Power Delivery Engineering

EIT Training Review:

Progress Report

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Review Period:

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API - Application Programming Interface

BOQ - Bill of Quantities

CAD - Computer-Aided Design

COE - Center of Excellence

DBOUS - Design Base and OU Support

Dx - Distribution

EIT - Engineer in Training

GIS - Geographical Information Systems

GUI - Graphical User Interface

HV - High Voltage

ITU - International Telecommunications Union

LES - Lines Engineering Services

OHS - Occupational Health and Safety

OU - Operating Unit

PDE - Power Delivery Engineering

PTM&C - Protection, Telecommunications, Metering & Control

SAGC - South African Grid Code

SCADA - Supervisory Control and Data Acquisition

SCOT - Steering Committee of Technology

SLA - Service Level Agreement

UHF - Ultra High Frequency

VHF - Very High Frequency

1. INTRODUCTION

The purpose of this report is to reflect what I have learned and experienced during my past six months as an EIT (E*ngineer in Training)* at Eskom in PDE (*Power Delivery Engineering*). As part of my training, after completing the rotational training, I had to select a department within PDE for my elective training. Thus, I chose Lines Engineering Services as my elective department, which is primarily responsible planning, design and construction of overhead lines. I spent the past 6 months working and learning there.

2. TRAINING ACTIVITIES

2.1 LINES ENGINEERING SERVICES

Level of Responsibility: Designing, Developing, Meeting

Standards/SOG/Procedures: The planning, design and construction of overhead power lines design

TRMSCAAC

Previous Training Used: Lines Design

Duration: 8 weeks

While at LES, I was given a project for bypass design at Eiger substation. Since I am not a qualified engineer, I was assigned the position of assistant design leader, working under supervision of a qualified engineer. My roles in this project are as follows:

- Profiling
- Conductor selection
- Structure selection
- Insulator selection

2.1.1 PROJECT DESCRIPTION

Eiger substation is situated in Alberton. The substation is connected to the transmission grid at 275kV level via the lines linked to Brenner, Lethabo, Etna, Prospect and Fordsburg substation. There are three 315MVA, 275/88kV transformers and three 80MVA, 88/33kV transformers at Eiger. There are also eight 88kV feeders and two 33kV feeders. Because of the age of some of the equipment at Eiger, over 40 years, and underrated equipment for the fault level prevailing at the substation, a plant Condition Criticality Assessment CCRA was carried out in December 2013 to identify the plant that requires refurbishment. Eiger substation was identified for refurbishment due to a number of equipment requirements based on age and compliance to fault levels at the station. Hence In order to minimize the risk of asset failure and increase the reliability of the substation, it was recommended that the aged equipment must be refurbished. The objective of the Eiger S.S Refurbishment project is to replace old and underrated equipment which will be done based on recommendation from the CCRA and it is expected that this will improve the operational integrity of Eiger substation.

On the 31th of August 2017, LES conducted a site visit to inspect the Eiger substation. The site visit was partaken as part of the Eiger Substation Refurbishment project in which a request was put forward to LES to design bypasses for the project at Eiger Substation. The site visit was conducted to check the space constraints, the orientation of the substation and the affected feeders, the different towers, the conductor arrangements and to get a general virtualisation of the substation.

Information regarding the Eiger Substation Refurbishment project can be found in the Eiger S.S Refurbishment DRT and the project Initiation report.

2.1.2. SCOPE OF WORK

Eiger substation was identified for refurbishment due to a number of equipment requirements based on age and compliance to fault levels at the station. This substation is almost 40 years old and some of its equipment has reached the end of design life. In order to minimize the risk of asset failure and increase the reliability of the substation, the aged equipment must be refurbished.

The fault levels studies at the Eiger substation up to 23 were done and the results showed that the majority of equipment at the station is underrated. There are also some safety risks to personnel operation at Eiger substation when the substation is run with equipment that is underrated for the prevailing fault level. A refurbishment project was thus recommended to replace all underrated equipment as follows

- Eiger 275 kV Yard — Upgrade equipment from 30 kA to 50 kA
- Eiger 88 kV Yard — Upgrade equipment from 32.7 kA to 40 kA
- Eiger 33 kV Yard — The 33 kV busbar belongs to a customer and they will be notified of any upgrades

The station electric showing all the affected feeders is shown on figure 1. There are four feeders to be refurbished on the 275kV busbar and there are four more feeders to be refurbished on the 88kV busbar. The feeders are highlighted in red on the station electric figure The buscoupler to be converted into hospital bays are highlighted in yellow in the figure. The site visit was to reconfirm and check the physical positions of the highlighted feeders at the substation. LES was requested to design and specify bypasses for the substation which will be used during the refurbishment. The bypasses are required because the substation is a critical substation hence supplying critical costumers and cannot afford to have outages.

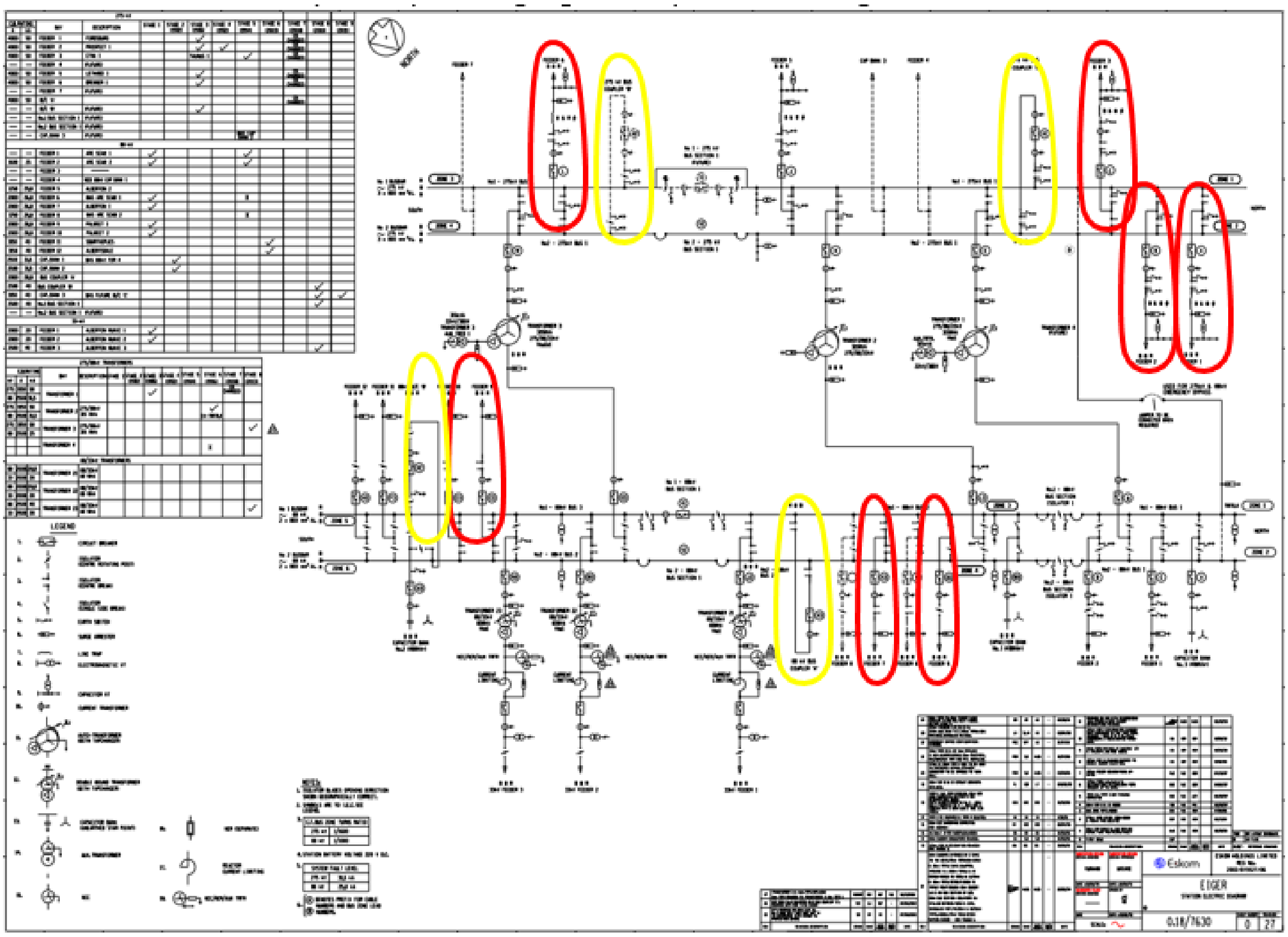
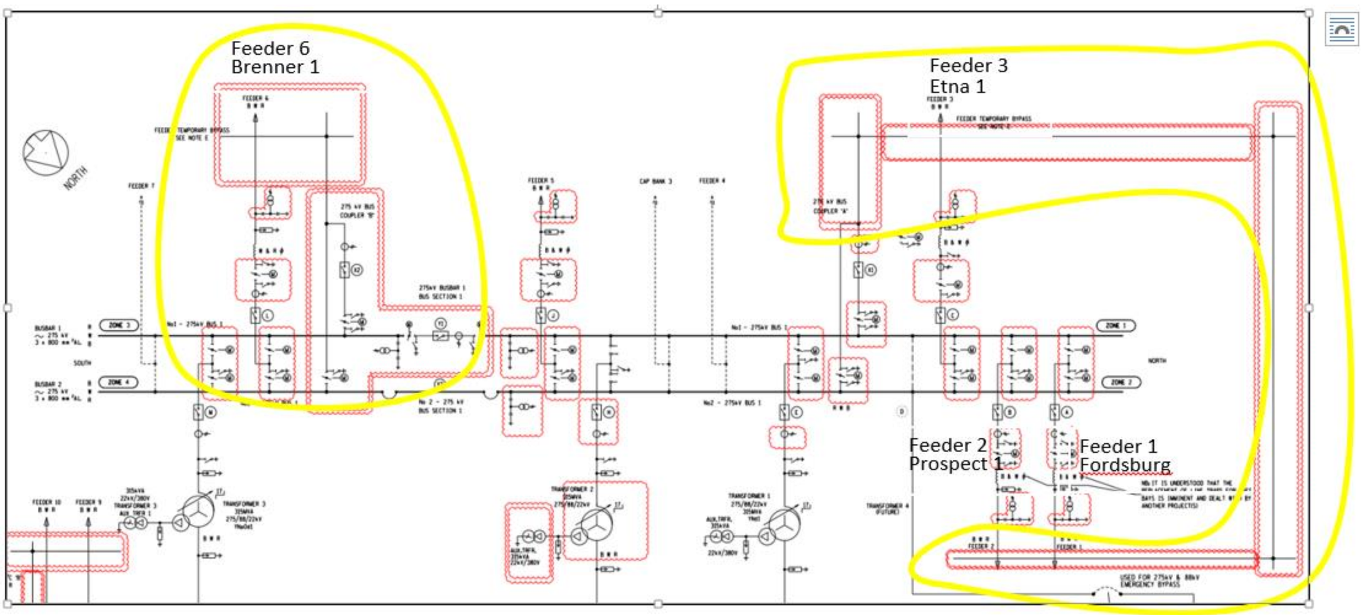


Figure 1: Station electric of Eiger substation showing all the affected feeders

LES was requested to design and specify bypasses for the substation which will be used during the refurbishment. The bypasses are required because the substation is a critical substation hence supplying critical costumers and cannot afford to have outages. The maximum outage that can be allowed is not more than two days (). Bypasses can be viewed as being virtual busbars. Hospital bays will be converted to feeders whenever a feeder is to be refurbished. The hospital bays can make use of bus couplers or spare bays. It is required that the hospital bays have protection too. The hospital bays will be connected to the bypass using jumpers and it will represent the feeder that will be taken out of service. The line coming into the substation will be connected to the bypass as will using jumpers. The required bypass is on the 275 kV and the 88 kV busbars substation. The refurbishment at Eiger affects some of the substations that are connected to the feeders to be refurbished. This is because they are uprating the equipment at Eiger thus, it means the equipment connected to the feeder that is being uprated have to be uprated as well. The respective substations affected are the Etna and Brenner substation. With Etna, Substation has proposed to implement a bypass inside the substation. For Brenner, a bypass is required on the feeder connected to Eiger, hence on the Brenner-Eiger Feeder. Since they are

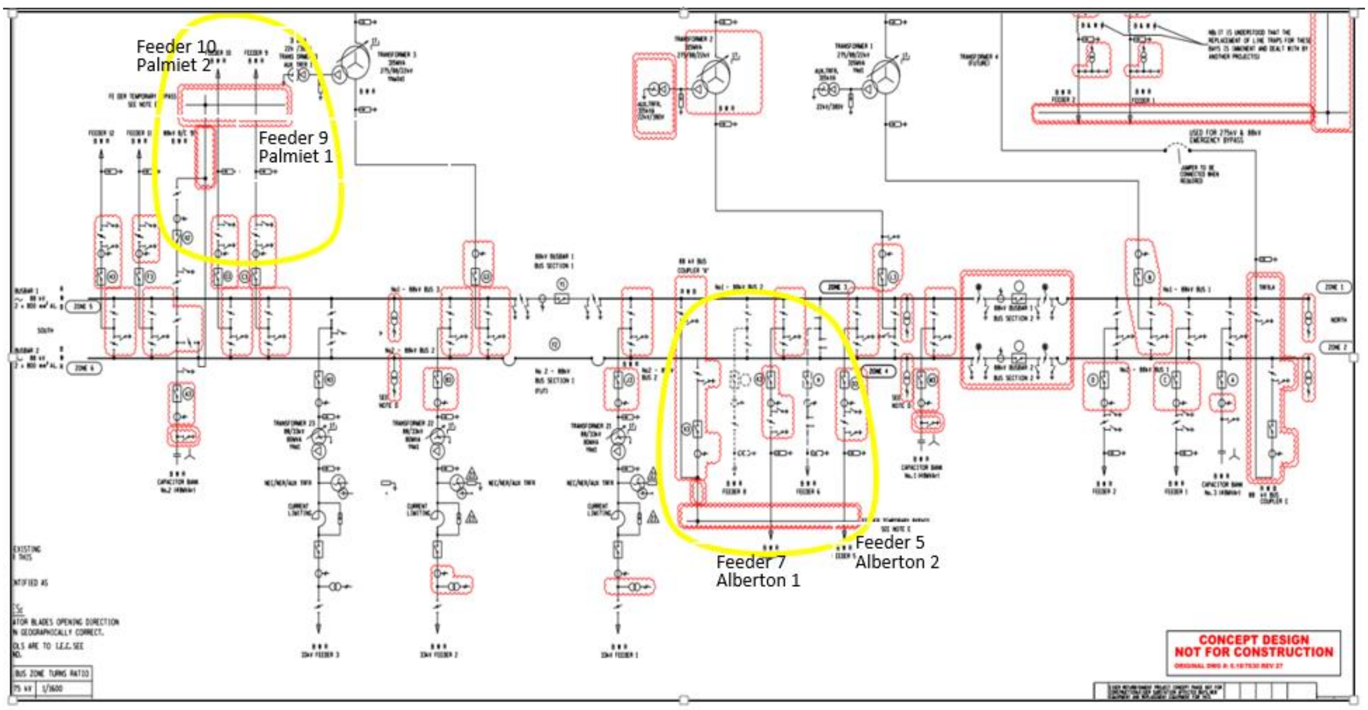
2.1.3. 275 KV BUSBAR

On the 275kV busbar, the feeders affected and the projection of the bypass is shown in the figure below. The affected figures are listed below as well



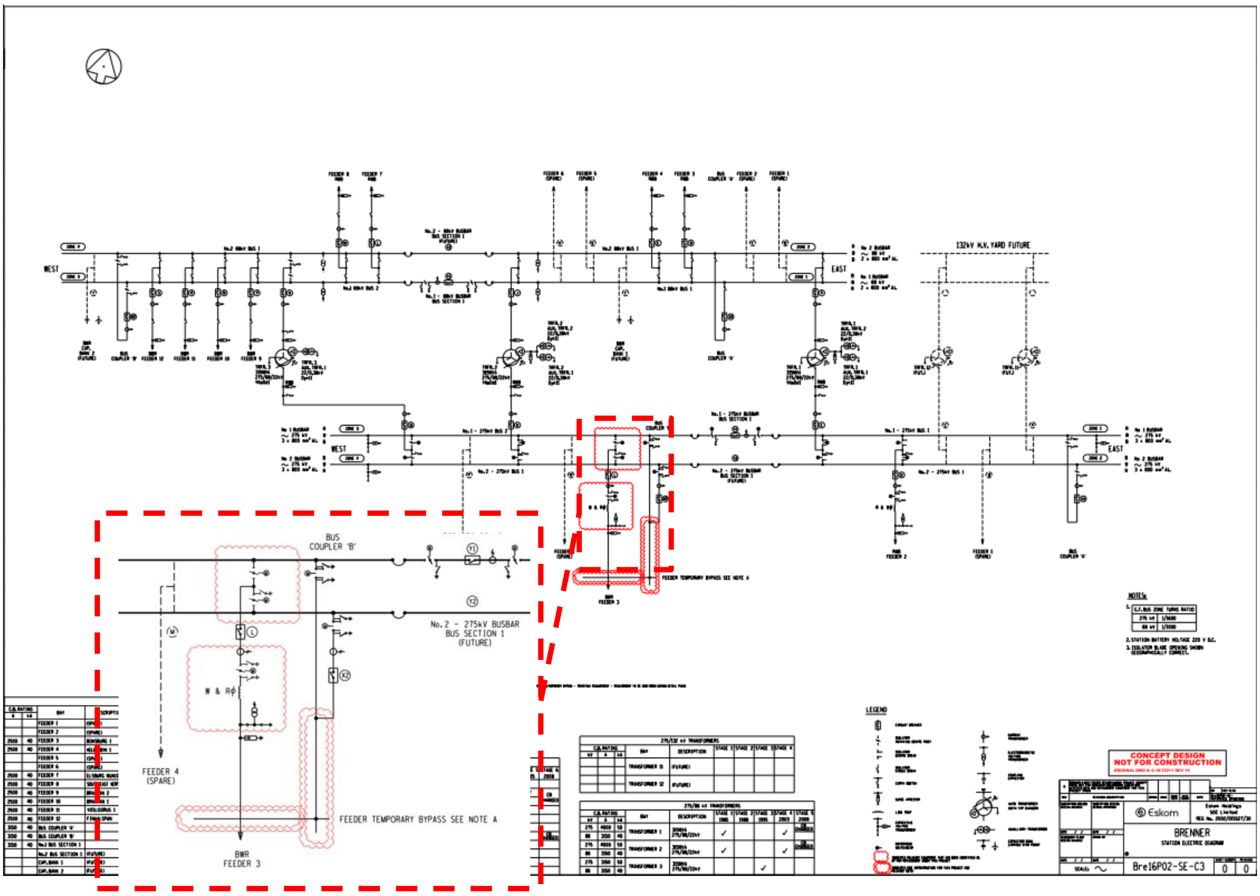
2.1.4.88 KV BUSBAR

On the 88kV busbar, the feeders affected and the projection of the bypass is shown on the figure below



2.1.5.BRENNER SUBSTATION AFFECTED FEEDER

The affected feeder at Brenner substation is the Brenner-Eiger feeder which is shown on the figure below.



3. SUBSTATION AND FEEDER INFORMATION AND FINDINGS

A walk down was done at the substation or site with the substation operator and the three engineers. A walk down to each feeder or incoming line into the substation affected by the refurbishments and or being part of the scope of work was checked. The walk down was conducted to check the space constraints, the orientation of the substation and the affected feeders, the different towers, the conductor arrangements and to get a general virtualisation of the substation and feeders. The findings are highlighted below. Figure 2 shows the aerial view of Eiger substation and the affected feeders which were checked.

Figure 2: Aerial view of Eiger substation

3.1. 275 KV FEEDER 6: EIGER-BRENNER 1

The 275 kV Eiger-Brenner 1 is a 43 km long line and the. The information about the line are as follows

Conductor type	Number of conductors	Number of earth wires	Type of earth wire	Conductor arrangement	Terminal tower type at Eiger substation	Power rating
ZEBRA	4	1	19/2.65	Horizontal	433E	

Figure 3 shows the aerial view of the Brenner feeder, figure 4 shows the terminal tower of the incoming line on the Brenner feeder and figure 5 shows the terminal tower label. It was found that there is an access road between the Brenner terminal tower and the live yard fence as shown on figure 4. The road was said to be a temporary road to access the live yard and that there is another road just behind the terminal tower. It was also observed that there was a small puddle between the terminal tower for Brenner and Lethabo indicating that this is a wet area.

Figure 3: Aerial view of the 275 kV Feeder 6: Brenner 1

Figure 4: The Brenner 1 feeder and terminal tower

Figure 5: The Brenner 1 feeder terminal tower label TR 433E 218

3.2. 275 KV FEEDER 3: ETNA

The 275 kV Eiger-Etna 1 is a 33 km line and has the following attributes.

Conductor type	Number of conductors	Number of earth wires	Type of earth wire	Conductor arrangement	Terminal tower type at Eiger substation	Power rating
ZEBRA	4	1	19/2.65	Horizontal	426 V	

Figure 6 shows the aerial view of the Etna feeder and figure 7 shows the terminal tower of the incoming line on the Etna feeder. Figure 8 shows the Brenner and Etna terminal towers. It was found that there is a wet area between the Etna terminal tower and the fence of the 275 kV live yard. This is highlighted on figure 8. According to the substation operator the wet area remains like that throughout the whole year and the water seem to be coming from underground. With reference to figure 8 and 9, there was a tree found next to the North-west corner of the 275 kV yard just close to the Etna terminal tower. An inquiry to check as whether the tree is a protected tree was proposed.

i.

Figure 6: Aerial view of the 275 kV Feeder 3: Etna

Figure 7: The Etna feeder and terminal tower

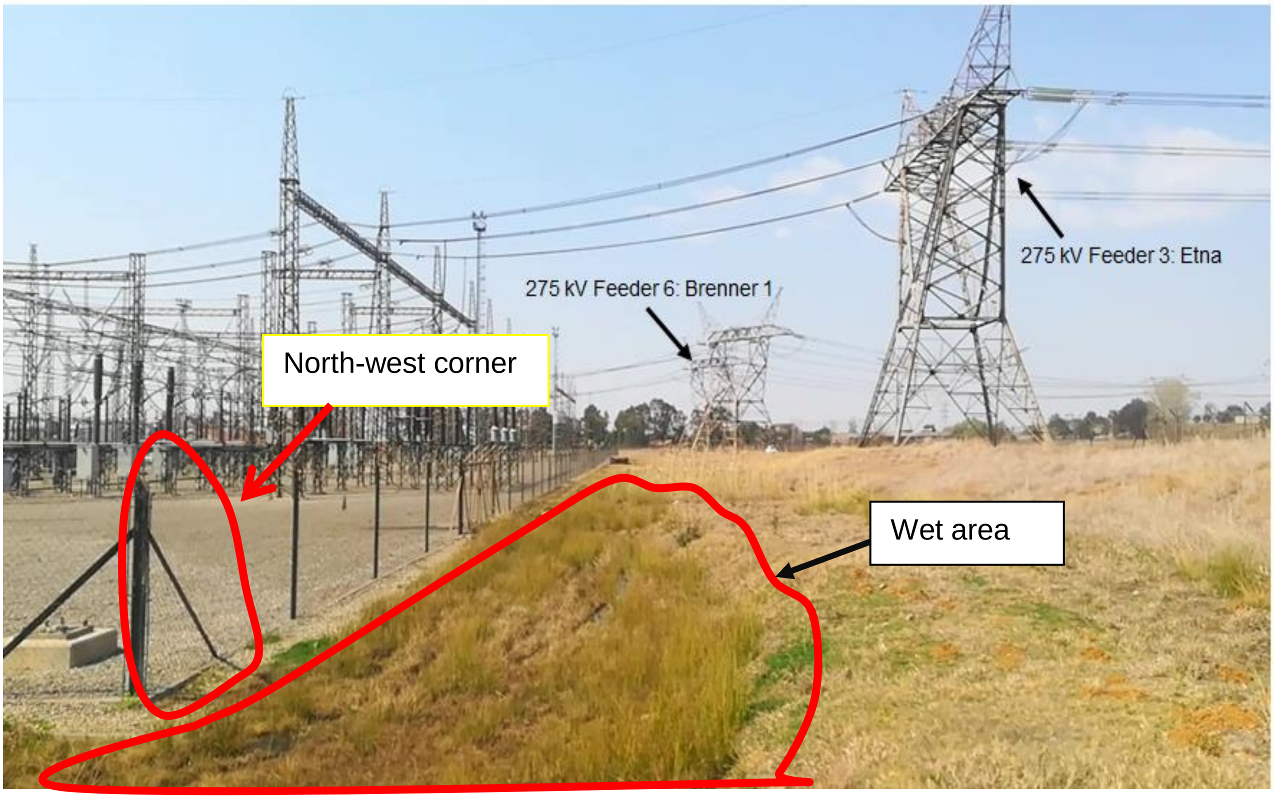


Figure 8: Brenner 1 feeder and Etna feeder showing wet area

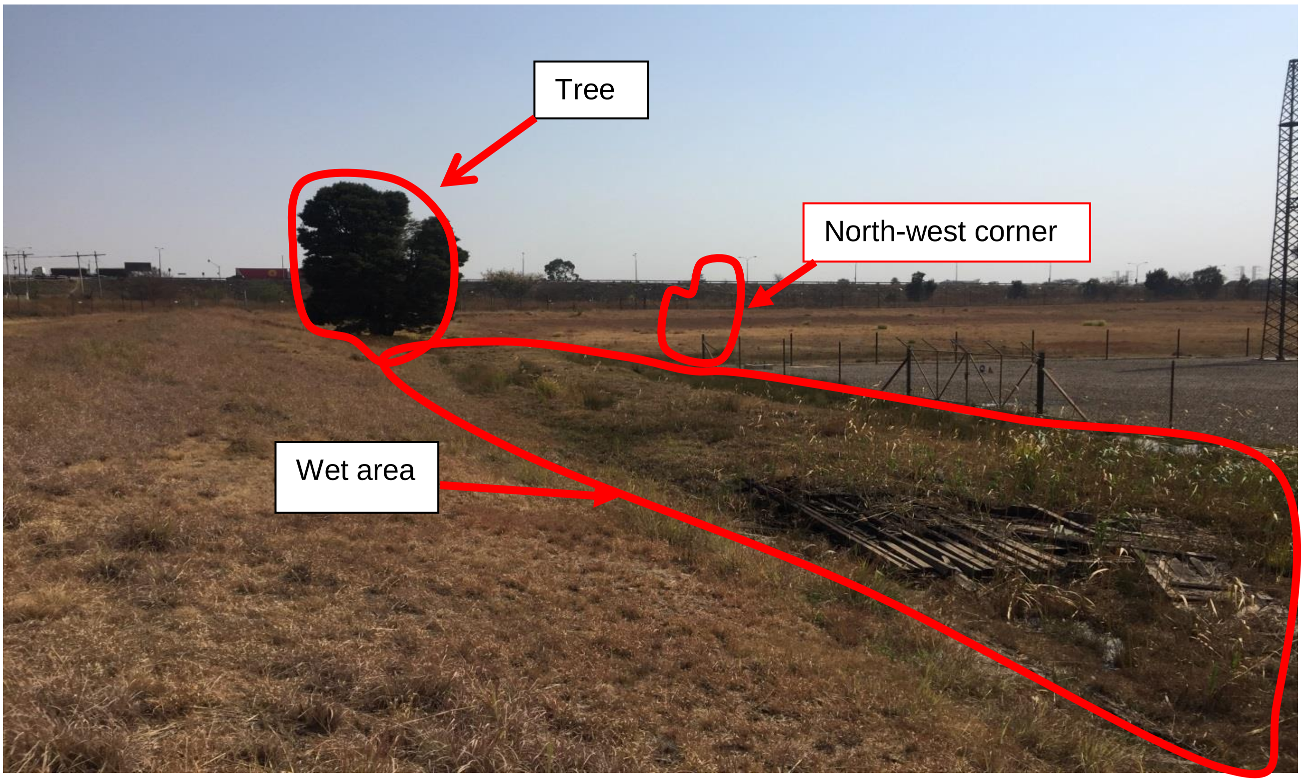


Figure 9: 275 kV yard North-West corner showing the tree and wet area

3.3. 275 KV FEEDER 1 FORDSBURG AND FEEDER 2 PROSPECT 1

The 275 kV Eiger-Fordsburg 1 line is a 19 km lines and the attributes are as follows

Conductor type	Number of conductors	Number of earth wires	Type of earth wire	Conductor arrangement	Terminal tower type at Eiger substation	Power rating

ZEBRA and BEAR	4	2	OPGW	Two horizontal with 1 vertical	424 V	

The 275 kV Eiger-Prospect 1 line is a 19 km lines and the attributes are as follows

Conductor type	Number of conductors	Number of earth wires	Type of earth wire	Conductor arrangement	Terminal tower type at Eiger substation	Power rating
BEAR	4	2	OPGW	Two horizontal with 1 vertical	424 V	

Figure 10 shows the aerial view of the Fordsburg and Prospect 1 feeders and figure 11 shows the terminal tower of the incoming lines on the Fordsburg and Prospect 1 feeders and their terminal towers.

Figure 10: Aerial view of the 275 kV Feeder 1 Fordsburg and Feeder 2 Prospect 1

Figure 11: Fordsburg feeder and Prospect 1 incoming lines plus the terminal tower

3.4. 88 KV FEEDER 5 ALBERTON 1 AND FEEDER 7 ALBERTON 2

Figure 12 shows the aerial view of the Alberton 1 and Alberton 2 feeders and figure 13 shows the terminal tower of the incoming lines on the Alberton 1 and Alberton 2 feeders and their terminal towers. It was found that there is access road between the two double circuit terminal towers for Alterton 1 and 2 and it was reported that the road is used to gain entry into the 88 kV yard. The access road introduces space constraints. It was also found that these two lines are double circuit lines and that only one circuit from each line is connected to a bay that is fully equipped. Meaning, one double circuit tower has both conductors for the two circuits but only has one circuit terminating in a bay that is fully equipped and the other circuit terminates on a bay that has no equipment's installed. This is as shown on figure14.

Figure 12: Aerial view of the 88 kV Feeder 5 Alberton 1 and Feeder 7 Alberton 2

Figure 13: Alberton 1 and Alberton 2 incoming line plus the terminal tower

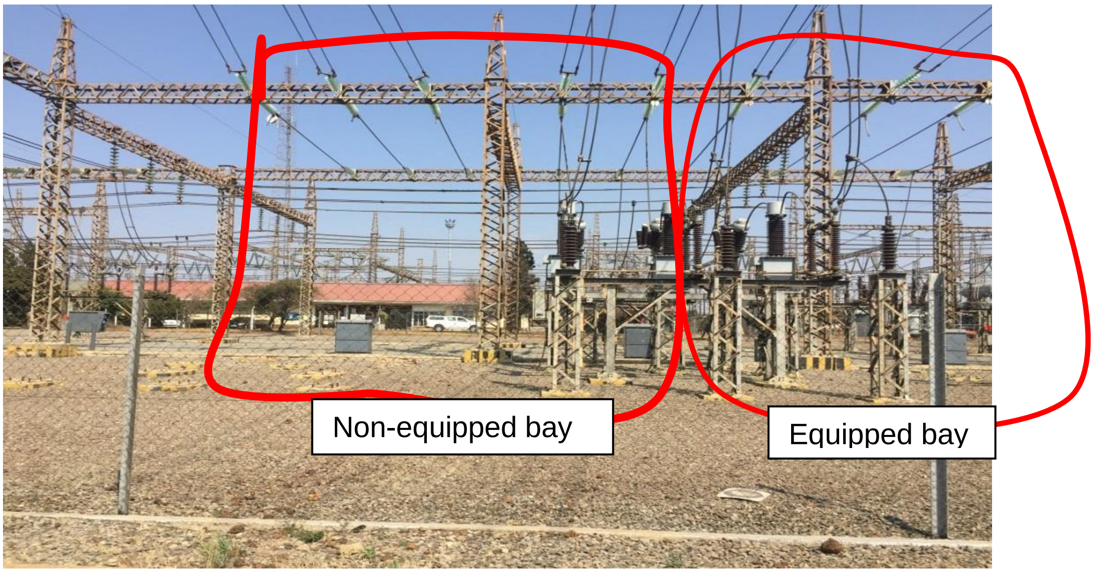


Figure 14: The equipped and non-equipped bays for Alberton 2

3.5. 88 KV FEEDER 9 PALMIET 1 AND FEEDER 10 PALMIET 2

Figure 14 shows the aerial view of Palmiet 1 and Palmiet 2 feeders and figure 13 shows the terminal tower of the incoming lines on Palmiet 1 and Palmiet 2 feeders and their terminal towers.

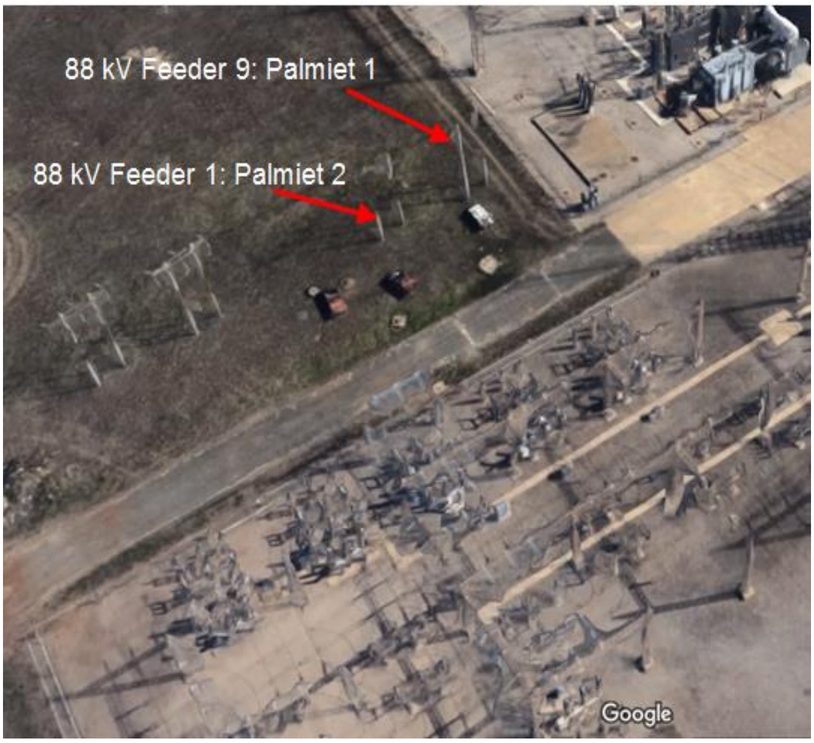


Figure 15: Aerial view of the 88 kV Feeder 9 Palmiet 1 and Feeder 10 Palmiet 2

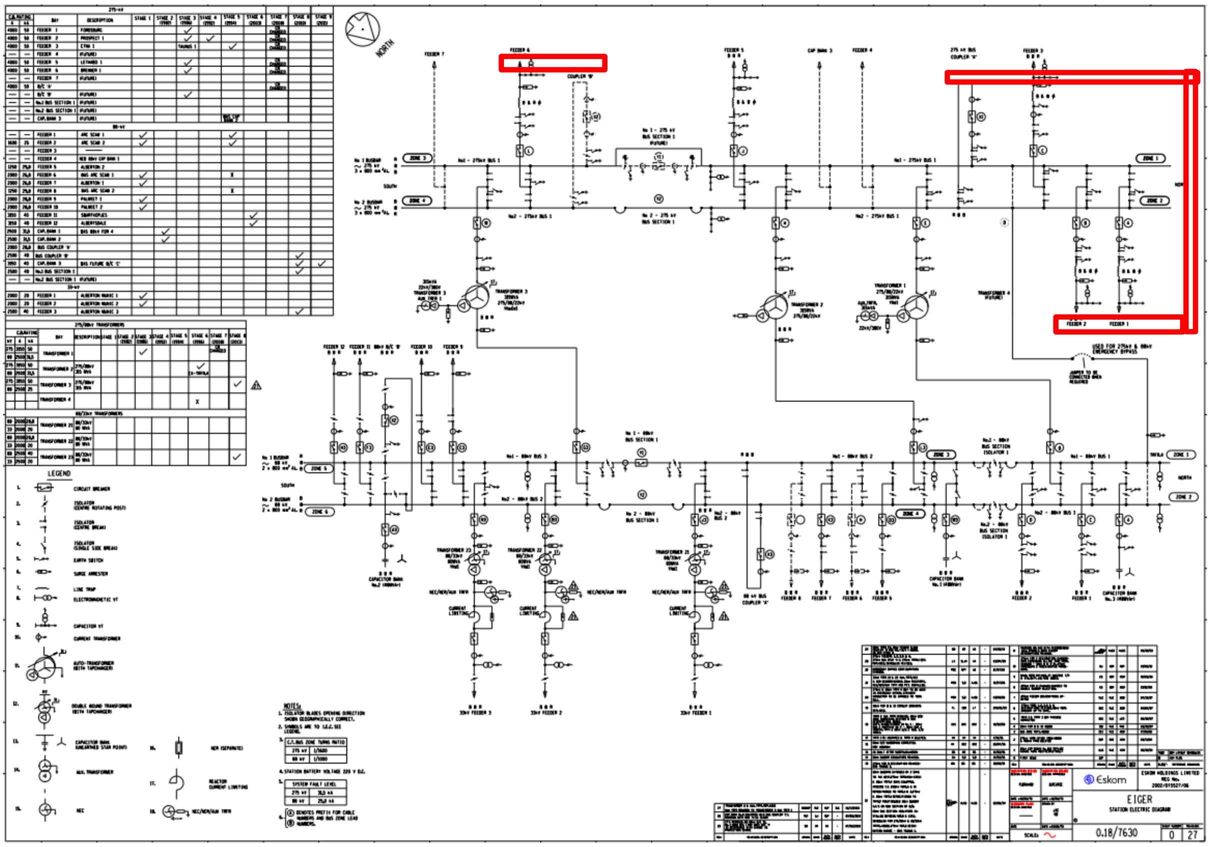
Figure 16: Palmiet 1 and Palmiet 2 incoming line plus the terminal tower

4. LES PROPOSED BYPASS ROUTE AND RECOMMENDATIONS

4.1. PROPOSED BYPASS ROUTES AT EIGER AND COMMENTS

4.1.4. Proposals for Bypass 1 on the 275 kV busbars

Considering the Brenner-Elger feeder, there are three options proposed. The first is to build a coupler for the feeder a lot as indicated in the figure, this will require that equipment be installed on the coupler bay. The second option is to have a bypass that stretches all the way and joins the bypass that passes underneath Etna conductor. This is as shown on Figure addsdds. If possible with this option, there might not be any need to install the equipment to make the bus coupler as the bypass can use Coupler A. Problems was the wetland and the small excess road. But there is another road behind.



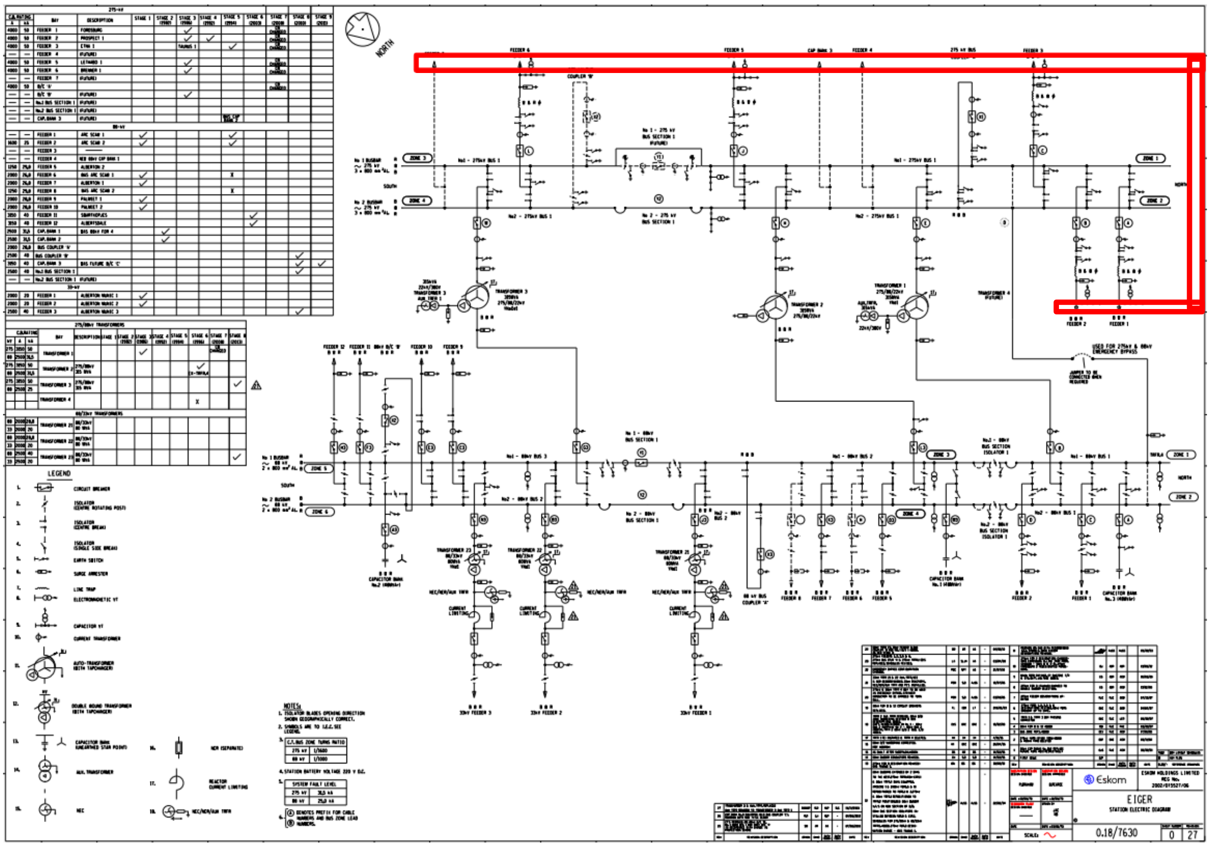


Figure 17: Option A

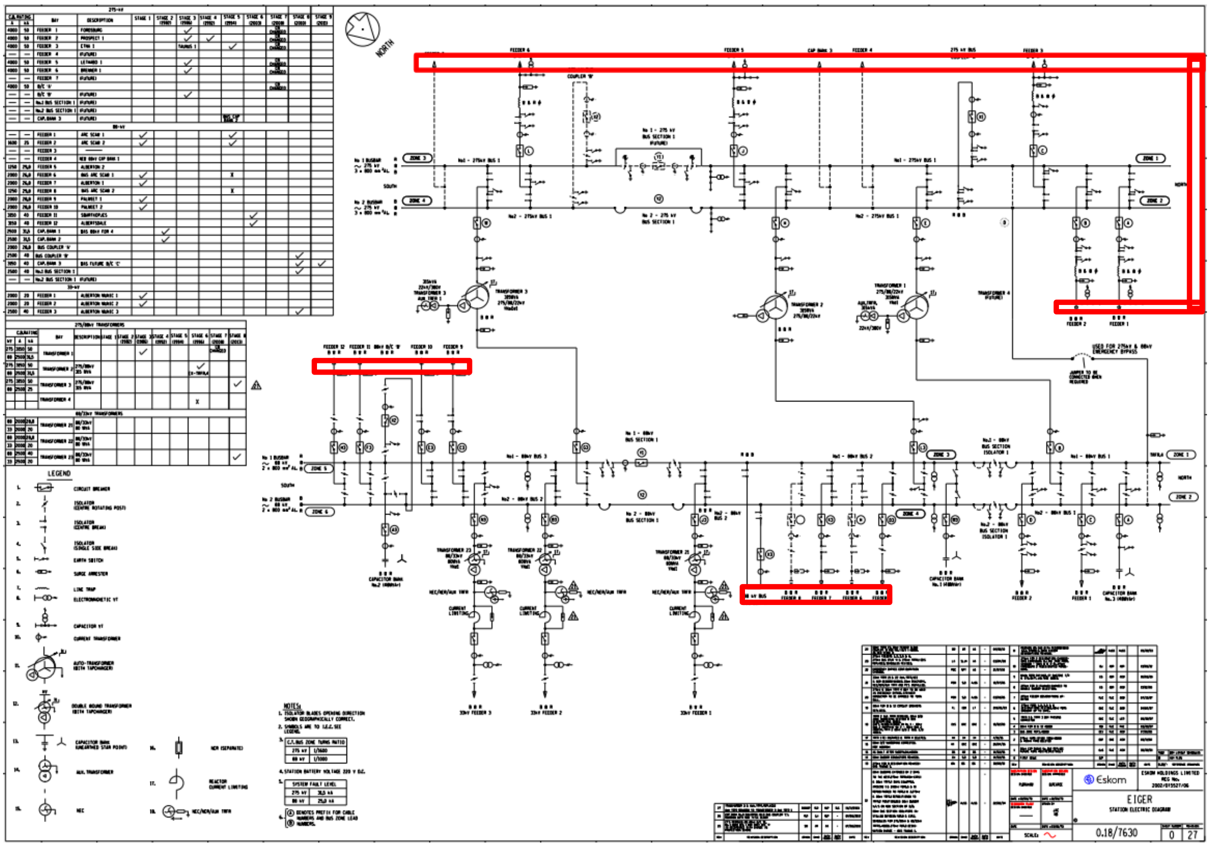


Figure 18: Option B

5. RECOMMENDATIONS AND SUGGESTIONS

- Option B was chosen due to the fact that it eliminates the need for equipping a buscoupler which might increase the total cost of the project
- The underpass covers all the feeders, so it caters for future work and it will be energised at one point.

6. DESIGN OPTIMAZATION

6.1. CONDUCTOR OPTIMIZATION AND SELECTION

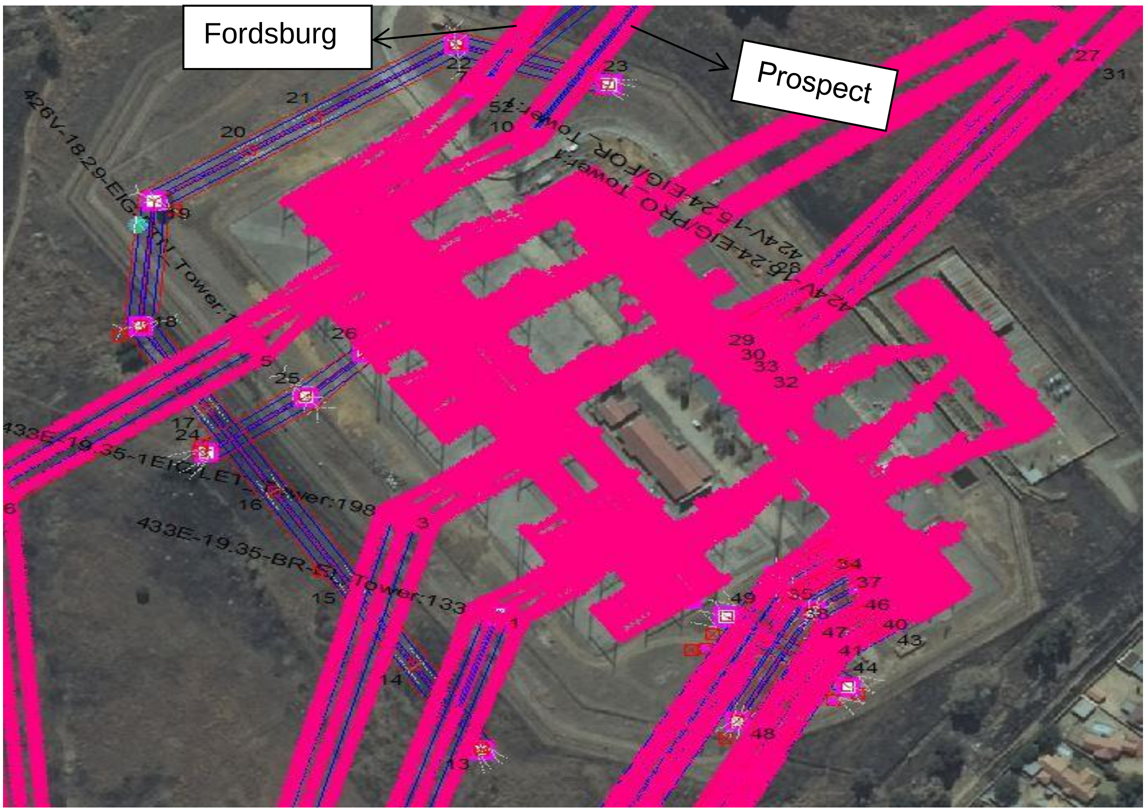
No conductor optimisation study was done for this project; however a conductor was chosen to match the existing line's current carrying capability. Table 1 shows the different conductors used on the lines entering the Eiger substation and their ratings. The ratings were obtained from calculations done using the conductor optimization spread sheet. The bypass to be designed has to have the same ratings as the 4-Zebra conductor. The proposed conductor is the twin-Bull or 2-Bull as shown in table 1below .The template temperature on the conductor was increased from 50°C to 70°C to be able to meet the ratings of the 4-Zebra. This however will results in shorter spans and hence increase the number of towers.

LINE	LENGTH (Km)	CONDUCTOR BUNDLE	RATE A (MVA)	RATE B (MVA)	TEMPLATE TEMPERATURE
Eiger-Brenner	43	4 x Zebra	1353	1947	50°C
Eiger-Etna	33	4 x Zebra	1353	1947	50°C
Eiger-Fordsburg	19	4 x Bear	993	1461	50°C
Eiger-Prospect	19	4 x Bear	993	1461	50°C
Proposed bypass	0.5	2 x Bull	1445	2017	70°C

Table 1: Line summary

6.2. PROFILING AND STRUCTURE SELECTION

The Eiger woodpole bypass is about 500m in length and underpasses EIGER-Brenner, Eiger-Etna, Eiger-Lethabo, Eiger-Fordsburg and Eiger-Prospect lines. The C values for stringing on the wooden pole structures of the bypasses is 300m, and 250 between the terminal structure and the guntree to ensure clearances are met and structure utilization is within limits.

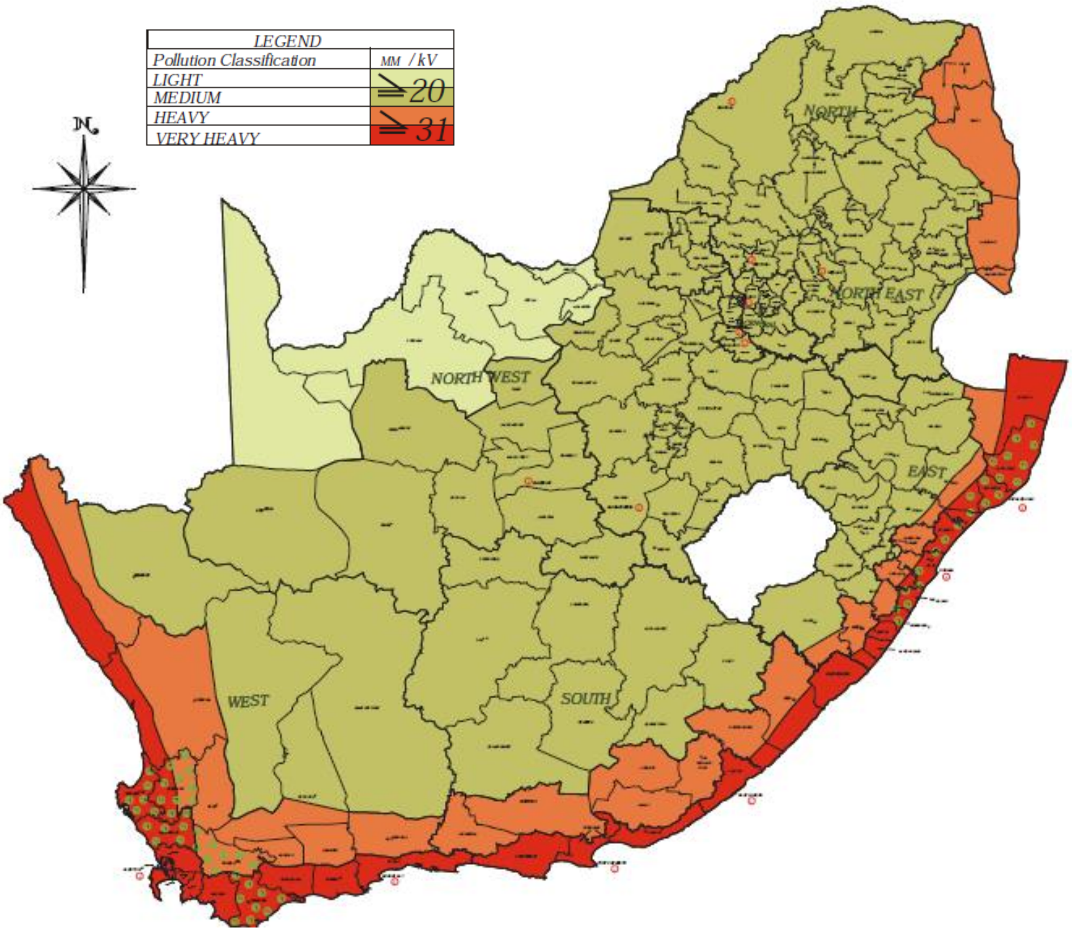


6.3. INSULATOR SELECTION

The insulator selection for this line was based on standard insulator specifications for the assembly length required namely 25mm/kV.

6.3.1. POLLUTION MAP

According to the general pollution map, the study area falls in a medium to heavy pollution zone; refer to **Error! Reference source not found.**. According to IEC 60815, the minimum recommended specific creepage for this type of environment pollution level is 25mm/kV. For composite insulators, Eskom uses 31mm/kV for heavy pollution zones.



6.3.2. INSULATOR REQUIREMENT

The culmination of the design process is the specification of insulator types (glass cap and pin, composites etc.) and related parameters. These aspects are discussed in the paragraphs that follow.

6.3.2.1. Material Considerations

Eskom will always prefer the use of glass insulators on their lines unless there are factors which contribute to glass being excluded. The use of wooden poles requires the use of composite insulators due to its low weight to length ratio when compared to glass.

6.3.2.2. Creepage

Since the proposed line falls in a medium to heavy pollution zone as well as the length for the insulator required is standardised for 25mm/kV .

6.3.2.3. Arcing Distance

These are according to SANS 10280 for 400kV and can be found in Table 3 below.

6.3.2.3. Electrical Withstand Levels

These are according to SANS 10280 for 400kV and can be found in Table 3 below.

6.3.2.4. Mechanical Strength and End fittings

For all wood pole configurations, 210 kN insulators will be suitable to carry the low catenary strung conductor. The selection of 210kN insulators for the phase conductor on the bypass was based on the worst case weather case tension on the spans of the bypass.

Each insulator choice was made based on the worst case ice loading, max swing and -5 degree weather cases on the bypass. Each strength class of insulator is coupled to a specific end fitting size, as specified by IEC 305. Accordingly, ball and socket end fittings of 20mm for 210 kN.

6.4. INSULATOR RECOMMENDATIONS

In terms of the key insulator parameters, **Error! Reference source not found.**3 provides a summary of suggested values to be used in insulator specifications for composite insulators.

Table 3 Proposed composite insulator characteristics

COMPOSITE INSULATOR	210
Creepage Distance [mm/kV]	**25**
Dry Arcing Distance [mm]	**≥1450**
Connecting Length	**Shortest possible**
End-fitting Size [mm]	**20**
BIL (kV)	**550**
BSL (kV)	**230**

7. VALUE ADDED

Value added to the Business:

During the past six months of training, I was given a project that provided me the platform to add value to business.

The project I was involved in was the design of a bypass at Eiger substation. My role was to write a chapter on insulator selection, conductor optimization and profiling. I successfully complited the design and currently waiting for the next LES DRT.

Value added to me:

As a new EIT coming straight from varsity, a large portion of my knowledge was theoretical. Thus, I was curious and keen to know as to whether what I have been learning at varsity is relevant in corporate world. I got the opportunity to link theory and practical on a deep level. Eskom gave me the opportunity to understand how the corporate the past six months of training, I gained a lot of practical exposure. For once in my life I got the world operates and how standards are developed. I was given real work to do, and that boosted my confidence as an aspiring engineer.

Awareness and Application of Work-related Standards

I quickly managed to realize that In order to be a competent engineer, I should familiarise myself with standards used in corporate world. Everything I do should comply with latest Eskom standards. These include international standards such as ITU (International Telecommunications Union) standards and various IEEE standards, SCOT which develops standards for Eskom, HV regulations and the SAGC (South African Grid Code). Each department uses standards and regulations that are relevant to that department and the technologies they work with.

OHSA

The Occupational Health and Safety act is of cardinal importance within Eskom, as Eskom places such a high regard on the safety of its employees. Eskom has a *Zero Harm* approach, which means that everything must be done in a manner conducive with this philosophy. The following is a list of

Five Life Saving Rules of Eskom:

1. Open, Isolate, Test, Earth, Bond and/or Insulate before touch
2. Hook up at heights
3. Buckle up
4. Be sober
5. Ensure you have a permit to work

Leadership Opportunities and Networking Achieved

Due to the nature of my training program, I got the opportunity to meet and engage into technical and none technical matters. I was awarded the opportunity to work with different people portraying different characters. I attended and participated in various meetings, thus that helped me improve my networking skills.

I was assigned as an assistant design leader for a bypass at Eiger substation, as a result, my network of knowledgeable and experienced professionals has grown a lot, and I now have a solid base of contacts and experts who can be consulted further along my career path.

Pro-activity and Innovation

During my past training, I contacted many engineers asking them to inform me when they going to site so that I can get exposure, especially on the construction and manufacturing sides of engineering. I even asked to join the HVDC study committee at LES, and I’m currently doing studies that will help me innovate something new in the world of HVDC transmission.

Awareness of Professionalism

I attended many meetings during the past six months of training, and I've been observing how professionals conduct themselves. This made me realize that professionalism is what sets individuals apart and especially in the engineering industry, is one of the most important qualities to have.

5. CONCLUSION

I have completed six months of my EIT training at Eskom, and I am in a position where I can explain and describe how every department I have been through fits into the Eskom hierarchy, and received practical and theoretical knowledge pertaining to these departments. Although the first few months of training was mostly theoretical, I still got the opportunity to do a lot of practical work. The work and the exposure I received thus far, changed the perception I viewed engineering from. I am looking forward to grow as an engineer, and find fulfilment in the work being done.