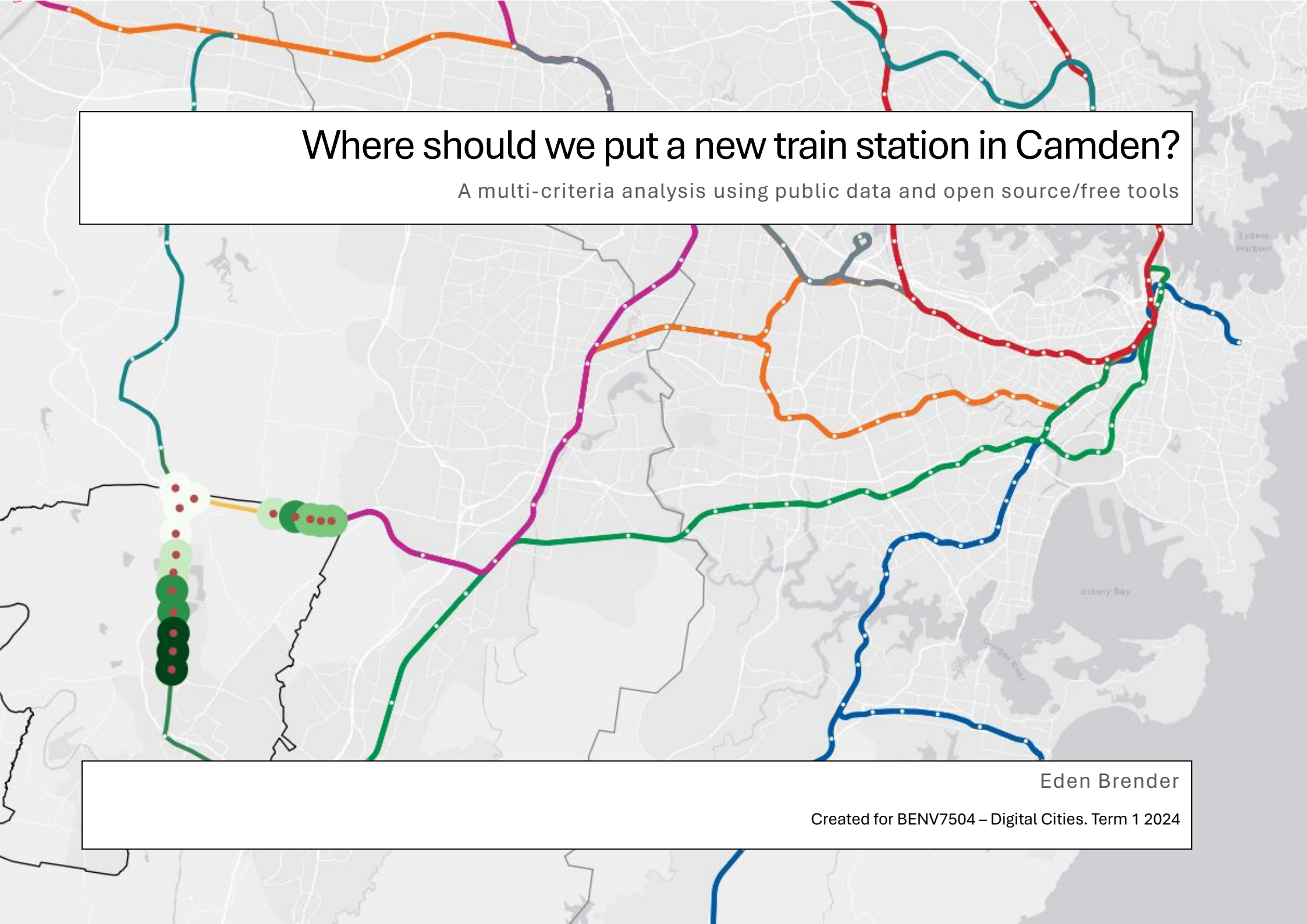
Where should we put a new train station in Camden?

A multi-criteria analysis using public data and open source/free tools



Eden Brender

Created for BENV7504 – Digital Cities. Term 1 2024

Contents

This report pertains to unceded Dharug, Gundagurra and Tharawhal land. No treaty was every signed, sovereignty was never ceded. I acknowledge the ongoing connection of aboriginal people across Australia to land, sky and waterways, and pay my respects to elders past and present.

This land always, and always will be aboriginal land.

Executive Summary

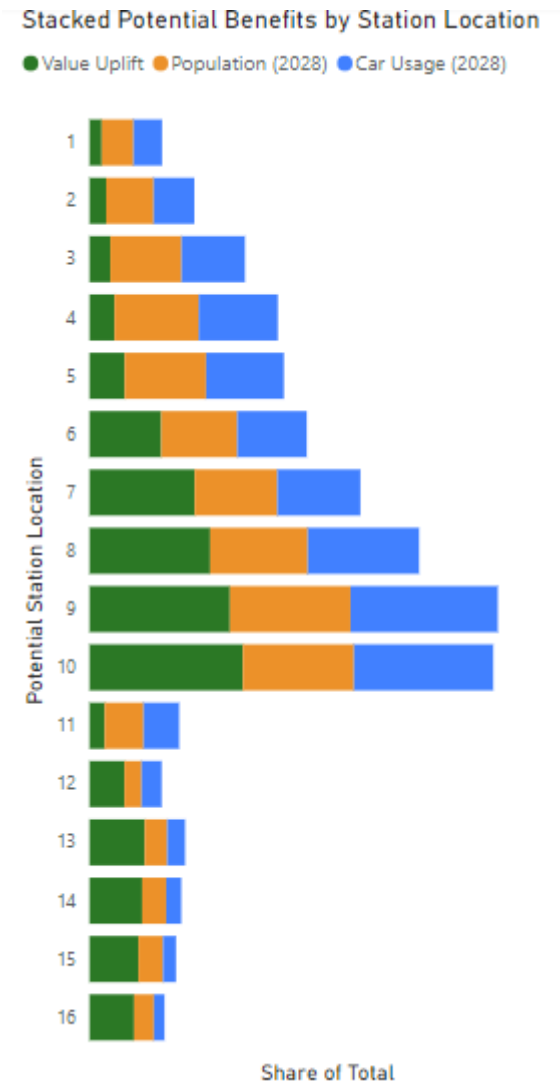
This report provides a comprehensive analysis aimed at determining the optimal location for a new train station within the Camden Local Government Area (LGA) in Sydney. With a projected significant population increase by 2041 and the need to provide connect residents to the new business centre of Bradfield and Nancy Bird-Walton Airport, the report seeks to enhance public transport options for current and future residents.

Six selection criteria were established, each with quantifiable metrics to assess potential station locations. These criteria are: Proximity to existing or proposed train lines, impact on ecological communities, alignment with planning priorities, projected population benefiting from the station, property value increase, reduction in car usage

The methodology involved extensive data gathering and processing, utilizing publicly available datasets and tools like QGIS for analysis. Metrics were derived from the assessment criteria and tested at 16 potential station locations, evaluating future population growth, property value uplift, and reduction in car usage for each location.

The report's findings, presented via an interactive map and dashboard available at the project website, highlight station location 9 (-34.00524, 150.73905) as the recommended site, based on the stacked benefits analysis. This location aligns with existing railway corridors, avoids impact on threatened ecological communities, and is projected to maximally benefit a significant population while positively impacting property values and reducing car dependency.

The discussion section emphasizes the role of open data, visualization, and analysis tools in achieving reliable results. Despite the complexity of the task, the report successfully leveraged publicly available resources to identify an optimal station location within 700 metres of the location chosen by TfNSW, demonstrating the efficacy of such approaches in urban planning and infrastructure development.



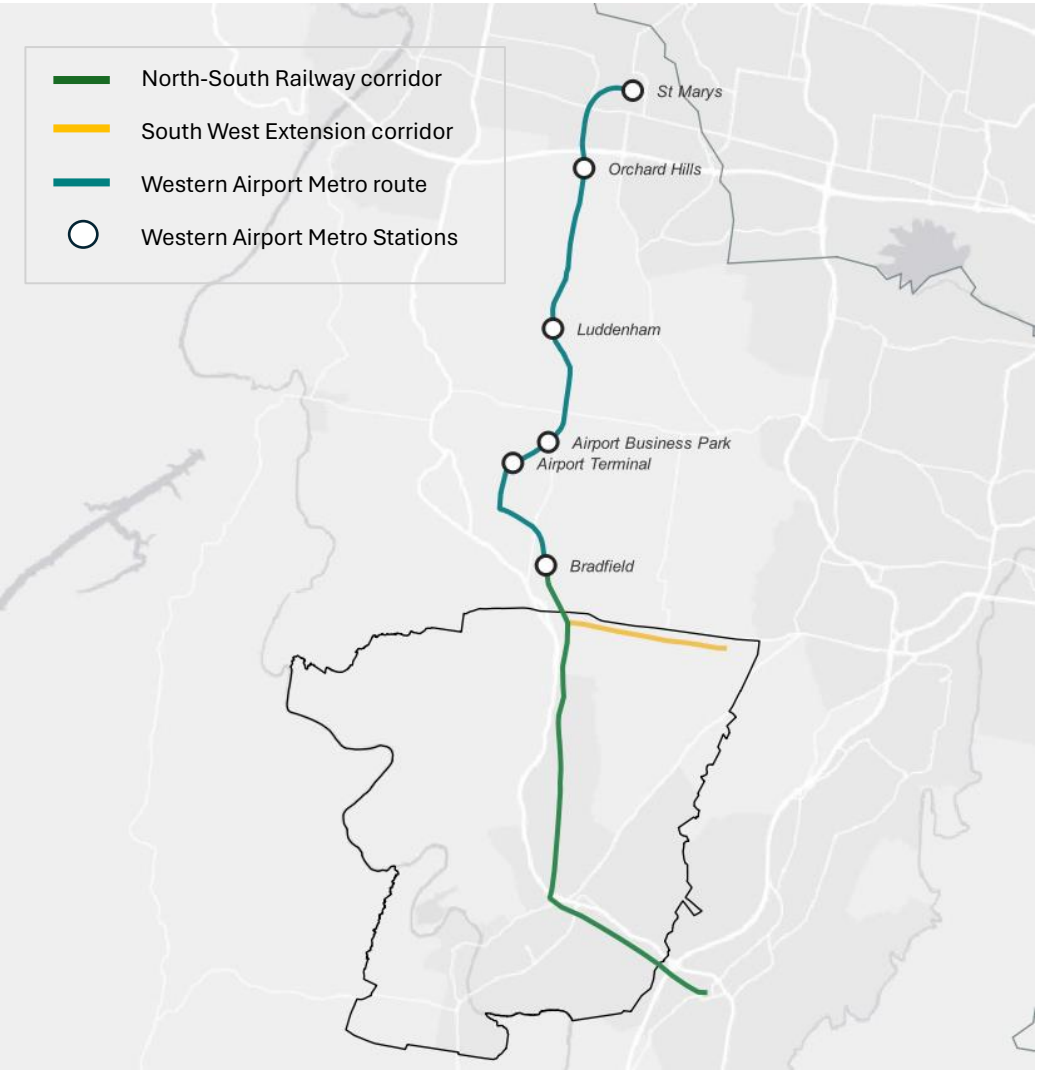
Note: Project results are best viewed on the project website, which contains an interactive map and dashboard, as well as download links for the underlying files and datasets. **It took a long time to make**. Please view the results on the project website

Context

By 2041, Camden - which contains a large part of the south west growth area - will have an extra 100,000 residents (ID 2021). 53,000 residents will likely drive their car to work today (ABS 2016, ID 2021). Sydney has one of the largest tolling networks in the world, and the southwest of the city bears most of the burden (O'Sullivan 2023). Giving these new residents - as well as our existing residents – viable public transport alternatives will make a meaningful contribution to the life of our local area.

Camden is ideally located to benefit from the development of Nacy Bird-Walton airport and neighbouring Bradfield, both in terms of access to a new employment centre, and because of the new Western Sydney Airport metro line that connects Bradfield to the T3 Western Line at St Marys (figure 1).

Since 2015, Camden has had land earmarked for future railway corridors (Camden Council 2020). These corridors connect the Western Sydney Airport Metro line to the T2 Inner West and Leppington line. Assuming these corridors will be developed into new train lines, this report seeks to answer the question:



If we want to provide the most benefit to future residents of Camden, where should be put a new train station?

Selection Criteria

To decide the best location for a train station, six criteria have been considered. Each have a quantifiable metric that will be used to evaluate the suitability of potential locations. These are summarised in table 1. An explanation of each metric is included below.

A. Is the site on an existing or proposed train line?

Creating new rail lines is particularly expensive and difficult in a planning context, therefore any proposed station should lie on an existing or proposed train line (figure 1).

B. Will building a station here impact any threatened ecological communities?

Due to increasing development in the Western Parkland City, there is immense pressure on the natural environment. Camden Council is home to 44.2 km^2 of threatened ecological communities (NSW Department of Climate Change, Energy, the Environment and Water 2022), and future infrastructure developments should be targeted to areas that do not require the removal or modification of any TEC.

Camden LGA

Table 1. Summary of location criteria and metrics

Camden LGA

Figure 1. Airport Metro Stations and Earmarked Railway Corridors

Figure 2. Airport Metro Stations and Earmarked Railway Corridors

	proposed train line?	
B	Will building a station here impact any threatened ecological communities?	Yes/No
C	Is the site selection aligned with Council and State planning priorities?	Yes/No
D	How many people will directly benefit from the train station in the future?	Population living within a 2km radius by 2028
E	What effect will the new station have on property value?	Property value increase for all properties within a 2km radius
F	What impact might the station have on car usage?	Number of commutes to work by car made by people living within a 2km radius by 2028

C. Is the site selection aligned with Council and State planning priorities?

Any new station should support the planning goals of the State and Council. At a state level, the most relevant planning document is the SEPP precinct plans – specifically the South West Growth Area (DPE 2023). At a council level, land re-zoning and release has begun in the SWGA (Camden Council 2023). Only areas that have been released or re-zoned are considered as suitable for quick delivery of a train station.

D. How many people will directly benefit from the train station in the future?

Train stations should benefit the maximum number of people. Understanding how many people are likely to use a train station for a given location provides insight into the ideal location (figure 2). Projecting this into the future more closely reflects the likely delivery time of a new station.

E. What effect will the new station have on property value?

Wen et al. (2018) have found that property values increase for residents who live within 2 km of a newly built train station. The benefit is inversely correlated to distance from the train station, and becomes negligible after 2 km. This benefits residents by increasing re-sale profits and benefits the Council by increasing taxation income from rates. Maximizing the return on investment is a goal of this project.

F. What impact might the station have on car usage?

Reducing car dependency is a goal of this project for environmental, social and economic reasons. Understanding how many cars could potentially be taken off the road provides insight into the ideal station location.

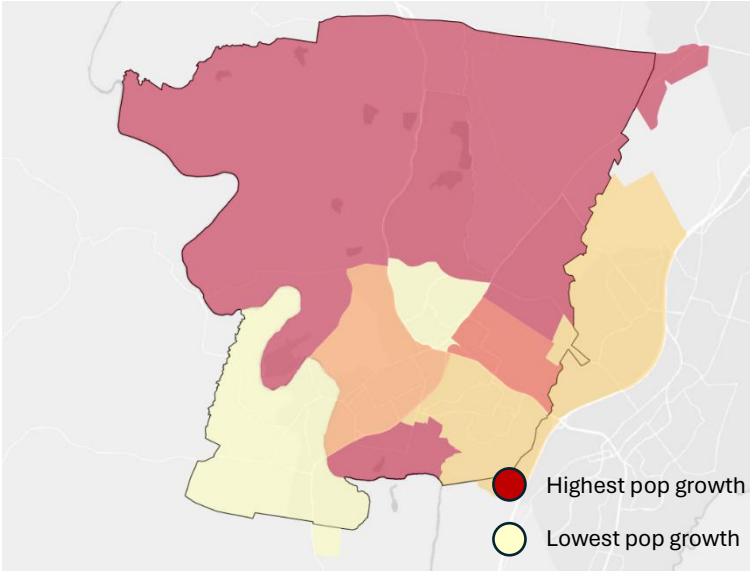


Figure 3. Population Growth in Camden (ABS 2016).

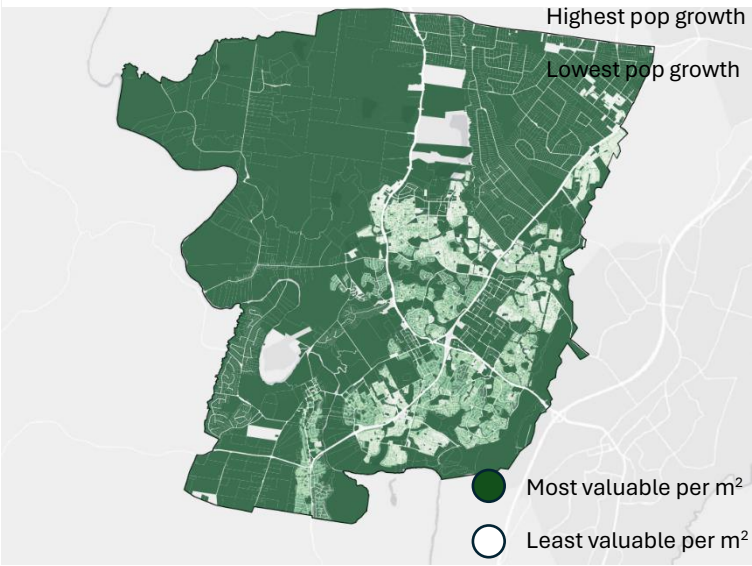


Figure 3. Property value per m2 in Camden (NSW Valuer General 2023).

Most valuable per m²

Least valuable per m²

Required Data

All data used in this project is publicly available and summarised below (table 2). For ease of processing, data sources accessed via API were clipped to a relevant area and stored statically in a local geopackage (.gpkg). This file is available from the project website.

Table 2. Summary of data layers used in the project.

Data layer required	Metric	Underlying Dataset(s)	Processing required	Agency	Format	Source
SA2 Boundaries	A-F	ASGS ABS Structures	Clip, exported to geopackage	ABS	ArcGIS Rest Server	Link
LGA Boundaries	A-F	ASGS Non ABS Structures	Clip, exported to geopackage	ABS	ArcGIS Rest Server	Link
Existing Train Routes	A	GTFS	Filter by Description Ends with "Station", Points to Path	TfNSW	.zip	Link
Existing Train Stations	A	GTFS	Filter by Description Ends with "Station"			
Future Train Routes	A	Metro Map PDFs	Georeferencing and digitizing	Sydney Metro	.pdf	Link
Future Train Stations	A					
Planning districts	B	SEPP Precincts – Western Parkland City	Clip, exported to geopackage	DPE	ArcGIS Rest Server	Link
Camden Land Release/Zoning	B	Land release map PDF	Digitizing	Camden Council	.pdf	Link
Ecological Value	B	Greater Sydney TECs	Clip to Camden LGA	OEH	ArcGIS Rest Server	Link
Population	D	Regional Population Change	Join to SA2 shapefile	ABS	.xlsx .	Link
Population Growth	D					
Lot Boundaries	E	NSW Cadastre (Lots)	Clip to Camden LGA	NSW Spatial	ArcGIS Rest Server	Link
Existing Property Value	E	Land Value Summaries	Join to Lot boundaries dataset	NSW Valuer General	.zip	Link
Commute Data	F	2016 SA2 General Community Profiles	Aggregating MTWP by category Divide by population	ABS	.xlsx	Link

Metrics

A detailed description of the workflow is included in appendix 1, and a summary diagram is included (figure x).

Categorical Metrics: A-C

To ensure any potential station achieved metrics A-C (table 1), QGIS was used to create vector layers which describe the location of current (TfNSW 2024) and future (Sydney Metro 2021) train routes, land released as part of the south west growth area (Camden Council 2023), and threatened ecological communities (NSW Department of Climate Change, Energy, the Environment and Water 2022). These layers were combined to create a line of possible locations for a new train station, then 16 equidistant points were created along the line, for which metrics D-F were evaluated.

Continuous Metrics: D-F

For each of the 16 potential locations, QGIS was used to generate 4 concentric buffers at intervals of 500m (figure 5). Inside each of these buffers, values were derived for metrics D-F. In general, metrics D-F only consider data from within Camden LGA – for example, metric D (population with a 2 km radius) only includes people who will live within Camden **and** who will live within 2 kilometres (figure 4). More detailed descriptions of how metrics D-F were derived, and a workflow diagram are included below.

D. Population living within 2 kilometres by 2028

This metric is calculated by applying the growth formula (1) to the 2023 population within a 2km ring surrounding each point, using the 2022-2023 growth rate. 2023 population was derived using SA2 level data (ABS 2021) divided by the percentage of the SA2 area that a 2km radius covers.

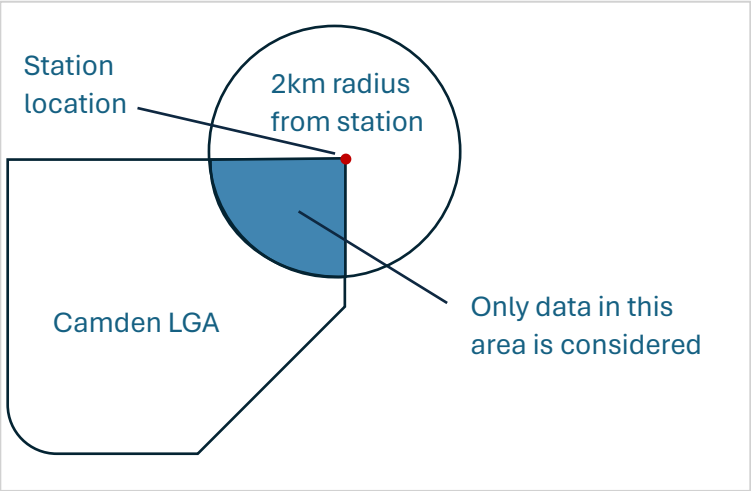


*Figure 4. Statistics are calculated only for areas that are both within Camden, **and** within 2 km of a potential train station location.*

$$Pop_{Future} = Pop_{Present} \times (1 + i)^n$$

Where:
$Pop_{Present}$ = 2023 population within 2km of location
I = rate of population growth between 2022 and 2023
n = 5 years

Equation 1. Population growth formula

E. Property value increase for all properties within a 2-kilometre radius

This metric is calculated using the total current value of property (NSW Valuer General 2023) (NSW Spatial 2024) within four concentric buffer zones from a potential station location, each 500 metres wide. In each of these zones, the current property value is multiplied by a different coefficient of property uplift. These coefficients are derived from Wen et al. (2018, p. 16) using the model 12 OLS values for a completed station. These are shown in figure 5.

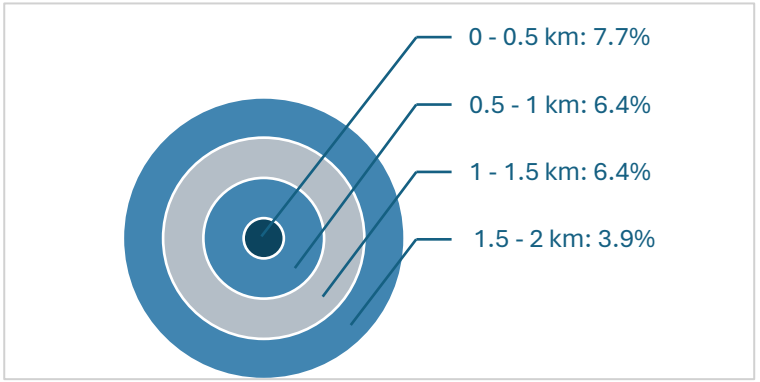


Figure 5. A train station improves property values differently, depending on proximity.

F. Number of commutes to work by car made by people living within a 2-kilometre radius by 2028

This metric was calculated by multiplying metric D (above) by the percentage of residents who travelled to work by driving a car (not as a passenger) on the night of the 2016 census (ABS 2016). This figure is derived using SA2 level data. 2021 census data was not used due to the large number of respondents working from home during that census (figure 6).

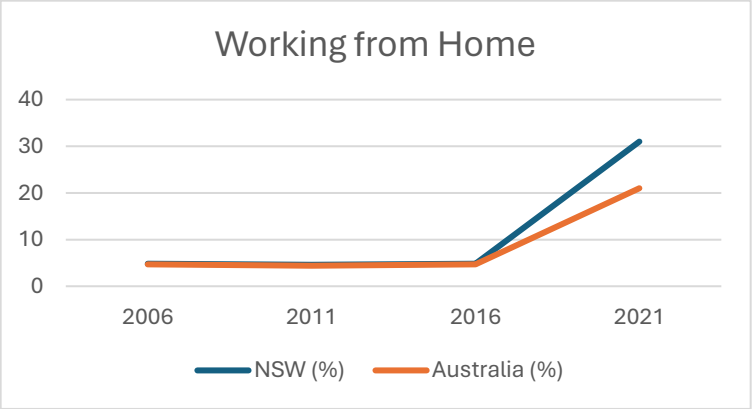


Figure 6. Census data from 2021 does not represent long-term working from home trends (ABS 2022).

Workflow Diagram

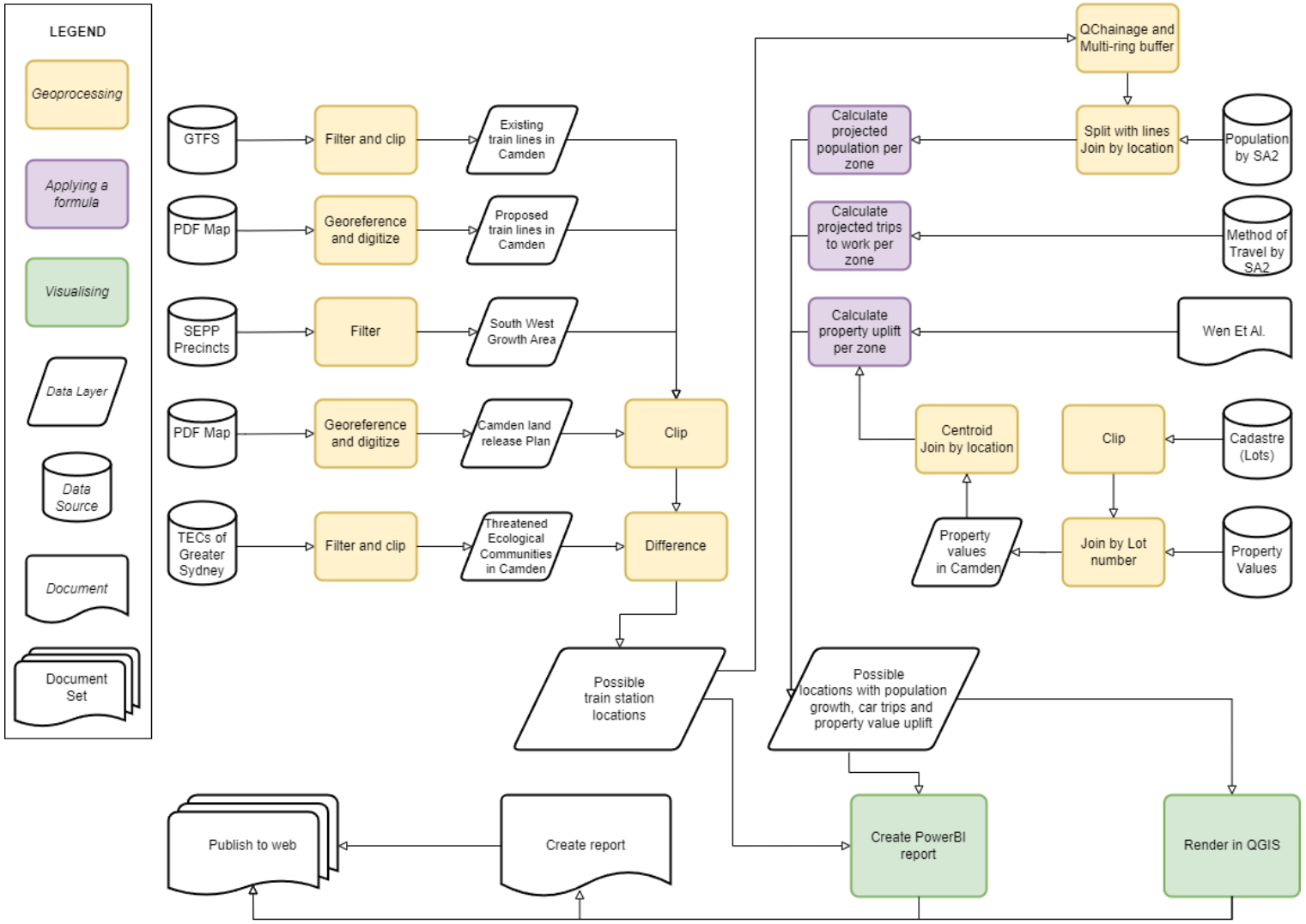


Figure 7. Technical workflow to create project dataset, analysis, and publications.

Results

The data created for this project is visualised as both an interactive map and dashboard. These are accessible via the **project website** along with the underlying data layers, which are available for download. While the findings are best understood through the interactive tools on the website, images of the results and a table of values for each possible locations are also included here (figures 8-15) (table 3) (appendix 2).

Table 3. Metrics D-F for 16 potential station locations.

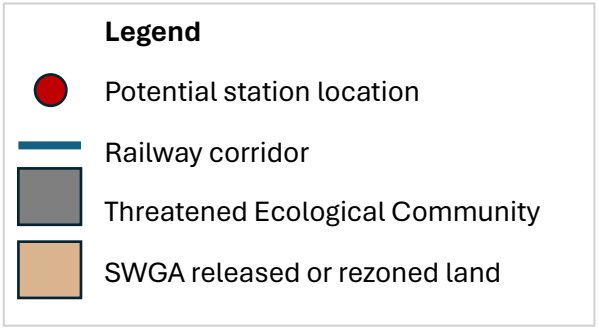
Potential Location	Longitude	Latitude	D. Population within 2km by 2028	E. Value Uplift	F. Daily Car Usage by 2028
1	150.7419763	-33.94063457	38,161	$83,055,411.00	9,081
2	150.7437215	-33.94859495	56,959	$113,275,249.00	12,974
3	150.7416241	-33.95871299	85,454	$141,187,376.00	20,234
4	150.7415441	-33.9670621	101,040	$170,104,685.00	25,214
5	150.7401339	-33.97401176	97,724	$239,113,677.00	24,786
6	150.7392447	-33.98113389	91,212	$488,446,767.00	22,150
7	150.7397378	-33.98969173	99,128	$716,237,146.00	26,477
8	150.7394789	-33.99804141	117,100	$821,463,647.00	35,497
9	150.7390532	-34.00523831	144,608	$956,448,610.00	46,951
10	150.7382765	-34.012415	133,275	$1,044,303,040.00	44,398
11	150.7506976	-33.94498456	46,690	$102,941,398.00	11,353
12	150.7882089	-33.95161051	20,557	$237,728,227.00	6,407
13	150.7985975	-33.9529921	27,032	$375,710,264.00	5,695
14	150.8057241	-33.95412815	28,918	$358,170,008.00	4,800
15	150.8106828	-33.95487581	29,530	$332,901,287.00	4,128
16	150.8157188	-33.95494381	23,891	$302,905,554.00	3,369

Metrics A-C: Possible Locations

The existing railway corridors are in the north-east of Camden, as is the south west growth area (SWGA).

Not all parts of the SWGA have been released, specifically the section at Rossmore (point A in figure 8) which contains a significant volume of threatened ecological communities. The northwest of Camden also contains large volumes of threatened ecological communities.

Possible locations were generated every 500 m in earmarked railway corridors that are within the SWGA and do not contain TECs.



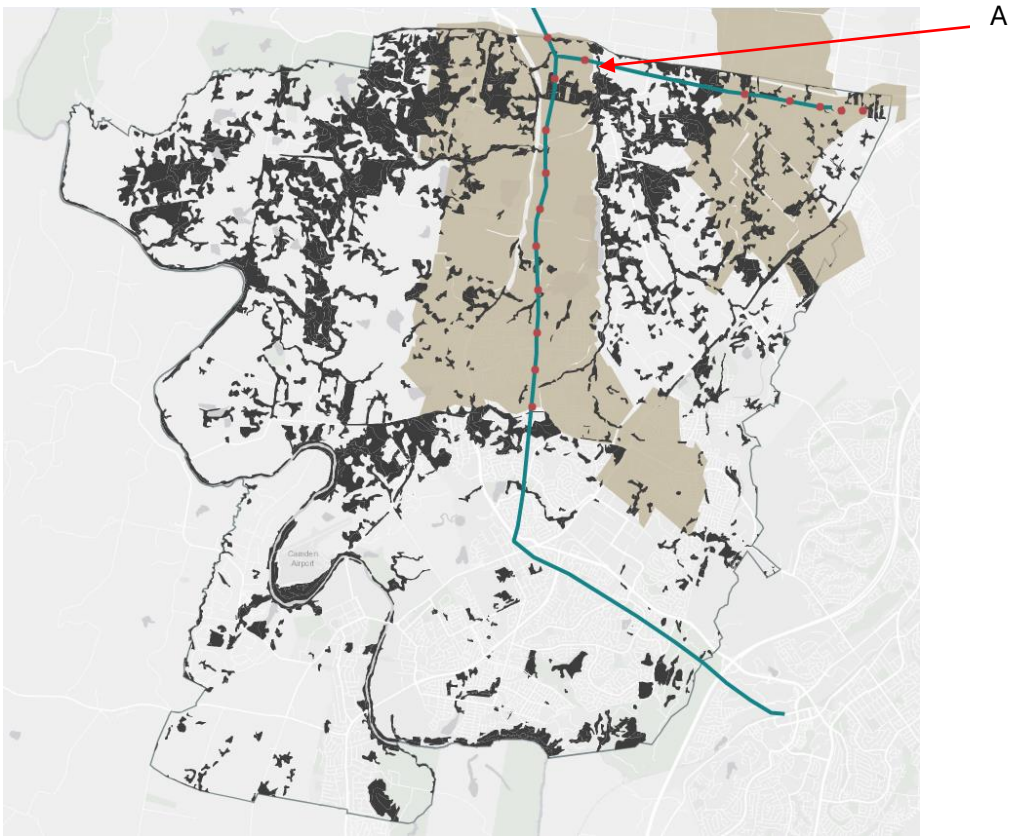


Figure 8. Potential station locations.

Metric D: Population within 2 kilometres by 2028

Projected population is significantly concentrated toward the middle of the LGA (figure 11). This is because of population dynamics generally (the spatial distribution of the current population and growth rate) (see figure 2), and also because the LGA borders clip the 2-kilometre area of study (figure 4). This suggests that stations near the centre of the LGA will attract the most users who live within Camden.

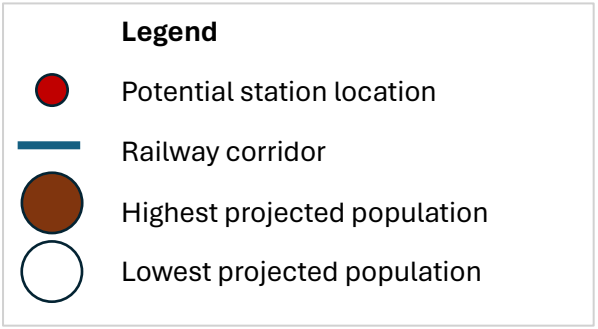


Figure 10. Expected population living within 2 kilometres of the station.

Metric E: Property Value Uplift

Property value uplift is concentrated around the centre of the LGA. This is caused by two factors. First, more land has been released to date around the centre of Camden. The property value data used considers only existing properties.

Second, only areas within the LGA are evaluated (figure 4). This means that for stations on the edge of the LGA, relatively fewer property values are considered. This effect is somewhat smaller for this metric than others, as the highest percentage value uplift occurs within 0.5 kilometres of the station (figure 11).

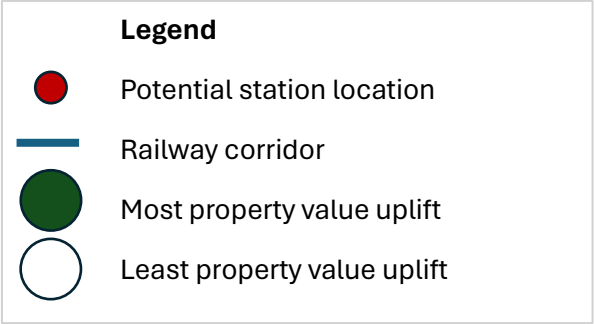


Figure 11. Property value uplift caused by the delivery of a new train station (existing properties only).

Metric F: Total Car Usage by 2028

Total car usage is generally correlated with projected population, except for point A near Leppington station (figures 10,12). This suggests that proximity to a train station has a negative impact on car usage.

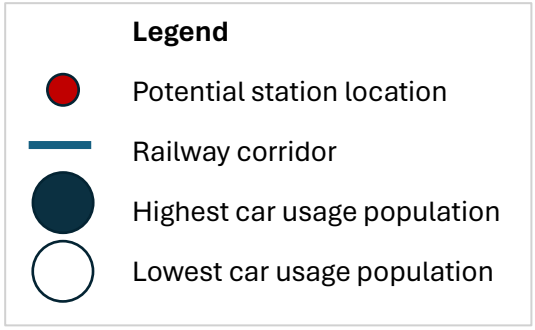


Figure 12. The total number of car trips made per day by residents in figure X.

Stacked Benefits by Station Location

Figure 13 stacks the share of total benefits by each station location. This analysis is somewhat simplistic, as it assumes that all three benefits have equal weighting.

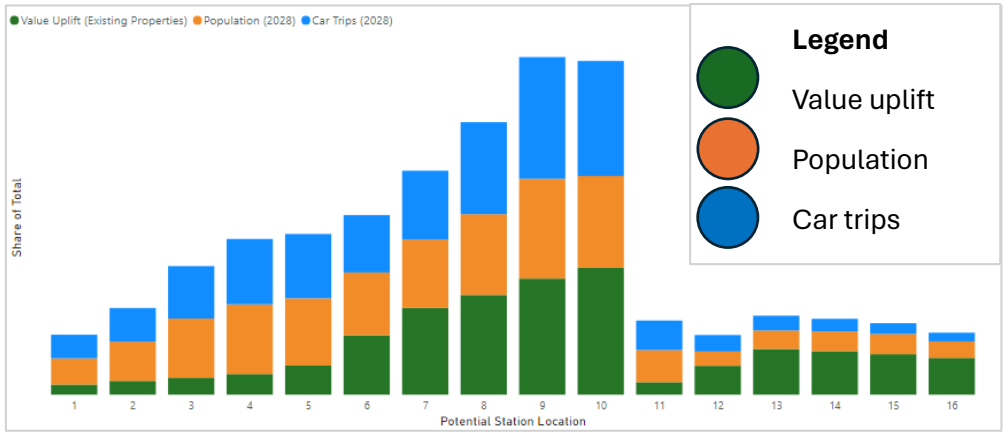


Figure 13. Stacked benefits by potential location.

Population Density by Distance from Station

Figure 14 shows data for all potential station locations on one scatter plot.

It shows that population density generally trends upward as distance from the station increases. This is an interesting finding which suggest that land around the railway corridor is more sparsely population than other land. Perhaps landholders along the corridor have avoided subdividing their land as they expect future price increases due to railway announcements. Further investigation of this could form the basis of future reports.

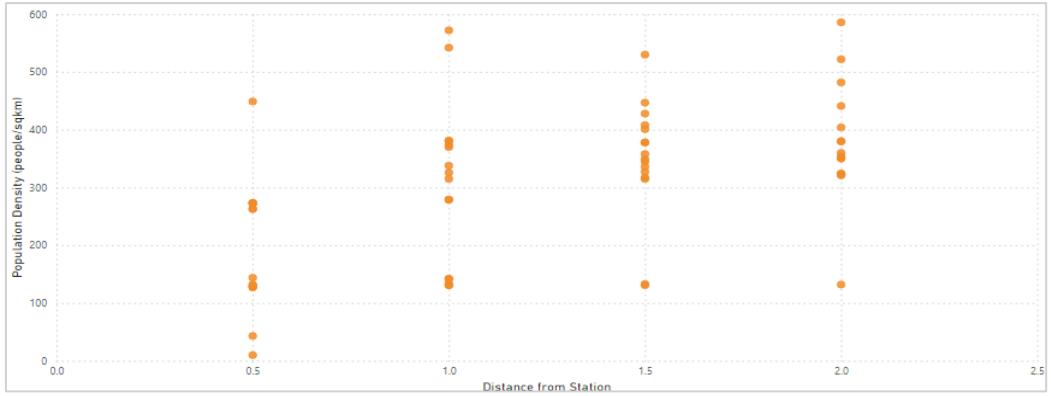


Figure 14. Spatial distribution of population density relative to station proximity.

Property Value Uplift by Distance from Station

Figure 15 shows data for all potential station locations on one plot. It shows that value uplift is relatively consistent across the distribution, despite the increase in area. This is likely because of the differential way uplift is calculated in each zone (figure 5).

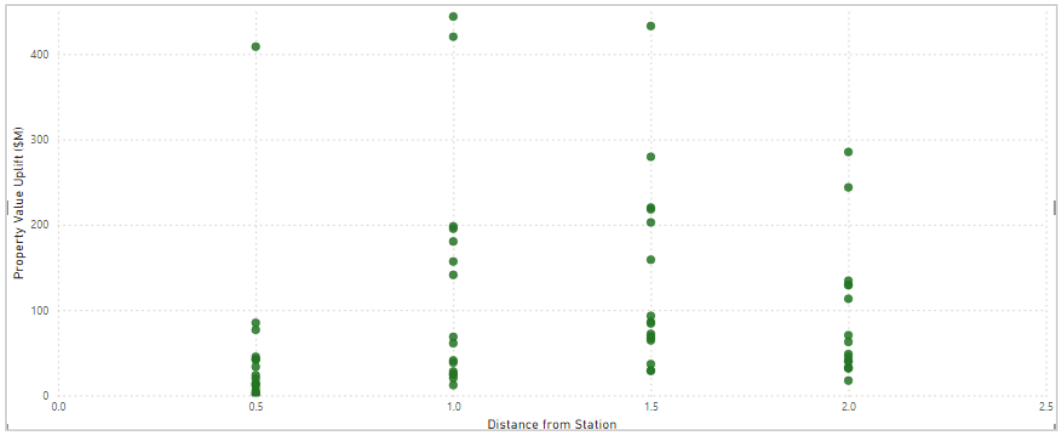


Figure 15. Spatial distribution of property value uplift caused by station delivery.

A note about data selection

Metrics D-F are strongly positively correlated to their distance to the centre of the LGA (figures 10-12). This is because of the method of data selection, which excluded data points outside the borders of the LGA (figure 4). The decision to exclude these data points was a deliberate one, based on the projects stated goal: how to locate a train station such that it will provide the most benefit to future residents of Camden. For example, property value uplift benefits the council by creating higher rates, but only for properties that fall within the LGA. If properties outside the LGA had been considered in the metric, it would provide an inaccurate snapshot of increased potential rate takings.

The population projection method used is somewhat rudimentary, as it does not take into account the rezoning of land within the LGA as part of the SWGA which will facilitate higher densities.

Recommendation

Considering the stacked benefits of each potential location (figure 13), station location 9 (-34.00524, 150.73905) is recommended.

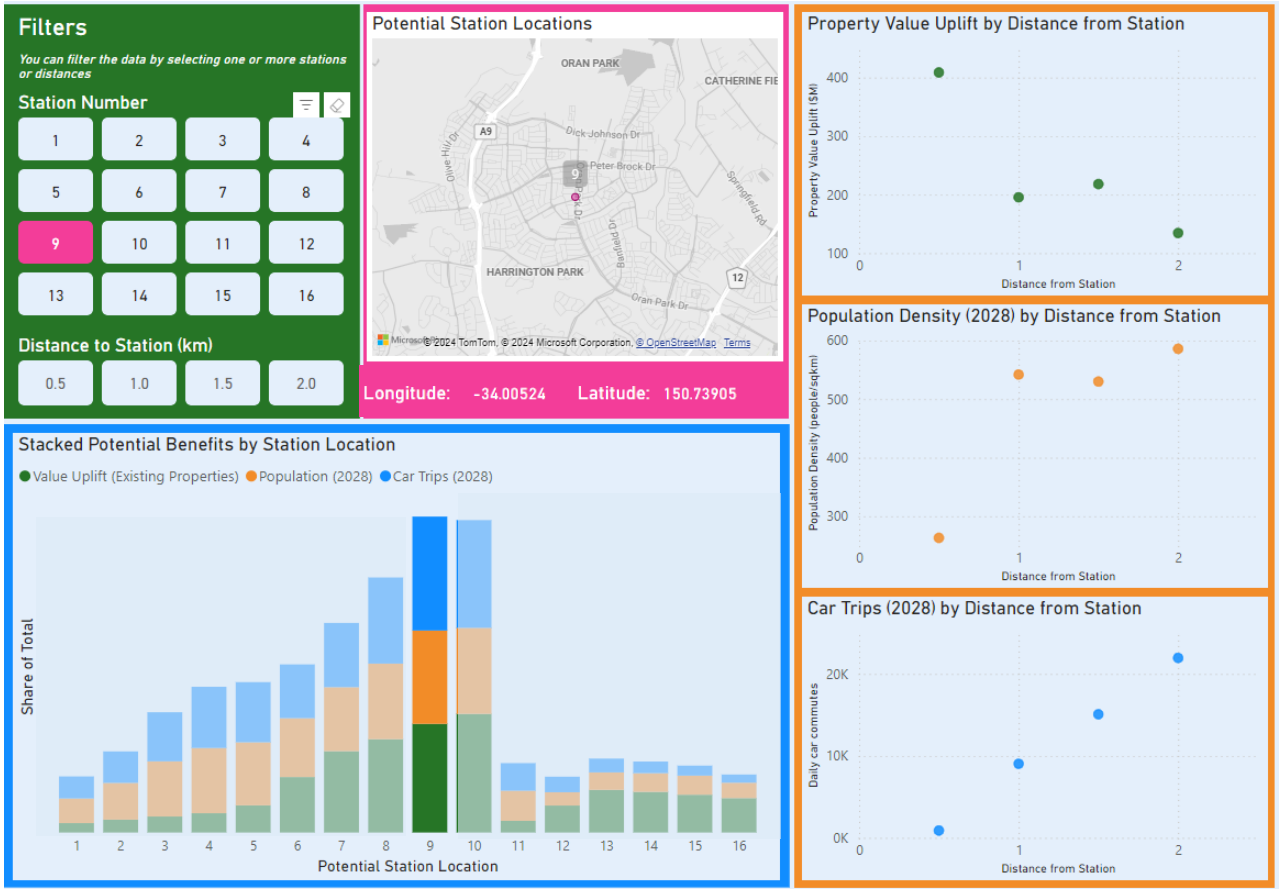


Figure 16. Screenshot of the project dashboard filtered to show only data points about location 9.

Figure17. Street view images of location 9.

Discussion of results and the role of open data, visualisation and analysis tools

This project used only publicly available data, analysis was done using the open-source tool QGIS, and the results were hosted on the free and publicly available site GitHub. The only paid tool used was PowerBI, but similar results could likely be achieved using the free google data studio.

In 2015 TfNSW announced their plans to develop a rail line in the North South rail corridor, and proposed locations for stations along the line. One of those stations was Oran Park, which lies just 700 metres from station location 9 (figure x). This report has 201km^2 (the size of Camden LGA) from which to identify the ideal location for a new train station. To have independently reached a result that is within 1 kilometre of TfNSW's recommendation is a testament to the power of publicly available data and free and/or open-source tools.

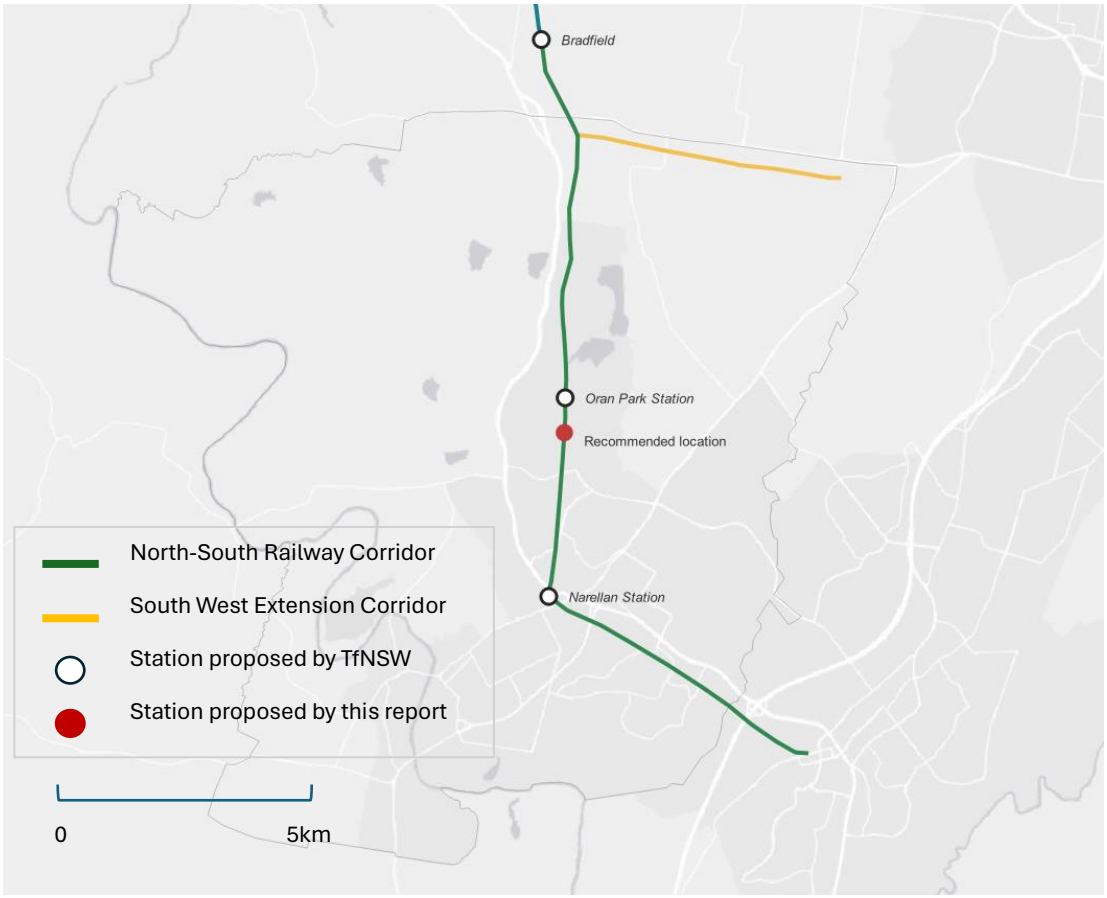


Figure 18. Location of the recommended location and Transport for NSW's location.

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Appendix 1 – Description of workflow

a. Identify possible areas
    i. Get existing and current train line data
    ii. Get state and council planning priority data
    iii. Get TEC data
    iv. Process these to create a line where current or proposed train lines are, that is within planning priority areas (council and state), and that does not contain a threatened ecological community.
b. Create a representative set of 16 possible points (spacing =500m) with 2km multi-buffers (each 500m wide)
c. Evaluate the following for each buffer zone
    i. Population in 2028
        1. Split zones along SA2 borders
        2. Calculate the percentage of the SA2 area that each feature occupies
        3. Calculate population growth using the following formula {XXX} and multiply by the percentage from step 2.
    ii. Number of car trips in 2028.
        1. Split zones along SA2 borders
        2. Calculate the percentage of the SA2 area that each feature occupies
        3. Calculate the number of trips per day using the following formula {XXX} and multiply by the percentage from step 2.
    iii. Uplift in value as a result of new station.
        1. Assign each property a centroid
        2. Filter out properties outside buffer zones
        3. 1 to many join points to buffer zones
        4. Use {XXX} to calculate value uplift
        5. Aggregate data to buffer zones
d. Aggregate data for buffer zones to each point.
e. Define symbology
f. Export the map to HTML using qgis2web
g. Manual tweaks to code
h. Publish to GitHub Pages – SolarTea1/github.io

Appendix 2 – Table of metrics D-F for each location and buffer zone

id	Station Buffer ID	Station ID	Buffer ID	Buffer radius(km)	D. Population 2028	F. Car Trips 2028	Area SQKM	PopulationPerSQKM	CarTripsPerSQKM	E. Value Uplift	Value Uplift per SQKM
1	5.4	5	4	2	44426	11523	117	380	98	129890867	1106059
2	10.2	10	2	1	28610	9812	50	572	196	443985772	8826210
3	10.3	10	3	1.5	35982	11569	84	428	138	279695196	3335842
4	1.2	1	2	1	3561	1120	25	142	45	25186496	1008865
5	7.1	7	1	0.5	4648	956	17	273	56	13037640	777276
6	1.3	1	3	1.5	14300	3520	41	349	86	29165440	717903
7	1.1	1	1	0.5	346	31	8	43	4	11382448	1360371
8	7.4	7	4	2	51555	15529	117	441	133	129095516	1099485
9	4.3	4	3	1.5	31738	8232	84	378	98	93263962	1111749
10	4.4	4	4	2	45607	11084	113	404	98	62767380	555751
11	7.2	7	2	1	13938	2867	50	279	57	141260291	2807212
12	16.2	16	2	1	5357	687	17	315	40	156899648	9387825
13	4.1	4	1	0.5	4648	956	17	273	56	2072063	123500
14	1.4	1	4	2	19954	4410	57	350	77	17321027	306102
15	7.3	7	3	1.5	28987	7125	84	345	85	432843699	5161043
16	13.1	13	1	0.5	1795	559	14	128	40	41926731	3083926
17	16.3	16	3	1.5	7193	923	22	327	42	72145971	3215654
18	4.2	4	2	1	19047	4942	50	381	99	12001280	238435
19	13.2	13	2	1	4060	1266	31	131	41	68566039	2229425
20	16.1	16	1	0.5	1657	516	13	127	40	33574387	2675504
21	16.4	16	4	2	9684	1243	30	323	41	40285548	1333545
22	3.1	3	1	0.5	4649	956	17	273	56	5962110	355321
23	13.3	13	3	1.5	6281	1958	48	131	41	220101011	4626115
24	13.4	13	4	2	14896	1912	46	324	42	45116483	970815
25	3.4	3	4	2	30501	6723	87	351	77	32244779	372410

26	3.2	3	2	1	19044	4940	50	381	99	38525754	765342
27	3.3	3	3	1.5	31260	7615	78	401	98	64454733	830384
28	15.3	15	3	1.5	8518	1093	27	315	40	66910103	2518032
29	12.2	12	2	1	4058	1265	31	131	41	61054790	1986010
30	15.4	15	4	2	11021	1415	34	324	42	40170858	1168314
31	12.3	12	3	1.5	6238	1944	47	133	41	86140497	1822535
32	15.1	15	1	0.5	1842	574	14	132	41	45366937	3251459
33	15.2	15	2	1	8149	1046	25	326	42	180453389	7097850
34	12.1	12	1	0.5	1799	561	14	129	40	19921201	1461364
35	12.4	12	4	2	8462	2637	64	132	41	70611739	1101516
36	14.1	14	1	0.5	1823	568	14	130	41	42243594	3058766
37	14.4	14	4	2	12201	1566	38	321	41	48510384	1274435
38	9.2	9	2	1	27100	9032	50	542	181	195393768	3883683
39	6.1	6	1	0.5	4647	956	17	273	56	3151995	187897
40	9.3	9	3	1.5	44508	15074	84	530	179	217998314	2599786
41	14.2	14	2	1	4114	1282	31	133	41	198100749	6358106
42	6.2	6	2	1	13939	2868	50	279	57	41080602	816298
43	14.3	14	3	1.5	10780	1384	34	317	41	69315281	2061211
44	9.1	9	1	0.5	4467	893	17	263	53	408665865	24368160
45	11.3	11	3	1.5	18343	4441	45	408	99	28803456	636560
46	9.4	9	4	2	68533	21952	117	586	188	134390663	1144789
47	11.4	11	4	2	22348	5025	62	360	81	31737026	510425
48	6.3	6	3	1.5	28195	6801	84	336	81	159004541	1895715
49	11.1	11	1	0.5	1872	588	13	144	45	14372820	1095215
50	6.4	6	4	2	44431	11525	117	380	99	285209629	2428844
51	11.2	11	2	1	4127	1299	29	142	45	28028096	968607
52	2.1	2	1	0.5	178	62	17	10	4	23697135	1412102
53	2.2	2	2	1	14078	3431	38	370	90	20381312	532503
54	8.3	8	3	1.5	37579	11398	84	447	136	202689452	2417015
55	8.4	8	4	2	56346	18402	117	482	157	113304288	965087

56	5.2	5	2	1	16918	4077	50	338	82	24180628	480457
57	10.1	10	1	0.5	7637	2446	17	449	144	76785001	4578959
58	8.1	8	1	0.5	4467	893	17	263	53	85111165	5074635
59	5.3	5	3	1.5	31733	8230	84	378	98	84300672	1004987
60	2.3	2	3	1.5	18598	4151	52	358	80	36761594	702276
61	8.2	8	2	1	18708	4804	50	374	96	420358742	8354435
62	2.4	2	4	2	24105	5330	68	354	78	32435208	474559
63	5.1	5	1	0.5	4647	956	17	273	56	741510	44199
64	10.4	10	4	2	61046	20571	117	522	176	243837071	2077305