.03	£ 3.00	Transformer

- Declared lead asset output: Addition – 3 units / Disposal – 3 units

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7 Future Pathways – Net Zero

7.1 Primary Economic Driver

The primary driver for this investment is asset condition and risk. The investment does not have a strong reliance on environmental benefits.

7.2 Payback Periods

A full CBA that would indicate the NPV results for all assessment periods will be carried out in the preparation of the RIIO-T3 business plan. Consumers benefit from reduced network risk immediately on completion of the project.

7.3 Pathways and End Points

The network capacity and capability that result from the proposed option has been tested against and has been found to be consistent with the network requirements determined from the ETYS and NOA processes. Additionally, the proposed option is consistent with the site-specific capacity requirements from SPT's Energy Scenarios.

7.4 Asset Stranding Risks

Electricity generation, demand and system transfers are forecast to increase under all scenarios. The stranding risk is therefore considered to be very low.

7.5 Sensitivity to Carbon Prices

Carbon price sensitivities will be applied to CBA proposed to be carried out for RIIO T3. The CBA outcome will be influenced by losses and will be sensitive to carbon prices.

7.6 Future Asset Utilisation

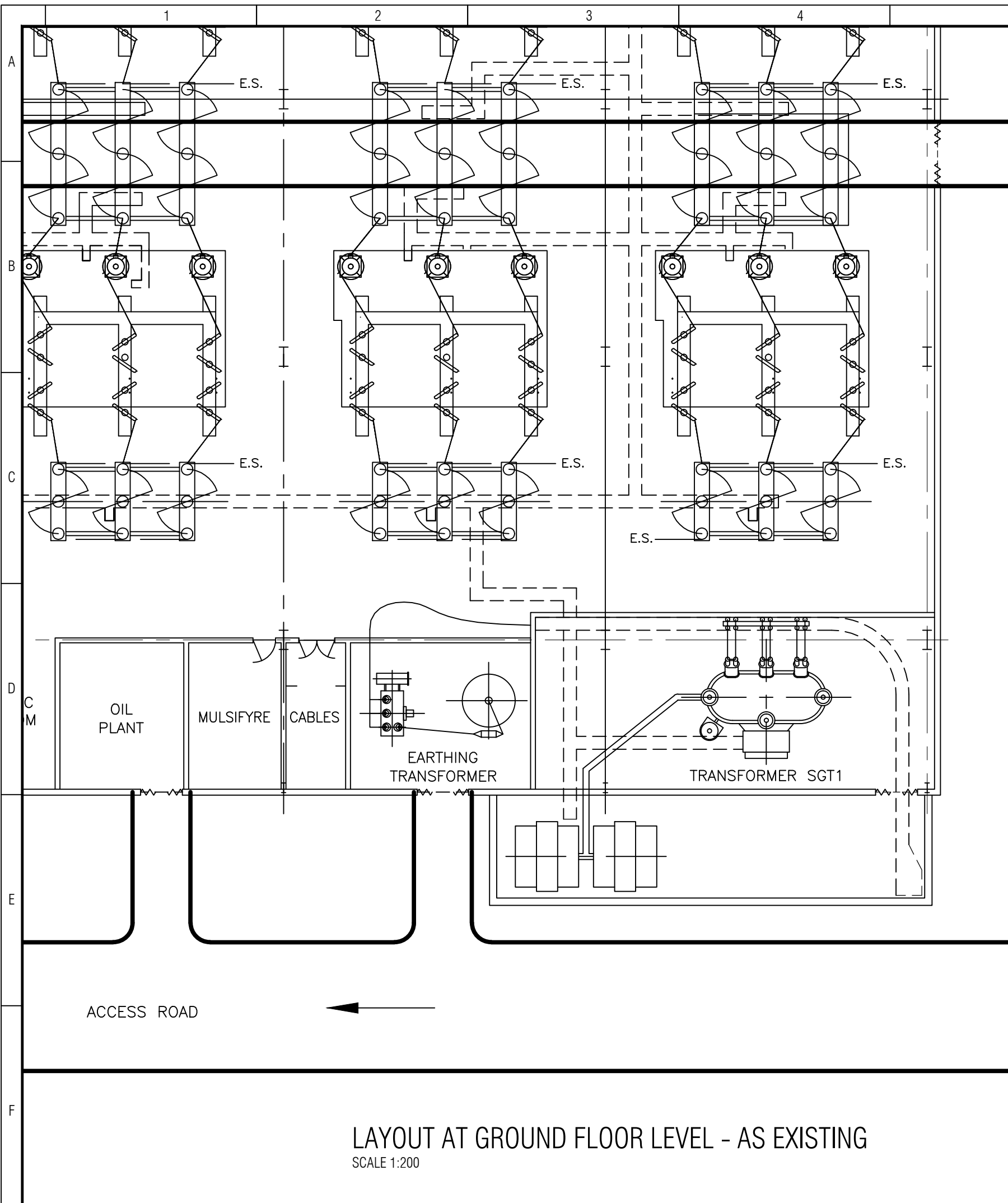
It has been assessed that the preferred option is consistent with the future generation and demand scenarios and that the risk of stranding is very low.

7.7 Whole Systems Benefits

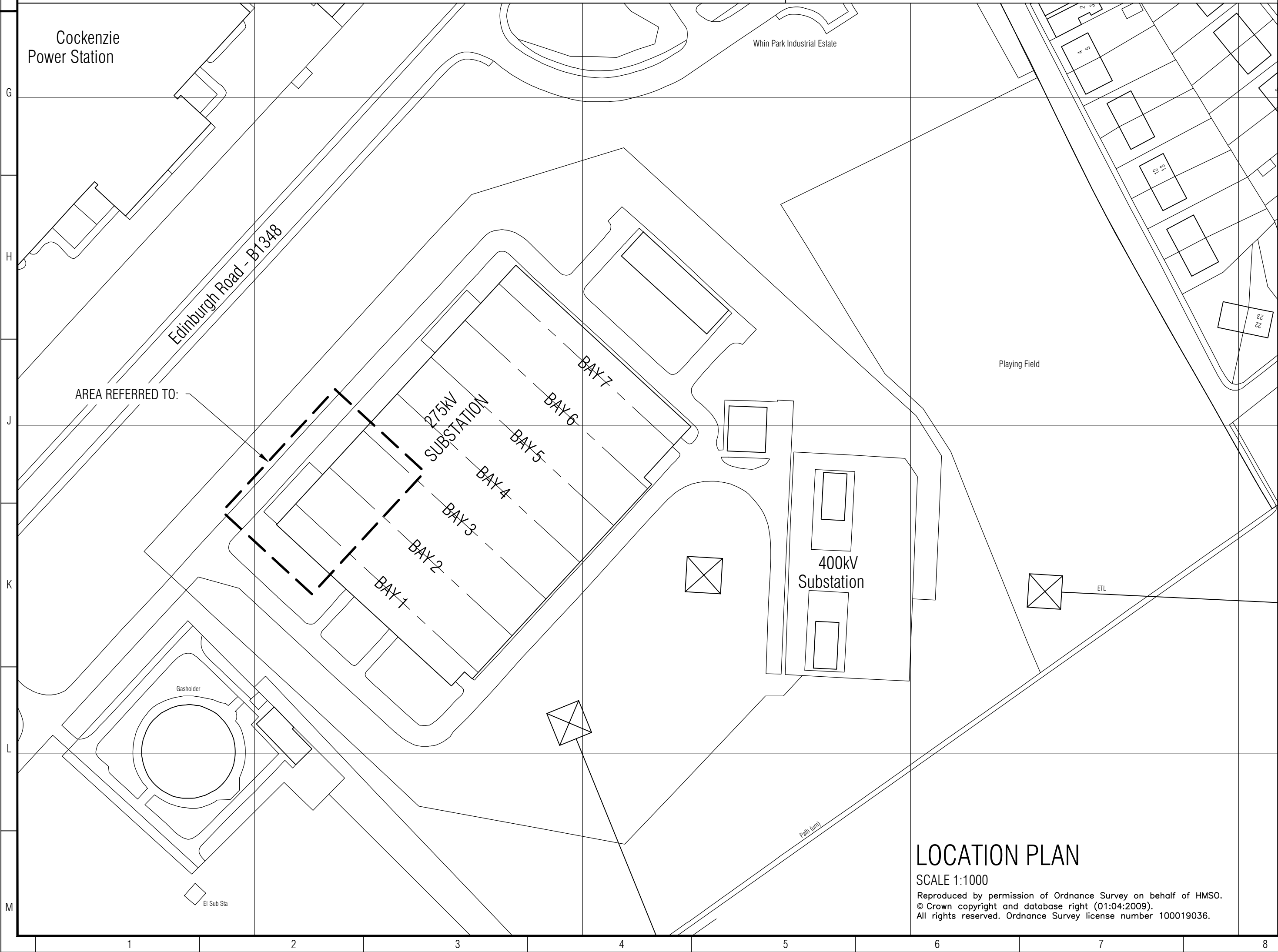
Whole system benefits have been considered as part of this proposal. The capacity and capability of the preferred option is consistent with the provision of whole system solutions.

8 Outputs included in RIIO T1 Plans

N/A

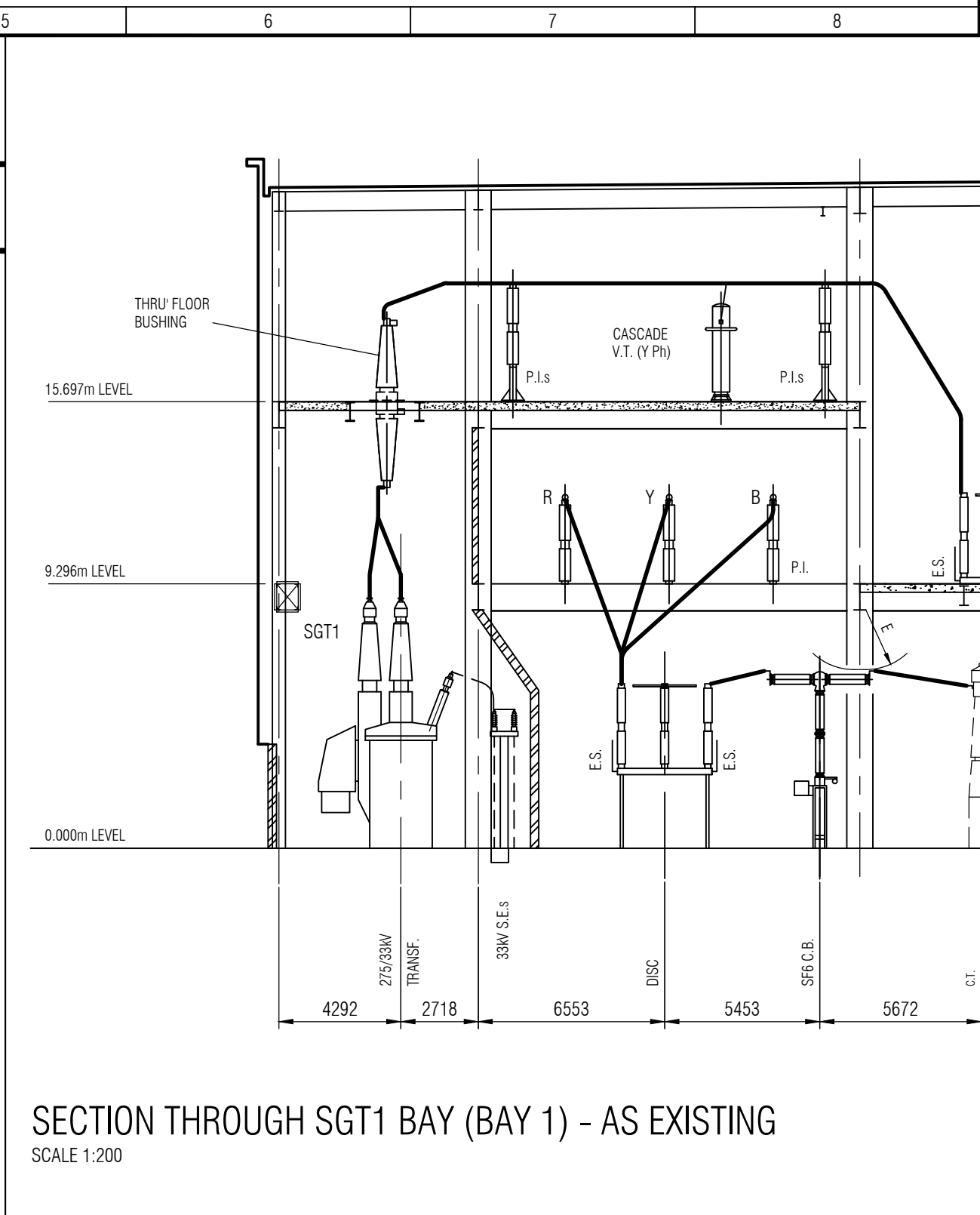


LAYOUT AT GROUND FLOOR LEVEL - AS EXISTING
SCALE 1:200

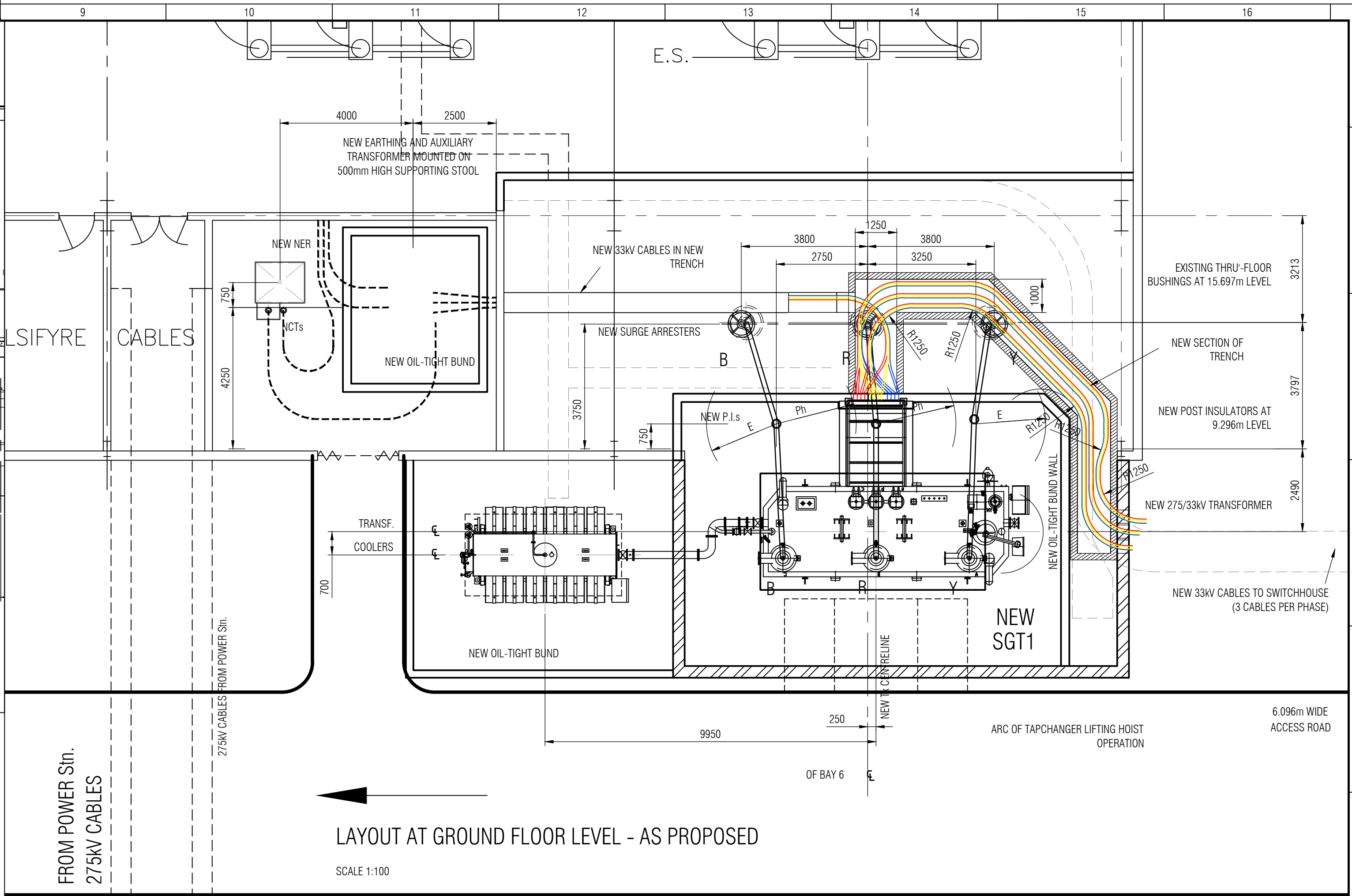


LOCATION PLAN
SCALE 1:1000

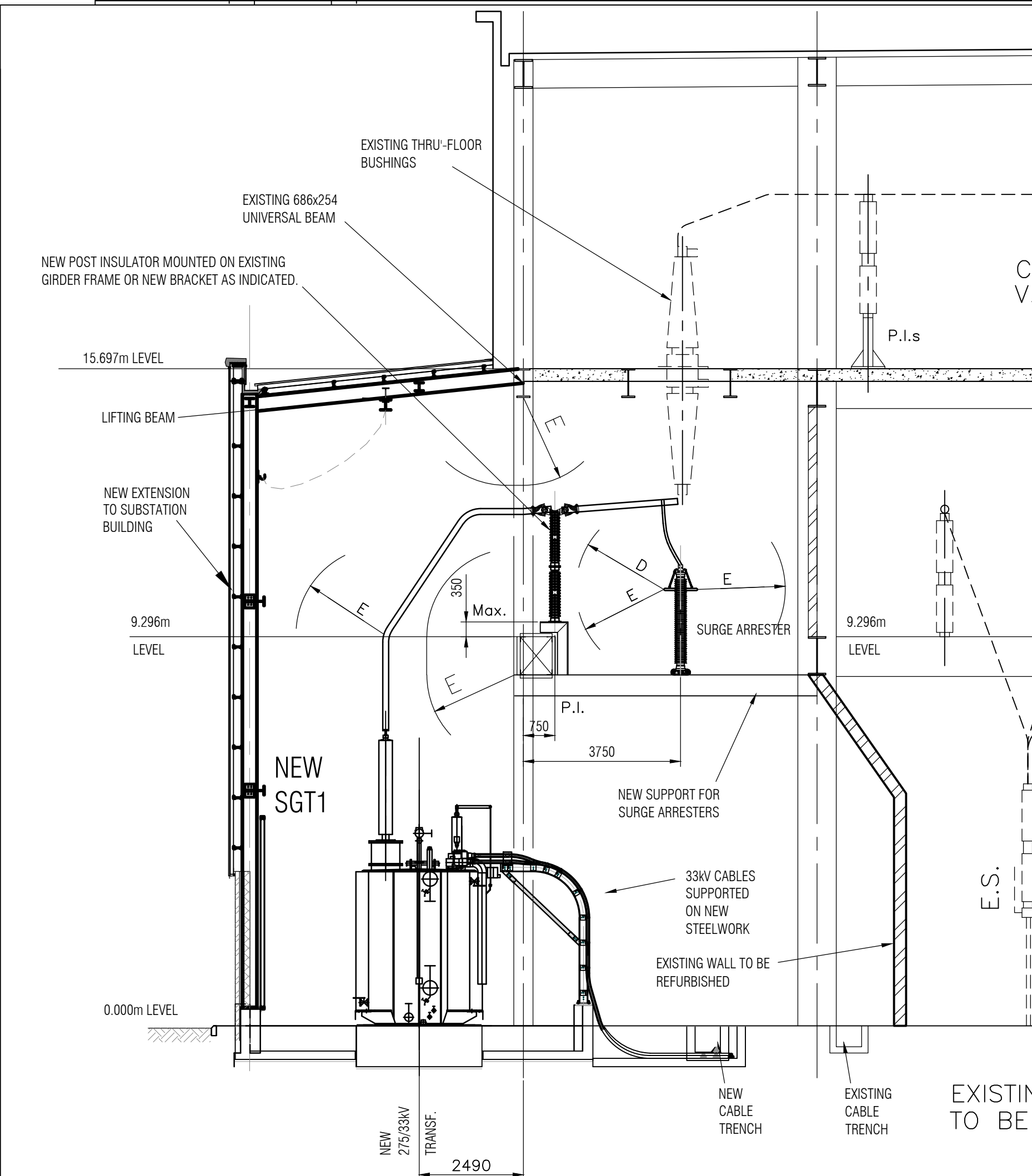
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SECTION THROUGH SGT1 BAY (BAY 1) - AS EXISTING
SCALE 1:200



LAYOUT AT GROUND FLOOR LEVEL - AS PROPOSED
SCALE 1:100



SECTION THROUGH SGT1 BAY (BAY 1) AS PROPOSED
SCALE 1:100

**THIS DRAWING HAS BEEN PRODUCED FOR
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NOTES:
CABLE ROUTES SHOWN ARE TAKEN FROM EXISTING RECORDS,
BUT ACCURACY OF ROUTES CANNOT BE GUARANTEED.

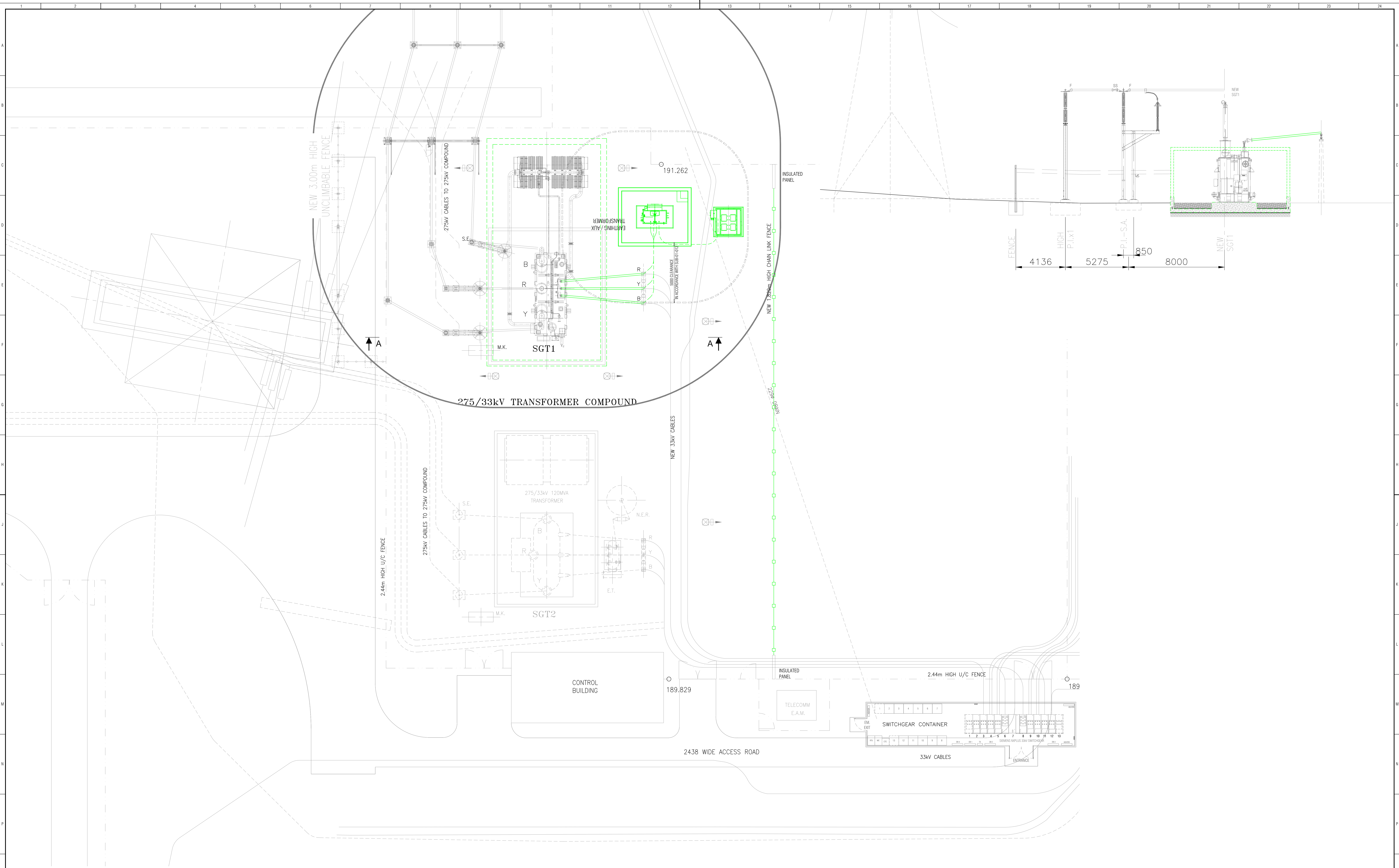
MINIMUM ELECTRICAL CLEARANCES	275kV	33kV
PHASE TO EARTH (E)	2.1m	0.5m
PHASE TO PHASE (P)	2.4m	0.5m
SECTION CLEARANCE (S)	4.8m	3.2m
SURGE ARRESTER (D)	2.1m	0.5m


SCALE AT 1:200



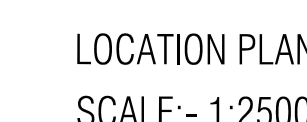
0.A	JM	Reviewed	Approved	Description of Change
Rev	Date	Drawn	Approved	Description of Change
Drawing Date				
Project: COCKENZIE TRANSFORMER SGT1 REPLACEMENT				
Location: COCKENZIE 275kV SUBSTATION Voltage: 275/33kV				
Drp. Title: PROPOSED ELECTRICAL LAYOUT OF COCKENZIE 275kV SUBSTATION FOR TRANSFORMER SGT1 REPLACEMENT				
Approval Status: N/A				
Drawn	Revd	Apprd	Drp. No.:	SP4146825
JM			Sheet: 0.A	Rev: A1
Scale: AS SHOWN				

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Rev.	Date	Drawn	Reviewed	Approved	Description of Change					
			Drawing Issue:		Project:					
No State			275KV STRATHAVEN SGT1		275KV TRANSFORMER REPLACEMENT					
General Notes:			Location:		STRATHAVEN 275/33KV COMPOUND			Voltage: 275/33KV		
N/A			Dwg. Title:		PROPOSED ELECTRICAL LAYOUT STRATHAVEN 275/33KV COMPOUND					
Drawn			Rev'd		Appt		Dwg. No.:		Sheet	Rev:
							SP4146828		0	0
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SCALE 1:100

NEW & EXISTING EQUIPMENT:

PROPOSED PLANT

EXISTING

LEGEND:

SGT	SUPER GRID TRANSFORMER
SA	SURGE ARRESTOR
PI	POST INSULATOR
CSE	CABLE SEALING END
DISC	DISCONNECTOR
E/SW	EARTH SWITCH
AUX Tx	AUXILIARY TRANSFORMER
NER	NEUTRAL EARTHING RESISTOR

MINIMUM ELECTRICAL CLEARANCES:

AS PER NGTS 2.1 ISSUE 3

E	PHASE TO EARTH
PH	PHASE TO PHASE
S	SECTION CLEARANCE (VERTICAL)
Sh	SECTION CLEARANCE (HORIZONTAL)

MINIMUM INSULATION HEIGHT *

* INCLUDES ADDITIONAL 300mm TO COMPLY

SURGE ARRESTER CLEARANCES **

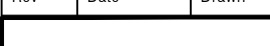
D	ARRESTER TO METAL OF SAME PHASE
E	ARRESTER TO EARTH
Ph	ARRESTER TO ARRESTER, BETWEEN PHASES

NOTES:

1. EXISTING LAYOUT TAKEN FROM DRAWING SP4102782.
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RA	JM				
Rev	Date	Drawn	Reviewed	Approved	Description of Change
		(Print Name) No State		Project KAIMES SGT2 275KV TRANSFORMER REPLACEMENT	
		(Print Name) N/A		Location: KAIMES 275KV SUBSTATION Withpage: 275	
		(Print Name) N/A		Dwg. Title: PROPOSED ELECTRICAL LAYOUT KAIMES 275KV SUBSTATION	
		Drawn	Revd	Apprd	Dwg. No.:
		JM			SP4146572
					Sheet Next Scale: