

City Transport Study

Greater Melbourne

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PostgreSQL / PostGIS / SQL / GTFS

A spatial analysis of public transport coverage, stop density and service frequency using transport schedules and Australian geographic boundaries.

Original analysis: October 2024

Public portfolio edition: September 2026

Reading this report

The original figures, analysis and SQL appendix are retained. Data-source references remain included. The following clarifications help interpret this exploratory work:

Geography: the SQL groups SA3 statistical areas. References to LGA in the original analysis should be read in that context. The map on printed page 27 shows Macedon Ranges despite its caption naming Nillumbik-Kinglake.

Catchments: the appendix applies ST_Buffer to geographic SRID 7844. The intended 400 m / 800 m catchments require recomputation in a suitable projected coordinate system before being used as distance-based evidence.

Frequency: six departures in an hour does not by itself establish evenly spaced ten-minute service. These results describe a historical schedule snapshot, not live service performance.

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Introduction

This study explores public transport accessibility across Greater Melbourne using a spatial database workflow. It examines where train, tram and bus stops are located, how stop density varies between areas, and how scheduled services compare.

Questions

- How does stop density differ across the metropolitan area and between transport modes?
- Which areas have comparatively high, low or no coverage for a transport mode?
- How do the selected areas compare in route coverage and scheduled departures?

Approach

I brought GTFS schedule records and ABS boundaries together in PostgreSQL/PostGIS, prepared spatial tables, joined routes to stops, and produced mapped comparisons. The work demonstrates relational data preparation, SQL aggregation, spatial joins, conditional classification and geospatial visualisation.

The report preserves the original 2024 analysis. It is an exploratory comparison of a historical dataset, with the technical clarifications noted on the cover. It does not establish current service levels or measure actual passenger journeys, delays or ridership.

Methodology

Dataset overview

The analysis combines PTV General Transit Feed Specification (GTFS) data with Australian Bureau of Statistics digital boundary files. GTFS supplies schedules, routes, trips, stop locations and route-shape points. Geographic boundaries provide the framework for comparing transport provision across Greater Melbourne.

Database preparation

GTFS files were extracted from their archive and loaded into PostgreSQL using SQL scripts. Boundary shapefiles were imported with GDAL/ogr2ogr into PostGIS. DBeaver was used to inspect the restored tables and their record counts. Relationships between stops, stop times, trips and routes supported multi-table queries.

The workflow used a Docker-based database environment, PostgreSQL and PostGIS. Spatial aggregation and filtering were used to prepare the Greater Melbourne analysis area. The SQL appendix contains the underlying data preparation and analytical queries.

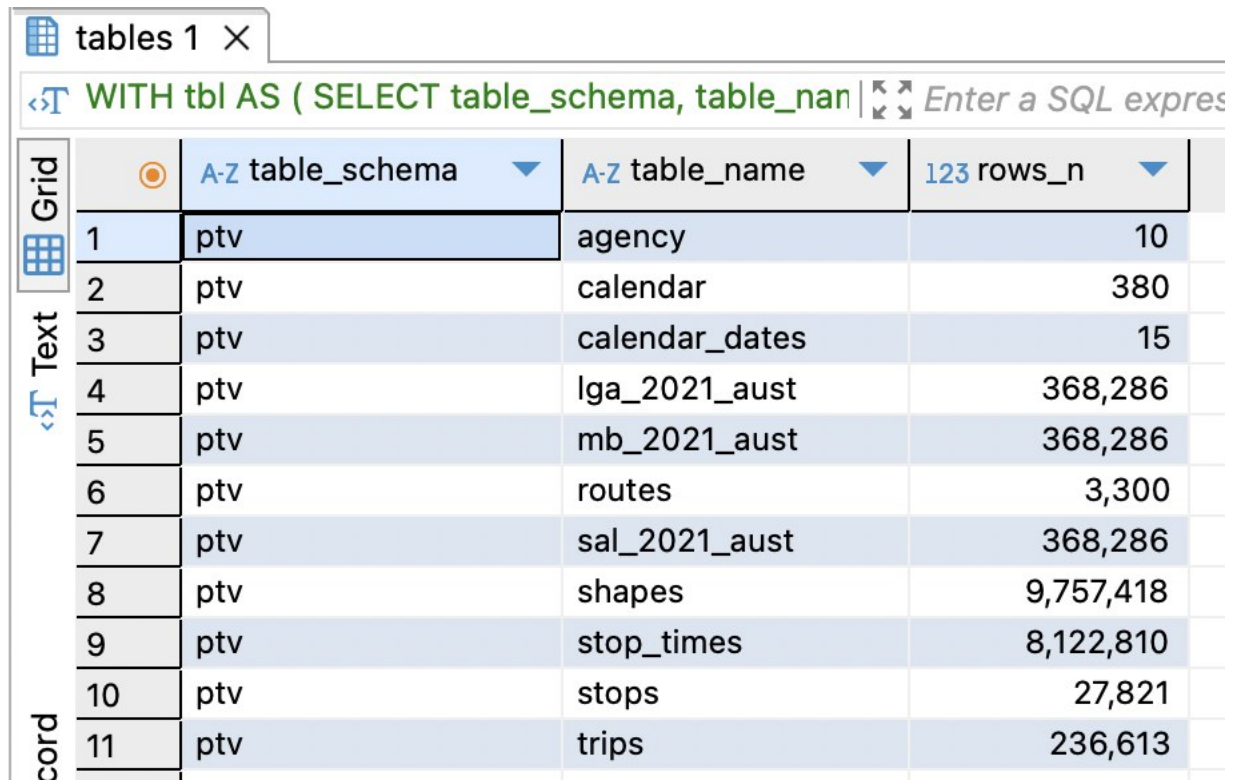
Spatial analysis and interpretation

The analysis compares train, tram and bus stop density, ranks areas by density, and explores route coverage and scheduled departures. The database groups SA3 fields, although the original report uses the label LGA. The public case study uses the more precise term SA3 area.

Geometries use GDA2020 (SRID 7844). This is a geographic coordinate system: distance buffers must be recalculated in a suitable projected coordinate system before claiming validated metre-based walking catchments. See the cover notes for further interpretation limits.

Source references are retained in the References section of the original report.

Screenshot of results of the tables restored



	A-Z table_schema	A-Z table_name	123 rows_n
1	ptv	agency	10
2	ptv	calendar	380
3	ptv	calendar_dates	15
4	ptv	lga_2021_aust	368,286
5	ptv	mb_2021_aust	368,286
6	ptv	routes	3,300
7	ptv	sal_2021_aust	368,286
8	ptv	shapes	9,757,418
9	ptv	stop_times	8,122,810
10	ptv	stops	27,821
11	ptv	trips	236,613

Fig. Screenshot showing all the tables after the data restoration process.

Data Preprocessing

SQL script for “mb2021_mel”

```
-- Data Preprocessing
-- 'mb2021_mel' with only mesh blocks in Greater Melbourne
CREATE TABLE ptv.mb2021_mel AS
SELECT *
FROM ptv.mb_2021_aust
WHERE gcc_name21 = 'Greater Melbourne';
```

Fig. Screenshot showing the code for creating the table “mb2021_mel” that only contains the mesh blocks in Greater Melbourne.

tables 1 X				
WITH tbl AS (SELECT table_schema, table_name, rows_n FROM information_schema.tables WHERE table_schema = 'public' AND table_name LIKE 'mb%') Enter a SQL expression to filter results				
Grid	☐	A-Z table_schema ▼	A-Z table_name ▼	123 rows_n ▼
1	☒	ptv	mb2021_mel	59,483

Fig. Screenshot showing the table “mb2021_mel” with only Greater Melbourne mesh blocks.

Data processing steps

1. One large polygon for Melbourne Metropolitan boundary

```
-- Part C
-- 1. Make single polygon boundary.
-- Create a table to store the Melbourne Metropolitan boundary.
CREATE TABLE melbourne_boundary AS
SELECT ST_Union(geom) AS geom
FROM mb2021_mel;
```

Fig. SQL statement for creating one large polygon for Metropolitan Melbourne.

Rationale: Melbourne's metropolitan boundary was created through spatial aggregation using PostGIS's ST_Union function to merge individual mesh block geometries from mb2021_mel into a single unified polygon. This boundary established the spatial framework for Greater Melbourne analyses.

2. Adding geometry to stops

```
-- 2. Add geometry table to stops.
ALTER TABLE stops
ADD COLUMN geom geometry(Point, 7844);

UPDATE stops
SET geom = ST_SetSRID(ST_MakePoint(stop_lon, stop_lat), 7844);
```

Fig. SQL statement for adding geometry to stops.

Rationale: Database structure incorporated a 'geom' column for Point geometry using GDA2020 spatial reference system (SRID 7844), with coordinate data converted to geographical points via ST_MakePoint and ST_SetSRID functions.

3. & 4. Improved stops table

⇒ -- 3 and 4. Stops Improved Table

```
CREATE TABLE stops_with_route_info AS
SELECT
  st.stop_id::varchar,
  s.stop_name,
  s.stop_lat,
  s.stop_lon,
  s.geom,
  st.arrival_time,
  st.departure_time,
  t.trip_id::varchar,
  r.route_id::varchar,
  r.route_short_name,
  r.route_long_name,
  r.route_type,
  CASE
    WHEN r.route_type = 0 THEN 'Tram'
    WHEN r.route_type = 2 THEN 'Train'
    WHEN r.route_type = 3 THEN 'Bus'
    ELSE 'Unknown'
  END AS vehicle_type
FROM
  stops s
JOIN stop_times st
  ON s.stop_id::varchar = st.stop_id::varchar -- Type cast stop_id for join
JOIN trips t
  ON st.trip_id::varchar = t.trip_id::varchar -- Type cast trip_id for join
JOIN routes r
  ON t.route_id::varchar = r.route_id::varchar; -- Type cast route_id for join
```

Fig. Improved stops table with route and vehicle type information.

Rationale: The unified stops_with_routes table linked stops, stop_times, trips, and routes tables through identifiers, while CASE statements converted route_type numbers to vehicle categories, enabling comprehensive multi-modal transport analysis and service gap identification.

Data Analytics and Visualization

Public Transport Coverage Density (LGA)

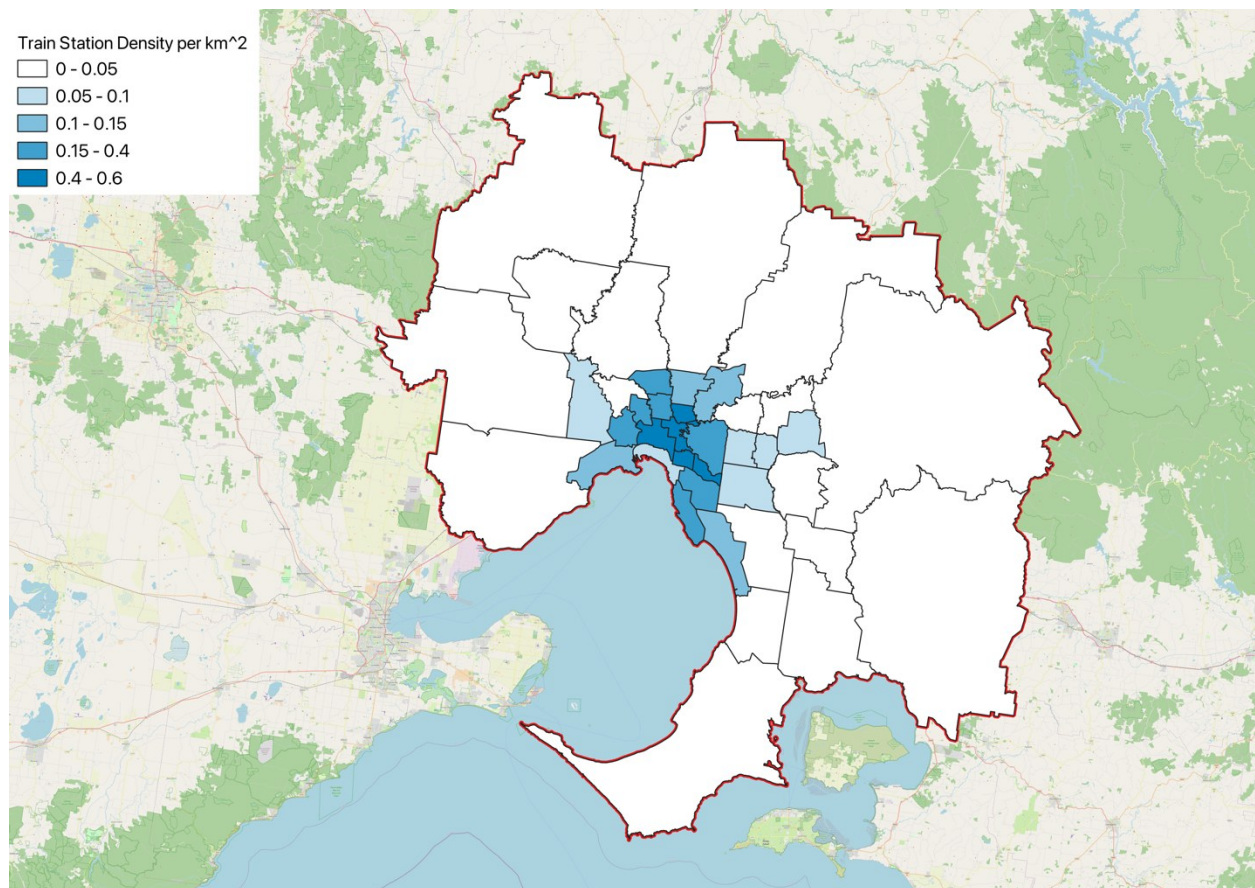


Fig. Heat map for stop density: the number of train stations in each LGA per square km. Jenks Natural Breaks classification.

lga_stop_count_by_type(+) 1 X							
SELECT lscbt.lga_name, lscbt.vehicle_type, Enter a SQL expression to filter results (use Ctrl+Space)							
Grid	A-Z lga_name	A-Z vehicle_type	123 stop_density_per_sqkm	123 num_stops	123 area_sqkm	geom	
1	Stonnington - West	Train	0.5867954263	7	11.9292	POLYGON ((144.98348560865963 -37.85475579905823	
2	Stonnington - East	Train	0.5830138903	8	13.7218	POLYGON ((145.04677517520125 -37.877217673536826	
3	Darebin - South	Train	0.5703083229	8	14.0275	POLYGON ((144.97947394020258 -37.75496383816490	
4	Melbourne City	Train	0.5096726309	16	31.3927	POLYGON ((144.9391663741957 -37.78257506558192, 1	
5	Yarra	Train	0.4850625003	10	20.6159	POLYGON ((144.96009517964018 -37.791105007064154	
6	Essendon	Train	0.3843007648	7	18.2149	POLYGON ((144.93637328610626 -37.76940907530962	
7	Glen Eira	Train	0.2702682781	11	40.7003	POLYGON ((144.9967511632215 -37.88348831014433, 1	
8	Moreland - North	Train	0.2633493428	8	30.3779	POLYGON ((144.9232330027555 -37.72899179416241, 1	
9	Brunswick - Coburg	Train	0.2449347494	5	20.4136	POLYGON ((144.9329719278543 -37.75870884501115, 1	
10	Boroondara	Train	0.2332715164	14	60.0159	POLYGON ((145.0034818111186 -37.80025089008966, 1	

Fig. Train station density, ranked by LGA.

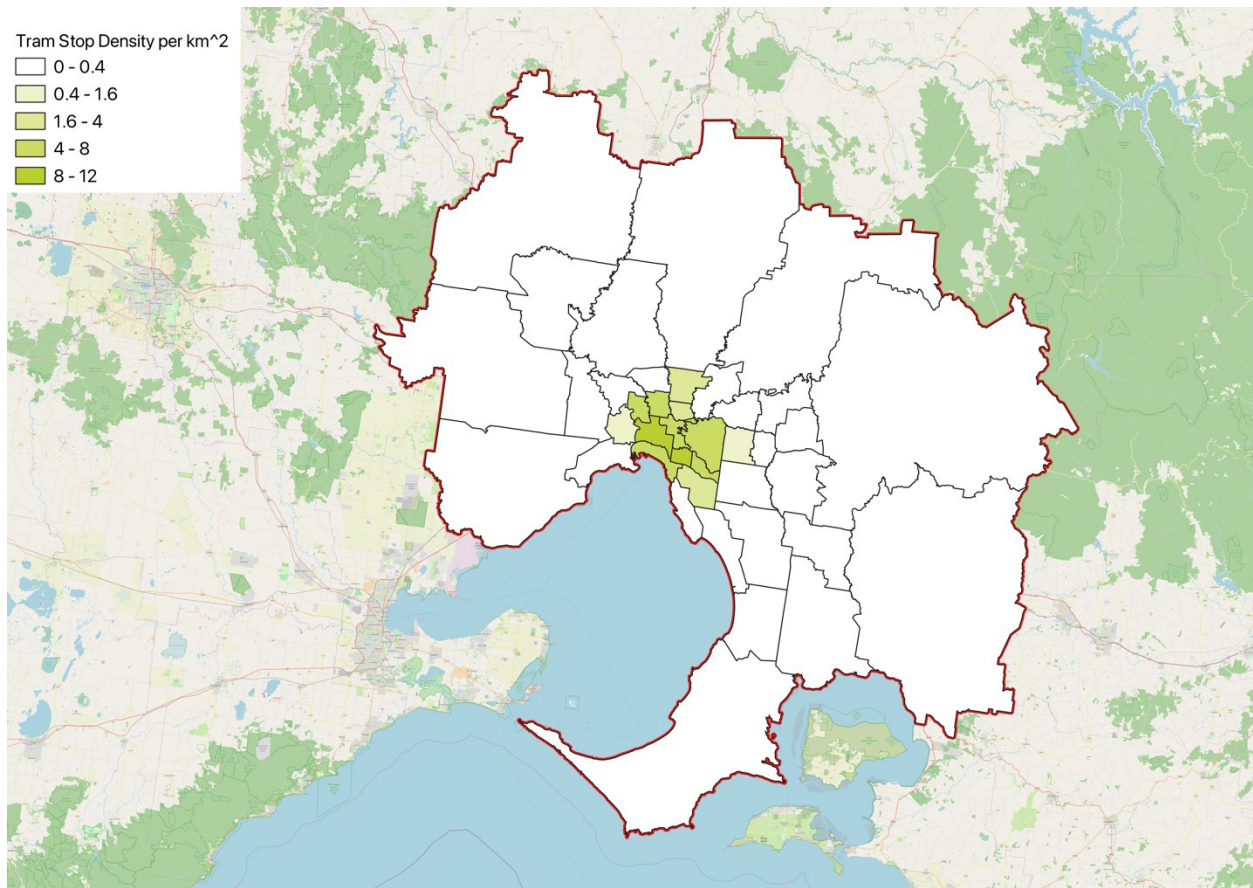


Fig. Heat map for stop density: the number of tram stops in each LGA per square km. Jenks Natural Breaks classification.

lga_stop_count_by_type(+) 1 X

SELECT lscbt.lga_name, lscbt.vehicle_type Enter a SQL expression to filter results (use Ctrl+Space)

	A-Z lga_name	A-Z vehicle_type	123 stop_density_per_sqkm	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	Tram	11.9873922811	143	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Melbourne City	Tram	8.9511255802	281	31.3927	POLYGON ((144.9391663741957 -37.78257506558192, 1
3	Yarra	Tram	7.6639875048	158	20.6159	POLYGON ((144.96009517964018 -37.791105007064154
4	Brunswick - Coburg	Tram	6.5152643336	133	20.4136	POLYGON ((144.9329719278543 -37.75870884501115, 1
5	Essendon	Tram	6.4233127824	117	18.2149	POLYGON ((144.93637328610626 -37.76940907530962
6	Port Phillip	Tram	6.3408353664	164	25.8641	POLYGON ((144.8976589452141 -37.83973092310672, 1
7	Stonnington - East	Tram	5.6843854305	78	13.7218	POLYGON ((145.04677517520125 -37.877217673536826
8	Boroondara	Tram	4.0489270343	243	60.0159	POLYGON ((145.0034818111186 -37.80025089008966, 1
9	Darebin - South	Tram	3.4218499376	48	14.0275	POLYGON ((144.97947394020258 -37.75496383816490
10	Glen Eira	Tram	2.850101842	116	40.7003	POLYGON ((144.9967511632215 -37.88348831014433, 1

Fig. Tram stop density, ranked by LGA.

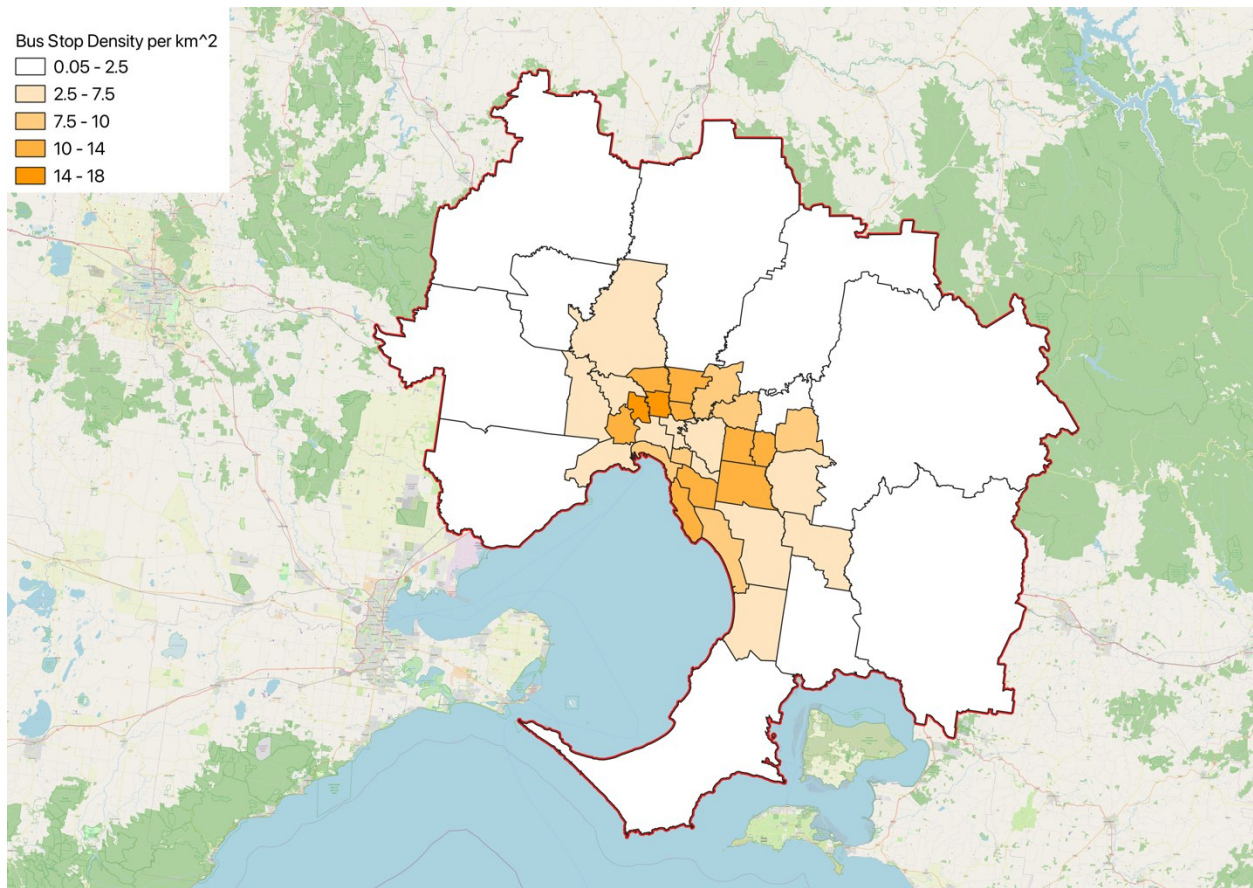


Fig. Heat map for stop density: the number of bus stops in each LGA per square km. Jenks Natural Breaks classification. All LGAs are served by bus, so the scale does not start at zero.

lga_stop_count_by_type(+) 1 X						
SELECT lscbt.lga_name, lscbt.vehicle_type, 123 stop_density_per_sqkm, 123 num_stops, 123 area_sqkm, geom						
Grid	A-Z lga_name	A-Z vehicle_type	123 stop_density_per_sqkm	123 num_stops	123 area_sqkm	geom
1	Brunswick - Coburg	Bus	17.3903672062	355	20.4136	POLYGON ((144.9329719278543 -37.75870884501115, 14
2	Essendon	Bus	15.1524301533	276	18.2149	POLYGON ((144.93637328610626 -37.76940907530962
3	Whitehorse - West	Bus	13.9271374214	530	38.0552	POLYGON ((145.1107142965036 -37.85512694780065, 1
4	Darebin - South	Bus	13.6873997505	192	14.0275	POLYGON ((144.97947394020258 -37.75496383816490
5	Glen Eira	Bus	13.513413906	550	40.7003	POLYGON ((144.9967511632215 -37.88348831014433, 1
6	Darebin - North	Bus	13.3861681333	528	39.4437	POLYGON ((144.97501343757042 -37.69412795748175, '
7	Maribyrnong	Bus	12.681820802	396	31.2258	POLYGON ((144.8577948937977 -37.82443390030119, 1
8	Bayside	Bus	12.4962712739	465	37.2111	POLYGON ((144.98361459345895 -37.90229248936129
9	Whitehorse - East	Bus	11.7427435867	312	26.5696	POLYGON ((145.15735803942704 -37.84578523096355,
10	Moreland - North	Bus	11.4886150787	349	30.3779	POLYGON ((144.9232330027555 -37.72899179416241, 1

Fig. Bus stop density, ranked by LGA.

Key Observations for Density

Greater Melbourne's public transport density analysis reveals concentrated train stations in inner-city LGAs, with decreasing density outward. Tram services follow a similar pattern but with limited geographical reach. While bus stops provide the most comprehensive coverage across all LGAs, significant density variations exist. Inner-city areas benefit from high-density, multi-modal integration, but service density notably declines outward from the CBD, especially for rail and tram services.

Best Service Density by Transport Type (LGA)

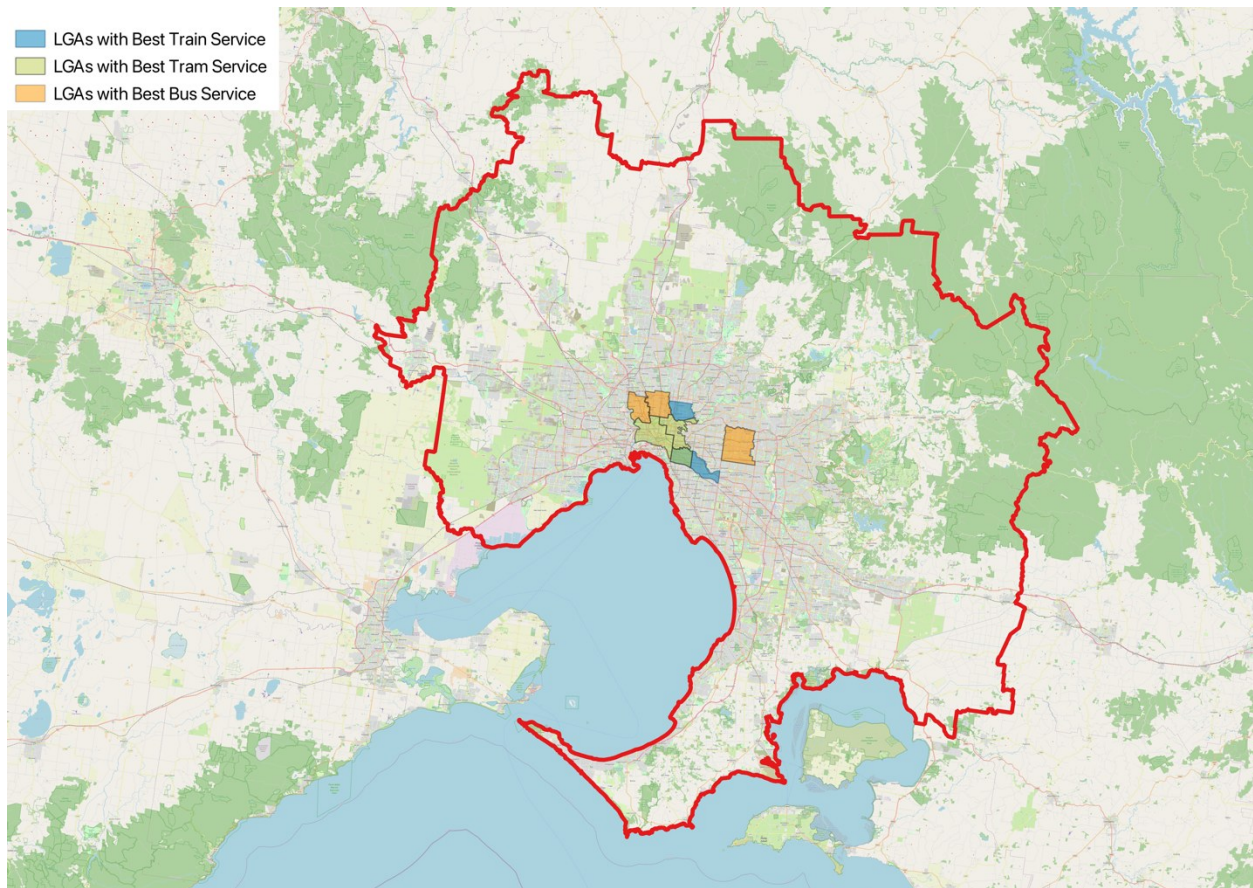


Fig. Top 3 LGAs for all types of transport by station/stop density.

lga_stop_density_with_geom_train 1						
SELECT lga_name, stop_density_per_sqkm						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	0.5867954263	Train	7	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Stonnington - East	0.5830138903	Train	8	13.7218	POLYGON ((145.04677517520125 -37.877217673536826
3	Darebin - South	0.5703083229	Train	8	14.0275	POLYGON ((144.97947394020258 -37.75496383816490

Fig. Top 3 LGAs for train station density.

lga_stop_density_with_geom_tram 1						
SELECT lga_name, stop_density_per_sqkm						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	11.9873922811	Tram	143	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Melbourne City	8.9511255802	Tram	281	31.3927	POLYGON ((144.9391663741957 -37.78257506558192, 1
3	Yarra	7.6639875048	Tram	158	20.6159	POLYGON ((144.96009517964018 -37.791105007064154

Fig. Top 3 LGAs for tram stop density.

lga_stop_density_with_geom_bus 1 X						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
	A-Z lga_name	stop_density_per_sqkm	A-Z vehicle_type	num_stops	area_sqkm	geom
1	Brunswick - Coburg	17.3903672062	Bus	355	20.4136	POLYGON ((144.9329719278543 -37.75870884501115, 14
2	Essendon	15.1524301533	Bus	276	18.2149	POLYGON ((144.93637328610626 -37.76940907530962
3	Whitehorse - West	13.9271374214	Bus	530	38.0552	POLYGON ((145.1107142965036 -37.85512694780065, 1

Fig. Top 3 LGAs for bus by stop density.

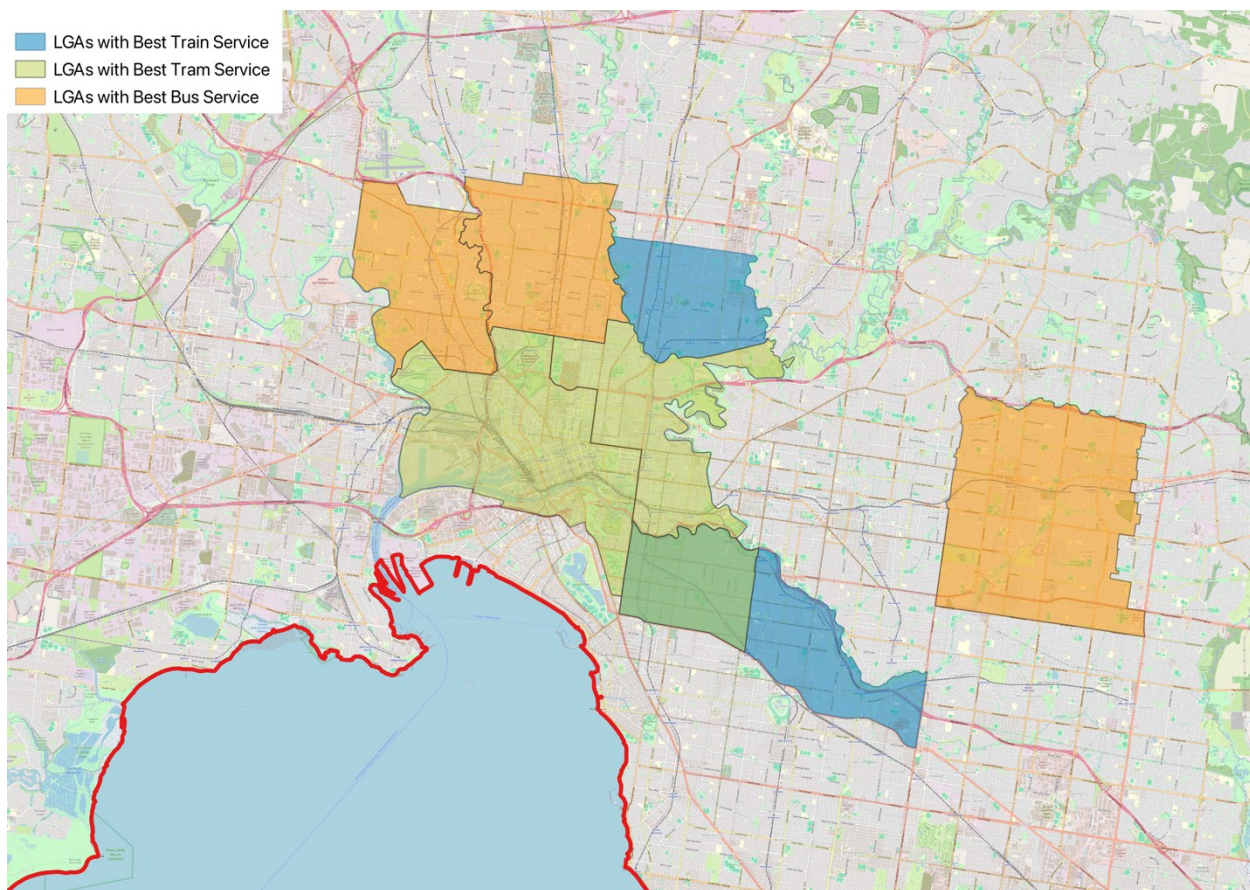


Fig. Zoomed in top 3 LGAs for all types of transport by station/stop density. **Stonnington West** has overlap for best train and tram stop density. Whitehorse West has good bus stop density despite not being adjacent to the rest of top LGAs.

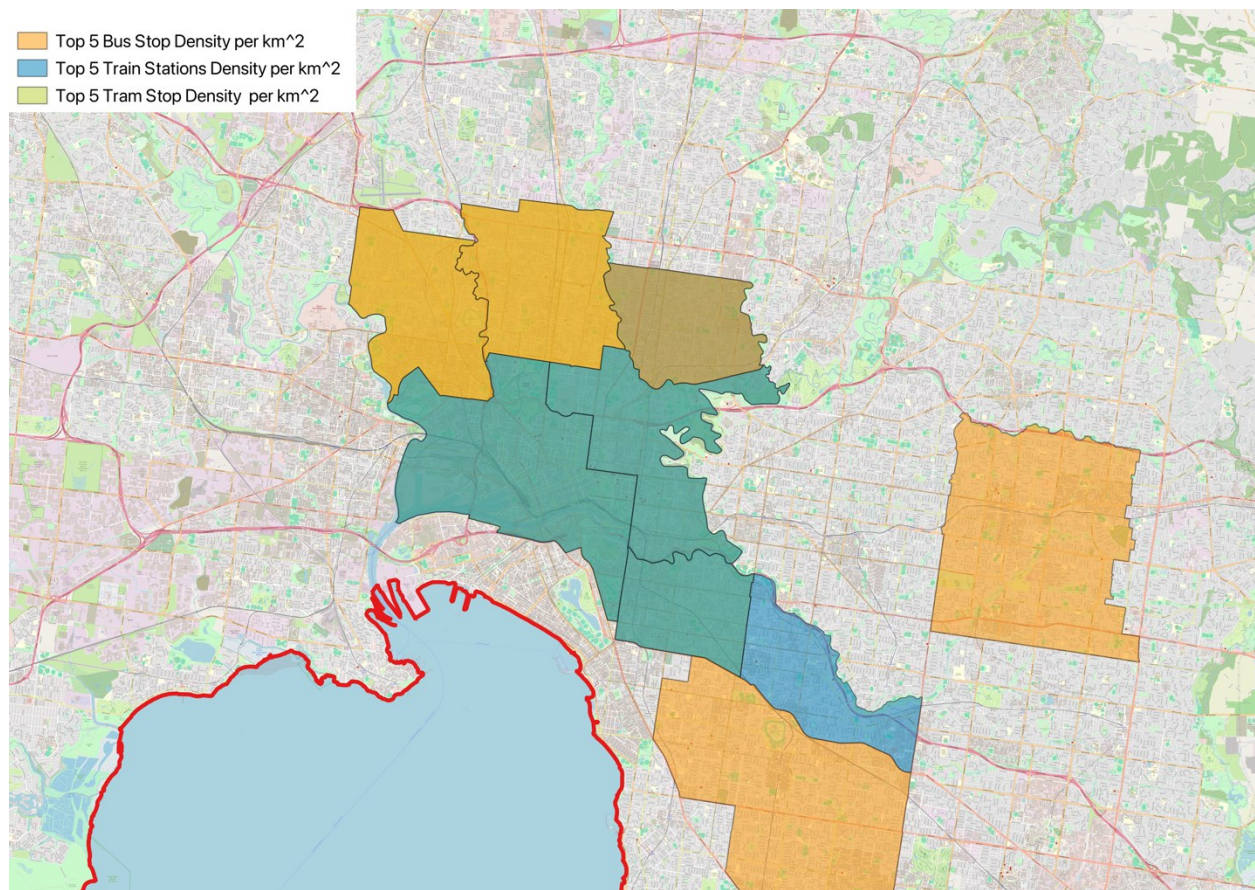


Fig. **Sensitivity Analysis:** top 5 LGAs for all types of transport by station/stop density. Like top 3, but with more overlap with two types of transport adjacent to CBD and in Darebin South. However, no LGAs has all 3 types of transport overlapping measured by top 5 station/stop density.

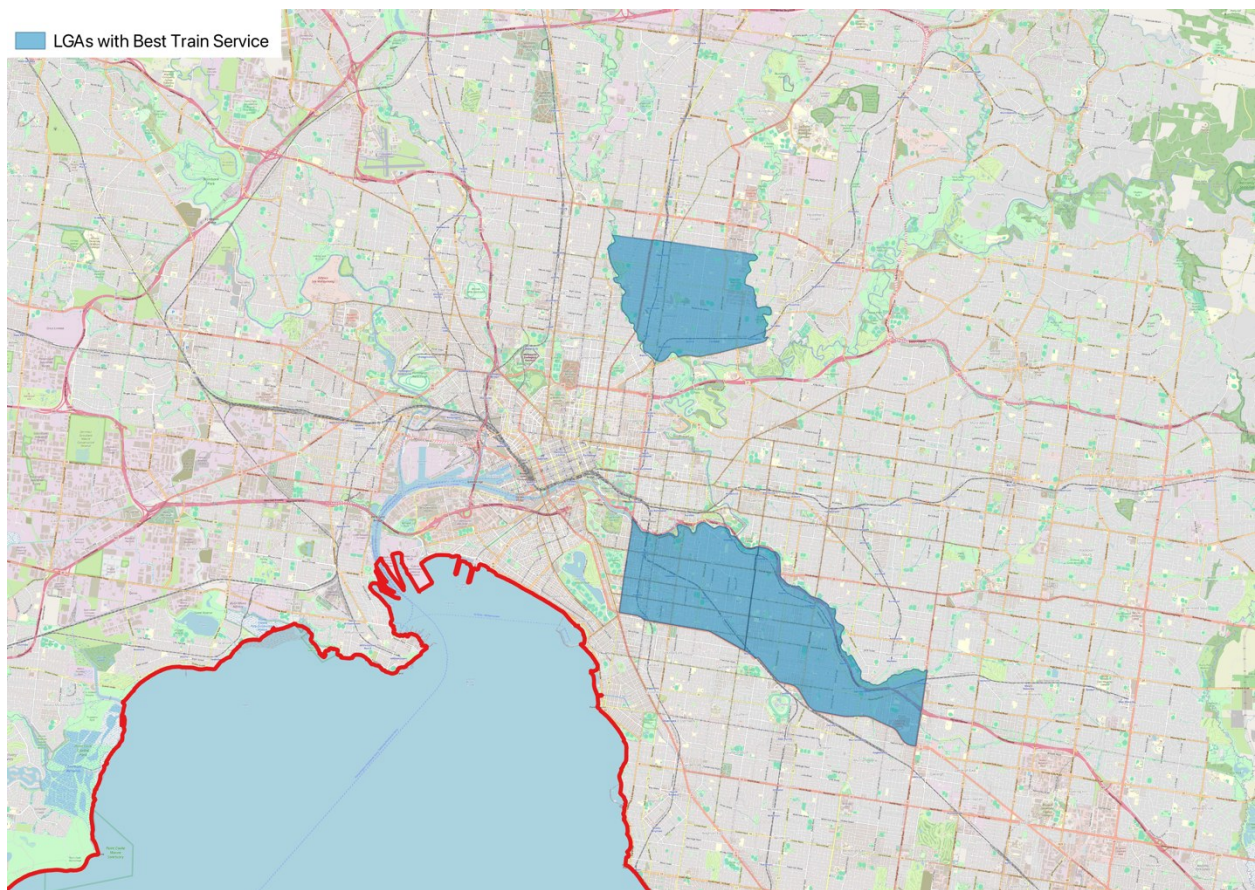


Fig. Top 3 LGAs for trains by station density.

lga_stop_density_with_geom_train 1 X						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
Grid	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	0.5867954263	Train	7	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Stonnington - East	0.5830138903	Train	8	13.7218	POLYGON ((145.04677517520125 -37.877217673536826
3	Darebin - South	0.5703083229	Train	8	14.0275	POLYGON ((144.97947394020258 -37.75496383816490

Fig. Top 3 LGAs for trains by station density.

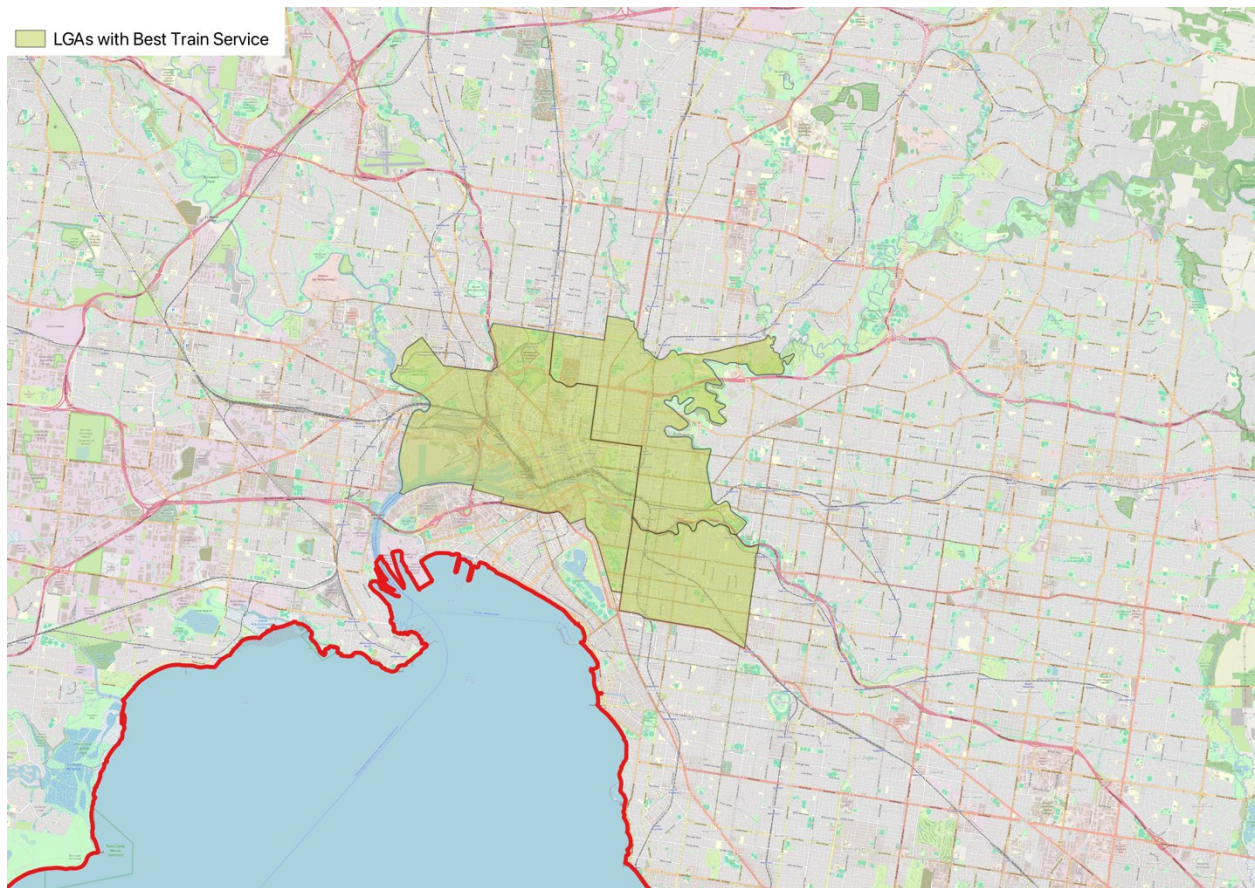


Fig. Top 3 LGAs for trams by stop density.

lga_stop_density_with_geom_tram 1						
SELECT lga_name, stop_density_per_sqkm						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	11.9873922811	Tram	143	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Melbourne City	8.9511255802	Tram	281	31.3927	POLYGON ((144.9391663741957 -37.78257506558192, 1
3	Yarra	7.6639875048	Tram	158	20.6159	POLYGON ((144.96009517964018 -37.791105007064154

Fig. Top 3 LGAs for trams by stop density.

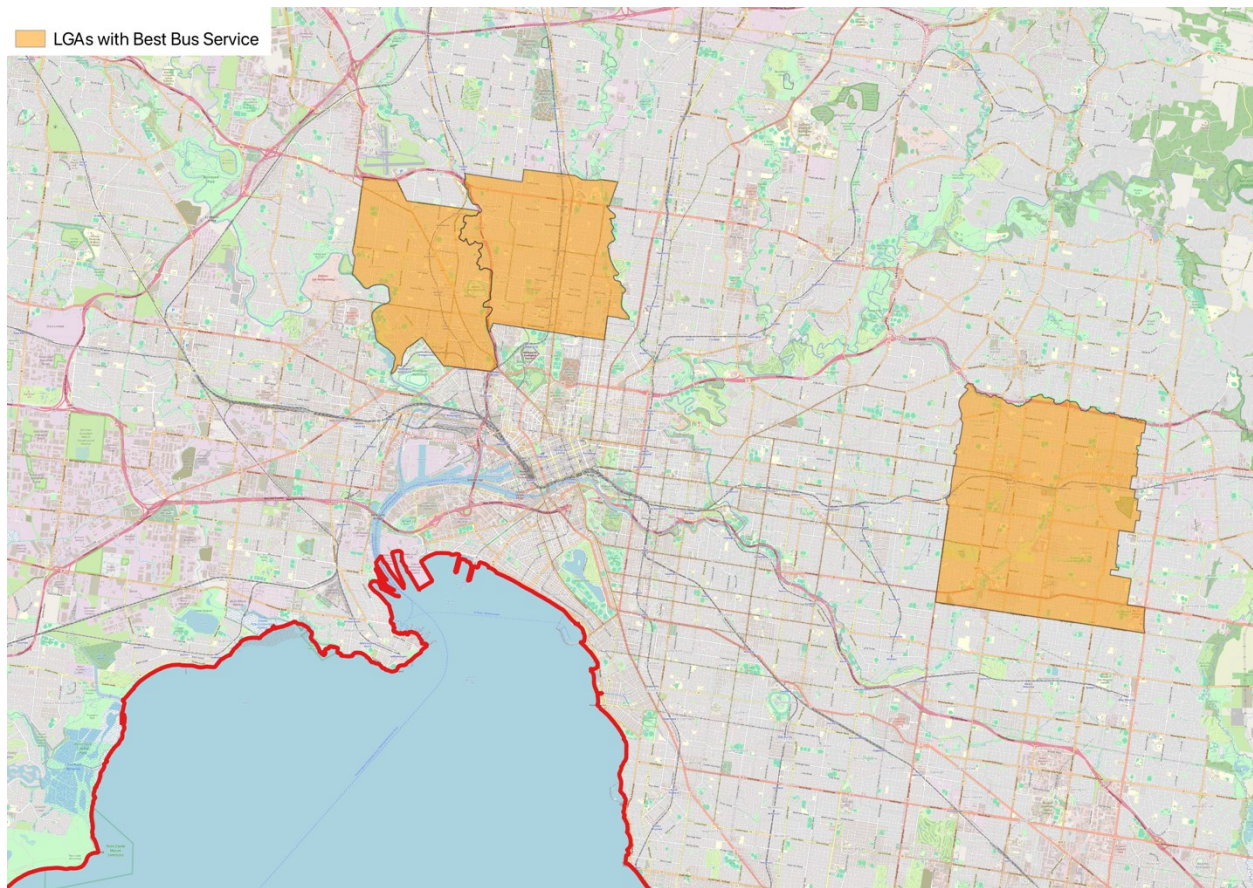


Fig. Top 3 LGAs for buses by stop density.

lga_stop_density_with_geom_bus 1 X						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Brunswick - Coburg	17.3903672062	Bus	355	20.4136	POLYGON ((144.9329719278543 -37.75870884501115, 14
2	Essendon	15.1524301533	Bus	276	18.2149	POLYGON ((144.93637328610626 -37.76940907530962
3	Whitehorse - West	13.9271374214	Bus	530	38.0552	POLYGON ((145.1107142965036 -37.85512694780065, 1

Fig. Top 3 LGAs for buses by stop density.

Key Observations for Best Service Density

Train station density peaks in inner-metropolitan LGAs, while tram services concentrate heavily in inner-city areas. Although bus services show the most equitable distribution, they still favor inner and middle-ring suburbs. Some areas demonstrate strategic modal compensation, where LGAs with lower train station density offset this through higher bus or tram stop density, indicating deliberate network planning for service coverage.

Worst Density by Transport Type (LGA)

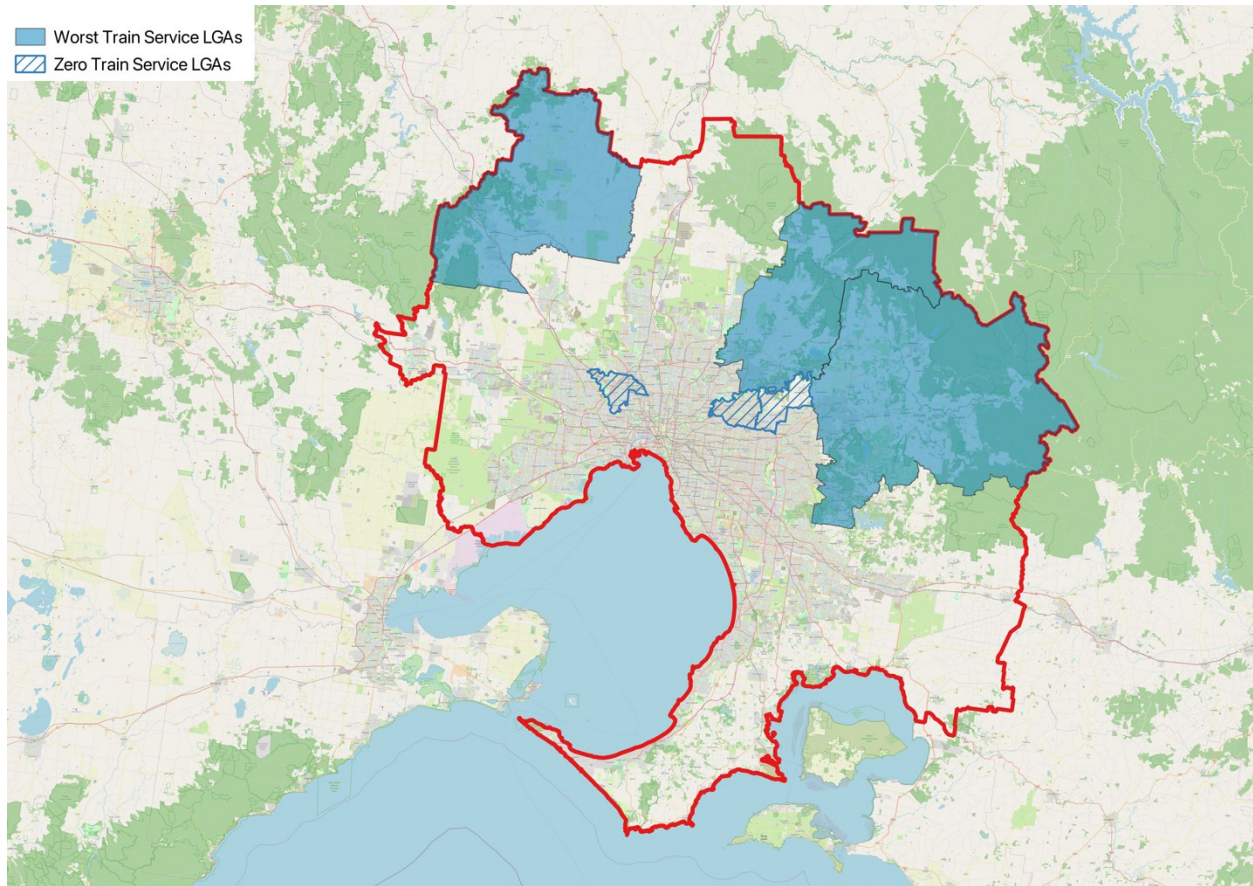


Fig. No service and bottom 3 service LGAs for trains by station density.

lga_stop_density_with_geom_train 1						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Yarra Ranges	0.0031134468	Train	5	1,605.9372	POLYGON ((145.28757086887074 -37.73689686932523,
2	Macedon Ranges	0.0040318224	Train	4	992.1072	POLYGON ((144.57295214194696 -37.5538186394429, 1
3	Nillumbik - Kinglake	0.005320789	Train	4	751.7682	POLYGON ((145.13532757098417 -37.68396317843565,

Fig. Lowest trains station density LGAs.

lga_stop_density_with_geom_train 1						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Manningham - West	0	Train	0	48.6725	POLYGON ((145.07295021354372 -37.75926368460467,
2	Manningham - East	0	Train	0	66.5619	POLYGON ((145.1734705312324 -37.803938841818514,
3	Keilor	0	Train	0	42.4249	POLYGON ((144.80517020588783 -37.70395652598565,

Fig. No train services in LGAs.

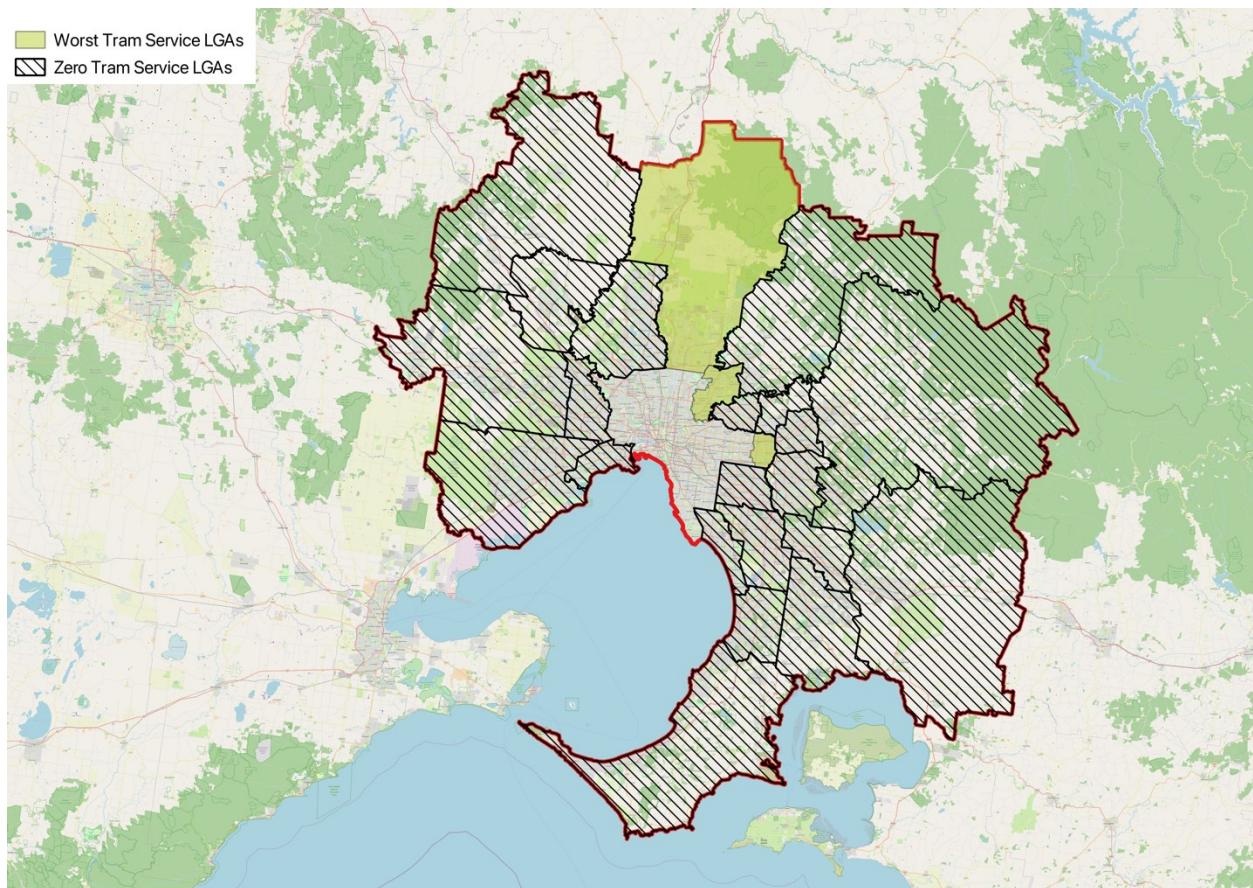


Fig. No service and bottom 3 non-zero service LGAs for trams by stop density.

lga_stop_density_with_geom_tram 1						
SELECT lga_name, stop_density_per_sqkm						
	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Whittlesea - Wallan	0.0060154024	Tram	6	997.4395	POLYGON ((144.9500138416196 -37.51126055463359, 1
2	Banyule	0.1117973338	Tram	7	62.6133	POLYGON ((145.0294986504941 -37.76454808165198, '
3	Whitehorse - East	0.1881849934	Tram	5	26.5696	POLYGON ((145.15735803942704 -37.84578523096355,

Fig. Lowest tram stop density LGAs.

lga_stop_density_with_geom_tram 1 X						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
Grid	Az lga_name	123 stop_density_per_sqkm	Az vehicle_type	123 num_stops	123 area_sqkm	geom
1	Manningham - West	0	Tram	0	48.6725	POLYGON (((145.07295021354372 -37.75926368460
2	Nilumbik - Kinglake	0	Tram	0	751.7682	POLYGON (((145.13532757098417 -37.68396317843
3	Yarra Ranges	0	Tram	0	1,605.9372	POLYGON (((145.28757086887074 -37.73689686930
4	Cardinia	0	Tram	0	1,282.3263	POLYGON (((145.37452578788333 -38.0593264573
5	Dandenong	0	Tram	0	151.051	POLYGON (((145.08869191102738 -37.93995183680
6	Monash	0	Tram	0	79.4734	POLYGON (((145.09612579129796 -37.92568861723
7	Melton - Bacchus Marsh	0	Tram	0	671.9435	POLYGON (((144.36818005332708 -37.68752779660
8	Hobsons Bay	0	Tram	0	62.2158	POLYGON (((144.75155300612428 -37.88167988346
9	Tullamarine - Broadmeadows	0	Tram	0	294.0938	POLYGON (((144.7757269809946 -37.610324823412
10	Casey - North	0	Tram	0	116.5028	POLYGON (((145.29334016566378 -38.02717963152
11	Knox	0	Tram	0	118.3018	POLYGON (((145.2547494315803 -37.944555998320
12	Brimbank	0	Tram	0	106.8497	POLYGON (((144.76060520307806 -37.70885477301
13	Macedon Ranges	0	Tram	0	992.1072	POLYGON (((144.57295214194696 -37.55381863944
14	Wyndham	0	Tram	0	544.119	POLYGON (((144.45069112011709 -37.867329743250
15	Frankston	0	Tram	0	129.5981	POLYGON (((145.09799284487832 -38.1625052688
16	Manningham - East	0	Tram	0	66.5619	POLYGON (((145.1734705312324 -37.803938841818
17	Sunbury	0	Tram	0	260.6846	POLYGON (((144.63165902878566 -37.58263381350
18	Maroondah	0	Tram	0	61.1872	POLYGON (((145.22674262809758 -37.83928877570
19	Mornington Peninsula	0	Tram	0	724.1681	MULTIPOLYGON (((144.6652876349247 -38.311750
20	Casey - South	0	Tram	0	292.9259	POLYGON (((145.2715078576388 -38.222913861212
21	Kingston	0	Tram	0	69.8632	POLYGON (((145.041808648287 -37.9483071736354

Fig. No tram services in LGAs.

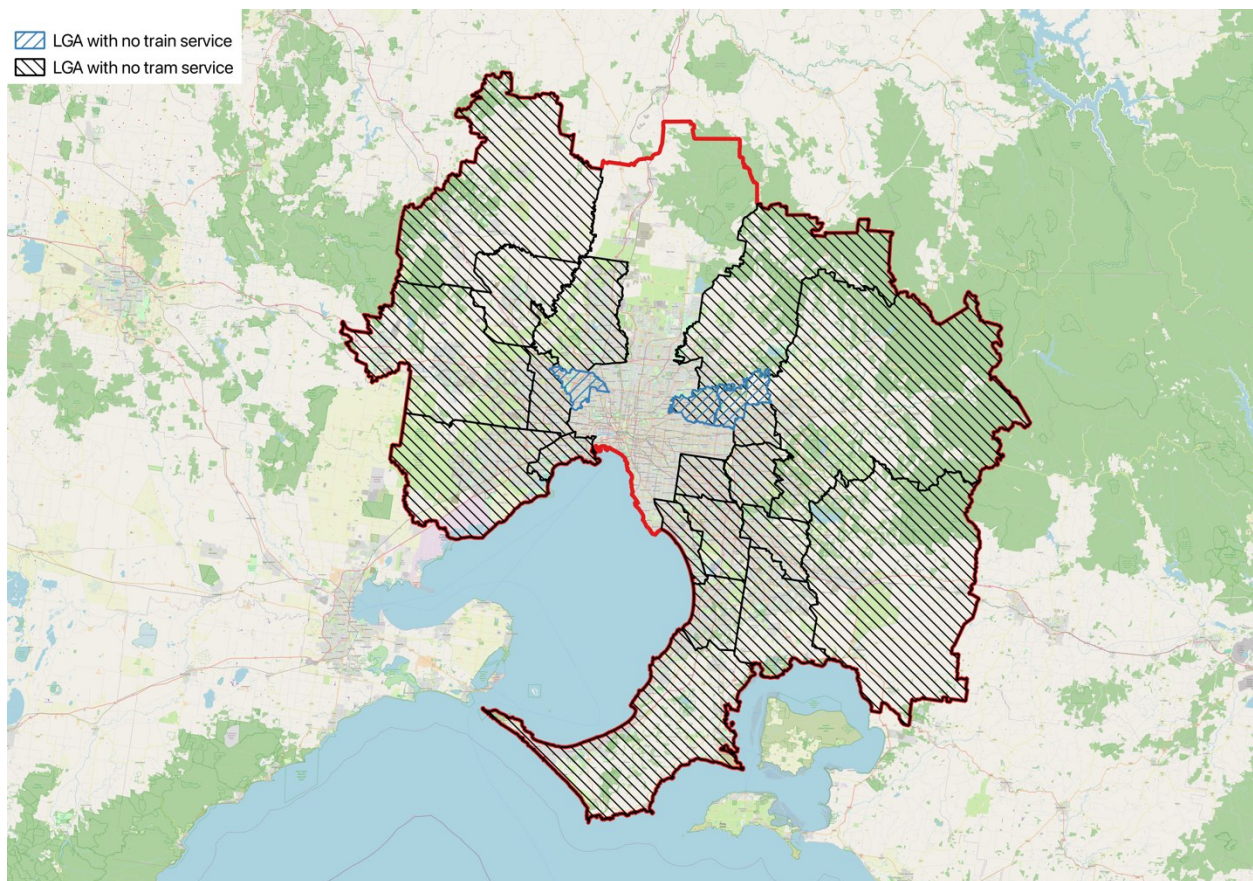


Fig. LGAs with no service of trains or trams. All LGAs are served by buses.

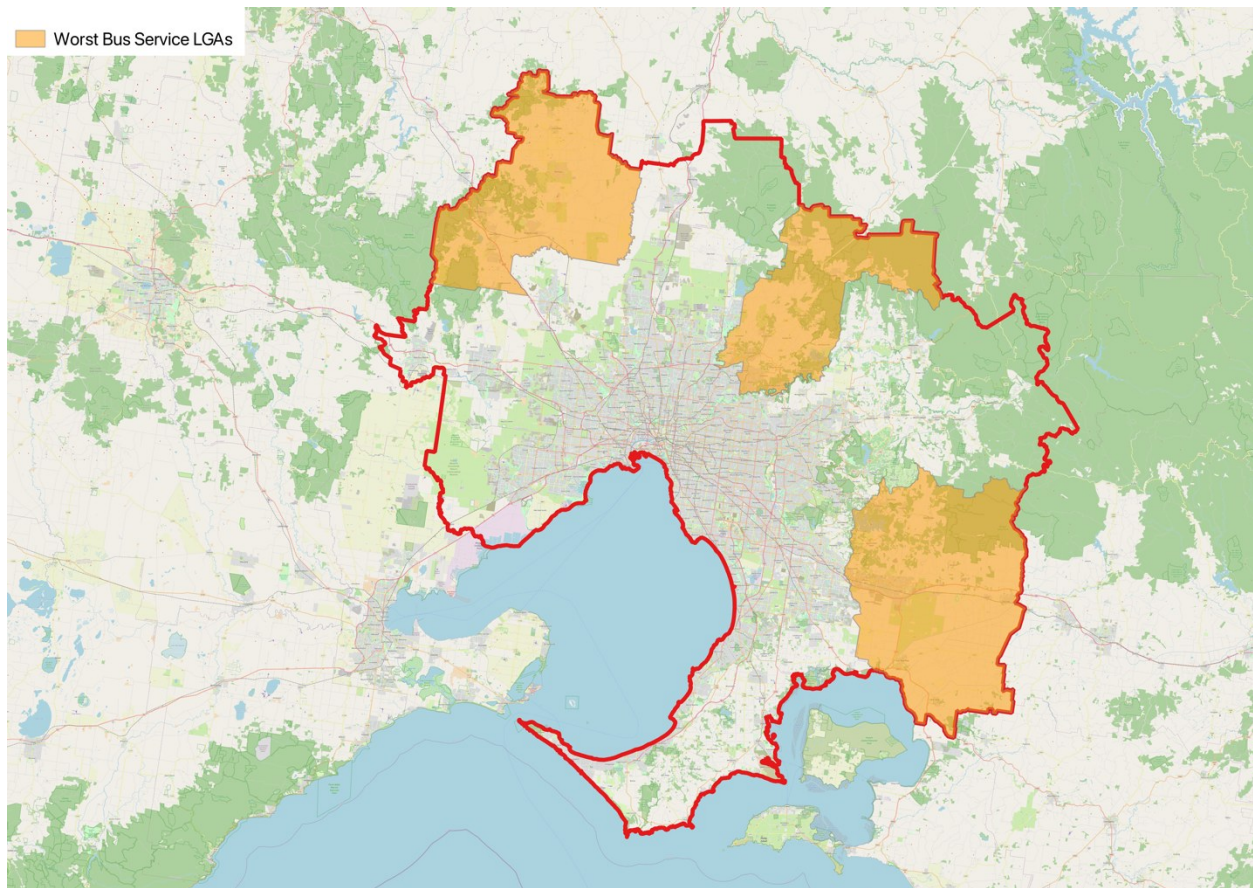


Fig. Bottom 3 service LGAs for buses by stop density. All LGAs have at least some bus services.

lga_stop_density_with_geom_bus 1						
SELECT lga_name, stop_density_per_sqkm Enter a SQL expression to filter results (use Ctrl+Space)						
	A-Z lga_name	stop_density_per_sqkm	A-Z vehicle_type	num_stops	area_sqkm	geom
1	Macedon Ranges	0.0594693799	Bus	59	992.1072	POLYGON ((144.57295214194696 -37.5538186394429, 144.
2	Cardinia	0.2440876398	Bus	313	1,282.3263	POLYGON ((145.37452578788333 -38.05932645739919, 14
3	Nillumbik - Kinglake	0.3445210904	Bus	259	751.7682	POLYGON ((145.13532757098417 -37.68396317843565, 145

Fig. Lowest bus stop density LGAs.

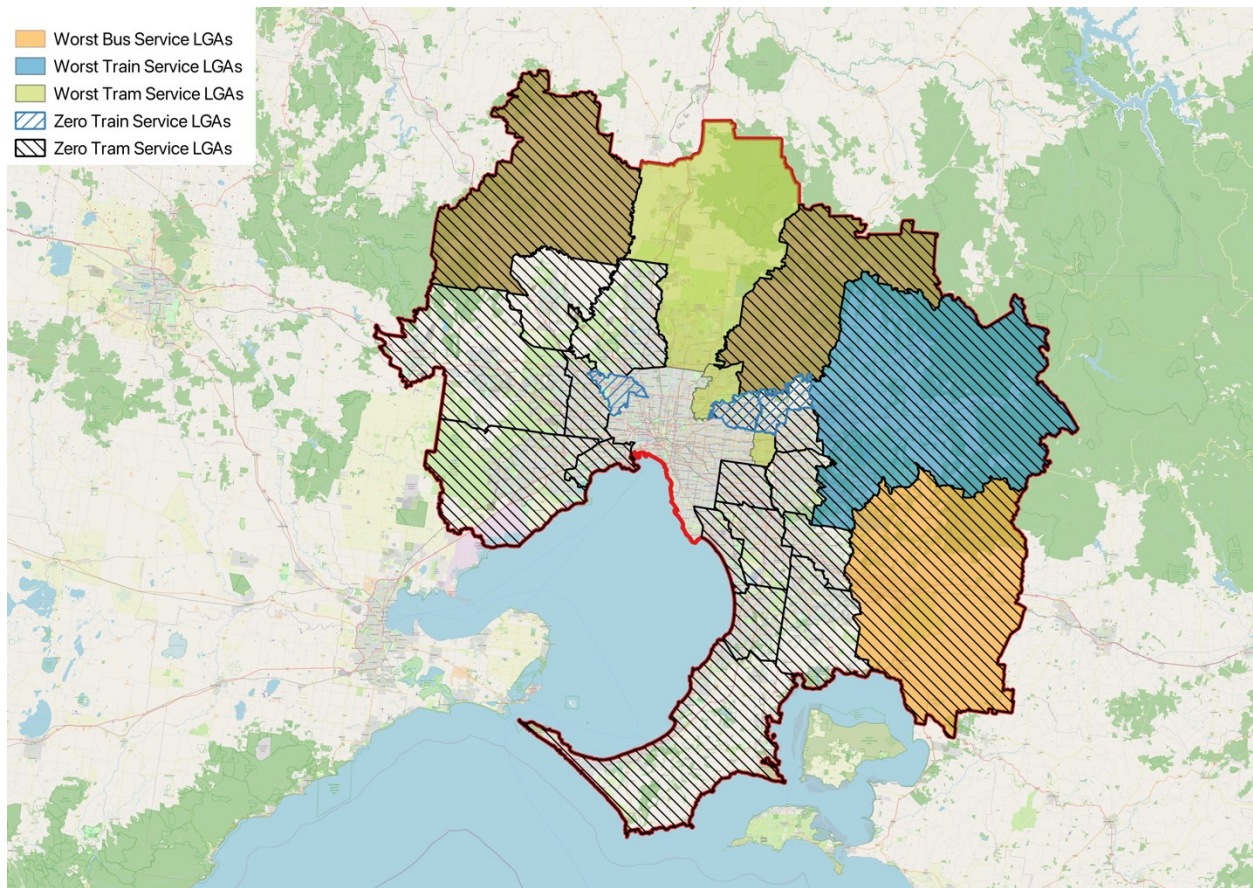


Fig. Bottom 3 service and zero service LGAs for all types of transport by station/stop density. There is significant overlap in the outer northern and eastern suburbs. Tram services are poor or non-existent outside of the inner-city suburbs

Key Observations for Worst Density

Multiple LGAs, particularly in outer northern and eastern suburbs, lack train and tram services, relying solely on buses. While Manningham West and East compensate for their lack of trains with above-average bus and tram coverage, Keilor demonstrates poor multi-modal integration, ranking only 18th in bus density. Significant service gaps persist in outer metropolitan areas including Macedon Ranges, Yarra Ranges, Cardinia and Nillumbik-Kinglake, where multiple modes of transport are underrepresented or absent.

Comparison: Top vs Bottom LGA

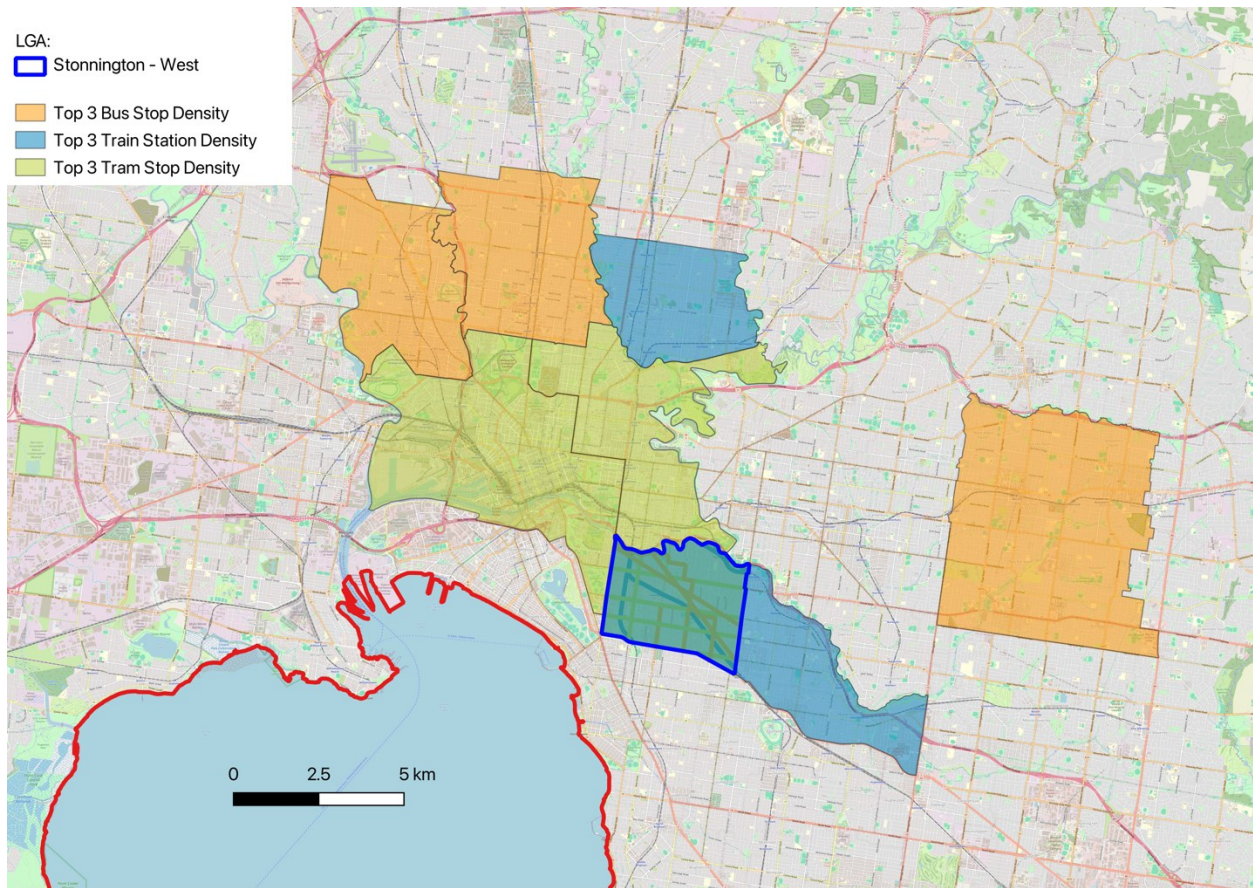


Fig. Bus, Tram and Train stop/station density in **Stonnington West**. This LGA is the only one that has both top 3 station/stop density for both trains and trams, and thus will be used as an example of a good accessibility LGA.

lga_stop_density_with_geom_train 1 X

SELECT lga_name, stop_density_per_sqkm | Enter a SQL expression to filter results (use Ctrl+Space)

Grid	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	0.5867954263	Train	7	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Stonnington - East	0.5830138903	Train	8	13.7218	POLYGON ((145.04677517520125 -37.877217673536826
3	Darebin - South	0.5703083229	Train	8	14.0275	POLYGON ((144.97947394020258 -37.75496383816490

Fig. Stonnington West has the best train station density.

lga_stop_density_with_geom_tram 1 X

SELECT lga_name, stop_density_per_sqkm | Enter a SQL expression to filter results (use Ctrl+Space)

Grid	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Stonnington - West	11.9873922811	Tram	143	11.9292	POLYGON ((144.98348560865963 -37.85475579905823
2	Melbourne City	8.9511255802	Tram	281	31.3927	POLYGON ((144.9391663741957 -37.78257506558192, 1
3	Yarra	7.6639875048	Tram	158	20.6159	POLYGON ((144.96009517964018 -37.791105007064154

Fig. Stonnington West has the best tram stop density, ahead of the City of Melbourne LGA.

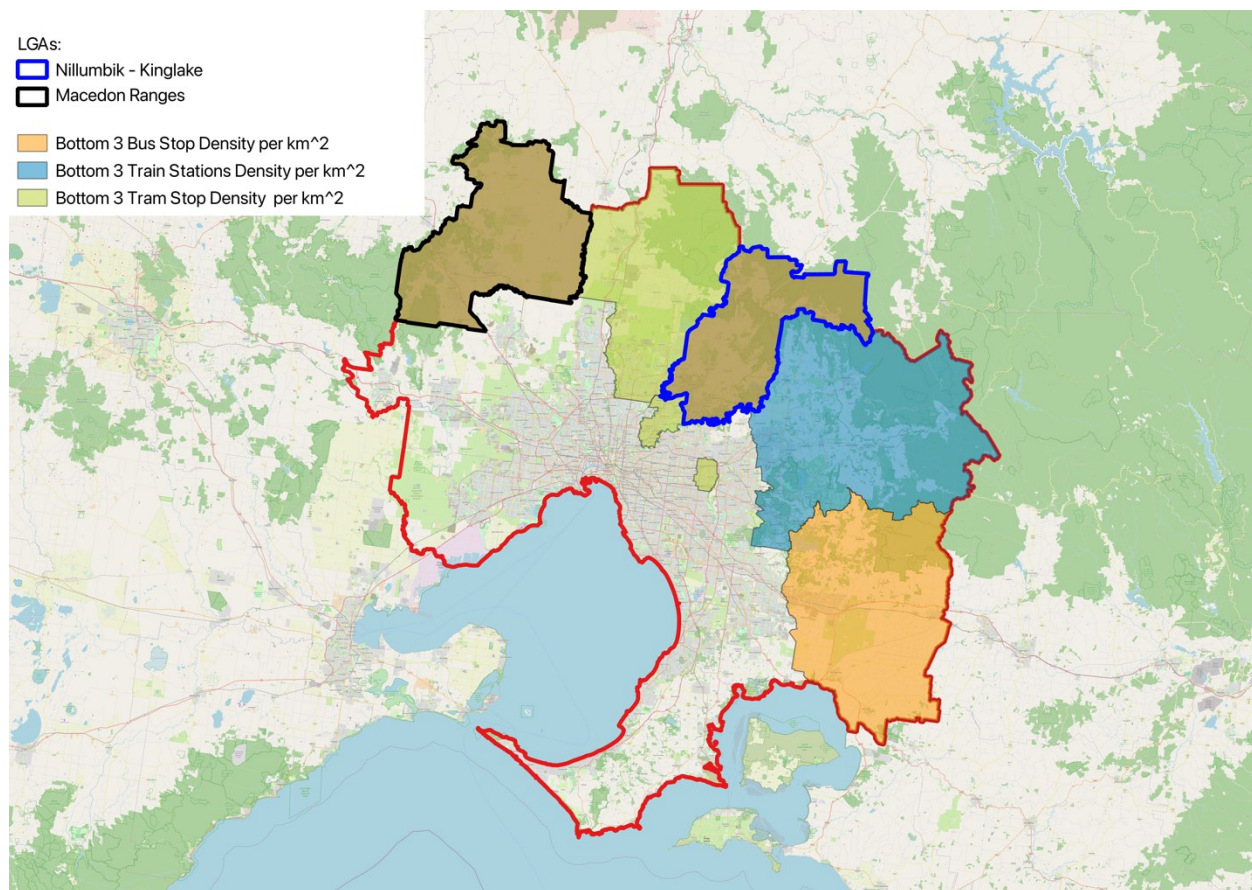


Fig. Bus, Tram and Train stop/station density in Macedon Ranges and Nillumbik – Kinglake. No trams, bottom 3 for buses and trains.

lga_stop_density_with_geom_bus 1 X

SELECT lga_name, stop_density_per_sqkm, vehicle_type, num_stops, area_sqkm, geom

	A-Z lga_name	123 stop_density_per_sqkm	A-Z vehicle_type	123 num_stops	123 area_sqkm	geom
1	Macedon Ranges	0.0594693799	Bus	59	992.1072	POLYGON ((144.57295214194696 -37.5538186394429, 144.
2	Cardinia	0.2440876398	Bus	313	1,282.3263	POLYGON ((145.37452578788333 -38.05932645739919, 14.
3	Nillumbik - Kinglake	0.3445210904	Bus	259	751.7682	POLYGON ((145.13532757098417 -37.68396317843565, 145

Fig. Lowest bus stop density LGAs. Macedon Ranges has the worst bus stop density.

The screenshot shows a SQL query editor with the following query:

```
SELECT lga_name, stop_density_per_sqkm, vehicle_type, num_stops, area_sqkm, geom
```

The results table has the following data:

	lga_name	stop_density_per_sqkm	vehicle_type	num_stops	area_sqkm	geom
1	Yarra Ranges	0.0031134468	Train	5	1,605.9372	POLYGON ((145.28757086887074 -37.73689686932523,
2	Macedon Ranges	0.0040318224	Train	4	992.1072	POLYGON ((144.57295214194696 -37.5538186394429, 1
3	Nillumbik - Kinglake	0.005320789	Train	4	751.7682	POLYGON ((145.13532757098417 -37.68396317843565,

Fig. Lowest trains station density LGAs. Macedon Ranges has the second worst train station density.

Key Observations – Best and Worst Station/Stop Density

Stonnington West and Macedon Ranges represent the extremes of Melbourne's transport accessibility. While Stonnington West ranks in the top 3 for both train and tram density, Macedon Ranges has Melbourne's worst bus density, second-worst train density, and no tram service—performing even more poorly than Nillumbik-Kinglake, which ranks in the bottom 3 across all modes.

Routes & Catchment: Top vs Bottom LGA

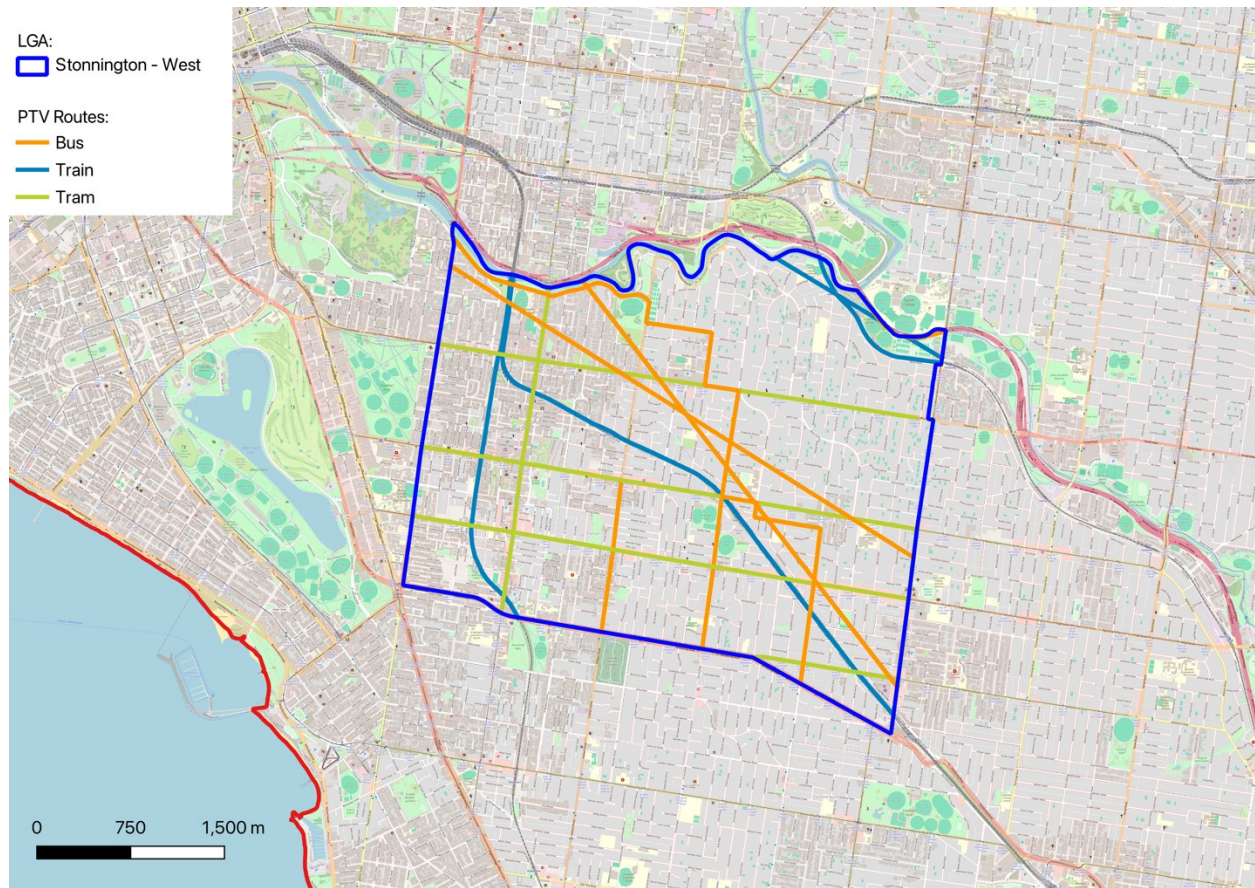


Fig. Bus, Tram and Train routes in Stonnington West LGA. All transport routes are well spaced out and offer extremely good coverage of the area with multiple train, tram and bus lines.

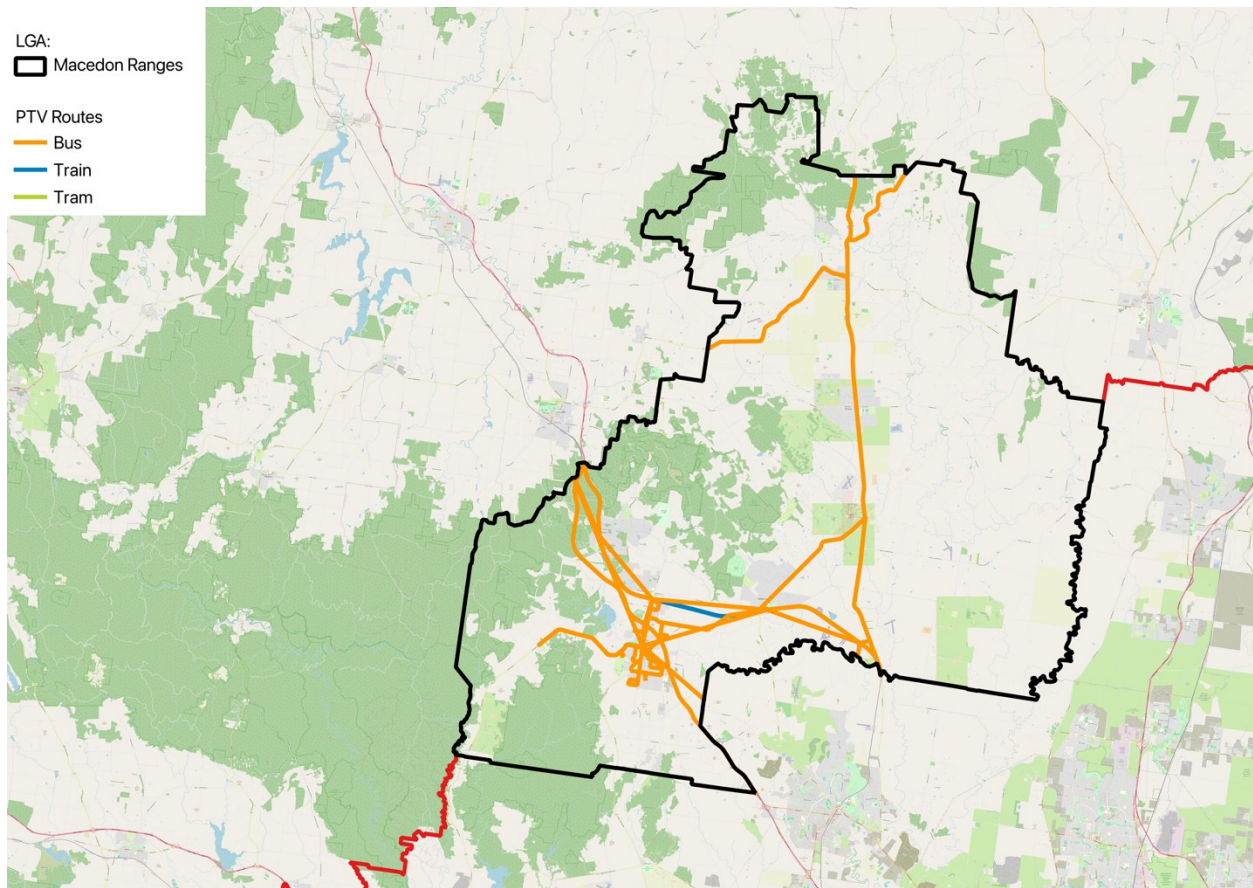


Fig. Bus, Tram and Train routes in Nillumbik – Kinglake LGA. There is a concentration of transport bus routes in the south-west of the LGA around Gisborne, only one V/Line train and no trams.



Fig. Bus, Tram and Train catchment zones in Stonnington West LGA. 400m is used for tram and buses, 800m is used for trains.

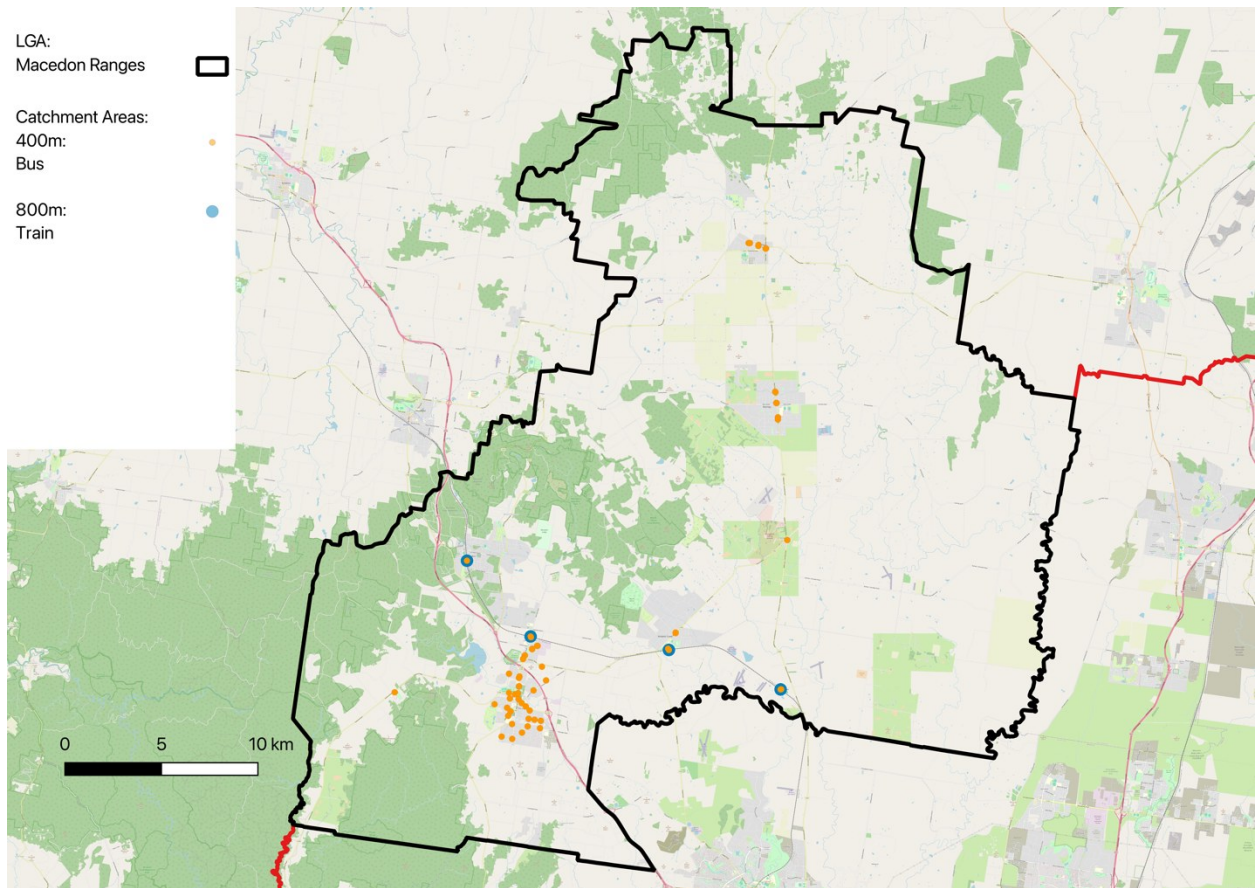


Fig. Bus and Train catchment zones in Macedon Ranges LGA. 400m is used for tram and buses, 800m is used for trains.

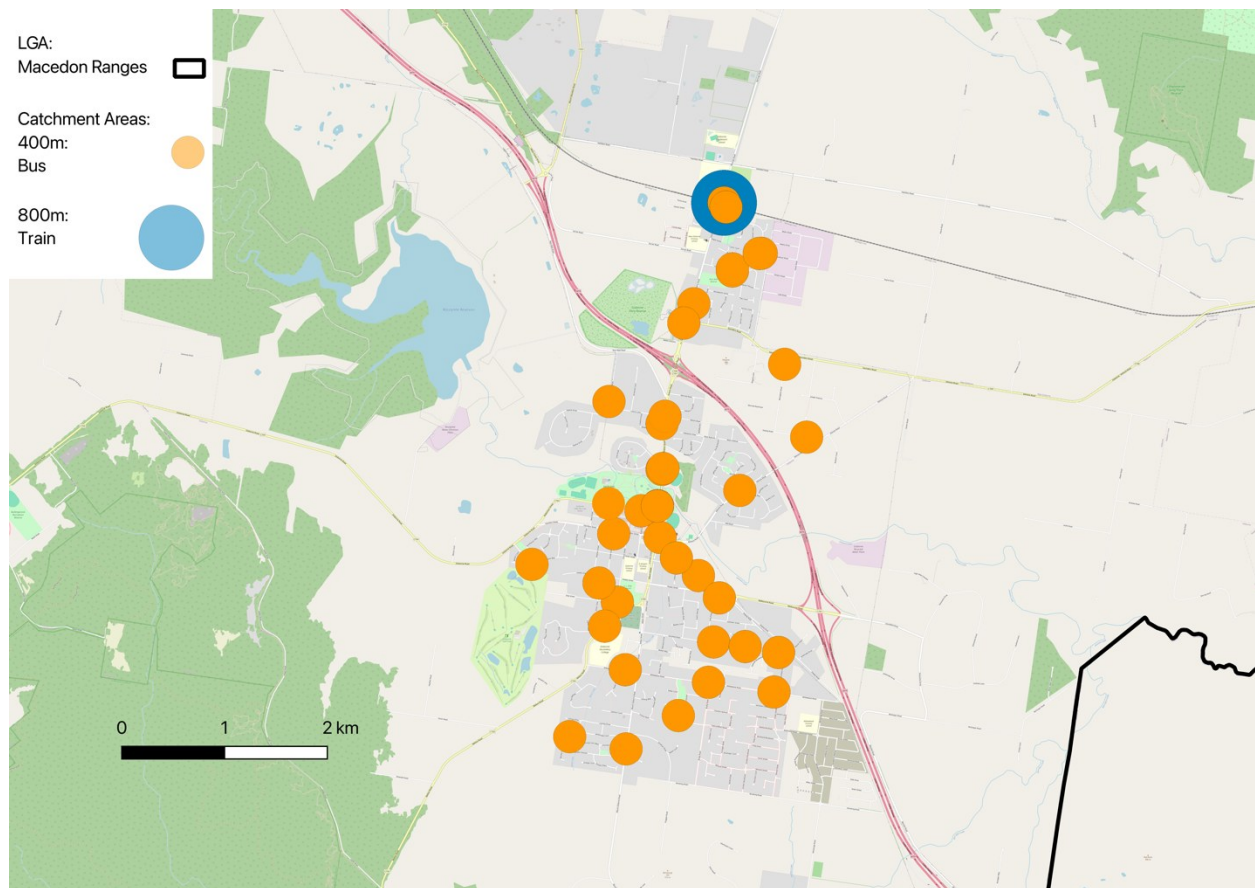


Fig. Zoom in on Gisborne – catchment zones in Macedon Ranges LGA. 400m is used for buses, 800m is used for trains.

Key Observation – Catchments Comparison

Stonnington West exhibits comprehensive coverage through multi-modal integration, with overlapping 400m tram/bus catchments and 800m train station catchments (Eady and Burt, 2019) leaving only the northeastern riverside area underserved. Conversely, Macedon Ranges' services concentrate around Gisborne's population centers, with stop density significantly below Stonnington West's levels. Bus stops frequently exceed the 400m walking standard, and the area lacks Stonnington West's multi-modal interchange options, offering only bus connections at V/Line stations.

Service Frequency: Top vs Bottom LGA

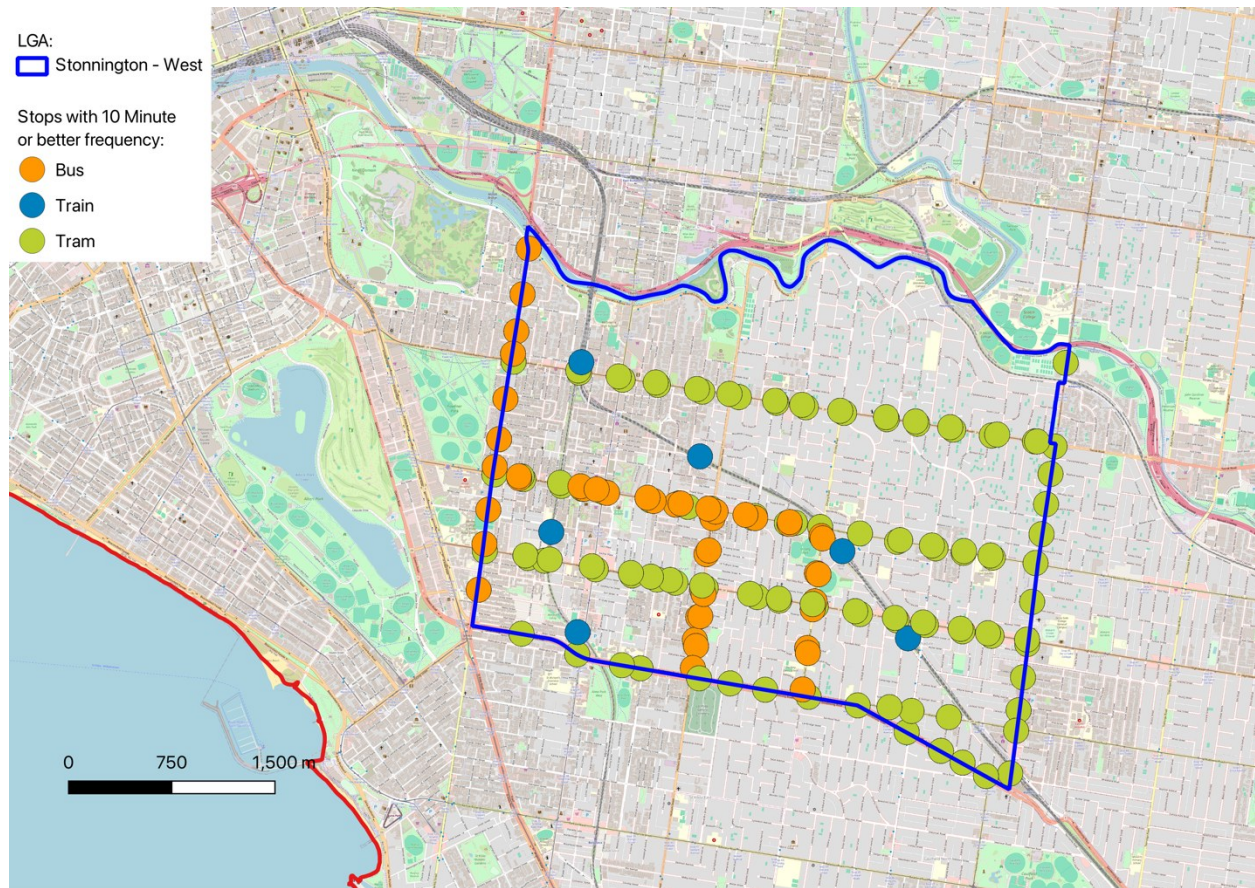


Fig. Monday 5-6pm Peak Transport Stops that have 10 minute or better frequency (6 times per hour) in Stonnington West.

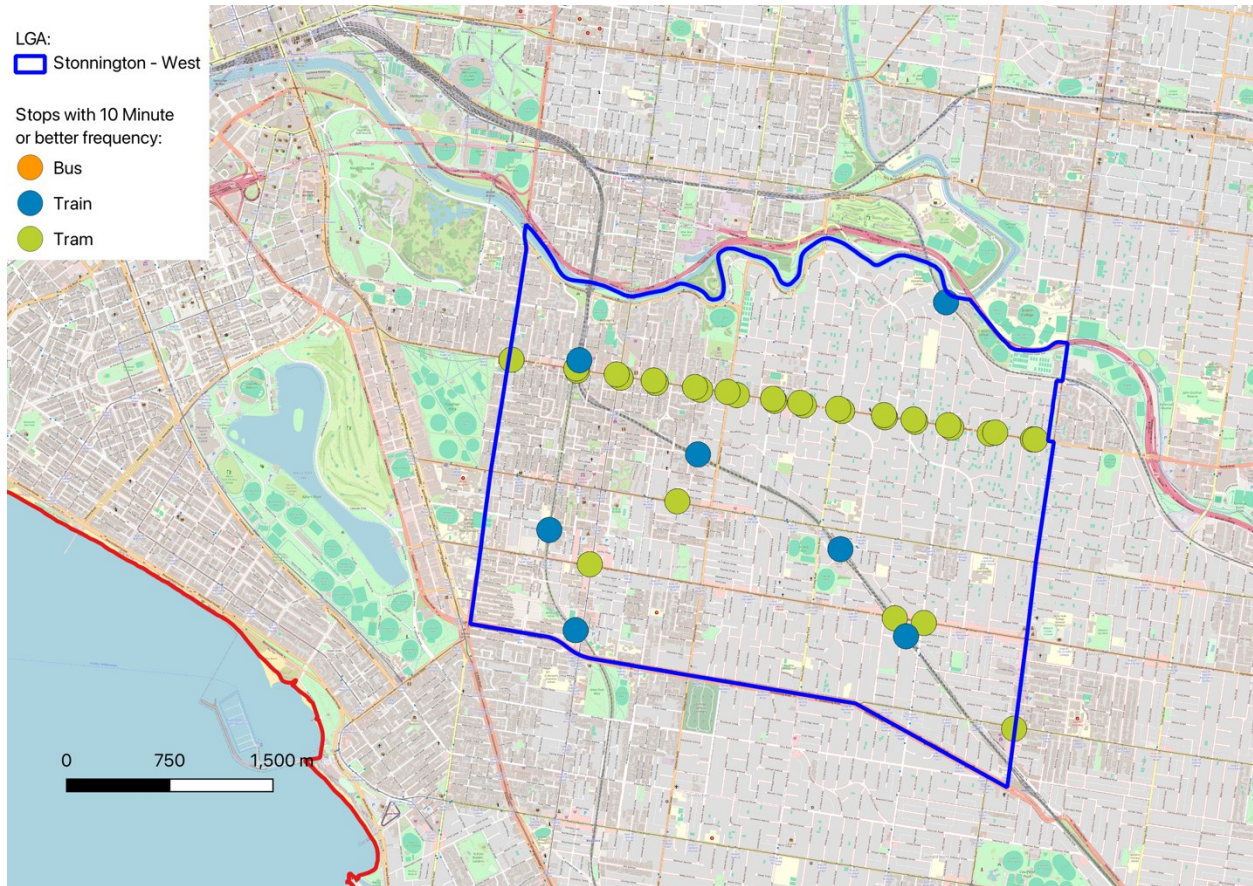


Fig. Sunday 2-3pm Off-Peak Transport Stops that have 10 minute or better frequency (6 times per hour) in Stonnington West.

Key Observations – Service Frequency

In Stonnington, most services meet the 10-minute frequency threshold at peak times (Eady and Burt, 2019; Infrastructure Victoria, 2023). Macedon Ranges does not have any services that have a 10 minutes or better frequency even during peak times, making public transport undependable and unreliable.

Results

The analysis reveals significant spatial disparities in public transport accessibility across Greater Melbourne, with a pronounced center-periphery gradient. Inner Local Government Areas (LGAs) demonstrate consistently superior service density across all transport modes, exemplified by Stonnington West's unique position in the top three rankings for both train and tram density. Modal distribution analysis shows buses providing the most extensive coverage across all LGAs, while trams demonstrate the most concentrated spatial distribution, primarily serving inner and some middle-ring suburbs.

Service frequency analysis indicates that only inner LGAs consistently meet the 10-minute frequency benchmark for "turn-up-and-go" service, particularly during peak hours. Significant service gaps exist in outer metropolitan regions, with areas like Macedon Ranges showing concurrent deficiencies across multiple transport modes, having Melbourne's worst bus density and second-worst train density with no tram service. However, some LGAs demonstrate effective modal compensation strategies, notably Manningham's enhanced bus/tram coverage offsetting the absence of train services. The analysis of catchment areas reveals that Stonnington West achieves comprehensive coverage through effective multi-modal integration, while Macedon Ranges services are confined to limited areas around population centers, with significant gaps in coverage even along existing routes.

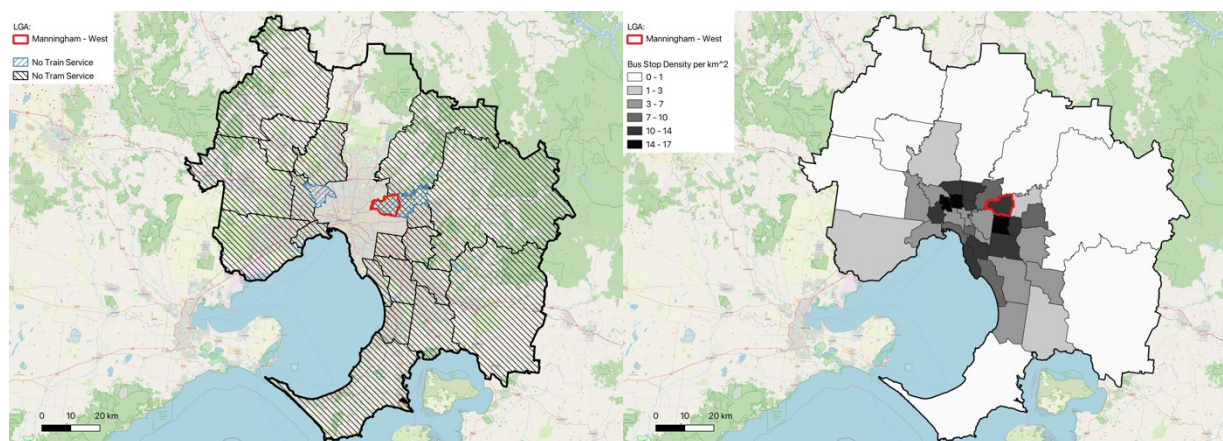


Fig. Manningham has higher bus stop densities to compensate for the lack of trains and trams.

Discussion

The findings raise important implications for transport planning and equity in Greater Melbourne. While density analysis provides valuable insights into service distribution, it must be interpreted within the broader context of urban development patterns and population distribution which was not a part of this dataset. The stark contrast between inner and outer suburban service levels presents both challenges and opportunities for strategic intervention. The success of compensatory service provision in areas like Manningham suggests a viable model for improving accessibility in other underserved regions.

The current distribution pattern raises concerns about transport equity, particularly given population growth trends in outer areas. The concentration of high-frequency services in inner areas may reinforce existing socio-economic disparities, suggesting the need for targeted intervention in poorly served areas. The effectiveness of multi-modal integration in inner LGAs demonstrates the potential benefits of coordinated transport planning, while the success of some outer LGAs in maintaining adequate service levels through alternative modes provides valuable lessons for future planning initiatives.

Conclusion

This study demonstrates that public transport accessibility in Greater Melbourne exhibits significant spatial variation, with clear advantages for inner metropolitan areas. While some regions show effective adaptation through modal compensation, others face substantial accessibility challenges requiring strategic intervention. Future planning initiatives should focus on enhancing service frequency in outer areas while implementing successful modal compensation strategies from high-performing regions. Further research examining the relationship between population density and service provision could provide additional insights for optimizing resource allocation across Greater Melbourne's public transport network.

References

Australian Bureau of Statistics. (2021a). *Digital boundary files*. ABS.

<https://www.abs.gov.au/statistics/standards/australian-statistical-geography-standard-asgs-edition-3/jul2021-jun2026/access-and-downloads/digital-boundary-files>.

Australian Bureau of Statistics. (2021b). *Greater Melbourne, Census all persons QuickStats*.

Australian Government. Retrieved October 26, 2024, from <https://www.abs.gov.au/census/find-census-data/quickstats/2021/2GMEL>.

Eady, J. and Burtt, D. (2019). Walking and transport in Melbourne suburbs. Victoria Walks, Melbourne, November 2019.

Infrastructure Victoria. (2023). *Fast, Frequent, Fair: How buses can better connect Melbourne*.

Infrastructure Victoria. Retrieved from

<https://www.infrastructurevictoria.com.au/resources/fast-frequent-fair-how-buses-can-better-connect-melbourne>.

Appendix – SQL Code

Part C- Data Preprocessing

----- Part C -----

----- Data Preprocessing -----

-- 1. Make single polygon boundary.

CREATE TABLE melbourne_boundary **AS**

SELECT ST_Union(geom) **AS** geom

FROM mb2021_mel;

-- 2. Add geometry table to stops.

ALTER TABLE stops

ADD COLUMN geom geometry(**Point**, 7844);

UPDATE stops

SET geom = **ST_SetSRID**(**ST_MakePoint**(stop_lon, stop_lat), 7844);

-- 3 and 4. Stops Improved Table

CREATE TABLE stops_with_route_info **AS**

SELECT

st.stop_id::varchar,

s.stop_name,

s.stop_lat,

s.stop_lon,

```

s.geom,
st.arrival_time,
st.departure_time,
t.trip_id::varchar,
r.route_id::varchar,
r.route_short_name,
r.route_long_name,
r.route_type,
CASE
    WHEN r.route_type = 0 THEN 'Tram'
    WHEN r.route_type = 2 THEN 'Train'
    WHEN r.route_type = 3 THEN 'Bus'
    ELSE 'Unknown'
END AS vehicle_type
FROM
    stops s
JOIN stop_times st
    ON s.stop_id::varchar = st.stop_id::varchar
JOIN trips t
    ON st.trip_id::varchar = t.trip_id::varchar
JOIN routes r
    ON t.route_id::varchar = r.route_id::varchar
;

-- EXTRA PREPROCESSING

```

-- Step 1: Create a table for LGA boundaries

```
CREATE TABLE lga_aggregated_boundaries AS  
SELECT  
    sa3_code21 as lga_code,  
    sa3_name21 as lga_name,  
    SUM(mb2021_mel.areasqkm21) AS lga_area_sqkm  
FROM mb2021_mel  
GROUP BY lga_code, lga_name;
```

-- Step 2. Aggregate mesh block geometries into LGA boundaries

```
CREATE TABLE lga_boundaries AS  
SELECT  
    sa3_code21 AS lga_code,  
    sa3_name21 AS lga_name,  
    ST_Union(geom) AS geom  
FROM mb_2021_mel  
GROUP BY sa3_code21, sa3_name21;
```

-- Step 3. Calculate the centroids of LGA boundaries

```
CREATE TABLE lga_centroids AS  
SELECT  
    lga_code,  
    lga_name,  
    ST_Centroid(geom) AS centroid_geom  
FROM lga_boundaries;
```

Data Analysis and Visualization

Data Preprocessing

----- Part C -----

----- Data Preprocessing -----

-- 1. Make single polygon boundary.

CREATE TABLE melbourne_boundary **AS**

SELECT ST_Union(geom) **AS** geom

FROM mb2021_mel;

-- 2. Add geometry table to stops.

ALTER TABLE stops

ADD COLUMN geom geometry(**Point**, 7844);

UPDATE stops

SET geom = **ST_SetSRID**(**ST_MakePoint**(stop_lon, stop_lat), 7844);

-- 3 and 4. Stops Improved Table

CREATE TABLE stops_with_route_info **AS**

SELECT

st.stop_id::varchar,

s.stop_name,

s.stop_lat,

s.stop_lon,

```

s.geom,
st.arrival_time,
st.departure_time,
t.trip_id::varchar,
r.route_id::varchar,
r.route_short_name,
r.route_long_name,
r.route_type,
CASE
    WHEN r.route_type = 0 THEN 'Tram'
    WHEN r.route_type = 2 THEN 'Train'
    WHEN r.route_type = 3 THEN 'Bus'
    ELSE 'Unknown'
END AS vehicle_type
FROM
    stops s
JOIN stop_times st
    ON s.stop_id::varchar = st.stop_id::varchar
JOIN trips t
    ON st.trip_id::varchar = t.trip_id::varchar
JOIN routes r
    ON t.route_id::varchar = r.route_id::varchar
;

-- EXTRA PREPROCESSING

```

-- Step 1: Create a table for LGA boundaries

```
CREATE TABLE lga_aggregated_boundaries AS  
SELECT  
    sa3_code21 as lga_code,  
    sa3_name21 as lga_name,  
    SUM(mb2021_mel.areasqkm21) AS lga_area_sqkm  
FROM mb2021_mel  
GROUP BY lga_code, lga_name;
```

-- Step 2. Aggregate mesh block geometries into LGA boundaries

```
CREATE TABLE lga_boundaries AS  
SELECT  
    sa3_code21 AS lga_code,  
    sa3_name21 AS lga_name,  
    ST_Union(geom) AS geom  
FROM mb_2021_mel  
GROUP BY sa3_code21, sa3_name21;
```

-- Step 3. Calculate the centroids of LGA boundaries

```
CREATE TABLE lga_centroids AS  
SELECT  
    lga_code,  
    lga_name,  
    ST_Centroid(geom) AS centroid_geom  
FROM lga_boundaries;
```

Public Transport Coverage Density (LGA)

----- Part 3 - Analysis -----

----- Density Analysis -----

-- Stop Count by Type of transport.

CREATE TABLE lga_stop_count_by_type **AS**

SELECT

lb.lga_name,
lb.lga_code,
vt.vehicle_type,
0 **AS** num_stops

FROM

lga_boundaries lb,
(**VALUES** ('Train'), ('Tram'), ('Bus')) **AS** vt(vehicle_type);

-- Spatial join for stop counts table

WITH stop_counts **AS** (

SELECT

l.lga_name,
l.lga_code,
s.vehicle_type,
COUNT(s.stop_id) **AS** num_stops

FROM

-- Transform LGA boundaries and stops to the same SRID (7844)

(**SELECT** lga_name, lga_code, **ST_Transform**(geom, 7844) **AS** geom **FROM** lga_boundaries) /

```

JOIN

    (SELECT DISTINCT stop_id, vehicle_type, ST_Transform(geom, 7844) AS geom
     FROM stops_with_route_info) s
ON ST_Within(s.geom, l.geom) -- Stop is within the LGA boundary
GROUP BY l.lga_name, l.lga_code, s.vehicle_type
)

-- Update the LGA table with stop counts
UPDATE lga_stop_count_by_type t
SET num_stops = sc.num_stops
FROM stop_counts sc
WHERE

    t.lga_name = sc.lga_name
    AND t.lga_code = sc.lga_code
    AND t.vehicle_type = sc.vehicle_type;

-- Add area column to LGA boundaries
ALTER TABLE lga_boundaries ADD COLUMN area_sqkm NUMERIC;

-- Update area_sqkm in lga_boundaries using data from lga_2021_aust
UPDATE lga_boundaries lb
SET area_sqkm = la.lga_area_sqkm
FROM ptv.lga_aggregated_boundaries la
WHERE lb.lga_code = la.lga_code;

-- BUS STOP DENSITY
CREATE TABLE lga_stop_density_with_geom_bus AS

```

SELECT

lscbt.lga_name,
lscbt.lga_code,
lscbt.vehicle_type,
lscbt.num_stops,
lb.area_sqkm,
lb.geom,

CASE

WHEN lb.area_sqkm > 0 **THEN** lscbt.num_stops / lb.area_sqkm

ELSE 0

END AS stop_density_per_sqkm

FROM

lga_stop_count_by_type lscbt

JOIN

lga_boundaries lb

ON lscbt.lga_code = lb.lga_code

WHERE

lscbt.vehicle_type = 'Bus';

-- TRAM STOP DENSITY

CREATE TABLE lga_stop_density_with_geom_tram **AS**

SELECT

lscbt.lga_name,
lscbt.lga_code,
lscbt.vehicle_type,
lscbt.num_stops,

```

lb.area_sqkm,
lb.geom,
CASE
    WHEN lb.area_sqkm > 0 THEN lscbt.num_stops / lb.area_sqkm
    ELSE 0
END AS stop_density_per_sqkm
FROM
    lga_stop_count_by_type lscbt
JOIN
    lga_boundaries lb
ON lscbt.lga_code = lb.lga_code
WHERE
    lscbt.vehicle_type = 'Tram';

-- TRAIN STATION DENSITY
CREATE TABLE lga_stop_density_with_geom_train AS
SELECT
    lscbt.lga_name,
    lscbt.lga_code,
    lscbt.vehicle_type,
    lscbt.num_stops,
    lb.area_sqkm,
    lb.geom,
CASE
    WHEN lb.area_sqkm > 0 THEN lscbt.num_stops / lb.area_sqkm
    ELSE 0

```

```

    END AS stop_density_per_sqkm
FROM
    lga_stop_count_by_type lscbt
JOIN
    lga_boundaries lb
    ON lscbt.lga_code = lb.lga_code
WHERE
    lscbt.vehicle_type = 'Train';

```

Best Service by Transport Type

-- TOP 3

```
create table top_3_bus AS
```

```
SELECT
```

```

    lga_name,
    stop_density_per_sqkm,
    vehicle_type,
    num_stops,
    area_sqkm,
    geom

```

```
FROM
```

```
    lga_stop_density_with_geom_bus
```

```
ORDER BY
```

```
    stop_density_per_sqkm DESC
```

```
LIMIT 3;
```

```
create table top_3_tram AS
```

SELECT

lga_name,
stop_density_per_sqkm,
vehicle_type,
num_stops,
area_sqkm,
geom

FROM

lga_stop_density_with_geom_tram

ORDER BY

stop_density_per_sqkm **DESC**

LIMIT 3;

create table top_3_train AS

SELECT

lga_name,
stop_density_per_sqkm,
vehicle_type,
num_stops,
area_sqkm,
geom

FROM

lga_stop_density_with_geom_train

ORDER BY

stop_density_per_sqkm **DESC**

LIMIT 3;

-- TOP 5 - Sensitivity Analysis

create table top_5_bus **AS**

SELECT

lga_name,
stop_density_per_sqkm,
vehicle_type,
num_stops,
area_sqkm,
geom

FROM

lga_stop_density_with_geom_bus

ORDER BY

stop_density_per_sqkm **DESC**

LIMIT 5;

create table top_5_tram **AS**

SELECT

lga_name,
stop_density_per_sqkm,
vehicle_type,
num_stops,
area_sqkm,
geom

FROM

lga_stop_density_with_geom_tram

ORDER BY

stop_density_per_sqkm **DESC**

LIMIT 5;

create table top_5_train **AS**

SELECT

lga_name,

stop_density_per_sqkm,

vehicle_type,

num_stops,

area_sqkm,

geom

FROM

lga_stop_density_with_geom_train

ORDER BY

stop_density_per_sqkm **DESC**

LIMIT 5;

Worst and Zero Service by Transport Type

-- BOTTOM 3

CREATE TABLE bottom_3_bus **AS**

SELECT

lga_name,

stop_density_per_sqkm,

vehicle_type,

num_stops,

```
    area_sqkm,  
    geom  
FROM  
    lga_stop_density_with_geom_bus  
WHERE  
    num_stops > 0  
ORDER BY  
    stop_density_per_sqkm ASC  
LIMIT 3;
```

```
CREATE TABLE bottom_3_tram AS  
SELECT  
    lga_name,  
    stop_density_per_sqkm,  
    vehicle_type,  
    num_stops,  
    area_sqkm,  
    geom  
FROM  
    lga_stop_density_with_geom_tram  
WHERE  
    num_stops > 0  
ORDER BY  
    stop_density_per_sqkm ASC  
LIMIT 3;
```

```
CREATE TABLE bottom_3_train AS

SELECT

    lga_name,

    stop_density_per_sqkm,

    vehicle_type,

    num_stops,

    area_sqkm,

    geom

FROM

    lga_stop_density_with_geom_train

WHERE

    num_stops > 0

ORDER BY

    stop_density_per_sqkm ASC

LIMIT 3;
```

```
-- ZERO SERVICE AREAS
```

```
CREATE TABLE zero_bus_lgas AS

SELECT

    lga_name,

    stop_density_per_sqkm,

    vehicle_type,

    num_stops,

    area_sqkm,

    geom

FROM
```

lga_stop_density_with_geom_bus

WHERE

num_stops = 0;

CREATE TABLE zero_tram_lgas **AS**

SELECT

lga_name,
stop_density_per_sqkm,
vehicle_type,
num_stops,
area_sqkm,
geom

FROM

lga_stop_density_with_geom_tram

WHERE

num_stops = 0;

CREATE TABLE zero_train_lgas **AS**

SELECT

lga_name,
stop_density_per_sqkm,
vehicle_type,
num_stops,
area_sqkm,
geom

FROM

```
lga_stop_density_with_geom_train
```

WHERE

```
num_stops = 0;
```

Catchment Area Comparison

----- 800m train (400m tram/bus) Ease of Access - Analysis -----

-- Route Shapes table

CREATE TABLE route_shapes **AS**

WITH shape_geoms **AS** (

SELECT

```
shape_id,
```

```
ST_MakeLine(
```

```
ST_SetSRID(ST_MakePoint(shape_pt_lon, shape_pt_lat), 7844)
```

```
ORDER BY shape_pt_sequence
```

```
) AS geom
```

FROM shapes

GROUP BY shape_id

)

SELECT DISTINCT

```
r.route_id,
```

```
r.route_short_name,
```

```
r.route_long_name,
```

CASE r.route_type

```
WHEN 0 THEN 'Tram'
```

```
WHEN 2 THEN 'Train'
```

```

        WHEN 3 THEN 'Bus'
        ELSE 'Other'
    END AS vehicle_type,
    sg.geom
FROM shape_geoms sg
JOIN trips t ON sg.shape_id = t.shape_id
JOIN routes r ON t.route_id = r.route_id;

```

```

CREATE TABLE route_shapes_with_lga AS
WITH shape_geoms AS (
    SELECT
        shape_id,
        ST_MakeLine(
            ST_SetSRID(ST_MakePoint(shape_pt_lon, shape_pt_lat), 7844)
            ORDER BY shape_pt_sequence
        ) AS geom
    FROM shapes
    GROUP BY shape_id
)
SELECT DISTINCT
    r.route_id,
    r.route_short_name,
    r.route_long_name,
    CASE r.route_type

```

```

        WHEN 0 THEN 'Tram'
        WHEN 2 THEN 'Train'
        WHEN 3 THEN 'Bus'
        ELSE 'Other'
    END AS vehicle_type,
    lb.lga_name AS lga_name,
    ST_Intersection(
        ST_Transform(sg.geom, 7844),
        ST_Transform(lb.geom, 7844)
    ) AS geom
FROM shape_geoms sg
JOIN trips t ON sg.shape_id = t.shape_id
JOIN routes r ON t.route_id = r.route_id
JOIN lga_boundaries lb
    ON ST_Intersects(
        ST_Transform(sg.geom, 7844),
        ST_Transform(lb.geom, 7844)
    )
AND lb.lga_name IN ('Stonnington - West', 'Macedon Ranges');

```

```

CREATE TABLE catchment_areas AS
WITH selected_lgas AS (
    SELECT *
    FROM lga_boundaries
    WHERE lga_name IN ('Stonnington - West', 'Macedon Ranges')

```

```

)

SELECT
    s.stop_id,
    s.stop_name,
    CASE s.route_type
        WHEN 0 THEN 'Tram'
        WHEN 2 THEN 'Train'
        WHEN 3 THEN 'Bus'
        ELSE 'Other'
    END as vehicle_type,
    l.lga_name,
    CASE s.route_type
        WHEN 2 THEN 800
        ELSE 400
    END as buffer_radius_m,
    s.geom as stop_point,
    ST_Transform(
        ST_Buffer(
            ST_Transform(s.geom, 7844),
            CASE
                WHEN s.route_type = 2 THEN 800
                ELSE 400
            END
        ),
        4326
    ) as catchment_area

```

```

FROM stops_with_route_info s
JOIN selected_lgas l
  ON ST_Intersects(ST_Transform(s.geom, 7844), ST_Transform(l.geom, 7844))
ORDER BY
  l.lga_name,
  CASE s.route_type
    WHEN 2 THEN 1 -- Train first
    WHEN 0 THEN 2 -- Tram second
    WHEN 3 THEN 3 -- Bus third
    ELSE 4      -- Other last
  END,
  s.stop_name;

```

Service Frequency Comparison

----- 10 Minute Interval Frequency - Analysis -----

```
CREATE TABLE frequency_analysis AS
```

```
WITH peak_services AS (
```

```
  SELECT
```

```
    s.stop_id,
```

```
    s.stop_name,
```

```
    s.route_type,
```

```
    r.route_id,
```

```
    r.route_short_name,
```

```
    l.lga_name,
```

```
    t.shape_id,
```

```

COUNT(DISTINCT t.trip_id) as service_count
FROM stops_with_route_info s
JOIN lga_boundaries l ON ST_Within(ST_Transform(s.geom, 7844), l.geom)
JOIN stop_times st ON s.stop_id = st.stop_id::varchar
JOIN trips t ON st.trip_id = t.trip_id
JOIN routes r ON t.route_id = r.route_id
JOIN calendar c ON t.service_id = c.service_id
WHERE
    l.lga_name IN ('Stonnington - West', 'Macedon Ranges')
    AND c.monday = 1
    AND (
        CASE
            WHEN st.arrival_time LIKE '24%'
            THEN (SUBSTRING(st.arrival_time FROM 3))::interval + interval '24 hours'
            ELSE st.arrival_time::interval
        END
    ) BETWEEN '17:00:00'::interval AND '18:00:00'::interval
GROUP BY
    s.stop_id, s.stop_name, s.route_type,
    r.route_id, r.route_short_name, l.lga_name, t.shape_id
HAVING COUNT(DISTINCT t.trip_id) >= 6
),
route_shapes AS (
    SELECT
        shape_id,
        ST_Transform(

```

```

        ST_MakeLine(
            ST_SetSRID(ST_MakePoint(shape_pt_lon, shape_pt_lat), 4326)
            ORDER BY shape_pt_sequence
        ),
        7844
    ) as route_geom
FROM shapes
GROUP BY shape_id
)
SELECT
    ps.*,
    CASE ps.route_type
        WHEN 0 THEN 'Tram'
        WHEN 2 THEN 'Train'
        WHEN 3 THEN 'Bus'
        ELSE 'Other'
    END as vehicle_type,
    s.geom as stop_point,
    rs.route_geom as route_shape
FROM peak_services ps
JOIN stops_with_route_info s ON ps.stop_id = s.stop_id
LEFT JOIN route_shapes rs ON ps.shape_id = rs.shape_id;

CREATE TABLE frequency_analysis_off_peak AS
WITH peak_services AS (

```

```

SELECT
    s.stop_id,
    s.stop_name,
    s.route_type,
    r.route_id,
    r.route_short_name,
    l.lga_name,
    t.shape_id,
    COUNT(DISTINCT t.trip_id) as service_count
FROM stops_with_route_info s
JOIN lga_boundaries l ON ST_Within(ST_Transform(s.geom, 7844), l.geom)
JOIN stop_times st ON s.stop_id = st.stop_id::varchar
JOIN trips t ON st.trip_id = t.trip_id
JOIN routes r ON t.route_id = r.route_id
JOIN calendar c ON t.service_id = c.service_id
WHERE
    l.lga_name IN ('Stonnington - West', 'Macedon Ranges')
    AND c.sunday = 1
    AND (
        CASE
            WHEN st.arrival_time LIKE '24%'
            THEN (SUBSTRING(st.arrival_time FROM 3))::interval + interval '24 hours'
            ELSE st.arrival_time::interval
        END
    ) BETWEEN '14:00:00'::interval AND '15:00:00'::interval
GROUP BY

```

```

s.stop_id, s.stop_name, s.route_type,
r.route_id, r.route_short_name, l.lga_name, t.shape_id
HAVING COUNT(DISTINCT t.trip_id) >= 6
),
route_shapes AS (
SELECT
    shape_id,
    ST_Transform(
        ST_MakeLine(
            ST_SetSRID(ST_MakePoint(shape_pt_lon, shape_pt_lat), 4326)
            ORDER BY shape_pt_sequence
        ),
        7844
    ) as route_geom
FROM shapes
GROUP BY shape_id
)
SELECT
    ps.*,
    CASE ps.route_type
        WHEN 0 THEN 'Tram'
        WHEN 2 THEN 'Train'
        WHEN 3 THEN 'Bus'
        ELSE 'Other'
    END as vehicle_type,
    s.geom as stop_point,

```

```

    rs.route_geom as route_shape
FROM peak_services ps
JOIN stops_with_route_info s ON ps.stop_id = s.stop_id
LEFT JOIN route_shapes rs ON ps.shape_id = rs.shape_id;

```

Screenshots of Tables

---- SCREENSHOTS FOR TABLES ----

-- HEATMAPS TRAM

SELECT

lscbt.lga_name,

lscbt.vehicle_type,

CASE

WHEN *lb.area_sqkm > 0* **THEN** *lscbt.num_stops / lb.area_sqkm*

ELSE 0

END AS *stop_density_per_sqkm,*

lscbt.num_stops,

lb.area_sqkm,

lb.geom

FROM

lga_stop_count_by_type lscbt

JOIN

lga_boundaries lb

ON *lscbt.lga_code = lb.lga_code*

WHERE

lscbt.vehicle_type = 'Tram'

order by *stop_density_per_sqkm* **DESC**;

-- HEATMAPS TRAIN

SELECT

lscbt.lga_name,

lscbt.vehicle_type,

CASE

WHEN *lb.area_sqkm > 0* **THEN** *lscbt.num_stops / lb.area_sqkm*

ELSE 0

END AS *stop_density_per_sqkm,*

lscbt.num_stops,

lb.area_sqkm,

lb.geom

FROM

lga_stop_count_by_type lscbt

JOIN

lga_boundaries lb

ON *lscbt.lga_code = lb.lga_code*

WHERE

lscbt.vehicle_type = 'Train'

order by *stop_density_per_sqkm* **DESC**;

-- HEATMAPS BUS

SELECT

lscbt.lga_name,

```

    lscbt.vehicle_type,
CASE
    WHEN lb.area_sqkm > 0 THEN lscbt.num_stops / lb.area_sqkm
    ELSE 0
END AS stop_density_per_sqkm,
lscbt.num_stops,
lb.area_sqkm,
lb.geom
FROM
    lga_stop_count_by_type lscbt
JOIN
    lga_boundaries lb
    ON lscbt.lga_code = lb.lga_code
WHERE
    lscbt.vehicle_type = 'Bus'
order by stop_density_per_sqkm DESC;

```