2015-2036

MMM – City Wide Integrated Public Transport Plan

VOLUME 3A

INTEGRATED
PUBLIC
TRANSPORT
NETWORK

MANGAUNG
AT THE HEART OF IT ALL

MMM IPTN Team
19 September 2019
Revision 6.0

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ABBREVIATIONS

Abbreviation	Full Description
ACSA	Airports Company South Africa
ADN	Airport Development Node
ADP	Airport Development Plan
AFC	Automated Fare Collection
AFCA	Automated Fare Collection Agent
APTMS	Advanced Public Transport Management System
ATC	Adaptive Traffic Control
BATHA	Botshabelo Amalgamated Taxi Association
BEPP	Built Environment Performance Plan
BOC	Bus Operating Company
BRT	Bus Rapid Transit
CBD	Central Business District
CBO	Community-based Organization
CCC	Centralised Control Centre
CCTV	Closed-circuit Television
CITP	Comprehensive Integrated Transport Plan
CM	Carbon Monoxide
CNG	Compressed Natural Gas
COGTA	Cooperative Governance and Traditional Affairs
CPI	Consumer Price Index
CPTR	Current Public Transport Record
CRM	Customer Relationship Management
DETEA	Department of Environmental Tourism Economic Affairs
ECE	Economic Commission of Europe
EM	Executive Mayor
EMF	Environmental Management Framework
EMV	Euro-Mastercard-VISA
FINMOD	Financial Model
GBTA	Greater Bloemfontein Taxi Association
GIS	Geographic Information System
GPRS	General Packet Radio Service
GPS	Global Positioning System
ha	Hectare
HC	Hydrocarbons
HHS	Household Survey
HOD	Head of Department
HR	Human Resources
ICE	Internal Combustion Engine
IDP	Integrated Development Plan
IEM	Integrated Environmental Management

ABBREVIATIONS

Abbreviation	Full Description
IMC	Integrated Marketing and Communication
IPTN	Integrated Public Transport Network
IRPTN	Integrated Rapid Public Transport Network
ITP	Integrated Transport Plan
ITS	Intelligent Transport System
IVT	In-Vehicle Time (IVT) (in Minutes)
JOC	Joint Organizing Committee
JSC	Joint Steering Committee
km	Kilometre
LAN	Local Area Network
LED	Light Emitting Diode
LIM	Linear Induction Motor
MFMA	Municipal Financial Management Act
MITP	Mangaung Integrated Transport Plans
MMC	Member of Mayoral Committee
MMM	Mangaung Metropolitan Municipality
MOU	Memorandum of Understanding
MRE	Municipal Regulatory Entity
MSA	Municipal Systems Act
NATMAP	National Transport Master Plan
NDOT	National Department of Transport
NDP	National Development Plan
NEMA	National Environmental Management Act
NGO	Non-governmental Organization
NLTA	National Land Transport Act
NLTTA	National Land Transport Transition Act
NMT	Non-Motorised Transport
NOX	Nitrogen Oxide
NT	Number of Transfers (NT)
OCR	Optical Character Recognition
OD	Origin-Destination
OLS	Operating Licenses Strategy
OOP	Office of the Premier
PDM	Patronage Demand Model
PDOT	Provincial Department Of Transport
PDP	Professional Driver Permit
PLTF	Provincial Land Transport Framework
PM	Particulate Matter
PMU	Project Management Unit
POS	Point of Sale
PRASA	Passenger Rail Agency of South Africa
PT	Public Transport

ABBREVIATIONS

Abbreviation	Full Description
PTIG	Public Transport Infrastructure Grant
PTIS	Public Transport Infrastructure and Systems Grant
PTNOG	Public Transport Network Operational Grant
PTOG	Public Transport Operational Grant
PTZ	Pan-Tilt-Zoom
PvT	Private Transport
RoW	Right of Way
RTPI	Real-time Passenger Information
SABS	South African Bureau of Standards
SAC	Schedule Adherence and Controlling
SANRAL	South African National Road Agency Limited
SANS	South African National Standards
SANTACO	South Africa National Taxi Council
SDA	Service Delivery Agreement
SDF	Spatial Development Framework
SIP	Strategic Integrated Projects
SMME	Small Medium and Micro Enterprise
SP	Stated Preference
SVMS	Strategic Variable Message Signs
SWOT	Strength Weakness Opportunity Threat
THALSDTA	Thaba Nchu Long and Short Distance Taxi Association
TIMS	Traffic Management and Information System
TIS	Traveller Information System
TOM	Ticket Operating Machines
TSP	Traffic Signal Priority
ULSD	Ultra Low Sulphur Diesel
UTC	Urban Traffic Control
VDM	Vehicle Docking Manager
VMS	Variable Message Sign
VOC	Vehicle Operating Company
VOIP	Voice Over Internet Protocol
VTTS	Value of Travel Time Savings (VTTS) (in Rand/hour)
VWTS	Value of Waiting Time Savings (VWTS) (Rand/hour)
WAN	Wide Area Network
WP	Work Package
WT	Waiting Time (WT) (in Minutes)
WULA	Water Use License Application

1 Introduction

The Draft First Order Operational Plan 2014(Ops. Plan-2014) applied a full network design methodology developed from various international best practices. The outline of the methodology is presented in Figure 1-1. The methodology represents an integrated approach between land use, public transport passenger movement, infrastructure provision and passenger convenience.

This Section of the citywide IPTN Plan is structured according to the design-methodology and provides detail of the Vision, Goals and Objectives for the IPTN. These provide the guiding principles for the design of the system, data used presented in the transport register, the result of data analysis and estimate future demand of the IPTN and culminate into the geographical extent of the IPTN for MMM.

The Vision, Goals and Objectives for the IPTN stem from the cities' Transport vision. However, the Goals and Objectives for public transport was refined to set the guiding principles for the development of an integrated public transport system where rail- and road-based modes are integrated with non-motorised transport and provide access to all categories of public transport user, exiting and future.

1.1 IPTN Design Mythology

The design methodology applied for the development of the citywide IPTN is:

- Cross-cutting elements that were incorporated into each element and design process are:
  - Sustainability Action Plan
  - Universal Accessible
- Contextualise the spatial orientation of the city, including the City's demographic profile (population density, income levels, car ownership, passengers with categories of special needs, etc.).
- Land Use Model (2015, 2025, 2036), stemming from the latest SDF, BEPP and IDP;
- Define primary and secondary demand corridors (movement networks);
- Develop geographic extent of citywide IPT Network;
- Select appropriate road links to service the identified network, based on existing public transport operators' services areas and routes;
- Evaluate the full IPTN defined in terms of:
  - network coverage;
  - transfer between routes and services;
  - the directness of routes and services; and
  - corridor and route spacing.
- Where necessary, the network is adjusted to comply with minimum design principles.
- The full network is divided into functional public transport corridors based on primary and secondary demand corridors and spatial coverage. For each of these corridors' routes, services and patronage per route are derived through the development of a public transport matrix for the base and horizon years and the assignment of these trips to the selected IPTN.
- The selection of the optimum system scenario for the IPTN is derived through an alternative analysis process where operational (route design, fleet, operational hours etc.) alternatives are defined, infrastructure sized cost, and operational cost derived for the operational alternatives.
- The implementation of these alternatives is quantified through the development of implementation strategies, where implementation options are defined, and the impact of implementation strategies or variation in strategies are compared and evaluated in terms of the impact on passenger experience, capital cost, operational cost and the impact on the timeline of citywide implementation.
- These combinations of alternatives and implementation strategies are combined into system scenarios and through the application of a business model compared, and the optimum system scenario selected. This optimum system scenario reflects specific network-, system design and implementation strategy that's financial constraint to the available budget.
- The output of the above processes is:
  - **20-year IPTN citywide implementation plan** is developed on a strategic level for the optimum system selected through the option analysis process and reflect the selected system performance in terms of the high-level key performance indicators set in the PTNG guidelines.
  - **10-year Public Transport Improvement Program** is developed to guide the implementation of the system,
  - **10-year implementation plan per project** identified in PTIP**.**

This design methodology stems from the Vision, Goals and Objectives defined for the MMM IPTN and related systems.

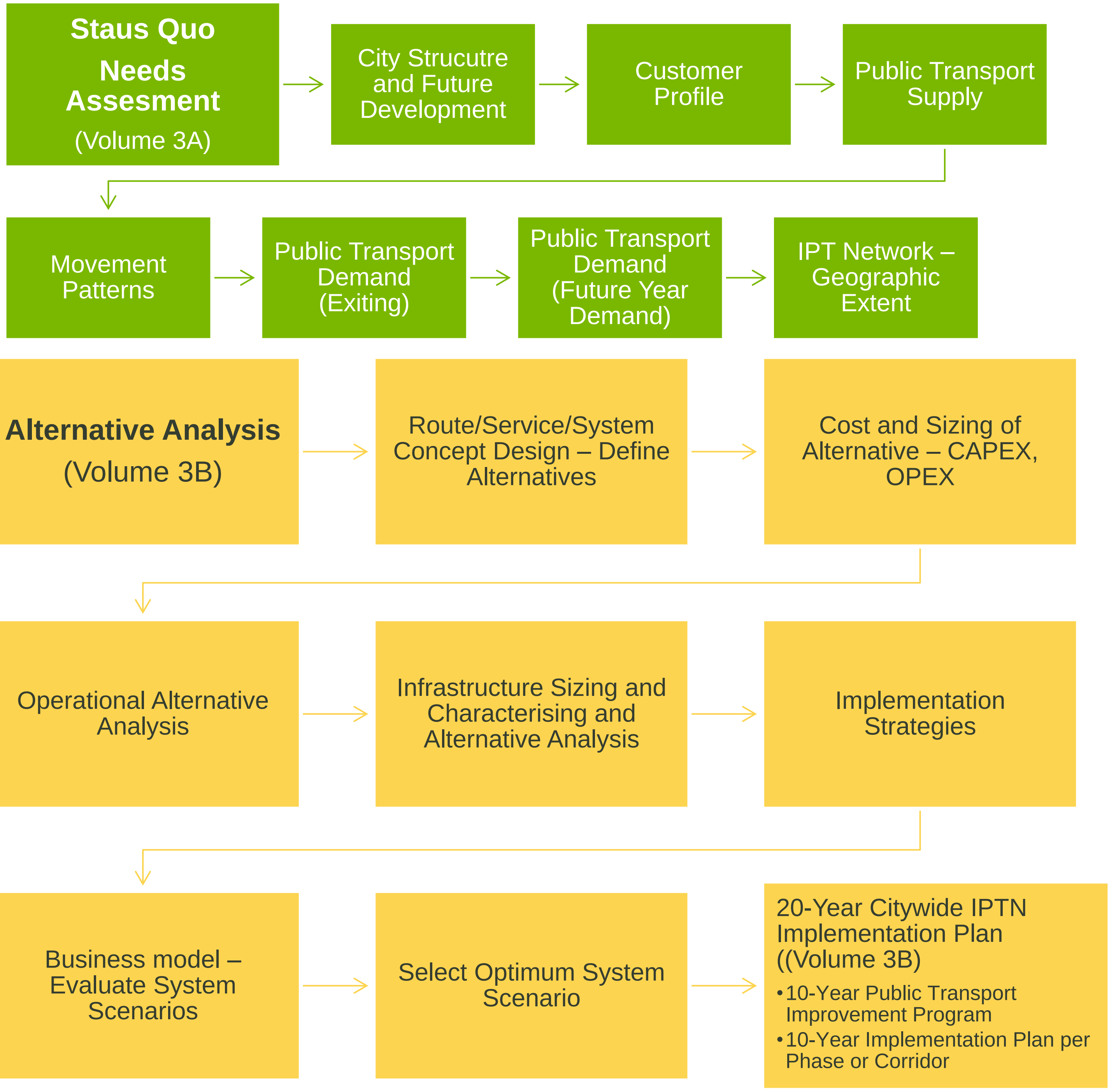


Figure 1-1: City-wide IPTN and System Development Methodology

2 Public Transport Vision, Goals and Objectives

2.1 Vision for Transport and System

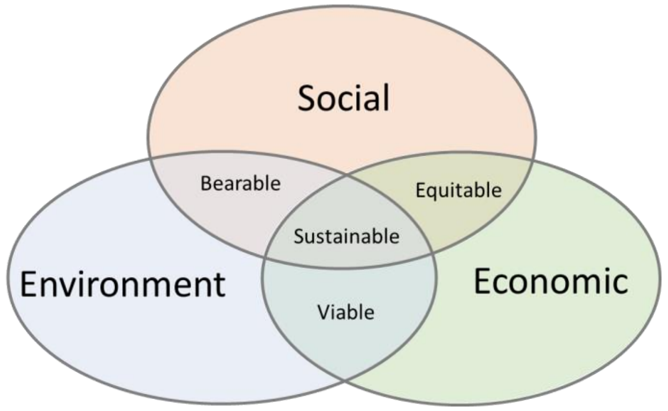
The transportation vision defined for the city is:

"By 2036 Mangaung is recognised nationally and internationally as a safe and attractive place to live, work and invest, is served by an effective, efficient, reliable, safe, affordable and convenient transport system with a public transport focus, providing high levels of mobility and accessibility for the movement of people and goods, with a focus on integrated strategic planning between spatial development, transportation systems and economic development to enhance the quality of life in the area with minimum negative impact on the environment".

This vision will be the basis of the design principles for the IPTN system.

2.2 Goals

Goals and policy guidelines enable the Hauweng Unit to plan services and allocate available resources in a consistent, rational, and systematic manner. These also provide a context for developing detailed service standards and planning criteria, and for establishing performance measures. When service policies conflict with economic limitations brought about by fare policies and available public funding, resources should be administered most cost-effectively.



The primary goal of the IPTN is to develop a public transport network and related systems that provide the best possible service to the greatest number of people at the least total cost and which is in the long term sustainable (environment, social, financial). The goals are:

- To establish and maintain a network of high-quality urban and rural public transport services for residents and visitors.
- To provide access to places of residence, work, school, business, shopping, and recreation with the amount and type of service appropriate to each. This implies a minimum level of service on routes where minimum acceptable levels of ridership and revenues cannot be realised.
- To decrease private vehicle, use by attracting new customers (i.e., choice riders), thereby helping to reduce traffic congestion, air pollution, and energy consumption.
- To provide and ensure reasonable service for the elderly, passengers with categories of special needs, young, and low-income people.
- To operate public transport vehicles safely and comfortably.

2.3 Objectives

The overarching objective derived from the goals of the integrated public transport system is to design, manage, operate, and maintain the system so that it will be attractive enough for patrons to ensure its continued use. Furthermore, the designed route structure and services offered will provide access to major trip generators, setout to be simple and clear to users, and will be economically efficient in the longterm.

The objectives identified stemming from the goals for the system for the planning of new services or adjusting existing ones include:

2.3.1 Objective 1 - Provide Accessible Services

Scheduled public transport services should meet the travel needs of most residents in the service area. Service should be placed to provide all segments of the population with access to areas of employment and essential services. This approach should apply especially to low- and middle-income families, the elderly and passengers with categories of special needs, and others who do not or cannot operate a private motorised vehicle.

The system design should focus transit service to major land uses and major trip generators, such as employment, shopping, medical, education, and recreation centres. Special concern should be directed to providing service to those groups who depend on public transport to satisfy their local and long-distance transportation needs.

- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Service Area and Route Coverage
    - *Provide public transport services and routes within 500m of 80% of the population.*
    - *Serve major employment concentrations, schools, hospitals, other education institutions.*
    - *Serve social housing and high density residential mixed-use developments as primary origin and destination.*

2.3.2 Objective 2 – Ensure Route and System Coordination

Routes and services should be as simple and direct as possible. Transfers, duplication of services, and indirect routings should be avoided. Road-based public transport services should complement rather than compete with rail lines so that each mode is used to its best advantage. Where rail lines exist, they should provide the line-haul function and bus or mini-, or midi-bus taxi services should feed to the rail service. In areas with-out rail transit, buses should continue to perform both line-haul functions and bus or midi-bus can provide feeder services. Park-and-ride areas may be appropriate to reinforce ridership, especially at high capacity transfer facilities.

- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Route Structure and Spacing
    - *Fit routes to major streets and land use patterns. Provide a basic grid system where streets form grid; provide radial or radial-circumferential system where irregular or radial street patterns exist.*
    - *Space routes at about 1.5km in urban areas, 2km in low-density suburban areas, per community position in rural areas and closer where terrain inhibits walking.*
  - Route Directness-Simplicity
    - *Routes should be direct and avoid circuitous routings. Routes should be not more than 20 percent longer in distance than comparative trips by car.*
    - *Route deviation shall not exceed 8 min per round trip, based on at least ten customers per round trip.*
    - *Generally, there should be no more than two branches per trunk-line route.*

2.3.3 Objective 3 - Coordination with Provincial, Metropolitan and Local Development

Service planning should permit expansion of public transport services, as warranted, into newly developing areas. This calls for continued surveillance of (a) new residential, industrial, commercial, and institutional development; (b) new road alignments and designs; and (c) traffic control measures and devices. This allows ongoing adjustments to designs and measures so that public transport service is not difficult or unduly expensive. Service expansion should disrupt existing services as little as possible.

2.3.4 Objective 4 – Provide convenient services

These can be provided through:

- Public transport service should be perceived as convenient. If door-to-door travel times for present and potential riders can not be minimised, the highest quality facility available must be used.

- Better routings between principal passenger origins and destinations and efficient spacing of routes and stops should minimise transfers, walking distances, and service changes.
- Easily remembered schedules can be provided where public transport service headways exceed 10 min (for example, "clockface" schedules).
- Passenger shelters should be provided at major boarding and transfer points and at key locations where service is infrequent.
- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Route Length
    - *Routes should be as short as possible to serve their markets; excessively long routes should be avoided. Long routes require more liberal travel times-because of the difficulty in maintaining reliable schedules.*
    - *Route length generally shall not exceed 25 km round-trip or 2 hours.*
  - Route Duplication
    - *There should be one route per arterial except on approaches to the CBD or a major transit terminal. A maximum of two routes per street (or two branches per route) is desirable. ·*
    - *Express service should utilise freeways or expressways to the maximum extent possible.*
    - *Express and local services should be provided on separate roadways, except where frequent local service is provided.*
  - Passenger Shelters
    - *Provide at all CBD stops.*
    - *Provide at major inbound stops in residential neighbourhoods.*
    - *At stops that serve >100 or more boarding and transferring passengers per hour.*
  - Bus Route and Destination Signs
    - *Provide front and. side-mounted signs.*
    - *The front sign should give at least route number and general destination; side sign should give route number and name (front sign may give all three types of information).*
  - Passenger Information Service
    - *Provide telephone information service for the period that the system operates.*
    - *Ninety-five percent of all calls should be answered in 5 min.*
  - Route Maps and Schedules
    - *Provide dated route maps annually.*
    - *Provide printed schedules every quarter or when service is changed.*
    - *Schedules should provide route map (for route and corridor).*
  - Bus Stops:
    - *Stop frequency: Urban areas at least 1km apart (500m walking distance).*
    - *Stop location: Depends upon convenience and safety; no parking in curb lane all day or peak-hrs, far side; parking in the curb lane, near side (except where conflicting with right turns).*
  - Passenger Access Criteria (Optional)
    - *Waiting areas to be designed to LOS C with a dedicated area for passenger with categories of special needs.*

2.3.5 Objective 5 – Provide a system and service that is safe

- Public transport service should continue to be safer than other urban transport modes and should be located, designed, and operated to promote the safety of public transport passengers, -employees, and the general public. All elements of the system should be designed to minimise accident exposure.
- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Passenger and Revenue Security System
    - *Exact fare procedures-generally usable.*
    - *Provide radio communication for the driver with a secret emergency alarm.*
    - *Arrange enforcement through existing entities.*

2.3.6 Objective 6 – Provide Quality Equipment

- New concepts and improvements in public transport vehicle designs should be used within the limits of financial policy. Vehicles should be mechanically reliable, smooth-riding, quiet, easy to get in and out of, well-lighted, attractive and appealing to passengers, and thoroughly cleaned regularly.
- Bus service should minimise air and noise pollution by establishing rigid maintenance standards.
- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Bus Maintenance
    - *Spares should not exceed 10 to 12 percent of the scheduled fleet.*
    - *Ensure that each five thousand-km' preventative maintenance inspection is done.*

2.3.7 Objective 7 – Dedicated Personnel

- Personnel policies encourage safe, dependable, and comfortable public transport services.
- Consistently improvements in methods of recruiting and training operating personnel to ensure safe, efficient operations by helpful, competent, courteous, and neat operators. Street supervisors should monitor schedule performance and control emergency situations.
- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Driver Courtesy, Efficiency, Appearance monitoring and enhancement trough training
  - Carefully select, supervisors, and discipline drivers.
  - Avoid extremes in personal appearances.
  - Provide driver incentive programs.

2.3.8 Objective 8 – Ensure service efficiency

- Peak-hour and off-peak service should optimise the use of human resources, vehicles, and other resources and encourage maximum use of the entire public transport system. Under- used services drain resources. Service efficiency can also be increased by (a) maximising average operating speeds,(b) minimising ratio of recovery time to revenue-producing time, and (c) minimising operation of redundant or competitive services.

- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Service Period
    - *Regular service: 05:00 to 20:00, Mon.-Fri.*
    - *Priority Hours: weekday commuter, 6:00-09:00 and 15:00-18;00; Saturday - 07:00-08:00; Sundays, 08:00-09:00;*

- *Suburban feeder service: weekdays, 6:00-9:00 am, 4:00-7:00 pm (Some services 05:00-20:00)*
- *Provide Saturday and Sunday service over principal routes except in rural/agricultural areas (Where Sunday service is optional and need needs to be determined based on demand).*

- Policy Headways Desirable-Minimum Service Frequency:
  - *Peak Hour: minimum 15-20 min,*
  - *Midday: 30 min in an urban area;*
  - *Early Morning, Evening: 60 minutes for urban areas otherwise per demand.*
- Loading Standards (Policy headways may result in considerably lower load factors.):
  - *Peak period: 100-115 percent.*
  - *Early Morning/Midday/evening: 75-100 percent.*
  - *Express services: 100-125 percent.*
  - *Suburban: 85-100 percent.*
- Route Speeds:
  - *Central area: minimum 16 km.*
- Service Reliability
  - *Peak: 80 percent of buses 0 to 5 min late.*
  - *Off-peak: 90-95 percent of buses 0 to 5 min late.*

2.3.9 Objective 9 - Service Monitoring and Responsiveness

- Operations planning and research staff, continually monitoring services for opportunities to increase ridership and efficiency can adjust services to reflect changes in travel patterns and make public transport competitive with the car.
- Ongoing efforts will shorten journey times, enhance passenger comfort and convenience; and maintain fares perceived to be comparable to private car costs.
- Service changes should be developed cooperatively with the communities and neighbourhoods involved.
- Measures of Effectiveness/Design Guidelines to achieve these objectives are:
  - Service Evaluation
    - *Examine physical constraints/street patterns for reliability.*
    - *Estimate ridership and costs.*
    - *Compare with existing route performance.*
  - Service Criteria
    - *Twenty to 25 passengers per bus per hour weekdays; 15 - Saturday; 10 - Sundays and holidays. Fewer riders if route impairs continuity or transfers.*
    - *Fares should cover 40 to 50 percent of the direct costs of service.*
  - Frequency of Change
    - *Major changes not more than 2 or 3 times per year. Other changes may be at other times.*
  - Length of Trial Period
    - *Minimum 6 months of experimental service.*

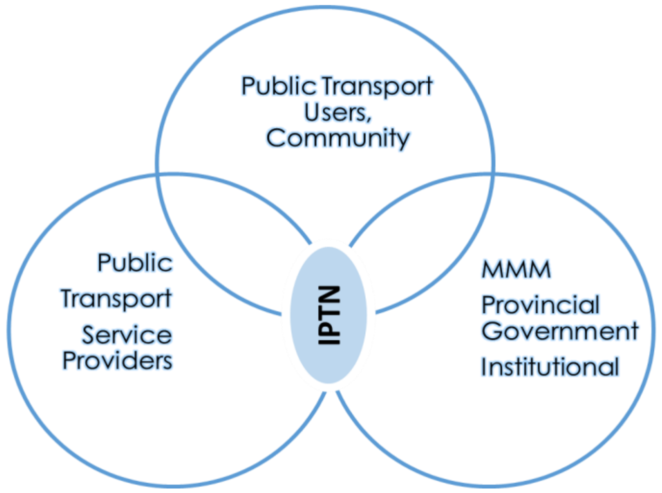
3 Status Quo (Needs Assessment)

3.1 Introduction

The needs assessment determines the status quo of public transport in the city and the potential demand that will be required to be accommodated in the IPTN. The status quo provides insight into the passenger experience of the existing system and the public transport system level of service provided. The chapter capture transport-related issues and problems and needs of the municipality's residents. The chapter will focus on public transport with selected private vehicle analysis.

The implementation of a city-wide integrated public transport network requires an understanding of:

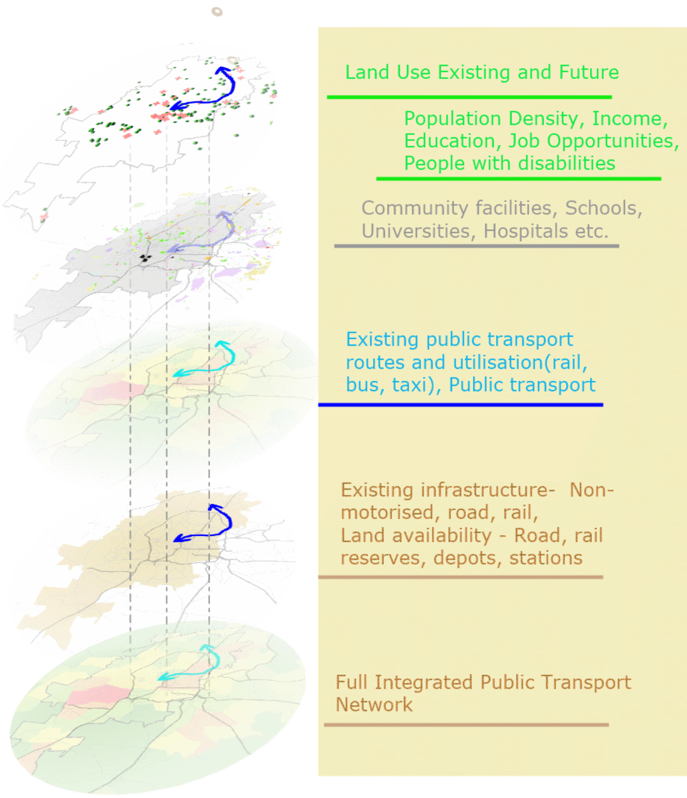
- Existing public transport users' profiles (age, income sources, employment etc.);
- Public transport level of service provided to these users;
- Operational and business characteristics of existing public transport operators/service providers,
- Existing and future demand corridors in the city;
- Existing public transport facility infrastructure and roadways and rail infrastructure operating along; and
- Institutional structures that plan and govern existing public transport operations.



The status quo attained from the above compared to requirements for an integrated public transport system provides the elements that need to be improved within the current public transport system. The minimum requirements for an integrated public transport system are based on best practice and standards set by the National Department of Transport for public transport systems in South Africa.

Public transport best practice set out to establish a system that provides a safe and efficient system to all public transport user categories, that is environmental, economic and financially sustainable, and which is effectively managed and operated through well-established institutional and business structures.

The planning and implementation of an integrated public transport network and system thus require a balanced approach to provide services that accommodate the needs of residents, incorporate existing operators, infrastructure provision and the revenue that can be earned.

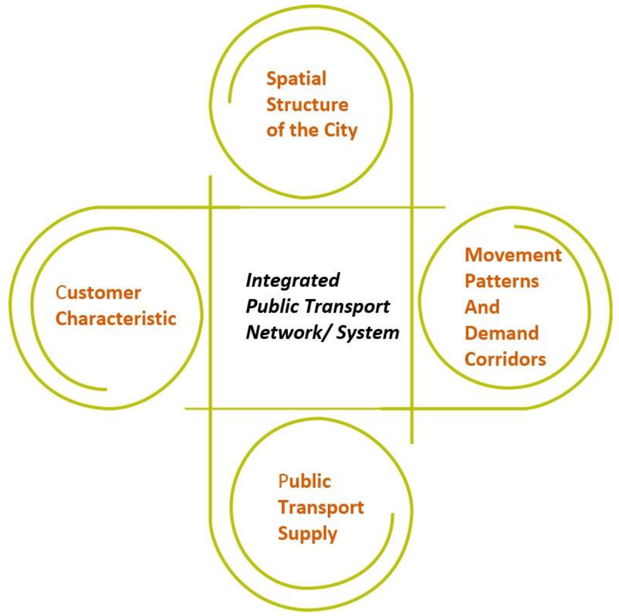


3.2 Methodology

3.2.1 Customer Profile

The customer profile provides insight into the people that the system needs to accommodate. This section summarises and quantifies the population characteristics, people with categories of special needs and public transport experience.

- The design questions that guided the analysis are:
  - Who is the customer/user that the city needs to accommodate and provide for?
  - What is the current experience of public transport users? Why did the customer select a specific mode?
  - Where will implementation impact businesses and other economic activities?
  - Where did the city observe these customers? Along which routes, the volume of passengers/users, to where, how did they transfer and utilise the existing system?



3.2.2 Public Transport Supply

Determine the public transport supply and the level of service in terms of waiting time, journey time, operational hours, fares, service areas and other identified aspects of supply.

3.2.3 City Spatial Structure and Demand Corridors

The approach and data incorporated in the development of the City Spatial Structure and to derive the Demand corridors are:

- Contextualise the spatial orientation through the development of a Land Use Model for the base year 2015, and through applying the SDF and macroeconomic forecasting develop land-use scenarios for 2025 and 2036;
- Derive the City's demographic profile (population density, income levels, car ownership, etc.). The profile was obtained for the base year 2015 and through the application of the future year scenarios of the land-use model determine the 2025 and the 2036 profile.

- Demand Corridors are derived through:
  - Obtaining regional and local travel patterns and mode use from Mangaung Metropolitan Municipality (MMM) Household Travel,
  - Determine existing public transportation demand to identify main travel corridors (classified public transport link counts, public transport facility surveys and bus and taxi on-board surveys). Align these corridors with the origins and destinations as defined from the spatial structure and MMM HTS 2017(once available),
  - Develop public transport matrix for the base and future year to define functional public transport corridors (refer to Section),
  - Define existing primary and secondary demand corridors (movement networks) from the above data. Corridors are categorised as follows:
    - Primary Corridor:

  - *Two or more public transport modes operate along the corridor;*
  - *Combination of origin and destination pair demand more than 1000 peak hour passengers*
- Secondary Corridor:
  - *A public transport mode operates along the corridor*
  - *Combination of origin and destination pair demand range between 501 to 1000 peak hour passengers*
- Minor Corridor:
  - *A public transport mode operates along the corridor*
  - *Combination of origin and destination pair range between 30 to 500 peak hour passengers*

- Develop citywide IPTN based on demand corridors, existing public transport supply and land use.

3.3 Citywide Network Validation

3.3.1.1 Network Validation Criteria

The principles that were selected to validate the citywide network to meet the objectives set for the system pertaining to the geographic extent are:

- Area coverage of the network (Access to Public Transport);
- Transfer between routes and services (Mobility);
- The directness of routes and service (Mobility); and
- Spacing between routes and corridors (Economic Feasibility, Frequency of Service versus Accessibility).

3.3.1.2 Area Coverage

One of the first factors to consider in transit system design is the extent of the network and the area it covers/serves. A transit network should ideally cover to the greatest extent possible while balancing what is economically reasonable and socially desirable/equitable.

Areas within a 5-minute walking distance from transit stations are the primary service areas; the highest number of potential passengers living in this area can be expected to make use of the available service, provided it is of satisfactory quality.

Areas with a 5 to 10-minute walking distance from a public transport stop represent the secondary service area; in this area, the percentage of people willing to use the transit service reduces rapidly, the further they are from a public transport stop.

The unwillingness of people to walk long distances is illustrated in **Figure 3-1**. The figure illustrates that people living or working in an area that requires more than 10 minutes of walking to a public transport stop, will require some form of feeder system in conjunction with the primary transport service.

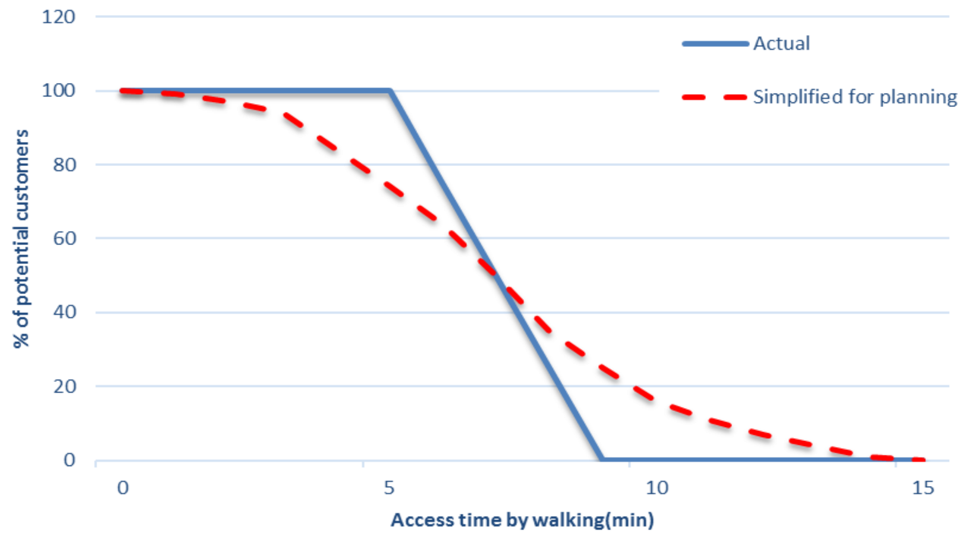


Figure 3-1: Potential Transit Passengers using Transit as a Function of Walking Access Time

3.3.1.3 Transfer between Routes and Services

Once the area coverage has been determined, various operational factors should be examined, such as possible transfers between routes and different modes. Passengers always prefer a direct ride as opposed to one that requires a transfer. Passengers exhibit a reluctance to transfer primarily due to the conditions under which transfer takes place. Public transport users are not likely to transfer or switch mode if the total journey length is less than 10 km. A passenger will transfer mode within the first 5km of the journey given that the next and possible final leg of the journey is more than 10km. This rule will be used to determine if transfers can be allowed on primary demand corridors.

3.3.1.4 Directness of Routes

The directness of a route can be defined as the ratio between the actual travel distance between two points when using the transit system, and the straight-line distance between the two points. This ratio should preferably be minimised, although this can prove to be quite difficult in some cases because transit routes are constrained by street patterns and topography. The best way to minimise the "Directness of route ratio" is to create routes that connect large traffic generators (land use) and place routes along the highest passenger desire lines, while serving populated areas in between as much as possible.

Optimising the directness of the route is often in direct conflict with an attempt to maximise coverage. The best coverage is often obtained by using circuitous routes, rather than direct routes. Direct routes are justified in areas where transit demand is high, but in areas with low demand, service would be too infrequent if direct routes where used.

3.3.1.5 Spacing Between Corridors and Routes

The spacing between routes should consider the distance between parallel routes determined by the density of travel demand along parallel corridors. As mentioned before, a person is well served by a transit system if he/she resides within a 5-minute walking distance of the transit line (approximately 400m if a person walks at a speed of 1,3m/s).

For a given transit demand in one direction, there is an option of either supplying a few routes with frequent service or many routes with infrequent services. In general, it is preferable to have fewer lines with while service rather than many lines with infrequent services.

If there is sufficient demand, the line spacing of 800m is advised (which means the maximum walking distance from transit service will be 400m). However, if demand is not substantial enough to support lines so close to each other, spacing can be increased to 1,6km, which will result in a maximum walking distance of 800m (10 minutes), which is also still acceptable. Spacing larger than this will typically result in poor coverage.

4 Spatial Structure

4.1 Mangaung Spatial Development Framework and Built Environment Performance Plan (BEPP)

The main statutory document which guides and directs development towards achieving the future spatial vision of Mangaung is the Mangaung Spatial Development Framework (2016) (see Figure 4-1 and Figure 4-2).

The MSDF aims to address the spatial and socio-economic inefficiencies of the metropolitan area and to achieve a spatial structure which complies with the norms and principles of the Spatial Planning and Land Use Management Act (SPLUMA), including Spatial Justice, Spatial Efficiency, Spatial Sustainability, Spatial Resilience and Good Governance.

In order to achieve this, the MSDF suggests an integrated approach comprising several significant interventions summarised as follow:

- Improving the functional integration and relationship between Bloemfontein, Botshabelo and Thaba Nchu by enhancing development along the N8 corridor and/or the railway line running parallel to it;
- Stimulating economic growth and mixed-use development in the eastern and south-eastern parts of Bloemfontein which would create a more balanced city structure for the town (refer to Figure 4-4), and benefit communities in Mangaung Township, Botshabelo and Thaba Nchu;
- Strengthening the city core through CBD regeneration and consolidating the urban structure by way of an Urban Edge;
- Enhancing local economic development in Bothsabelo and Thaba Nchu and between these two areas by way of corridor development (refer to Figure 4-5). This includes the establishment of a labour based manufacturing hub/IDZ at Botshabelo, and reinforcing Thaba Nchu to become a rural market town; and
- Improving access from the surrounding rural communities to these areas.

The MSDF states that this approach will reduce the competing pressures between the different areas, reinforce the soundness and inherent strengths and efficiency of the compact basic city structure, and optimise the use of limited public and private sector resources.

The Mangaung Development Concept and Approach as noted above is confirmed in the Mangaung Urban Network and Integration Zone Plan (Figure 4-3) which was submitted to National Treasury as part of the Mangaung Built Environment Performance Plan (BEPP) report. The following key findings and proposals, as illustrated in Figure 4-3 are important to note:

- The N8 corridor linking three secondary nodes (Airport Node, Botshabelo and Thaba Nchu) is identified as an activity corridor focused on integrating these secondary nodes through several development initiatives. This corridor consists of road (National Route N8) and rail infrastructure and is earmarked as a strategic corridor initiative in the National Development Plan (NDP) as part of the Strategic Integrated Projects (SIP) group 7.
- The Botshabelo-Thaba Nchu Integration Zone/Corridor linking the Botshabelo CBD with the Thaba Nchu CBD, consisting of the following links:
- Botshabelo main road linking the Botshabelo CBD to the N8 Corridor;
- N8 Corridor from Botshabelo up to Thaba Nchu;
- Brand Street in Thaba Nchu linking into the core of Thaba Nchu; and
- Possible integration of surrounding land uses with the Thaba Nchu railway station.
- As part of a major intervention to stimulate economic development in the eastern parts of Bloemfontein, the proposed Airport Development Node has been identified as a key secondary node to be developed. The proposal is to develop it in two distinct phases. Phase 1 comprises land (700 ha) to the south of route N8 and covers the areas of Shannon and Bloemspruit. The area to the north of route N8 (1100 ha) is intended to be developed as Phase 2 and will cover the area east of the Bram Fisher National Airport up to the alignment of the proposed eastern bypass route, as well as land to the north and north-west of the airport. A critical factor to the successful development of this node would be the construction of the eastern bypass route through Bloemfontein which links to the N1 freeway to the north and south of the town. This route will provide regional access to the Airport Node for north-south moving national and local traffic, and will enhance the total viability of the proposal as the local economy of Bloemfontein will not be sufficient to sustain development of this magnitude.
- The Mangaung Built Environment Performance Plan also identified a number of underserved townships earmarked for upgrading, consolidation and infill development. As illustrated on Figure 4-3 these include the Grasslands area to the east; Bloemside Phase 1, 2 and 3 to the south thereof; a number of underserved townships representing the southern parts of Mangaung (including Batho, Bochabela, Phahameng, Namibia, Freedom Square, Rocklands, JF Mafora and Kopanong); and Lourierpark to the south-west. Development in these areas includes the upgrading of infrastructure and amenities, promotion of local economic development, and the upgrading/formalisation of informal settlements.
- Several mixed-income and mixed housing typology project areas were identified – the so-called "7 Land Parcels" initiative, including Brandkop 702 north of Lourierpark, Brandkop Race Track to the north thereof adjacent to the south of route N8 west, Cecilia directly to the north of N8 west, Pellissier infill development, Vista Park Phase 2 and Phase 3 which are located to the west of Church Street, and Hillside View located to the east of Church Street (see Figure 4-4).
- The Mangaung Built Environment Performance Plan also identified five "urban hub" areas earmarked to consolidate mixed economic activities. In the western parts of the City, it includes the areas surrounding route N8 in Schoemanpark immediately west of the N1-N8 intersection, as well as the area surrounding route R64 north of Langenhovenpark and west of the Nelson Mandela Road/R64-N1 interchange. The remaining two urban hubs reflected in the Built Environment Performance Plan are the Mangaung Township to the east of the Hamilton-Vista economic activity area and the Schoemanpark (Ooseinde-Transwerk Industrial cluster) located to the east of the CBD along N8 East.
- Figure 4-4 also indicates five Integration Zones intended to enhance the functional integration and linkages between disadvantaged communities and the Bloemfontein CBD (the sixth Integration Zone is between Botshabelo and Thaba Nchu – see Figure 4-5).

Mangaung Spatial Development Framework

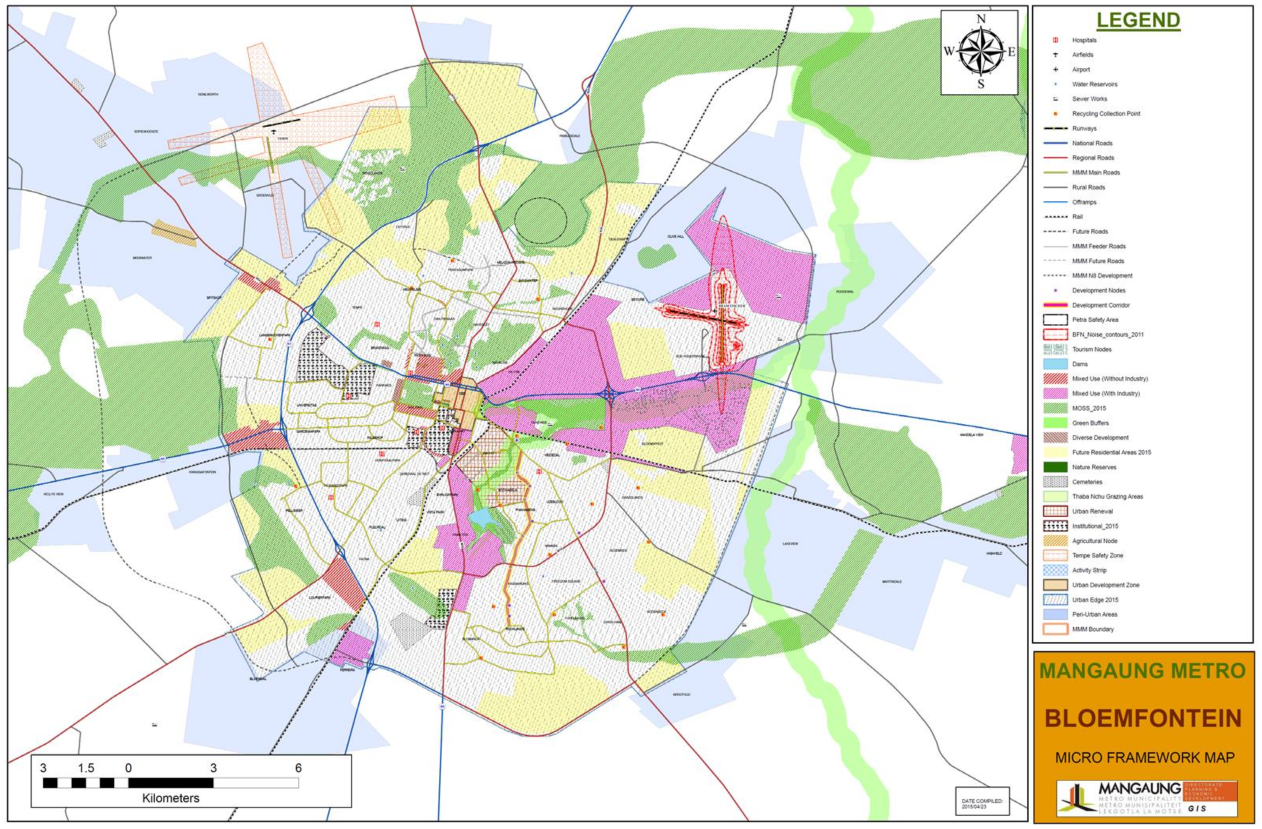


Figure 4-1: Mangaung Spatial Development Framework

Mangaung Urban Network and Integration Zone Plan

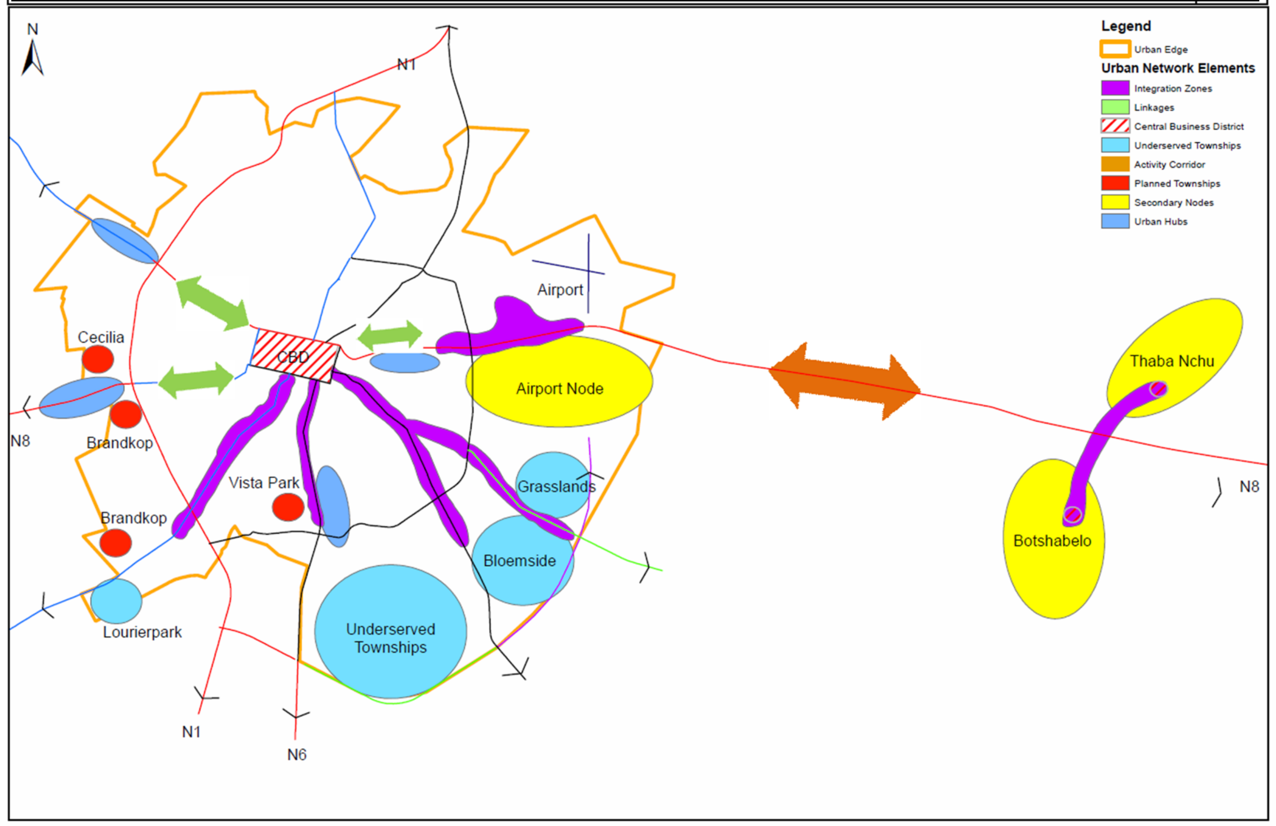


Figure 4-3: Mangaung Urban Network and Integration Zone Plan

Botshabelo and Thaba Nchu Spatial Development Framework

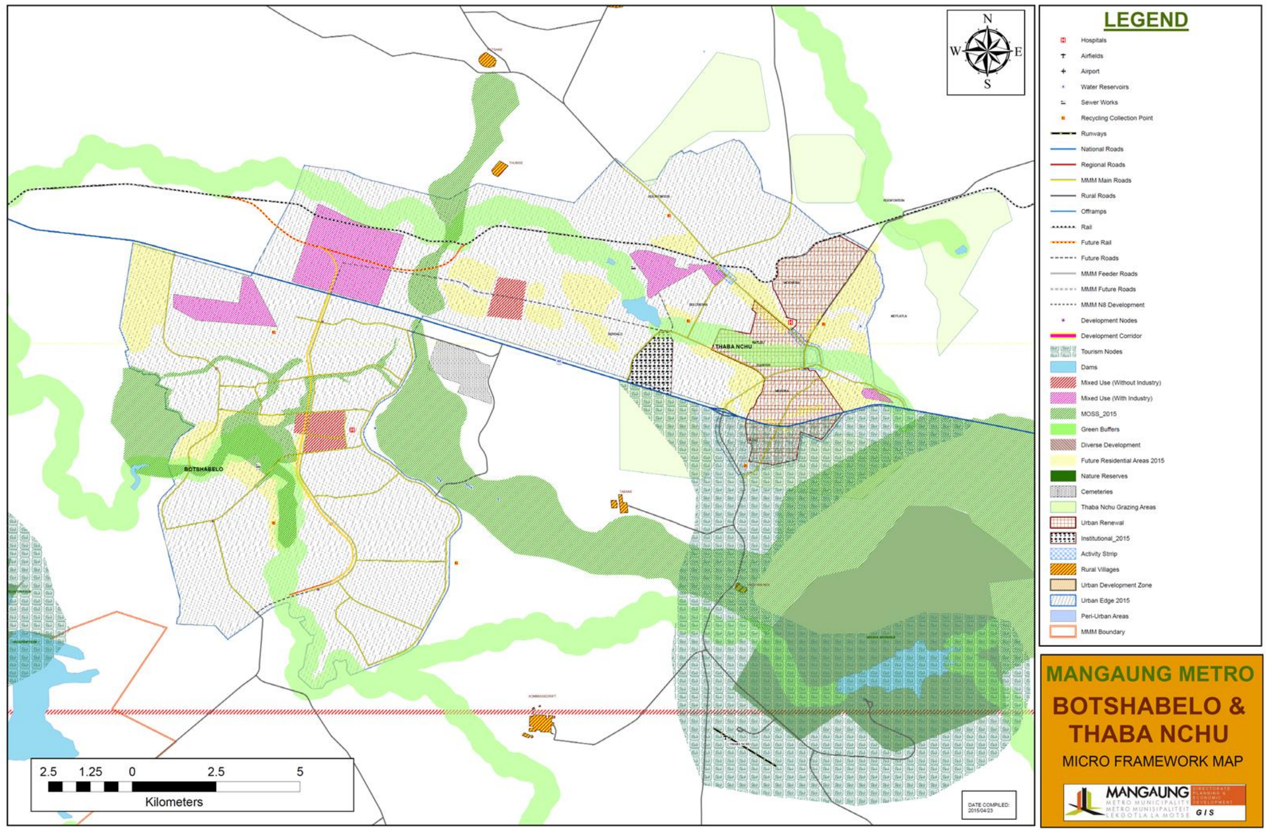


Figure 4-2: Botshabelo and Thaba Nchu Spatial Development Framework

Mangaung Restructuring Interventions

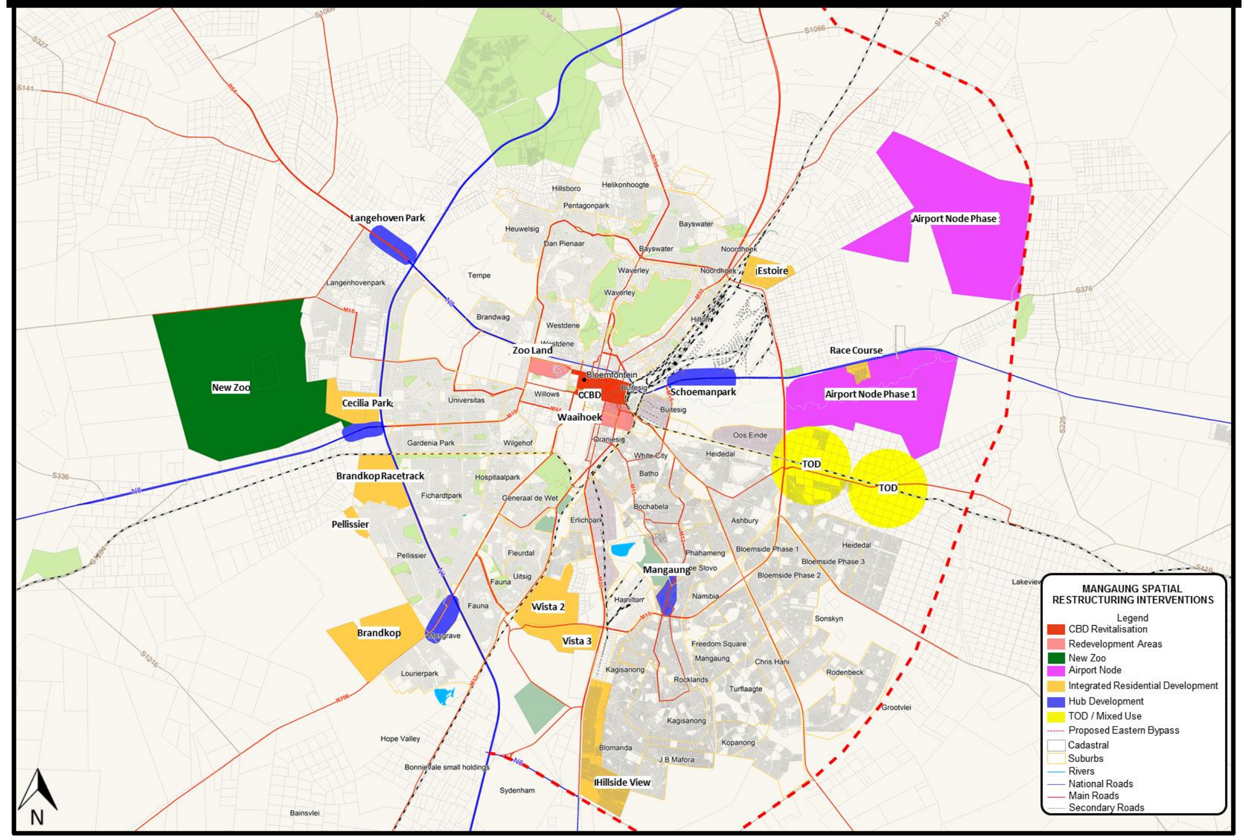


Figure 4-4: Mangaung Restructuring Interventions

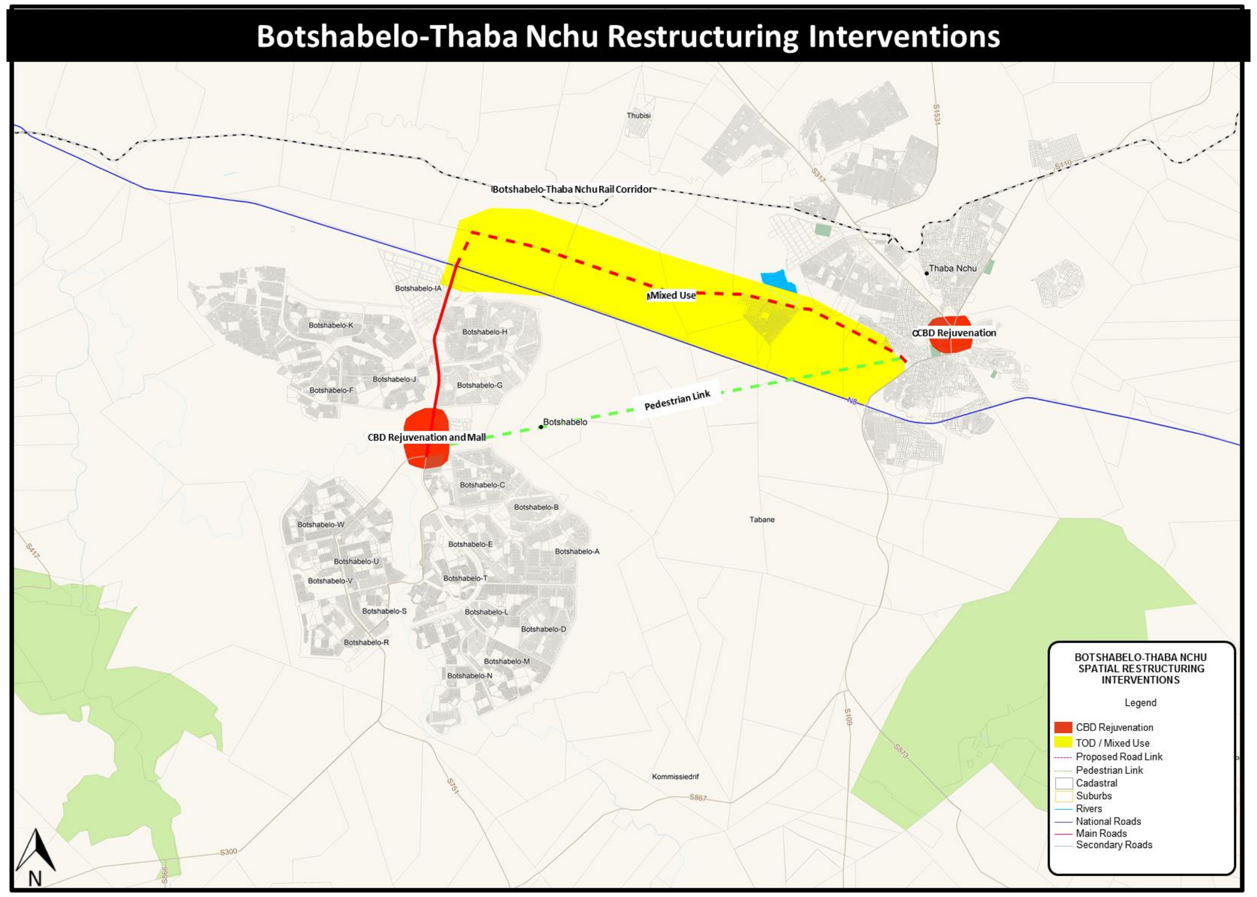


Figure 4-5: Botshabelo-Thaba Nchu Restructuring Interventions

4.2 Land-use Derived Main Origins and Destinations

The observed demand provides the existing public transport and private vehicle movement within the transport system. This demand is influenced by the supply of public transport services, i.e. routes and the services that public transport operators provide to passengers. These routes and services provided are based on where operators can earn the highest revenue and not necessarily serving the origins and destinations between which passengers prefer to travel.

To attain where people move and where they most likely would travel was obtained through:

- Development conceptual origin-destination matrix based on land-use (SDF and existing land uses); and
- Determining the origin-destination pairs from the household travel survey for Mangaung specific.

The primary, secondary and minor origins and destinations were determined from the land-use model for 2015. The land-use model provides a zoning system for the city and the number of people living in each zone and the number of job opportunities provided in each zone. For the identification of primary, secondary and minor origins and destinations, the population density per zone is used to rank origin zones, and the total number of formal and informal jobs per zone is used to rank destination zones. Zones were classified into primary, secondary and minor origins based on the following criteria:

- Primary origin – population density of more than 5 500 people per square kilometre;
- Secondary origin – population density of 3 000-5 499 people per square kilometre.

The criteria used for destination zone classification are:

- Primary destination – more than 10% of total jobs are provided in a specific zone;
- Secondary destination – between 5% and 10% of total jobs are provided in the zone.

The result of the ranking of the zones from an origin and destination point is presented in Figure 4-6 present the primary origins and destinations, and Figure 4-7 present the secondary origins and destinations.

The Mangaung household travel survey was analysed, and the total number of public transport person trips generated or attracted per zone were determined for the AM peak period (3hours). The traffic zones were categorised based on the 3-hour trips generated (origins) or attracted (destination) for work purpose and education purpose trips. Figure 4-8 presents the zones that attract the highest number of work trips and Figure 4-9 indicate the zones generated the highest number of work-related person trips. Figure 4-10 presents the zones that attract the highest number of education-related purpose person trips and Figure 4-11 present the zones that generate the highest number of education-related person trips. The main origins and destination identified, through both these processes, correlated in terms of main education- and work destinations and origins.

Figure 4-12, Figure 4-13 and Figure 4-14 conceptually show the movement patterns between the identified main origins and destinations for work- and education-related trips. Local movement in Bloemfontein, Botshabelo and Thaba Nchu are evident and movement from Botshabelo and Thaba Nchu to Bloemfontein and the inverse thereof. The quantification and volume were derived from the household travel survey origin-destination matrix and is presented as part of the demand modelling results.

- Primary movements:
  - South-eastern areas of Bloemfontein (highest density residential) to Bloemfontein CBD (30% of MMM jobs provided in CBD)
  - Botshabelo and Thaba Nchu to Bloemfontein CBD
- Secondary Movements:
  - From/to Bloemfontein CBD to Bloemfontein Suburbs
  - From/to Botshabelo suburbs to Botshabelo CBD and industrial area
  - From/to Thaba Nchu suburbs to Thaba Nchu CBD and industrial area
- Minor movements:
  - Within suburbs of areas towards primary and secondary movements and diagonal to primary and secondary movements. Direct movement between secondary nodes, not via CBD's.

Figure 4-6: Primary Origins-Destinations

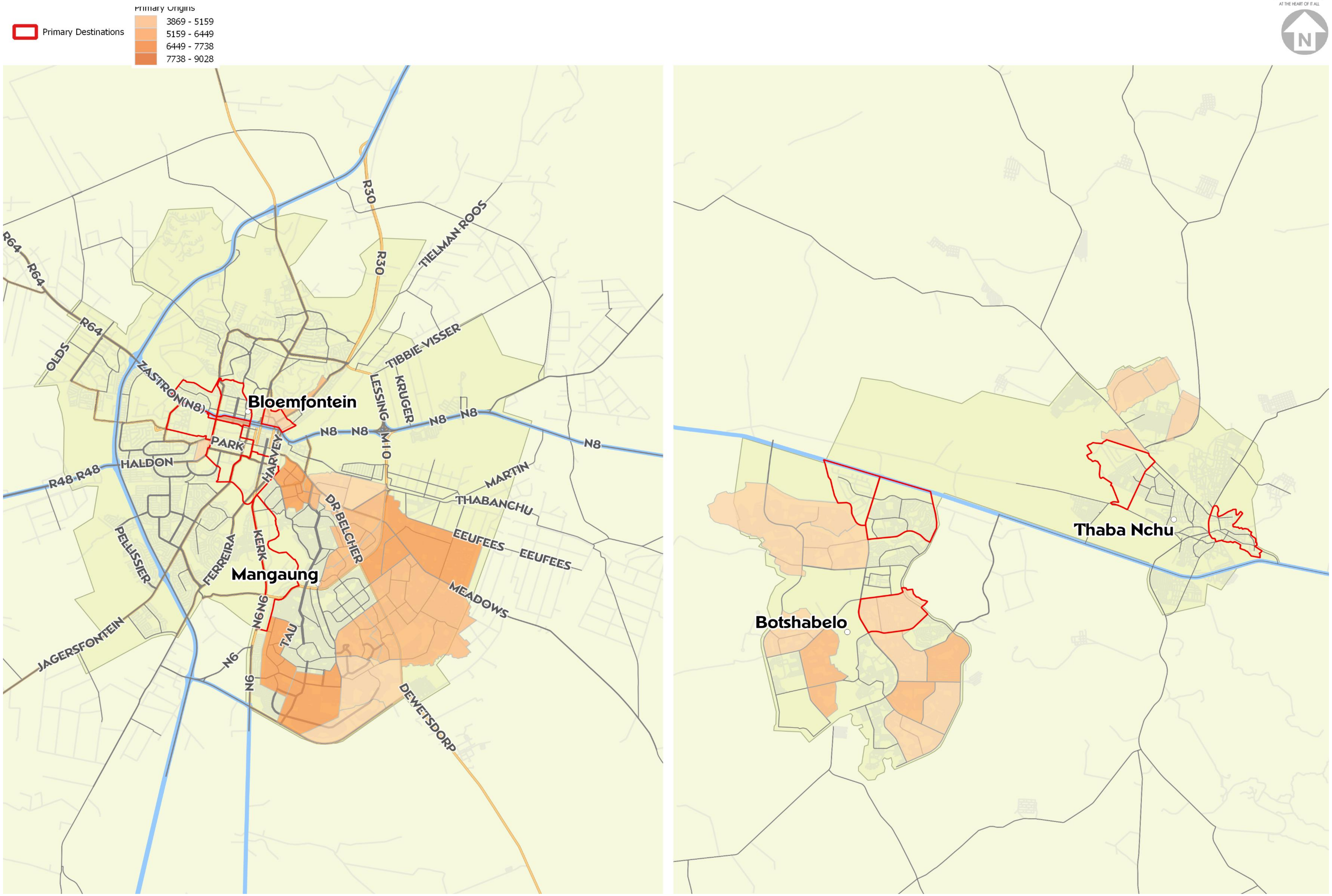


Figure 4-7: Secondary Origins-Destinations

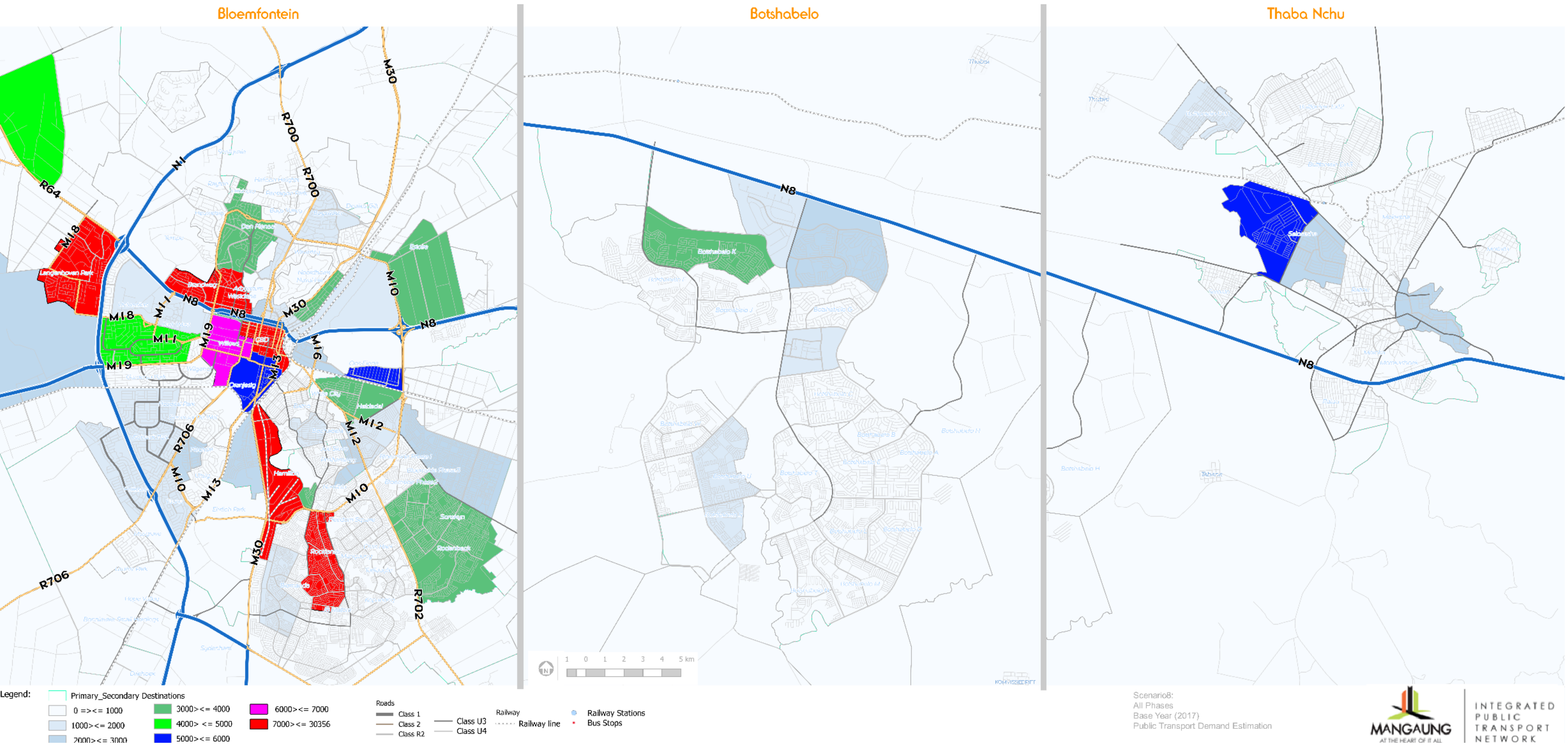


Figure 4-8: Work Trips Destinations

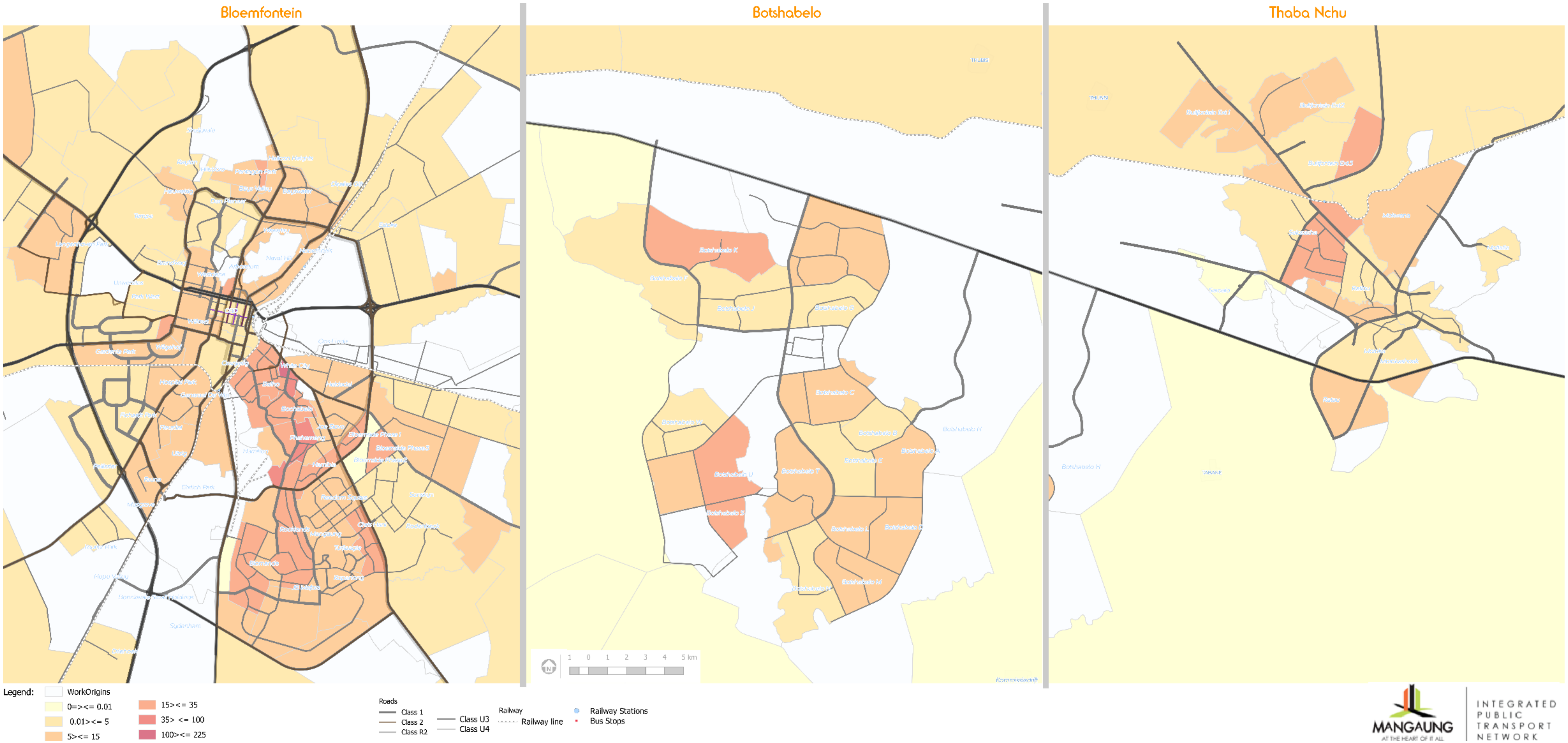


Figure 4-9: Work Trips Origins

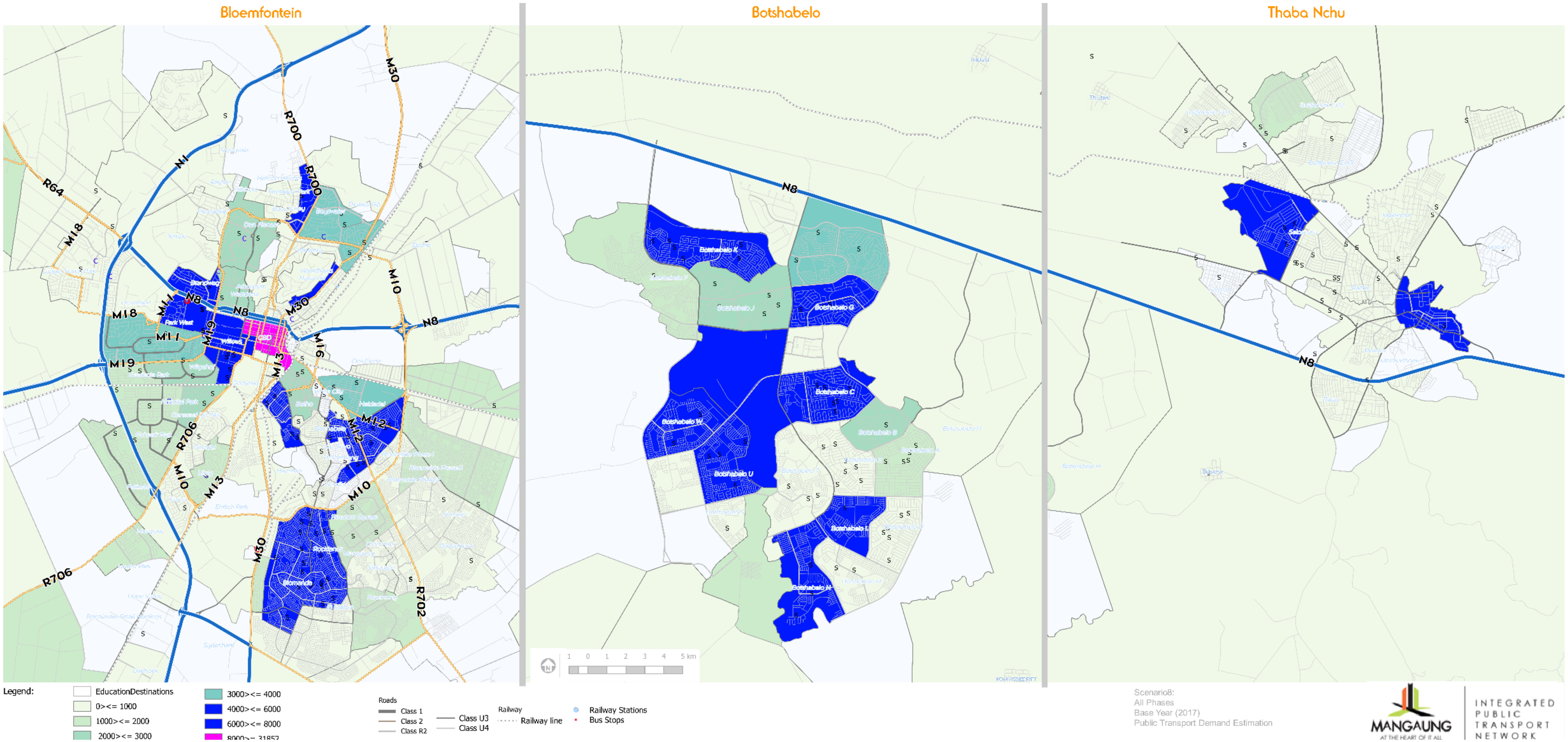


Figure 4-10: Education Trips Destinations

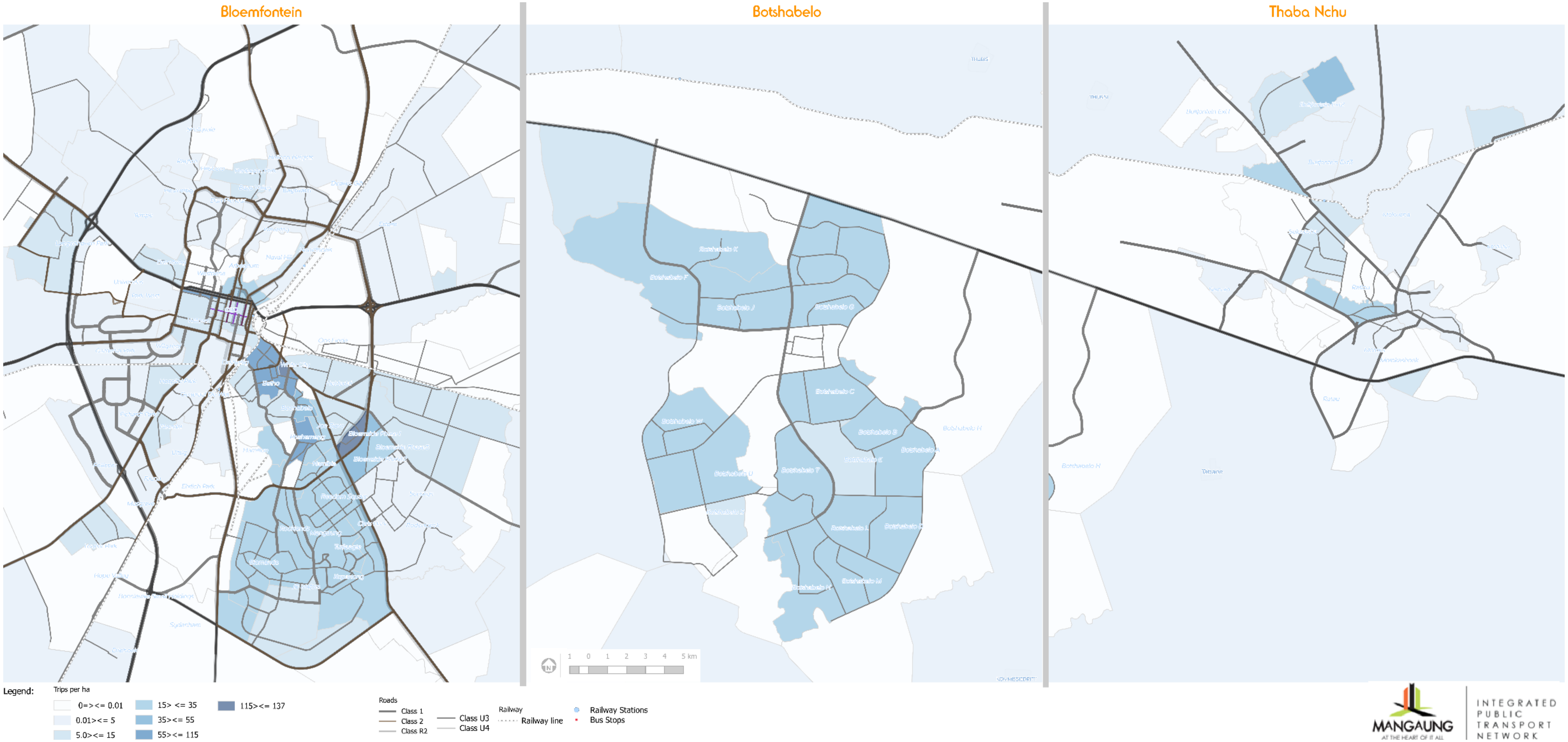


Figure 4-11: Education Trips Origins

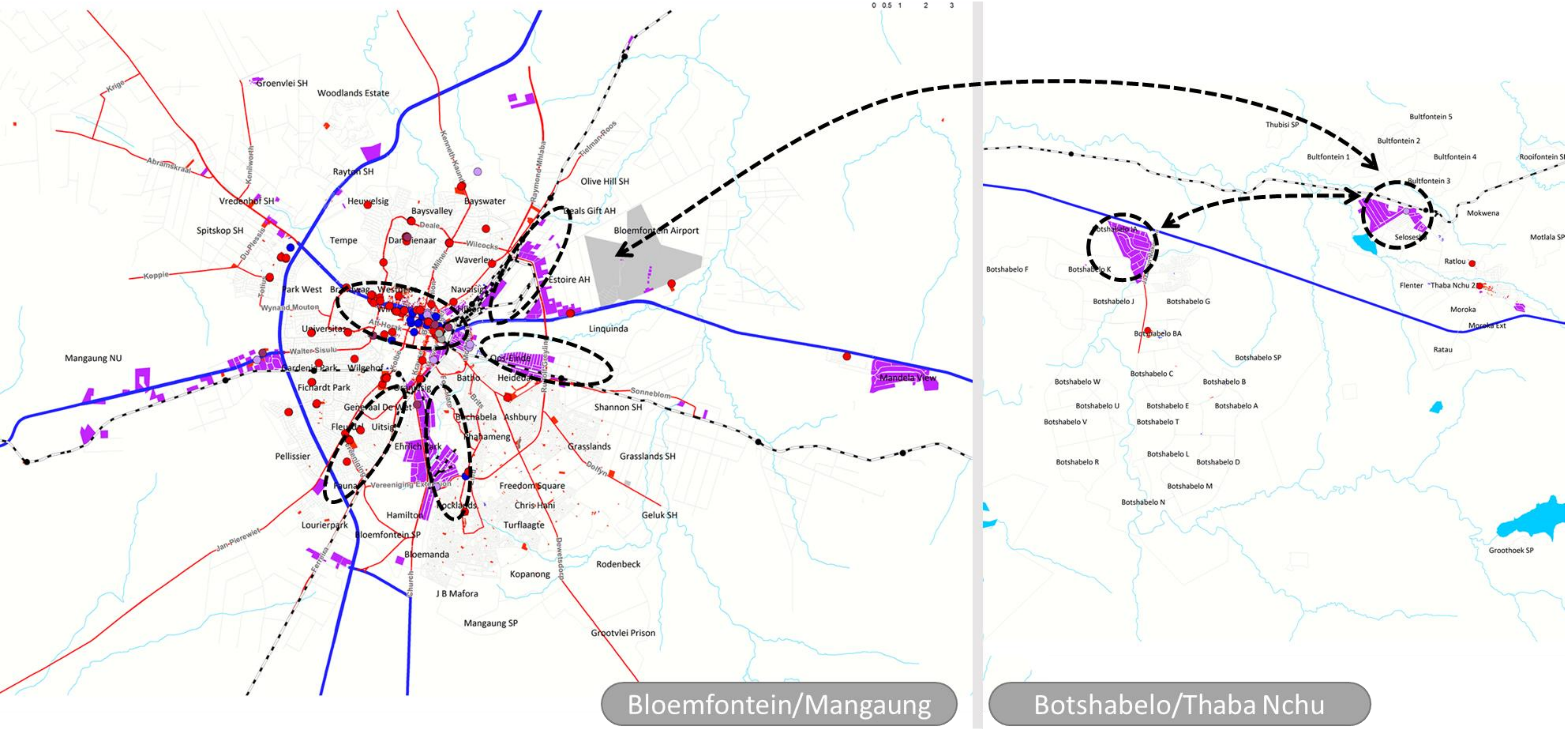


Figure 4-12: Regional Movement – Retail and Industrial Areas

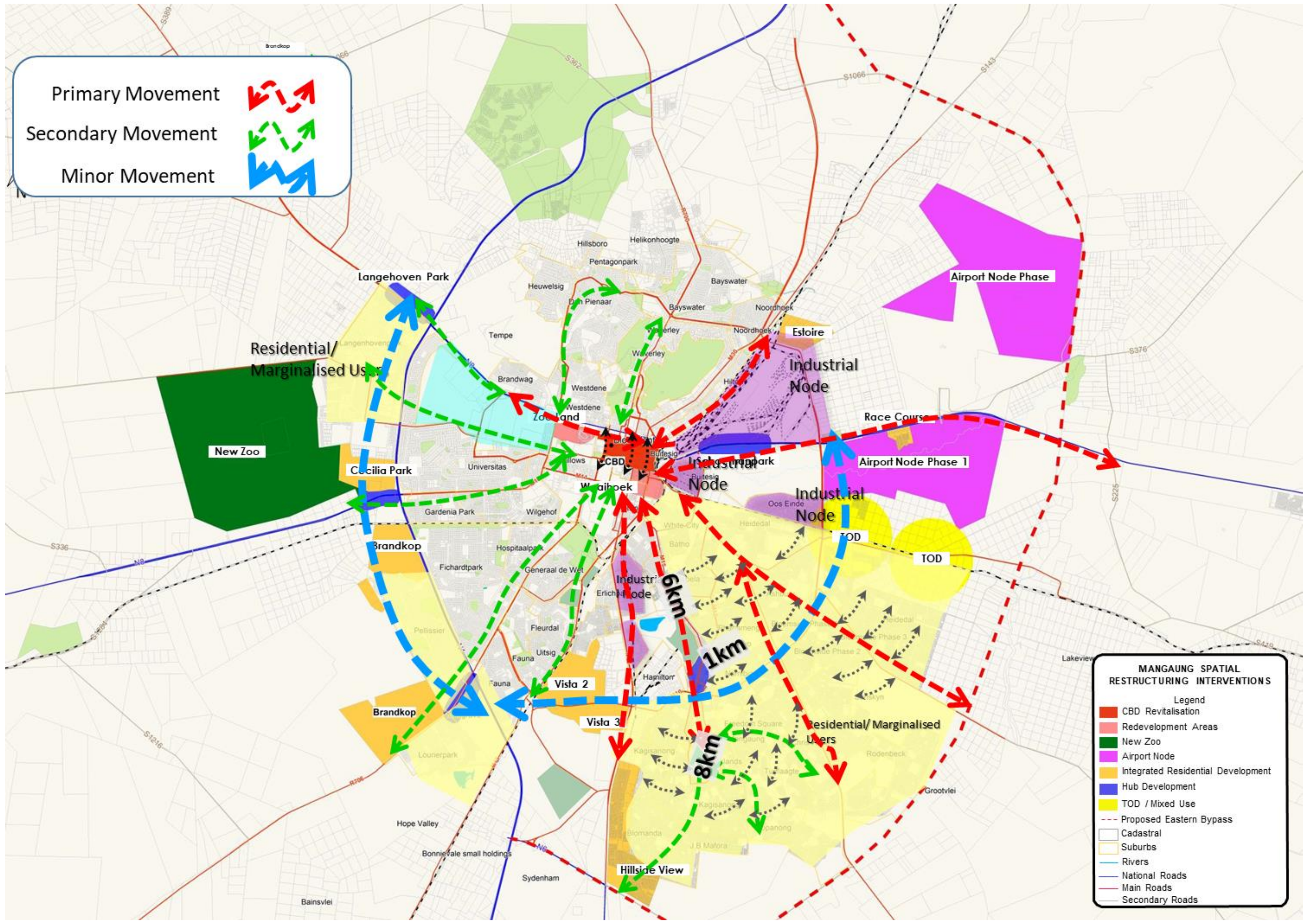


Figure 4-13: Movement between main land-uses – Bloemfontein

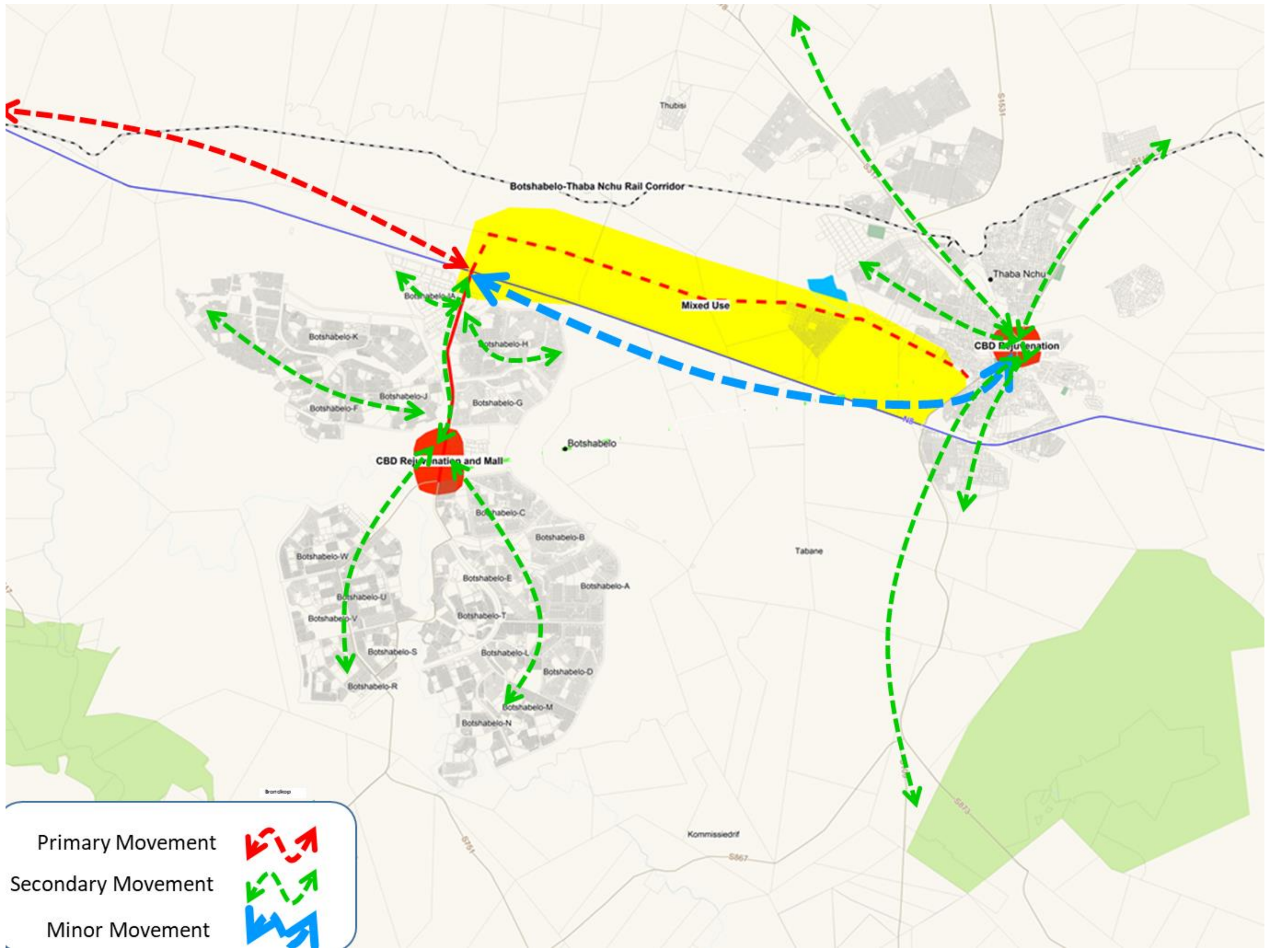


Figure 4-14: Movement between main land-uses – Botshabelo and Thaba Nchu

5 Customer/Passenger Characteristic

5.1 Population Composition

The population in the Mangaung MM were in the order of 775 180 people in 2011, of which 44% (344 430) lived in the South Eastern Quadrant of Bloemfontein, followed by 34% (264 000) who lived in the Botshabelo/ Thaba Nchu area. The remaining urban area of Bloemfontein holds 16% (120 158) of the population and the surrounding rural area 6% (46 591). Refer to Table 5-1 and Diagram 5-1. The population composition of the Mangaung MM is shown in Diagram 6.2.

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Table 5-1: Mangaung MM: Population Composition by Population Group, Census 2011

Reporting Zones	Black African	Coloured	Indian or Asian	White	Other	Total	%
South Eastern Quadrant	309,020	29,932	1,165	3,449	864	344,430	**44%**
Bloemfontein Remaining	39,393	5,520	1,403	73,055	787	120,158	16%
Botshabelo /Thaba Nchu	261,606	950	597	334	513	264,000	34%
Rural	38,267	1,402	162	6,640	120	46,591	6%
Mangaung MM	**648,286**	**37,804**	**3,327**	**83,478**	**2,284**	**775,179**	100%
%	**84%**	**5%**	**0%**	**11%**	**0%**	**100%**	

Diagram 5-1: Mangaung MM: Population Distribution, 2011

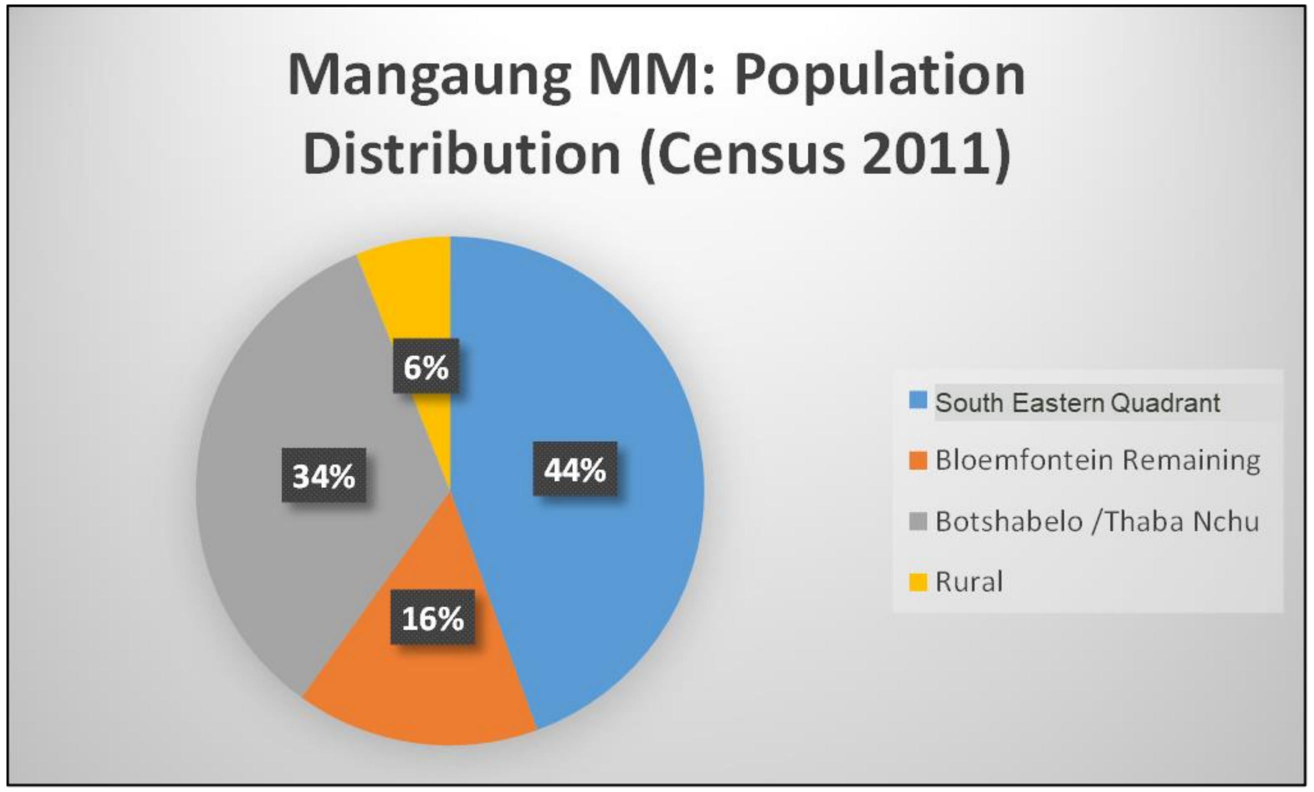
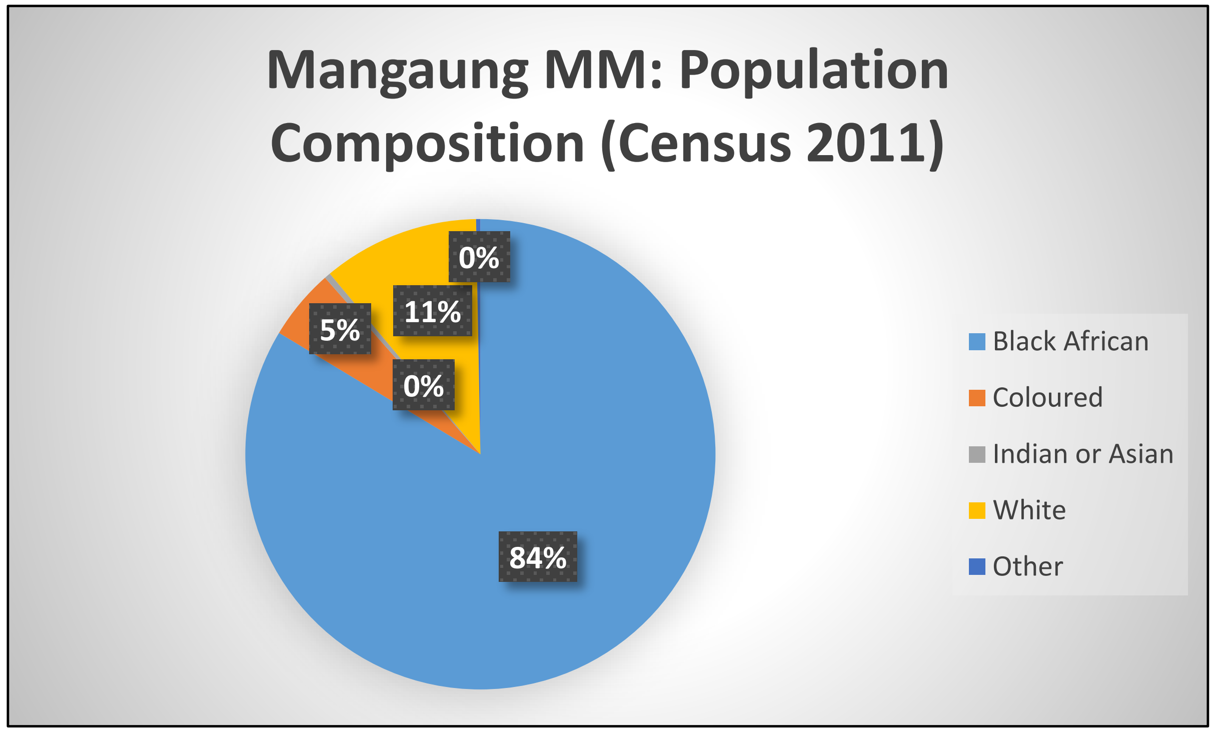


Diagram 5-2: Mangaung MM: Population Composition, 2011



The age distribution of the population is reflected in Table 5-2 and Diagram 5-2. Important to note is that 15% of the population could be regarded as young adults (119 336), and 44% is of working age (338 032), which means that a large number of people will be dependent on public transport to get to and from work and/or educational facilities each day.

Table 5-2: Mangaung MM: Age Distribution, Census 2011

Reporting Zones years	Pre School (0-5)	School Going (6-18)	Young Adult (19-25)	Working age (26-62)	Pensioners (62+)	Total
South Eastern Quadrant	42,895	75,307	52,873	156,517	16,841	344,433
Bloemfontein Remaining	8,674	19,161	22,177	57,498	12,645	120,155
Botshabelo /Thaba Nchu	35,994	67,710	38,323	105,183	16,792	264,002
Rural	5,483	9,823	5,963	18,834	3,048	43,151
Mangaung MM	93,046	172,001	119,336	338,032	49,326	771,741
Reporting Zones	**Pre School %**	**School Going %**	**Young Adult %**	**Working age %**	**Pensioners %**	**Total %**
South Eastern Quadrant	12%	22%	15%	45%	5%	100%
Bloemfontein Remaining	7%	16%	18%	48%	11%	100%
Botshabelo /Thaba Nchu	14%	26%	15%	40%	6%	100%
Rural	13%	23%	14%	44%	7%	100%
%	**12%**	**22%**	**15%**	**44%**	**6%**	**100%**

Diagram 5-3: Mangaung MM: Age Distribution, 2011

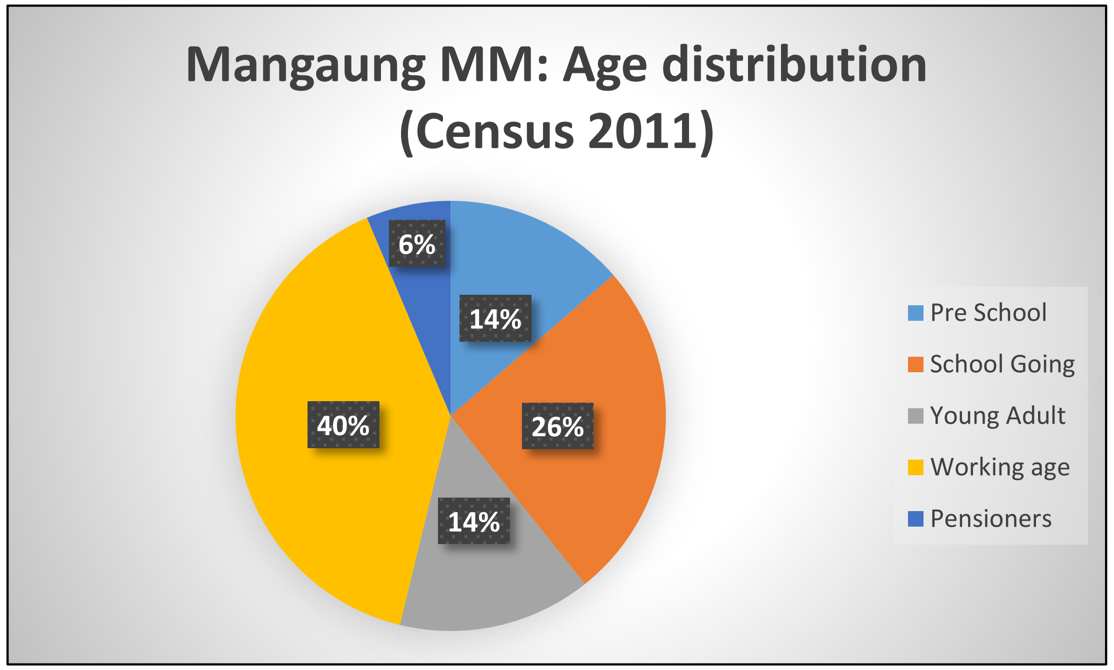


Table 5-3 to Table 5-5 reflect the people with categories of special needs which have a bearing on the provision of public transport in the Mangaung area:

- Persons with degrees of walking and climbing difficulties are reported to be in the order of 11 746 people (3% of the population).
- Persons with assistive devices and medication (e.g. walking stick/frame) equals 8324 people (2% of the population).
- Persons with assistive devices and medication (e.g. wheelchair) equals 5904 people (2% of the population).

- 44% of MMM population reside in the South Eastern Quadrant of Bloemfontein area,
- 34% of the population reside in Botshabelo and Thaba Nchu
- The remaining population resides in the remainder of settlements (Soutpan, Dewetsdorp, Wepener, Talla, Springfontein etc.) and agricultural holdings;
- 11% of the population have difficulty walking and climbing (including "other" category)

Table 5-3: Mangaung MM: Persons with Walking or Climbing Difficulties, Census 2011

Reporting Zones	No difficulty	Some difficulty	A lot of difficulty	Cannot do at all	Other	Total
South Eastern Quadrant	302,936	7,690	2,405	1,651	29,748	344,430
Bloemfontein Remaining	98,078	2,632	644	374	18,433	120,161
Botshabelo /Thaba Nchu	235,352	7,017	2,120	1,481	18,017	263,987
Rural	37,477	1,243	394	237	3,804	43,155
Mangaung MM	**673,843**	**18,582**	**5,563**	**3,743**	**70,002**	**771,733**
Reporting Zones	**No difficulty %**	**Some difficulty %**	**A lot of difficulty %**	**Cannot do at all %**	**Other %**	**Total %**
South Eastern Quadrant	88%	2%	1%	0%	9%	100%
Bloemfontein Remaining	82%	2%	1%	0%	15%	100%
Botshabelo /Thaba Nchu	89%	3%	1%	1%	7%	100%
Rural	87%	3%	1%	1%	9%	100%
Mangaung MM	**87%**	**2%**	**1%**	**0%**	**9%**	**100%**
Note: Other includes: Do not know, Undetermined, Unspecified, Not Applicable						

Table 5-4: Mangaung MM: Persons with Assistive Devices and Medication – Walking Stick or Frame, Census 2011

Reporting Zones	Yes	No	Other	Total
South Eastern Quadrant	8,324	317,637	18,468	344,429
Bloemfontein Remaining	4,317	98,183	17,664	120,164
Botshabelo /Thaba Nchu	7,786	248,977	7,228	263,991
Rural	1,683	38,992	2,474	43,149
Mangaung MM	**22,110**	**703,789**	**45,834**	**771,733**
Reporting Zones	**Yes %**	**No %**	**Other %**	**Total %**
South Eastern Quadrant	2%	92%	5%	100%
Bloemfontein Remaining	4%	82%	15%	100%
Botshabelo /Thaba Nchu	3%	94%	3%	100%
Rural	4%	90%	6%	100%
Mangaung MM	**3%**	**91%**	**6%**	**100%**

Note: Other includes: Do not know, Unspecified, Not Applicable

Table 5-5: Mangaung MM: Persons with Assistive Devices and Medication – Wheelchair, Census 2011

Reporting Zones	Yes	No	Other	Total
South Eastern Quadrant	5,904	319,073	19,450	344,427
Bloemfontein Remaining	3,177	99,274	17,708	120,159
Botshabelo /Thaba Nchu	4,313	252,218	7,463	263,994
Rural	1,002	39,643	2,509	43,154
Mangaung MM	**14,396**	**710,208**	**47,130**	**771,734**
Reporting Zones	**Yes %**	**No %**	**Other %**	**Total %**
South Eastern Quadrant	2%	93%	6%	100%
Bloemfontein Remaining	3%	83%	15%	100%
Botshabelo /Thaba Nchu	2%	96%	3%	100%
Rural	2%	92%	6%	100%
Mangaung MM	**2%**	**92%**	**6%**	**100%**

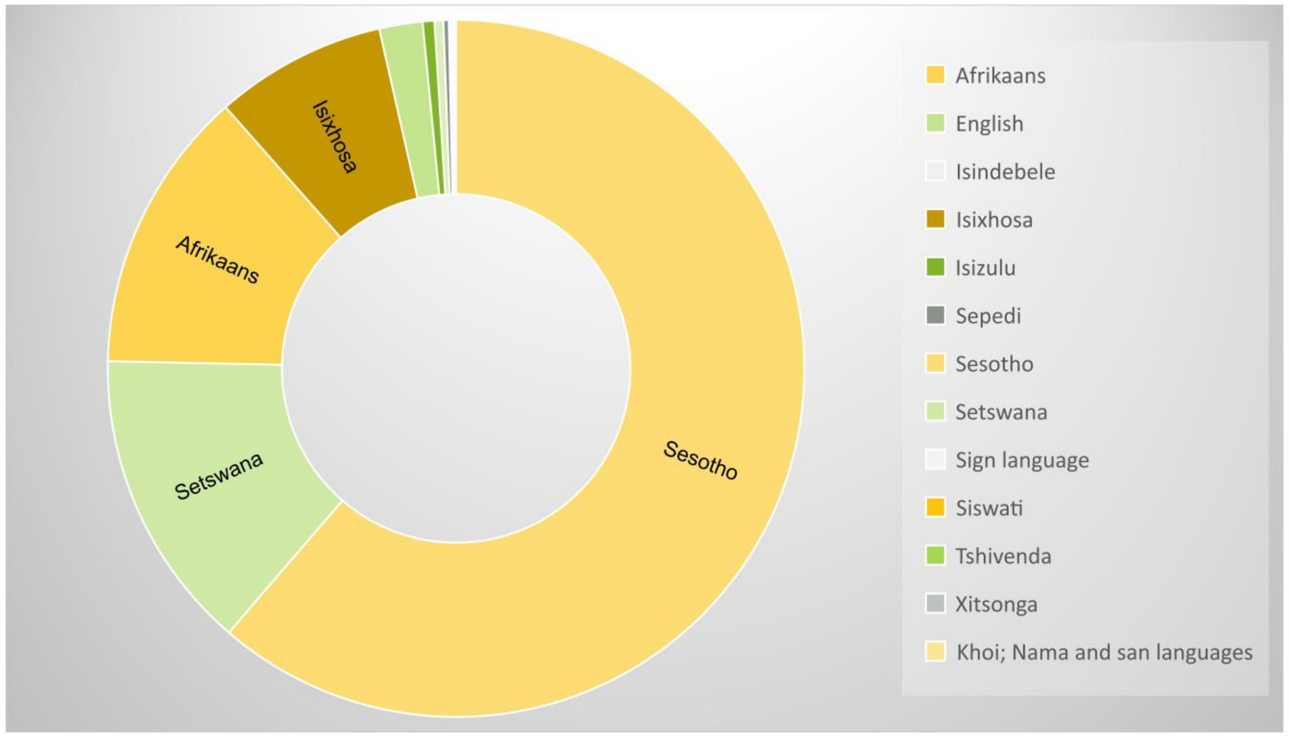
Note: Other includes: Do not know, Unspecified, Not Applicable

5.2 Community Survey 2016

The community survey of 2016 provided insight into passengers with special need and detail on language and other characteristics of the population of Mangaung that will use the IPTN system.

- Passenger with categories of special needs. The percentages for Mangaung per category reported are:
  - Persons with degrees of walking and climbing difficulties are reported to be 6% of the population.
  - Persons with a degree of difficulty seeing equals 2% of the population.
  - Persons with a degree of difficulty hearing equals 2% of the population
  - Persons with a degree of difficulty communication equals 2% of the population
  - Persons with a degree of difficulty Remembering/Concentrating equals 7% of the population
  - Persons with a degree of difficulty self-care equals 4% of population
- Main languages in Mangaung are presented in Diagram 5-4 below.

Diagram 5-4: Language Distribution in MMM



5.3 Population Density

Figure 5-1 depicts the number of people per traffic zone (regional scale). It is evident that a large number of people are located in the south-eastern quadrant of Mangaung, as well as in the Botshabelo and Thaba Nchu areas, but also in the rural areas north and south of Thaba Nchu.

- Highest density of population resides in southern quarter of Bloemfontein Area
- Social grants are the main source of income to a significant proportion of Botshabelo and Thaba Nchu residents

5.4 Population Employment Status and Income

Thee employment status per the Household Travel Survey 2016 is presented in Figure 5-2, the majority of people in the Botshabelo and Thaba Nchu area are unemployed, and their main source of income is from social grants (Refer to Figure 5-3). The IDP 2018/19 indicate that the unemployment rate in Botshabelo stands at 32.9 % which result in significant urban dependency on Bloemfontein. The population density

These areas are most like to be dependent on subsidised public transport and thus need detail attention when the IPTN is planned and design. The system design needs to acknowledge the characteristics of these areas when determining the service type and fare structure.

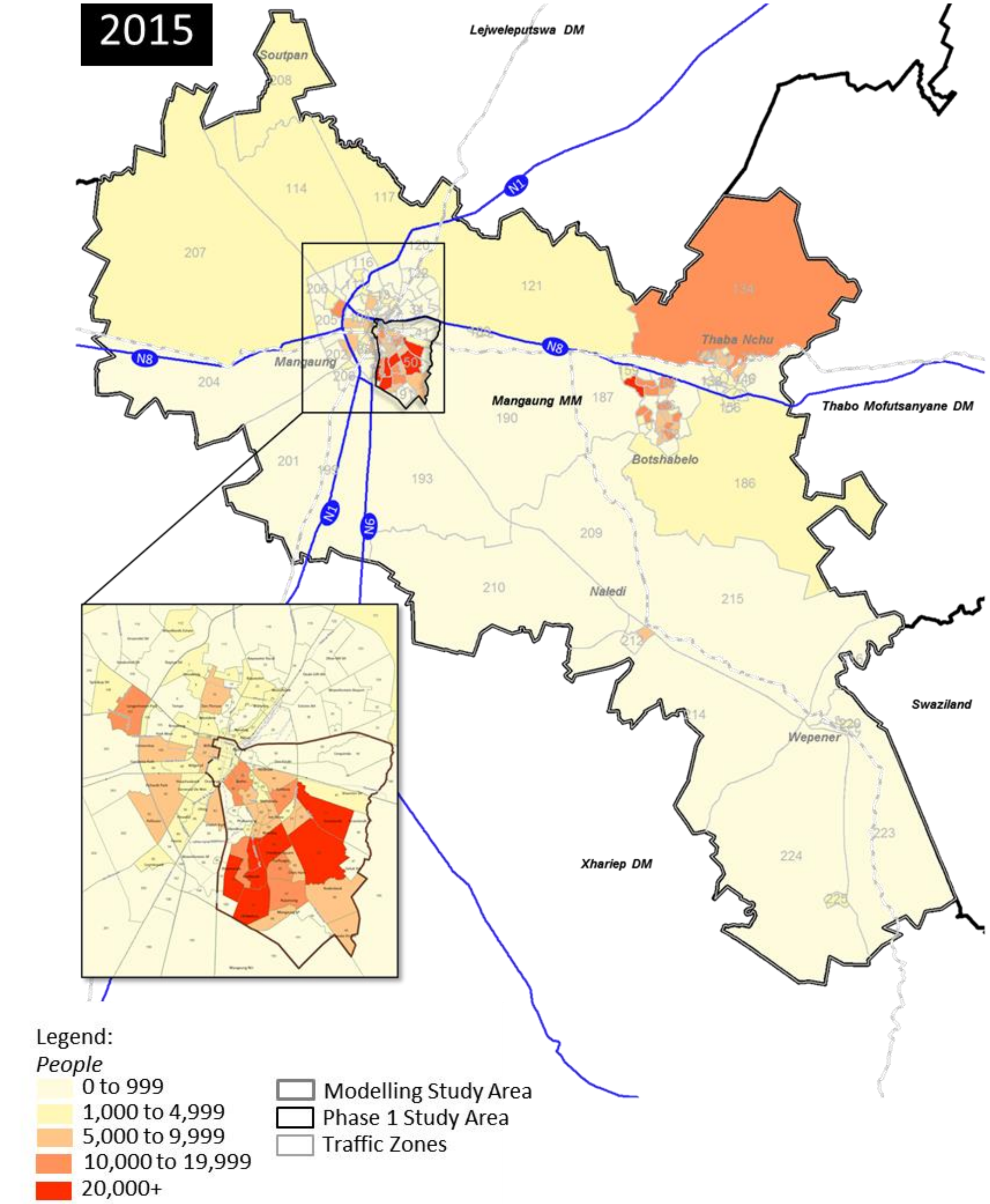


Figure 5-1: Mangaung MM Study Area – Population per Traffic Zone, 2015 and 2036

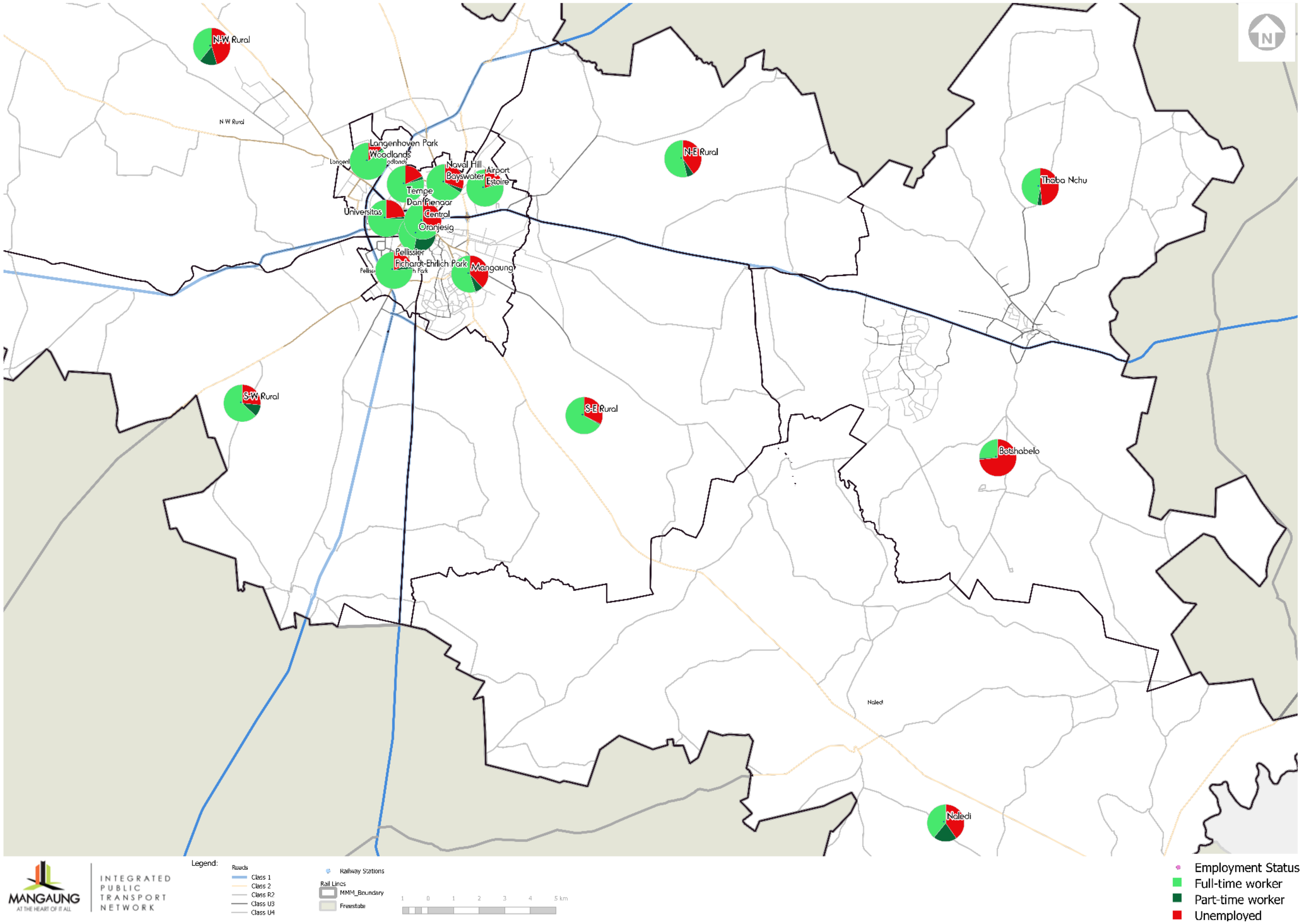


Figure 5-2: Employment Status (MMM HHTS 2016)

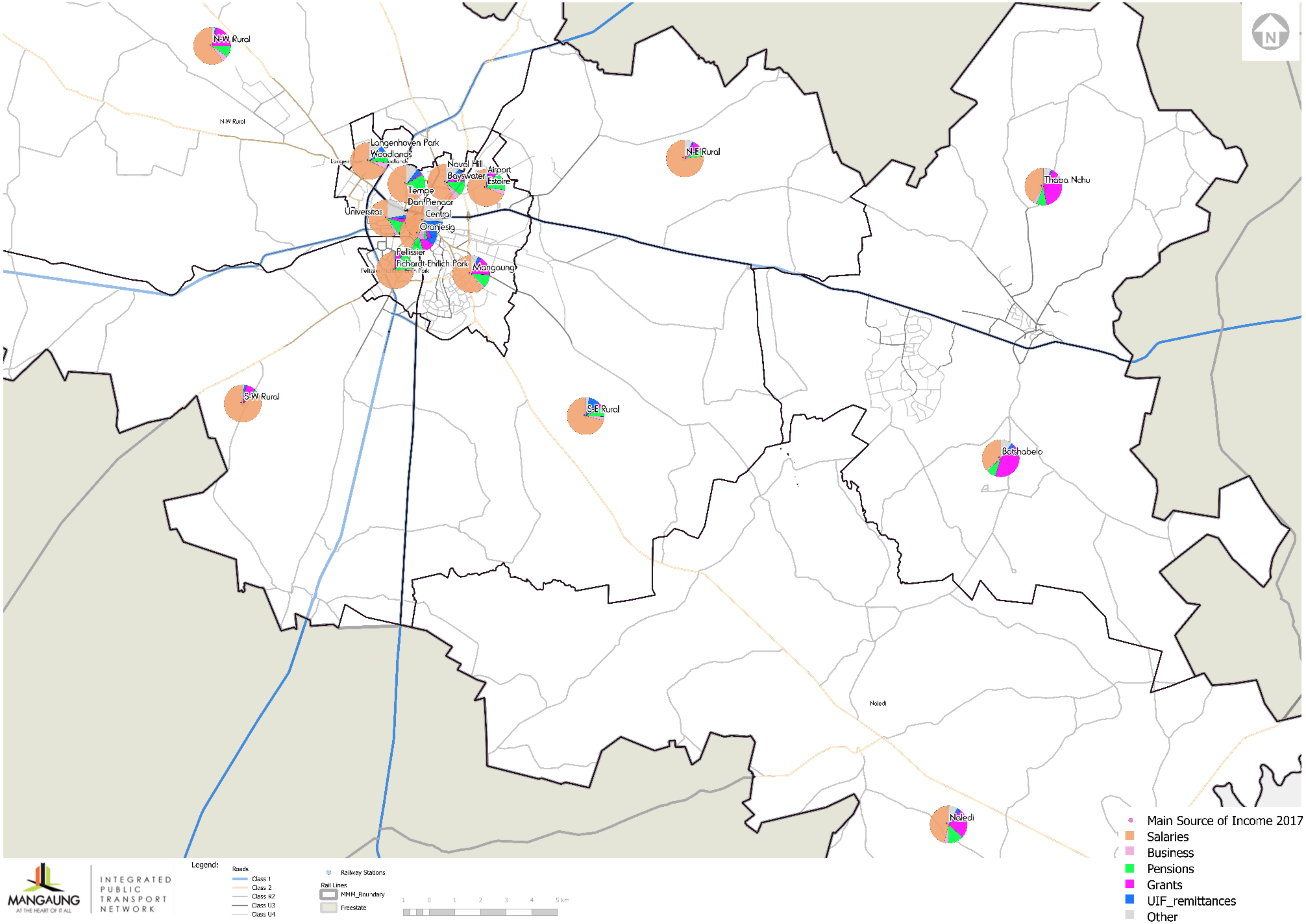


Figure 5-3: Main Source of Income (MMM HHTS 2016)

5.5 Public Transport User – Mode Choice

5.5.1 Mode of travel

Table 5-6 lists the mode combinations of all trips. Transfers were made in less than one percent of trips. Unfortunately, the walks sections too, between and after motorised trips were not consistently recorded and are therefore omitted from the mode combination list.

Table 5-6: Mode combinations

Mode combination	% of all trips
Walk all the way	22.6
Minibus-taxi	39.6
Bus	4.5
School bus	5.6
Company transport	1.1
Car driver	15.3
Car passenger	7.5
Lift club	2.8
Taxi-Taxi	0.1
Taxi-Bus	0.0
Bus-taxi	0.0
Bus-Bus	0.0
Other	0.9

Table 5-7 provides information at zone level about the main mode of transport of all trips. Minibus taxi is the mode used most often for trips in the Mangaung Municipality, followed by car and walking trips. Only ten percent of the trips in the municipality is made by bus. The highest bus usage is by people living in Botshabelo, the highest taxi usage for people living in Mangaung and Thaba Nchu and the highest car usage by people living in Oranjesig, Tempe/Dan Pienaar and Pellissier/Fichardt-Ehrlich Park. Naledi residents make the biggest proportion of walking trips per zone.

Figure 5-4 provides a picture of the breakdown between trips made by public transport, private transport, and walking all the way. About half of all trips made by residents of the Mangaung Municipality are made by public transport, twenty-seven per cent by all the private transport modes combined, and 23 percent by walking.

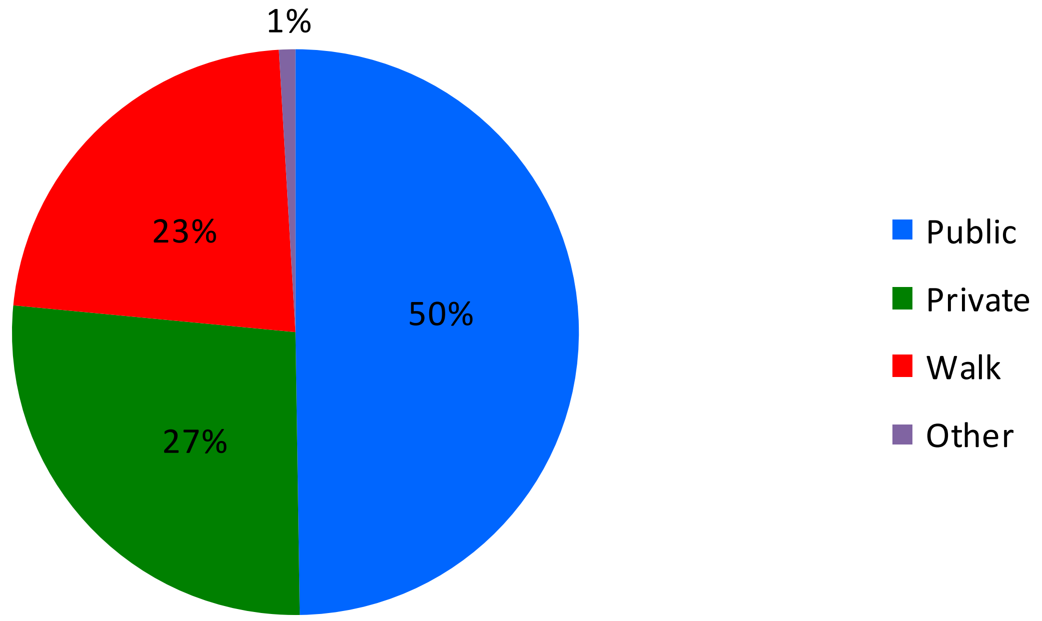


Figure 5-4: Mode of transport in the Mangaung Municipality – all trips

Table 5-7 provides information at zone level about the main mode of transport of all trips. Minibus taxi is the mode used most often for trips in the Mangaung Municipality, followed by car and walking trips.

Only ten percent of the trips in the municipality is made by bus. The highest bus usage is by people living in Botshabelo, the highest taxi usage for people living in Mangaung and Thaba Nchu and the highest car usage by people living in Oranjesig, Tempe/Dan Pienaar and Pellissier/Fichardt-Ehrlich Park. Naledi residents make the biggest proportion of walking trips per zone.

Table 5-7: Main mode of transport – all trips

Reporting Zone	Bus	Taxi	Company transport	Lift Club	Car	Walk all the way	Other
Central	5.6%	21.5%	0.0%	0.6%	29.0%	42.1%	1.2%
Oranjesig	1.0%	7.5%	0.0%	1.8%	73.6%	16.1%	0.0%
Mangaung	6.8%	54.7%	0.7%	4.3%	14.1%	18.6%	0.7%
Airport/Estoire	9.8%	19.2%	2.3%	1.8%	64.0%	2.5%	0.3%
Naval Hill/Bayswater	1.7%	13.9%	1.4%	2.6%	54.9%	25.0%	0.5%
Tempe/Dan Pienaar	6.3%	5.7%	1.5%	0.9%	78.0%	7.0%	0.6%
Langenhoven Park/Woodlands	12.7%	8.7%	0.5%	1.5%	71.1%	3.9%	1.6%
Universitas	3.6%	18.4%	0.2%	0.0%	50.4%	26.6%	0.7%
Pellissier/Fichardt-Ehrlich Park	3.5%	8.9%	0.8%	2.0%	71.9%	10.8%	2.1%
Thaba Nchu	14.7%	60.0%	0.4%	3.7%	8.0%	12.8%	0.3%
Botshabelo	19.1%	35.9%	1.9%	1.6%	9.0%	31.6%	0.9%
N-E Rural	1.2%	23.0%	3.6%	3.6%	37.4%	30.1%	1.0%
N-W Rural	7.2%	29.1%	2.7%	0.8%	26.7%	33.5%	0.0%
S-W Rural	2.5%	22.2%	0.6%	4.2%	52.4%	17.0%	1.1%
S-E Rural	9.0%	28.3%	0.0%	1.7%	39.5%	18.0%	3.5%
Naledi	5.9%	19.3%	0.6%	0.8%	17.7%	52.4%	3.3%
Mangaung Municipality	**10.1%**	**39.6%**	**1.1%**	**2.8%**	**22.8%**	**22.6%**	**0.9%**

5.5.2 Work Trips

5.5.2.1 Main mode of trips to work

Figure 5-5 portrays the split between public, private and walk for walk trips. Almost half of the work trips are made by public transport and only 13 percent on foot.

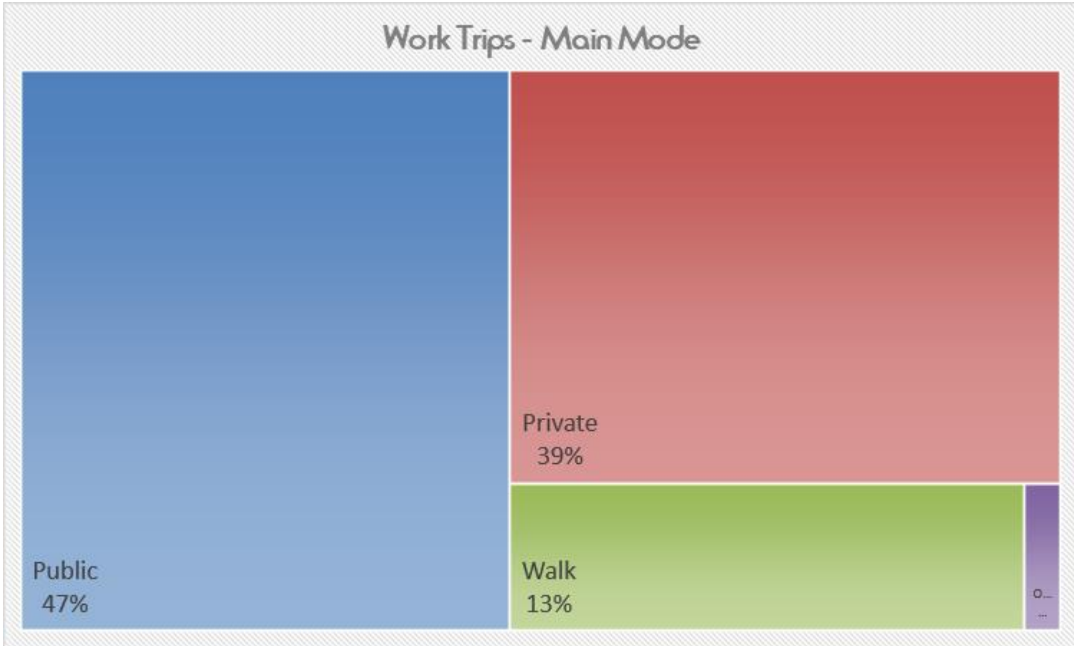


Figure 5-5: Mode of transport in Mangaung Municipality – work trips

Table 5-8 provides information about the main mode of work-related trips. In the case of work trips, the proportion of taxi and car trips are almost equal, and a smaller proportion of trips on foot. Car trips dominate in the central areas and the southern rural areas but are over 25 percent in all zones except for Thaba Nchu and Botshabelo where the proportion of car trips is below ten per cent. Taxi trips dominate in Mangaung, Thaba Nchu and Botshabelo. In the latter two areas, high proportions of work trips by bus were made. In Naledi and the N-W rural zone, walk trips dominate and in the N-E rural zone, the work trips are almost equally spread between taxi, car and walk trips.

Table 5-8: Main mode of work trips

Reporting Zone	Bus	Taxi	Company transport	Lift Club	Car	Walk all the way	Other
Central	5.6%	21.5%	0.0%	0.6%	29.0%	42.1%	1.2%
Oranjesig	1.0%	7.5%	0.0%	1.8%	73.6%	16.1%	0.0%
Mangaung	6.8%	54.7%	0.7%	4.3%	14.1%	18.6%	0.7%
Airport/Estoire	9.8%	19.2%	2.3%	1.8%	64.0%	2.5%	0.3%
Naval Hill/Bayswater	1.7%	13.9%	1.4%	2.6%	54.9%	25.0%	0.5%
Tempe/Dan Pienaar	6.3%	5.7%	1.5%	0.9%	78.0%	7.0%	0.6%
Langenhoven Park/Woodlands	12.7%	8.7%	0.5%	1.5%	71.1%	3.9%	1.6%
Universitas	3.6%	18.4%	0.2%	0.0%	50.4%	26.6%	0.7%
Pellissier/Fichardt-Ehrlich Park	3.5%	8.9%	0.8%	2.0%	71.9%	10.8%	2.1%
Thaba Nchu	14.7%	60.0%	0.4%	3.7%	8.0%	12.8%	0.3%
Botshabelo	19.1%	35.9%	1.9%	1.6%	9.0%	31.6%	0.9%
N-E Rural	1.2%	23.0%	3.6%	3.6%	37.4%	30.1%	1.0%
N-W Rural	7.2%	29.1%	2.7%	0.8%	26.7%	33.5%	0.0%
S-W Rural	2.5%	22.2%	0.6%	4.2%	52.4%	17.0%	1.1%
S-E Rural	9.0%	28.3%	0.0%	1.7%	39.5%	18.0%	3.5%
Naledi	5.9%	19.3%	0.6%	0.8%	17.7%	52.4%	3.3%
Mangaung Municipality	10.1%	39.6%	1.1%	2.8%	22.8%	22.6%	0.9%

5.5.2.2 Travel Time to Work per Mode

Figure 5-6 displays the mean travel times (minutes) of work trips by zone, and it clearly shows where the longer than average and shorter than average travelling times are. The mean travel time for all work trips starting in the municipality is 38 minutes.

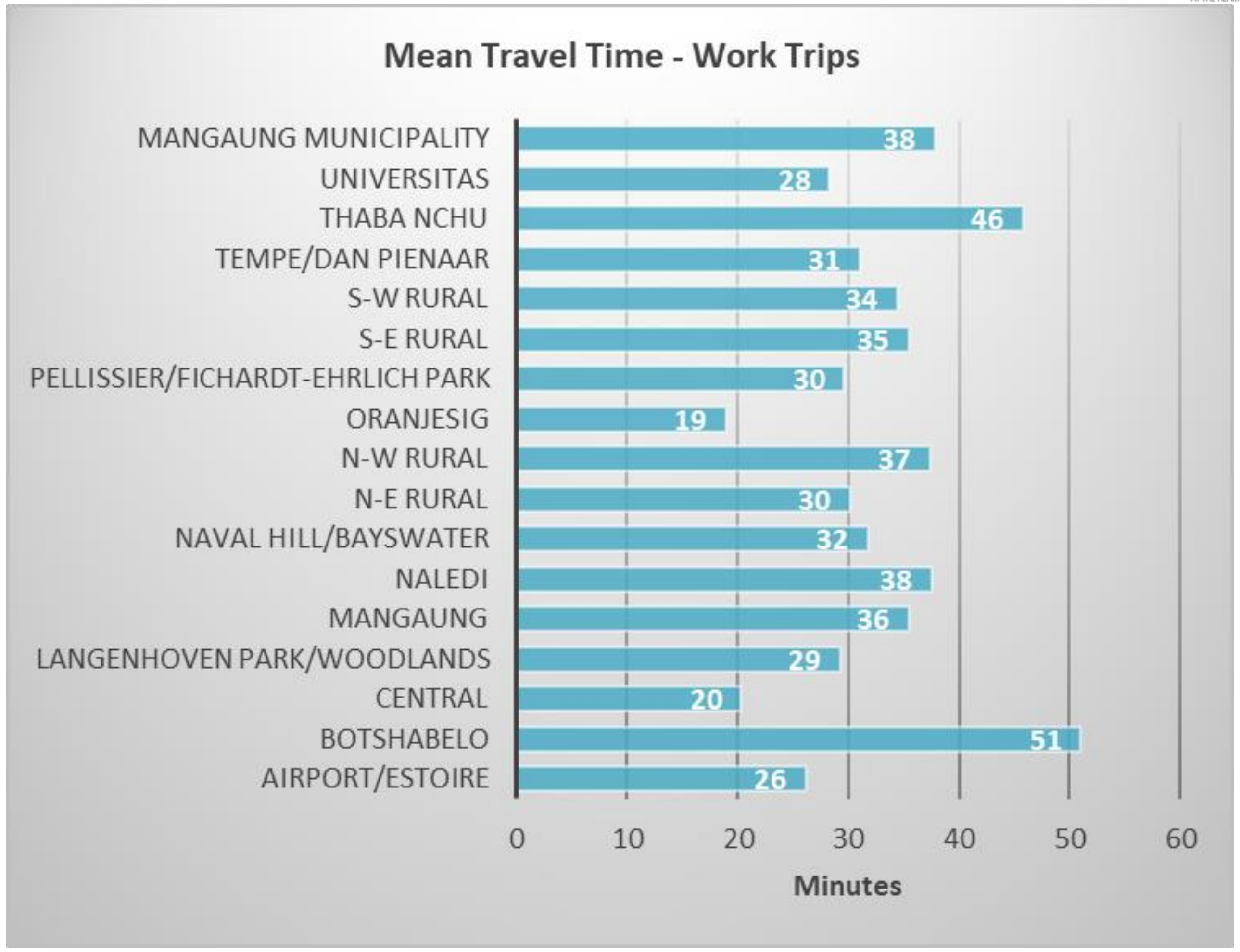


Figure 5-6: Mean travel time (minutes) by zone – work trips

Table 5-9 provides information about the travel time to work by the main modes. Not surprisingly, more than 40 per cent of work trips on foot takes 15 minutes or less. On the other hand, more or less the same proportion of work trips takes longer than an hour.

Table 5-9: Travel time to work by main mode

	Percentage of work trips				
Main mode	5 - 15 mins	16 - 30 mins	31-45 mins	46 - 60 mins	61 mins+
Bus	0.8%	11.4%	16.0%	26.3%	45.5%
Taxi	4.5%	37.9%	24.0%	22.9%	10.8%
Company transport	9.8%	27.9%	25.4%	31.5%	5.4%
Lift Club	7.9%	44.8%	27.7%	14.6%	5.0%
Car	19.8%	51.1%	10.9%	14.7%	3.5%
Walk all the way	42.2%	37.9%	8.3%	5.7%	5.8%
Other	7.3%	82.0%	10.6%	0.0%	0.0%

Figure 5-7 shows the mean travel times for work trips by different modes, ranging from 22 minutes for work trips on foot to 62 minutes for work trips by bus.

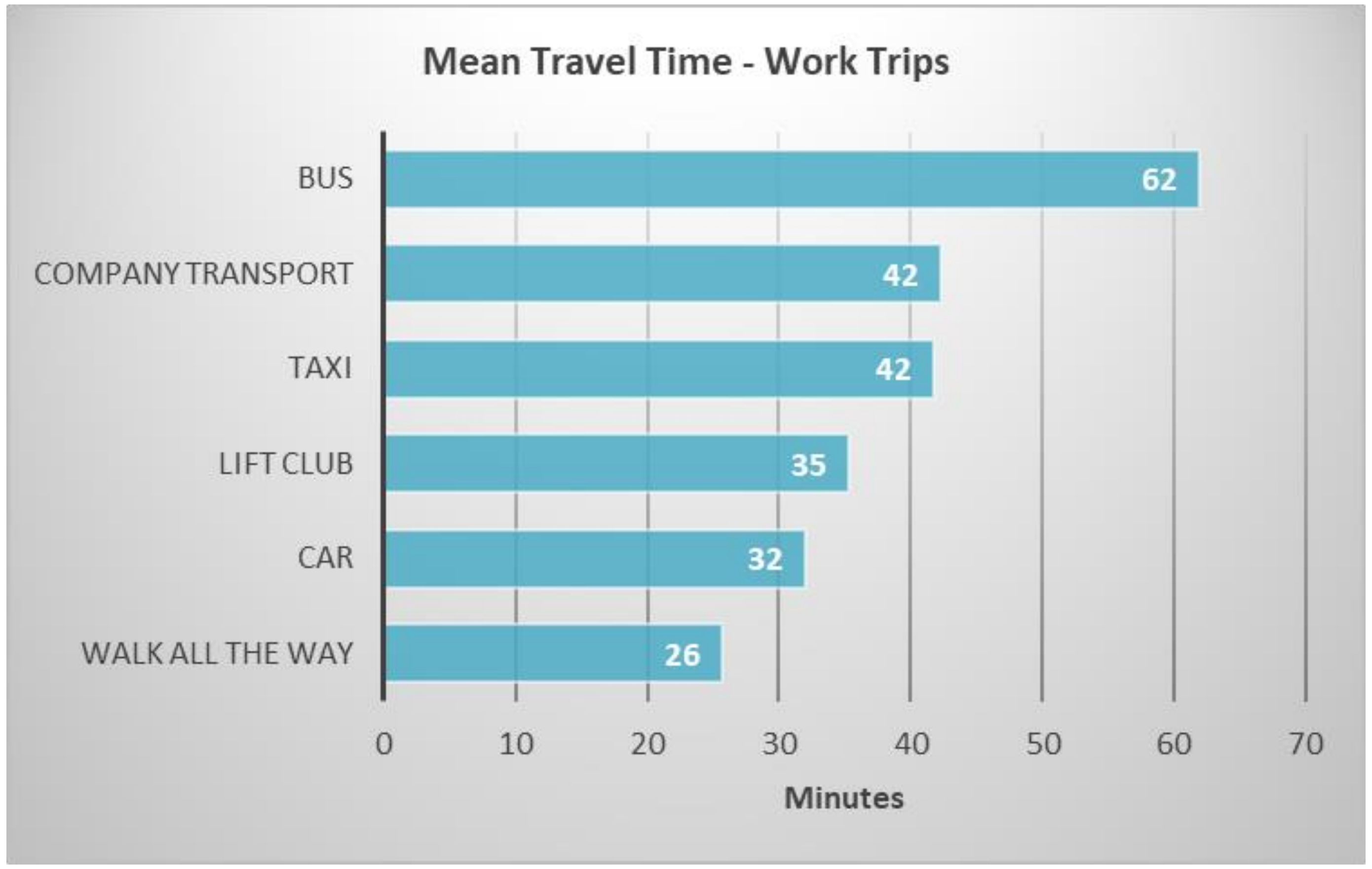


Figure 5-7: Mean travel time (minutes) by main mode – work trips

5.5.2.3 Work trip destinations.

Table 5-10 shows that 45 percent of work trips have destinations within the same reporting zone and 55 percent in a different zone. In most zones, the minority of work trips are made to destinations within the same zone. Thaba Nchu, North West Rural and Naledi, where 85 percent of work trips are made internally, are exceptions to this rule.

Table 5-10: Destination type for work trips

Reporting Zone	Internal	External
Central	28.4%	71.6%
Oranjesig	26.6%	73.4%
Mangaung	40.8%	59.2%
Airport/Estoire	38.3%	61.7%
Naval Hill/Bayswater	13.8%	86.2%
Tempe/Dan Pienaar	50.2%	49.8%
Langenhoven Park/Woodlands	16.1%	83.9%
Universitas	19.2%	80.8%
Pellissier/Fichardt-Ehrlich Park	14.4%	85.6%
Thaba Nchu	62.5%	37.5%
Botshabelo	52.3%	47.7%
N-E Rural	55.5%	44.5%
N-W Rural	71.9%	28.1%
S-W Rural	40.4%	59.6%
S-E Rural	3.0%	97.0%
Naledi	85.2%	14.8%
Mangaung Municipality	**45.4%**	**54.6%**

47% of work trips made by public transport
Thaba Nchu:

- 81% of work trips made by public transport
- 37% of work trips end at destinations external to Thaba Nchu
- 40% of all work trips mean travel time is +45 minutes

Botshabelo:

- 72% work trips made by public transport
- 48% of work trips end at destinations external to Botshabelo
- 40% of all work trips mean travel time is + 45 minutes

Bloemfontein:

- 63% work trips made by public transport
- 59% of trips end in destinations external to Mangaung
- 22% of work trips - mean travel time is + 45 minutes

5.5.3 Trip to Education Institutions

5.5.3.1 Main Mode to Education

Table 5-11 provides information about the modes used for trips to educational institutions. Overall, 38 percent of these trips were made on foot, and in Naledi, as many as 74 percent. Taxis account for 30 percent of trips to education and in Thaba Nchu for almost half. School buses play an important role in scholar transport in the Mangaung Municipality, providing transport for 16 percent of trips in the survey area, and in the Airport/Estoire area for 40 percent of the trips. Car is significant in the central, higher car-owning zones, but also, and especially in the N-E rural zone. Lift clubs feature quite prominently in Thaba Nchu and the N-E Rural zone.

Table 5-11: Main mode to educational institutions

Reporting Zone	School bus	Bus	Taxi	Lift Club	Car	Walk all the way	Other
Central	10.3%		29.3%	1.4%	9.1%	46.9%	3.0%
Oranjesig	3.6%		11.8%	6.7%	36.4%	41.6%	
Mangaung	15.1%	1.0%	39.4%	9.4%	5.9%	29.1%	
Airport/Estoire	40.0%		9.7%	8.5%	41.7%		
Naval Hill/Bayswater	5.2%		16.6%	8.9%	37.6%	31.8%	
Tempe/Dan Pienaar	24.0%		14.9%	4.1%	42.4%	11.8%	2.7%
Langenhoven Park/Woodlands	33.3%	0.8%	9.1%	3.5%	52.4%	0.9%	
Universitas	6.9%	2.3%	26.5%		18.0%	46.3%	
Pellissier/Fichardt-Ehrlich Park	13.6%	1.1%	9.4%	2.2%	40.6%	30.3%	2.7%
Thaba Nchu	9.0%	10.5%	47.0%	16.3%		17.2%	
Botshabelo	17.4%	3.8%	23.9%	1.0%	1.6%	52.2%	
N-E Rural	7.9%	11.0%		17.0%	64.1%		
N-W Rural	21.5%		26.3%	3.6%	1.8%	46.7%	
S-W Rural	10.8%		18.9%	8.1%	29.7%	32.5%	
S-E Rural	23.1%	2.3%	22.1%	4.9%	26.8%	20.8%	
Naledi	16.8%	1.6%	5.5%		1.9%	74.2%	
Mangaung Municipality	**16.0%**	**2.5%**	**29.5%**	**5.7%**	**8.6%**	**37.5%**	**0.1%**

Figure 5-8 shows the split between trips made by public and private transport and on foot. Private transport plays a relatively small role in travel for educational purposes.

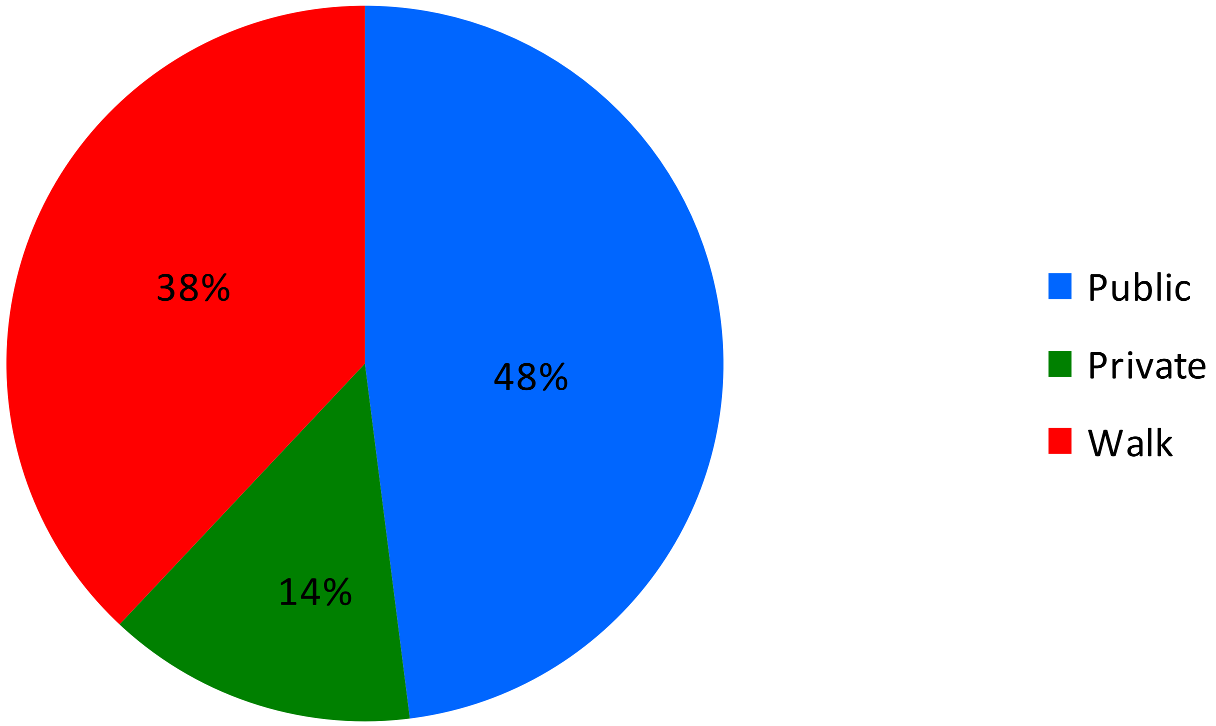


Figure 5-8: Mode of transport to education in Mangaung Municipality

Figure 5-9 displays the mean travel time in different zones. The times range between a short of 18 minutes in the Central zone and a long of 49 minutes in Naledi, with the mean travel time for the municipality at 32 minutes.

- **37,5% of education** trips are **walk all the way** trips; and
- 54% education trips are by public transport, school bus or lift clubs.

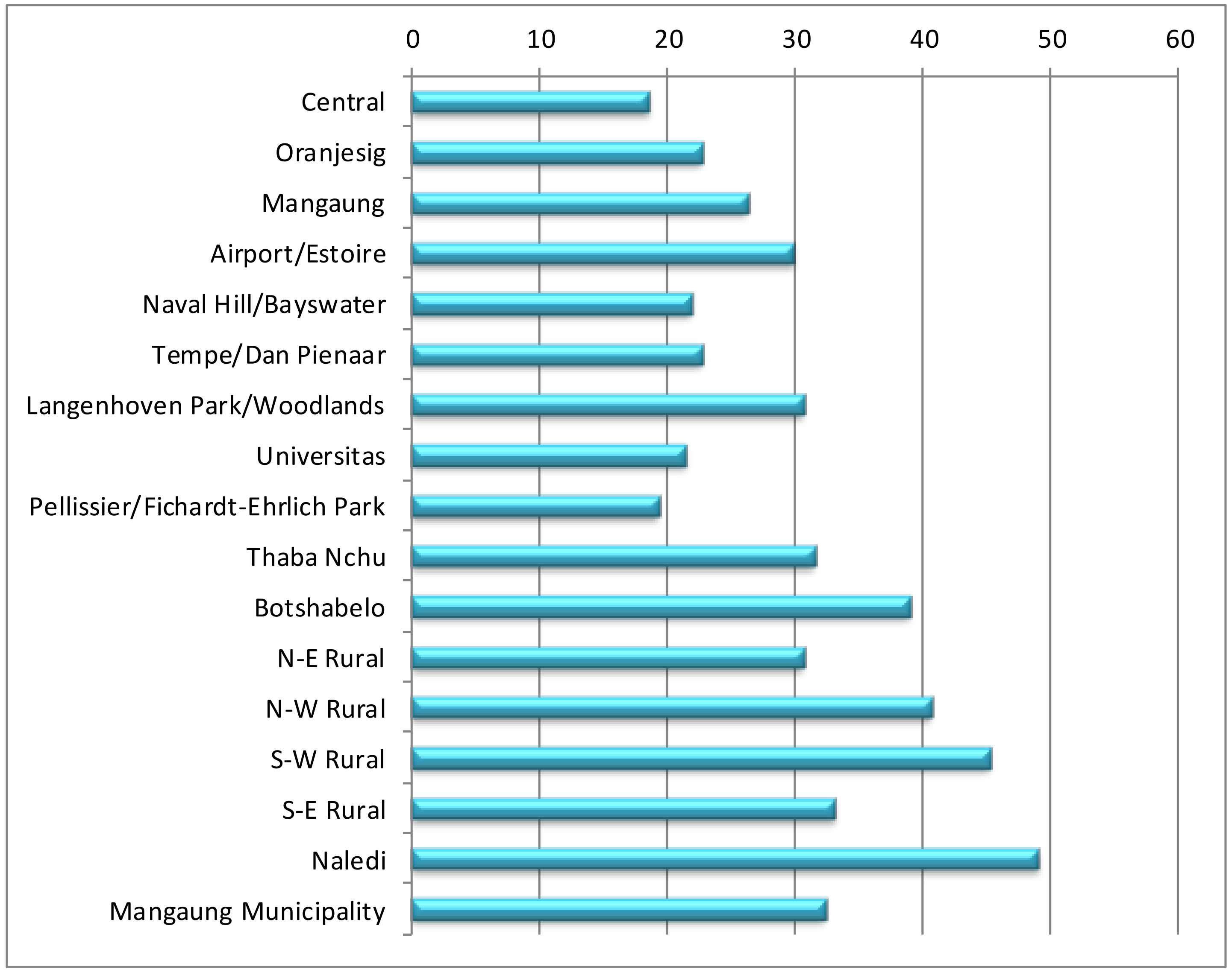


Figure 5-9: Mean travel time(minutes) to education

6 Public Transport Services

Public transport is provided by several operators and include:

- Midi-bus services
- Subsidised bus services
- Metered taxi services
- Long-distance commuter rail services.

6.1 Midi-bus Services and Operators

6.1.1 Routes and Services

Three associations provide taxi services:

- Greater Bloemfontein Taxi Association (GBTA). Operating in Bloemfontein CBD, - suburbs and Mangaung;
- Thaba Nchu Long and Short Distance Taxi Association (THALSTA). Operating in Thaba Nchu, to Bloemfontein CBD, Botshabelo and several long-distance routes to neighbouring towns;
- Botshabelo Amalgamated Taxi Association (BATA). Operating in Botshabelo, to Bloemfontein CBD, Thaba Nchu and several long-distance routes to neighbouring towns.

Each of the associations have several routes registered to members and these routes based on the Operating Licenses are provided within specific suburbs or services areas. The service areas per association are presented in Figure 6-1 and respectively.

The detail of the facility types per association is presented in Table 6-1.

Table 6-1: Number of Formal and Informal Public Transport Facilities per Mode

Urban Node	Mode	Formal	Informal	Total
Bloemfontein	Minibus-Taxi	4	12	16
Thaba Nchu	Minibus-Taxi	1	2	3
Botshabelo	Minibus-Taxi	2	2	4

The institutional structure and ownership within the minibus-taxi industry in Bloemfontein, Botshabelo and Thaba Nchu is also formalised, with three taxi associations established that provide paratransit commuter services in Mangaung, namely (Refer to Table 6-2):

- Greater Bloemfontein Taxi Association (GBTA)
- Thaba Nchu Long and Short Distance Taxi Association (THALSDTA)
- Botshabelo Amalgamated Taxi Association (BATA)

Table 6-2: Mangaung Metropolitan Municipality Mini-bus Taxi Association Information

Operator	Members	Routes	Vehicles
Greater Bloemfontein Taxi Association	2 331	95	2 609
Thaba Nchu Long and Short Distance Taxi Association	318	26	374
Botshabelo Amalgamated Taxi Association	*	80	*

*Note: * denotes that no member or vehicle information was provided for Botshabelo Amalgamated Taxi Association*

6.1.2 Operational Hours

Taxi services are operated throughout the day with higher frequency services during the peak hours of the day. The on-board surveys of the selected taxis in the Bloemfontein area yield the following on operational hours:

- CBD services – 05:00 – 18:00
- Northern suburbs and Universitas – 05:00-19:00
- Hyperama Area – 05:30 – 19:30
- Turflaagte, Freedom Square – 06:00 – 19:30
- Mafora, Rocklands areas – 06:00 – 19:30.

Taxi services are provided throughout the city between 05:00 and 19:30 during weekdays and weekends. The frequency of service varies and is a direct response to demand along a specific route or at a rank.

6.1.3 Passenger Waiting Time

The detailed analysis and data methodology to obtain the average passenger waiting times at selected ranks in the Bloemfontein, Botshabelo and Thaba Nchu areas are presented in the Transport register (Volume 1 of the IPTN Plan). The positions of the ranks in the Bloemfontein area are presented in Figure 6-8.

To determine the waiting time of passengers the total passenger waiting time was used and comprise of the waiting time at the rank for a vehicle to arrive plus the time spend waiting in the vehicle till departure was analysed. The average waiting times were recorded for a week (7days) and are presented in:

- Figure 6-2 for Botshabelo Blue rank and the result of the analysis per day and peak period is:
  - Weekday AM Peak Period – Average waiting time 15 – 30 Minutes;
  - Weekday PM Peak Period – Average waiting time 7 – 11 Minutes;
  - Weekend – Average waiting time 8 – 26 Minutes.
- Figure 6-3 - Industrial rank and the result of the analysis per day and peak period is:
  - Weekday AM Peak Period – Average waiting time 21 – 50 Minutes;
  - Weekday PM Peak Period – Average waiting time 7 – 11 Minutes;
  - Weekend – Not surveyed.
- Figure 6-4 - Thaba Nchu 4+1_SB rank and the result of the analysis per day and peak period is:
  - Weekday AM- and PM Peak Period – Average waiting time 4 – 6 Minutes;
  - Weekend – Average waiting time 4 – 14 Minutes.
- Figure 6-5 - Thaba Nchu 4+1_JB rank and the result of the analysis per day and peak period is:
  - Weekday AM Peak Period – Average waiting time 8 – 10 Minutes;
  - Weekday PM Peak Period – Average waiting time 3 – 7 Minutes;
  - Weekend AM peak Period – Average waiting time 5 – 14 Minutes.
- Figure 6-6 – Bloemfontein Bastion Square rank and the result of the analysis per day and peak period is:
  - Weekday AM Peak Period – Average waiting time 15 – 30 Minutes;
  - Weekday PM Peak Period – Average waiting time 13 – 19 Minutes;
  - Weekend AM peak Period – Average waiting time 10 – 18 Minutes.
- Figure 6-7 – Bloemfontein Mafora Central rank and the result of the analysis per day and peak period is:
  - Weekday AM Peak Period – Average waiting time 21 – 50 Minutes;
  - Weekday PM Peak Period – Average waiting time 7 – 11 Minutes.

- Taxi services run from 05:00 – 19:30,
- The average waiting time of a passenger **at ranks** during the morning peak period vary between 10–20 minutes; and during the PM peak period between 4–6 minutes.

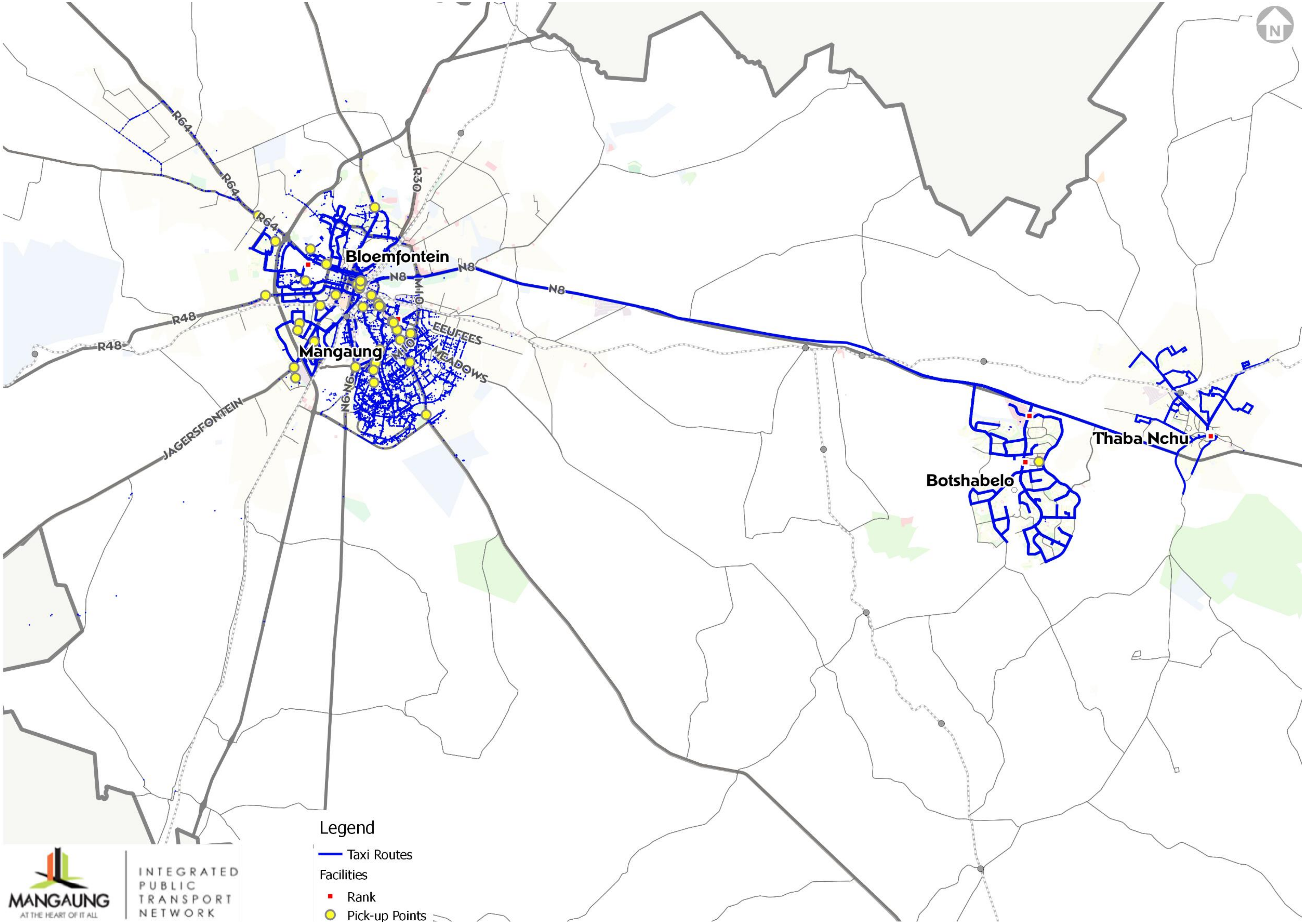


Figure 6-1: Midi-bus Taxi Services Areas/Routes

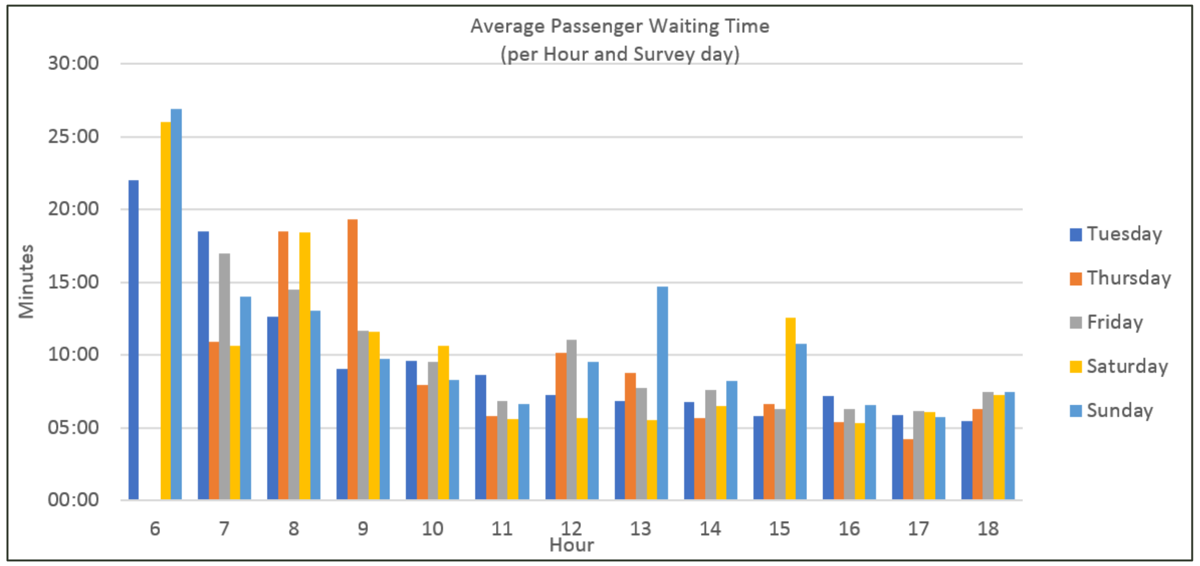


Figure 6-2: Average Passenger Waiting Time at the Botshabelo Blue Rank

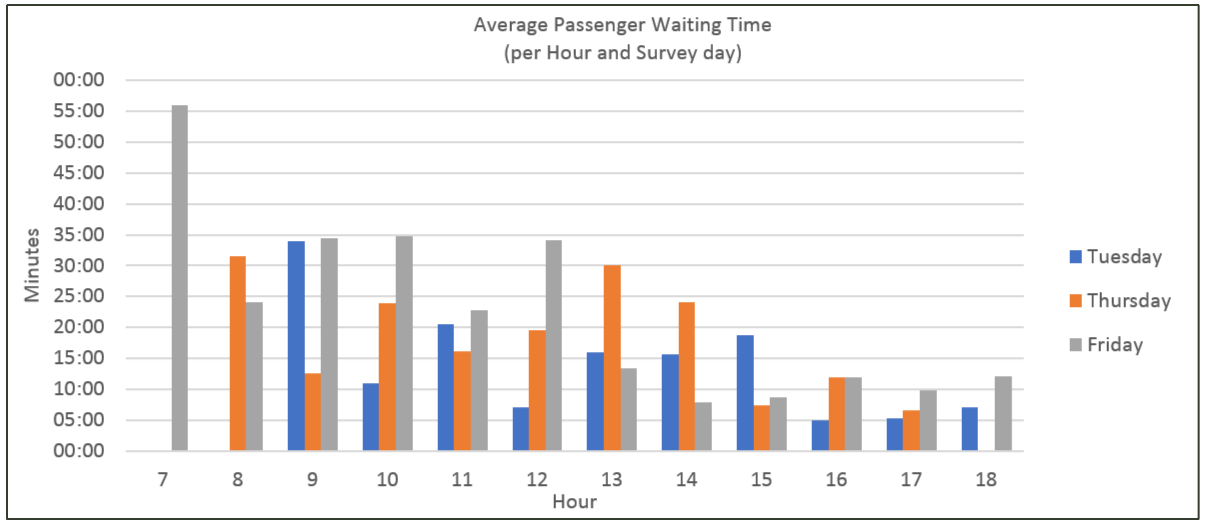


Figure 6-3: Average Passenger Waiting Time at the Industrial Rank

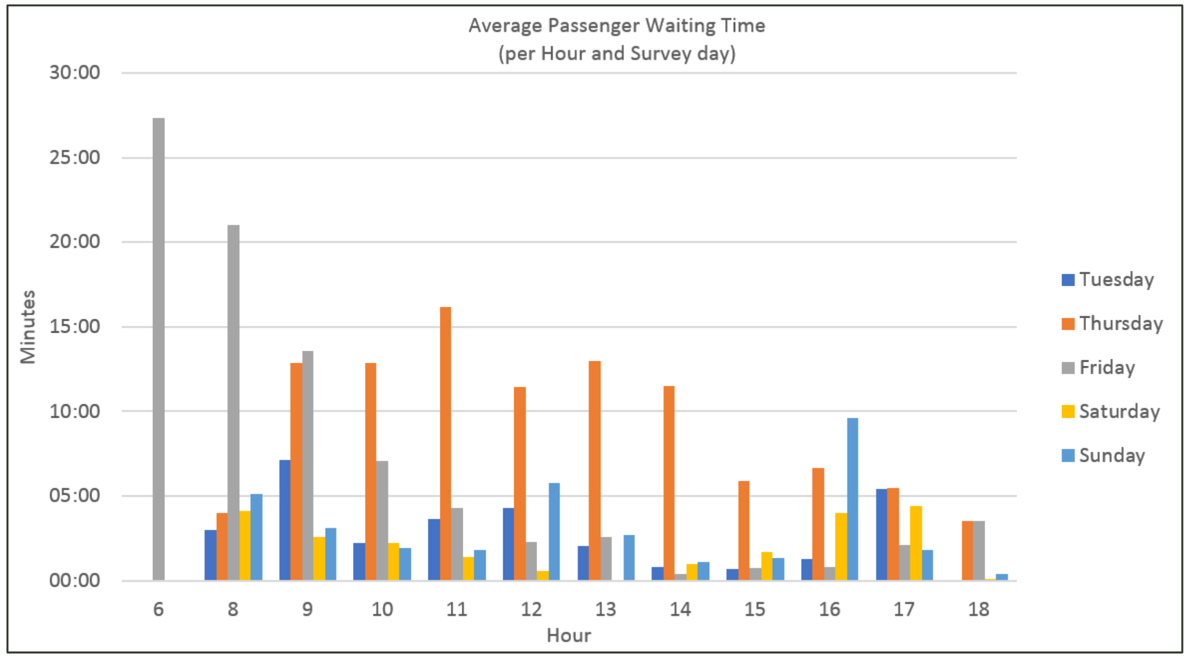


Figure 6-4: Average Passenger Waiting Time at the Thaba Nchu 4+1_SB Rank

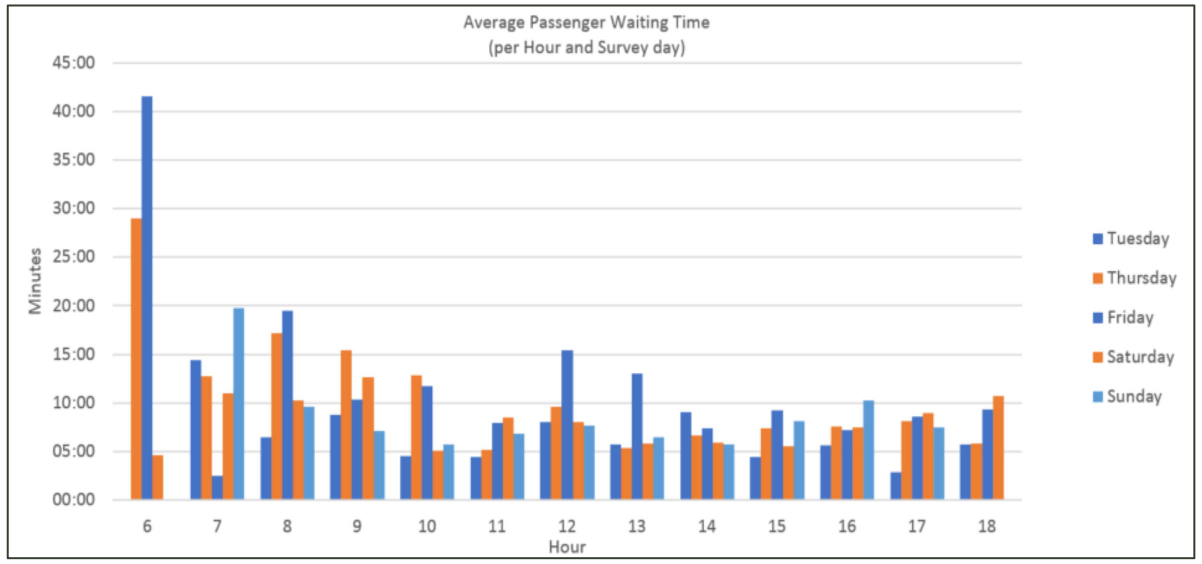


Figure 6-5: Average Passenger Waiting Time at the Thaba Nchu 4+1_JB Rank

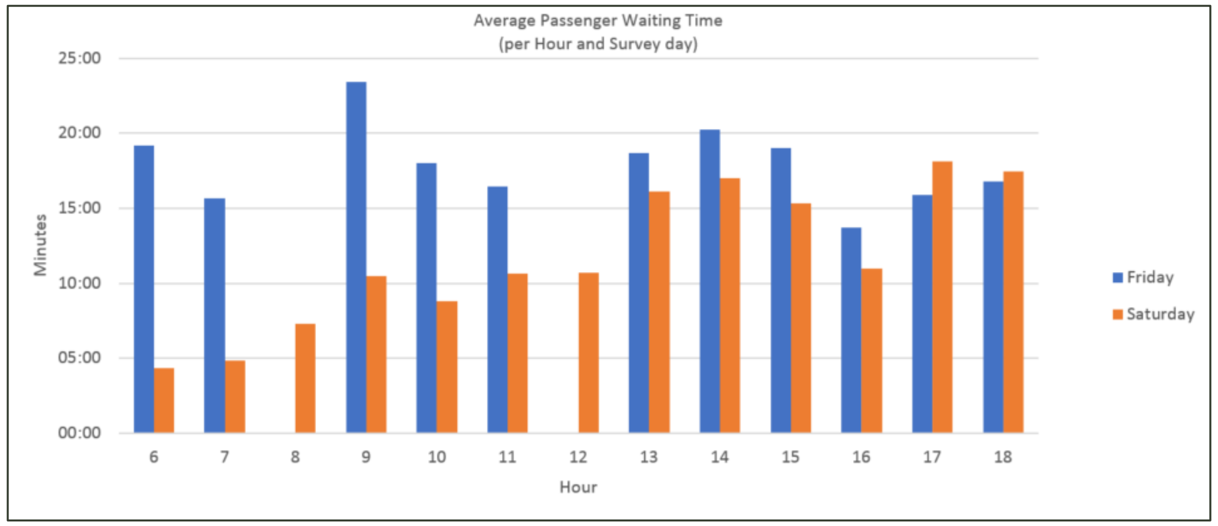


Figure 6-6: Average Passenger Waiting Time at the BSQ Rank

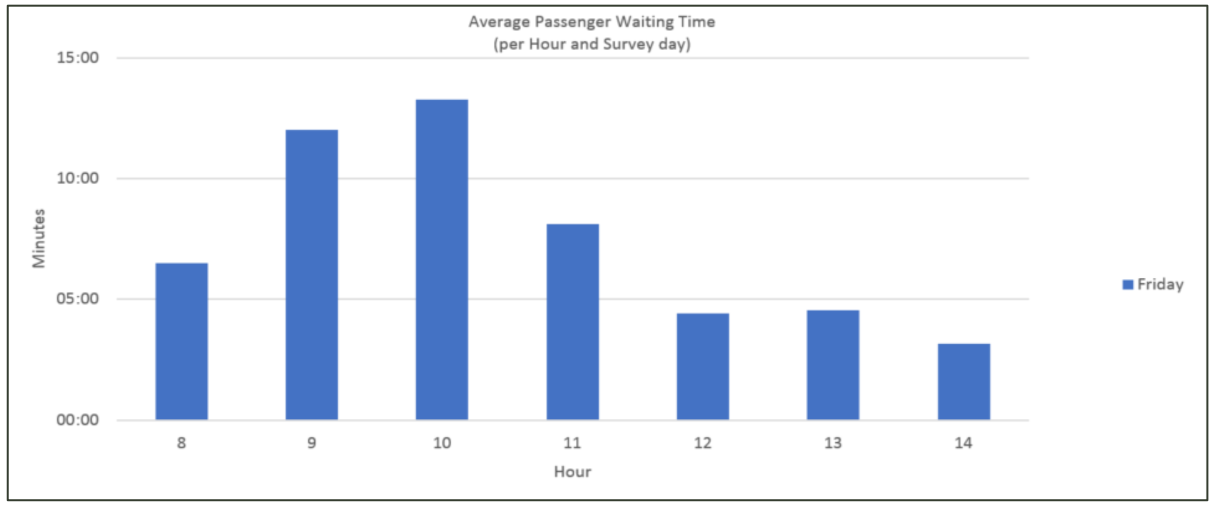


Figure 6-7: Average Passenger Waiting Time at the Mafora Central Rank

Figure 6-8: Bloemfontein Ranks and Pick-up Points

6.1.4 Taxi Onboard Surveys

The taxi on-board surveys comprise of a total of 300 vehicles to be tracked for seven days 24-hours per day. The selection of vehicles was based on the total number of vehicles operating along routes provided by the taxi industry. The detail of the sample and the outcome of the analysis are provided in the transport register. The onboard surveys include taxi services in the South Eastern Quadrant of Bloemfontein, Bloemfontein CBD and partial surveys for the south-western and western areas of Bloemfontein. The onboard surveys provided the data to estimate the business value of the existing taxi operations but also valuable insight into passenger activity along routes. It is acknowledged that the data represent passenger activity based on existing services and routes provided and do not necessarily reflect where passengers ultimately want to travel.

The passenger boarding and alighting information are presented in activity maps and assisted in the determination of stop and station positions along IPTN routes. The South Eastern Quadrant of Bloemfontein activity map is presented in Figure 6-9.

Detailed surveys for the remaining areas in MMM will be required for the development of detailed operational plans. The requirement and areas are presented in later sections of the IPTN – Implementation Plan per corridor.

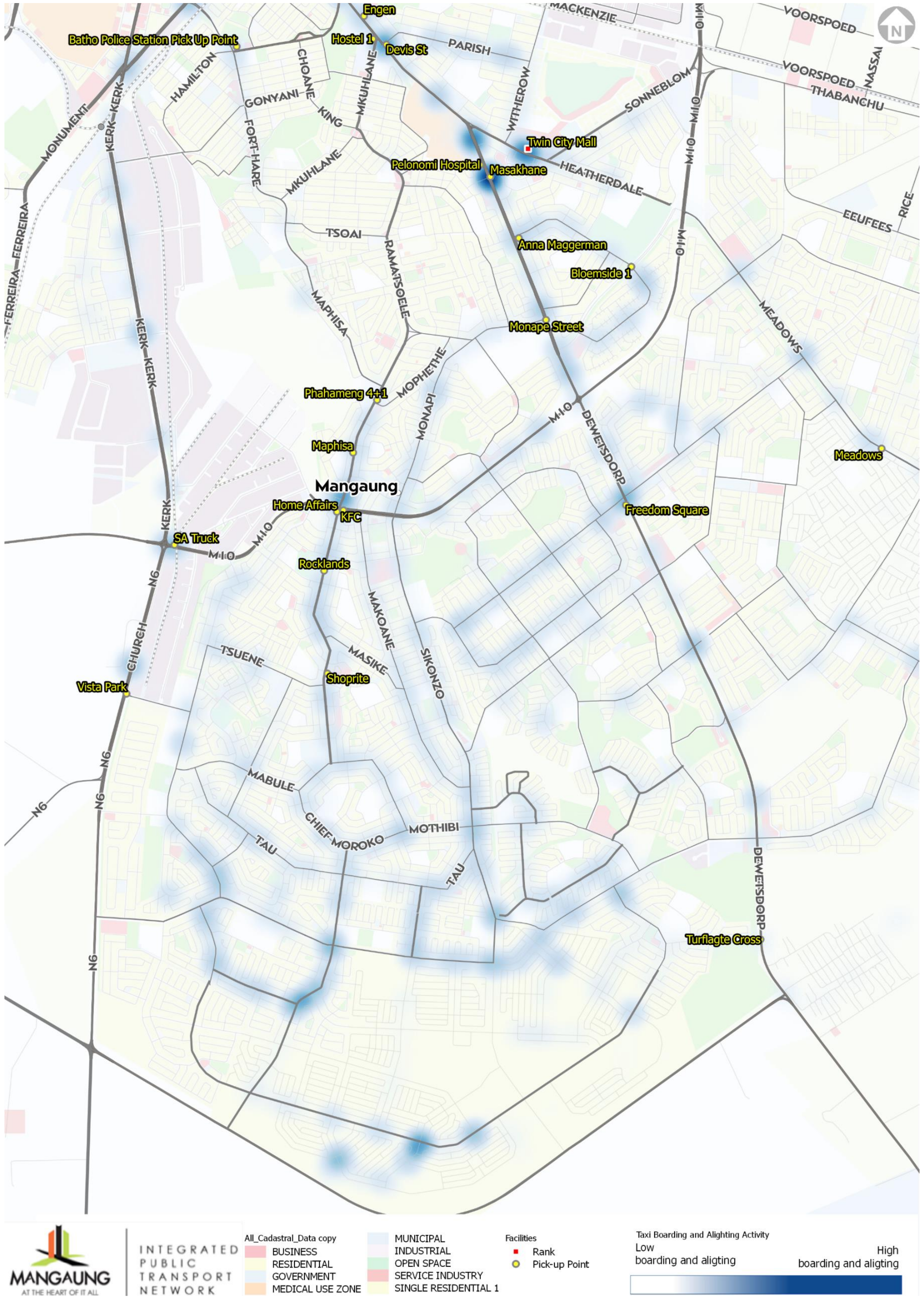


Figure 6-9: Taxi Onboard Surveys 2016 – Passenger Activity

6.2 Bus Operational Areas

6.2.1 Itumeleng Bus Service trading as Interstate Bus Lines (IBL) Routes and services

The contracts operated by Itumeleng Bus Service (t/a Interstate Bus lines-IBL) provides for subsidised public passenger transport services between Bloemfontein and Thaba Nchu, Botshabelo, Mangaung and Soutpan as well as distribution services to be operated from Central Park Terminus to Bloemfontein's residential areas. The provincial contracts payment certificates indicate that the services are operated by 214 buses (203 peak- and 11 spare buses). IBL operates these services in terms of 5 tendered contracts that are funded through the Public Transport Operational Grant (PTOG) using allocations made by the National Treasury in terms of the Division of Revenue Act (DORA). The Free State Department of Police, Roads and Transport acts as contracting authority for the contracts. The contracts with IBL for services operated between Bloemfontein and Botshabelo, Thaba Nchu and Mangaung were entered into in 1998. The contract for services operated between Bloemfontein and Soutpan was entered into in January 2015.

A detailed report on the contracts and services are provided as part of the transport register in Volume 1 of the IPTN Plan.

IBL is the main subsidised bus service provider in the Mangaung Metropolitan Municipality. The incorporation of these services into the IPTN is envisaged in the long-term implementation of the IPTN system.

The main origin-destination pairs serviced by IBL is from Thaba Nchu and Botshabelo to Bloemfontein CBD, and several distribution services in the Bloemfontein area. During 2016 approximately 40 000 passengers were transported per day between Thaba Nchu/Botshabelo and Bloemfontein area. Figure 6-11 shows the daily passenger volumes for both travel directions.

Several formal bus facilities are provided in the MMM area, and a summary of these are presented in Table 6-3, and the route network and facilities are depicted in Figure 6-12 IBL Route NetworkFigure 6-12.

Table 6-3: Bus Facilities per Area

Urban Node	Mode	Formal	Informal	Total
Bloemfontein	Bus	2	0	2
Thaba Nchu	Bus	1	0	1
Botshabelo	Bus	1	0	1

6.2.2 Passenger Waiting Times and Level of Service

A detailed waiting time survey was not conducted during the period of investigation; however, some indications were given by IBL of buses not arriving due to breakdowns as well as buses arriving more than 30 minutes late. A summary of the information of the survey mentioned above is shown in Table 6-4 below and reflect the **annual** number of trips.

Table 6-4: Passenger waiting times and Level of Service

Scheduled Trips	Additional Trips	Trips that were held back	Did not Operate	Late >30 minutes	Total Trips Operated
223 368	16	312	496	194	222 382
	0,01%	0,14%	0,22%	0,09%	
		1 002			
		0,45%			

It can be seen from the table above that IBL had the minimum breakdowns or increased capacity requirements (<0,1%) where additional trips had to be performed to maintain the same level of service. The overall total number of no shows or where the delays were so long that it disrupted the service are given as 1 002 trips. Even with this number of no shows (disruption to the service), the number only represents 0,45% of the overall total number of trips operated.

It should, however, be noted that the range of time delays are too coarse which implies that in order to provide a good level of service, one should measure time delays at 5 min interval from 5 to 30 minutes. The percentage of defaults in these ranges might be far higher than expected. Any delay in the scheduled time of 15 minutes and longer provides a substantial delay to commuters and reduces the level of service dramatically. It might thus in future be necessary to conduct a customer satisfaction survey in order better quantify the time delays. According to the existing information, the contracted service complies almost 99,5% with the contractual requirements.

6.2.3 Operational Hours

Bus services are operated at scheduled times and according to a published time table. The operational hours of the subsidised service start at 03:30 in the morning and the last services are scheduled between 23:30-24:00. The services operated before 05:00 in the morning start at positions towards Botshabelo, Thaba Nchu and other rural areas. A few services start in the Mangaung area in the suburbs of Phelindaba, Freedom Square and Turflaagte. These routes terminate at different points and include Thaba Nchu, Central Park, the National Hospital and Universitas Hospital.

The majority of services are provided between 05:00- 09:00 and 14:00-19:00.

The subsidised services are spread across a 20-hour period per day and the distribution of trips (percentage) in the peak and off-peak periods of the are:

- 03:30 AM to 04:59 AM - 3% of trips;
- 05:00 AM to 08:59 AM - 40% of trips (4 hours);
- 09:00 AM to 01:59 PM - 5.7% of trips;
- 02:00 PM to 06:59 PM - 46.6% of trips (5 hours);
- 07:00 PM to 12:00 PM - 5.0% of trips.

A significant number of the subsidised service terminate or start at Hoffman Square and Central Park. The average service frequency from these facilities varies between 25-30 minutes with the highest frequency of service at 8 minutes to Langenhoven Park during 06:00-07:00 AM. During this hour, eight trips services are provided to Langenhoven Park from Central Park, according to the 2016 survey data.

- Bus services run from 03:30 – 23:30,
- The average service frequency from Central Park and Hoffman Square during the morning peak period is 25-30 minutes.
- The highest services frequency during the morning peak period is 8 minutes

6.3 Metered Taxis

Metered taxi services are provided as an on-call service throughout the city. The main areas of operations are in the CBD and the vicinity of main retail centres.

At the majority of these retail centres, pick-up and drop-off bays are provided where passengers can gain access to services.

6.4 Commuter Rail

In the Mangaung Metropolitan Municipality, no daily commuter rail services are operated. Only long-distance services are provided to and from Bloemfontein 3 times a week. These two directional trips passing through Bloemfontein station include the following:

- Johannesburg to Bloemfontein
- East London to Bloemfontein
- Port Elizabeth to Bloemfontein.

The Bloemfontein rail station is situated at the intermodal facility, but no direct link exists between the rail platforms and the intermodal facility that provides for taxi and bus operations.

6.4.1 Future Rail

Several route alignments were considered to provide a commuter rail service from Botshabelo and Thaba Nchu to Bloemfontein. The proposed alignments are presented in Figure 6-10. The detail feasibility study to determine the sustainability of daily commuter service between the mentioned areas needs to be developed.

Figure 6-10: Proposed Thaba Nchu/ Botshabelo Rail alignments (Thaba Nchu Rejuvenation Study)

- Long distance passenger rail services are provided in the Mangaung Metropolitan Municipality Areas

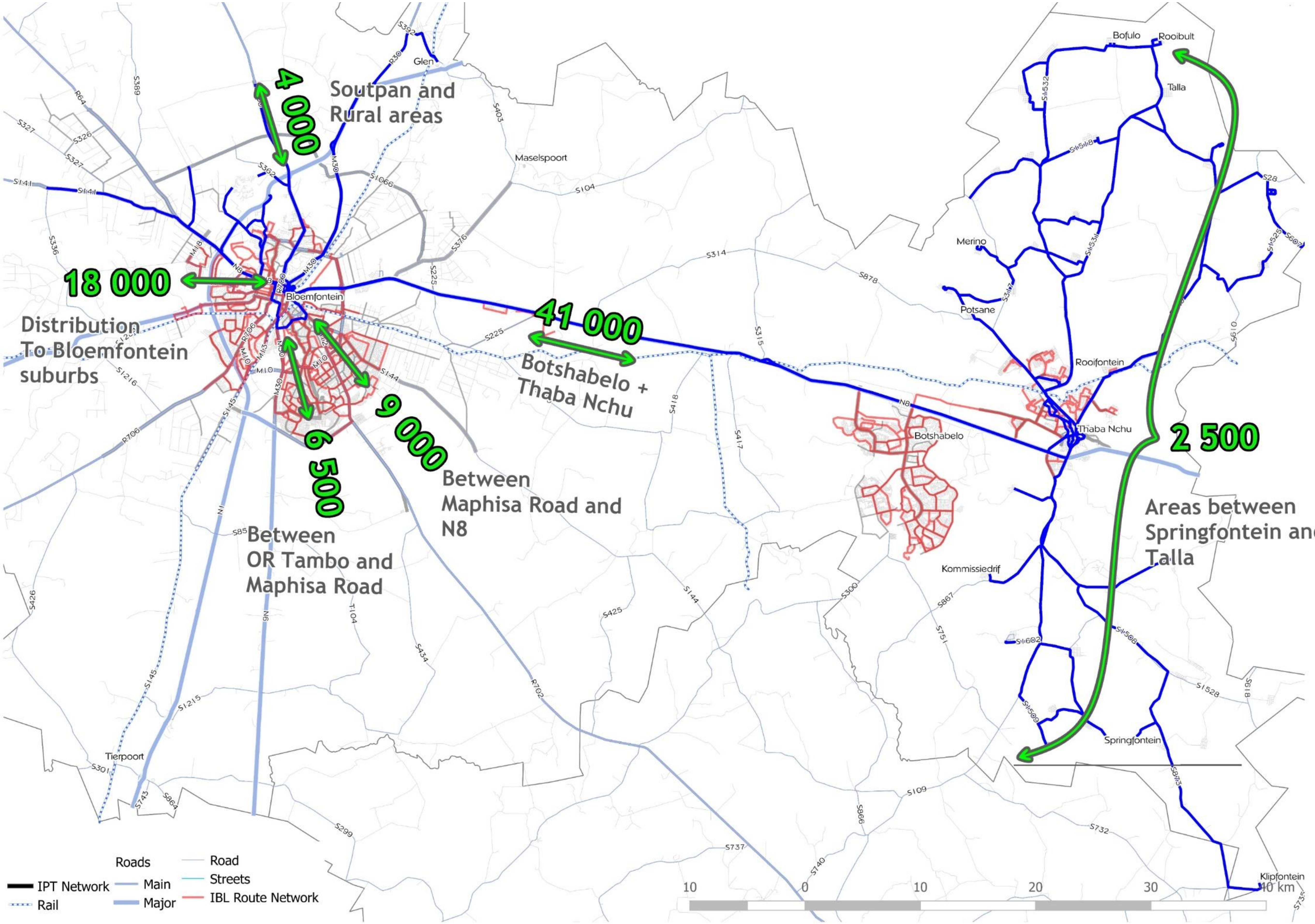


Figure 6-11: IBL 2015 Daily Passenger Summary

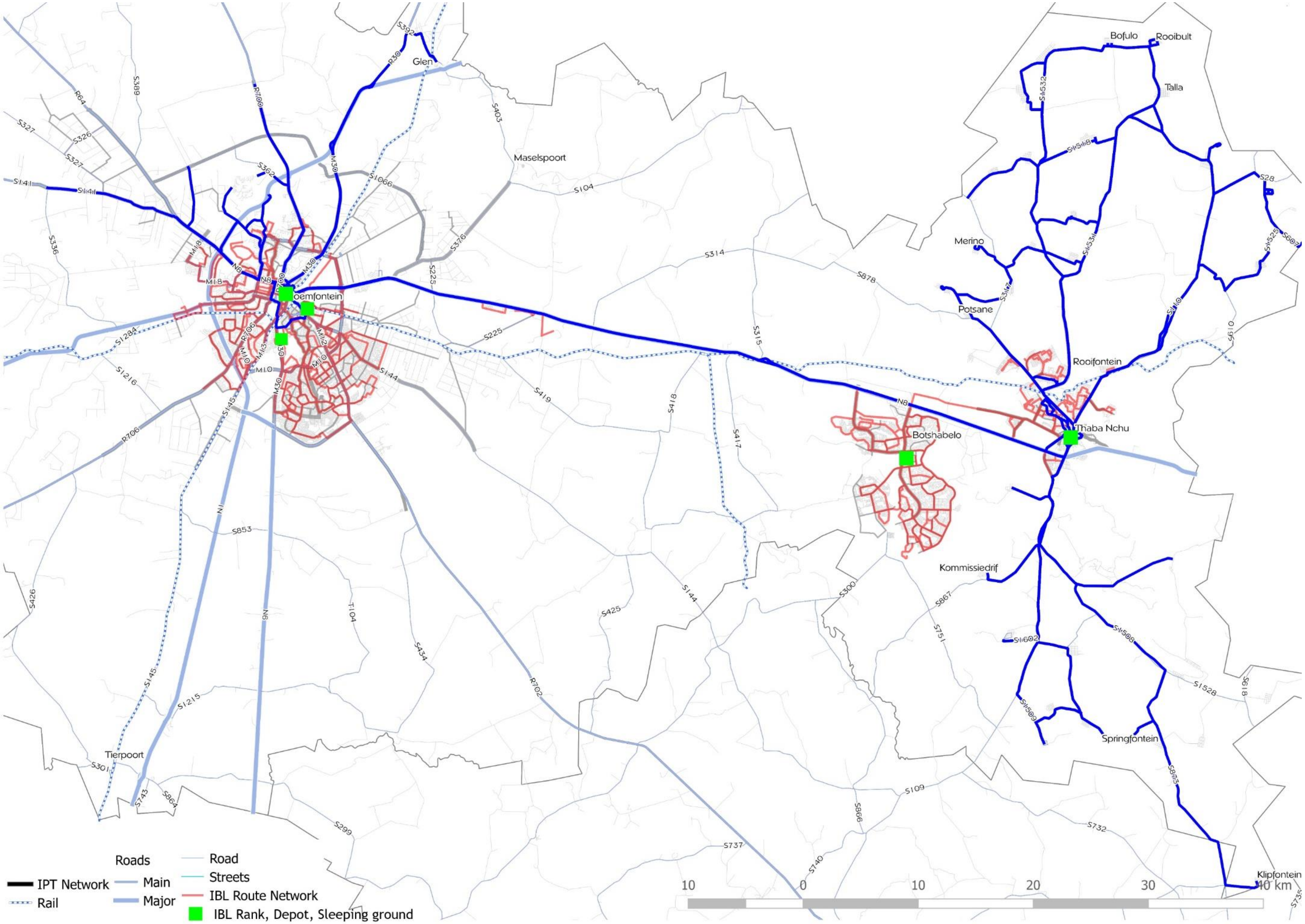


Figure 6-12 IBL Route Network

6.5 Road Network

A radial form characterises the existing road network in the Bloemfontein urban node. The road network is characterised by several road classes, of which Class 1 (National Roads / Freeways) and Class 2 (Arterials) form structuring elements within the urban nodes. The following key road network elements characterise the Bloemfontein urban node (Refer to Figure 6-13):

- Class 1: National Roads / Freeways
  - National Route N1 (connecting Gauteng to Cape Town)
  - National Route N8 (connecting Botshabelo / Thaba Nchu, Bloemfontein and Kimberly)
  - National Route N6 (connecting East London and Bloemfontein)
- Class 2: Arterials
  - Raymond Mhlaba Street (R30)
  - Kenneth Kaunda Road (R700)
  - General Dan Pienaar Road
  - Nelson Mandela Drive (R64)
  - Walter Sisulu (N8 western extension)
  - Jagersfontein / Curie / Kolbe Avenue (R706)
  - Ferreira Road
  - Church Street (M30 / N6 southern extension)
  - Dewetsdorp Road (R702)
  - Meadows Street
  - Thaba Nchu Road

The radial road network is also characterised by an outer and an inner ring road system. The outer-ring road is formed by the N1, approaching from the north, hugging the western boundary of Bloemfontein, and exiting to the south. The N6 extension along the southern boundary between the N1 and the R701 completes a portion of the outer ring road loop. The eastern portion of the ring road loop has not been constructed, but plans are afoot to complete this portion of the ring road, thereby linking the N6 extension (from R706) up with the N1 (towards the north). This extension of the ring road's eastern section will provide very important regional access to the eastern parts of Bloemfontein urban node, and particularly to the planned Airport Node Development.

The inner ring-road is formed by the M10 alignment which runs along the southern and eastern boundaries of the Bloemfontein urban node, which becomes Rudolf Greyling Avenue as the M10 crosses the National Route N8, thereafter becoming Wilkocks Road and Deale Road forming the northern edge of the inner ring-road, thereafter turning south again along General Dan Pienaar and Parfitt Avenue, which forms the western boundary of the inner ring-road.

Several future road links are proposed within Mangaung Municipality, most notably:

- N6 extension along the eastern edge of Bloemfontein from Dewetsdorp Road towards the north linking at Renoster Avenue (Refer to Figure 6-14 and Figure 6-13).
- Renoster Avenue extension (north-west from the Airport) along the western boundary of Bloemfontein reconnecting at N6/N1 interchange (south of Bloemfontein) (Refer to "B" Figure 6-14).
- Du Plessis Road extension along the western edge of Bloemfontein urban node (following a similar alignment to the National Route N1) (Refer to "C" on Figure 6-14).
- Thaba Nchu / Botshabelo east-west link from Brand Street (Thaba Nchu) north of the N8 alignment linking into the main road intersection of Botshabelo (Refer to "D" on Figure 6-14).

6.6 Rail Network and Stations

Mangaung is served by two railway lines, namely:

- Bloemfontein-Maseru railway line which connects Thaba Nchu to Bloemfontein along the National Route N8 corridor alignment in an east-west direction
- Johannesburg-Bloemfontein-East London / Port Elizabeth railway line, which traverses the Bloemfontein urban node in a north-south direction

Currently these railway lines carry no commuter services within the Mangaung area, and they are exclusively used by Transnet Freight Rail (TFR) for freight transport and by Shosholoza Meyl for long-distance passenger transport along the Johannesburg – Bloemfontein – Port Elizabeth service, the Johannesburg – Bloemfontein – East London service and the Cape Town – Kimberley – Bloemfontein – Pietermaritzburg – Durban service.

The following railway infrastructure initiatives are planned within the Mangaung area:

- According to the Spatial Development Framework (SDF) a railway connection proposal has been made to connect Botshabelo to the Thaba Nchu-Bloemfontein Railway line section.
- A feasibility study is planned to determine the feasibility of developing an additional railway link/siding to serve the Airport Development Node (Phase 2)
- The PRASA railway upgrade program has issued a tender for a Rail Feasibility Study of the N8 rail corridor (which forms part of the Strategic Integrated Project (SIP) 7).

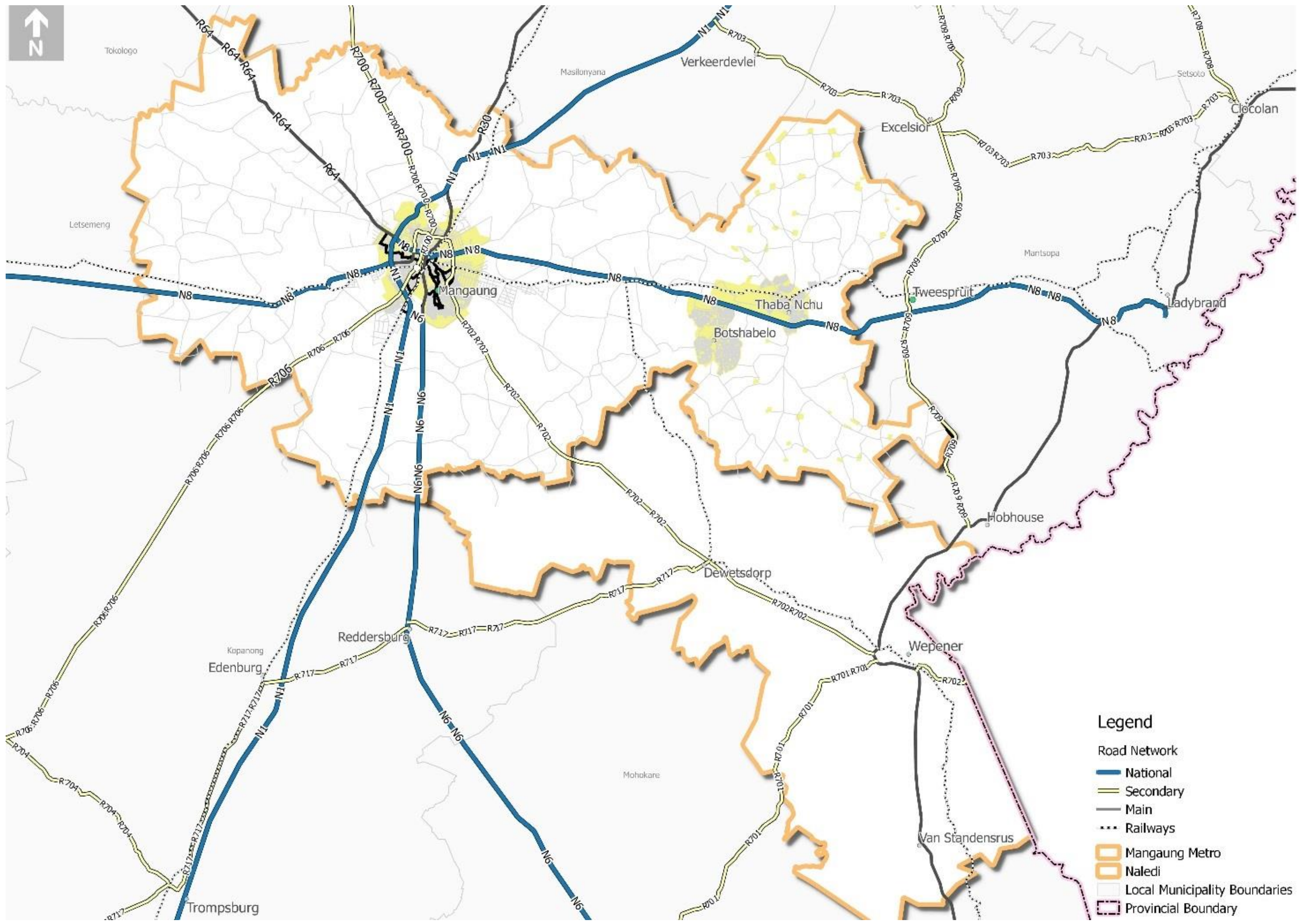


Figure 6-13: MMM Transport Network (Ops. Plan 2014)

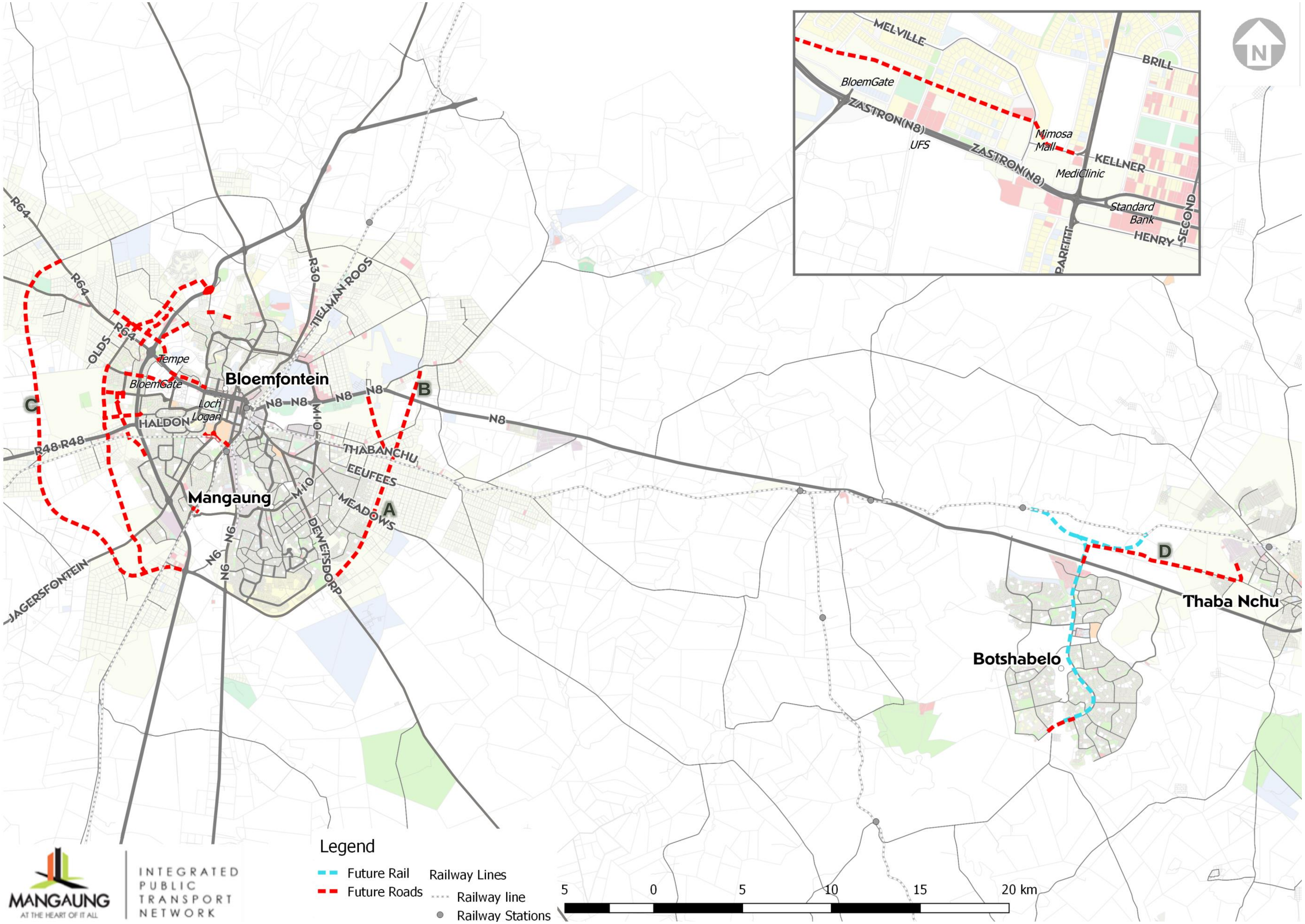


Figure 6-14: Bloemfontein, Botshabelo and Thaba Nchu Road Network

7 Public Transport Demand Estimation

To select demand corridors that need to be incorporated into the IPTN, the existing and future public transport demand needs to be determined. The determination of the public transport demand for the IPTN comprise of the base year and horizon year estimated public transport demand.

This demand is derived from observation along the existing public transport corridors, obtaining the current movement patterns and mode split through the household travel survey. The future year demand estimation is based on the land-use model and scenarios developed as part of the land-use model. The land-use model development process applies macro economic forecast and the effect of the implementation of the spatial development framework to population and jobs and derives the future year population and jobs offered in the city.

The section is structured and provides the approach and results of:

- Land Use model and Economic forecast which form the base for the future year public transport matrix estimation and validation for the base year public transport matrix;
- Approach, methodology and results of the public transport matrix estimation (base year and future years) and assignment of public transport person trips to the IPT network.
- Determination of public transport demand corridors and quantifying patronage for the base year and future year per demand corridor.

This process resulted in the main demand corridors, which informed the route design and provided the patronage per IPTN route and functional public transport corridor, for the base and future years.

7.1 Land Use Model - Base Year and Future Year Scenarios

The purpose of the land-use model is to translate the Spatial Transformation/ Restructuring Strategy (Section 4) into households, population and workers. The allocation was done per traffic zone which served as input into the transportation modelling process. The development process, deliverables and results are provided in summary.

The delineation of the traffic and reporting zones, as well as the methodology and sources of information used in creating the land-use model, is provided in Annexure B. The economic forecast that provided the growth scenarios, and premises for the land-use model growth scenarios are provided in annexures:

- Annexure C: THE IHS DEMOGRAPHIC MODEL;
- Annexure D: IHS GLOBAL ECONOMIC OUTLOOK; And
- Annexure E: IHS SOUTH AFRICAN ECONOMIC OUTLOOK, MARCH 2016.

7.1.1 Zoning Systems

The zoning system comprises 225 traffic zones, which were aggregated into 16 reporting zones for ease of presentation purposes.

The criteria used in the delineation process were:

- Freeways, major routes and railway lines.
- Natural barriers, such as rivers and ridges.
- Census 2011 Sub Place Boundaries.
- Existing and future land use.
- SDF proposals.

The modelling study area and associated traffic zones are depicted in Figure 7-1, and the reporting zones in Phase 1 (priority short term focus area) is illustrated in Figure 7-3.

7.1.2 Base Year (2015) and Design Years (2025, 2036)

The base year of the land use model is 2015. Design years decided upon were medium-term (2025) and long term (2036). IHS Information and Insight provided the base year, as well as future year control totals pertaining to households, population, economically active population and workers. Six scenarios were developed:

- Population growth: Low, Middle, High.
- Economic growth: Low, Middle, High.

The middle scenario (both population and economic growth) was perceived to be the most appropriate/ realistic to use in the land-use model (see Annexure B).

7.1.3 Deliverables by Traffic Zone

The following deliverables were provided per traffic zone (base year and design years) (Examples of database attached as Annexure F):

- Dwelling Units (low, middle, high income).
- Population (low, middle, high income).
- Economically Active Population (formal, informal and unemployed) = productions.
- Floor Area (m²): retail and office.
- Formal Workers by type e.g. retail, office, industrial, commercial, local serving, agricultural and mining, construction transport and domestic workers = attractions.
- Informal Workers.
- Unemployed People.

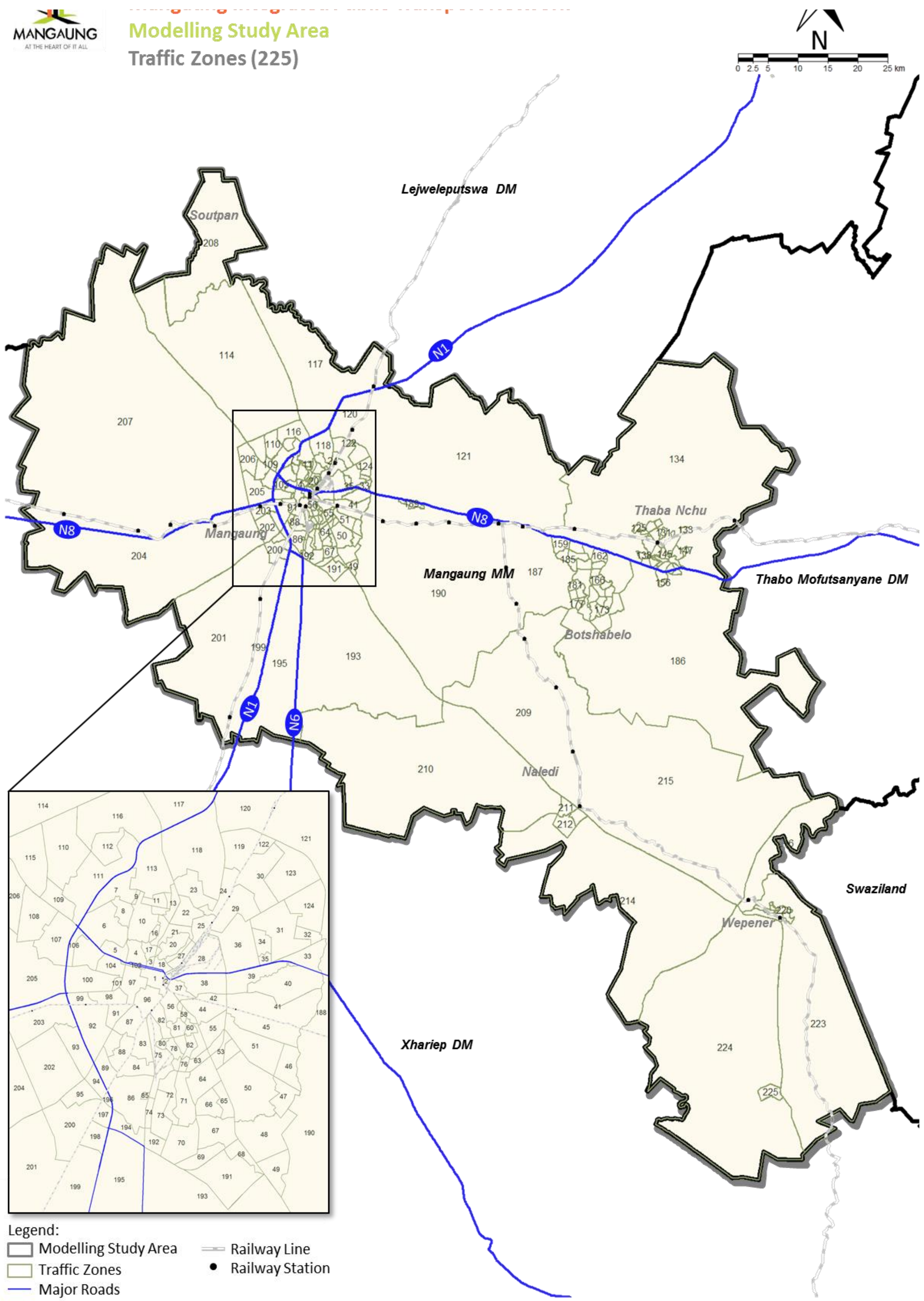


Figure 7-1: Modelling Study Area - Traffic Zones

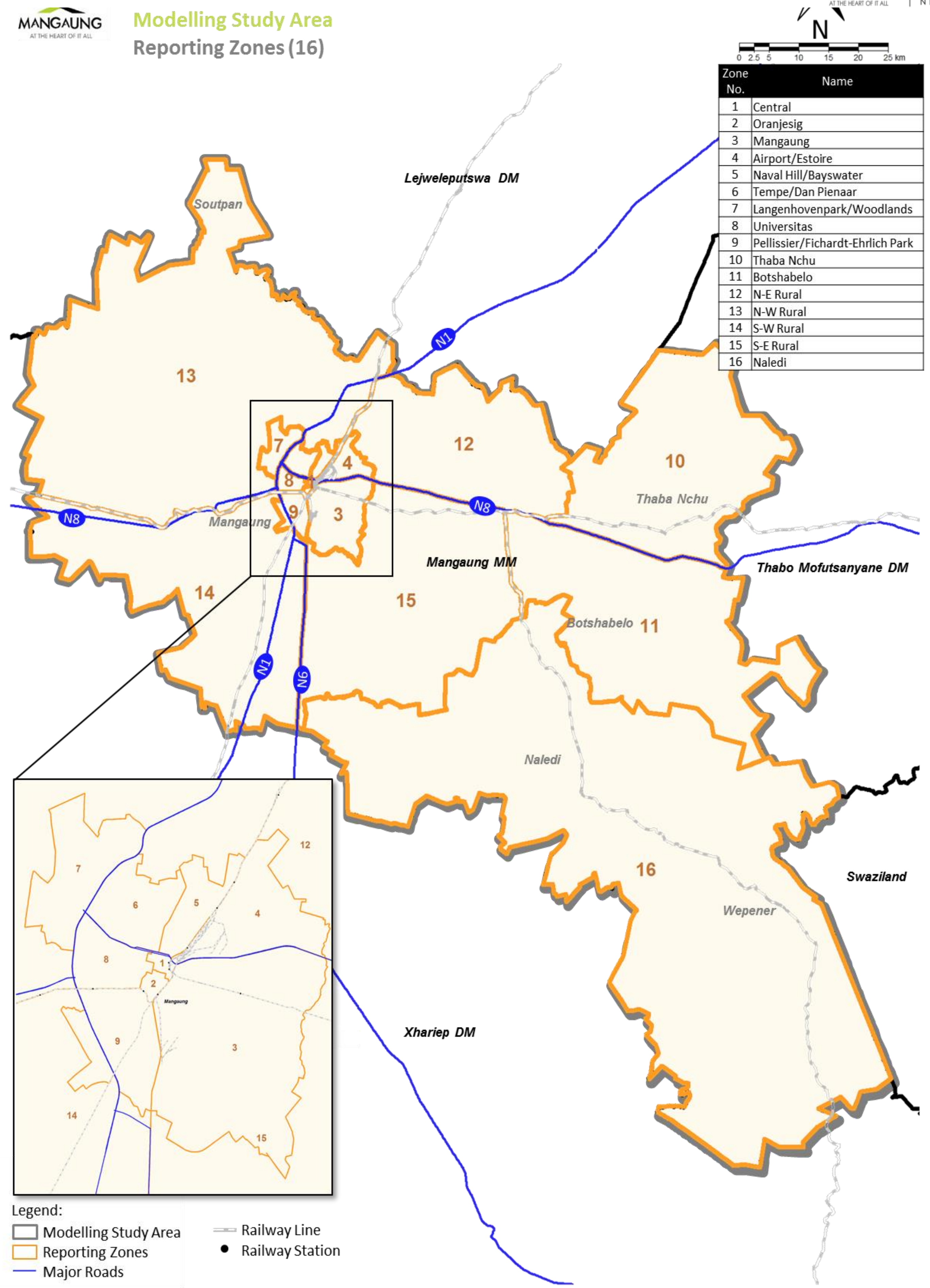


Figure 7-2: Modelling Study Area - Reporting Zones

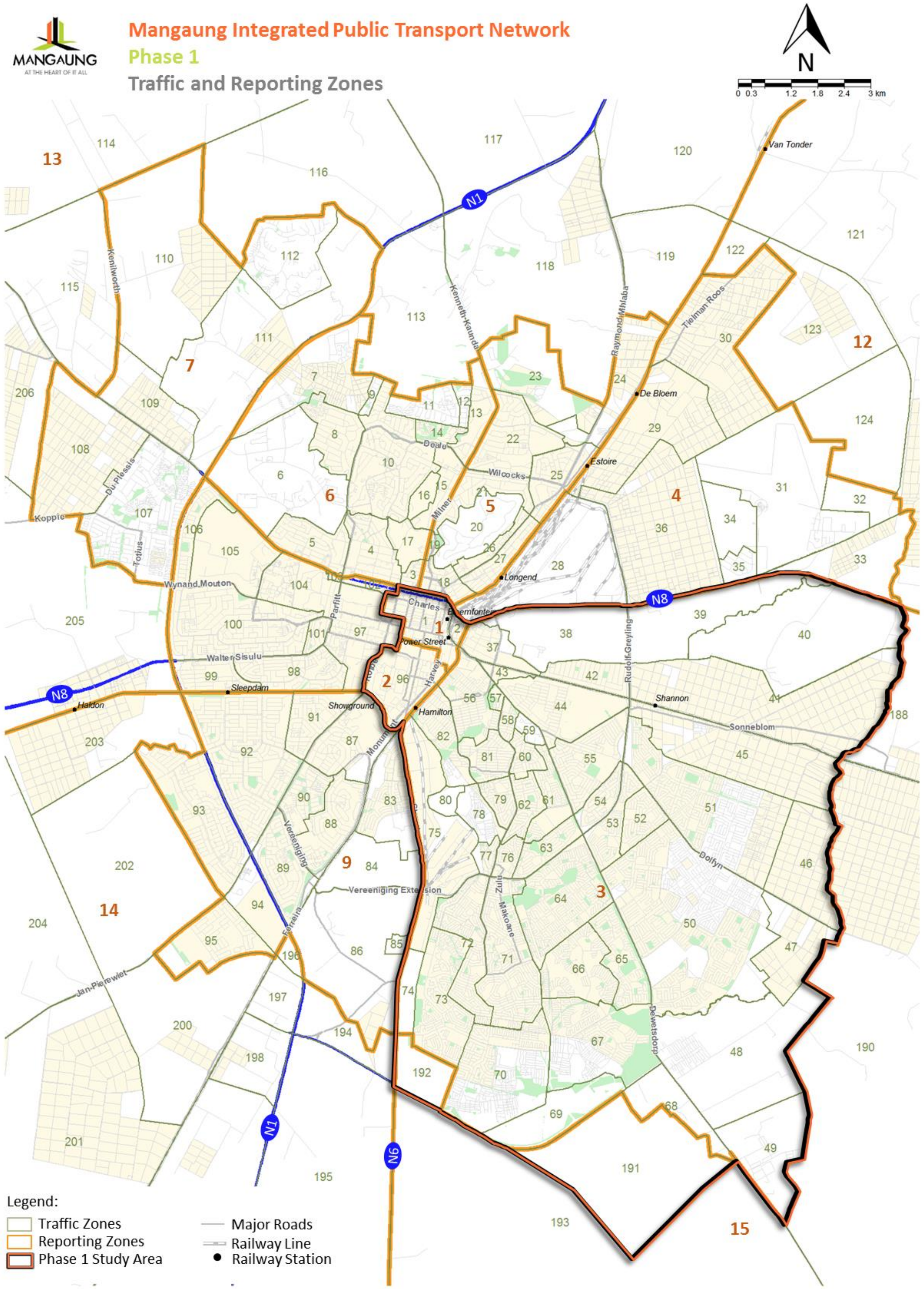


Figure 7-3: Phase 1 - Traffic and Reporting Zones

7.1.4 Land Use Model Results 2015 - 2036

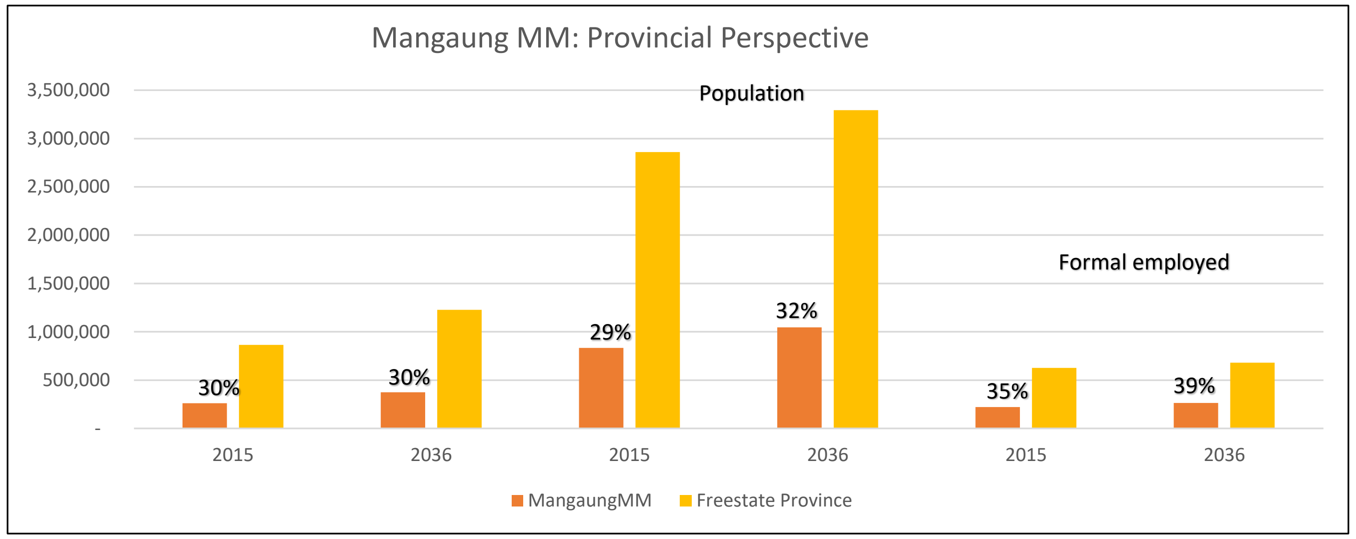
The results can be displayed in several ways, depending on the level of detail required, for instance:

- Municipal Level;
- Per phase 1 and phase 2;
- Per 5 Restructuring Objectives;
- Per Planning zone and;
- Per Traffic zone.

7.1.5 Municipal Level Results

Mangaung Metropolitan Municipality is centrally located within the Free State Province and comprises three prominent urban centres surrounded by an extensive rural area. The urban areas include Bloemfontein, Botshabelo, and Thaba Nchu. Bloemfontein is the judicial capital and one of the largest cities in South Africa. Mangaung Metropolitan Municipality constitutes 30% of all the households in the Free State Province, 29% of the population and 35% of all the formal job opportunities. Its relative position (%) is expected to stay constant regarding households but slightly increase regarding population (32%) and formal workers (39%) (see Diagram 7-1).

Diagram 7-1: Mangaung MM – Provincial Perspective



7.1.6 Results per Phase 1 9South Eastern Quadrant Bloemfontein) and Phase 2 (Remainder of MMM)

Figure 7-4 shows the relative position of Phase 1 Priority Development Area in comparison with the remainder of the study area. The CBD and the south-eastern quadrant of the Mangaung Metropolitan Municipality constitute 45% of all households, 44% of all population and 40% of all formal workers.

The relative contribution of Phase 1 is expected to continue in future on almost the same levels with increments of 46 500 households, 85 200 people and 12 000 job opportunities in the next 21 years.

Table 7-2 highlights the distribution of formal workers per phase and per type. The formal workers serve as the attractions in the model.

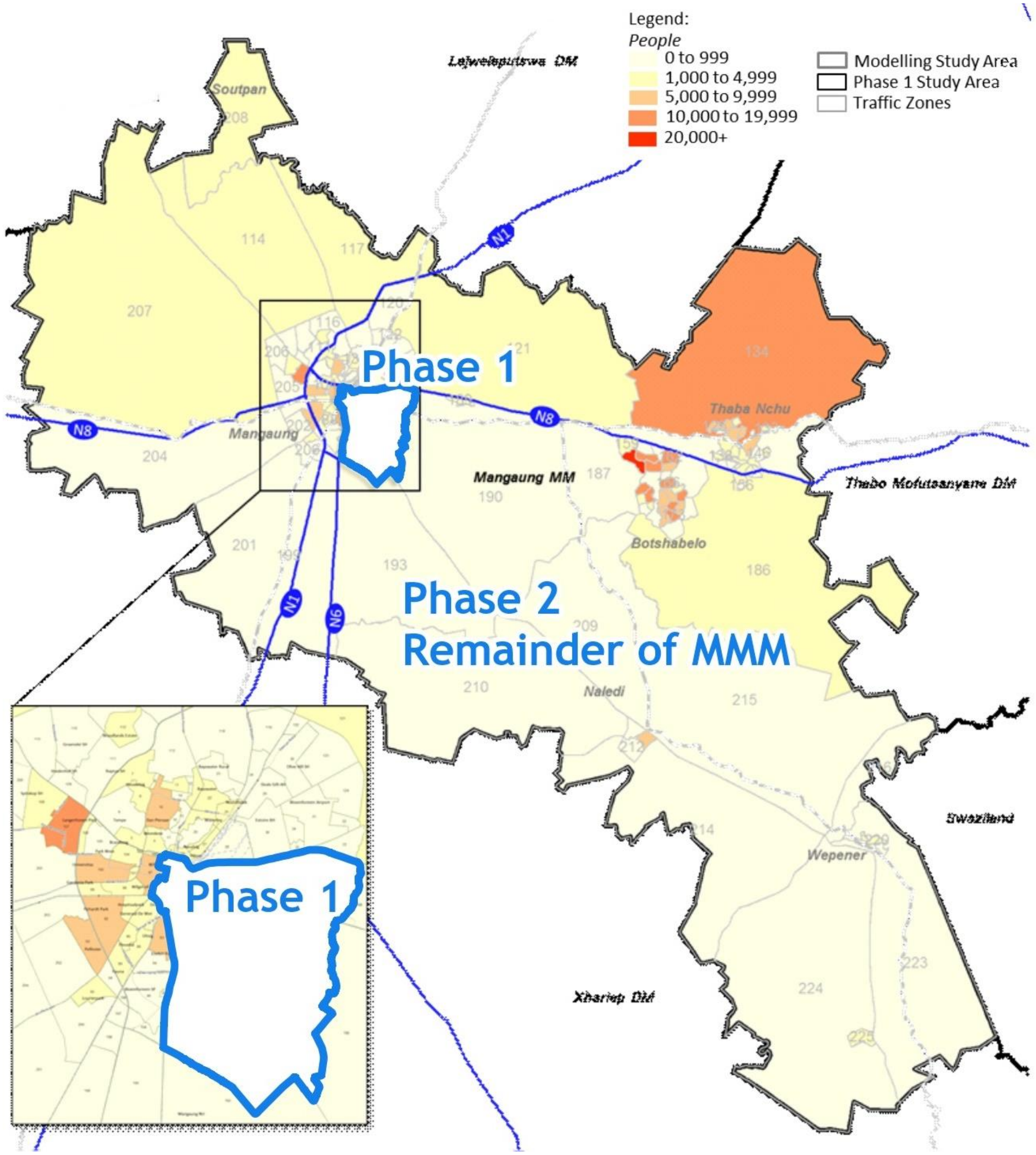


Figure 7-4: Distribution of Dwelling Units, Population and Formal Workers per Phase 2015-2036

Table 7-1: Municipal Level Results – Land Use Model

PHASES	HOUSEHOLDS			HOUSEHOLDS (%)		
	2015	2025	2036	2015	2025	2036
Phase 1	116,546	142,821	163,088	45%	44%	44%
Phase 2	144,695	180,702	211,362	55%	56%	56%
Mangaung	**261,242**	**323,524**	**374,451**	**100%**	**100%**	**100%**

PHASES	POPULATION			POPULATION (%)		
	2015	2025	2036	2015	2025	2036
Phase 1	369,784	415,308	455,006	44%	44%	44%
Phase 2	463,357	527,962	590,320	56%	56%	56%
Mangaung	**833,141**	**943,270**	**1,045,326**	**100%**	**100%**	**100%**

PHASES	FORMAl WORKERS			FORMAL WORKERS (%)		
	2015	2025	2036	2015	2025	2036
Phase 1	88,227	91,724	100,213	40%	40%	38%
Phase 2	132,901	137,763	162,787	60%	60%	62%
Mangaung	**221,129**	**229,487**	**263,000**	**100%**	**100%**	**100%**

Table 7-2: Mangaung MM IPTN: Formal Workers per Phase and per Type, 2015

PHASES	Retail	Office	Industrial&Commercial	Local Serving	Defence Activities	Agriculture & Mining	Construction	Transport	Domestic workers	Total Formal
Phase 1	13,086	31,595	9,331	16,694	1,058	49	4,081	3,543	8,789	**88,227**
Phase 2	18,388	21,989	13,405	35,086	3,334	9,820	6,949	4,794	19,136	**132,901**
Mangaung MM	**31,474**	**53,584**	**22,737**	**51,780**	**4,392**	**9,869**	**11,031**	**8,336**	**27,925**	**221,129**
PERCENTAGE DISTRIBUTION PER PHASE										
Phase 1	42%	59%	41%	32%	24%	1%	37%	42%	31%	**40%**
Phase 2	58%	41%	59%	68%	76%	100%	63%	58%	69%	**60%**
Mangaung MM	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**	**100%**
PERCENTAGE DISTRIBUTION PER TYPE										
Phase 1	15%	36%	11%	19%	1%	0%	5%	4%	10%	**100%**
Phase 2	14%	17%	10%	26%	3%	7%	5%	4%	14%	**100%**
Mangaung MM	**14%**	**24%**	**10%**	**23%**	**2%**	**4%**	**5%**	**4%**	**13%**	**100%**

The total formal workers in Mangaung MM is estimated to be 221 100, of which 40% (88 200) work in the priority Phase 1 area and 60% (132 900) in the Phase 2 area.

The public sector and other business activities (office workers) constitute 24% of all workers, followed by local serving workers (23%). Local serving workers include education-, health-, social- and other local services.

Retail (14%) and domestic workers (13%) are the third and fourth-largest category of workers. The relative size of industrial workers (10%) is low, compared to the ratio in other metropolitan areas. The remaining workers constitute 15% of the total workers (Diagram 7-2).

Diagram 7-2: Mangaung MM - % Distribution of Formal Workers, 2015

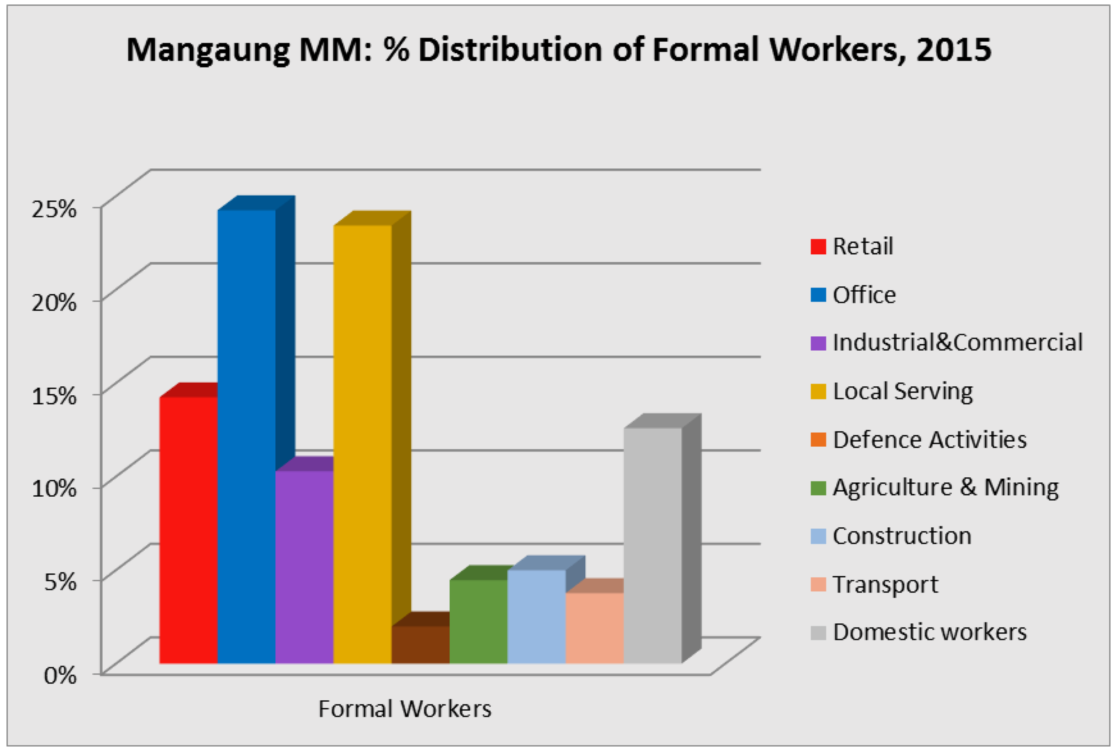


Figure 7-5 shows that the relative population size of the Bloemfontein urban area (63% in 2015) is expected to grow to 66% in 2036, while the Botshabelo/ Thaba Nchu area is expected to decrease from 32% to 27%. The population of the surrounding rural area is expected to increase slightly from 5% in 2015 to 7% in 2036.

Figure 7-6 depicts the distribution of formal workers in 2015 compared with 2036. The relative distribution of formal workers is expected to stay constant at 77% located in the urban area of Bloemfontein, and 14% in the Botshabelo/ Thaba Nchu areas, provided that special interventions create additional job opportunities in the latter CBD's, new nodes and industrial areas be successful. In order to retain the relative size of the job sector in the rural areas, special job creation initiatives will also have to be put in place in the agriculture and mining sector (Soutpan).

7.1.7 Results per Transformation Objectives

As discussed previously, the Mangaung Integrated Development Plan identified the following five key focus areas/ Objectives towards achieving a balanced city structure:

Restructuring Objectives and Strategy	
• Promote Economic Development	• 3 Central Business District • N8 Corridor (Airport Node) • Industrial Development Nodes/ SDZ's • Other Nodes (Waaihoek, New Botshabelo Node, Soutpan, disadvantaged communities)
• De-racialising the built environment	• 7 Land Parcels (Cecilia/ New Zoo, Pellissier infill, Brandkop, Vista X2, 3, Hillside View X34, 35, Estoire)
• Promote Intensification/ Densification	• IRPTN Corridor (Phase 1 & CBD) • Existing Urban Area
• Prevent/ Curb Spatial Fragmentation	• Limit expansion • Promote spatial integration
• Support Rural Development	• Enhance rural development in identified nodes

The results are depicted in Table 7-3 (Job Opportunities) and Table 7-4 (Dwelling Units). More than half (54%) of the increase in job opportunities in the next 21 years can be expected to take place in the economic nodes which consist of CBD's (25%), followed by the N8 Corridor/ Airport Node (14%), other and newly developed nodes (11%), and the industrial areas (5%). A relatively large increase (27%) is expected to develop in the proposed "7 Land Parcels" areas, followed by a further 13% along the Phase 1 BRT corridor and in the suburbs.

Regarding the increase in dwelling units, the largest growth is expected to take place in the existing urban footprint of the suburbs (31%), and a further 10% within the Phase 1 BRT corridor, which together means an increase of 40% which will contribute significantly to densifying the existing urban fabric. 28% of the increment has been placed in nodes, which will contribute to the feasibility of the provision of public transport services in the future.

The "7 Land Parcels" is expected to absorb 18% of all new growth in future (see Figure 7-7 and Figure 7-8). Detailed results per Transformation Objective is available Annexure F (Job Opportunities and Dwelling Units).

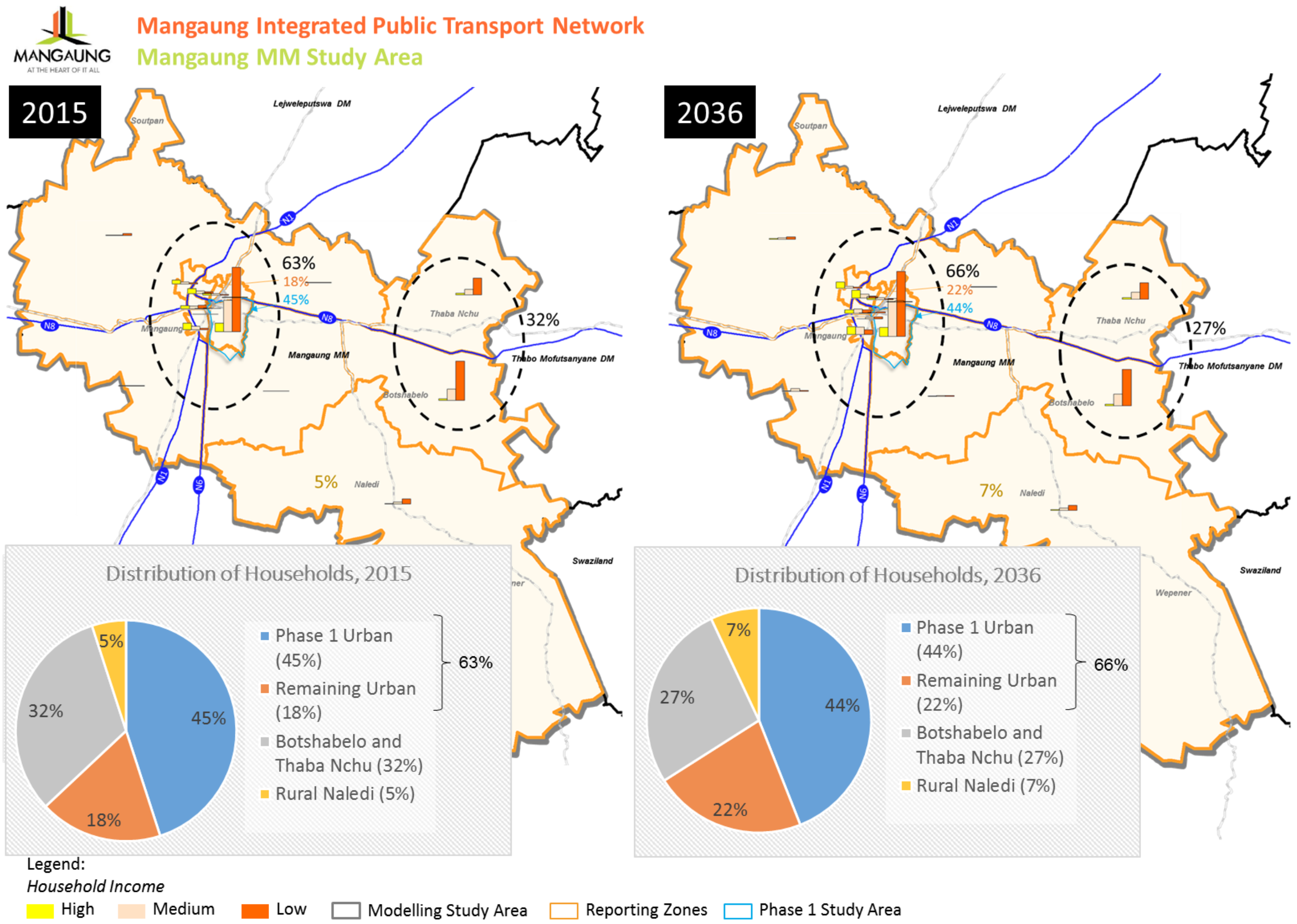


Figure 7-5: Distribution of Dwelling Units per Income 2015 and 2036

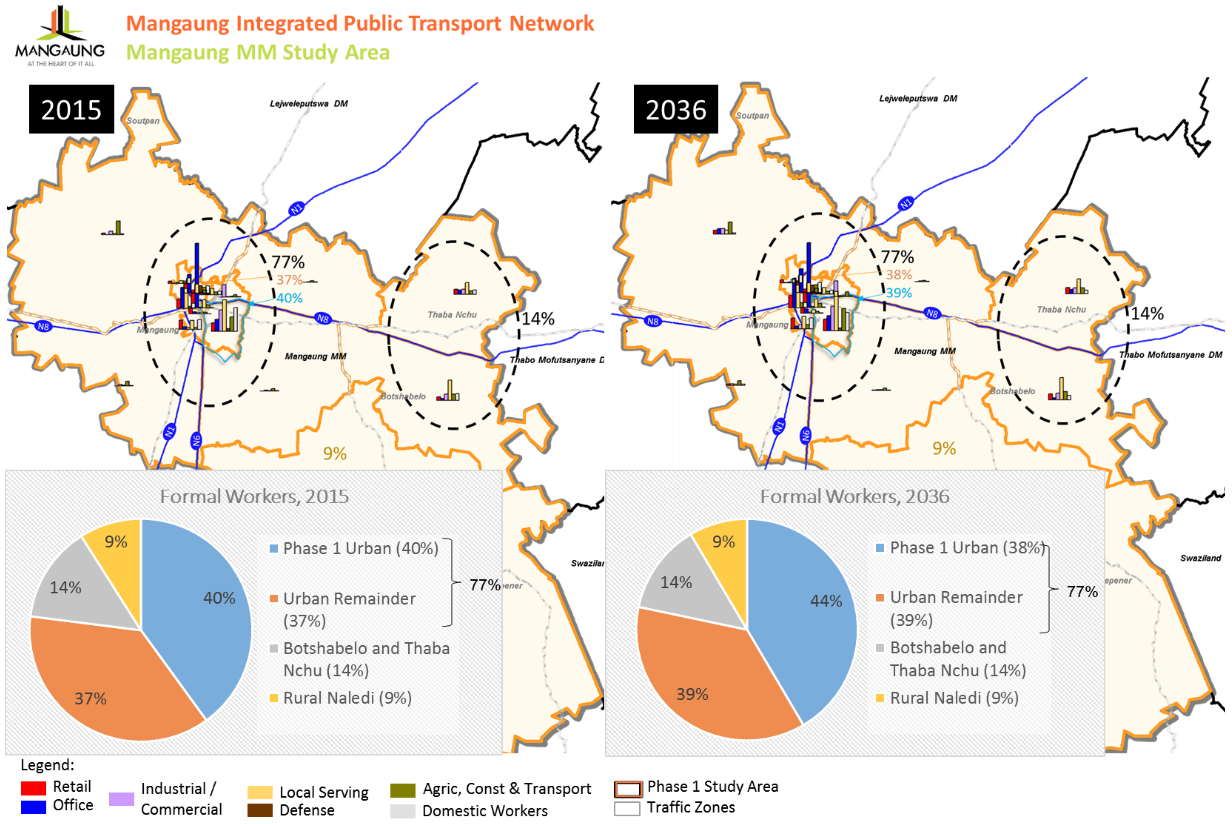


Figure 7-6: Distribution Formal Workers 2015 and 2036

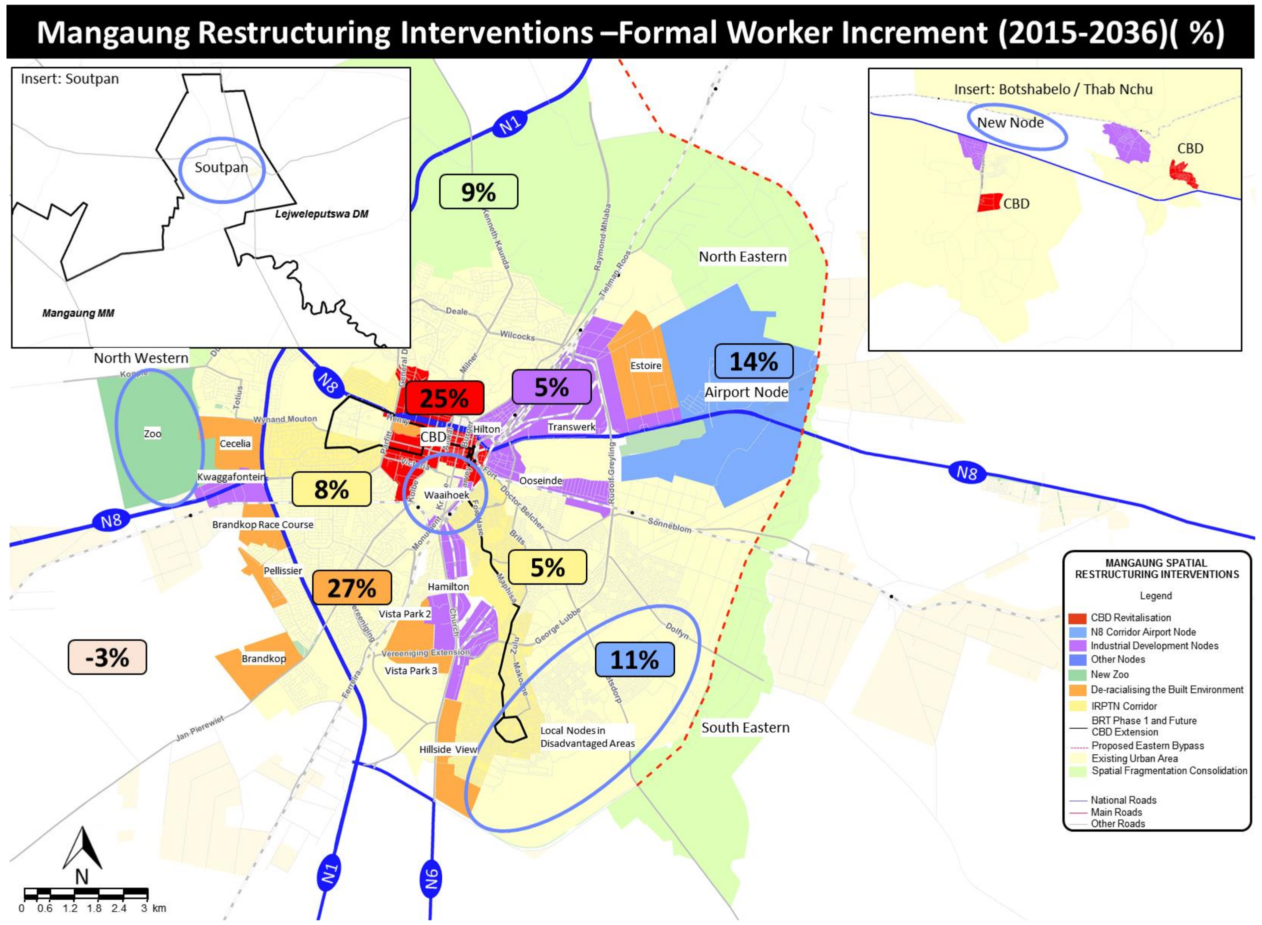


Figure 7-7: Mangaung Restructuring Interventions – Formal Worker Increment (2015-2036) (%)

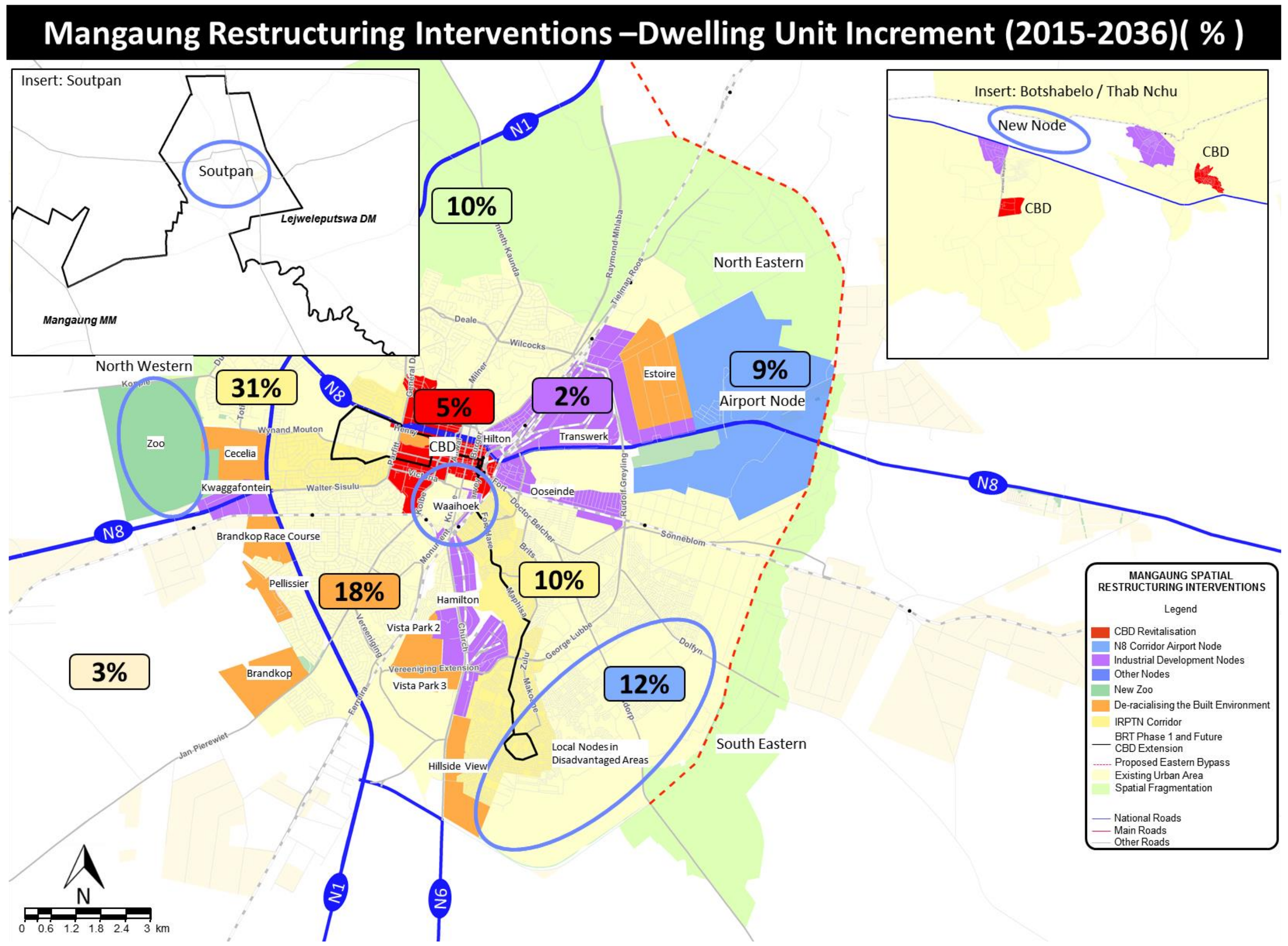


Figure 7-8: Mangaung Restructuring Interventions – Dwelling Unit Increment (2015-2036) (%)

Table 7-3: Spatial Transformation Objectives (Jobs) – Results 2015 – 2036

IDP Objective	Existing 2015 Jobs	2036 Jobs	Increment 2015 - 2036 Jobs	Existing 2015 (%) Jobs	2036 (%) Jobs	Increment 2015 - 2036 (%) Jobs
-ECONOMIC DEVELOPMENT	108,319	130,854	22,535	49%	50%	54%
• Central Business Districts	65,531	75,844	10,313	30%	29%	25%
• N8-Corridor	1,742	7,410	5,668	1%	3%	14%
• Industrial Development Nodes/SDZ's	27,148	29,271	2,123	12%	11%	5%
• Other Nodes	13,897	18,328	4,431	6%	7%	11%
-DE-RACIALISING THE BUILT ENVIRONMENT	6,757	18,216	11,459	3%	7%	27%
• 7 Land Parcels	6,757	18,216	11,459	3%	7%	27%
-INTENSIFICATION/DENSIFICATION/INFILL	85,271	90,900	5,629	39%	35%	13%
• IRPTN Corridor	18,379	20,560	2,181	8%	8%	5%
• Existing Urban area	66,892	70,340	3,448	30%	27%	8%
-SPATIAL FRAGMENTATION	5,778	9,407	3,629	3%	4%	9%
-RURAL DEVELOPMENT	15,003	13,622	(1,381)	7%	5%	-3%
TOTAL MANGAUNG MM	221,129	263,000	41,871	100%	100%	100%

Table 7-4: Spatial Transformation Objectives (Units) – Results 2015 – 2036

IDP Objective	Existing 2015 Units	2036 Units	Increment 2015 - 2036 Units	Existing 2015 (%) Units	2036 (%) Units	Increment 2015 - 2036 (%) Units
-ECONOMIC DEVELOPMENT	63,888	96,016	32,127	24%	26%	28%
• Central Business Districts	6,934	12,889	5,954	3%	3%	5%
• N8-Corridor	1,146	11,163	10,016	0%	3%	9%
• Industrial Development Nodes/SDZ's	6,253	8,478	2,225	2%	2%	2%
• Other Nodes	49,555	63,486	13,932	19%	17%	12%
-DE-RACIALISING THE BUILT ENVIRONMENT	2,512	22,995	20,484	1%	6%	18%
• 7 Land Parcels	2,512	22,995	20,484	1%	6%	18%
-INTENSIFICATION/DENSIFICATION/INFILL	176,545	222,267	45,722	68%	59%	40%
• IRPTN Corridor	41,652	52,750	11,097	16%	14%	10%
• Existing Urban area	134,892	169,517	34,625	52%	45%	31%
-SPATIAL FRAGMENTATION	6,686	18,019	11,333	3%	5%	10%
-RURAL DEVELOPMENT	11,612	15,154	3,542	4%	4%	3%
TOTAL MANGAUNG MM	261,242	374,451	113,209	100%	100%	100%

7.1.8 Results per Reporting Zone

Figure 7-9 illustrates the distribution of households per income group in 2015 and 2036. It is evident that within the Bloemfontein urban area, the majority of the low and middle-income households live in the south-east (Mangaung area), whereas the majority of the high-income households are located in the north-western suburbs. Although the majority of the low-income households will still be living in the Mangaung area in the future, an increase in middle-income households is expected in the western suburbs, mainly because of the “7 Land Parcels” initiative.

Figure 7-10 illustrates the distribution of job opportunities by Type in 2015 and 2016.

Note the dominance of office/ retail workers in and around the Bloemfontein CBD area, and it is expected to further increase in future when the redevelopment plans of the Zoo Lake precinct and other infill developments realise. Local Serving Workers (education-, health-, and other services) constitute the majority of the workers in the Universitas area.

Industrial Development is expected to increase in the N8 Corridor, while local service-; construction-; and transport workers are expected to increase in the Mangaung area, as more community facilities will be needed in future, and as the BRT gets constructed.

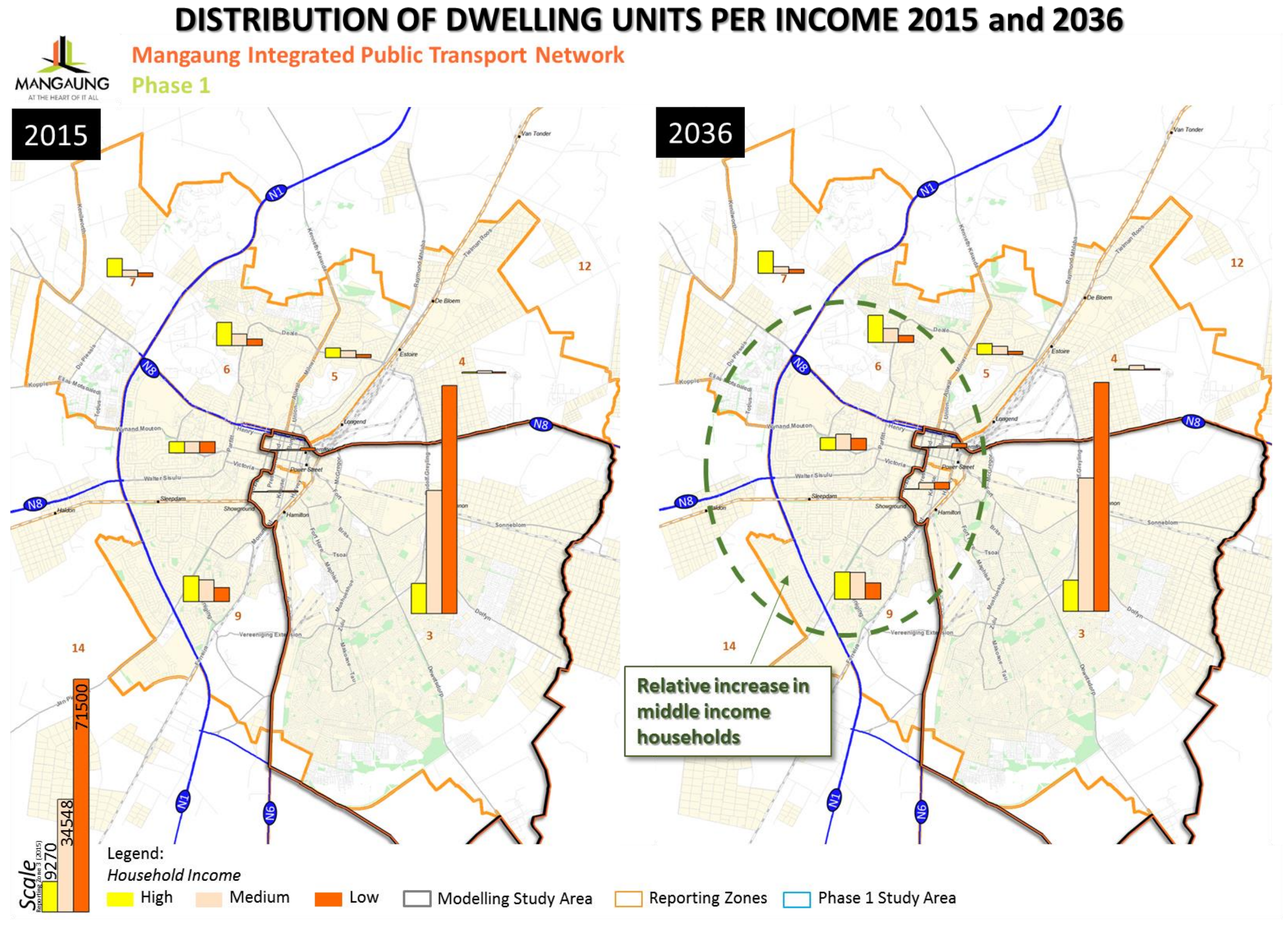


Figure 7-9: Distribution of Dwelling Units per Income 2015 and 2036

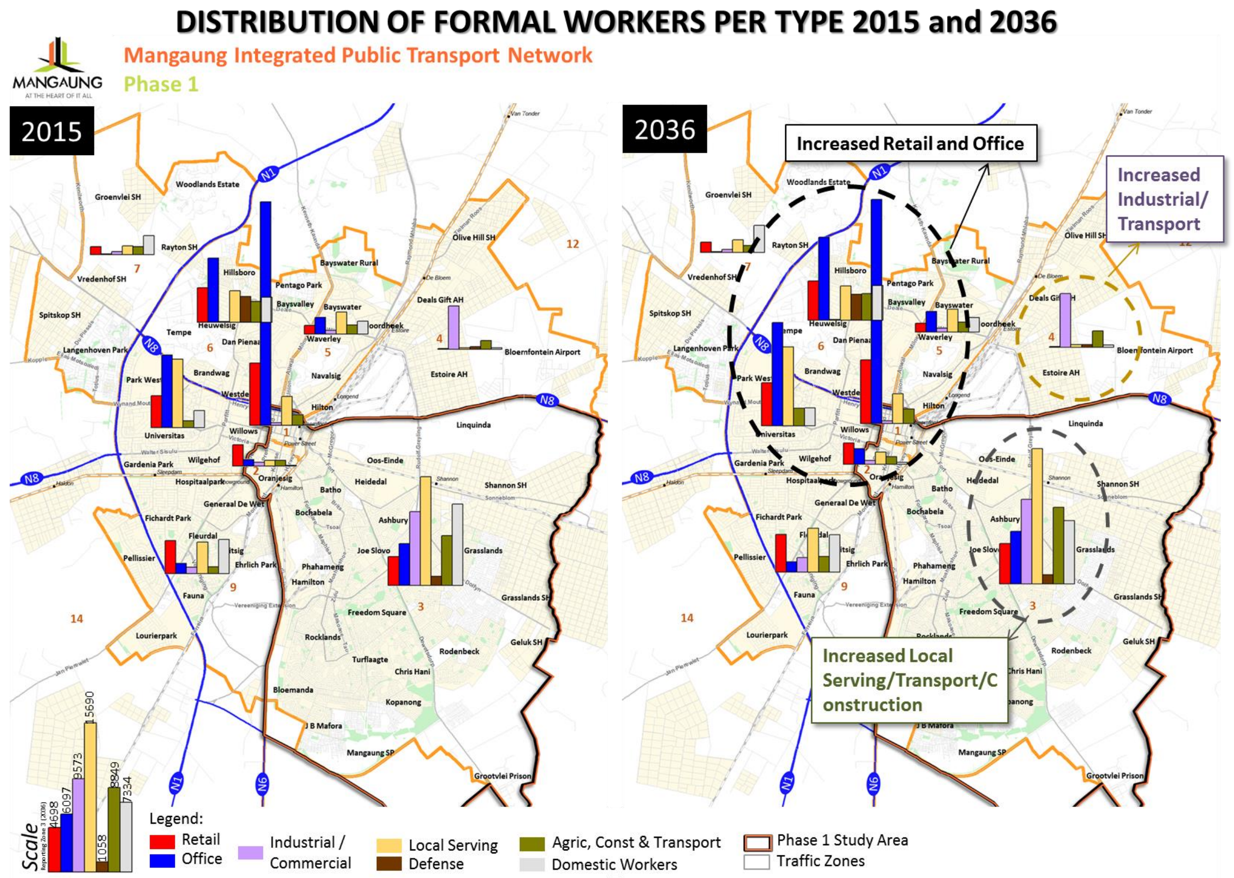


Figure 7-10: Distribution of Formal Workers per Type 2015 and 2036

7.1.9 Results per Traffic Zone

Figure 7-11 depicts the number of people per traffic zone (regional scale). It is evident that a large number of people are located in the south-eastern quadrant of Mangaung, as well as in the Botshabelo and Thaba Nchu areas, but also in the rural areas north and south of Thaba Nchu.

Figure 7-12 depicts the number of people per traffic zone (urban scale). The largest number of people are presently located in central Mangaung.

In future, the increase is visible along the N8-Corridor, the CBD, and also in the "7 Land Parcel" projects of Estoire, Hillside View, Vista Park 2 and 3, Brandkop, Pellisier and Cecilia.

A further increase of population is also expected in the Langenhoven Park/ Woodlands Estate/ Rayton area to the north-west of the city.

From Figure 7-13, it is evident that apart from the CBD, the highest residential densities are found in a north-south direction in Mangaung along Maphisa Road (Phahameng, Kagisanong). Future densities will increase along the proposed Phase 1 of the BRT, as well as in most of the suburbs in general, as infill and redevelopment take place.

Figure 7-14 illustrates the total number of formal workers per traffic zone in the Bloemfontein urban area. As expected, the highest concentration of formal workers is found in the CBD and surrounding zones, as well as in the Hamilton Industrial area. It is expected that apart from the growth in the CBD, and the old Zoo redevelopment, the new Kwaggafontein/ Cecilia node will also be a prominent node in future.

Figure 7-15 illustrates the formal worker density per hectare per traffic zone, and it is evident that the intensity of economic development is the highest in the CBD and surrounding zones (existing and in future).

DISTRIBUTION OF POPULATION 2015 and 2036

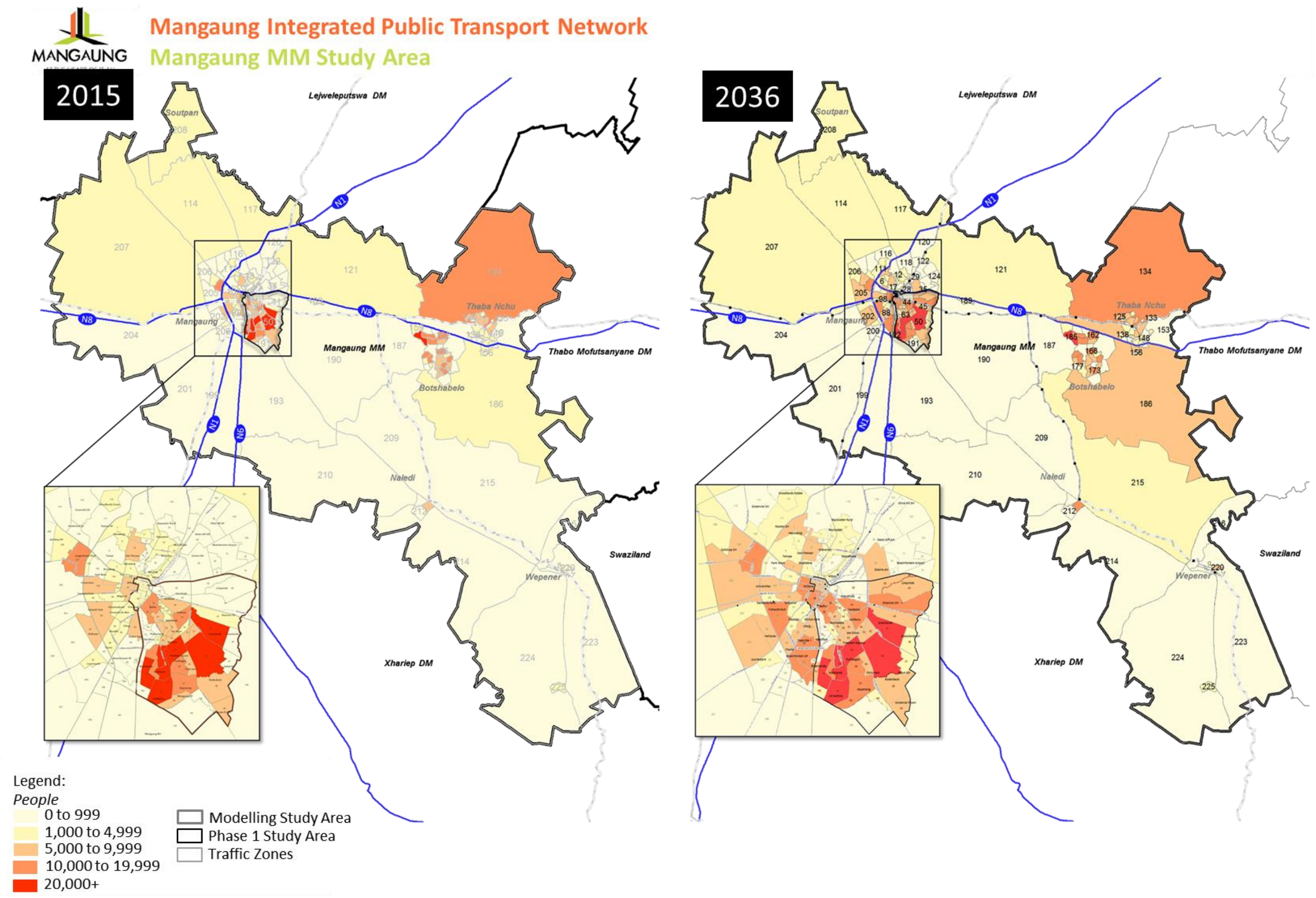


Figure 7-11: Mangaung MM Study Area – Population per Traffic Zone, 2015 and 2036

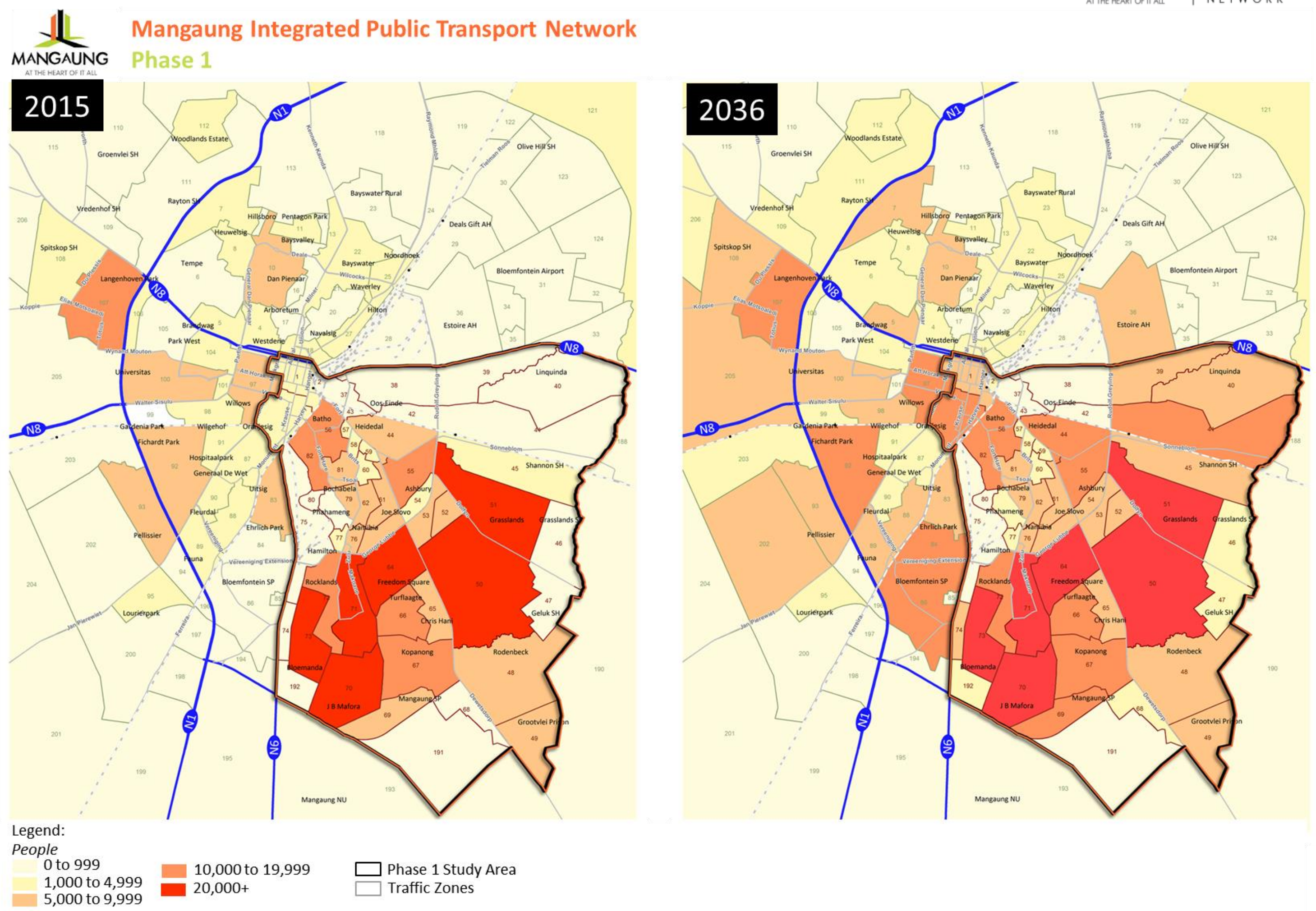


Figure 7-12: Mangaung MM Study Area – Population per Traffic Zone, 2015 and 2036

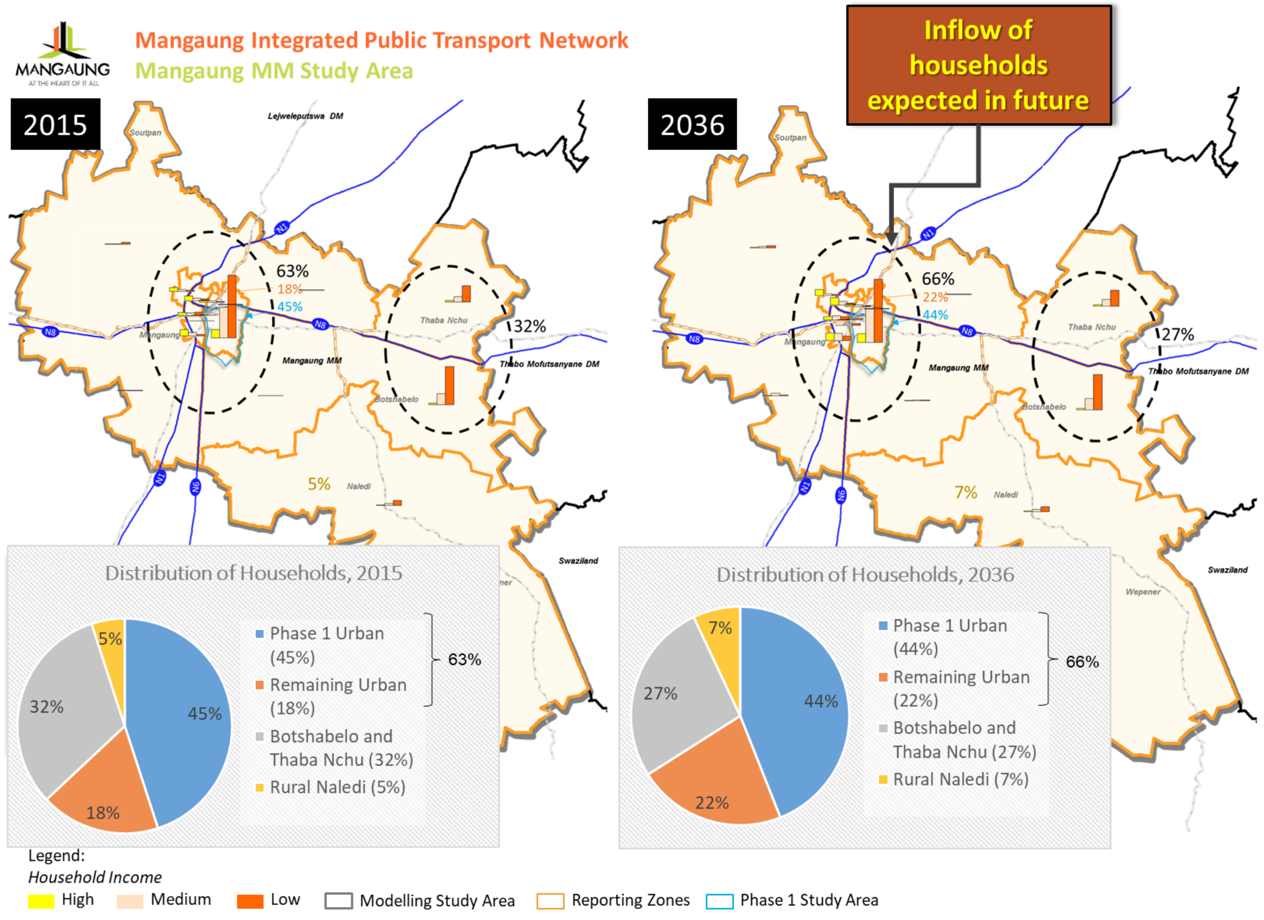


Figure 7-13: Residential Density: (Dwelling Units/ha) 2015-2036

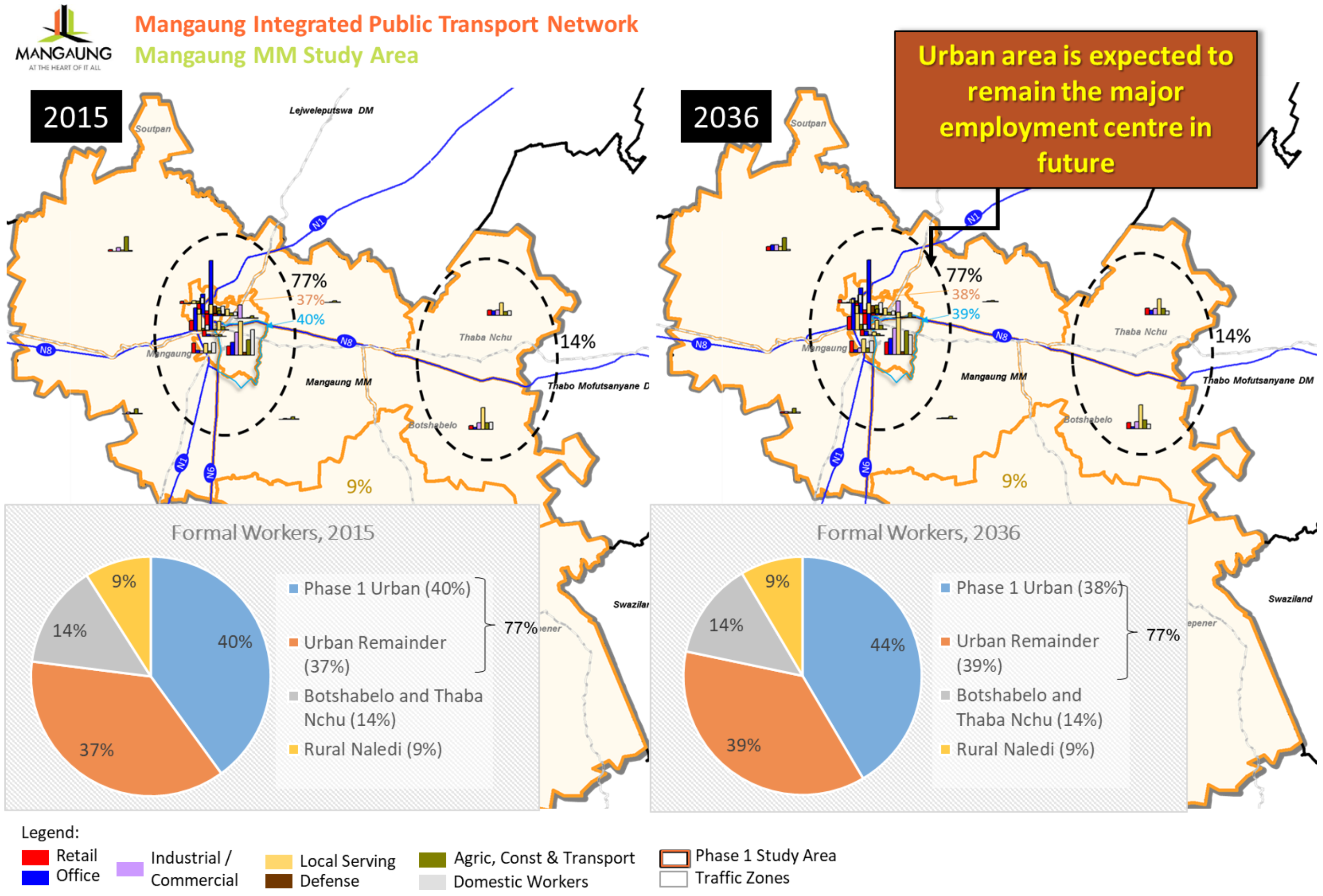


Figure 7-14: Number of Formal Workers per Traffic Zone 2015-2036

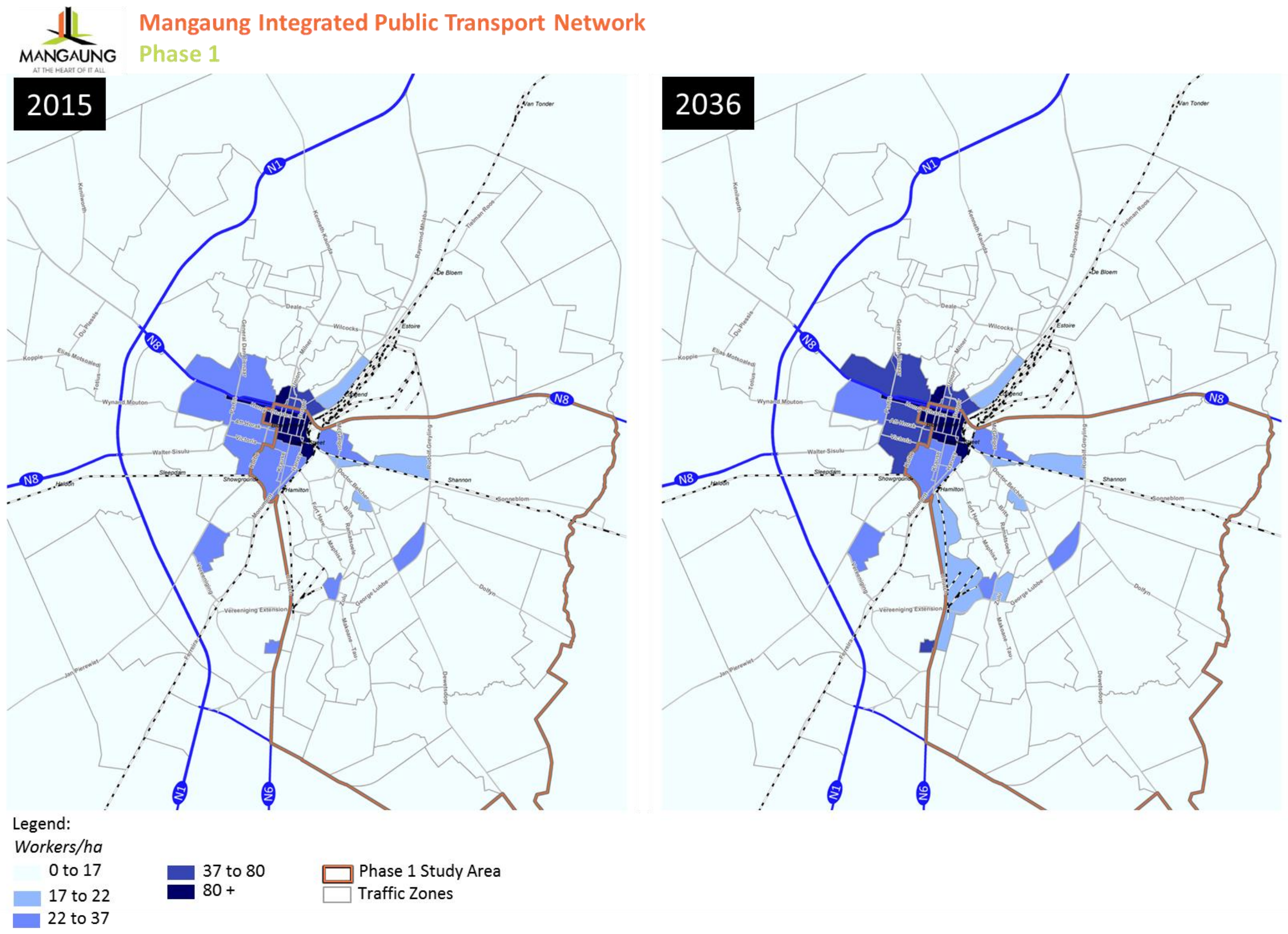


Figure 7-15: Formal Workers Density per Traffic Zone

7.2 Observed Demand

Observed demand is the public transport demand (persons observed travelling) derived from infield transport surveys. The observed demand was obtained through traffic surveys commissioned from March 2016 to November 2018. The detail pertaining to survey methodology and results are presented in Volume 2 of the IPTN report.

To determine the demand and to validated the assignment of the public transport matrix, count positions are planned and selected where public transport corridor (movement) converge. These are usually where main roads intersect or at main access points to the CBD, retail or residential areas. These points selected from the surveys are presented in Figure 7-18 (Bloemfontein) and Figure 7-19 (Botshabelo and Thaba Nchu).

A combination of vehicle occupancy classified link counts (12-hour) and 7-day electronic counts were used in determining the peak period and peak hour public transport passengers. The total AM peak period public transport passengers derived from the surveys are presented in Figure 7-18 and Figure 7-19 and was used to verify the public transport matrix assignment. The detailed calculation and validation process are detailed in Annexure J.

During the AM peak hour, the majority (80%) of person trips observed are **towards** the CBD, while during the PM peak hour the directional split varies at most of the selected count positions with the majority (>60%) of person trips **from** the CBD.

The survey analysis further indicated that the peak hour factor or the percentage of the total number of trips made within a specific hour during the peak period (3-hours) are evenly spread across the 3 hours within the peak period. In other cities, the peak period is characterised by one peak hour where more than 45% of passengers are made in the specific hour. The implication of this is that a large number of public transport vehicles are only utilised within the specific peak hour and not during the rest of the day.

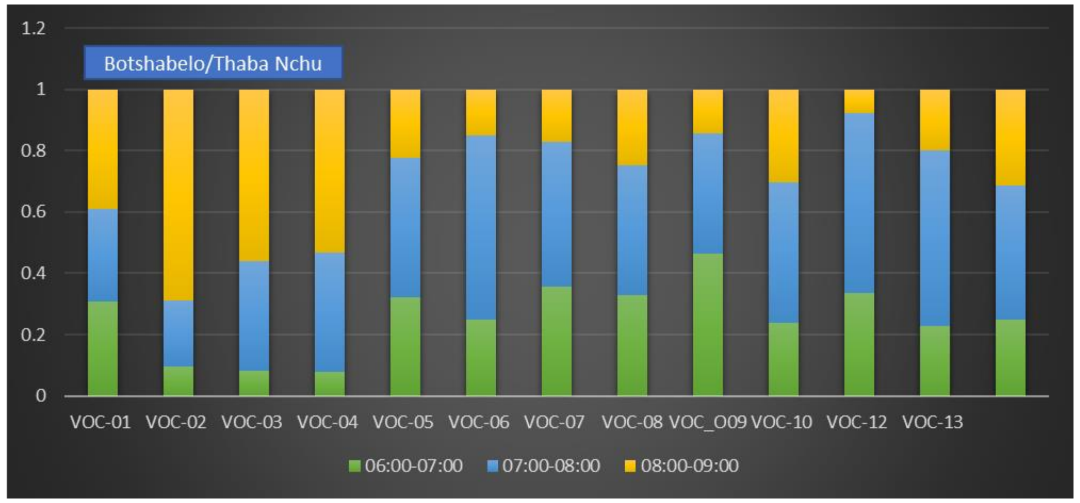


Figure 7-16: Public Transport Passenger AM Peak Period and Hourly Spread per Count Site 2017

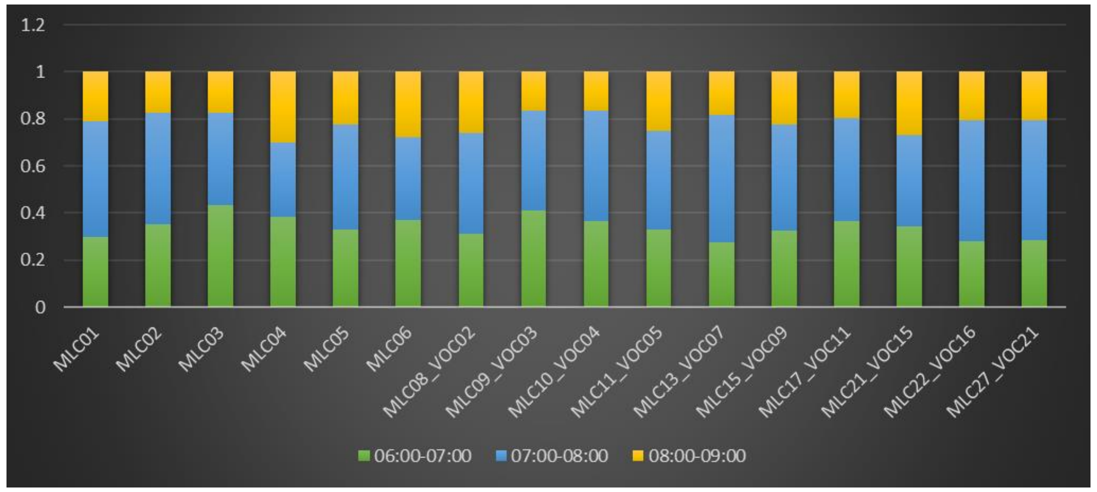


Figure 7-17: Public Transport Passenger AM Peak Period and Hourly Spread per Count Site 2016

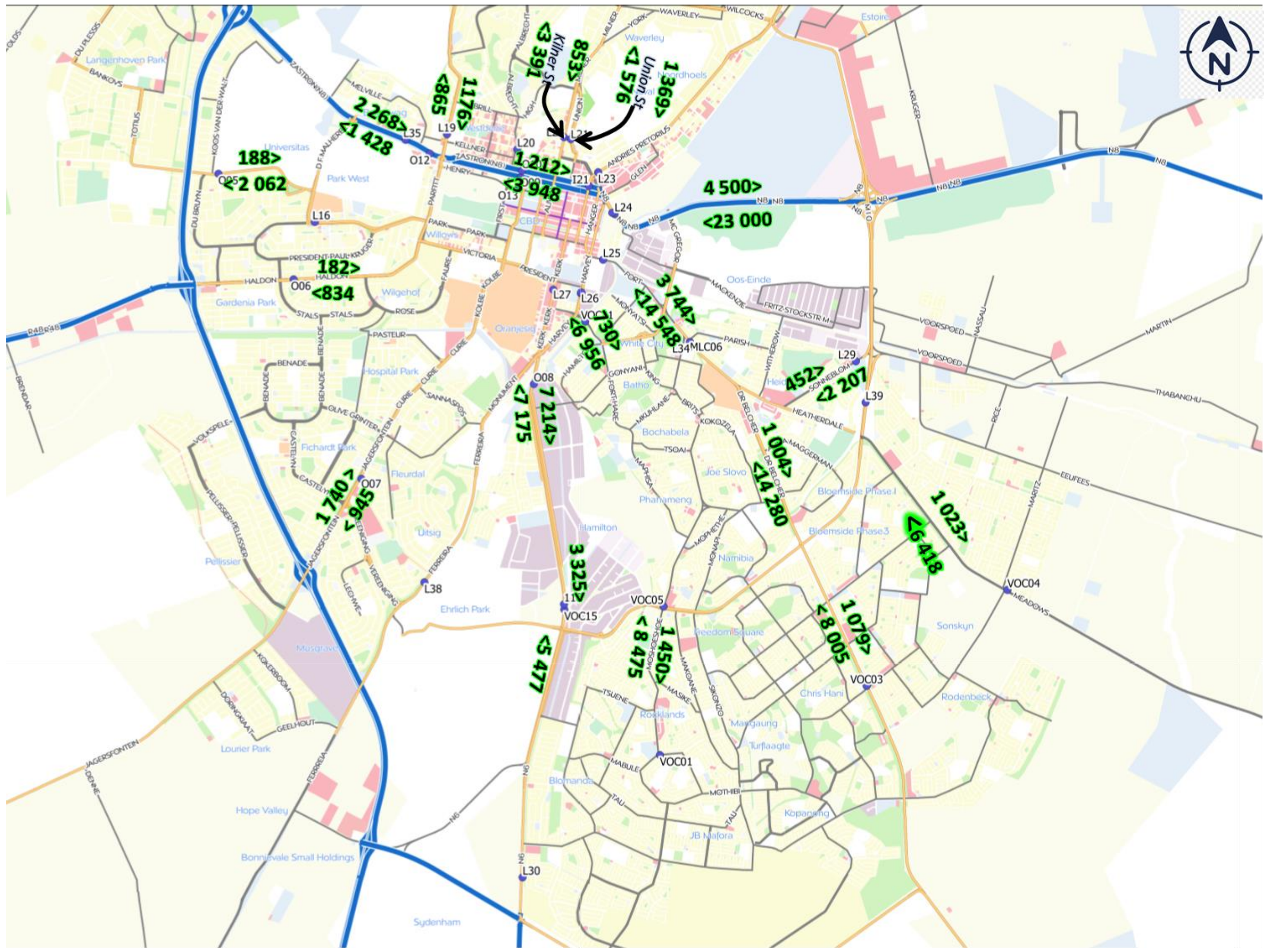


Figure 7-18: Bloemfontein/Mangaung - AM Peak Period – Observed Passenger Volumes

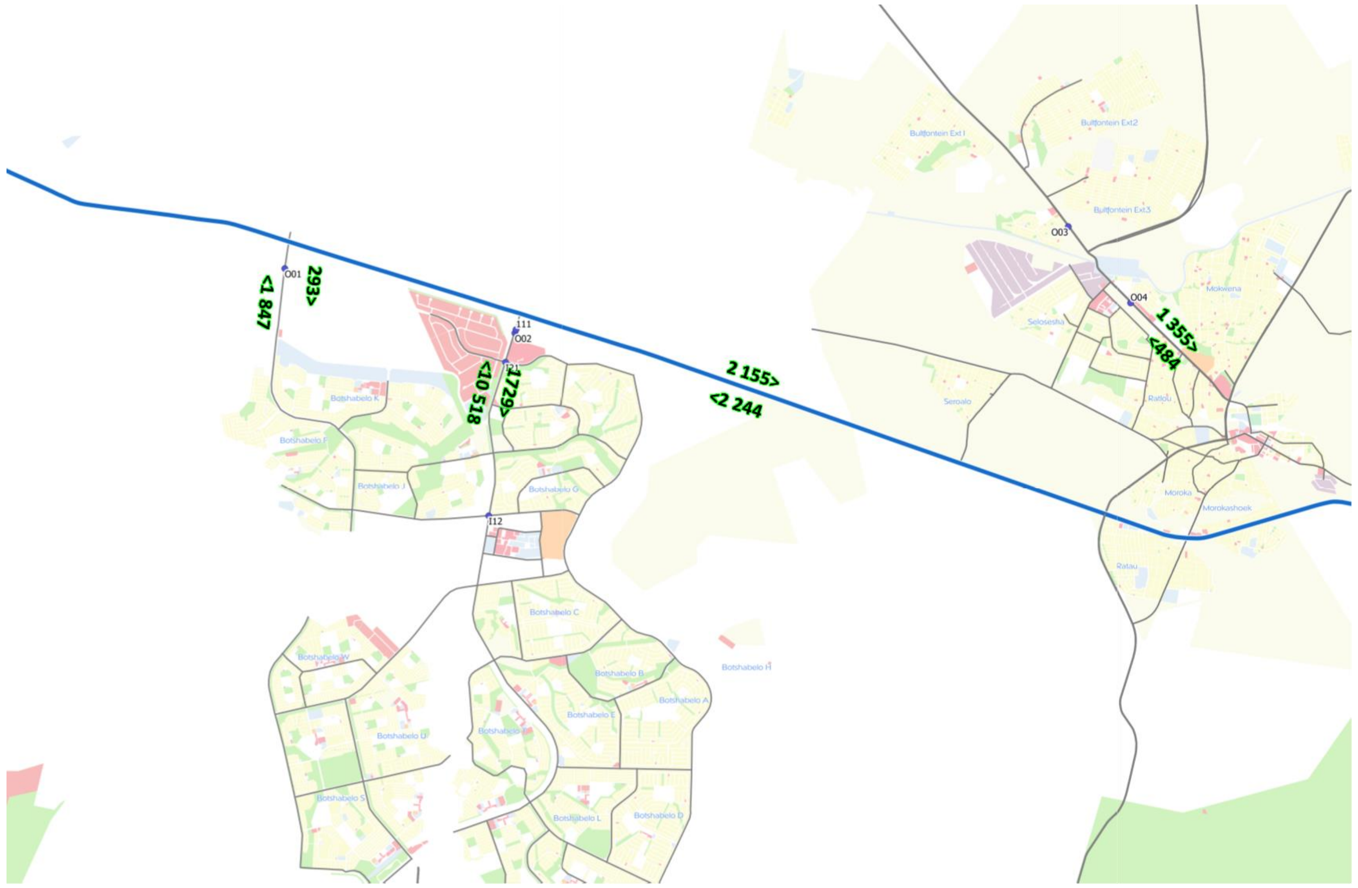


Figure 7-19: Botshabelo/Thaba Nchu - AM Peak Period – Observed Passenger Volumes

8 Public Transport Matrix Estimation Approach and Methodology

An EMME/4 multi-modal model was developed in the previous phase of planning, but as a planning tool, it had certain limitations in its application, evidenced by demand forecasts that seemed to significantly overestimate ridership on the planned IPTN service. This is not unique to Mangaung but has also been the experience of other Cities planning to implement IPTN and BRT. Some of the limitations include that the land use data and zoning system was relatively course, the public transport matrix could be improved with new data not available at the time, and there was some uncertainty on the accuracy of the competing bus and taxi routes coded, based on the information available at the time.

The possibility of substantially improving/refining the previous mode choice (EMME/4) model was explored, but although certain new data is now available (e.g. on existing public transport systems and trip rates from the household travel survey data (HHTS)), other key data such as Stated Preference Surveys is not, and much of the constraints relating to land use and data and data on the existing, competing modes, remain somewhat uncertain and a challenge. The EMME/4 model is also a mode *choice* model, whereas in the Mangaung context, the introduction of new IPTN Services is not so much deemed to be a new mode (competing against competing modes remaining on the network), as it is deemed a *rationalisation* mode (replacing the shape and form of existing services) and is therefore not necessarily the optimum tool for the purpose. Furthermore, the time and budget constraints, and the fact that a Stated Preference Survey (which is needed to calibrate the mode choice model to ensure it is fit for purpose) will not be carried out, made this option impractical.

An alternative approach to quantify the potential demand on the system, was therefore proposed to and agreed with the MMM. This methodology estimates demand from first principles (as has been done in the development of the Phase 1 Operational Plan (April 2017)) but refining the methodology to incorporate the new HHTS data. The approach shifts from modelling *mode choice* (between existing modes on the same corridor and the new, competing mode) using a conventional demand model, to basing the demand estimates purely on the portion of existing public transport users that will be served geographically by the new system (which is planned to incrementally replace the existing services), vs the portion that will need to continue to use their existing mode until the new services cover their area as well. This is determined by analysing the surveyed and observed movement patterns between key zones, against the proposed services that would be provided in these zones, in the various stages of roll-out of the larger network.

The focus of this approach is therefore to get the *public transport passenger origin-destination matrix* as accurate as possible (from a combination of data from the household travel surveys, the classified counts and vehicle occupancy counts, and the on-board taxi surveys) and to make informed assumptions on the services that can realistically be implemented per the planned roll-out or phasing plan, based on the assigned demand patterns revealed by the analysis.

SATURN modelling software was used for the following:

- Matrix editing (it is not practical to do in a spreadsheet format due to the format of >50 000 records per matrix and a number of matrices are needed) and estimation.
- As an assignment tool, to assign the passenger demand matrix onto the network
- Validation and calibration of the model using the built-in statistical analysis tools
- As an analysis tool (e.g. select link analysis) to disaggregate total link flows to origin-destination flows in order to draw conclusions on connectivity, route choice and estimated ridership by link and on key OD pairs served by the proposed services and
- Visual representation of results for reporting purposes (data was exported to GIS for this purpose)

It should be noted that SATURN was therefore not applied in its conventional capacity (a traffic model simulating the performance of intersections under the given vehicular traffic demand) but instead was essentially used as an assignment tool and for its analysis capabilities. A peak period person trip matrix of all the current public transport users was developed. The person trips were then assigned to the network in an all-or nothing assignment, to simulate and visualise people's travel desire lines as recorded in the Household Travel Survey data. The all-or-nothing assignment assigns trips to/from each origin-destination pair, to the route with the shortest travel time, with no capacity constraints. The assignment and subsequent select link analysis provide valuable insights into the current public transport movements or patterns, which is not always evident when only the link volumes on key corridors are looked at.

8.1 Assignment network and zone connectors

The existing link-based EMME/4 model was converted into SATURN format (buffer network) and reviewed for correctness in terms of continuity and coverage. Where key routes on the public transport network were missing due to the coarseness of the more strategic nature of the previous EMME/4 model, additional links were added. New links were also coded to extend the network to include the main roads of interest in Botshabelo and Thaba Nchu. Furthermore, future planned roads were removed from the base year network.

The EMME/4 link classification was not relevant to the purpose for which the network is developed, and all links were therefore reclassified into new categories, to more easily assigning link speeds (average public transport travel speeds).

The link speeds of public transport trips per type of road were calculated for each mode and weighted by the number of passengers on each mode, extracted from the HHTS data. This was done by dividing the distance of each public transport trip (calculated from the origin and destination coordinates that were geocoded in the questionnaire) by the reported travel time. The trips were classified into two categories, namely trips under 30km and trips longer than that since the long-distance trips are at higher average speeds. The in-town routes (in Bloemfontein and the built-up areas of Botshabelo and Thaba Nchu) were coded as 20km/hr and all long-distance roads (e.g. links between Botshabelo or Dewetsdorp and Bloemfontein) as 70km/hr.

The link capacity (normally set in vehicles per hour) was not relevant in the assignment of the passenger flows, since the all-or-nothing assignment assumes unlimited capacity. However, the correct link length is important to ensure the modelled travel time of each route is realistic, and that the relative travel time difference between alternative routes are reflected. This was checked and where necessary corrected, using data extracted from GIS and/ or calculated for each link in SATURN, using the node coordinates.

The previous EMME/4 model's zones were completely different from the zones used in the land-use model and HHTS and were thus discarded. The zone coordinates for the new zones (please refer to Figure 8-2) were imported, and a set of new zone centroid connectors linking each zone to the network was coded.

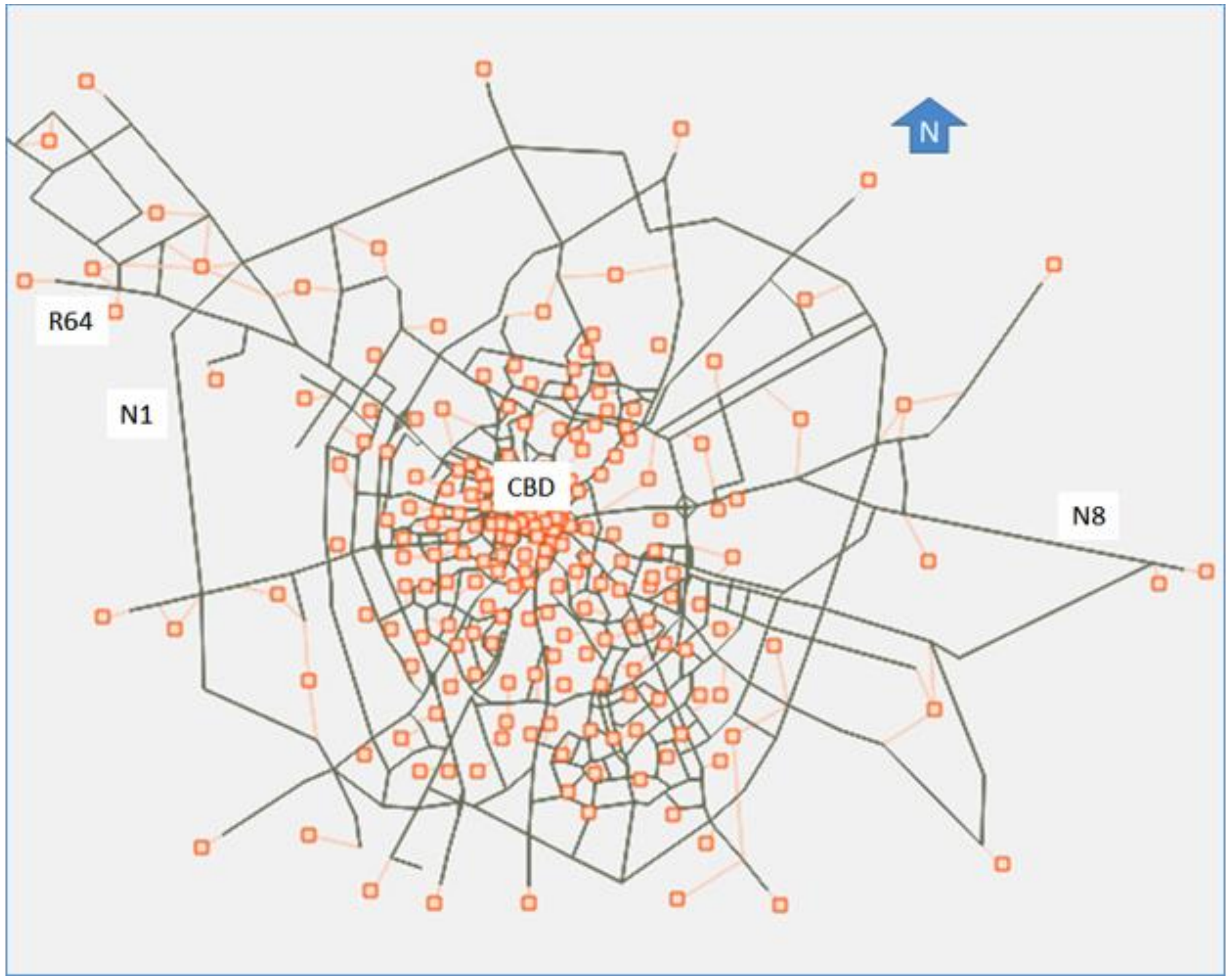


Figure 8-1: EMME/2 Model Network Extent

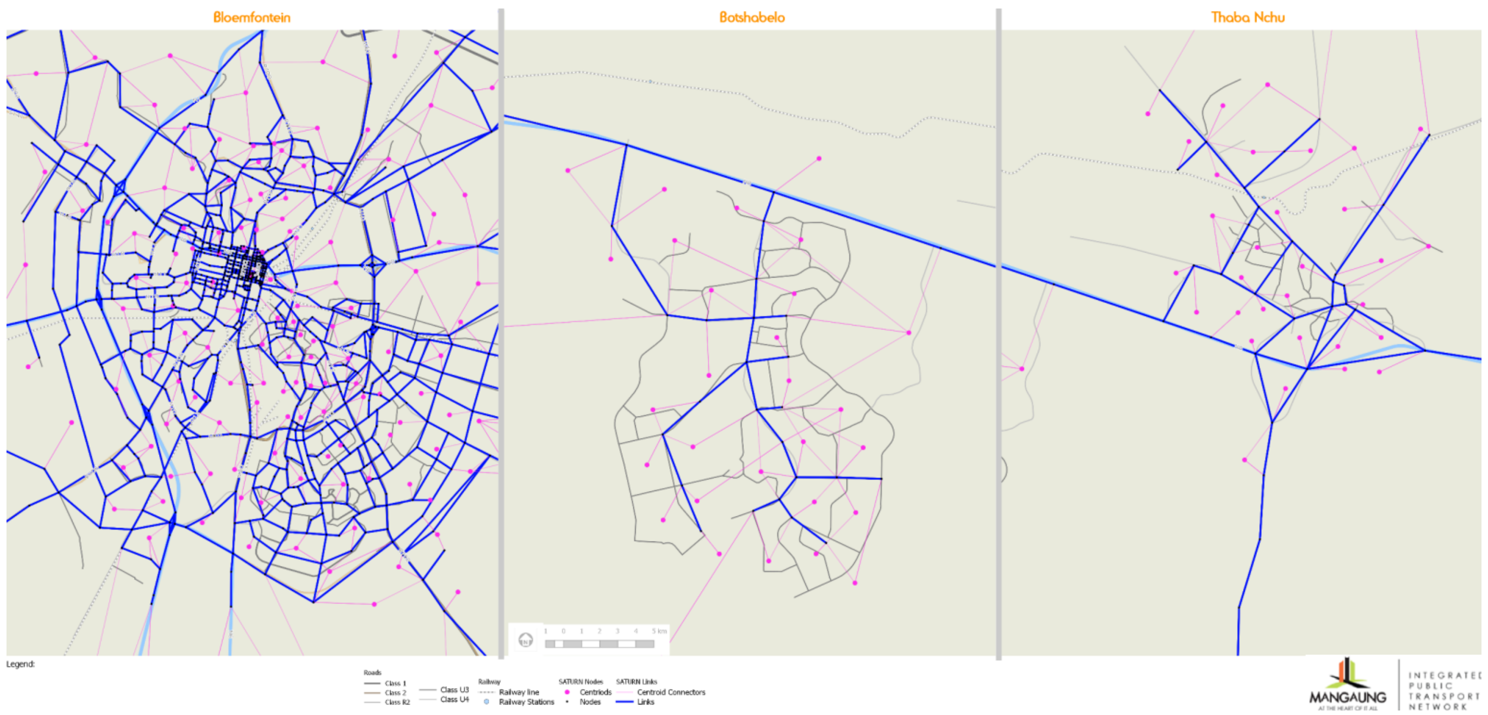


Figure 8-2: SATURN Network and Zones

8.2 Base Year Public Transport Trip Matrix Estimation

8.2.1 Matrix Estimation Approach

SATURN's matrix estimation module SATME2 was used to develop the base year trip matrix. SATME2 updates the initial base year trip matrix (hereafter referred to as the 'prior matrix'), using the available traffic counts.

The model uses an iterative procedure to find a set of balancing factors for each counted link to ensure that the assigned flows match the counts within certain user defined limits. The matrix estimation program SATME2 produces a trip matrix which is the best fit to available count data while at the same time remaining as near as possible to the initial trip matrix.

The prior matrix is the matrix extracted directly from the scaled Household Travel Survey data, as discussed in more detail in the following section.

8.2.2 Trip Data

The HHTS data consist of three datasets, namely:

- **Household data** (e.g. household size, vehicle ownership, mode choices to access services, income and transport expenditure etc.)
- **Person data** (data on each household member, e.g. gender, age, education, work status or occupation, and daily trip making characteristics (high level) by mode over seven days)
- **Trip data** (detail per trip, e.g. mode, purpose, start time and duration, walk component, trip cost, and origin and destination, etc.). The trip data portion of the questionnaire asked about all trips of all household members older than six years, on a specific weekday.

The base year matrix was developed from the **trip data** in the HHTS data, by extracting the number of person trips done on all modes of public transport, and for all purposes, during the *morning peak period*.

The distribution of trips from this dataset is shown in Figure 8-3. On average, this data indicates a total of 2.01 trips per person daily. The unusually high peak between 7:00 and 8:00 (62% of the peak period flows) is discussed later in this section.

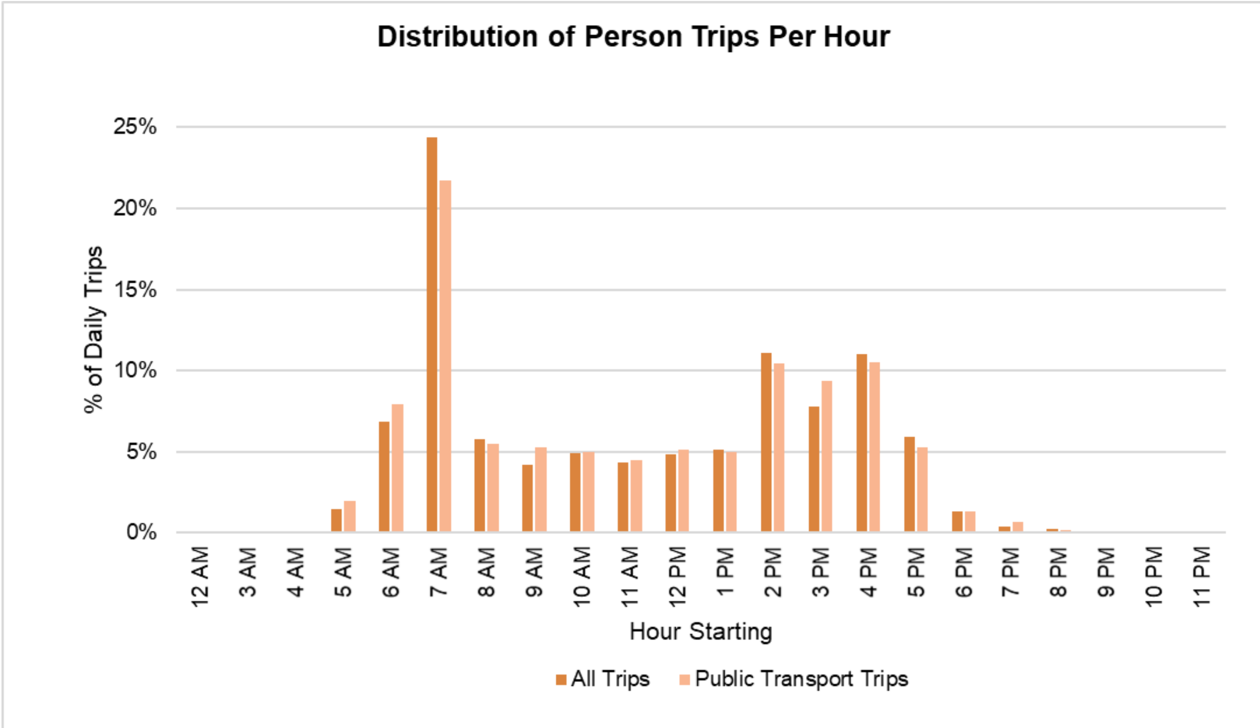


Figure 8-3: Trip Distribution from Trip Data

The daily trip rates from the trip data source were also compared to the daily trip rates recorded in the **person data**, which recorded all trips by all household members, over a 7-day period. This is shown in **Table 8-1**. According to this dataset, the average weekday trip rate is 1.32 – only 66% of the daily trip rate from the trip data set. Given that the trip data from the HHTS when assigned to the network gave flows that were significantly larger than what was observed in the count data, the matrix was factored down by this factor, to account for the discrepancy between the two datasets.

Table 8-1: Daily Trip Generation by Mode from Person Data

Mode	Mon	Tue	Wed	Thu	Fri	Sat	Sun	Grand Total	Average Weekday	Ave. Weekday %
4+1	9,978	6,882	5,559	8,842	6,705	7,552	5,758	51,276	7,593	1%
Animal	0	0	0	0	0	0	0	0	0	0%
Bakkie Taxi	5,354	3,981	4,057	3,869	5,775	2,711	3,149	28,896	4,607	0%
Bicycle	4,705	32,604	11,189	10,692	11,230	8,125	1,360	79,904	14,084	1%
Bus	50,186	44,088	45,616	50,984	57,437	21,633	16,657	286,602	49,662	4%
Car Driver	213,318	202,355	205,859	199,785	205,176	112,535	102,537	1,241,563	205,298	17%
Car Passenger	82,823	81,963	85,675	78,369	84,606	43,055	56,879	513,371	82,687	7%
Company	14,620	14,634	15,670	14,803	12,970	4,277	2,290	79,264	14,540	1%
Lift Club	20,708	20,195	19,975	21,378	19,868	3,574	4,978	110,676	20,425	2%
MBT	236,155	215,374	229,268	217,039	225,784	78,347	71,653	1,273,621	224,724	18%
Meter Taxi	1,074	1,190	1,263	1,829	1,144	1,150	0	7,650	1,300	0%
Motorcycle	576	783	1,510	525	783	2,057	325	6,558	835	0%
Other	385	174	24	333	2,012	666	0	3,594	586	0%
Schoolbus	73,279	71,033	72,306	75,203	70,403	1,531	3,064	366,820	72,445	6%
Walk	560,658	531,466	534,712	546,830	489,867	199,094	207,446	3,070,073	532,707	43%
Grand Total	1,273,820	1,226,722	1,232,683	1,230,481	1,193,760	486,309	476,093	7,119,868	1,231,493	100%
Population	930,495									
Trips per person per day	1.37	1.32	1.32	1.32	1.28	0.52	0.51	7.65	1.32	

Initially, the origin-destination trip data was extracted for the *morning peak hour*, since this is the flow that will determine the optimal mode and size of vehicle needed, governing the fleet needed to serve passenger demand during the busiest hour. However, when the first assigned flows were compared to counted traffic flows, there were significant discrepancies and after further analysis it was deducted that the accuracy of the HHTS relating to interviewees' recollection of start time of their trips, maybe suspect, resulting in an unrealistically high peak hour (62%of the peak period trips occurring in the peak hour), as illustrated in Figure 8-3.

For this reason, the data were extracted for the full 3-hour morning peak and the peak hour data was later factored, using factors derived from the *traffic count data* instead. Table 8-2 indicates the distribution of the trips in the three morning peak hours from the traffic counts. The three-hour peak period flow was therefore factored by 44% instead of 62% to obtain peak hour flows.

Table 8-2: Distribution of Peak Hour Traffic within the Peak Period

Area	6:00 – 7:00	7:00 – 8:00	8:00 – 9:00	Count Year
CBD, Western Areas and Botshabelo	25%	44%	31%	2017
South Eastern Quadrant	34%	44%	22%	2016
Recommended Factor	26%	44%	30%	100%

The difference in Peak hour in Botshabelo area versus city:

CBD	32%	50%	18%	2017
Western Quadrant City	31%	51%	18%	2017
Botshabelo	14%	32%	54%	2017

The number of trips by time of day, by mode and by trip purpose, is included in the tables in Annexure K and Annexure L. The prior trip matrix (before matrix estimation and adjustments made in the course of the validation process) is included is Annexure M.

8.2.3 Validation of Trip Matrix

Validation is done to give a measure of the goodness of fit of the modelled to the observed phenomena, both in specific areas of the network and over the network as a whole. In all models, errors may be present in the network coding (for example missing links or centroid connectors that distort the modelled flows), the matrix (e.g. HHTS data issues) or in the observed data (counts).

Many of these errors are only picked up in the validation stage and it is an iterative procedure between estimating the matrix and validating its outputs (the assigned passenger flows) against the observed flows.

Errors in the observed data are very common, and modelled flows might also highlight incorrect counts. In this case, counts were also done on different days of the week, and in different years and it is not unusual to have a variation of 10% or more in traffic counts carried out at the same intersection at different times.

In terms of the origin-destination (O-D) data, it is a limitation that the HHTS confidence levels are acceptable on the reporting zone level (16 reporting zones), the latter being used to determine the sampling rate. However, this more aggregate sample rate unfortunately means that the confidence level of the O-D data on the smaller zone level (225 zones) is lower. For example, many OD pairs will show no trips because the sample is too small to pick up the smaller flows with any accuracy, but this is compensated for by 'seeding' the zero cells with a very small value in the prior matrix to ensure these OD pairs can be factored up in the matrix estimation process to more closely correspond with counts indicating small flows between such zones. Care should, therefore, be taken when interpreting data on the TAZ zone level, taking cognisance of the limitations of the HHTS data.

The purpose of a modelling tool should be considered when assessing the acceptability of its validation. No model can be expected to represent reality completely (it is by nature a simplification) except within a range or tolerance. The level of precision that is sought needs to be commensurate with the accuracy or precision of the input data, and it is important to ensure the accuracy is adequate for the decisions which need to be taken, that decision makers understand the quality of the information with which they are working and that they take into account the inherent uncertainties in reaching decisions.

Given that the assignment tool is not a conventional demand model, the validation focussed on scaling the matrix correctly so that the overall number of public transport trips observed on the network on the key corridors of interest corresponds with the observed flows in these locations. The AM model's R-squared (R^2) statistic and a scatterplot visually indicating the correspondence is used for this purpose.

The assigned passenger flows were validated against estimates of passenger demand from the classified counts and applying the surveyed vehicle occupancies of the various modes on the key public transport corridors (occupancy counts were available at 43 locations that were surveyed between 2013 and 2017).

The relative number of trips originating and ending in each zone were also inspected visually to identify any obvious discrepancies. For example, it was noted that a very high number of trips end in Zone 187, the rural and mostly open land west of Botshabelo. On closer inspection of these records, it appears that many of them have "Botshabelo" as its only locational identifier and these were therefore reassigned to Zone 165 since this is where the main transport hub and shops are, and in one of the land use shapefiles it is identified as "CBD". The records with some information in the street or suburb column indicating the sub-area, were assigned as follows:

- Ext E/ Jazzman: Zone 168
- Ext F: Zone 185
- Ext H: Zone 162

Lastly, select link analysis was done to and from the zones with higher trip generation and/or attraction, to visually identify any obvious anomalies.

Comparison of modelled flows with passenger flows estimated from counts

A very large database of counts, done in a number of different years over the past five years was available to use. A subset of 50 counts on the key links was selected for the validation of the matrix and flows assigned from it. These are indicated in Figure 8-5.

Where the flows differed significantly from the counts, counts were scrutinised to ensure they seem correct since there were a few places where the count quality was previously identified as suspect (independently from the modelling). For example, VOC 1 – 4 AM count data seemed far too low when compared to the flows emanating from the HHTS data, and checked against bus data obtained from IBL, and bus and taxi vehicle counts. It was therefore decided to use the PM peak counts with the directions swopped instead. However, it is recommended that new counts be done with sufficient quality control to ensure this critical input is correct, if possible. In the final validation, two of these counts were removed from the subset of 50 since it is clear it is not accurate.

Examples of other changes made to the network and or zones during the course of the validation are as follows:

- The grade-separated “interchange” at the intersection of M10/Sonnebloem did not allow all movements so additional links were coded to correct this
- Adjustment of zone connectors to more accurately reflect how trips enter or exit into/out of an area given the road network that is coded
- Some very large zones were split into smaller zones (for example Zone 50) to ensure a more realistic distribution of trips on a larger number of links instead of a very concentrated point of entry or exit.
- The flows in the off-peak direction were initially too low in most locations. Given the small sample size per zone, it is believed that the HHTS underestimated the number of trips between zones in the off-peak direction. The AM prior matrix was therefore transposed and multiplied by 10% (based on analysis of the counts), and this was added to the prior matrix, to “seed” some of the empty cells with slightly bigger numbers than the flat seed value previously used on the empty cells. This corrected most of the off-peak direction issues and resulting in an excellent fit.

The comparison of modelled and observed flows of the final validated matrix is shown in Figure 8-4 and indicates a high level of correlation, indicating that the matrix estimation process was able to adjust the prior matrix to accurately match the observed flows.

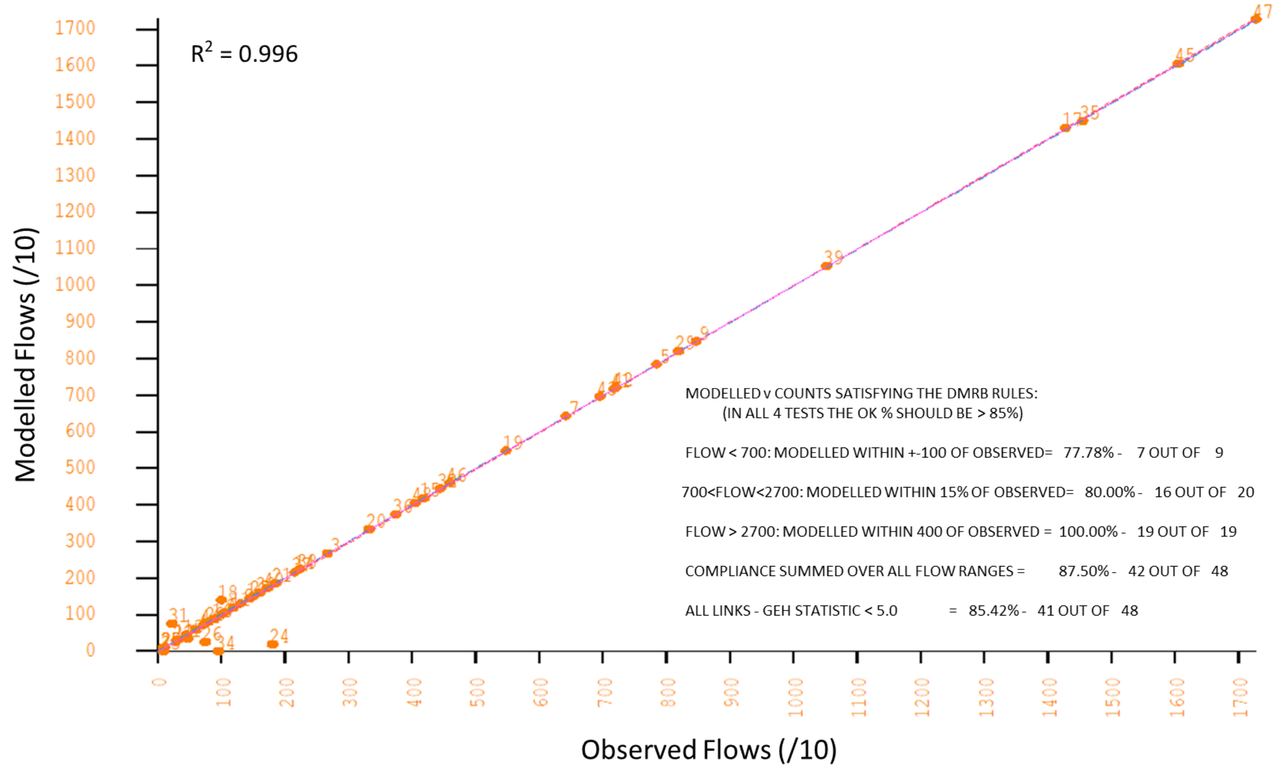


Figure 8-4: Goodness of Fit – Comparison of modelled and observed flows.

8.2.4 Validation Conclusion

As the assigned flows correspond closely to the observed flows, it was concluded that the modelling tool reflected reality sufficiently for the purpose it was developed for, and the final base year AM network was therefore deemed fit for purpose.

The hourly person trips link volumes when the base year peak period public transport matrix is assigned to the network, and factored to the peak hour, is indicated in Figure 8-6. The Base Year, validated matrix is included in Annexure N and the assigned trips to the network is provided in Annexure Q.

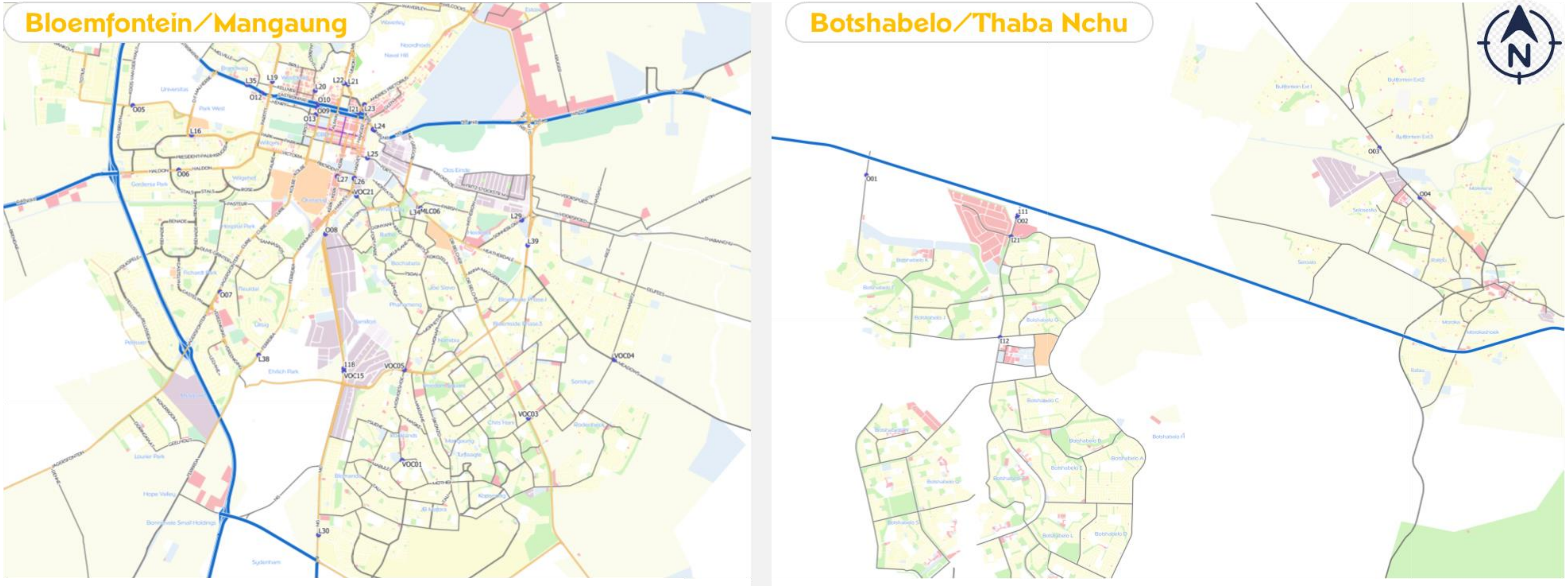


Figure 8-5: Location of Counts used for Matrix Validation

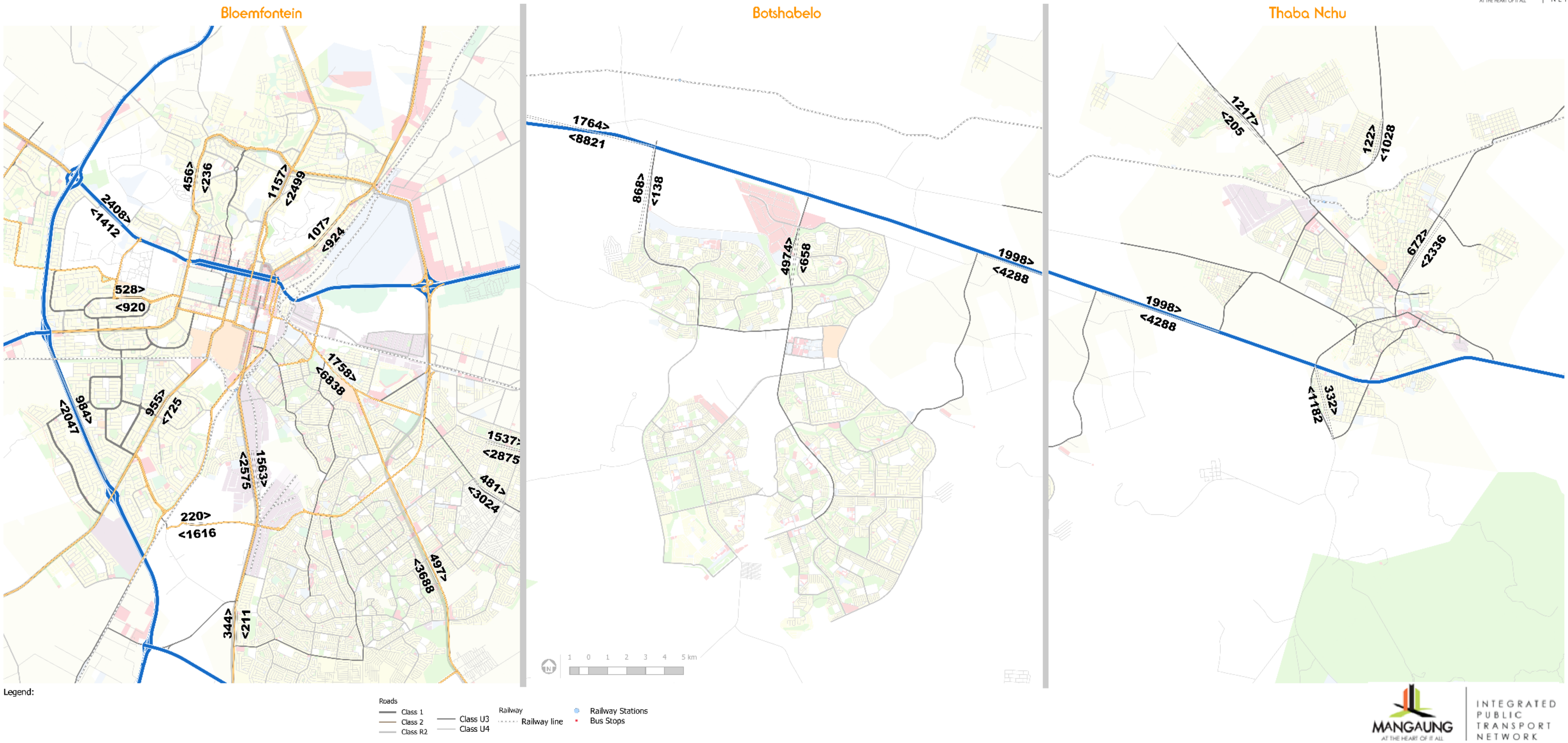


Figure 8-6: Base Year Public Transport AM Peak Hour Link Flows (person trips)

8.3 Future Year Matrix

8.3.1 Approach

Two horizon year matrices were developed, namely for 2025 and 2036, using the land use growth forecast for each zone as the basis. The horizon year land use is discussed in more detail in Section 4, but the forecasts provided the expected future population and number of jobs for each zone, and the input data is included as Annexure O. Reference was also made to a number of TIAs done for planned developments.

The base year matrix was first factored up by multiplying the origin zones (rows) with the growth factors obtained by dividing the 2025 year zonal *population* by the base year population, and then by multiplying the destination zones (columns) by the growth factors obtained by dividing the 2025 year *zonal jobs* by the base year jobs (or 2036 by 2025 jobs for the 2036 horizon year matrix). This methodology assumes that the number of public transport person *trips* originating in a zone will increase in the same proportion than the *population increase* (in other words that the number of trips per person and the mode share of public transport remains constant over time). Similarly, in the morning peak period, the number of public transport *trips* ending in a zone, will grow proportionately to the number of *new jobs* expected to be added into a zone.

The exception to this approach was zones that are currently undeveloped or largely undeveloped (vacant land) that are earmarked for large new developments. Although the additional population and jobs forecast for these zones will result in a high growth factor, it cannot be applied to zones with zero trips or a very low number of trips in the base year matrix. The distribution of trips to/from these zones are also not likely to be realistic (it is unlikely to be reflected in the matrix, given the limitations of the sample size per Zone of the HHTS).

For these zones, the trip distribution of a similar fully developed nearby zone, or zones, with a similar character, were copied and proportionately factored to the relative proportions of populations in these zones. For example, Vista Park 2 is planned in Zone 84 (currently vacant), south of Zones 88 and 83. The base year trips to and from zones 83 and 88 were copied into a new temporary zone 840, to provide a basis for the distribution of trips to and from the new is 84. For example, if a certain percentage of trips from these zones ends in the CBD, it was assumed the same percentage of trips from the newly developed Vista Park would also go to the CBD. In this example, the total population of zones 83 and 88 is 4637 people (2015), while the expected population of Vista Park 2 is expected to be 3983 people, once developed. The temporary zone 840's trips were therefore factored by a factor of 3983/4637 = 86% and then renamed to zone 84.

For Zone 39, the site of the Mangaung Airport Development Node (South), or MADN(S), the destination trip distribution of the Industrial Zone 42 was used.

It was noted that some zones show a negative growth rate, but this was checked, and it was decided to leave it as is given that it originates from the land-use projections, which must have assumed some de-densification and likely the impact of migration to other areas in Bloemfontein or to other areas of South Africa.

The resultant 2025 and 2036 matrices are included in Annexure P.

8.3.2 Results Horizon Year 2025 and 2036

The growth rate per analysis zone is presented in Table 8-3 and the assigned person trips for the AM peak hour for the horizon year 2025 and 2036 are presented in Figure 8-7 and Figure 8-8.

The growth per annum is in line with the estimated growth projected as part of the land use and macro-economic studies projections.

Table 8-3: Percentage Growth per Annum per Analysis Area

	2025		2036
Phase 1 _Maphisa	1.5%		1.4%
OR Tambo	1.5%		1.4%
Dr Belcher	1.1%		0.5%
Botshabelo	1.0%		0.6%
Thaba Nchu	1.5%		1.4%
CBD	3.4%		3.4%
Circular Routes	1.9%		1.0%

MANGAUNG AT THE HEART OF IT ALL INTEGRATED PUBLIC TRANSPORT NETWORK

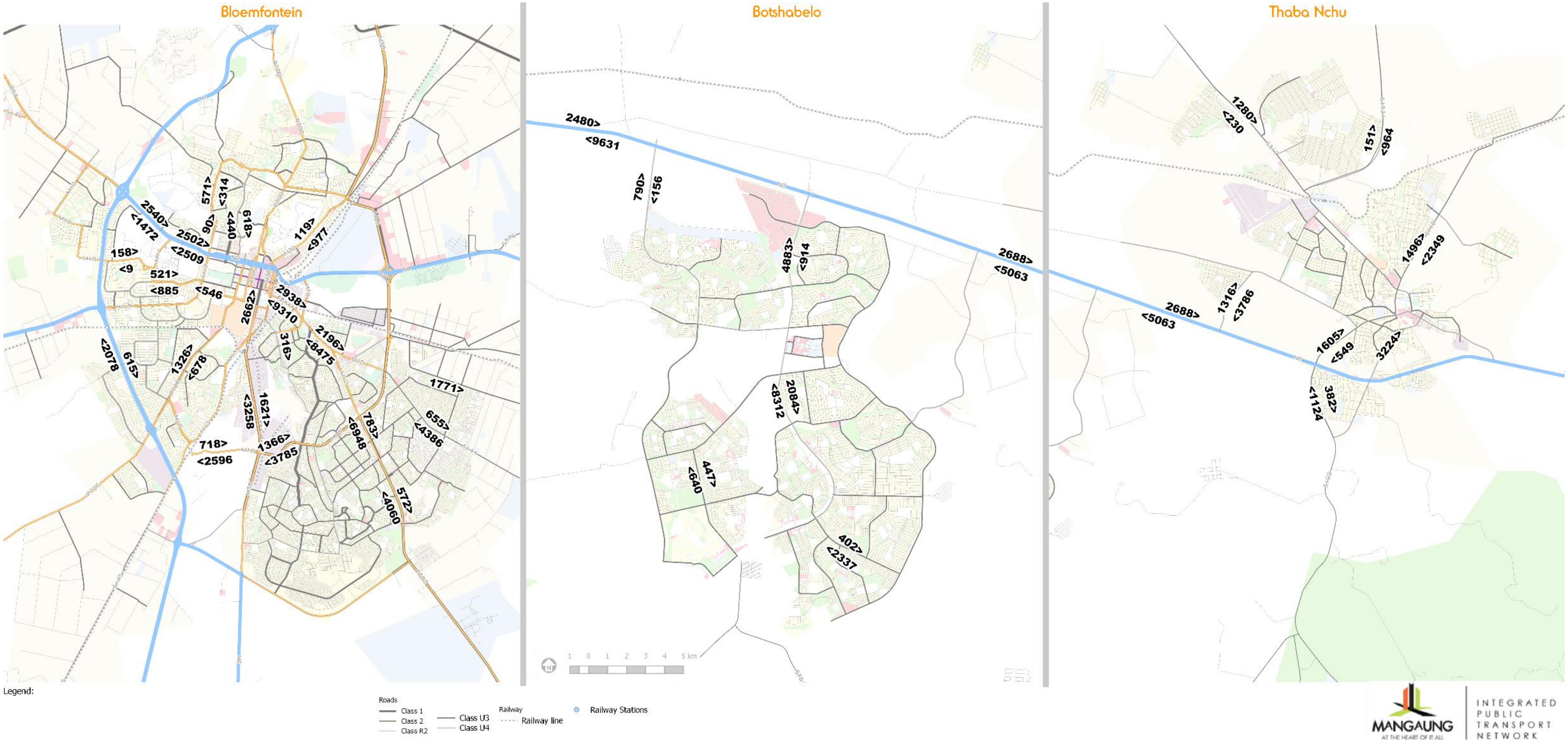


Figure 8-7: 2025 Full Implementation with long-distance trips - AM Peak Hour Person Trips

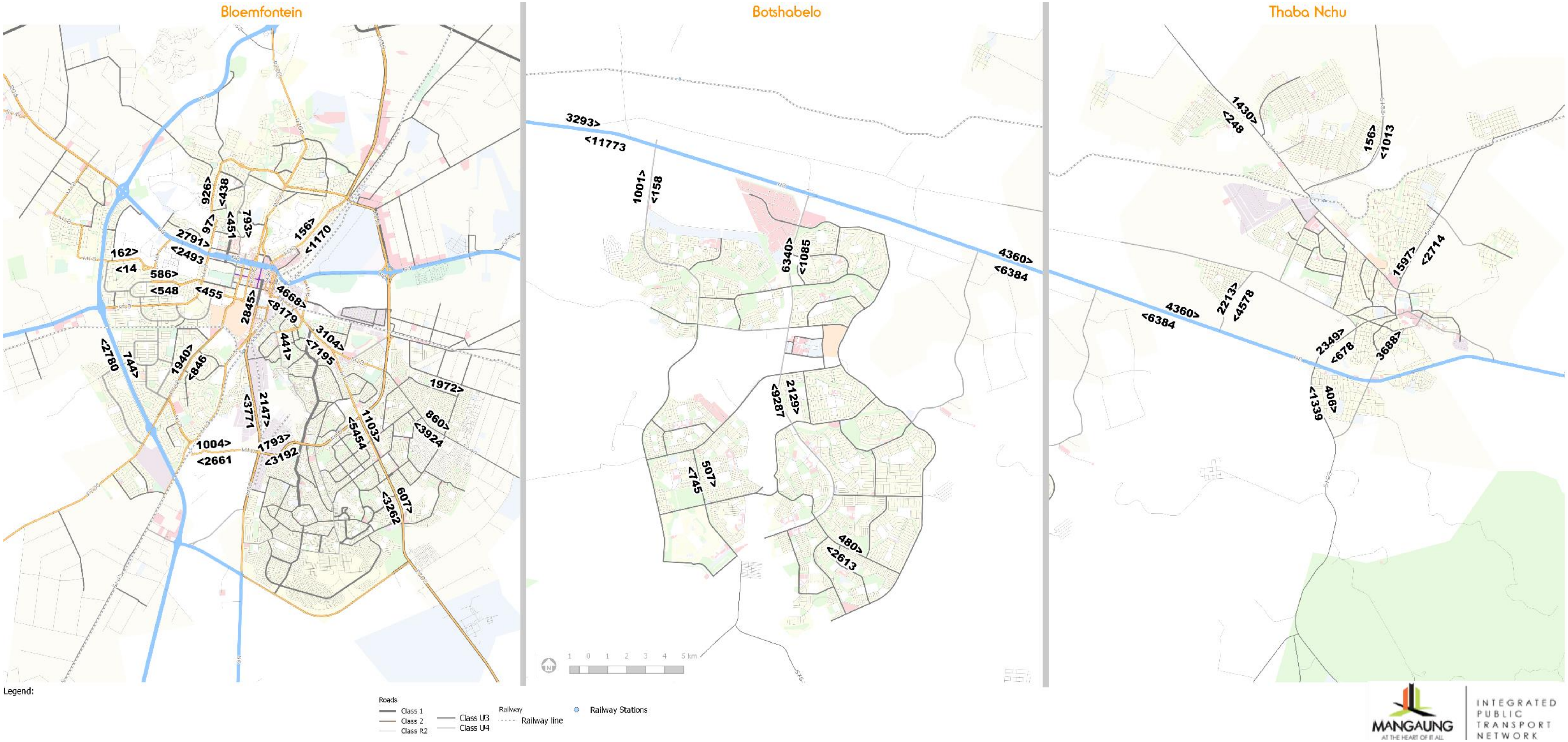


Figure 8-8: 2036 Full Implementation with long-distance trips AM Peak Hour Person Trips

9 IPTN Public Transport Demand Corridors

The primary and secondary movements were determined considering the city spatial structure and the possible movement between residential areas and areas where employment is provided. To detail these high-level movements, the main origin-destination pairs were derived from the assigned public transport matrix through select link analysis methodology. These main origin-destination pairs provide the demarcation of functional public transport corridors. These corridors were compared to existing public transport operators' areas and the functional corridors were demarcated.

9.1 Select Link Analysis

The select link analysis methodology disaggregates total link flow, to origin-destination flows, in order to draw conclusions on connectivity, route choice, estimated ridership by link and identify key OD pairs that transfers at a specific point in the IPT Network.

Select link analysis methodology present the flow of passengers through or passing by a specific point in the public transport network. The points selected for the select link analysis represent points in the network where roads and public transport routes intersect or split in several directions. Thus, representing the start, end or midpoint of a public transport corridor.

The flows along the links are the result of the assignment of the public transport matrix per previous discussions. The points in the network selected, the origin-destination pairs and the passenger volume for the morning peak hour are presented in Figure 9-1 to Figure 9-11 for the eleven selected points in the IPTN.

6_FinNetw_selectlink copy copy copy
0 - 30
30 - 627
627 - 941
941 - 1255
1255 - 1569
1255 - 1569

Indicating passenger volume passing by link/point and the volume from origins to destinations during morning peak hour

✖ The points selected for select link analysis

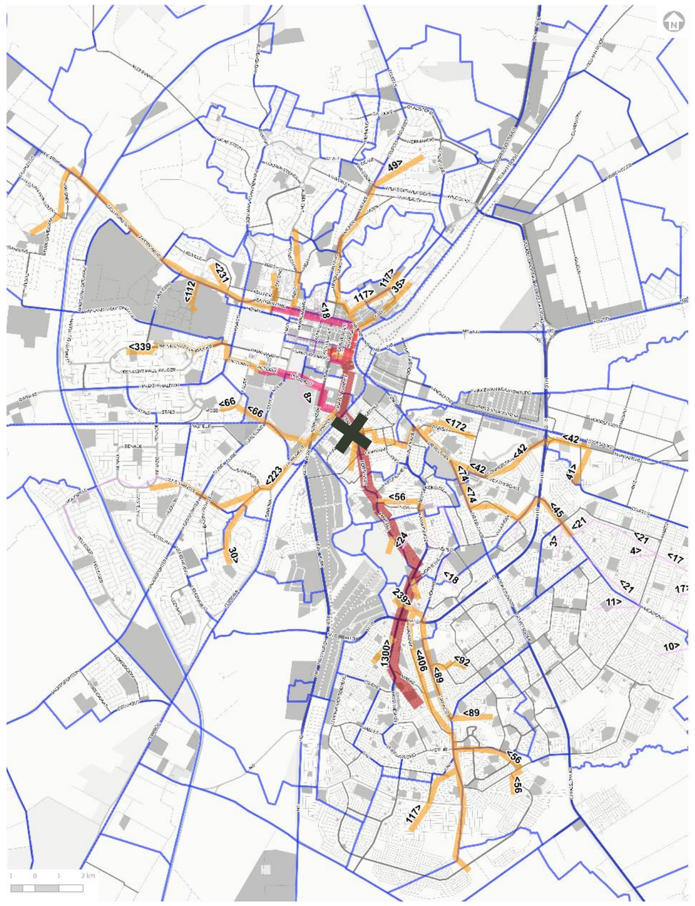


Figure 9-1: Maphisa

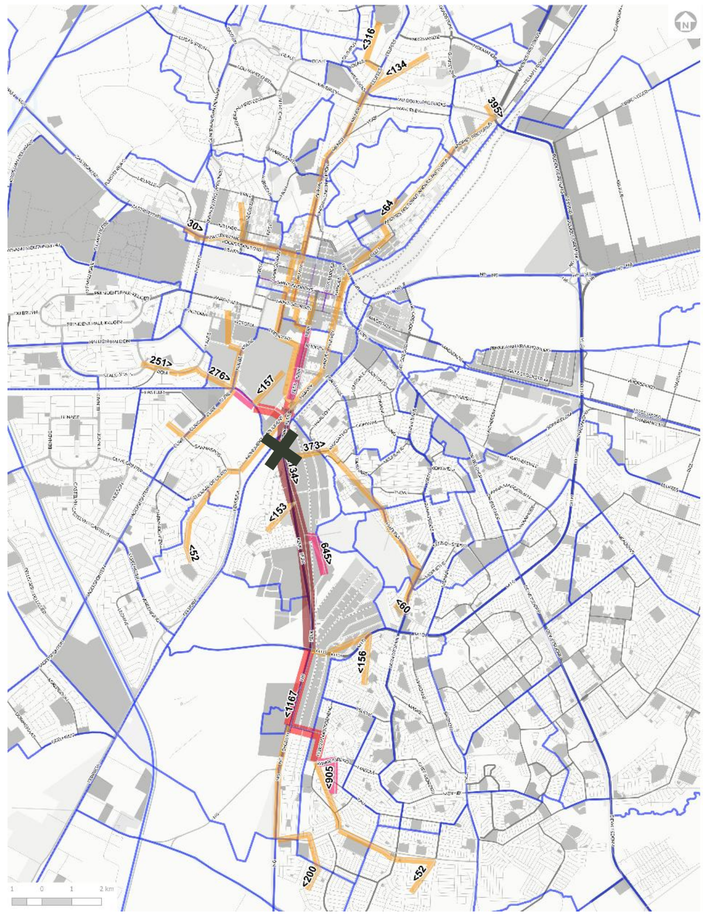


Figure 9-2: OR Tambo

Figure 9-3: Freedom Square

Figure 9-4: Botchabela

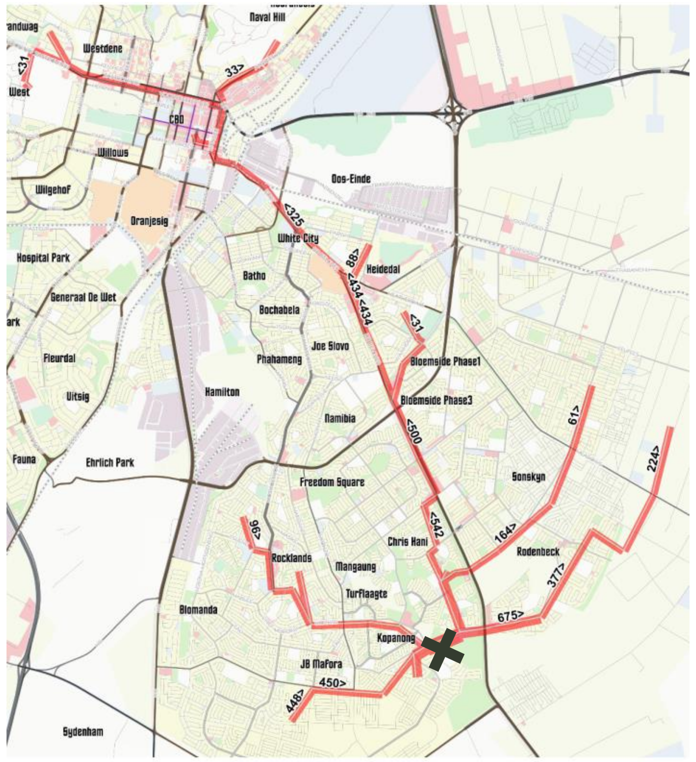


Figure 9-5: Kopanong

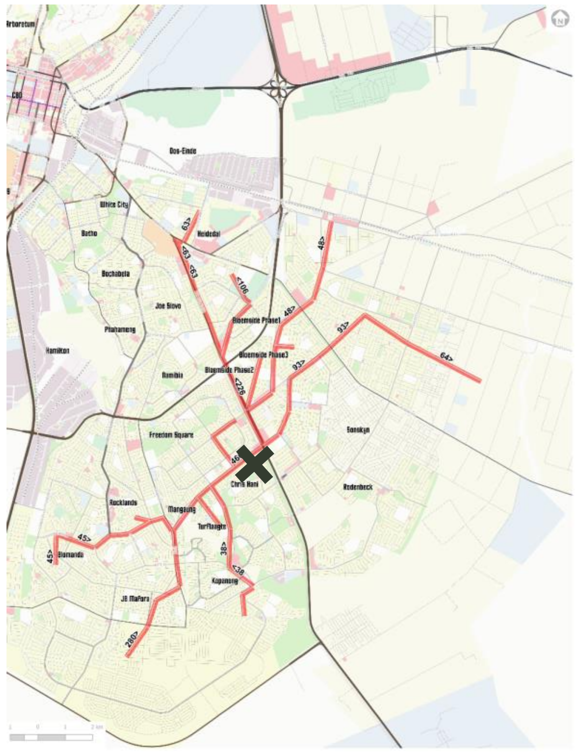


Figure 9-6: Chris Hani

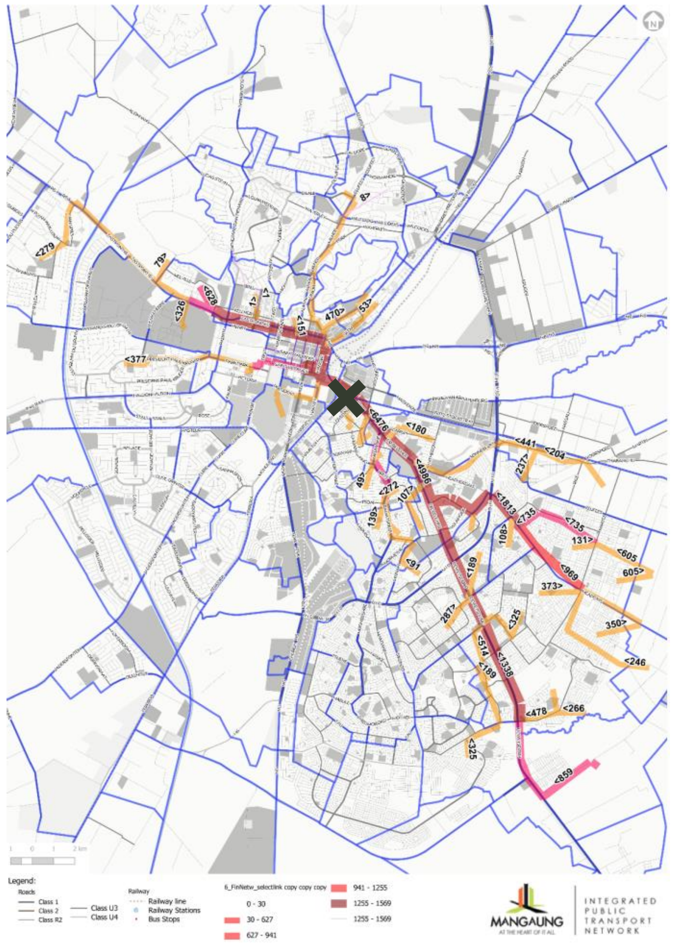


Figure 9-7: Dr Belcher

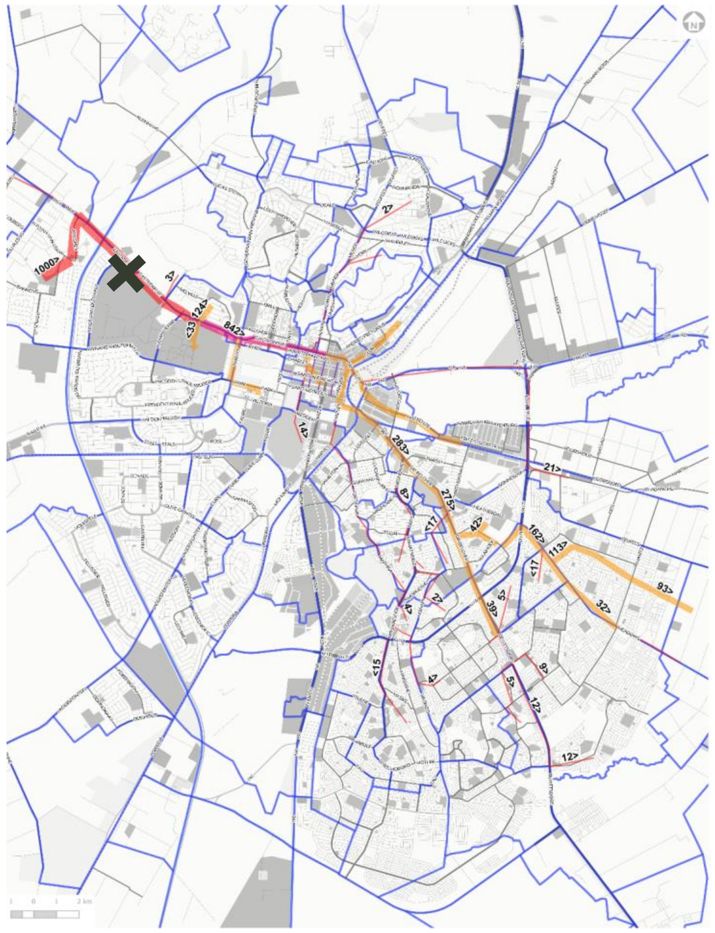


Figure 9-8: Langenhoven Park 1

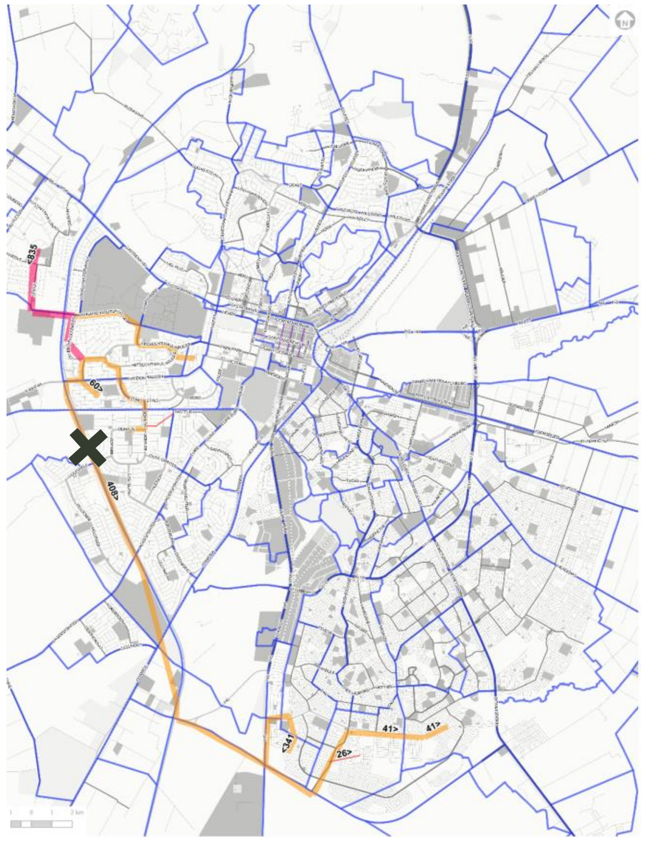


Figure 9-9: Langenhoven Park 2

Figure 9-10: Botshabelo

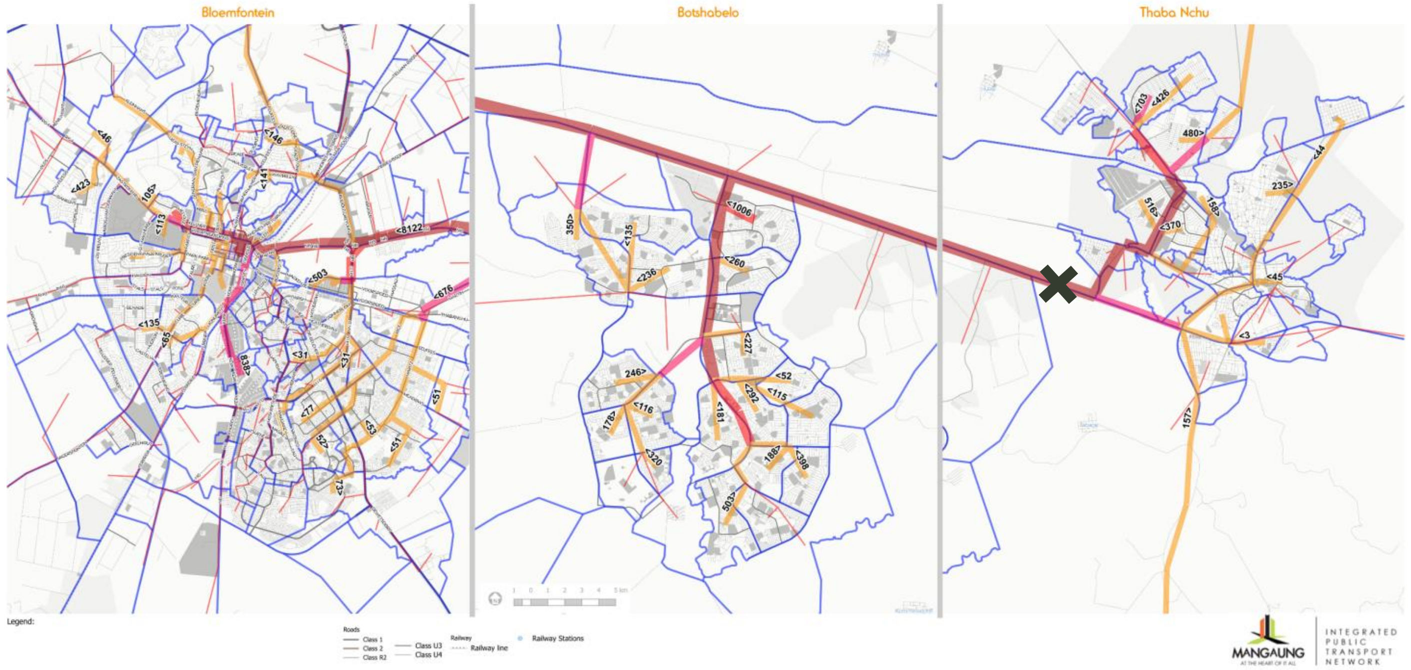


Figure 9-11: Thaba Nchu

9.2 Functional Public Transport Corridors

The select link analysis in combination with existing public transport operator operational areas and the city spatial structure provided the premises for the demarcation of the public transport corridors. The functional public transport corridors are public transport service areas, with one or two main roads that facilitate movement in the corridor supported by several local roads or sub-corridors that feed or distribute passengers from the main corridor to suburbs or points of interest. The identified functional public transport corridors are presented in Figure 9-12 for the metro and detail for Bloemfontein is presented in Figure 9-13. The percentage trips generated and attracted by each functional public transport corridor per design year are presented in Diagram 9-1 to Diagram 9-3 derived from the base year public transport matrix (Refer to previous sections for detail pertaining to development).

The CBD and Brandwag/Universitas corridors attract 30% of the peak hour volumes, and Turflaagte/Heidedal/Rondenbeck/Bloemanda and Batho/Rocklands/JB Mafora corridors generate 50% of trips during the morning peak hour for the 2017 design year. The internal trips were excluded in these figures. The total number of trips generated per functional public transport corridor including internal trips are presented in Table 9-1. The highest number of trips are generated in Botshabelo and Thaba Nchu. These trips represent all public transport trip purposes, work, education, social and others made in the peak hour by public transport.

The rural areas within the boundaries of MMM attract/generate 4% of total public transport trips. These areas are classified as rural corridors, route and service design will be done according to demand.

The detail of volume between and internal trips per functional public transport corridor is provided in Annexure R and provide the main origin-destination pairs per functional public transport corridor. The origin-destination pairs are classified into primary-, secondary- and minor corridors.

These origin-destination pairs will be used in combination with the select link analysis to design routes and services per functional public transport corridor. The design of routes and services are detailed in the Options analysis in Volume 3B. The result of the options analysis is the recommendation of the most optimum route and service design per functional public transport corridor, taking into consideration, passenger experience, cost-effectiveness.

Diagram 9-1: 2017 Percentage Trips Generated per Analysis Area

Corridor	Percentage Trips Generated (AM Peak Hour)	Percentage Trips Attracted (AM Peak Hour)
Airport	1%	8%
Batho/Rocklands/JB Mafora	22%	16%
Botshabelo	9%	1%
Brandwag, Universitas	4%	15%
CBD	3%	15%
Dan Pienaar/ Helicon Heights/Bayswater	4%	8%
Langenhoven Park	4%	4%
Rural	16%	4%
Thaba Nchu	6%	6%
Turflaagte/Heidedal/Rondenbeck/Bloemanda	28%	15%
Wilgehof/Fichardt Park/Lourier Park	3%	7%

Diagram 9-2: 2025 Percentage Trips Generated per Analysis Area

Corridor	Percentage Trips Generated (AM Peak Hour)	Percentage Trips Attracted (AM Peak Hour)
Airport	3%	9%
Batho/Rocklands/JB Mafora	23%	15%
Botshabelo	7%	2%
Brandwag, Universitas	4%	15%
CBD	5%	15%
Dan Pienaar/ Helicon Heights/Bayswater	4%	7%
Langenhoven Park	2%	2%
Rural	14%	4%
Thaba Nchu	6%	6%
Turflaagte/Heidedal/Rondenbeck/Bloemanda	28%	16%
Wilgehof/Fichardt Park/Lourier Park	4%	7%

Diagram 9-3: 2036 Percentage Trips Generated per Analysis Area

Corridor	Percentage Trips Generated (AM Peak Hour)	Percentage Trips Attracted (AM Peak Hour)
Airport	4%	11%
Batho/Rocklands/JB Mafora	25%	14%
Botshabelo	8%	2%
Brandwag, Universitas	4%	16%
CBD	6%	13%
Dan Pienaar/ Helicon Heights/Bayswater	4%	6%
Langenhoven Park	2%	2%
Rural	15%	5%
Thaba Nchu	6%	7%
Turflaagte/Heidedal/Rondenbeck/Bloemanda	20%	18%
Wilgehof/Fichardt Park/Lourier Park	5%	7%

Table 9-1: Peak Hour 2017 Base Year Public Transport Matrix Assigned to the Network (work, education, social, other), internal and between main origin-destination pairs

Peak Hour 2017 Trips	Destinations										
Origins	**Batho/ Rocklands/ JB Mafora**	**Botshabelo**	**Brandwag, Universitas**	**CBD**	**Dan Pienaar/ Helicon Heights/ Bayswater**	**Langenhoven Park**	**Rural/Airport**	**Thaba Nchu**	**Turflaagte/Heidedal/ Rondenbeck/ Bloemanda**	**Wilgehof/Fichardt Park/ Lourier Park**	**Main Origins**
Batho/Rocklands/JB Mafora	6,601	97	1,924	1,986	1,137	961	1,159	154	5,602	1,892	21,513
Botshabelo	370	20,484	1,763	1,026	694	2	330	845	667	74	26,257
Brandwag, Universitas	774	223	416	521	146	54	196	135	610	173	3,248
CBD	733	131	190	-	59	7	371	87	496	25	2,101
Dan Pienaar/ Helicon Heights/Bayswater	1,000	83	500	258	799	95	274	114	216	354	3,692
Langenhoven Park	408	2	526	71	209	0	403	35	468	233	2,355
Rural/Airport	436	131	1,112	2,923	1,357	872	3,257	2,420	1,073	539	14,120
Thaba Nchu	886	144	510	302	173	198	988	15,132	687	154	19,171
Turflaagte/Heidedal/ Rondenbeck/Bloemanda	5,310	77	2,818	2,814	1,583	398	3,677	146	7,445	1,441	25,711
Wilgehof/Fichardt Park/Lourier Park	645	37	558	199	52	26	115	47	184	124	1,986
Main Destinations	**17,162**	**21,410**	**10,317**	**10,099**	**6,209**	**2,613**	**10,770**	**19,115**	**17,450**	**5,009**	**120,154**

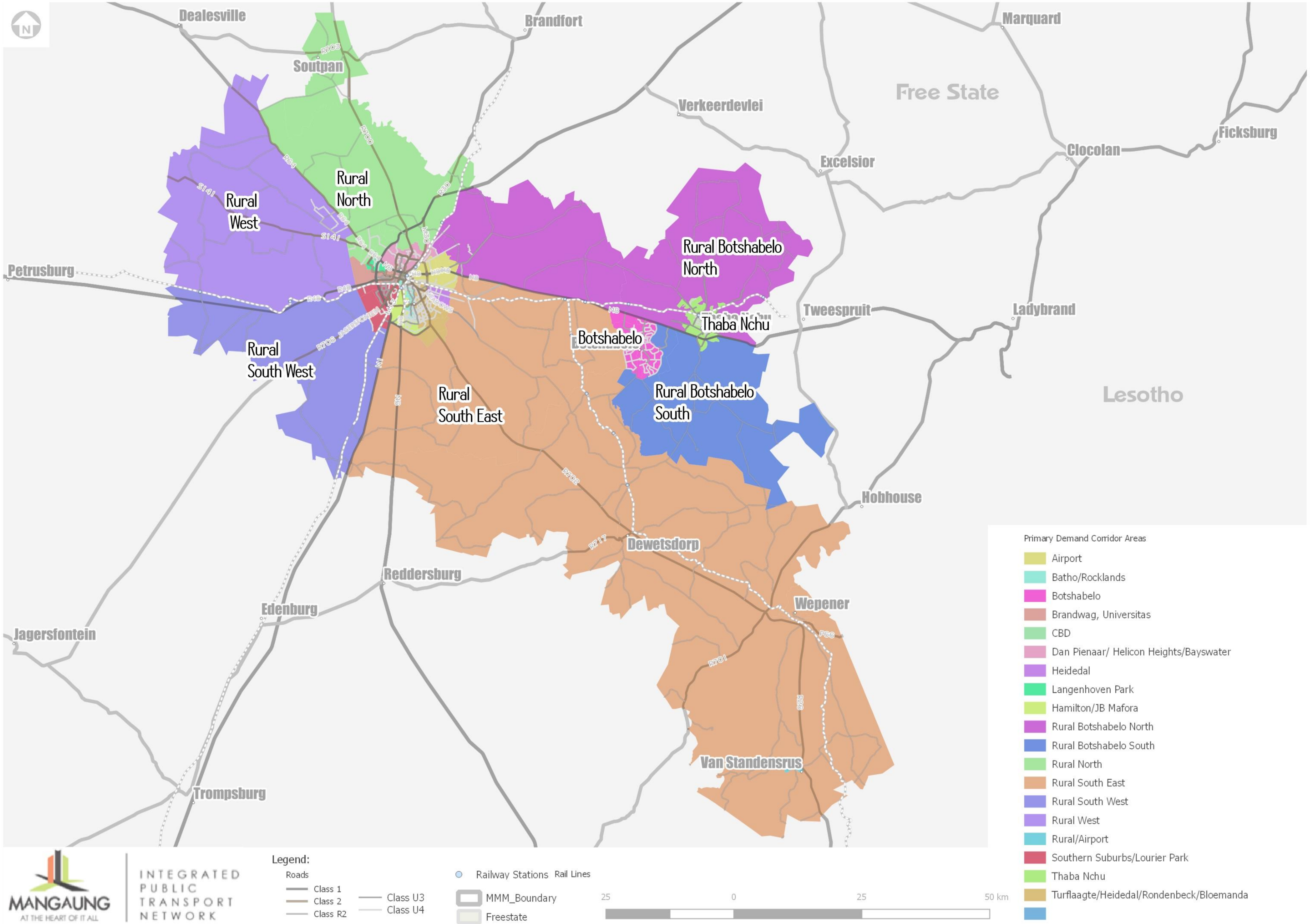


Figure 9-12: Mangaung Metropolitan Functional Public Transport Corridors

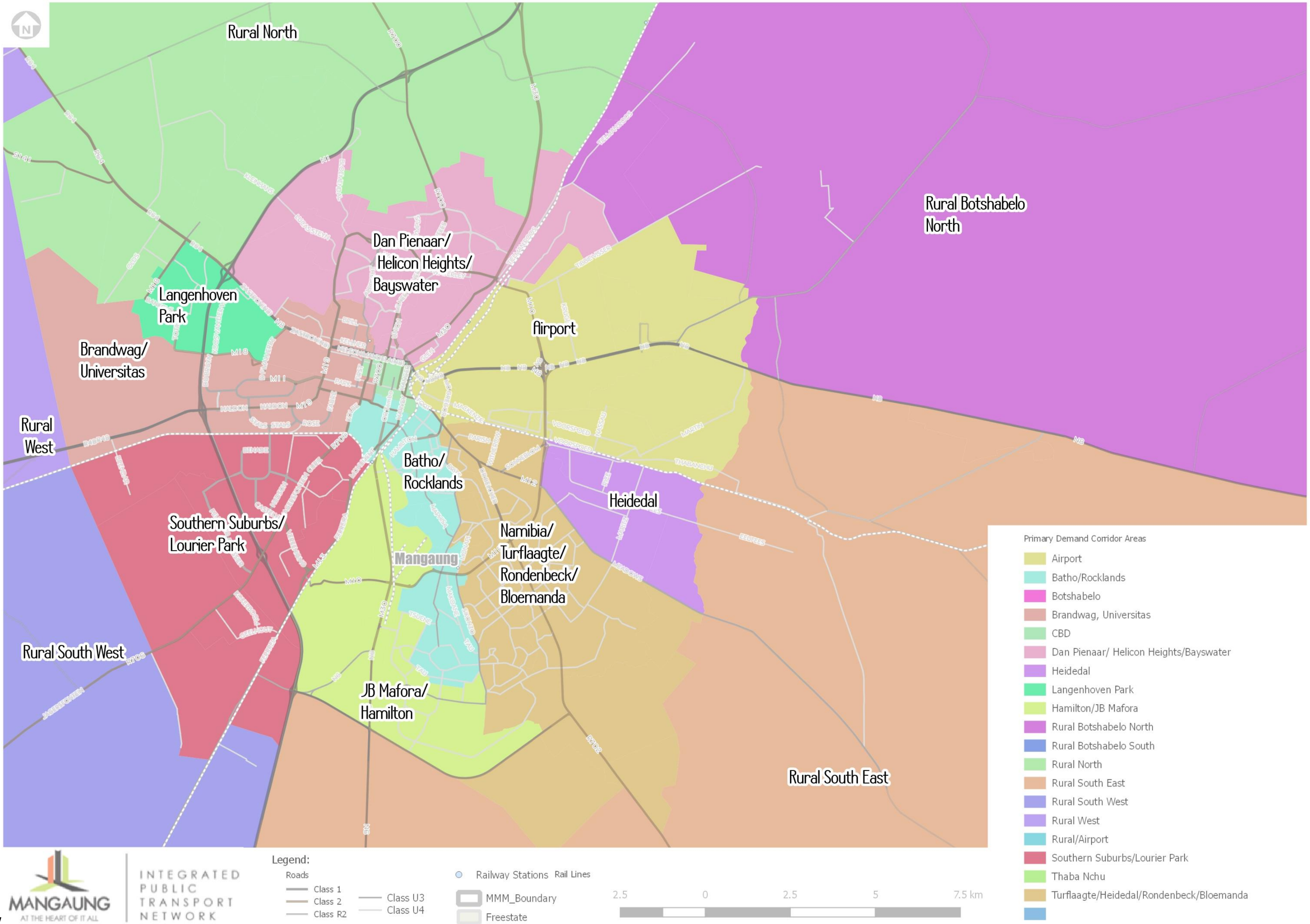


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Figure 9-13: Mangaung Metropolitan Functional Public Transport Corridors – Bloemfontein Detail

10 MMM Citywide Integrated Public Transport Network

10.1 Determination of Geographic Extent of IPTN

The development of the citywide network seeks to link the primary and secondary origins through the selection of road links where the majority of trips were assigned based on the public transport matrix assignment process. This network is compared to roads utilised by existing public transport operators and represent the combination of the two mentioned networks.

This network is supper imposed on to the road hierarchy and compared to the road hierarchy and road reserve per road class. Some of the roads selected as part of the IPTN are Class 2 and Class 3 roads that represent the mobility roads of the city. The primary function of these road classes is to provide mobility to passengers during their journey. The primary function of routes or part of routes that utilise Class 2 or Class 3 roads within the IPTN network is thus to provide mobility along the IPTN routes and in return optimise journey times along sections of the IPT Network.

Whereas along other sections of the network the primary function will be to load and off-load passengers, providing access to the public transport system. However, the classification of roads where stations and stops are located, preferably, needs to be classified as Class 4, Class 5 or an activity street within 750m prior to and after stops and stations. This is the preferred option pertaining to road class, but it is acknowledged that this cannot be implemented immediately. However, when roadmaster plans are developed for the areas where the IPTN transverse this need to be considered and accommodated.

The above methodology ensures that sections of the IPTN provide mobility and still sufficient accessibility to users to the system. Thus, access to the system and acceptable journey times.

It needs to be emphasised that to have acceptable journey times; public transport vehicles need to be able to operate along mobility roads with limited stopping along these roads. This scenario is where the distance between an origin and destination is more than 35km and a significant part of the route is required to operate as an express services at higher operating speed.

The result of the above methodology is presented in Figure 10-2 and resulted in a network that brings public transport service within 800m walking distance from residential and main employment destinations. The proposed full network for the Bloemfontein, Botshabelo and Thaba Nchu is shown Figure 10-2, superimposed on the existing land use.

10.2 MMM IPTN Validation

The validation criteria defined to determine if the network provides in mobility, accessibility and sustainable transport principles are:

- Area coverage of the network (Access to Public Transport)
  - The proposed network area coverage is presented in Figure 10-3. The figure indicates 500m walking distance buffers from the proposed full network. Some of the Bloemfontein areas are not within 500m of a network link. These areas are primarily low-density areas and network links can be developed through providing feeder routes in these areas.
  - Table 10-1 provides the percentage population within a 500m radius of an IPTN service. 86% of the population resides within 500m of an IPTN service once the full network is implemented.
- Transfer between routes and services (Mobility):
  - The full network development addresses coverage and directness of routes. It is, however, also necessary to determine the ideal location for transfer stations and stops. For this purpose, it is advisable that transfer does not occur within 5km from the end or start of a journey or route.
  - The full network and distances from the main origins towards the CBD are presented in Figure 10-6 and Figure 10-4. The M10 is approximately 6.5km from the intermodal facility in the CBD in almost all travel directions. For a passenger to transfer at the M10 would be the optimum point for transfers in the wider network. It needs to be considered that the travel time from Rocklands to the CBD is 19 minutes during peak hour a transfer will lead to increased travel time. Thus, in the design of services it is recommended that services are provided where passengers can transfer to gain access to minor destinations through link services that do not end in the CBD and direct services from residential areas to the CBD without transfers.
  - The same criteria apply to Botshabelo and Thaba Nchu. To force transfers within these towns can lead to significant inconvenience. However, one transfer from the mentioned towns to Bloemfontein will optimise the utilisation of vehicles and optimise operational cost.
- The directness of routes and service (Mobility);
  - The network was designed from a primary, secondary and minor origin-destination perspective and provides direct links between primary and secondary origins and destinations. During the design of implementation phases and services per phase, the directness of routes and services need to be re-evaluated based on primary and secondary origins and destinations identified.
- Spacing between routes and corridors (Economic Feasibility, Frequency of Service versus Accessibility):
  - The corridors are spaced 1,6km apart, and where road networks are not available, some of the network links encroached into service/catchment areas. The implementation of routes and services along the network need to be evaluated from a financial sustainability perspective. Although network coverage and route spacing comply with standards, the implementation of routes and services need to be considered from a financial and institutional perspective. Budget and capital funding, and operational and industry transition need to be secured before a new route or service is operationalised (Refer to Figure 10-1).
  - These aspects will be evaluated in more detail as part of the options analysis process.

Figure 10-1: Spacing between Routes

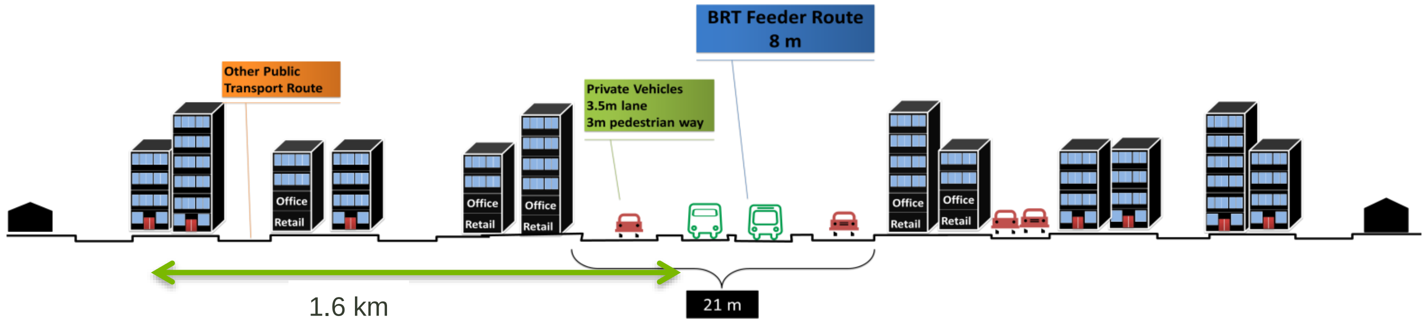

Table 10-1: 2015 - Population within 500m radius of IPT Network

Area	Population	Percentage Population	Services by IPTN Network
Bloemfontein	508,121	61%	56% Bloemfontein 466,059
Botshabelo	191,733	23%	20% Botshabelo 167,212
Thaba Nchu	76,393	9%	8% Thaba Nchu 68,888
Rural Areas (Dewetsdorp, Wepener, Soutpan, Talla etc.)	57,081	7%	2% 14,868
	833,328	100%	86%

Table 10-2: Population and Formal Jobs per Functional Public Transport Corridor

	Population	Percentage of Jobs
Maphisa/Moshoeshoe Or Tambo	19.39%	12.31%
Dr Belcher	27.00%	8.86%
CBD	14.56%	57.10%
Botshabelo	21.95%	7.67%
Thaba Nchu	9.04%	5.69%

Bloemfontein/Mangaung **Botshabelo/Thaba Nchu**

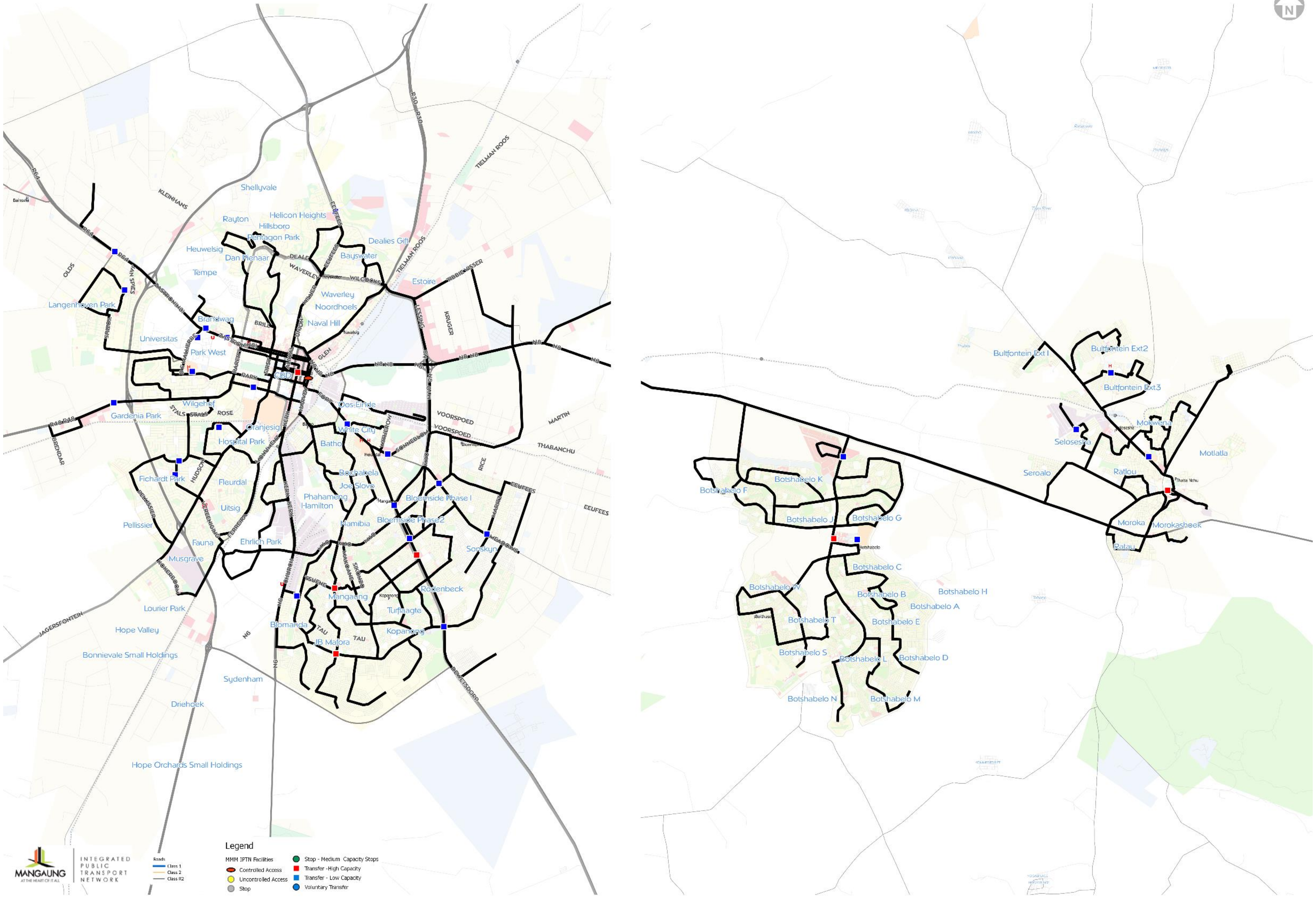

Figure 10-2: Citywide Integrated Public Transport Network

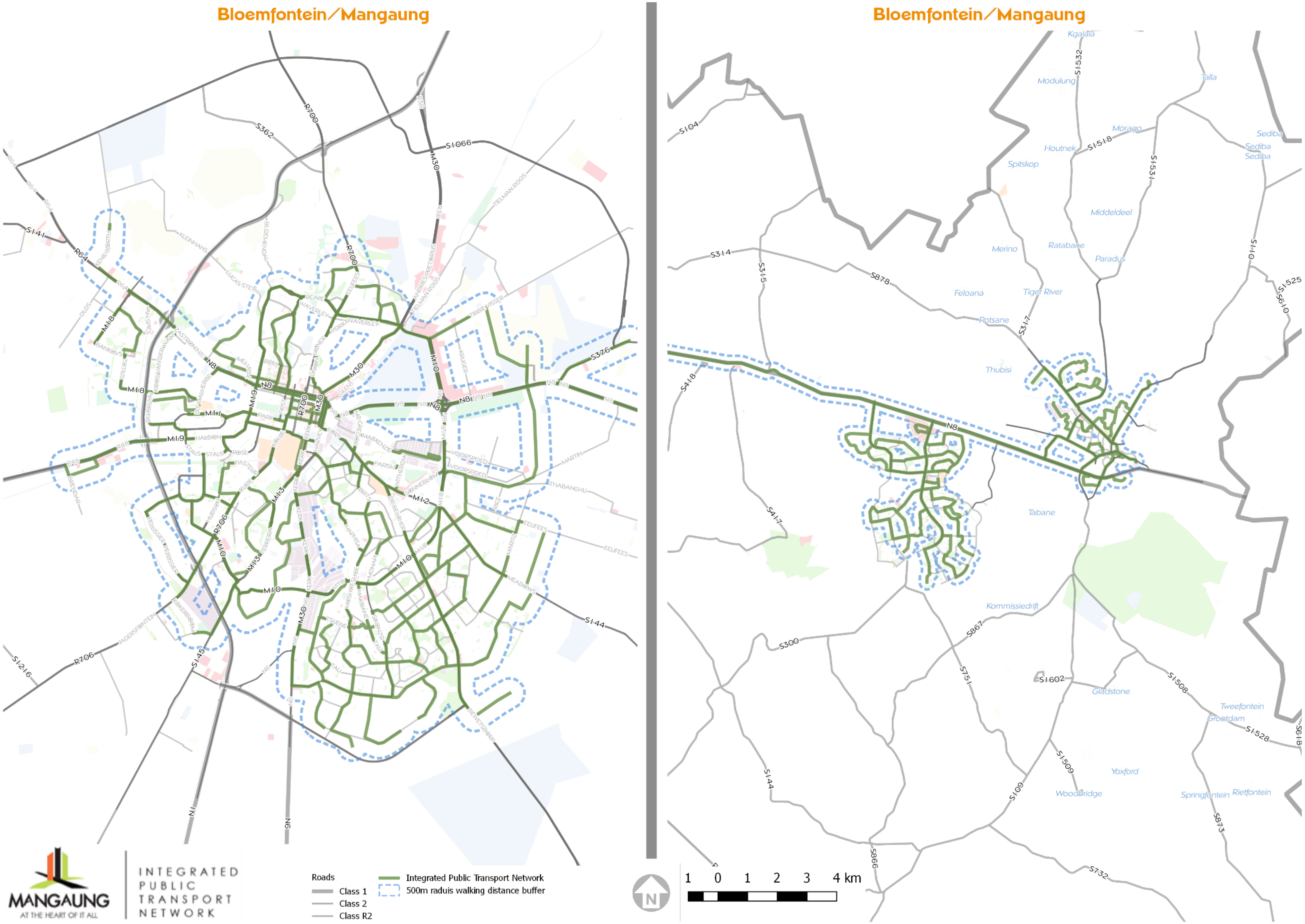

Figure 10-3: Walking Distance (800 m) – Validation

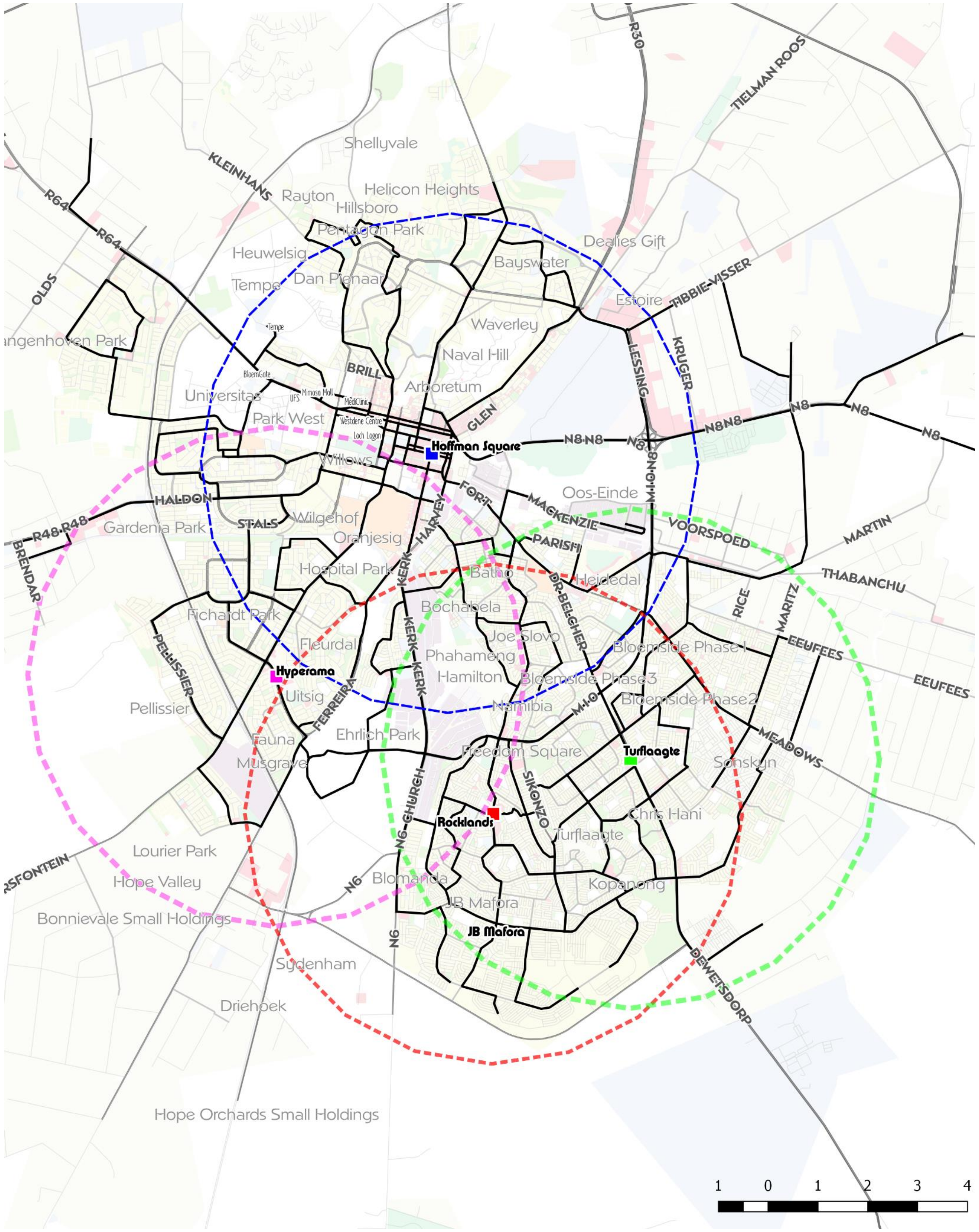

Figure 10-4: Bloemfontein 5km Radius from Identified main Points in Corridor

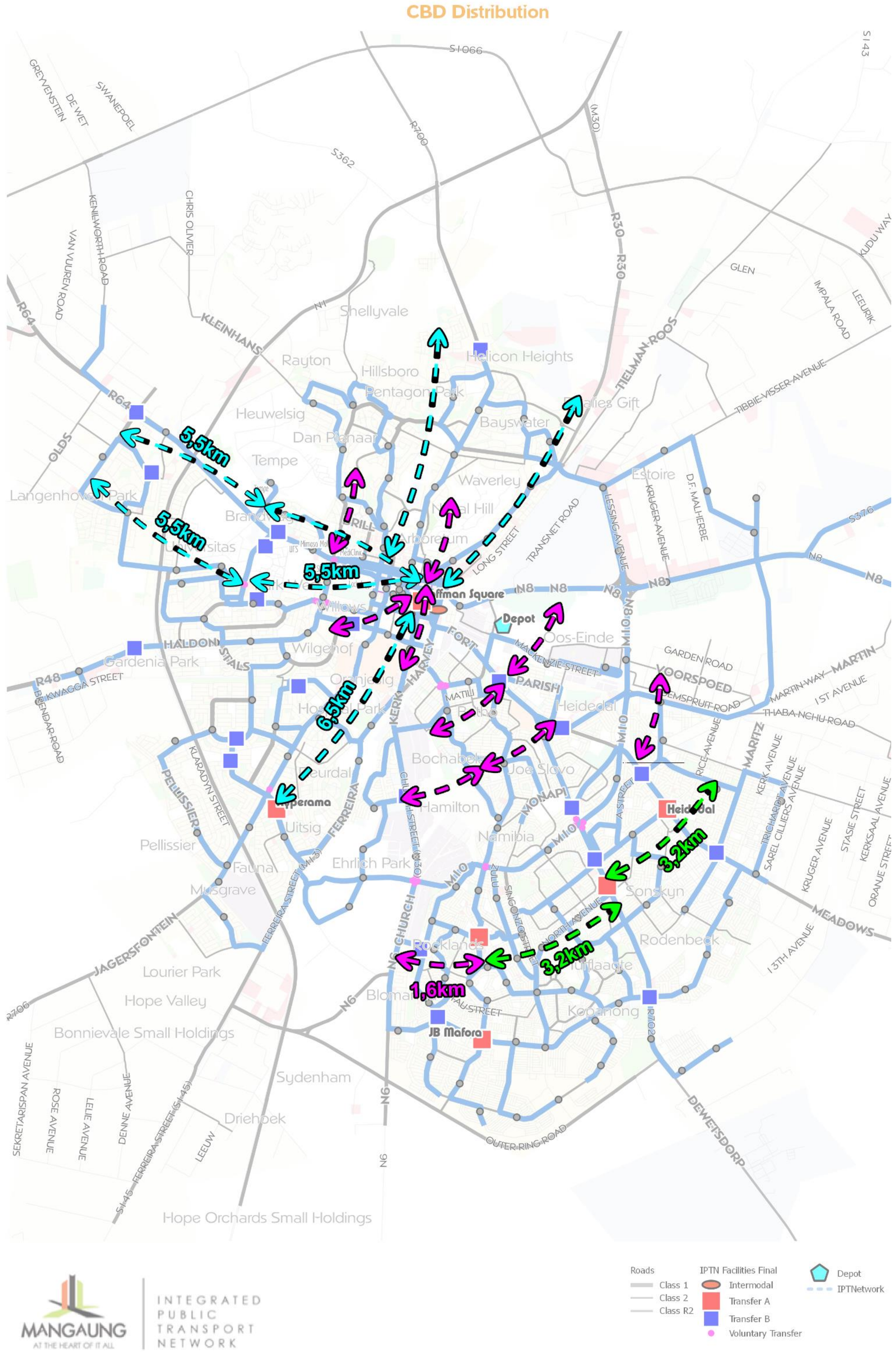

Figure 10-5: Bloemfontein - Spacing between Main Corridors

Figure 10-6: Botshabelo and Thaba Nchu -5km Radius from Identified main Point sin Corridor

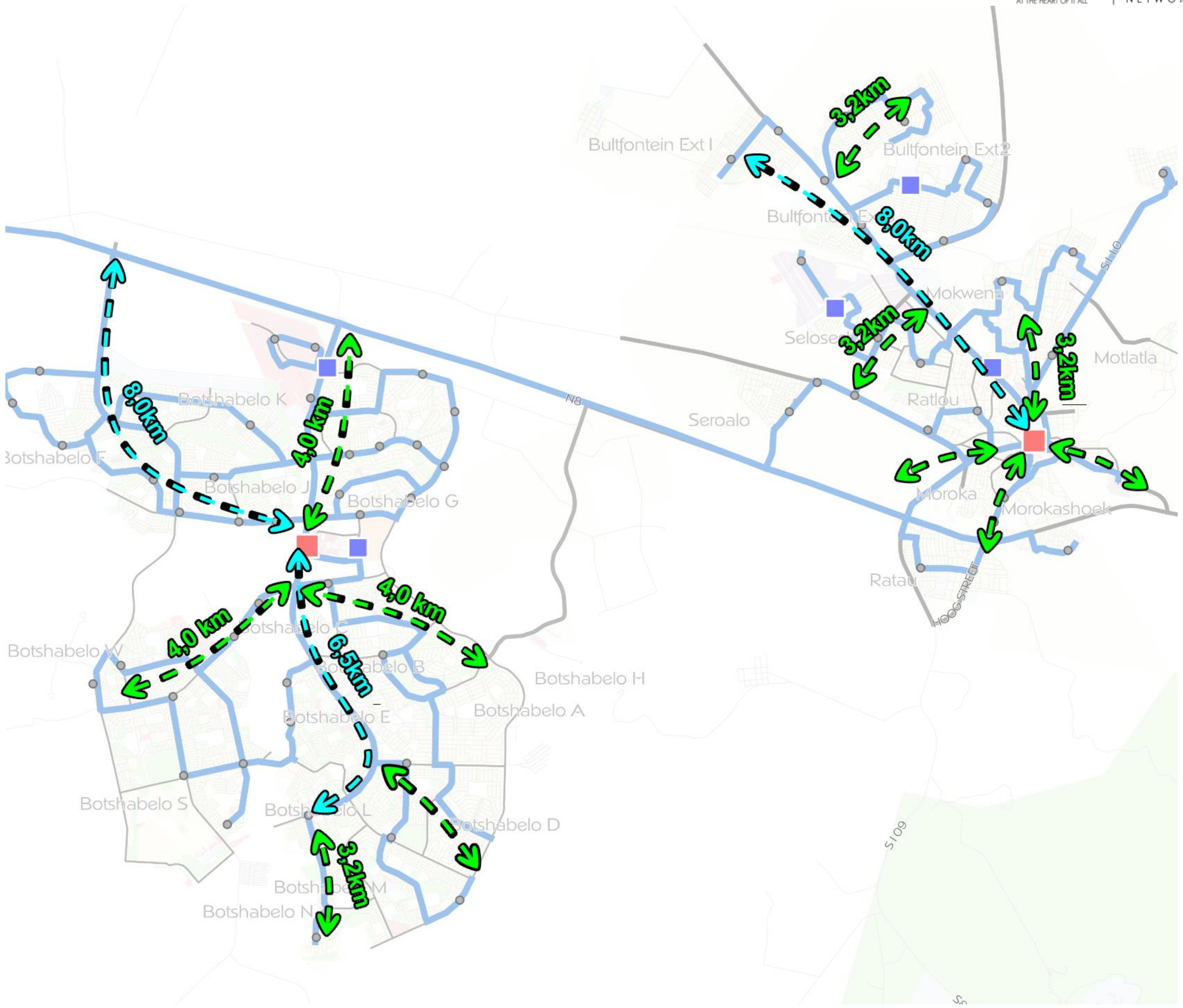

Figure 10-7: Botshabelo and Thaba Nchu - Spacing between Main Corridors

Annexure A: DETAIL MAPS AND LAYOUTS OF NEW DEVELOPMENTS

Annexure B: B Background to Demographic Projections and Economic Forecasts

Annexure C: THE IHS DEMOGRAPHIC MODEL

Annexure D: IHS GLOBAL ECONOMIC OUTLOOK

Annexure E: IHS SOUTH AFRICAN ECONOMIC OUTLOOK, MARCH 2016

Annexure F: EXAMPLES OF DELIVERABLES PER TRAFFIC ZONE

Annexure G: On-Board Taxi Survey Reports

Annexure H: Pedestrian Surveys

Annexure I: Traffic Impact study for OR Tambo and Maphisa/Moshoeshoe Corridors

Annexure J: Public Transport Validation Counts

Annexure K: TRIP PURPOSE BY TIME OF DAY - ALL MODES (FROM TRIP FILE)

Annexure L: TRIPS BY MODE BY TIME OF DAY - ALL TRIP PURPOSES (FROM TRIP FILE)

Annexure M: Public Transport Base Year Prior Matrix

Annexure N: VALIDATED BASE YEAR MATRIX

Annexure O: INPUT LAND USE PROJECTIONS

Annexure P:2025 and 2036 Matrices

Annexure Q: Assigned Volumes per Functional Public Transport Corridor

Annexure R: Detail Origin Destination Pairs Per Functional Corridor

Annexure S: First Order Mode Selection

Annexure T: Route Design Options Per Functional Public Transport Corridor Route Design Options per Functional Public Transport Sub-Corridor

Annexure U: Vehicle Specifications

Annexure V: Private and Heavy vehicle volumes 2017

Annexure W: Passengers per route and station per corridor

Annexure X:CBD Traffic Impact Study – IPTN

Annexure Y: Road Infrastructure Maintenance and Upgrades

Annexure Z: Waiting Areas Guidelines Per Number of Passengers in the peak 15-minutes of the peak hour

Annexure AA: Station Sizing

Annexure BB: Hoffman Square – Capacity Calculation

Annexure CC: MMM IPTN NMT Plan

Annexure DD: Detailed Infrastructure per Corridor

Annexure EE: Detail Route

Annexure FF: Facility Sizing per Design Year

Annexure GG: Route Details per Design Year Trunk, Feeder and Complementary Routes (31_Excel File)

Annexure HH: Detail Operational Cost and Revenue Calculation Per Route

Annexure II: NMT Infrastructure Projects Parameters

Annexure JJ: Operational Cost and Revenue per Route Design Options and Functional Public Transport Corridor

Annexure KK: Subsidised Bus Service Volumes and routes per functional public transport corridor

Annexure LL: Phase 1 Business Plan

Annexure MM: Environmental Strategy and Action Plan

Annexure NN: Universal Access Strategy and Action Plan

Annexure OO: Industry Transition

Annexure PP: Legal and Compliance

Annexure QQ: Marketing Communications

Annexure RR: Stakeholder Participation

Annexure SS: Economic Impact

Annexure TT: Social Impact

Annexure UU: Signage and Wayfinding

Annexure VV: Traffic Management

Annexure WW: Household Travel Survey Technical Report and Results