Mean Streets: residential intensification strategies for roadway corridors

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Abstract

Activity Nodes and Corridors form the spatial backbone of plans for urban intensification in Australian and overseas cities that are predicted to sustain substantial population growth and which have predominantly developed through the reproduction of a diffuse (suburban) pattern of urbanisation. Perth, in Western Australia, is an exemplary case study of such a city - poised on the threshold of rapid population expansion with clear policy directives toward this polycentric model of intensification. The research presented focuses its investigation on busy roadway corridors in Perth which provide excellent public transport connectivity, as distinct components of this blueprint for a more compact future city. These linear strips present as promising sites for residential intensification with the potential to promote economic participation, reduced automobile dependence and the efficient use of existing infrastructure. In addition these sites are often subject to blight with existing dwellings presenting neglected and abandoned frontages.

These physically degraded characteristics which suggest a propensity for redevelopment are however principally the result of the severe environmental conditions in these locations, as ever increasing volumes of vehicular traffic produce noise, air and visual pollution. The concentrations of pollutants in these roadside settings presents challenges in creating quality residential environments which sustain health and wellbeing. Traditional dwellings and development models respond poorly to these conditions, restricting the ability to undertake everyday activities in outdoor and naturally ventilated settings without the risk of exposure to elevated levels of pollutants and the harm and annoyance this can engender.

If residential intensification is to be pursued in these locations and a costly health and social burden to our communities is to be avoided, typologies of attached housing which respond to the specific constraints of this context, that still provide increased density and meet broader quality objectives for the residential environment, need to be developed.

Keywords
residential intensification, urban design, housing, activity corridors, design quality, residential environment

Introduction

Strategic planning in most Australian cities is attempting to assert specific targets for residential intensification to configure more compact city forms. Targets for urban consolidation in the vicinity of 50 to 70% are in evidence in Australian capital cities (Department of Planning and Local Government (SA) 2010; Western Australian Planning Commission 2010; Department of Infrastructure and Planning (QLD) 2009; Department of Planning & Community Development (VIC) 2008).

Perth, in Western Australia, is a city which has predominantly developed through the reproduction of a diffuse (suburban) pattern of urbanisation. Almost 80% of households occupy a standalone dwelling compared to Melbourne with 73% and Sydney with 64% (Australian Bureau of Statistics (ABS) 2006). It is a city whose growing metropolitan area is collapsing previously distinct urban

figure 1: Urbanised Extent Diagrams
source: (Susteren 2007)
and rural territories forming a continuous and yet relatively fragmented low density urban pattern stretching along the south western coastal plain of Australia (figure 1). Perth is predicted to sustain substantial population growth – increasing from 1.7M inhabitants to a city of between 3 and 4M inhabitants by 2050. Perth has prescribed a target of accommodating 47% of the future growth in dwellings within the existing urban footprint (Western Australian Planning Commission 2010).

Away from city centres a substantial role in accommodating this infill development is expected from transport corridors which sustain high levels of public transport accessibility (Transit Corridors or Activity Corridors), particularly in the central and middle sectors of the metropolitan area. Corridors are urban systems which comprise linearly arranged public transport and utilities infrastructure and the urban fabric which is coupled to this.

**Background**

Transit Corridors can be generally categorised as either those which convey a street based public transport system which is integrated with the vehicular carriageway such as tramways and buses, or a separate, dedicated reserve arrangement such as light rail, passenger rail and bus rapid transit. Dedicated reserve systems generally have exclusive rights of way, priority over other transport modes and boardings restricted to purpose built facilities such as stations, whereas road or street based public transit systems are generally characterised by relatively frequent stops, at-grade boardings and priority conflicts with private motor vehicles, cyclists and pedestrians. Each type represents a substantially different issue for residential intensification. One is a point-based model clustering around discrete nodes, whereas the other is a linear diagram adhering to a highly accessible transit conduit.

Diffuse Australian cities such as Perth have expansive networks of street based public transport systems with either existing, or the potential for, excellent accessibility profiles to key regional and sub-regional destinations. This research focuses on these locations, the roadway corridors, as promising sites to accommodate a substantial component of the future residential intensification task (Adams 2009).

**Corridor Typologies**

In Perth street based Transit Corridors convey combustion powered buses. These corridors can be categorised into three distinct types (figure 2) according to their traffic characteristics,
control of access, reserve width, structure of the adjacent urban fabric and movement tasks within their sub-regional sectors.

For example Radburn Ribs are corridors traversing in a perpendicular direction from a principal inter-regional public transport artery such as a commuter rail link in the middle and outer zones of the city. Traffic flows along Ribs are directionally focused toward the interchange with the artery, and relatively free flowing owing to their generous design standards and control of access. Reserves for Ribs are wide relative to other roads in the metropolitan area as the planning envisaged significant buffers, opportunities for capacity improvements and the planting of significant stands of trees and other vegetation.

Ribs act as the primary distributor for adjacent urbanised areas, providing the critical link to the principal interchanges that enable integration with the broader metropolitan movement network. The adjacent land uses are organised into a mosaic of mono-functional (predominantly residential) cells separated by streets often arranged in a curvilinear pattern.
Groups of these cells are typically connected to the Rib in a regular yet dispersed fashion via a secondary arrangement of local distributor roads.

Each Rib is the principal movement conduit of a relatively contained urban system. This entire system exhibits a degree of autonomous functioning providing sites of exchange, production, recreation, education and community facility within a mosaic of residential cells.

The second site type considered is the Arterial Roadway and the third is the Inter-City Roadway. Importantly, all of the routes identified traverse through or, are adjacent to urbanised areas which support substantial residential populations. These communities are arranged in blocks configured by a local street network which provides the requisite infrastructure for vehicular access. These local streets are directed toward more substantial roads that, in increments of functionality, begin to accrete the locally generated traffic as well as providing access through different zones of the city to various destinations and other significant nodes in the broader urban network. This hierarchical structure of the road network in the Perth Metropolitan Area has been formalised through publication of the Functional Road Hierarchy which identifies four incremental tiers of functionality.
The residential environment of the urbanised areas attendant to each of the roadway corridor types is understood fundamentally as a series of neighbourhoods comprised of residential blocks structured and bounded by a local street network (figure 4). Blocks are cohesive units of individual residential parcels with shared boundaries and a road frontage. The agglomerated pattern of blocks affords permeability of movement throughout the neighbourhood and the broader urban mosaic. This aggregation of repetitive components of individually owned, single household occupied and standalone dwelling types into a conjoined block structure creates a highly contiguous and socially resilient formal element (Gandelsonas 1999).

Walkability and Zoning

The availability of walking access to the public transport facility along the roadway corridor, is a fundamental ordering device in intensification arguments. Pedestrian accessibility emphasises the potential for increased use of public transport, which is linked to a host of desirable urban outcomes that underscore the justification for increasing population in these locations.
The terms of the corridor residential intensification argument is framed by the broad impetus to accommodate population within the existing urbanised area, the identification of different types of roadway corridors that exhibit superior public transport frequency and connectivity as potentially excellent locations for this, the formal arrangement of the urbanised areas adjacent to these corridors and the ordering principle of walking proximity to public transport.

Blanket rezoning approaches, based on a singular concept such as walkable proximity, when applied in the context of the formal and social contiguity of existing neighbourhoods, and a relatively democratic planning process are highly problematic. The application of such an absolute principle appears insensitive to the established qualities of the existing neighbourhood structure and threatens massive upheaval of existing social fabric (figure 5).

Transformation Measures

Which parts then, of the existing neighbourhoods within the urban system of roadway corridors, can be transformed to accommodate additional population whilst respecting their social and formal integrity?
Inspection of the various roadway corridor types reveals that many residential buildings fronting or immediately adjacent to the carriageways are of older stock, have been poorly maintained, are subject to repeated short durations of household tenure and generally display various hallmarks of obsolescence (figure 6). The immediate roadside environments are perceived as hostile to pedestrian and non-motorised road users as priority is afforded to the unrestricted motion of motorised vehicles with an emphasis on the preservation of ‘through’ traffic capacity. This effectively erodes its capability to provide a social setting (Sennett 1996). The lack of shade/cover and expanse of paved surface also creates uncomfortable micro-climates. Assessments such as Land:Capital ratio of these flanking properties remain to be undertaken in detail however it is speculated that these would most likely reveal a high potential for redevelopment (Newton et al. 2011).

figure 6: Charles Street, Perth – an Arterial Roadway Corridor

It is proposed that one of the principal determinants of the blight evident in these locales is the impact of exposure to pollutants generated by the proximity of substantial volumes of vehicular traffic. Further the situation appears exacerbated as both traditional dwelling types and typical residential redevelopment models seem to perform poorly in providing residential environments which address these conditions. The typical redevelopment model in Perth is single lot grouped housing with habitable rooms and outdoor living zones chiefly oriented toward the sides of the dwelling (figure 7). Under these configurations there appears little or no barrier between the pollutant source and the receivers.
The chief pollutant types which directly impact on dwellings and their settings in these locations are noise, airborne particulates & gasses, visual and waterborne. Of these noise, air and water pollutant levels can be quantitatively determined with visual pollutants less easily appraised. Water borne pollutants, apart from very local deposition during rain events, are often transported through stormwater collection systems to sites remote from their source. These impacts are therefore more specific to the nature and precise location of their disposal. Noise and air quality are the only pollutant types which can be reliably assessed in a general sense for the residential environments along roadway corridors. Importantly however these pollutant types are two of the most important criteria when considering a contextual assessment of the quality of residential environments and also the likelihood of poor health and wellbeing outcomes (Fornara et al. 2010; Braubach 2007).

Environmental noise has been identified as one of the most significant determinants of a resident’s perception of their overall satisfaction with their residential environment and this general attribute is also an indicator of an increased likelihood of health-related problems in the neighbourhood (Braubach 2007). Noise exposure is recognised generally as a major health problem (Öhrström et al. 2006; enHealth 2004; WHO 1999). In Australia the enHealth Council, which has the responsibility for implementing the National Environmental Health strategy, identifies that ‘there is now sufficient evidence internationally that community noise may pose a general public health risk’ and that the ‘potential public health dimensions of this issue will grow significantly’ (enHealth 2004, pix). Health impacts related to noise exposure
include the cumulative adverse effects of annoyance, stress, disturbed relaxation and sleep. Impaired social and learning environments attributable to noise exposure also lead to the potential for adverse effects on cognitive capabilities.

Motor vehicles are also known sources of a host of airborne pollutants resulting from incomplete combustion, friction wear on elements such as brake pads and substances resulting from leaks, spills and faulty operation. In most instances the presence of air pollution is less immediately apparent than noise as it occurs in the suspension of fine particles in the air or in the movement of gaseous compounds which may be difficult to sense. In general there is mounting epidemiological evidence that exposure to air pollution from transport sources is responsible for the increased likelihood of serious health problems and outcomes such as carcinogenic and mutagenic action, aggravation of disease (asthma and bronchitis), acute toxic systemic effects and increased infant morbidity and mortality. (American Lung Association 2011; Ntziachristos et al. 2007; BITRE2005; Mathuros Ruchirawata and Jantamas Tuntaviroona 2005; Bates et al. 1988). In particular, the potential toxicity of fine and ultrafine particulate matter has gathered importance in this research field (Krewski D and Thurston G 2009; Dockery 2001).

The study proposes that the blight evident along roadway corridors, indicating a propensity for redevelopment, is coupled with elevated exposure levels to noise and air pollution. Exposure to both noise and airborne pollutants from traffic is largely related to proximity and line of sight (Environmental Protection Authority (VIC) 2006; Mathuros Ruchirawata and Jantamas Tuntaviroona 2005). In order to simplify the analytical task noise levels from roadways are used to provide a proxy indicator for air quality in lieu of more complex air quality modelling. Additionally, noise levels can be used to gauge the potential for visual pollution problems as very high noise levels would generally only result from the direct line of sight to substantial volumes of moving vehicles. Noise exposure levels therefore promise to provide a relatively easily measurable first order indicator of critical contextual aspects contributing to the diminished quality and potentially hazardous nature of the residential environment along roadway corridors.

It has been hypothesised that typical housing models are mostly unable to ameliorate noise exposure and may in fact exacerbate its impacts on inhabitants. If this is the case then design policy in these environments is currently ineffective, and the application of a ‘business as usual’ approach to the residential intensification of these sites risks cementing a considerable future public health cost and social burden into the fabric of cities. The absence of housing models that respond more appropriately to this context implies that
much of the housing stock in these compromised locations is or will become potentially suitable for redevelopment.

What therefore is the extent of the ‘elevated exposure levels’ along roadway corridors? How far back from the pollutant source (carriageway) are residential properties impacted to warrant reconfiguration? This is dependent on a number of factors but principally, under this analysis, it pertains to the value of the noise exposure level beyond which typically configured residential environments are deemed to be significantly compromised. There are two terms to this argument – the establishment of a threshold exposure level, and the definition of what exactly is meant by ‘residential environment’.

The Residential Environment

In this inquiry the term residential environment refers to at least the dwelling and its immediate setting – the individually and collectively owned spaces around the place of residence. These are the locations where important behaviours and acquaintances related to the domestic environment are generated, regulated and fostered (MacKay 2004; Birdwell-Pheasant and Lawrence-Zuniga 1999; Rapoport 1982; Turnbull 1978; Gehl 1977; Jacobs 1961). Communal and private acts that sustain notions of personal and collective identity and belonging, allow the development of support networks, teach tolerance and respect and provide security and passive surveillance – what Sorkin (2005) has described as the ‘binding agents of human ecology’. This definition of residential environment extends beyond a simplistic comprehension of the private rooms of the dwelling to include the external activity zones. These are critical domains in mediating social relations and this criticality is emphasised in more concentrated living environments (Gehl 1977) such as those implicated in the residential intensification argument represented here.

For the purposes of this investigation the term residential environment is further qualified in terms of those settings of ‘sustained habitation’ – where exposure to pollutants is likely to be prolonged and therefore significant. This allows the analysis to be specific in identifying those parts of the residential environment that are critical in terms of their exposure conditions. This equates to a definition which comprises at least the following five activity zones:

- sleeping
- living
- work rooms
private outdoor areas
communal pedestrian courts & gardens

Exposure Levels

There are perhaps two approaches to establishing threshold levels of environmental noise exposure. The first is to establish a threshold beyond which the majority of persons are physically disturbed or annoyed. This has been the traditional approach where policy sought to determine a minimum standard by applying maximum tolerable levels. Current Australian standards describe both satisfactory and maximum thresholds for internal areas of residential environments (Standards Australia 2000; World Health Organisation (WHO) 1999; Standards Australia 1989). They also take into account the adjacency of busy roads highlighting the possibility of reduced sensitivity to noise in such locations and propose the following general maximum levels (expressed as an average value over a 24 hour period):

- sleeping areas 40 dB $L_{Aeq}$
- living areas 45 dB $L_{Aeq}$
- work rooms 45 dB $L_{Aeq}$
- outdoor areas 60 dB $L_{Aeq}$
- common areas 55 dB $L_{Aeq}$

The second approach to noise exposure levels is to identify desirable acoustic environments for particular activities based on either amenity or health and wellbeing related objectives. For example in an outdoor living environment what background value of noise allows the majority of speech at a normal volume to be intelligible across a table (1 to 2 metres)? This acoustic objective would inform a steady state value of the order of 45 dBA.

As a recommended setting for a residential environment the two approaches can indicate markedly different values, for example ranging from 45 to 60 dB $L_{Aeq,24hr}$ for external settings. Such a variation represents over a doubling in perceived loudness (Federal Highway Administration 2010). This dramatic variation is principally related to the fact that settings external to the dwelling are generally not considered habitable zones of the residential environment under traditional mitigation analysis techniques. The discussion presented here however has emphasised the critical importance of particular outdoor zones in the effective functioning of residential settings particularly as population density is increased.
For interior dwelling zones however there is general agreement between the noise levels arrived at through both approaches, although values for ideal acoustic environments would always generally be lower than those arrived at using a concept of tolerable values. A confounding factor in establishing, predicting and measuring interior noise levels however is the assumption in the application of policy and standards that windows remain closed.

Research in Sweden as part of the Soundscape Support to Health programme (Öhrström et al. 2006) has identified substantial reductions in the likelihood of the disturbance of daytime activities within homes exposed to high traffic noise levels when there is access to a quiet side of the dwelling (approximately 45 dB $L_{Aeq,24\text{hr}}$). Similarly a significant reduction in the disturbance of outdoor activities such as relaxation was observed for dwellings having access to a quiet side (Öhrström et al. 2006). This study also identified that not being able to keep the windows open while sleeping and relaxing were the most annoying limitations of bedrooms and living areas exposed to high traffic noise levels and that general sleep disturbances also increased significantly in these locations. The threshold for a marked increase in sleep disturbances corresponded to an external sound exposure level in the range 42-46 dB $L_{Aeq,\text{night}}$ and for relaxation 48-52 $L_{Aeq,24\text{hr}}$.

In addition to the annoyance and stress generated from not being able to leave a window open - the ‘windows closed’ assumption - presents two additional problems:

- in the absence of usually complex purpose built systems for multiple dwellings, opening windows is the principal means by which effective ventilation (as required under the building code) is achieved; and
- opportunities for passive cooling and the flow on benefits to household expenditure and reduction in domestic energy use are substantially curtailed.

Therefore in order to promote quality residential environments it is proposed that the assumption of windows permanently closed in a habitable room during prolonged occupation to achieve an appropriate acoustic environment be discarded. It is effectively providing a mechanism by which second tier residential environments are permitted. An alternative objective which is more supportive of amenity, health and wellbeing is to stipulate that one ‘major opening’ must be able to be left open in calculating the noise levels of internal activity zones.

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1 A major opening is a window or door that provides ‘substantial external means of light or view’ and generally exceeds one square metre. (Western Australian Planning Commission 2010)
Based on a review of the different approaches to establishing acoustic settings, the values implicated by these, and any adjustments for the reduced sensitivity of the setting (Shepherd et al. 2010) the following acoustic objectives have been established:

- 45 dB $L_{Aeq,24hr}$ for a minimum of 2/3 of private habitable rooms and all living areas with at least one major opening left open; and
- limiting environmental noise exposure in principal outdoor living areas and 50% of communal pedestrian court areas to a target level of 45 dB $L_{Aeq,24hr}$ with a maximum threshold of 50 dB $L_{Aeq,24hr}$.

To recap - the research is utilising noise exposure as an indicator to determine the extent to which existing residential environments along busy roadway corridors are substantially compromised in terms of amenity and health and wellbeing outcomes. The broad objective is to then utilise this analysis to help configure and prove residential environments in these locations that are supportive of these desirable outcomes.

**Transformation Extents**

Noise modelling has been employed to determine the performance of both existing and proposed residential environments. Values are calculated adjacent to roadways based on the volume and type of vehicles, their speed and the proximity of the receiver to the carriageway edge. It has been hypothesised that existing housing models within the generally elevated sound field around roadways (>45 dB $L_{Aeq,24hr}$) fail to meet the acoustic objectives for a quality residential environment. Modelling of a typical redevelopment typology reveals that this is indeed the case (figure 9a). Only the very rear of the furthermost dwelling provides what would be considered a protected residential environment.

The noise impact penetration of various typical traffic volume ranges of the four regional road types of the Functional Road Hierarchy, within the catchment of the various corridor systems, has been calculated (table 1). Although this analysis suggest a maximum penetration of two lots the traffic volumes along the principal routes in the corridor catchment can reach up to 25-50 000 vehicles per day (vpd). this would equate to a noise penetration distance of between 100 and 200 metres. For typical lot dimensions this could equate to a depth of up to 6 lots.
<table>
<thead>
<tr>
<th>ROAD CLASSIFICATION</th>
<th>TYPICAL TRAFFIC VOLUME RANGE (vpd)</th>
<th>NOISE IMPACT PENETRATION</th>
</tr>
</thead>
<tbody>
<tr>
<td>local distributor</td>
<td>3 000 to 6 000</td>
<td>35m (1 lot)</td>
</tr>
<tr>
<td>district distributor B</td>
<td>6 000 to 8 000</td>
<td>45m (1 lot)</td>
</tr>
<tr>
<td>district distributor A</td>
<td>8 000 to 15 000</td>
<td>60m (2 lots)</td>
</tr>
<tr>
<td>primary</td>
<td>15 000+</td>
<td>&gt;60m (&gt;=2 lots)</td>
</tr>
</tbody>
</table>

Table 1: Alignment of road classification with noise impact penetration

These calculations however assume propagation of an uninterrupted sound field. Although dwellings immediately fronting the source generally exist in this uninterrupted condition buildings behind are subject to the barrier effects of these frontage structures and the exposure conditions of their residential environments may be mitigated. In addition, as indicated, although a ‘quiet’ condition may be desirable a slightly elevated noise regime may be more acceptable for a large majority of persons living in a busy urban setting. This understanding tends to ameliorate the depth of exposure and in some instances only the front one or two lots may be confidently assessed as sufficiently impacted to warrant consideration of redevelopment.

It can be determined with some certainty that for busy primary and district distributor routes the majority of existing residential environments within 100 metres of the carriageway edge, are likely to be exposed to noise levels that indicate potentially inferior, harmful and, possibly pathogenic settings for habitation. For other lower tier classified roads it is likely that only the first lot is compromised. What is generated from the application of this logic is a diagram which illustrates those properties which under the current development paradigm fail to provide residential environments that support amenity, health and wellbeing and are therefore potentially suited to redevelopment (figure 8).
This is a markedly different diagram to the blanket approach of the walkable catchment. The methodology has identified the sites associated with proximity to the public transport facility along the corridor that appear suitably compromised by their urban setting to warrant consideration for intervention. The process recognises that areas of the existing neighbourhood, although situated within the walkable catchment, have no general physical contextual constraints attributable with their position in proximity to busy roadway corridors to justify redevelopment.

**Dwelling Configurations**

The subsequent challenge is to suggest ways of configuring dwellings in these compromised residential environments that better addresses their context. What are the design directives which enforce quality and in particular those that address the critical indicator of noise exposure benchmarked through the acoustic objectives?

A noise exposure analysis of different configurations of dwelling development has been undertaken (figures 9 & 10). What is apparent in the initial block models is that in order to meet the acoustic objectives habitable rooms must have a major opening on a protected quiet side of the building and that side aspects do not achieve this. The analysis confirms the problems of deep footprint traditional row or terrace type housing along the frontage
where rooms along the street and side are unable to meet the acoustic objectives (figure 9b & c). Shallow building footprints, measured perpendicular to the carriageway however allow habitable rooms to be ‘sleeved’ along the protected face preserving their access to a quiet side (figure 9d).

Greater potential for a protected and quality dwelling environment is realised when a larger development site is considered (figures 9c, 9d & 10). This allows the establishment of a longer continuous frontage ‘barrier’ building which in turn creates a greater proportion of the plot situated within an acoustic shadow. Larger development sites such as those acquired through the amalgamation of two or more typical housing lots present other advantages which although not specifically part of the acoustic objectives are worth mentioning. For example the more efficient arrangement of vehicular access affords the contemplation of the provision of consolidated private, communal and public zones. These spaces which are often not provided in single lot development typologies can be linked to a host of desirable outcomes for higher density living environments such as settings for neighbourhood
interaction, significant tree planting, deep soil zones and the establishment of community gardens.

figure 10: Noise Exposure Analysis of Amalgamated Block Types & Building Configurations

When another critical consideration such as desirable solar orientation of dwellings and outdoor living zones is overlayed onto the acoustic objectives further variations in built form are precipitated (figures 10c & d).

Ideally, from the point of view of the acoustic objectives and the implications these have for residential environment quality, the built form model for the redevelopment sites would present a continuous built frontage along the busy roadway (figure 11). This would allow the creation of the largest possible protected zone in the ‘interior’ sites. This then gives the flexibility to configure relatively standard ‘multi-residential’ dwelling types such as row housing within the acoustic shadow (figure 12).

2 The term multi-residential refers to any form of attached housing
figure 11: Schematic Redevelopment Strategy for Neighbourhood Precinct

figure 12: Schematic Redevelopment Strategy for Arterial Block
Conclusion

The creation of consolidated development sites which are implicated by this ideal redevelopment model presents a substantial challenge. The optimal arrangement of a continuous strip building along the frontage of a block along busy roadways would be dependent on strict regulatory control. This would present significant staging challenges particularly with undeveloped neighbouring sites. Nonetheless the benefits of an appropriately configured continuous frontage building in these locations are significant enough to restate – it provides perhaps the greatest assurance that a suitable quality of the residential environment adjacent to roadway corridors, in terms of its key contextual parameters, can be achieved. Even the amalgamation of two typical residential lots into a development parcel provides substantial improvements to the potential to provide quality residential settings adjacent to busy roadways when compared to a typical single lot arrangement. Therefore land assembly and mechanisms through which it is incentivised remains an important ingredient in the progression of the design proposition.

There are other tasks implicated in the subsequent development of the precinct model - for instance the need to develop and model detailed housing typologies which allow the experience of habitation in these settings to be understood and the potential development yields to be calculated. Additionally the research could form a basis for the development of specific design policy overlays on these types of corridor environments to ensure quality objectives are met and to avoid cementing a costly health and social burden through inappropriate development. The work also prompts consideration of the role of these fringing sites in relation to the operation and performance of their adjacent neighbourhoods and the possibility of alternative business models for implementation. These relatively neutral sites could well be some of those initially preferred by local communities in the enactment of recently suggested Neighbourhood Development Corporations (Kelly 2011).

Whilst the research does not solve the problems of implementation it deliberately moves the discussion related to the intensification of corridors beyond strategic planning into the realms of architecture and urban design. It is hoped this is a significant progression, one which enables a more realistic discussion about the benefits, feasibility and desirability of this pattern of urbanisation. The focus on quality, health and wellbeing and its manifestation into the noise exposure modelling is a critical aspect of the methodology derived from the specific context. It utilises one of the fundamentally understood objectives of dwelling (i.e. provision of a healthy environment) to make explicit the rationale for design intervention and therefore give authority to the outcome. This is in contrast to urban transformations based
on principles which may not be widely interpreted as fundamentally authoritative such as walkable access to public transit, or so easily understood such as formal design approaches. Therefore the method, focussing on a goal such as public health which is widely accepted and valued, promises to garner community support for intensification patterns and thereby overcome some of the resistance which curtails its implementation.

The research has highlighted that a different approach to the configuration of the residential environment is likely to be required along busy roadway corridors as traffic volumes have and continue to intensify and also our knowledge concerning aspects of quality, health and wellbeing continues to improve. Traditional standalone models of dwelling and residential development appear markedly unsuitable and an alternative urban planning and design approach is required if road corridor intensification is to remain a component of the future urbanisation pattern of Australian cities.
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