# Tongaat Hullette Developments

## Cornubia Phase 2

## Technical Note 02 - N2/M41 AIMSUN Micro-simulation Analysis

| | | |
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Tongaat Hullette Developments

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# 1. Introduction

The aim of this technical note is to describe the methodology and information used to develop the AIMSUN Micro simulation model of the higher order roads surrounding the Cornubia Development.

This micro simulation model was developed to assess the capacity and functioning of the major roads surrounding the Cornubia Development, more specifically to test the impacts of the traffic generated by Cornubia onto the surrounding road network when it is fully developed, i.e. the ultimate traffic scenario.

This short report consists of the following sections:

- Study Area
- Road Network
- Traffic Volumes
- Network Performance
- Road Infrastructure Phasing
- Conclusions

## 2. Study Area

The Cornubia Phase 2 Development is surrounded by Mount Edgecombe to the West, Umhlanga to the East, and Blackburn to the north. The M41 forms the western boundary, with the N2 forming the southern boundary as shown in Figure 1 below.

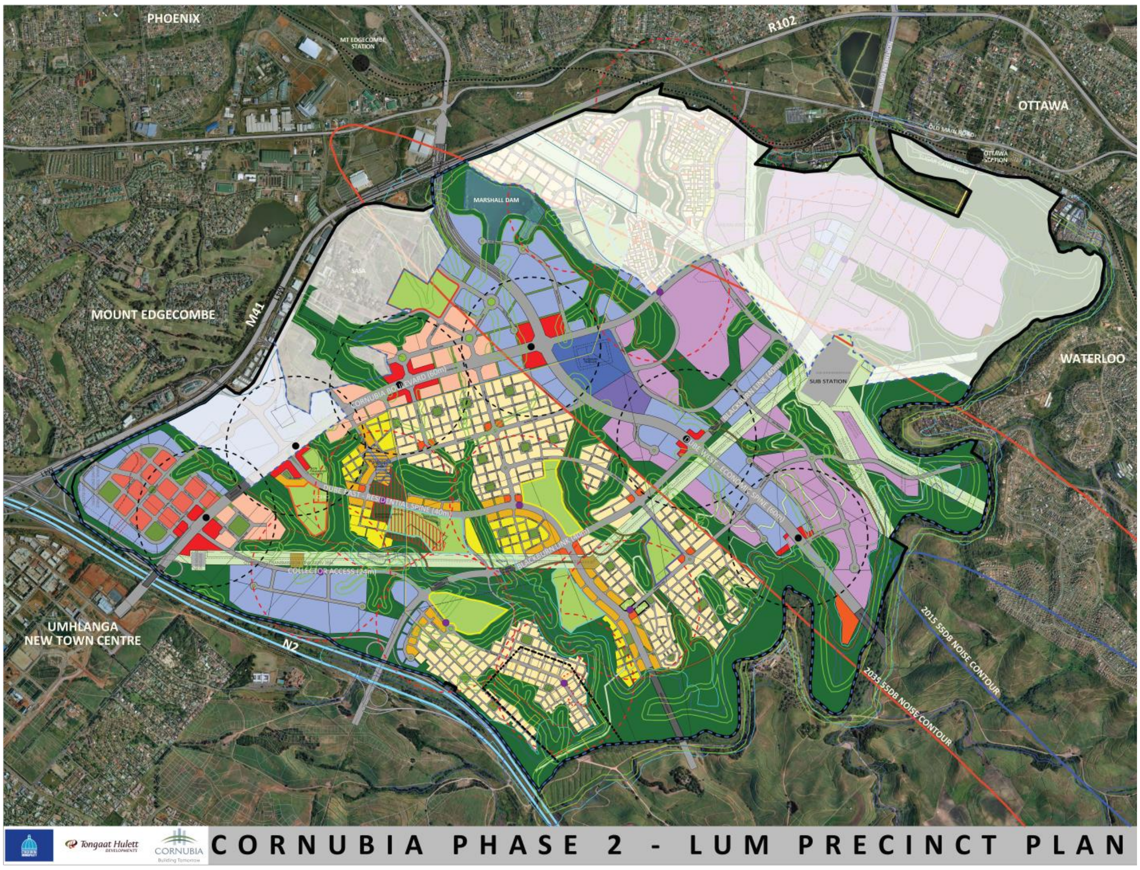


**Figure 1: Study Area**



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# 3. Road Network

The road network was built in AIMSUN using preliminary design drawings as well as scaled aerial photographs, which was made up of the following roadway sections:

- Phoenix Highway
- M41 Highway
- N2 Freeway
- Minor roads linked to the M41 & Phoenix Highway

These major roads were connected by the following interchanges:

- Phoenix Highway & Marshall Dam Interchange
- Mount Edgecombe Interchange
- Blackburn Interchange

The extents of the road network that was modelled includes the N2 immediately south of the Mount Edgecombe Interchange; the N2 immediately north of the Blackburn Interchange; the M41 towards Umhlanga immediately east of the Mount Edgecombe Interchange; and the M41 immediately west of the Phoenix Highway Interchange.

These interchanges were all modelled at their Ultimate stage of development using preliminary design drawings that were sourced from the respective Consultants responsible for their design. The Mount Edgecombe Interchange is currently being constructed to the layout that was modelled, however Marshall Dam Interchange and Blackburn Interchange will be constructed as required with the growth of the Cornubia Phase 2 Development. The phasing of the required infrastructure is discussed in Section 5 of this report.

The road network that was modelled in shown in Figure 2 below.

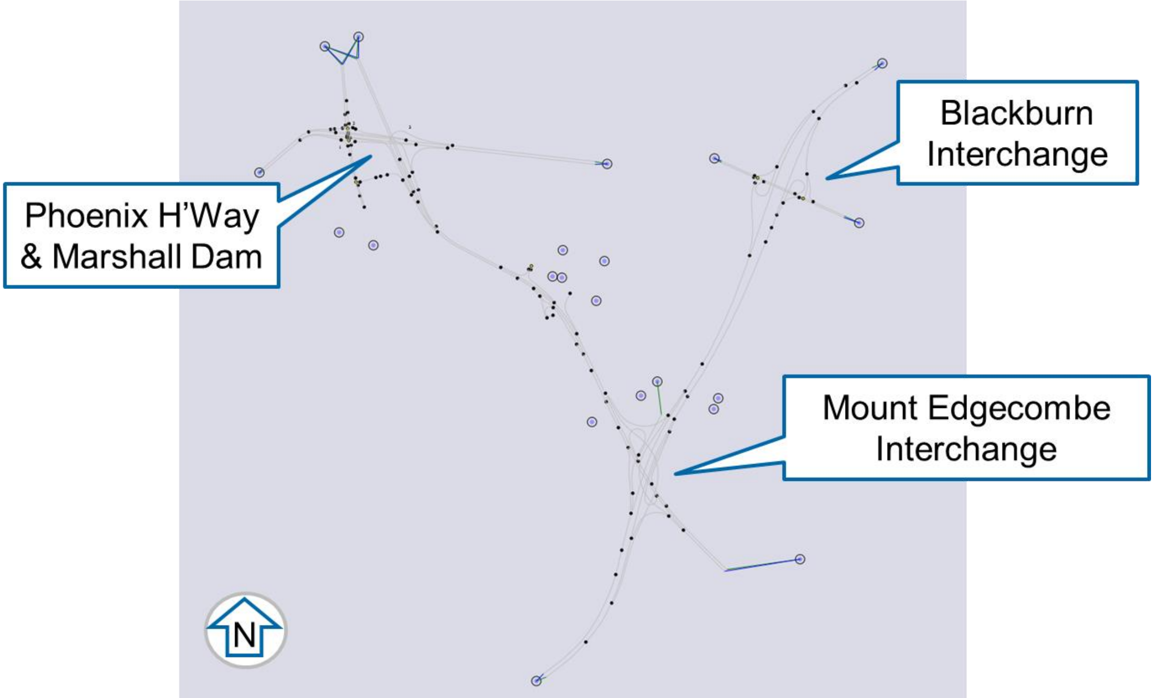


**Figure 2: Road Network Overview**

The road types and associated capacities that were used for this AIMSUN model are shown in Table 1 below, which was used in the TransCAD model of Cornubia that was developed for the Phase 2 traffic study.

| Road Type | Speed Limit (km/h) | Capacity Per Lane |
|---|---|---|
| Freeway | 120km/h | 2000 |
| On/Off Ramp | 60km/h | 1500 |
| External Arterial | 80km/h | 1600 |
| Local Arterial | 50km/h | 1200 |
| Collector | 40km/h | 800 |
| Street | 30km/h | 400 |

**Table 1: Road types and associated capacities**

# 4. Traffic Volumes

The ultimate traffic volumes from Cornubia Phase 2 was extracted from the validated TransCAD model that was produced for this traffic impact study. The TransCAD model was based on traffic information collected from the eThekwini Municipality, SMEC, and Hatch Goba, from projects that they were currently involved in for the areas in question, together with the generated trip matrix for the Cornubia Development. The total traffic for each peak period was 31 055 PCUs for both the AM and PM peak. Heavy vehicles and public transport vehicles were converted into PCU equivalents. The trip matrix consisted of 21 ‘zones’ that were extracted from TransCAD creating a sub network from the full network of Cornubia, that consisted of the extents mentioned above.

# 5. Network Performance

The performance of the road network and interchanges were assessed using the Highway Capacity Manual (HCM) Level of Service (LOS) Methodology, which uses the calculated section density to predict a LOS for interchange ramps, and delay in seconds for interchange intersections, that represents its operating conditions. LOS A represents unhindered free flow conditions, and LOS F representing poor conditions with possible service breakdown. The service performance criteria table extracted from the HCM is shown below in Table 2.

| LOS | Density Range (pc/km/ln) | Delay (Seconds) |
|---|---|---|
| A | 0 – 7 | 0 – 10 |
| B | >7 – 11 | >10 – 20 |
| C | >11 – 16 | >20 – 35 |
| D | >16 – 22 | >35 – 55 |
| E | >22 – 28 | >55 – 80 |
| F | >28 | > 80 |

**Table 2: LOS Criteria**

## 5.1 Mount Edgecombe Interchange

The Mount Edgecombe Interchange has directional ramps in all directions allowing for free flow high capacity movements. This high capacity was shown in the LOS results that demonstrated this interchange performs well under the abovementioned conditions, with majority of movements operating at a LOS A or LOS B.

Figure 3 shows the ramp descriptions and Table 3 shows the respective ramp LOS measures as calculated from the densities calculated by the AIMSUN Model.

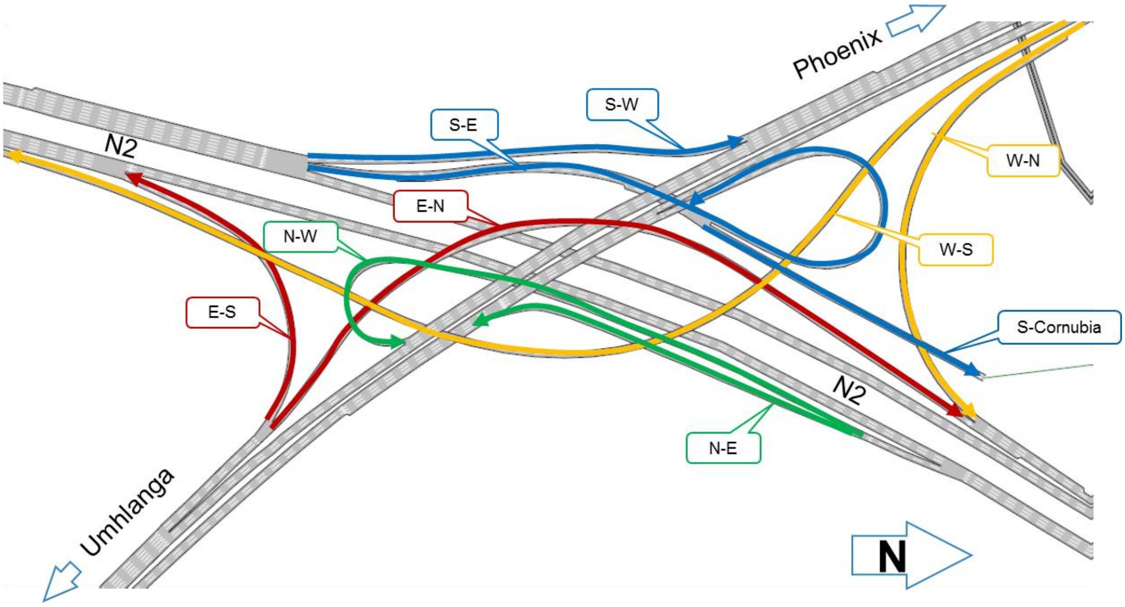


**Figure 3: Mount Edgecombe Interchange Layout & Ramp Descriptions**

The ramp performance results extracted from the AIMSUN model show that this interchange will operate well. The good service levels can be seen in the AIMSUN simulation animation which does not show any congestion on any of the interchange directional ramps or freeway sections. The LOS result for each ramp was calculated using the HCM methodology and is shown below in Table 3. The volume to capacity ratios (V/C) show that this interchange operates below its design capacity.

| | Name | Capacity | Delay (Sec) | Density | LOS | Flow | Speed | V/C |
|---|---|---|---|---|---|---|---|---|
| **AM Peak** | MI - SW | 3,000 | 22.35 | 9.05 | LOS B | 1,069 | 67.94 | 0.36 |
| | MI - SE | 3,000 | 21.97 | 8.48 | LOS B | 1,180 | 67.90 | 0.39 |
| | MI - WS | 3,000 | 9.63 | 6.70 | LOS A | 1,057 | 71.63 | 0.35 |
| | MI - WN | 1,500 | 9.33 | 5.24 | LOS A | 519 | 78.98 | 0.35 |
| | MI - ES | 3,000 | 4.40 | 8.26 | LOS B | 846 | 77.68 | 0.28 |
| | MI - EN | 3,000 | 7.36 | 3.96 | LOS A | 584 | 77.36 | 0.19 |
| | MI - NE | 1,500 | 3.58 | 13.37 | LOS C | 844 | 73.45 | 0.56 |
| | MI - NW | 3,000 | 1.49 | 7.89 | LOS B | 511 | 70.38 | 0.17 |
| | MI - SC | 3,000 | 19.88 | 2.42 | LOS A | 314 | 67.41 | 0.10 |

| | Name | Capacity | Delay (Sec) | Density | LOS | Flow | Speed | V/C |
|---|---|---|---|---|---|---|---|---|
| **PM Peak** | MI - SW | 3,000 | 5.37 | 6.42 | LOS A | 781 | 79.62 | 0.26 |
| | MI - SE | 3,000 | 5.10 | 6.07 | LOS A | 840 | 76.91 | 0.28 |
| | MI - WS | 3,000 | 17.98 | 9.57 | LOS B | 1,411 | 67.71 | 0.47 |
| | MI - WN | 1,500 | 8.51 | 7.78 | LOS B | 537 | 79.53 | 0.36 |
| | MI - ES | 3,000 | 9.29 | 11.25 | LOS B | 1,195 | 72.64 | 0.40 |
| | MI - EN | 3,000 | 7.95 | 4.12 | LOS A | 860 | 77.11 | 0.29 |
| | MI - NE | 1,500 | 1.99 | 8.89 | LOS B | 571 | 75.64 | 0.38 |
| | MI - NW | 3,000 | 1.42 | 7.35 | LOS B | 474 | 70.29 | 0.32 |
| | MI - SC | 3,000 | 3.92 | 2.01 | LOS A | 263 | 78.26 | 0.09 |

**Table 3: Mount Edgecombe AIMSUN Model results**

## 5.2 Blackburn Interchange

The Blackburn Interchange layout is proposed to be a partial clover type interchange as shown in Figure 4 below, together with the ramp descriptions. Table 4 which follows shows the respective AIMSUN simulated performance and LOS measures.

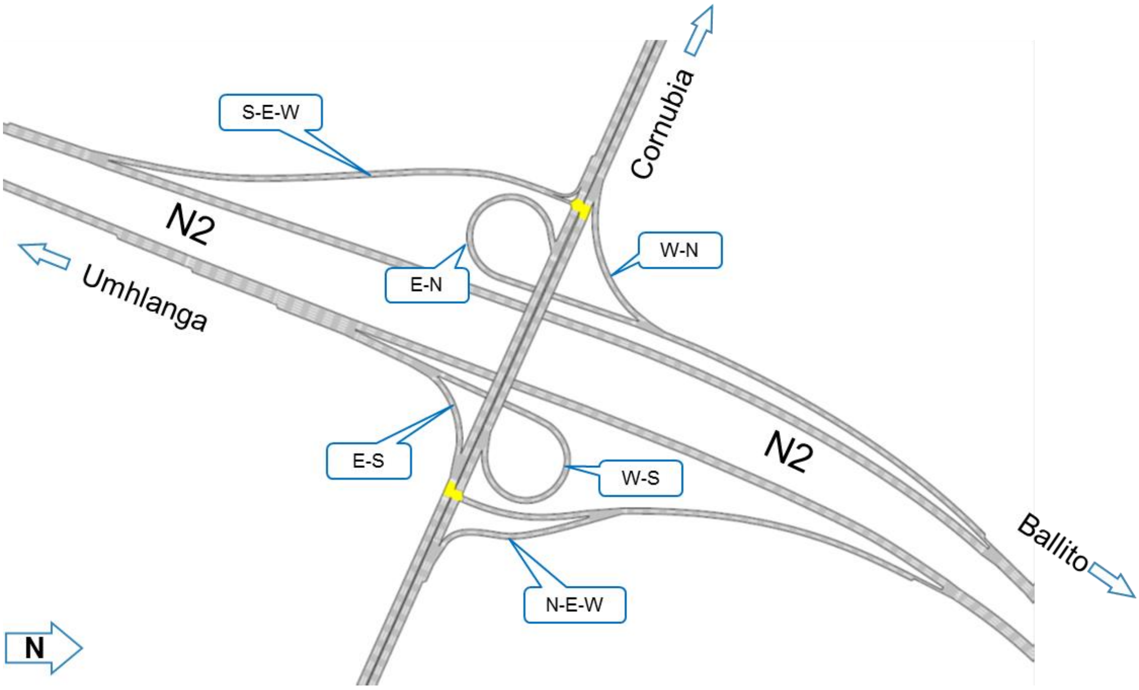


**Figure 4: Blackburn Interchange Layout & Ramp Descriptions**

The AIMSUN Model results show that this interchange also operates well, and this is also visible the video animation. Table 4 below shows that all movements operate at a LOS A or B, and the volume to capacity ratios for this interchange are also low, showing that this interchange has spare capacity and will be able to cope with additional traffic demands.

| | Name | Capacity | Delay Time | Flow | Speed | Density | LOS | V/C |
|---|---|---|---|---|---|---|---|---|
| **AM Peak** | BI - SEW | 3,000 | 13.2477 | 956 | 76.9914 | 7.10471 | LOS B | 0.32 |
| | BI - WN | 3,000 | 10.623 | 647 | 70.085 | 4.78932 | LOS A | 0.22 |
| | BI - WS | 3,000 | 43.0454 | 674 | 67.7771 | 5.3415 | LOS A | 0.22 |
| | BI - NE | 3,000 | 4.24311 | 1,174 | 76.1394 | 9.42399 | LOS B | 0.39 |
| | BI - NW | 3,000 | 28.062 | 345 | 59.5103 | 8.21836 | LOS B | 0.12 |
| | BI - ES | 3,000 | 17.5205 | 232 | 82.5164 | 1.80955 | LOS A | 0.08 |
| | BI – EN | 3,000 | 25.4731 | 669 | 63.7974 | 5.1495 | LOS A | 0.22 |

| | Name | Capacity | Delay Time | Flow | Speed | Density | LOS | V/C |
|---|---|---|---|---|---|---|---|---|
| PM Peak | BI - SEW | 3,000 | 24.8939 | 258 | 69.6043 | 6.89236 | LOS A | 0.09 |
| | BI - SW | 3,000 | 6.77976 | 651 | 82.0691 | 2.52645 | LOS A | 0.22 |
| | BI - WS | 3,000 | 21.9727 | 612 | 78.2409 | 4.94131 | LOS A | 0.20 |
| | BI - NE | 3,000 | 3.36518 | 670 | 77.2012 | 5.21543 | LOS A | 0.22 |
| | BI - NW | 3,000 | 26.5232 | 612 | 59.5898 | 13.4842 | LOS C | 0.20 |
| | BI - ES | 3,000 | 22.2939 | 284 | 79.0544 | 2.19942 | LOS A | 0.09 |
| | BI - EN | 3,000 | 28.5876 | 1,171 | 61.9592 | 9.17606 | LOS B | 0.39 |

**Table 4: Blackburn Interchange AIMSUN model results**

## 5.3 Phoenix Highway & Marshall Dam Interchange

This interchange is consists of two closely spaced interchanges, the first being the Phoenix Highway & R102 diamond interchange, and the second being the Marshall Dam Interchange which leads into Cornubia Development and connects the preceding interchange to the M41 towards Umhlanga. The Marshall Dam Interchange has directional ramps including dedicated public transport lanes but, these lanes were not considered in the analysis as they do not influence the performance of the interchanges due to their dedicated lanes. Figure 5 below shows the interchange layout and ramp descriptions followed by Table 5 (Phoenix Highway Interchange) and 6 (Marshall Dam Interchange) which shows the respective modelling results.

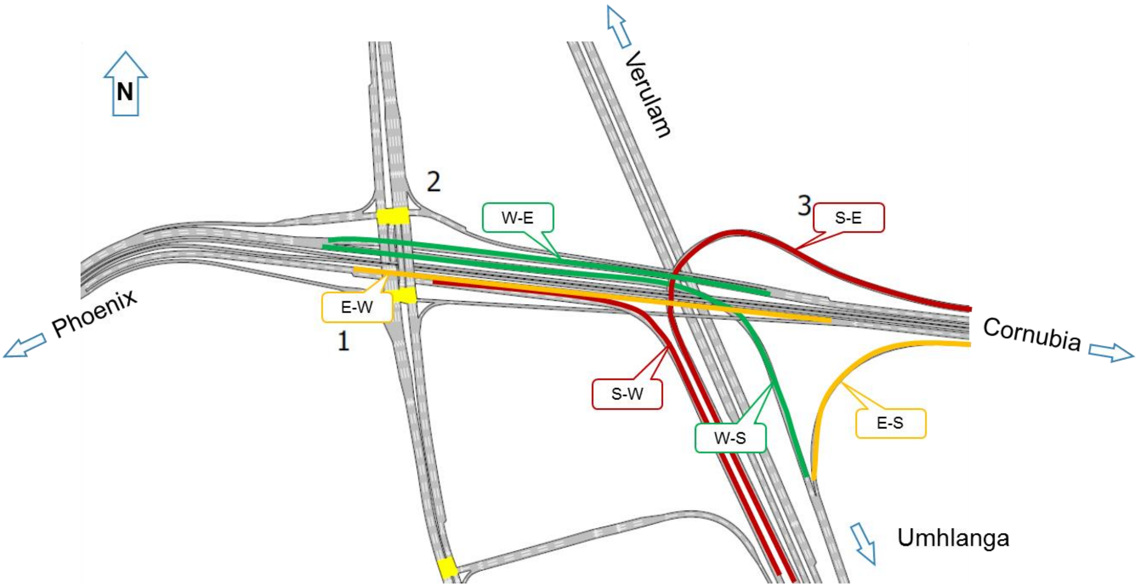


**Figure 5: Phoenix Highway & Marshall Dam Interchange**

| | Name | Delay Time | Flow | Speed | LOS |
|---|---|---|---|---|---|
| **AM Peak** | PHI - EN/S | 0.70759 | 328 | 79.3854 | A |
| | PHI - WN/S | 1.34036 | 457 | 63.1229 | A |
| | PHI - SE | 4.20251 | 98 | 64.8455 | A |
| | PHI - SN | 17.4728 | 732 | 35.1844 | B |
| | PHI - SW | 29.0214 | 360 | 35.701 | C |
| | PHI - NS | 34.644 | 932 | 33.891 | C |
| | PHI - NW | 16.4803 | 174 | 43.7395 | B |
| | PHI - NE | 4.1463 | 66 | 68.0223 | A |

| | Name | Delay Time | Flow | Speed | LOS |
|---|---|---|---|---|---|
| **PM Peak** | PHI - EN/S | 2.29449 | 462 | 78.0471 | A |
| | PHI - WN/S | 0.687702 | 209 | 64.3142 | A |
| | PHI - SE | 9.79127 | 355 | 57.2495 | A |
| | PHI - SN | 18.3094 | 971 | 34.5802 | B |
| | PHI - SW | 14.6994 | 240 | 45.8285 | B |
| | PHI - NS | 19.0795 | 639 | 48.9454 | B |
| | PHI - NW | 16.3458 | 389 | 41.6269 | B |
| | PHI - NE | 3.02239 | 80 | 70.0275 | A |

**Table 5: Phoenix Highway Interchange AIMSUN model results**

The Phoenix Highway Interchange had to be assessed separately from the Marshall Dam Interchange due to the different types of interchanges. The Phoenix Highway Interchange level of service results is determined by the two signalised intersections that make up the Diamond Interchange, as shown in the results above in Table 5. The Marshall Dam interchange level of service results are determined by the ramp capacities which are shown below in Table 6.

| | Name | Delay Time | Speed | Capacity | Density | Flow | LOS | V/C |
|---|---|---|---|---|---|---|---|---|
| **AM Peak** | MDI - ES | 1.6255 | 74.328 | 1,500 | 3.2392 | 208 | LOS A | 0.12 |
| | MDI - EW | 0.187017 | 80.9173 | 1,500 | 1.10229 | 97 | LOS A | 0.06 |
| | MDI - WS | 1.50136 | 65.7046 | 3,000 | 5.78871 | 754 | LOS A | 0.21 |
| | MDI - WE | 1.23037 | 83.7111 | 3,000 | 1.68796 | 291 | LOS A | 0.09 |
| | MDI - SE | 1.84467 | 75.3303 | 3,000 | 5.21236 | 682 | LOS A | 0.19 |
| | MDI - SW | 1.59109 | 73.0705 | 3,000 | 0.658834 | 88 | LOS A | 0.02 |

| | Name | Delay Time | Speed | Capacity | Density | Flow | LOS | V/C |
|---|---|---|---|---|---|---|---|---|
| PM Peak | MDI - ES | 2.65536 | 74.3838 | 1,500 | 10.8245 | 693 | LOS B | 0.46 |
| | MDI - EW | 1.10934 | 79.1788 | 1,500 | 3.56433 | 304 | LOS A | 0.20 |
| | MDI - WS | 0.970107 | 66.0926 | 3,000 | 1.16823 | 152 | LOS A | 0.05 |
| | MDI - WE | 1.04199 | 84.4811 | 3,000 | 0.55154 | 95 | LOS A | 0.03 |
| | MDI - SE | 2.17218 | 74.0696 | 3,000 | 1.5935 | 205 | LOS A | 0.07 |
| | MDI - SW | 3.05062 | 71.6648 | 3,000 | 3.42318 | 450 | LOS A | 0.15 |

**Table 6: Marshall Dam Interchange AIMSUN model results**

The results show that both these interchanges operate well with the Marshall Dam Interchange operating at LOS A for both peak hours in all directions. The Phoenix Highway Interchange also operated well with LOS results ranging from A to C which is still acceptable of good performance.

## 5.4 Weaving Analysis

A weaving analysis was carried out for the N2 freeway between the Mount Edgecombe Interchange and the Blackburn Interchange, as well as the M41 between the Marshall Dam Interchange and the Flanders Overpass. The HCM (2000) methodology was used which required the 4 major weaving movement traffic flows in order to calculate a density based on the number of lane changes that is required for a vehicle to carry out the desired movement.

The individual flows were determined by building statistical streams within AIMSUN, with the number of lanes given by the geometric layout proposed.

The results show that the N2 sections tested for weaving capacity operate at a LOS from B to C in both northbound and southbound directions, and during both peak hours. The M41 sections also operate at a LOS from B to C in both directions and both peak hours. These results show that vehicles can manoeuvre easily into their desired lane without negatively affecting the through capacity of the respective freeway sections.

Detailed results can be provided on request.

## 5.5 Sensitivity Analysis

Due to the level of infrastructure being tested, a sensitivity analysis was carried out at a high level to test the robustness of the road network and interchanges for this report. The ultimate traffic matrix was factored up by 15% and thereafter 30% and then simulated using AIMSUN. The results showed that the N2 freeway would reach capacity in both the 15% and 30% analysis scenarios well before the interchanges showed signs of strain.

The smaller intersections linked to the M41 showed strain, however, this traffic congestion did not back up onto the M41. These intersections were not upgraded as this report focuses on the interchanges.

### 5.5.1 15% Additional Traffic

The AM Peak simulation showed congestion on the N2 northbound before the Mount Edgecombe Interchange, and needed to be upgraded to 5 lanes to accommodate the large traffic volumes and the high weaving movements. The rest of the network performed acceptably with no visible congestion.

The PM peak scenario showed acceptable performance with no facility breakdown shown.

### 5.5.2 30% Additional Traffic

The AM Peak simulation showed the N2 northbound before the Mount Edgecombe Interchange at breakdown conditions and had to be further upgraded to 6 lanes which was then able to cope with this traffic demand. The Blackburn Interchange N2 northbound on ramp showed signs of strain in the AM Peak scenario and was resolved by extending the merge lane to the N2, giving vehicles sufficient space to merge successfully without hindering through traffic performance.

The PM Peak scenario showed the N2 southbound from the Mount Edgecombe Interchange was not able to cope with the additional traffic, and was upgraded to 5 lanes southbound. This upgrade worked acceptably clearing the breakdown conditions.

# 6. Road Infrastructure Phasing

The Cornubia Phase 2 development is planned to be constructed in further sub-phases, and the purpose of this section is to describe when key infrastructure is required to be constructed. This section is based on various analysis scenarios that were tested using TransCAD to assess the infrastructure requirement timing based on envisaged the land uses that will be developed. The Mount Edgecombe Interchange is currently being constructed and was therefore not part of this assessment.

| | **Road Infrastructure** | **Development Land Use** |
|---|---|---|
| Stage 1 | Flanders Interchange | Phase 1+ Retail Park (170 000sqm)+N2 Business Estate (65 000 sqm) + 2 995 Residential Units |
| Stage 2 | N2 overpass to Umhlanga and N2 Slip+ Marshall Dam Interchange | Phase 1+ 650 000sqm Commercial (includes Retail park and N2 Business estate) + 7 740 Units + 3 400sqm Social Facilities |
| Stage 3 | Blackburn Boulevard | Phase 1+ 840 000sqm Commercial (includes Retail park and N2 Business estate) + 17 670 Units + 12 300 sqm Social Facilities + Industrial 190 000sqm |
| Stage 4 | Blackburn Interchange + R102/Northern Drive Interchange* | Phase 1+ 950 000 Commercial (includes Retail park and N2 Business estate) + 23 970 Units + 20 000 sqm Social Facilities + Industrial 320 000sqm |

*Note: R102/Northern drive interchange analysis forms part of the Cornubia Phase 1 TIA

**Table 7: Road Infrastructure Phasing**

# 7. Conclusion

The aim of the development of this AIMSUN Micro Simulation traffic model was to evaluate the performance of the road network surrounding the Cornubia Phase 2 Development zone. The AIMSUN model was developed with the geometric and traffic volume input from the planning studies and preliminary design drawings of the interchanges and Cornubia Phase 2 road infrastructure.

The results from the model show that this road network will be able to accommodate the forecasted ultimate traffic demands at a good level of service during both peak hours. The weaving capacities of the connecting roadways were also found to perform well, with acceptable levels of service during both peak hours.

The interchanges showed sufficient spare capacity beyond the ultimate scenario predicted traffic, however, the N2 freeway between the interchanges proved to be their limiting factor. Upgrading the N2 sufficiently to accommodate any future traffic shows that the interchanges will still function well during both peak hours.