Appendix J

# GPR survey of the route for the new 20'' Jet fuel feeder pipeline at OR Tambo International Airport

**Report No.: PER0256**


**Client:** Megchem Pty Ltd

**Attention:** Nollie Nel – Engineering Manager

**Address:** 1 Louwrens Muller Street
Secunda
2302

**Tel:** 084 554 9668


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| **CLIENT** | : | **Megchem Pty Ltd** |
| **CONTACT PERSON** | : | **Nollie Nel** |
| **PROJECT** | : | **GPR survey for 20'' Jet Fuel pipeline** |
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| **REPORT** | : | **Dr Chris Ringas ……..** |
| | | **B.Sc, M.Sc (Eng.), Ph.D** |
| | | **NACE CP Specialist (No.7715)** |
| | | **Leon Engelbrecht B.Sc, M.Sc** |
| **REVIEWED** | : | **Martyn Sherratt ……..** |
| | | **Pr. Eng (970483)** |
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## 1. INTRODUCTION

PPT Engineering Services (Pty) Ltd, hereinafter referred to as PES, was appointed by Megchem to undertake a GPR survey along the proposed route for the new 20’’ Jet Fuel feeder pipeline at OR Tambo International Airport.

The GPR survey was carried out in November 2024 along the planned route for the new fuel pipeline, running from the Fuel Farm to Bravo Apron at the Oliver Tambo International Airport in Kempton Park. The aim of the survey was to detect possible buried infrastructure along the proposed route.

## 2. METHODOLOGY

A Mala GPR with a 250 MHz or an 800MHz antenna, depending on the soil conditions, was used during the survey. A series of parallel lines (12) were run along the proposed pipeline route at a distance of between 15 and 20 cm apart. A swath of about 2 to 2.5m wide was surveyed this way along the proposed pipeline route. This was done in an attempt to detect any utilities that might cut across the planned route.

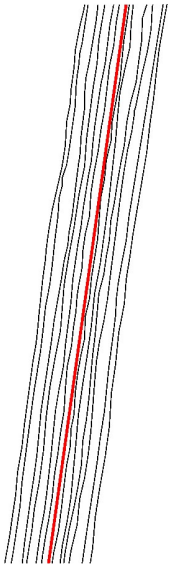

Figure 1. A typical surveyed area with the planned route in red and the surveyed lines in black.

The survey area along the pipeline was broken up into blocks during the survey. This made it easier to process the data.

The positions of the survey lines were recorded with a Leica GPS that was interfaced with the GPR system.

The individual lines where the processed and the possible pipe-like responses were marked. A single point reflector can have a response similar to a pipe or a linear reflector. The only way to resolve this problem is to survey a series of closely spaced parallel lines. A single point reflector will only show up on maybe one or two lines, whilst a pipe-like reflector would be visible on most of the lines. After processing each of the parallel lines, the data was merged and then plotted. A typical pipe-like reflection is shown in Figure 2.

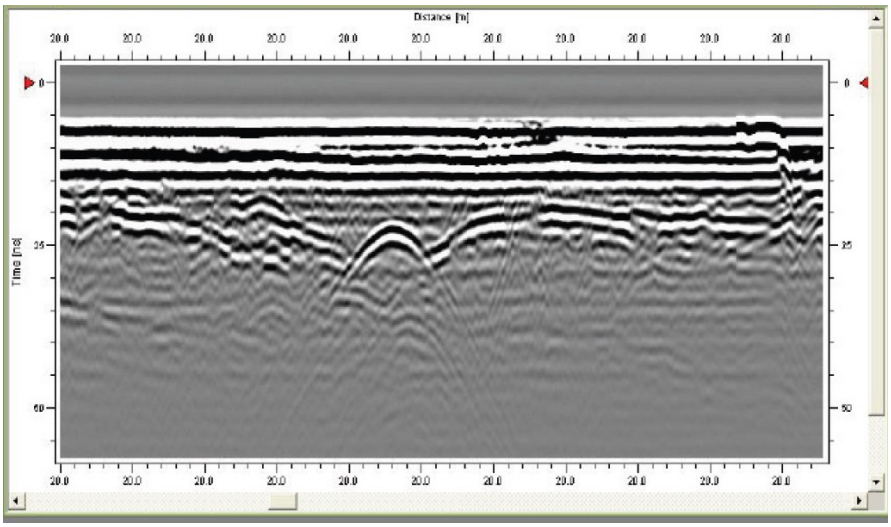


Figure 1: A typical Pipe-like reflector.

The depth of the “pipe-like” reflector can be estimated by analyzing the shape of the parabola. This **only** works correctly if the survey line is crossing the reflector at 90°. The depth estimates can vary by more than 50% if the reflector is not crossed at 90°. The depths given for the detected pipe-like structures are just an estimate, as there was no way to ensure that we crossed the anomalies at 90°.

Numerous “shallow “reflectors were detected (20 -30cm below the ground level). They had to be analyzed as there will always be shallow pipes/cables that have been installed on an industrial site over the years.

## 3. PROJECT CONSTRAINTS

The survey started after the rains had commenced. The rain had a negative effect in some areas on the data. The area along the Super South Gate Road acts as a drainage ditch for the water from the road. This severely limited the areas we could survey effectively.

The GPR system will only detect an object if there is a difference between the di-electric constant of the soil and the object. The interpreted depth of the detected object depends on the angle the object is crossed at, and the conductivity of the soil.

## 4. RESULTS

The results will be presented with the data starting from Bravo Apron, working southwards to the Tank Farm.

Bravo Apron Chamber Area

The equipment “enclave” or storage area just south of Bravo apron was surveyed. No continuous linear structures cutting across the planned route were detected. There were many shallow reflectors detected, but none of them were detected across all the lines, as shown in Figure 3.

Figure 2: Bravo Apron storage area reflectors (yellow) with the existing pipeline in red.

Grass Area between Bravo Apron and the Taxiway (01)

Five possible linear reflectors were detected in this area, as shown in Figure 4. Their depth varied from 25cm to 90cm. (All coordinates are referenced to the WGS84 geodetic datum.)

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| GP01_A | 28.2341350 | -26.1373592 | ~40cm to 50cm |
| GP01_B | 28.2341666 | -26.1373622 | ~40cm to 50cm |
| GP02_A | 28.2341095 | -26.1375385 | ~40cm to 50cm |
| GP02_B | 28.2341281 | -26.1375334 | ~40cm to 50cm |
| GP03_A | 28.2341005 | -26.1376003 | ~ 25cm to 40cm |
| GP03_B | 28.2341227 | -26.1375783 | ~ 25cm to 40cm |
| GP04_A | 28.2341019 | -26.1376146 | ~ 60cm to 90cm |
| GP04_B | 28.2341215 | -26.1376363 | ~ 60cm to 90cm |
| GP05_A | 28.2340940 | -26.1376378 | ~ 30cm to 50cm |
| GP05_B | 28.2341203 | -26.1376324 | ~ 30cm to 50cm |


Figure 3: Grass Area 01 Linear Reflector Positions.

First Taxiway South of Bravo Apron.

Four possible linear reflectors were detected in this area, as shown in Figure 5. Their depth varied from 25cm to 50cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| T1-A1 | 28.2340822 | -26.1377616 | ~ 30cm to 40cm |
| T1_A2 | 28.2341039 | -26.1377674 | ~ 30cm to 40cm |
| T1_B1 | 28.2340741 | -26.1377769 | ~ 30cm to 40cm |
| T1_B2 | 28.2340991 | -26.1377883 | ~ 30cm to 40cm |
| T1_C1 | 28.2340599 | 28.2340599 | ~ 25cm to 40 cm |
| T1_C2 | 28.2340780 | -26.1378913 | ~ 25cm to 40 cm |
| T1_D1 | 28.2340561 | -26.1379120 | ~ 30cm to 50 cm |
| T1_D2 | 28.2340826 | -26.1379168 | ~ 30cm to 50 cm |


Figure 4: Taxiway 01 Linear Reflector Positions.

Grass Area between the First and Second Taxiway South of Bravo Apron.

Five possible linear reflectors were detected in this area, as shown in Figure 6. Their depth varied from 25cm to 80cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| Grass02_A1 | 28.2340545 | -26.1380123 | ~ 35cm to 45cm |
| Grass02_A2 | 28.2340743 | -26.1380153 | ~ 35cm to 45cm |
| Grass02_B1 | 28.2340534 | -26.1380162 | ~ 35cm to 45cm |
| Grass02_B2 | 28.2340752 | -26.1380209 | ~ 35cm to 45cm |
| Grass02_C1 | -26.1380209 | -26.1380209 | ~ 25cm to 35cm |
| Grass02_C2 | 28.2340632 | -26.1381596 | ~ 25cm to 35cm |
| Grass02_D1 | -26.1381596 | -26.1382150 | ~ 60cm to 80cm |
| Grass02_D2 | 28.2340466 | -26.1382268 | ~ 60cm to 80cm |
| Grass02_E1 | 28.2340208 | -26.1382161 | ~ 60cm to 80cm |
| Grass02_E2 | 28.2340420 | -26.1382332 | ~ 60cm to 80cm |

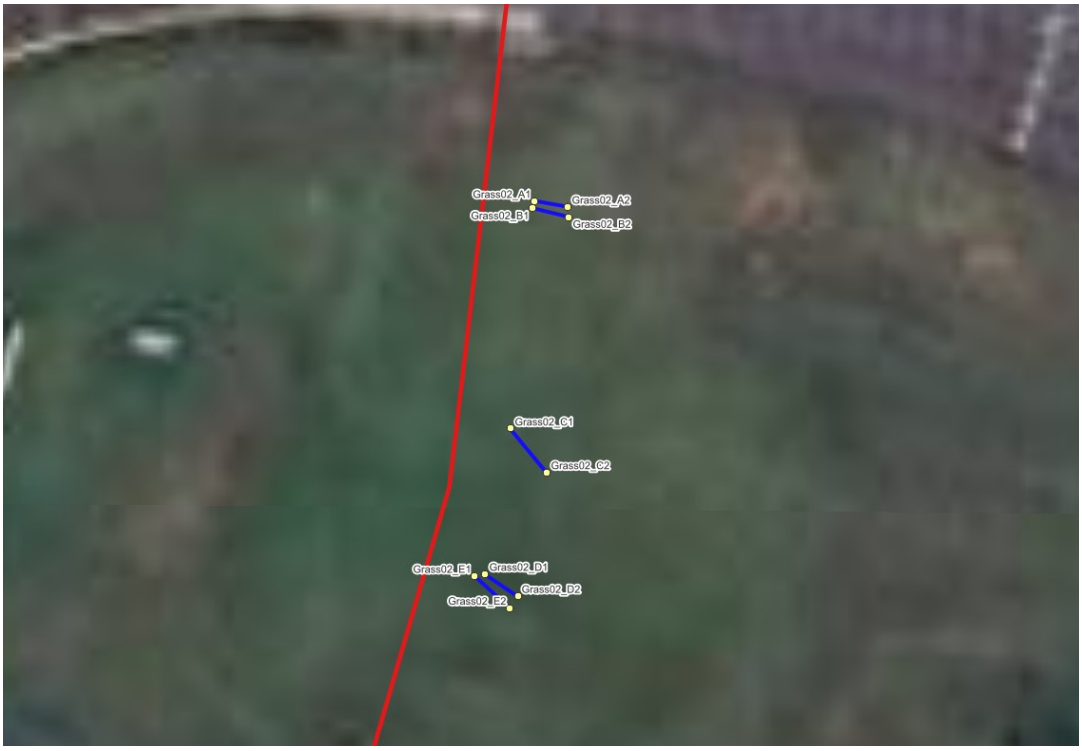


Figure 5: Grass Area between the First and Second Taxiway South of Bravo Apron, Linear Reflector positions.

Second Taxiway (02) south of Bravo Apron.

Five possible linear reflectors were detected in this area, as shown in Figure 7. Their depth varied from 30cm to 60cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| T02_A1 | 28.2339447 | -26.1384143 | ~ 40cm to 60cm |
| T02_A2 | 28.2339717 | -26.1384163 | ~ 40cm to 60cm |
| T02_B1 | 28.2339332 | -26.1384538 | ~ 20cm to 45cm |
| T02_B2 | -26.1384538 | -26.1384746 | ~ 20cm to 45cm |
| T02_C1 | 28.2338712 | -26.1386668 | ~ 30cm to 45cm |
| T02_C2 | 28.2339052 | -26.1386741 | ~ 30cm to 45cm |
| T02_D1 | 28.2338409 | -26.1387980 | ~ 30cm To 50 cm |
| T02_D2 | 28.2338606 | -26.1388057 | ~ 30cm To 50 cm |
| T02_E1 | -26.1388057 | -26.1388295 | ~ 30cm To 50 cm |
| T02_E2 | 28.2338542 | -26.1388346 | ~ 30cm To 50 cm |

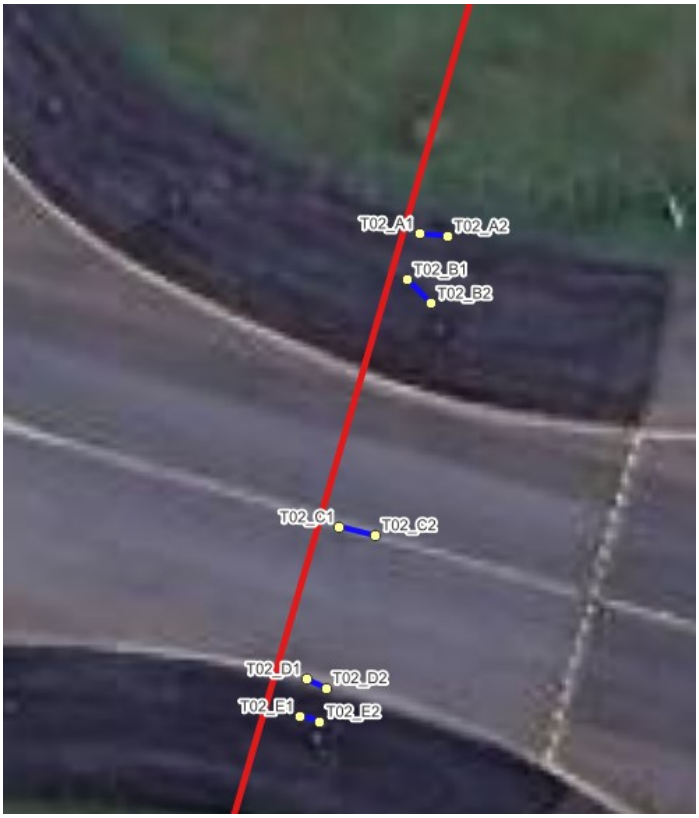


Figure 6: Taxiway 02 Linear Reflector Positions.

Figure 8 below shows an overview from Bravo Apron to Taxiway 02.


Figure 7: Overview from Bravo Apron to Taxiway 02.

Grass area up to 185m south of Taxiway 02.

Fourteen possible linear reflectors were detected in this area, as shown in Figure 9. Their depth varied from 20cm to 80cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| Grass03_A1 | 28.2337770 | -26.1390975 | ~ 40cm to 60cm |
| Grass03_A2 | 28.2338001 | -26.1391038 | ~ 40cm to 60cm |
| Grass03_B1 | 28.2336288 | -26.1395193 | ~ 50cm to 80cm |
| Grass03_B2 | 28.2336612 | -26.1395266 | ~ 50cm to 80cm |
| Grass03_C1 | 28.2336129 | -26.1395620 | ~ 20cm to 40cm |
| Grass03_C2 | 28.2336410 | -26.1395853 | ~ 20cm to 40cm |
| Grass03_D1 | 28.2336098 | -26.1395686 | ~ 20cm to 40cm |
| Grass03_D2 | 28.2336354 | -26.1395909 | ~ 20cm to 40cm |
| Grass03_E1 | 28.2335961 | -26.1396096 | ~ 25cm to 45cm |
| Grass03_E2 | 28.2336182 | -26.1396378 | ~ 25cm to 45cm |
| Grass03_F1 | -26.1396378 | -26.1397751 | ~ 40cm to 60cm |
| Grass03_F2 | 28.2335621 | -26.1397947 | ~ 40cm to 60cm |
| Grass03_G1 | 28.2335264 | -26.1398087 | ~ 20cm to 45cm |
| Grass03_G2 | 28.2335593 | -26.1398159 | ~ 20cm to 45cm |
| Grass03_H1 | 28.2335019 | -26.1398915 | ~ 30cm to 50cm |
| Grass03_H2 | 28.2335086 | -26.1398970 | ~ 30cm to 50cm |
| Grass03_H3 | 28.2335268 | -26.1398991 | ~ 30cm to 50cm |
| Grass03_I1 | 28.2334989 | -26.1398988 | ~ 30cm to 45cm |
| Grass03_I2 | 28.2335196 | -26.1399173 | ~ 30cm to 45cm |
| Grass03_J1 | 28.2334965 | -26.1399009 | ~ 30cm to 45cm |
| Grass03_J2 | 28.2335136 | -26.1399197 | ~ 30cm to 45cm |
| Grass03_K1 | 28.2334633 | -26.1400055 | ~ 40cm to 60cm |
| Grass03_K2 | 28.2334921 | -26.1400181 | ~ 40cm to 60cm |
| Grass03_L1 | 28.2334589 | -26.1400139 | ~ 40cm to 60cm |
| Grass03_L2 | 28.2334877 | -26.1400245 | ~ 40cm to 60cm |
| Grass03_M1 | 28.2334134 | -26.1401550 | ~ 20cm to 30cm |
| Grass03_M2 | 28.2334303 | -26.1401832 | ~ 20cm to 30cm |
| Grass03_N1 | 28.2334097 | 28.2334097 | ~ 20cm to 30cm |
| Grass03_N2 | 28.2334267 | -26.1401902 | ~ 20cm to 30cm |


Figure 8: Grass area up to 185m south of Taxiway 02.

Remainder of grass area up to Taxiway 03.

Thirteen possible linear reflectors were detected in this area, as shown in Figure 10. Their depth varied from 20cm to 70cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| Grass04_A1 | 28.2333164 | -26.1404338 | ~ 20cm to 35cm |
| Grass04_A2 | 28.2333308 | -26.1404466 | ~ 20cm to 35cm |
| Grass04_B1 | 28.2332982 | -26.1405325 | ~ 20cm to 35cm |
| Grass04_B2 | 28.2333095 | -26.1405380 | ~ 20cm to 35cm |
| Grass04_C1 | 28.2332856 | -26.1405487 | ~ 20cm to 35cm |
| Grass04_C2 | 28.2332990 | -26.1405584 | ~ 20cm to 35cm |
| Grass04_D1 | 28.2330480 | -26.1412359 | ~ 20cm to 35cm |
| Grass04_D2 | 28.2330802 | -26.1412269 | ~ 20cm to 35cm |
| Grass04_E1 | 28.2329719 | -26.1414385 | ~ 20cm to 35cm |
| Grass04_E2 | 28.2329925 | -26.1414598 | ~ 20cm to 35cm |
| Grass04_F1 | 28.2328598 | -26.1416456 | ~ 20cm to 35cm |
| Grass04_F2 | 28.2328927 | -26.1416542 | ~ 30cm to 45cm |
| Grass04_G1 | 28.2328531 | -26.1417050 | ~ 30cm to 45cm |
| Grass04_G2 | 28.2328714 | -26.1417182 | ~ 20cm to 35cm |
| Grass04_H1 | 28.2328304 | -26.1418152 | ~ 20cm to 35cm |
| Grass04_H2 | 28.2328480 | -26.1418359 | ~ 20cm to 35cm |
| Grass04_I1 | 28.2326656 | -26.1422278 | ~ 25cm to 40cm |
| Grass04_I2 | 28.2326938 | -26.1422425 | ~ 25cm to 40cm |
| Grass04_J1 | 28.2326177 | -26.1423298 | ~ 25cm to 40cm |
| Grass04_J2 | 28.2326456 | -26.1423400 | ~ 25cm to 40cm |
| Grass04_K1 | 28.2326507 | -26.1423919 | ~ 25cm to 40cm |
| Grass04_K2 | 28.2326665 | -26.1424112 | ~ 25cm to 40cm |
| Grass04_L1 | 28.2325370 | -26.1424920 | ~ 50cm to 70cm |
| Grass04_L2 | 28.2325805 | -26.1425042 | ~ 50cm to 70cm |
| Grass04_M1 | 28.2323353 | -26.1427242 | ~ 30cm to 50 cm |
| Grass04_M1 | 28.2323423 | -26.1427543 | ~ 30cm to 50 cm |

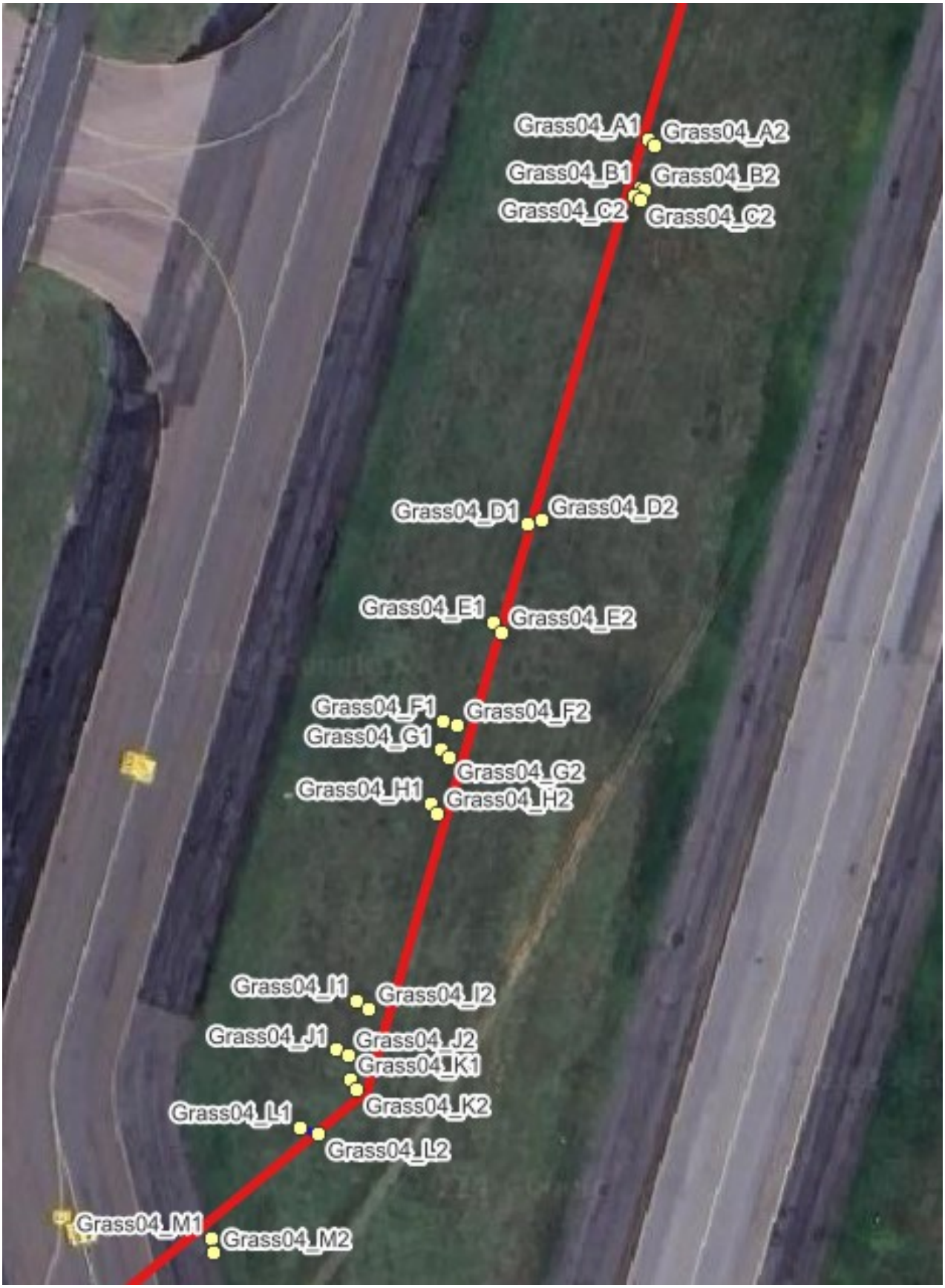


Figure 9: Remainder of grass area up to Taxiway 03.

Third Taxiway south of Bravo Apron.

Five possible linear reflectors were detected in this area, as shown in Figure 11. Their depth varied from 20cm to 60cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| T03_A1 | 28.2322285 | -26.1428245 | ~ 20cm to 40cm |
| T03_A2 | 28.2322608 | -26.1428409 | ~ 20cm to 40cm |
| T03_B01 | 28.2321255 | -26.1429170 | ~ 30cm to 50cm |
| T03_B02 | 28.2321393 | -26.1429321 | ~ 30cm to 50cm |
| T03_C01 | 28.2319962 | -26.1430172 | ~ 40cm to 60cm |
| T03_C02 | 28.2320190 | -26.1430291 | ~ 40cm to 60cm |
| T03_D1 | 28.2314390 | -26.1434104 | ~ 40cm to 60cm |
| T03_D2 | 28.2314537 | -26.1434568 | ~ 40cm to 60cm |
| T03_E1 | 28.2311842 | -26.1435736 | ~ 40cm to 60cm |
| T03_E2 | 28.2312018 | -26.1435825 | ~ 40cm to 60cm |


Figure 10: Taxiway 03 Linear Reflector Positions.

Super South Gate Access Road area.

The area next to the road could not be surveyed due to water/mud and the unevenness of the ground. The accessible flat areas next to the buildings were surveyed.

Damaged building just south of Taxiway 03.

Seven reflectors were detected in this area as shown in Figure 12. They appear to be water and sewer lines as they line up with the ablution facilities in the buildings.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| SS_A1 | 28.2309799 | -26.1439411 | ~ 50cm to 70cm |
| SS_A2 | 28.2309919 | -26.1439470 | ~ 50cm to 70cm |
| SS_B1 | 28.2309780 | -26.1439438 | ~ 50cm to 70cm |
| SS_B2 | 28.2309918 | -26.1439504 | ~ 50cm to 70cm |
| SS_C1 | 28.2309712 | -26.1439511 | ~ 50cm to 70cm |
| SS_C2 | 28.2309882 | -26.1439616 | ~ 40cm to 60cm |
| SS_D1 | 28.2306820 | -26.1444919 | ~ 40cm to 60cm |
| SS_D2 | 28.2306972 | -26.1445066 | ~ 40cm to 60cm |
| SS_E1 | 28.2306791 | -26.1444968 | ~ 40cm to 60cm |
| SS_E2 | 28.2306914 | -26.1445089 | ~ 40cm to 60cm |
| SS_F1 | 28.2306765 | -26.1445024 | ~ 40cm to 60cm |
| SS_F2 | 28.2306900 | -26.1445147 | ~ 40cm to 60cm |
| SS_G1 | 28.2306734 | -26.1445062 | ~ 40cm to 60cm |
| SS_G2 | 28.2306873 | -26.1445182 | ~ 40cm to 60cm |

There is a 315 kVA transformer installed at the road entrance to this damaged building. It is linked to another 315KVa transformer located 227m further south along the road. The connection between them is with an 11KV cable that is buried next to the fence. This information comes from electricians that were working on the

transformers whilst we were surveying. I could not detect any other cables running to these transformers.

The Air Chef’s optical fibre line runs along the area next to Super South Gate road, just east of the old 20-inch line. The marker positions were surveyed using the Leica GPS.

The access roads to buildings east of the Super Southgate access road were surveyed. Pipe-like reflectors were detected in some areas at depths varying from 1.1 m to 1.27 m where the old 20-inch pipe was supposed to be located.

The fibre optic cable(s) were detected at only one position at depth of approximately 75cm below the surface. There are surface markers for the optical fiber lines, and they were surveyed using the Leica GPS system.
Markers for a 1kVA line were also located. This line runs approximately 3.1 m to the west of the old 20-inch line for a distance of approximately 203 m. It could not be determined where the line originated from or where it finally ends as the surface markers abruptly started and ended. It could not be determined if this line is still active.

Figure 11: Red = Original 20 Inch line; Green = Buried 11 kVA line, Blue = Buried 1 kVA line, Cyan = Buried Optical Fibre line.

Super South Gate Inside area.

Three possible linear reflectors were detected in this area, as shown in Figure 13. Their depth varied from 30cm to 70cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| SSG_A1 | 28.2276527 | -26.1490374 | ~40cm to 60cm |
| SSG_A2 | 28.2276727 | -26.1490472 | ~40cm to 60cm |
| SSG_B1 | 28.2275850 | -26.1491297 | ~40cm to 60cm |
| SSG_B2 | 28.2275889 | -26.1491601 | ~40cm to 60cm |
| SSG_C1 | 28.2274490 | -26.1493106 | ~30cm to 50cm |
| SSG_C2 | 28.2274658 | -26.1493309 | ~30cm to 50cm |


Figure 12: Super Southgate Linear reflector positions.

Super Southgate special access Area.

This area was surveyed as the planned route was obstructed by large metal plates that were dumped on the path, as shown in Figure 14. There is a hydraulic vehicle barrier on the inside of this area as well as a fire hydrant next to the building. The pipes leading to the fire hydrant were not detected as they appear to run against the side of the building.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| SGSA_A1 | 28.2272266 | -26.1497730 | ~ 60cm to 80cm |
| SGSA_A2 | 28.2272609 | -26.1497664 | ~ 60cm to 80cm |
| SGSA_B1 | 28.2272230 | -26.1497826 | ~ 60cm to 80cm |
| SGSA_B2 | 28.2272659 | -26.1497726 | ~ 60cm to 80cm |


Figure 13: Super South Gate special access area Linear reflector positions.

Tank Farm secure parking area.

Five possible linear reflectors were detected in this area, as shown in Figure 15. Their depth varied from 40cm to 90cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| TFSP_A1 | 28.2270489 | -26.1497902 | ~ 70cm to 90cm |
| TFSP_A2 | 28.2270921 | -26.1498102 | ~ 70cm to 90cm |
| TFSP_A3 | 28.2271154 | -26.1498249 | ~ 70cm to 90cm |
| TFSP_B1 | 28.2269995 | -26.1498701 | ~ 60cm to 80cm |
| TFSP_B2 | 28.2270271 | -26.1498866 | ~ 60cm to 80cm |
| TFSP_B3 | 28.2270552 | -26.1499159 | ~ 60cm to 80cm |
| TFSP_C1 | 28.2268549 | -26.1499551 | ~ 50cm to 70cm |
| TFSP_C2 | 28.2268637 | -26.1499675 | ~ 50cm to 70cm |
| TFSP_C3 | 28.2268760 | -26.1499774 | ~ 50cm to 70cm |
| TFSP_D1 | 28.2268447 | -26.1499572 | ~ 60cm to 80cm |
| TFSP_D2 | 28.2268541 | -26.1499706 | ~ 60cm to 80cm |
| TFSP_D3 | 28.2268724 | -26.1499827 | ~ 60cm to 80cm |
| TFSP_E1 | 28.2268099 | -26.1499798 | ~ 40cm to 60cm |
| TFSP_E2 | 28.2268205 | -26.1499976 | ~ 40cm to 60cm |

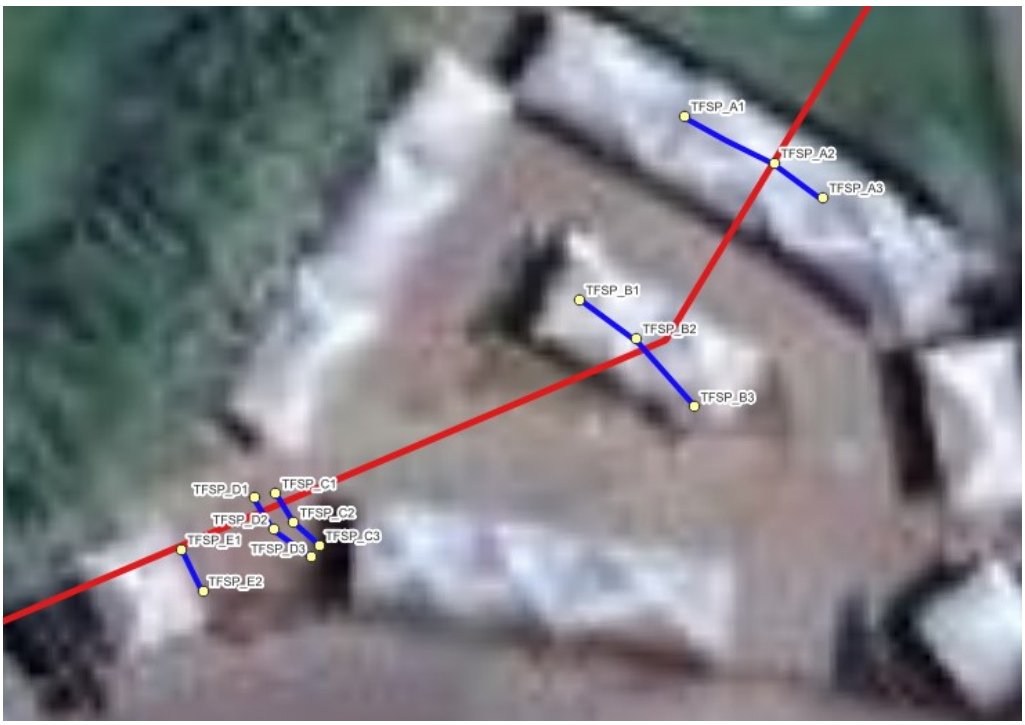


Figure 14: Tank Farm safe parking area Linear Reflector Positions.

Tank Farm Area.

Twelve possible linear reflectors were detected in this area, as shown in Figure 16. Their depth varied from 20cm to 60cm.

| Name | Longitude | Latitude | Estimated Depth |
|---|---|---|---|
| TF_A1 | 28.2258580 | -26.1503691 | ~ 30cm to 40cm |
| TF_A2 | 28.2258643 | -26.1503987 | ~ 30cm to 40cm |
| TF_B1 | 28.2259609 | -26.1503286 | ~ 20cm to 40cm |
| TF_B2 | 28.2259806 | -26.1503358 | ~ 20cm to 40cm |
| TF_C1 | 28.2260102 | -26.1503096 | ~ 20cm to 40cm |
| TF_C2 | 28.2260268 | -26.1503329 | ~ 20cm to 40cm |
| TF_D1 | 28.2260422 | -26.1502947 | ~ 20cm to 40cm |
| TF_D2 | 28.2260607 | -26.1503157 | ~ 20cm to 40cm |
| TF_E1 | 28.2262085 | -26.1502314 | ~ 30cm to 40cm |
| TF_E2 | 28.2262165 | -26.1502657 | ~ 30cm to 40cm |
| Culvert_F1 | 28.2262503 | -26.1502272 | 0 |
| Culvert_F2 | 28.2262805 | -26.1502387 | 0 |
| Culvert_G1 | 28.2262884 | -26.1502028 | 0 |
| Culvert_G2 | 28.2263418 | -26.1502140 | 0 |
| TF_H1 | 28.2264846 | -26.1501760 | ~ 30cm to 40cm |
| TF_H2 | 28.2265047 | -26.1501969 | ~ 30cm to 40cm |
| TF_I1 | 28.2266017 | -26.1501522 | ~ 30cm to 40cm |
| TF_I2 | 28.2266232 | -26.1501099 | ~ 30cm to 40cm |
| TF_J1 | 28.2267230 | -26.1500684 | ~ 30cm to 40cm |
| TF_J2 | 28.2266232 | -26.1500805 | ~ 30cm to 40cm |
| TF_J3 | 28.2267300 | -26.1500879 | ~ 30cm to 40cm |
| TF_K1 | 28.2267269 | -26.1500700 | ~ 30cm to 40cm |
| TF_K2 | 28.2267571 | -26.1500796 | ~ 30cm to 40cm |
| TF_L1 | 28.2267602 | -26.1500569 | ~ 40cm to 60cm |
| TF_L2 | 28.2267635 | -26.1500569 | ~ 40cm to 60cm |
| TF_L3 | 28.2267727 | -26.1500653 | ~ 40cm to 60cm |
| 11KVA Cable join | 28.2267053 | -26.1500030 | Surface Marker |

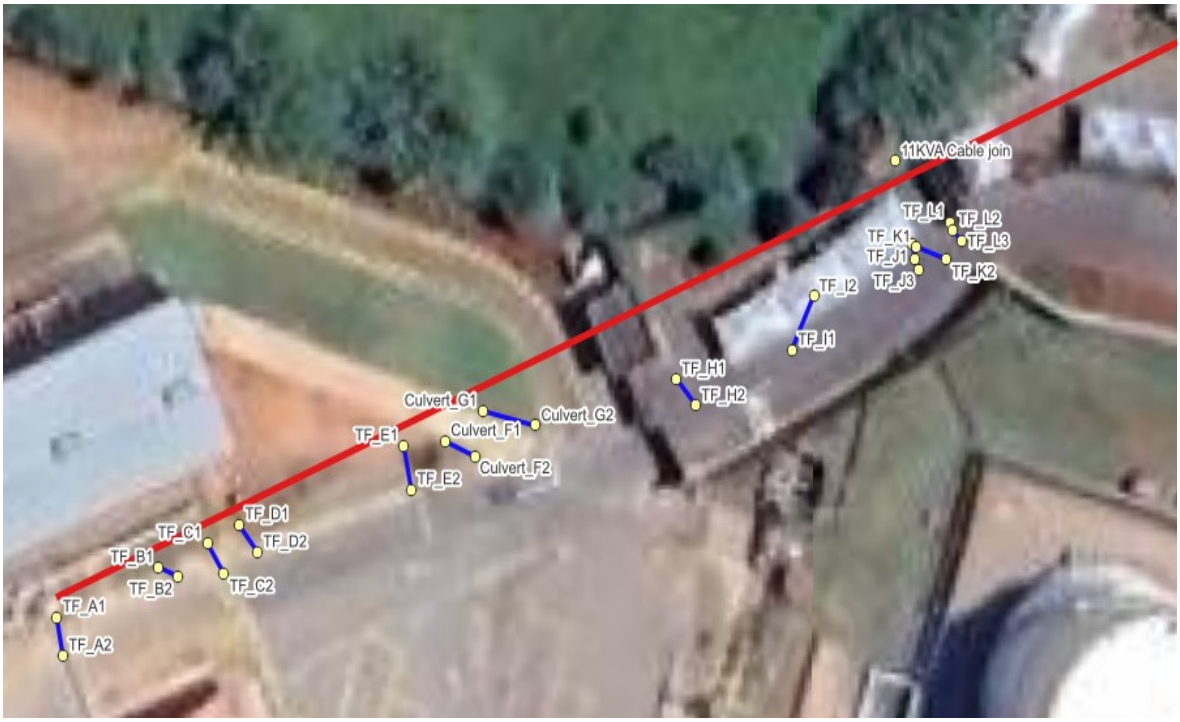


Figure 16. Tank Farm Linear Reflector Positions.

There is a ground marker for an 11kVA cable joint in the parking lot corner just outside the entrance to the tank farm. The area is too congested to survey around the marker. An attempt was made, but nothing was detected.

## 5. SUMMARY AND RECOMMENDATIONS

The 11 kVA cable is the main obstacle detected during the survey.

There are several shorter linear reflections indicated in each section. These do not appear to be long or continuous. These locations should be hand excavated for verification should the final pipeline route be located directly over any of these reflections.