

Peak Hour Passenger Train Crowding Levels in Sydney and Their Implications for Urban Consolidation

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Abstract

The Sydney Metropolitan Region has a long established Heavy Rail Network, serving mainly residential suburbs west of the City Centre. Peak hour train service frequencies on most lines leading to the Sydney CBD are now close to the reliable capacity limits of timetabled operating headways (18 trains per hour). There is only limited capacity with the existing rail network (10% at most) to run additional trains into the Sydney City Centre CBD in the actual morning peak 1 hour period on weekdays. In consequence regional growth in rail passenger demand now primarily results in increased levels of crowding of the peak hour trains on most of the rail lines in the vicinity of the Sydney CBD.

This situation has major implications for the locations of new residential in the Inner, Middle Ring and Outer Suburban areas of Sydney. In the Outer Suburban areas, new rail links and new rail stations are required to for basic accessibility and equity reasons to give new residential areas access to the government funded rail network. In the Inner and Middle Ring suburbs, where the remaining spare capacity in the existing heavy rail network is now almost exhausted, new rail projects, either metro lines, extensions of the existing Inner West light rail or significant heavy rail network improvements will need to come rapidly on-stream to provide the necessary additional rail passenger capacity in peak periods.

*Note: The view and opinions which are expressed in this paper are based on the private research investigations of the author and do not specifically represent the views of Arup.

1. Sydney's Road and Rail Networks

The history, development and function of Sydney's road and rail systems has some similarities but also many differences. The road system now serves widely dispersed travel patterns and needs throughout the daytime and evening on both weekdays and weekends. The rail system is much more focussed on meeting the morning and afternoon peak weekday travel demands for commuting trips, in particular trips to and from the Sydney CBD and other nearby employment districts.

This distinction is illustrated by the ratio of peak hourly to daily travel demand. On most of Sydney's major roads, the peak hour proportion of total daily travel is typically less than 10 percent and can be as low as 6-7% on some routes (RTA, 2002). In contrast, the rail travel capacity and demand is much more "peak period" focussed and the passenger rail network is currently able to accommodate 25% of the total daily travel demand in either the morning or afternoon peak 1 hour periods, ie on trains arriving in the Central CBD area between 8-9 am on weekdays and departing between 5-6 pm (CityRail, 2006).

The Greater Sydney Metropolitan Region Rail Network has electric passenger train operations as far north as Newcastle (166 km) west to Lithgow (155 km) south along the coast to Kiama (120 km) and south west as far as Macarthur (57 km), see map in Figure 1

Figure 1 Greater Metropolitan Region Rail Passenger Rail Network



Source (State Rail, 2001) An introduction to State Rail planning processes for future rail operations and infrastructure in the Greater Sydney metropolitan region, December 2001. (the Epping to Chatswood Line which opened in February 2009 has been subsequently added in by the Author)

In the Sydney context, a comparison of the peak hour functional capacity of the heavy rail network vs road capacity is summarised by the peak hour peak direction capacity of a standard two track railway, either on the surface or in a tunnel, carrying twelve trains per hour at five minute intervals (1,000 passengers per train = 12,000 passengers per hour) This is equivalent in capacity to a ten lane freeway carrying 2000 cars per lane per hour in the peak direction at the current average peak hour commuter car occupancy level of 1.2 persons per car.

2. Existing Passenger Rail Network Operations

Sydney’s passenger rail network has six defined routes approaching the Sydney CBD, as illustrated by the route map in Figure 2 below. Some of these six routes combine the trains from a number of other lines further out, in particular, the train services from the Main South (via Liverpool) Main North (via west Ryde and Eastwood) and Richmond Lines (via Blacktown) all combine at Strathfield to travel on The Main West Rail Line (6 tracks = 43 trains per hour inbound) to the Sydney CBD.

Figure 2 : Sydney Metropolitan Rail Network and a.m. Peak Hour Loadings 2008

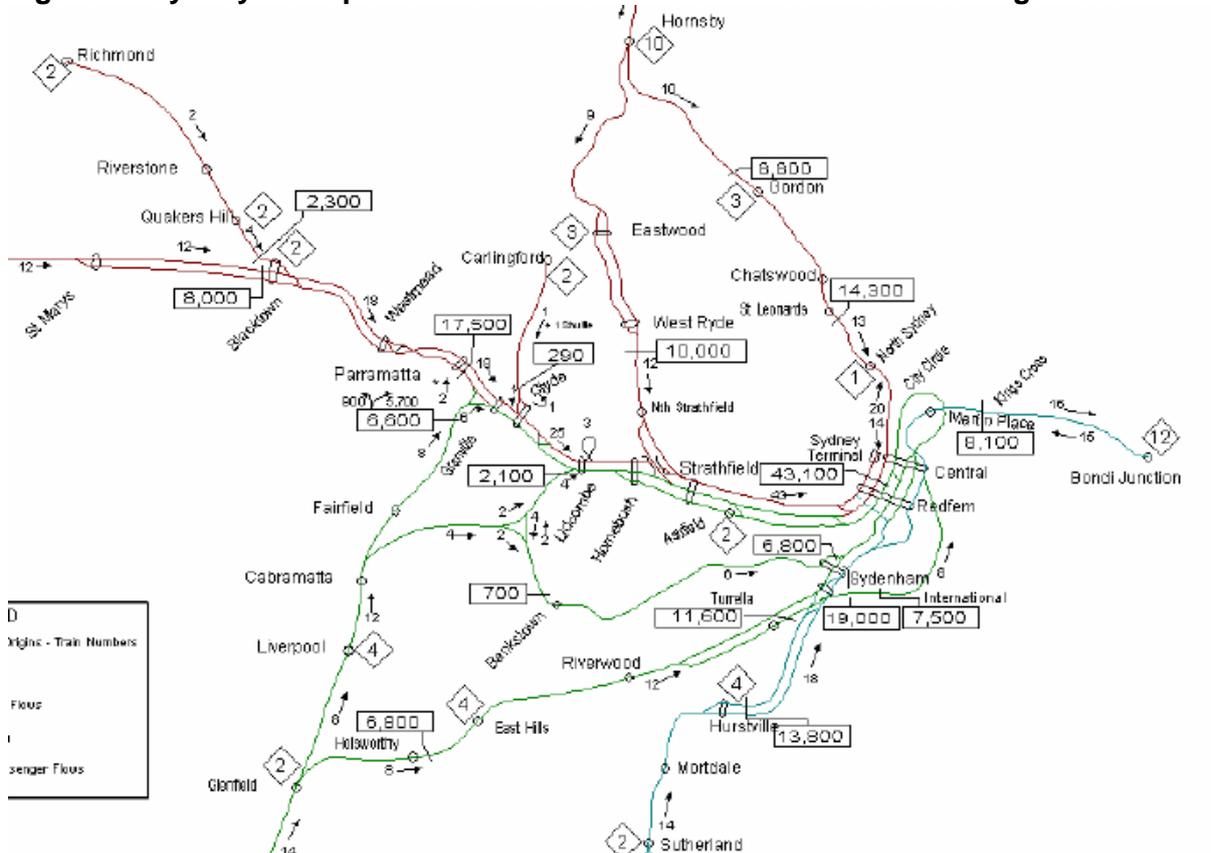


Table 1: Morning Peak Hour City Bound Passenger Train Operations (1 Hour Peak – March 2005)

Line (Year 2005)	Trains	Capacity	Utilisation	% Loading	Reasonable Spare Capacity
Main Western	42	42,000	34,995	83	7,000
Illawarra	17	17,000	15,270	90	1,700
North Shore	13	13,000	13,280	102	-300
Eastern Suburbs	13	13,000	7,110	55	5,900
Revesby / E Hills	12	12,000	10,670	89	1,300
Bankstown	6	6,000	5,570	93	400
Total All Lines	102	102,000	86,895	85	15,100

Source (CityRail, 2006)

Table 2: Morning Peak Hour City Bound Passenger Train Operations (1 Hour Peak – March 2008)

Line (Year 2008)	Trains	Capacity	Utilisation	% Loading	Reasonable Spare Capacity
Main Western	43	43,000	43,035	100	-100
Illawarra	18	18,000	18,180	101	-200
North Shore	13	13,000	14,325	110	-1,300
Eastern Suburbs	15	15,000	8,120	54	6,900
Revesby / E Hills	12	12,000	11,605	97	400
Bankstown	6	6,000	6,845	114	-800
Total All Lines	107	107,000	102,110	95	4,900

Source (CityRail, 2008)

Table 3: Morning Peak Hour City Bound Passenger Train Operations (1 Hour Peak – March 2010)

Line (Year 2010)	Trains	Capacity	Utilisation	% Loading	Reasonable Spare Capacity
Main Western	39	39,000	37,230	95	1,800
Illawarra	17	17,000	17,935	106	-900
North Shore	18	18,000	15,525	86	2,500
Eastern Suburbs	15	15,000	7,375	49	7,600
Revesby / E Hills	12	12,000	11,945	100	100
Bankstown	6	6,000	6,630	111	-600
Total All Lines	107	107,000	96,640	90	10,400

Source (CityRail, 2010)

The CityRail inbound passenger counts for the suburban trains are generally undertaken at a cordon of stations, approaching the CBD outer limits, at King Cross, St Leonards, Redfern and Sydenham. The only exceptions are for the East Hills via Airport Line Trains (where the

counts are undertaken at Wolli Creek Junction) and the inter-city trains where the counts are undertaken at the last major station before reaching the Sydney Metropolitan Area, (Glenbrook, Helensburgh and Woy Woy) as the primary intention of these train services is to provide capacity for longer distance commuters and other regionally based passengers.

Since the mid 1990's, all Sydney region peak hour train services, inner and outer suburban and inter-city have been operated by 8 car trains, as the practice before that time of operating combinations of 4, 6 and 8 carriage trains on the same actual track at theoretical 3 minute headways, was found to cause extremely unstable operating conditions and effectively ceased following a major timetable review in 1995/6.

For the purposes of this paper, the "reasonable operating capacity" of all the types of 8 car trains currently operating on the Sydney network is defined as approximately 1,000 persons per train. The actual seated capacity of the individual trains varies between 800-900 seats and a comfortable operating capacity limit for commuters who use trains on a regular basis, with all seats occupied and an additional 15% standing passengers as trains approach closer to the Central Sydney CBD, is approximately 1,000 persons per train.

CityRail train crowding tests undertaken prior to the 2000 Olympics have confirmed that under special event "crush" loading conditions, an 8 car train can accommodate approximately 2,000 persons, but such "crush" loading conditions are not likely to be attractive to regular weekday rail commuters as a lifestyle choice on a regular ongoing basis.

Table 4: Morning Peak Hour City Bound Passenger Train Operations (1 Hour Peak – March 2010)

Total All Lines	Trains	Capacity	Utilisation	% Loading	Reasonable Spare Capacity
March 2005	102	102,000	86,895	85	15,100
March 2008	107	102,000	102,110	95	4,900
March 2010	107	107,000	96,640	90	10,400

Source (CityRail, 2006/8/10)

The comparison of the 2005, 2008 and 2010 totals of 1 hour morning peak city bound train passenger loadings in Table 4 above, confirms very strong commuter rail patronage growth at +6% per annum occurred from 2005 to 2008, recovering from an earlier decline during the period 2001-2004. This growth was related to many factors, ie rapid urban consolidation around key railway stations along the Main West and Illawarra Rail Line Corridors, and also fuel price increases causing significant shifts from car to rail commuting on other lines. Despite the decline in peak passenger demand from March 2008 to March 2010, a strong underlying growth trend of +1,950 passengers per year (+2.2% per annum from March 2005) was still evident for the five year period from March 2005 to March 2010.

In early 2008 the Sydney CBD based rail services were effectively experiencing strong passenger growth and heading for a capacity 'meltdown" situation by 2010. This was effectively only averted by the short term consequences of the GFC (Global Financial "Industry" Crisis) leading to a sudden drop in CBD based Financial Services Sector employment and consequently peak hour rail commuting to the Central Sydney CBD area immediately after August 2008.

The other key finding from the rail network capacity analysis is Table 1,2 and 3 is the marked difference between the city bound capacity loadings on the Eastern Suburbs Line and the other lines. The Eastern Suburbs Line benefits from the "through routing" of most inbound Illawarra Line train services such that it's passenger loadings are still only on average about 50% of "practical operating capacity", even at the height of the morning peak hour.

Another recent change evident from the latest March 2010 passenger train survey results in Table 3, is the morning peak city bound passenger crowding levels on the North Shore Rail Line services have eased significantly with the addition of the Epping to Chatswood Rail Line Service in February 2009. The excess passenger loadings on trains on this line were previously among the worst of any lines in the CityRail network in both the 2005 and 2008 surveys but have now, as result of the 5 extra inbound train services in the peak hour, been reduced to much more acceptable levels. The proposed additional passenger growth from urban consolidation along this line in areas such as Ku-ring-gai is now more supportable.

In 2010, the most critical capacity line for city bound passenger loadings in the 1 hour actual peak period is now the Bankstown line. This is the line where increased capacity from additional peak hour train services, is now most badly needed.

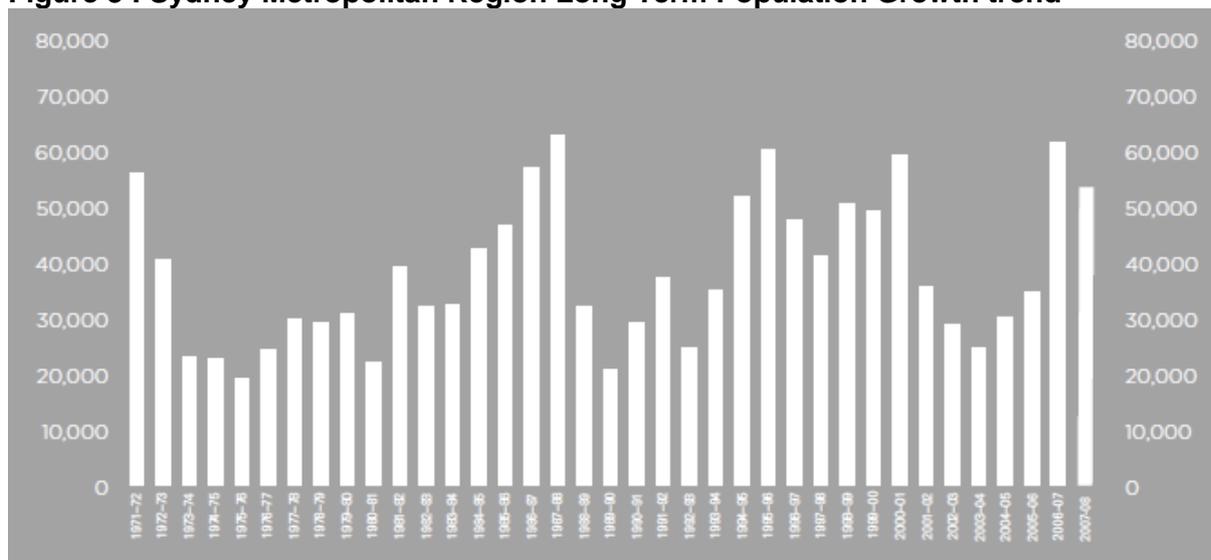
A key finding from the overall analysis of the 2005, 2008 and 2010 passenger train loadings is the considerable “mis-match” between the lines of the Sydney Metropolitan Region rail network which currently have “1 hour morning peak period” spare passenger capacity, and the areas of Sydney in which further urban consolidation is currently proposed or able to be supported.

This is highlighted by the March 2010 passenger capacity analysis, in Table 3, where approximately 70% of the current total spare capacity of the Sydney Metropolitan Region rail network in the 1 hour morning peak period, is effectively only available on the Eastern Suburbs line. However, this line in its current form, with only three railway stations, has very little potential to generate significant additional future passenger demand through urban consolidation, as it already has comparatively the highest population densities in the areas surrounding it’s railway stations, of any of the Sydney Metropolitan region rail lines.

3. Sydney Region Population Growth Trends

Historically, Sydney’s population growth has fluctuated over a series of five to ten year cycles, but the longer term trend as shown in Figure 2, has remained relative constant at an average figure of +42,500 persons per annum throughout a 40 year period since the early 1970’s. There is only a very hesitant trend towards a possible uplift in the average annual population growth rate over the most recent two year periods, 2006/7 and 2007/8 where growth has averaged +57,000 persons per annum.

Figure 3 : Sydney Metropolitan Region Long Term Population Growth trend



Source (DoP, 2010)

The current Sydney Region Metropolitan Growth Strategy (DoP, 2005) which was prepared in December 2005 is now under review. The December 2005 Metropolitan Strategy was based on year 2004 updates of population and dwelling numbers in the Sydney Region, estimated from new dwelling completions since the 2001 census.

The Year 2031 future population and dwellings growth targets for the Sydney Metropolitan Region which were proposed in 2005 were consistent with the longer term trends since 1962 but also assumed the current trend towards smaller average household sizes will continue for the foreseeable future. The December 2005 strategy proposed +640,000 new dwellings to be constructed within the Sydney Metropolitan Region, including the adjoining Central Coast Region, to accommodate predicted future long term population growth of +1.1 million persons at +40,740 persons per annum, namely:

- (in 2004) 1.60 million dwellings with 4.2 million people = 2.63 persons per dwelling
- (in 2031) 2.24 million dwellings with 5.3 million people = 2.37 persons per dwelling
- (Growth Increment 2004 to 2031 =) +640,000 dwellings @ 1.72 persons per dwelling

A draft review of the December 2005 Strategy has now been released as a consultation document (DoP, 2010), which proposes a substantially higher future population growth target for the "Sydney Region" of +57,000 persons per annum throughout a 30 year period from 2006 to 2036.

The corresponding new year 2036 total population target figure of 6.0 million persons (5.982 million to be precise) includes the Central Coast Region which has projected future population growth of 120,000 persons resulting in a future total of over 424,000 persons in 2036.

Also, as yet there are no sub regional forecasts presented but the predicted future dwellings growth target for the Sydney region overall is a 30 year growth target of +770,000 dwelling with an accompanying employment growth forecast of +760,000 jobs, ie a future jobs growth rate of 0.987 jobs per household.

This broadening of the basis of the Sydney Metropolitan Region growth strategy to include the Central Coast Region is an acknowledgement that Sydney's projected future population growth over a 30 year period can no longer realistically be contained within the traditionally accepted boundaries of the Sydney Metropolitan Region and will inevitably "spill over" into the adjoining Central Coast region.

There is also a future change in the future average persons per household estimates, whereby the previously projected continuing long term decline in the average household size in the Sydney region, to an average of only 2.37 persons per dwelling by 2031, has now been revised to predicted average of 2.51 persons per dwelling in 2031. This decline will presumably level out beyond that time with no significant further decline in 2036.

The future dwellings growth target of +770,000 dwellings from 2006 to 2036, to accommodate future projected population growth of +1.7 million persons, now represents a "future growth increment" of +770,000 dwellings at 2.21 persons per dwelling.

4. Proposed Distributions of New Dwellings in Sydney Region Growth Strategy Targets

In 2005, the Metropolitan Strategy proposed an approximate 70% vs 30% split between the projected dwellings growth via urban consolidation in existing urban areas, +420,000 dwellings, and the projected dwellings growth on "Greenfield Sites" of +220,000 dwellings, comprising +160,000 dwellings in the two designated "Growth Centres" and +60,000 dwellings in the remainder of the Land Release Program areas.

This 70% vs 30% split between new dwellings constructed by means of urban consolidation and new dwellings on Greenfield Sites is proposed to be retained in the latest metropolitan Strategy Review (DoP, 2010). The future 30 year dwellings growth target of +770,000 dwellings therefore represents;

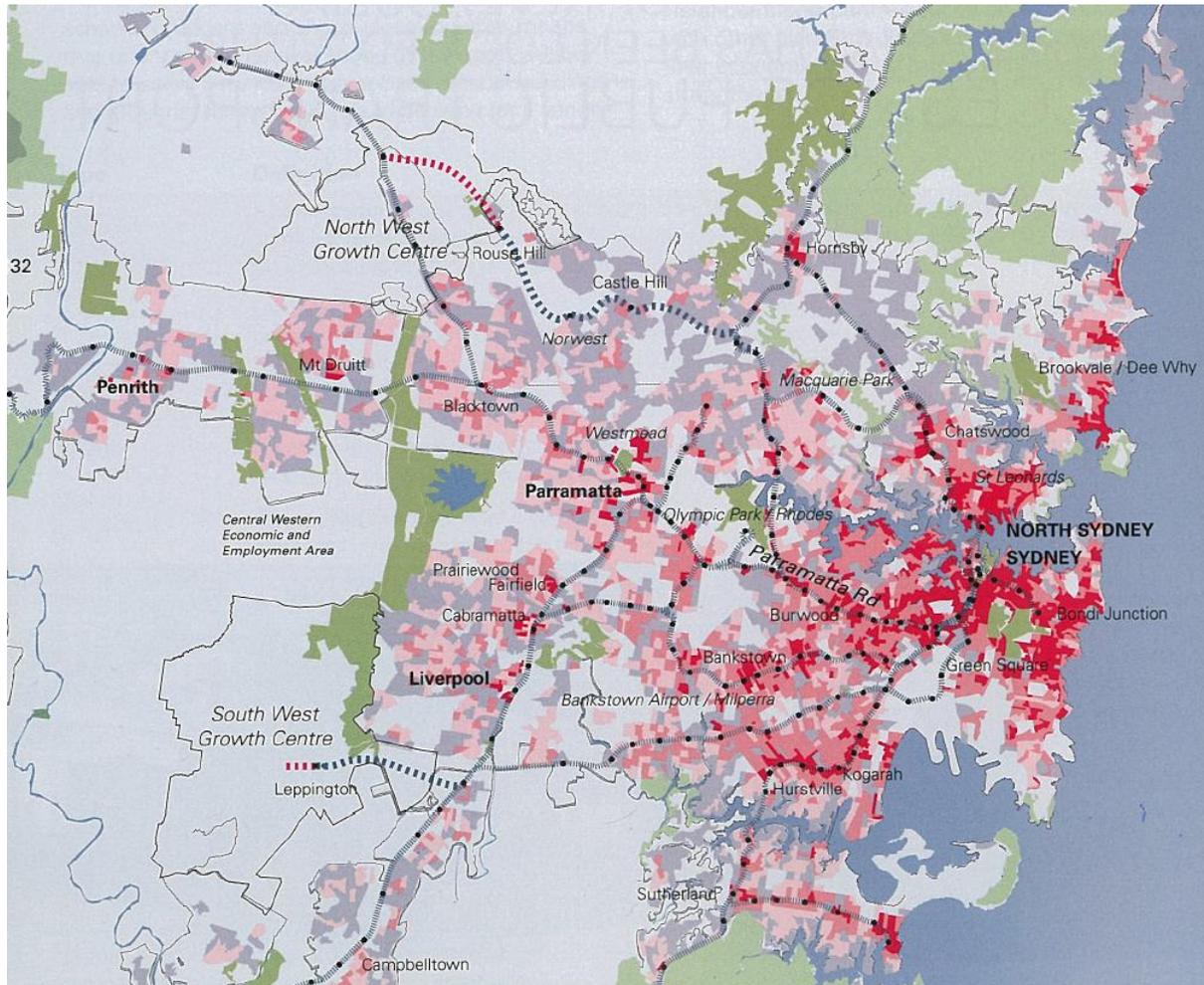
- +231,000 target for new dwellings in Greenfield areas
- +539,000 target for new dwellings in Urban Consolidation areas.

The +539,000 new dwellings which are proposed to be constructed, presumably by means of future urban consolidation according to Transit Oriented Development principles, will all therefore need a good level of accessibility to the metropolitan rail network by means of either walking, cycling or good local bus feeder connections.

5. The Potential for Future Urban Consolidation in Sydney Rail Station Catchments

A map of the existing dwelling density around all the railway stations in the Sydney Metropolitan Region, Figure 4, was produced for the December 2005 Metropolitan Strategy, based on the population data from the 2001 Census, which was the most recent census data which was available at that time.

Figure 4 : Sydney Region Dwelling Densities Showing– Longer Term Urban Consolidation Potential



Source (DoP, 2005). The red colour indicates the highest residential density level of 25 dwellings per hectare, the dark and light pink and grey colours represent densities of 12-25, 9-12 and 5-9 dwellings per hectare respectively

The highest dwelling and population densities, in excess of 25 dwellings per hectare, are currently to be found around the Eastern and Northern Beaches Coastal Suburbs and some Inner West, Lower North Shore, Bankstown and Illawarra Line railway stations.

Heading further out from the City Centre, there are many suburban railway stations which still have relatively low base population and dwelling densities, less than 15 dwellings per hectare typically, which can be considered to have good future potential for urban consolidation type development (Transit-Oriented Development). These railway stations are listed below in Table 5 in relation to sections of the relevant railway lines.

Table 5 : List of Sydney Region Railway Stations Potentially Suitable for Additional Residential Development by Urban Consolidation.

Railway Line	Stations With Low Dwelling Density in 2001, Potentially Suitable For Future Long Term Urban Consolidation	Number of Stations
Main West line (Central to Strathfield)	Central, Redfern, Macdonaldtown, Croydon	4
Main West line (Homebush to Parramatta)	Homebush, Flemington, Lidcombe, Olympic Park, Granville (Clyde should be excluded due to primarily industrial uses)	5
Main West line (Main North Section)	North Strathfield, Concord West, Rhodes, Meadowbank, Denistone, Eastwood, Cheltenham, Beecroft, Pennant Hills, Thornleigh, Normanhurst, Asquith, Mount Colah, Mount Kuringai, Berowra, Cowan, Brooklyn	17
Main West line (Carlingford Branch)	Rosehill, Camellia, Rydalmere, Dundas, Carlingford	5
Main West line (Main South Section)	Merrylands, Guildford, Fairfield, Canley Vale, Warwick Farm, Casula, Glenfield, Macquarie Fields, Ingleburn, Minto, Leumeah, Campbelltown, Macarthur, Menangle Park, Menangle, Douglas Park, Picton, Tahmoor, Bargo (Yennora should be excluded due to primarily industrial uses)	19
Main West line (Westmead to Penrith)	Westmead, Wentworthville, Toongabbie, Seven Hills, Blacktown, Doonside, Rooty Hill, Mount Druitt, St Marys, Werrington, Kingswood	11
Main West line (Richmond Branch)	Marayong, Quakers Hill, Schofields, Riverstone, Vineyard, Mulgrave, Windsor, Clarendon, East Richmond, Richmond	10
Main West line (Blue Mountains Section)	Lapstone, Glenbrook, Blaxland, Warrimoo, Valley Heights, Faulconbridge, Linden, Woodford, Hazelbrook, Lawson, Bullaburra, Wentworth Falls, Leura, Katoomba	14
Illawarra line (Erskineville to Hurstville)	Erskineville, St Peters, Tempe, Arncliffe, Banksia (Sydenham should be excluded due to Aircraft Noise issues)	5
Illawarra line (Penshurst to Engadine)	Oatley, Como, Jannali, Sutherland, Loftus, Engadine	6
Illawarra line (Cronulla Branch)	Kirrawee, Caringbah, Woolooware	3
North Shore line (Milsons Point to Chatswood)	Waverton, Wollstonecraft Artarmon,	3

North Shore line (Macquarie line stations)	North Ryde, Macquarie Park, Macquarie University	3
North Shore line (Roseville to Wahroonga)	Lindfield, Killara, Gordon, Pymble, Turramurra, Warrawee, Wahroonga	7
Eastern suburbs line (Kings Cross to Bondi Junction)	No Stations With Low Density Currently	0
Airport/ E Hills line (Green Square to Wolli Creek)	Green Square, Mascot, Wolli Creek	3
Airport/ E Hills line (Turrella to Holsworthy)	Turrella, Bardwell Park, Bexley North, Kingsgrove, Beverley Hills, Panania, East Hills, Holsworthy	8
Bankstown line (Marrickville to Bankstown)	Canterbury, Belmore,	2
Bankstown line (Yagoona to Berala)	Birrong, Regents Park	2
Bankstown line (Sefton to Carramar)	Sefton, Villawood, Carramar, (Leightonfield should be excluded due to primarily industrial uses)	3
Central Coast Line (Wondabyne to Warnervale)	Wondabyne, Woy Woy, Koolewong, Tascott, Point Clare, Gosford, Narara, Niagara Park, Lisarow, Ourimbah, Tuggerah, Wyong, Warnervale	13
Future South West Rail Link	Edmonson Park, Leppington	2
Future North West Rail Link	Cherrybrook, Castle Hill, Hills Centre, Norwest, Kellyville, Rouse Hill	6

As listed in Table 5 above, there are a total of 151 out of the existing 206 railway stations in the Sydney Metropolitan and Central Coast Regions, which currently have low dwelling densities (less than 15 dwellings per hectare typically) in their surrounding residential areas within an 800 metre radius walking distance catchment, where future urban consolidation type “Transit Oriented Developments” should be feasible.

Where these railway stations are located in existing or proposed major commercial centres, eg Westmead, Blacktown, Macquarie Park and Sutherland, future urban consolidation by means of High Rise High Density residential development in areas close to the railway station should clearly be feasible. However, the existing low density suburban nature of many of the other railway stations, means that high rise high density residential development is not really desirable as the basis of a future urban consolidation strategy for these railway stations. At the majority of the stations which are in existing low density residential catchments, more compatible medium density type townhouse or maximum 3 storey residential flat development should preferably form the major component of the future urban consolidation strategy. For this type of railway station a target of increasing the average dwelling density from typically 15 dwellings per hectare or less (throughout the 800 metre radius walking distance catchments) to approximately 25 dwellings per hectare in the future, should generally be feasible over a 25-30 year future period.

The overall future Sydney plus Central Coast Region “urban consolidation” growth strategy target of +539,000 dwellings represents an average of approximately +3,570 dwellings per existing railway station for approximately 151 potential future urban consolidation railway stations on the Sydney Metropolitan rail network, as listed in Table 5. Some of the major railway stations such as Blacktown which will clearly be able to accommodate a significant amount of future residential development in and around the town centre, to accommodate this general level of future residential growth. However, many other smaller railway stations,

in outlying areas adjacent to National Parks, such as Linden in the Blue Mountains, will clearly not be able to support significant levels of residential growth.

In practice the upper limit to the amount of future urban consolidation type development which is potentially able to be accommodated within the 151 identified railway station catchments on the Sydney Metropolitan Region Rail Network, would be a maximum of 4,000 additional dwellings per railway station, with an overall average figure of 2,000 additional dwellings per railway station which would represent an overlay of 10 additional dwellings per hectare (gross) over the 200 hectare catchment area within 800 metres walking distance of the station. In practice, good local bus feeder services will also assist in extending the effective railway station catchments, significantly beyond the 800 metre radius at many busy suburban stations.

6. Proposed Sydney Region Rail Network Capacity Improvements

There are four major proposed improvements to the Sydney Region Metropolitan Rail network in the Draft Metropolitan Strategy Review and its accompanying Transport Plan, (NSW Government, 2010) namely.

- The South West Rail Link, to Leppington
- The North West Rail Link, to Rouse Hill
- The Western Sydney Express Rail Services
- The Inner West Light Rail Extensions

The first two of these projects have previously been documented, at length, in numerous other government reports and publications. The other two are more recently proposed projects which are summarised here by the following extracts from the 2010 Metropolitan Transport Plan.

6.1 The Western Sydney Express Rail Services

The Western Express Rail Project Figure 5 will see two of the main west tracks which currently terminate at Central, extended via new track from Eveleigh and new underground platforms at Redfern to three other new railway stations at, Railway Square, “City West” below Sussex Street and “Wynyard West” near Barangaroo. This will achieve full future separation of the express, suburban and local tracks on the Main West line and eliminate the need for Main West line express trains to merge with suburban tracks at the Illawarra Junction, near Redfern.

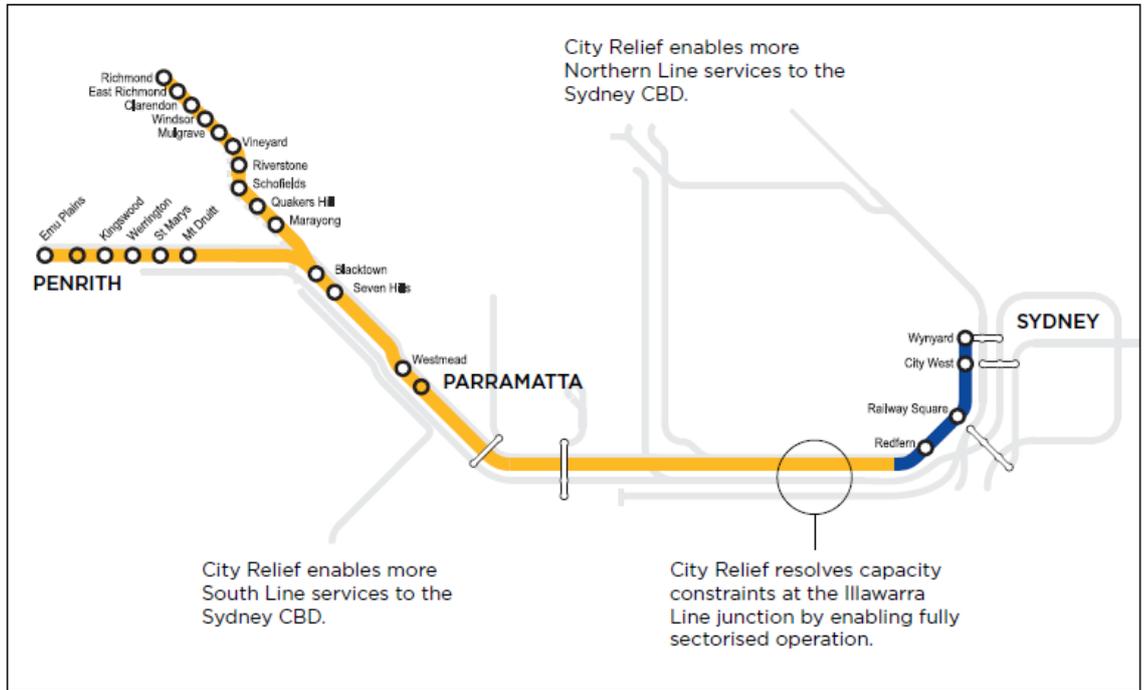
This will deliver improved capacity with faster trains from Sydney’s west to the CBD permitting up to six additional trains per hour (with an increased peak hour capacity of approximately 6,000 passengers per hour) to operate to and from the Sydney CBD.

6.1 The Inner West Light Rail Extensions

The Inner West Light Rail Extensions propose extensions at both the Sydney CBD end (from Haymarket to Barangaroo and Circular Quay) and the Outer end (from Lilyfield to Dulwich Hill including a new heavy rail interchange station at Lewisham on the Main West Rail Line suburban tracks) The existing Light Rail services operate with a practical capacity (including both seated and standing passengers) of 200 passengers per train).

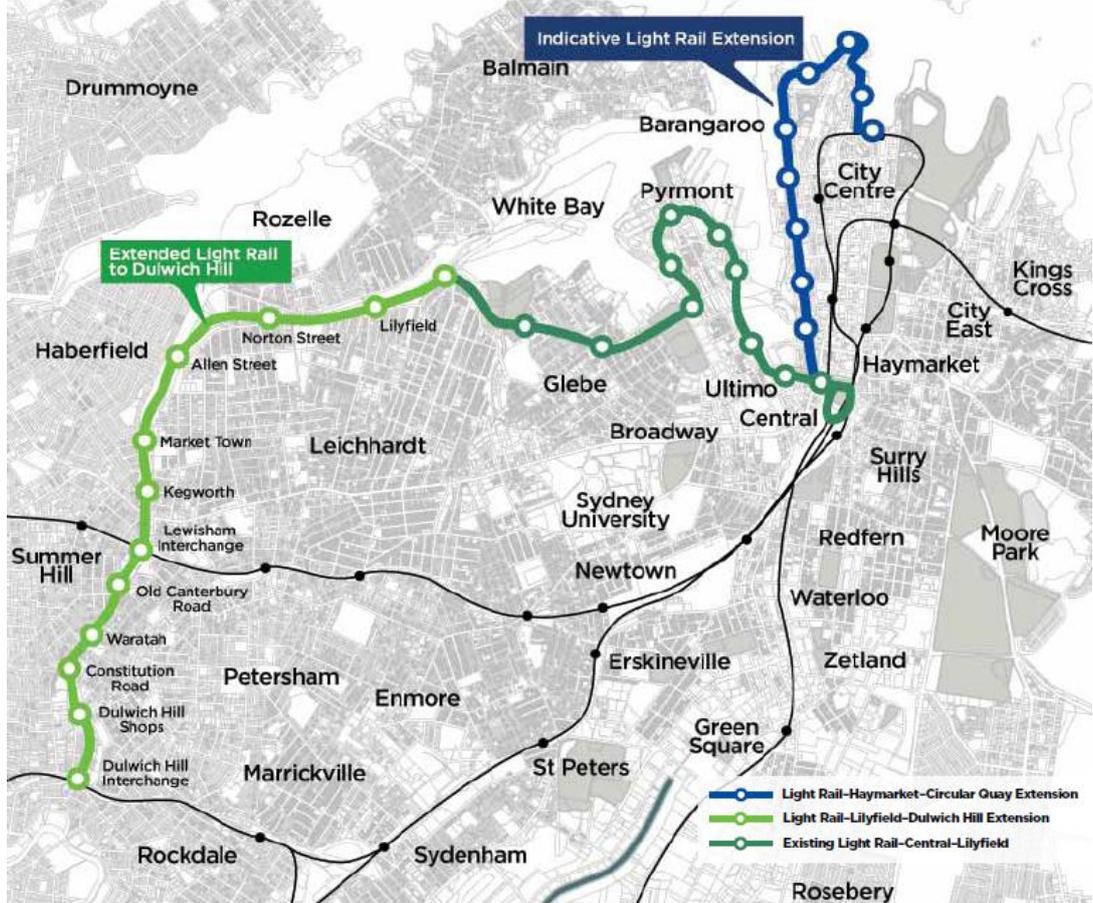
With the proposed extensions, the peak hour frequency of the services can improve from about 8 minutes currently (7 trains per hour) to a theoretical maximum of about 2.5 minutes in the future (24 trains per hour). The peak 1 hour city bound passenger capacity of the system will increase from about 1,400 passengers per hour currently to 4,800 per hour after the proposed extensions are completed, as illustrated by the map in Figure 6.

Figure 5: Concept Details of Western Sydney Express Rail Project



Source: NSW Government, 2010 Metropolitan Transport Plan

Figure 6 : Map of Proposed Extensions to Sydney Inner West Light Rail Routes



Source: NSW Government, 2010 Metropolitan Transport Plan

A recent discussion paper prepared by Dr Garry Glazebrook of The University of Technology, Sydney, (Glazebrook, 2008) estimated that with no additional rail network extensions or improvements, the limit of the Sydney Region Rail network to accommodate more city bound trains heading inbound towards the Sydney CBD in the actual 1 hour morning peak period, is probably an additional 7 trains per hour inbound, distributed across various lines (but mostly on the Bankstown line). This potentially increases the overall capacity of all inbound train services to the Sydney CBD from 107 trains currently (in March 2010) to a future potential maximum of 114 trains per hour, before any of the currently proposed rail network improvements are implemented.

If the three currently proposed heavy rail network extensions/ improvements which are identified in the latest NSW Government Planning and Transport Strategies (DoP, 2010) and (NSW Government, 2010), namely the NWRL, SWRL and WSER train services, are constructed in the future, these projects would each independently add a further six trains per hour (eighteen additional trains per hour in total) in the actual morning peak hour on a variety of rail lines heading inbound towards the Sydney CBD.

The future rail lines, by which these eighteen additional trains per hour would most likely approach the Sydney CBD, and their consequent effects in improving the overall Sydney Region rail network capacity are summarised by Table 6 below.

Table 6: Maximum Future Potential Morning Peak City Bound Passenger Train Operations (1 Hour Peak) with Additional NWRL, SWRL and WSER Train Services

Line (Year 2010)	Trains	Capacity	Current Utilisation (Year 2010)	Reasonable Spare Capacity
Main Western	48	48,000	37,200	10,800
Illawarra	21	21,000	17,900	3,100
North Shore	18	18,000	15,500	2,500
Eastern Suburbs	18	18,000	7,400	10,600
Revesby / E Hills	15	15,000	11,900	3,100
Bankstown	12	12,000	6,600	5,400
Total All Lines	132	132,000	96,500	35,500

Source: (Glazebrook, 2008) with minor modifications by the author

With the eighteen additional future trains per hour provided by the NWRL, SWRL and WSER train services, the future spare capacity on the Metropolitan Rail Network to accommodate additional morning peak hour commuter rail passenger growth, from future urban consolidation throughout the Sydney and Central Coast Regions, would be 35,500 city bound passengers per hour. This is a 37% increase above the current March 2010 morning peak 1 hour city bound rail passenger demand level.

However, approximately 10,600 passengers per hour of this future spare capacity is effectively “locked up” on the Eastern Suburbs rail line corridor where it is unable to serve future urban consolidation in the wider Sydney region, unless there is an extension of the existing heavy rail line beyond Bondi Junction, eg potentially to continue via Randwick and Kingsford and “loop around” to connect with the remainder of the Sydney Metropolitan Region rail network at Sydneham.

Also, the published CityRail passenger loading levels on the morning peak hour city bound Inter City train services, which are measured at outlying stations as these trains approach the edge of the Sydney Metropolitan area (Helensburgh, Glenbrook and Woy Woy), exclude any additional passengers who have boarded these trains at stations closer to

Sydney, such as Sutherland, Blacktown, Parramatta, Epping and Hornsby. These estimated additional inbound passengers are a total of 3,100 passenger in the peak 1 hour period.

When the theoretical spare capacity estimate of 35,500 inbound passengers per hour is adjusted to account for these two losses, the effective spare capacity of the Metropolitan Region heavy rail network to serve future urban consolidation throughout the Sydney Region is a much less impressive total of approximately 21,800 peak hour city bound passengers.

To this figure can however be added, the potential additional capacity of the proposed Inner West Light Rail System extensions (3,400 additional city bound passengers per hour), assuming the necessary feasibility studies receive the appropriate NSW Government endorsement when they are completed later this year. This would give an overall future Sydney Metropolitan Region rail network spare capacity limit, to support future urban consolidation, of 25,200 peak hour city bound passengers.

7. Provisional Limits to Future Urban Growth in Sydney Supported by The Rail Network

7.1 The Predict and Provide Model of Transport Planning

Throughout the period from the 1960's onwards, in most developed countries such as Australia, the "Predict and Provide" model of Transport Planning has been applied to new road network development in conjunction with new urban development.

In this process, a great deal of research effort, including the development of highly complex and detailed transport network models, is expended in predicting the future travel demands of the new residents and workforces of new urban areas and ensuring that an adequate road network is provided, or at least planned to be provided, to meet their future travel needs, often with extensive government subsidy.

In principle this philosophy is commendable and the only possible problem is really that a similar level of research effort and planning has not been expended on predicting and providing for the future public transport access needs, eg by bus or rail, for such communities.

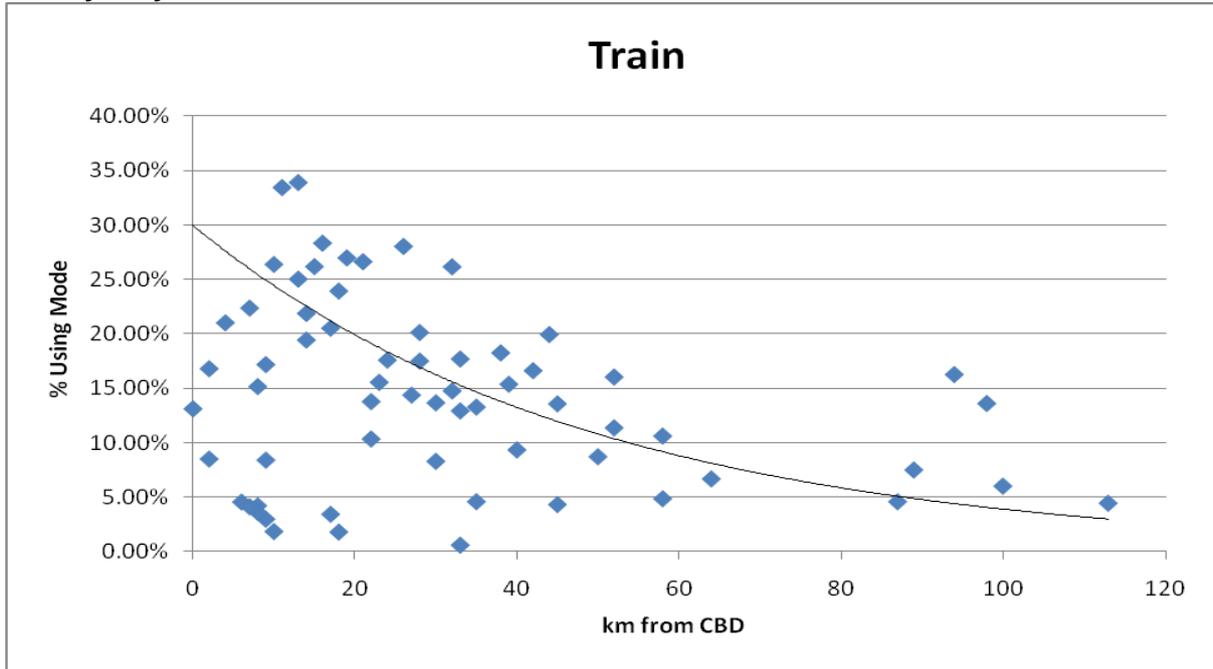
The current design benchmarks for passenger rail commuter usage of the Sydney Region rail network, for existing urban residential development at a range of distances from the Sydney CBD, is illustrated by the most recent Year 2006 Census data, by the chart in Figure 7 below.

For a future sustainable transport outcomes for the Sydney region, in terms of energy consumption and a whole range of other social, economic and environmental factors, it is important that the current benchmark level of public transport journey to work usage are at least maintained, if not generally improved, with future urban development.

From the chart in Figure 7, the current benchmark levels can be determined separately for both Urban Consolidation and future Greenfield site developments in the Sydney region, as follows.

- 20% Journey to work travel by rail for new Urban Consolidation type development located between 0-40 kilometres from the Sydney CBD (mid range figure for typical development located 20 kilometres from the Sydney CBD)
- 8% Journey to work travel by rail for new Greenfield type development located between 40-80 kilometres from the Sydney CBD (mid range figure for typical development located 60 kilometres from the Sydney CBD)

Figure 7 : Sydney Region %Rail Usage for Journey To Work Travel, by Distance From The Sydney CBD



Source 2006 Census, ABS, data for 64 Sydney Region Statistical Local Areas (SLAs)

7.2 Future Growth in Journey To Work Rail Travel Demand From New Urban Development

The future projected Sydney Region and Central Coast strategy for new urban growth proposes a total of 770,000 additional dwellings which will generate future morning peak 1 hour rail commuter travel demand as follows

Future Urban Consolidation Component = +539,000 Dwellings

- Future Growth in Journey to Work Trips by Employed Persons = +532,000 per day
- Future Growth in Journey to Work Rail Trips (20%) = 106,400
- Future Proportion Travelling to or Through the Sydney CBD (70%) = 74,500
- Future Proportion Travelling in Actual 1 hour peak (50%) = 37,250

Future Greenfield Site Component = +231,000 Dwellings

- Future Growth in Journey to Work Trips by Employed Persons = +228,000 per day
- Future Growth in Journey to Work Rail Trips (8%) = 18,200
- Future Proportion Travelling to or Through the Sydney CBD (70%) = 12,740
- Future Proportion Travelling in Actual 1 hour peak (50%) = 6,370

The combined future 1 hour morning peak demand for additional rail commuter journeys travelling inbound towards the Sydney CBD, from both these components of the future Metropolitan Growth Strategy, is a total of +43,620 additional city bound peak hour rail passengers. This is a future growth rate of +1,450 city bound peak hour rail passengers per year, over a 30 year period from 2006 to 2036.

However the maximum potential spare capacity of the Sydney Metropolitan Region Rail Network to accommodate this growth, with all the currently identified rail network capacity improvements completed, including the three Heavy Rail Line extensions and the proposed Inner West Light Rail extensions, is a total of only +25,200 additional peak hour city bound rail passengers.

This situation is however mitigated to a certain extent because by mid 2010, we are already 4 years into the future 30 year (+770,000 dwellings) growth strategy from 2006 to 2036, so the projected actual growth in peak hour city bound rail passenger demand from the year 2010 onwards is actually only 86.6% of the overall 30 year target, ie +37,800 trips.

Nevertheless the current Sydney Metropolitan Rail System, with all proposed improvements, is effectively only able to accommodate 67% of peak hour city bound rail passenger growth from the year 2010 onwards, ie 17 years growth from the year 2010 to the year 2027.

The four currently identified projects of the of “Metropolitan Rail Expansion Strategy” will therefore only provide sufficient additional capacity to meet a 17 year future growth strategy and will provide additional peak hour city bound rail passenger capacity to meet projected growth in demand, approximately as follows.

- Existing Spare Rail Network Capacity (7 extra trains) = 3 years growth to 2013
- Inner West Light Rail Extensions, needed by 2013 = 2 years growth to 2015
- South West Rail Link Completion, needed by 2015 = 4 years growth to 2019
- North West Rail Link Completion, needed by 2019 = 4 years growth to 2023
- Western Sydney Express Rail Services, needed by 2023 = 4 years growth to 2027

Under a future Metropolitan Rail Network development strategy such as this, the future timing of each project is potentially interchangeable, but the overall combined 13 year time horizon to the year 2023, for the completion of all projects, is fixed. Beyond the year 2027, at least one other additional, as yet unidentified future rail network expansion project will then be required to permit the continuing growth in metropolitan rail commuter passenger capacity to support the full extent of the proposed +770,000 dwellings urban growth strategy which is proposed in the Year 2036 Sydney Region Metropolitan Strategy.

7.3 Longer Term Potential for Future Rail Network Development

Beyond the year 2036 a more schematic future rail network development strategy for the Sydney Region is very crudely and schematically identified in the Draft Planning Strategy (DoP, 2010) as shown below in Figure 8, but there is no indication as to how any of the potential new rail network extensions, to be considered beyond the year 2036, may actually be identified as “real projects”.

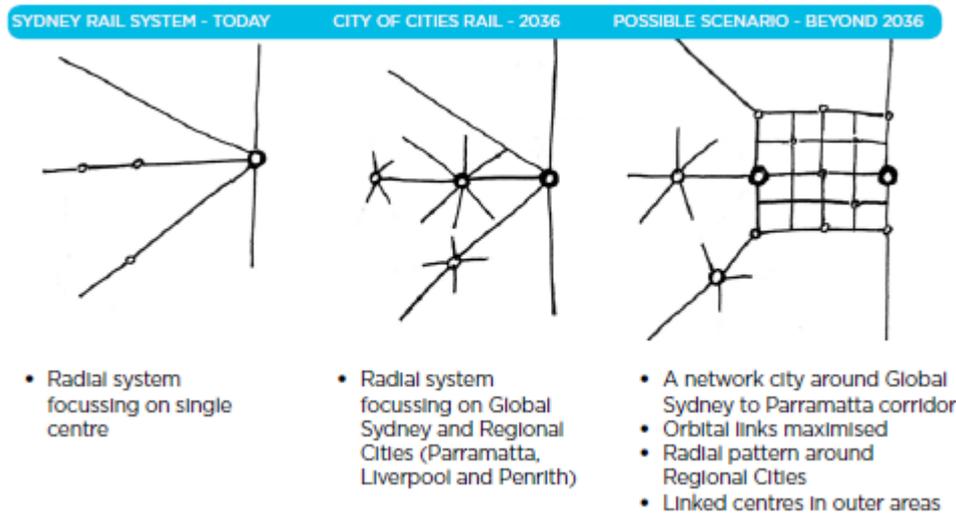
In principle rail projects such as

- An additional North South Heavy Rail Crossing of Sydney Harbour in the vicinity of the Sydney CBD, generally as proposed by the Sydney Morning Herald Long Term Public Transport Plan, (SMH Public Transport Inquiry, 2010)
- The approved but not yet built Parramatta to Epping extension of the Epping to Chatswood Rail line
- A potential extension of the Eastern Suburbs Railway Line via Charing Cross, Randwick, Kingsford, Eastlakes and Mascot to Sydenham
- An potential new underground Hurstville to Strathfield Rail Line

could all potentially meet the requirements for new rail projects under the longer term strategy objectives as outlined in Figure 8.

However, although these rail projects all significantly improve the overall connectivity of the Sydney Region rail network, they do not all actually improve the peak hour rail capacity for journeys to and from the Sydney CBD.

Figure 8: Future Schematic Graphic Illustrating Possible Longer Term Rail Network Extensions



Source: NSW State Government 2010 Draft Metropolitan Transport Plan

7.4 The Implication of Unsustainable New Urban Development

Research on the typical amount of household car travel which has recently been published by Dr Gary Glazebrook of the University of Technology in Sydney shows that the total variation in the amount of car travel per household in the Sydney Region, varies by as much as a factor of four between the typical inner city households (16,000 km per year on average) and households in the outer suburbs (61,000 km per year on average), Figure 9.

In addition to the implied additional fuel consumption, vehicle insurance and maintenance cost liability component of this additional motor vehicle usage, over a four and a half year period, the total amount of additional car travel undertaken by each new outer suburban household also generally corresponds to the current total life expectancy of a typical new motor vehicle (210,000 kms approximately) being consumed by each outer suburban household.

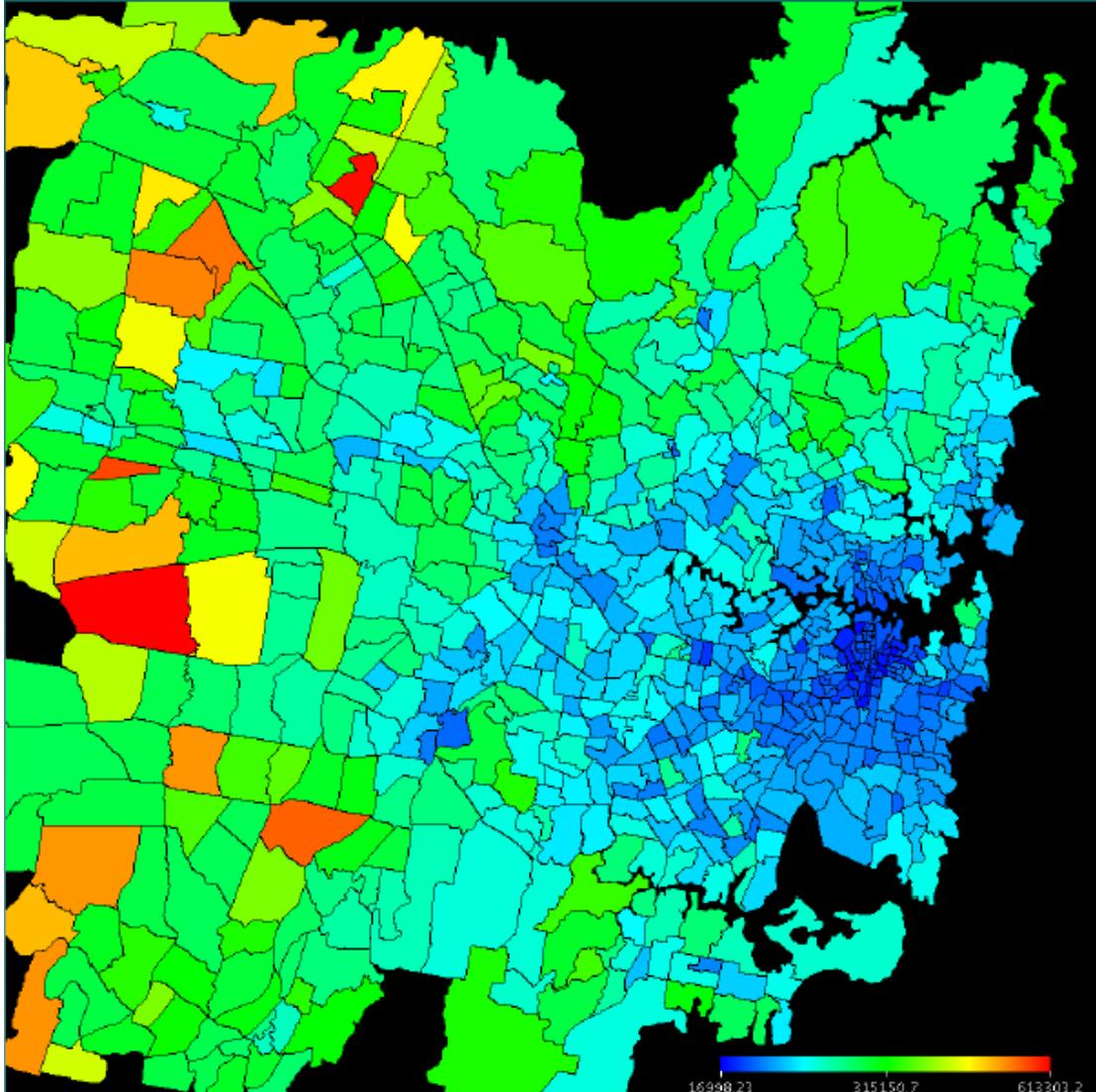
8. Summary and Conclusions

The Sydney Metropolitan Region Rail Network Currently Provides a total of 107 inbound morning peak hour train services to the Sydney CBD. This could potentially increase to 114 train services per hour without any major new rail lines or network improvements. This however represents approximately three years spare capacity, for the calculated future peak hour city bound passenger demand growth rates of the draft Year 2036 Metropolitan Development Strategy (+770,000 dwellings over a 30 year period) to be constructed in Sydney and the adjoining Central Coast Regions.

There are significant doubts about the realistic capacity of the projected future urban consolidation component (70%) of the year 2036 Metropolitan Development Strategy (+539,000 dwellings) being able to be accommodated in areas with reasonably good access to the light rail or heavy rail networks in Sydney. The maximum probable capacity is probably

more like 300,000 additional dwellings being able to be accommodated, primarily through new townhouse and low rise residential development, in the walking distance catchments of typical suburban railway stations, with a lesser proportion of high rise high density type residential development, in the major commercial centre railway station precincts.

Figure 9 : Sydney Region Annual Household Vehicle Kilometres of Car Travel



Source: A Plan for Sydney's Transport by Dr Garry Glazebrook, UTS, October 2008

The projected future Metropolitan Strategy growth increments for both Urban Consolidation (+539,000 dwellings) and Greenfield site residential development (+231,000 dwellings) will together generate an additional demand for morning peak hour travel to the central Sydney CBD area of approximately +37,800 city bound rail passenger trips per hour from the year 2010 onwards.

The future spare capacity of the Heavy Rail Network, with the proposed SWRL, NWRL and WSER project train services, and the Inner West Light Rail Extensions to both Circular Quay and Dulwich Hill, will be approximately +25,200 city bound rail passenger trips per hour. This will only be able to accommodate the additional rail travel demand from projected residential growth for a maximum 17 year future period (to the year 2027) and all these rail projects will need to be completed sequentially before this time, ie by the year 2023 at the latest.

Beyond the year 2027 further new Heavy Rail or Light Rail Projects will need to be formally identified and constructed in order to maintain the regional rail network capacity to service

the future Urban Consolidation and Greenfield development components of the overall Sydney Metropolitan Region urban growth Strategy.

Already some potential projects are evident, eg a new North South rail crossing of Sydney Harbour,(SMH Public Transport Inquiry, 2010) and a potential extension of the Eastern Suburbs Rail Line underground via Randwick and Kingsford, to connect with the Illawarra Rail Line at Sydenham, which is recommended by the Author, but it will be difficult to find other projects which meet the twin longer term objectives of improving connectivity in the rail network, while also providing improved capacity for peak hour rail commuter travel to and from the Sydney CBD.

9. References

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