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# Innovations in Topographically Sensitive Urban Design

Evaluating landform conservation strategies in Perth's northern suburbs

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## Introduction: suburban benching

In 1950s' California, the earliest examples of site terracing facilitated the expansion of standardised flatland suburban housing into hilly areas south of San Francisco (Bronson 1968). By the 1970s, large-scale earth works began to emerge in Australian suburban development. In Perth, Western Australia, earthmoving processes derived from the mining industry enabled steep coastal dunes to be remodelled to facilitate suburban sprawl. With Perth's sandy soils offering little resistance to heavy machinery, by the 1990s site preparation had progressed to the comprehensive re-engineering of the natural landform into suburb-scaled systems of levelled building lots retained with limestone block walls (See Kullmann 2014a; 2014b) (figure 1).

Referred to as 'benching' in the local development industry, the practice delivers numerous economic, urban, and infrastructural performance advantages over suburbs developed prior to the 1970s with minimal reshaping of the natural terrain. First, suburban benching facilitates the development of steep sites with the increased lot densities and larger dwellings that characterise the post-WWII

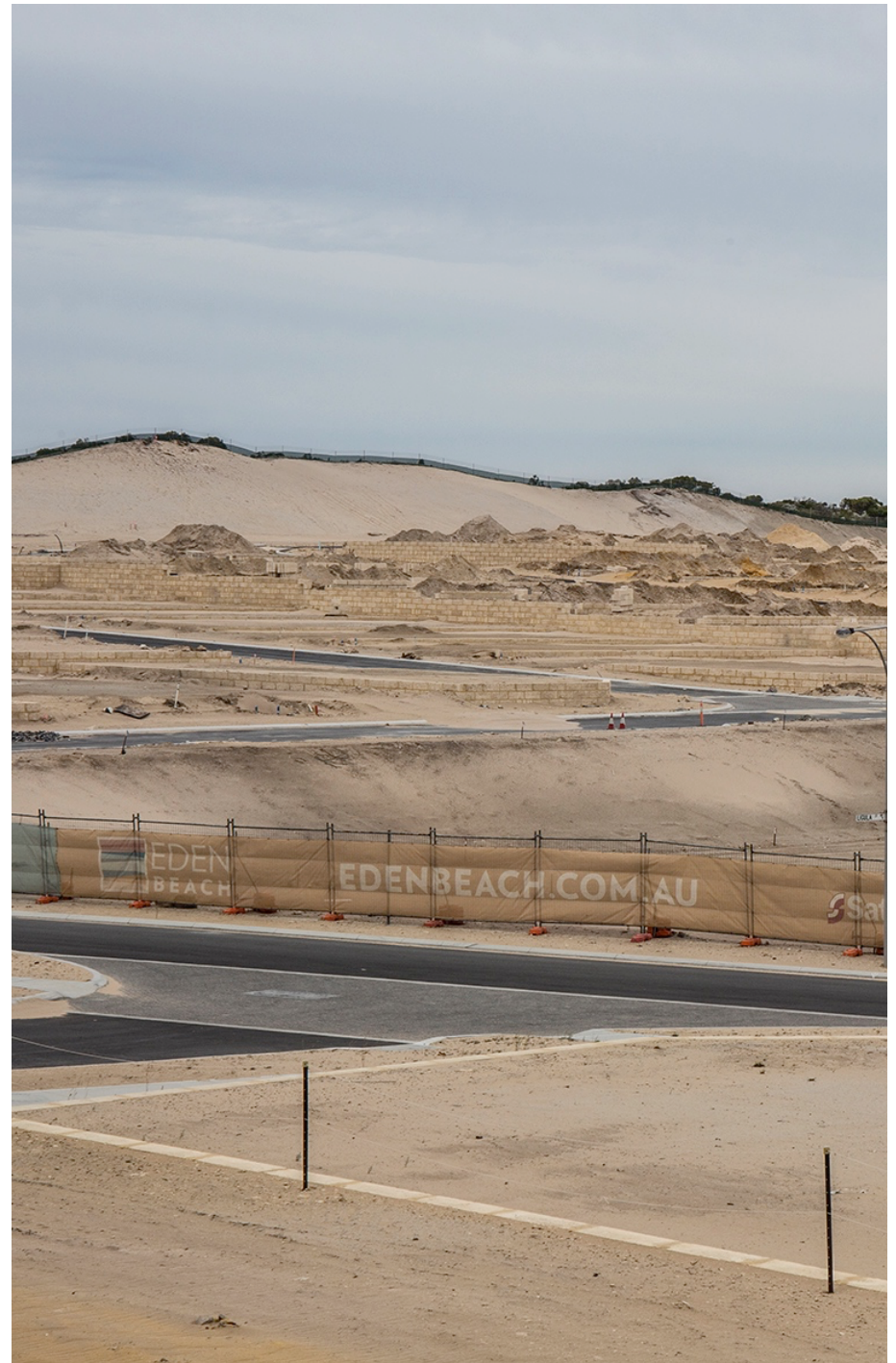


Figure 1. Example of total earthwork engineering for a suburban development in the City of Joondalup (Author 2015).

evolution of Australian suburbanisation. Australia wide, average residential lot sizes progressively decreased from 1020m<sup>2</sup> in the 1930s to 4420m<sup>2</sup> in the 2000s, with rear access 'cottage' lots often below 230m<sup>2</sup> (Kupke et al. 2011). While the trend towards smaller lots partially offsets affordability issues associated with the exponential growth in land values (Hayden 2004), the concurrent increase in average dwelling floor areas, which grew from around 90m<sup>2</sup> in the 1940s to 210m<sup>2</sup> by the mid-2000s, negates this. Accordingly, overall plot-ratios increased from as low as 10% on typical mid century quarter acre (1020m<sup>2</sup>) lots, to 60% and above in the 2000s (Hall 2008).

Second, the comprehensive regrading associated with suburban benching enables more efficient and robust stormwater and sewage infrastructure layouts when compared with the complexity of retrofitting infrastructure into older suburbs set on unmodified terrain. Similarly, comprehensive regrading facilitates desirable urban design outcomes, including legible road layouts, standardised street cross-sectional profile, and accessible grades. From a development perspective, benching increases residential lot yield and potentially maximises valuable views from each lot. Last, the level sites that benching creates enable the use of cost-effective concrete-slab construction methods and standardised model home templates irrespective of local topography. This arrangement has the added advantage of supporting indoor/outdoor continuity and contemporary 'lifestyle' uses of private outdoor space.

The historical relationship between landform modifications, plot ratios, infrastructure, building technology and suburban culture is illustrated through the comparison of three typical house/lot configurations in Perth's suburban development. In the 1940s, large lots, small dwellings and the utilitarian function of back yards left ample space for accommodating natural landform (figure 2a). Typically, dwellings were elevated on limestone foundations or timber stilts that precisely traced the footprint of the house. Additionally, houses were frequently rotated or setback to accommodate challenging landform on the lot. By the 1960s,

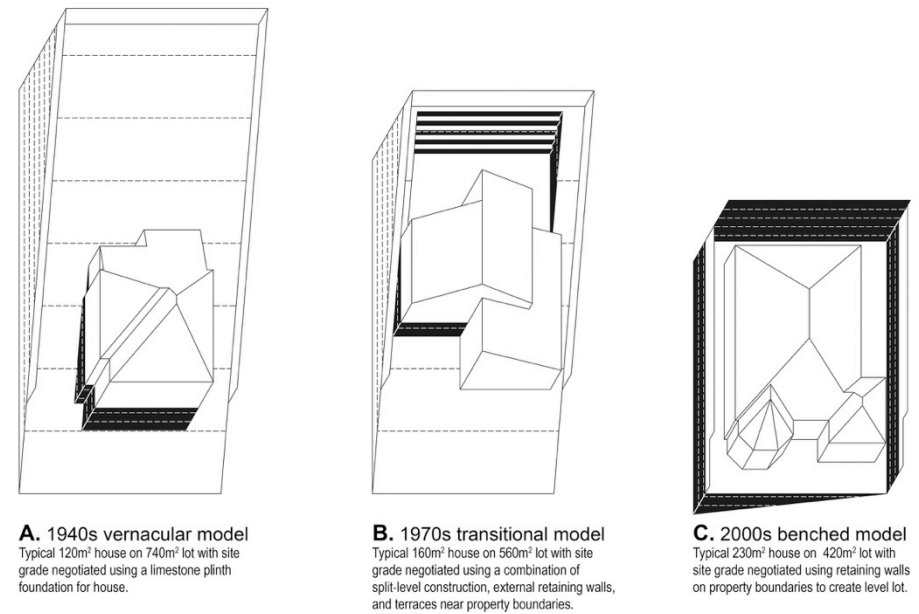


Figure 2. Schematic axonometric diagrams illustrating the lot-scale impacts of (a) vernacular, (b) transitional, and (c) contemporary benching suburban development techniques.

increasing dwelling footprints and decreasing lot sizes necessitated more proactive site-based solutions to the challenges posed by slope (figure 2b). Within the lot, terraced retaining walls commonly facilitated flat outdoor entertaining areas matched to the finished floor level of the house. Split-level floor plates that accommodate changes in site levels within the footprint of the building are also common in dwellings of this era. By the 2000s, plot-ratios surpassed 50%. Consequently, the lot/dwelling relationship inverted from a house set within its lot, to the lot constituted as a narrow setback around the house (figure 2c). Effectively absorbing the function of 1940s' limestone building foundations, retaining walls were displaced out to the property boundaries. In contrast to the piecemeal lot-by-lot landform interventions of earlier decades, the amalgamation of site boundaries with retaining walls compelled an infrastructural-scaled approach to suburban earthworks.



## Negative consequences of benching

Although levelling is a recurrent feature in the history of human settlement (Leatherbarrow 2004) and is expedient and economical for the suburban housing industry, the expansive scale of suburban benching generates negative biophysical and spatial consequences. First, the process of shifting, removing, and adding new sand requires removing all existing vegetation, which eliminates important sources of habitat, biodiversity, and human amenity in the suburban context (Cary and Williams 2000). The upper stratum of organic soil matter, which is often extremely old, provides a snapshot of past environmental conditions that may recur and impact the present. Once disturbed or eliminated, the micro-ecologies within endemic soil-strata cannot be easily repatriated. This in turn has ramifications for many soil-specific criteria, including stability, fertility, and ground water quality (Grose 2010).

Second, large-scale suburban benching substitutes the natural landform of a site with an artificial topographic system. Landform is a core element of overall landscape character, which in turn is a fundamental component of human spatial cognition, orientation and place making (Tuan 1974). Specifically, landform plays a key role in shaping the legibility of the urban environment, whereby “topographic gradients” (slope) are fundamental to directional differentiation (Lynch 1960, 96). While natural hydrologic systems strongly influence the formation of topographical gradients in unmodified terrain, these inherent gradients are often obfuscated in artificially re-engineered landscapes. Additionally, suburban benching potentially impacts the way urban actors physically, psychologically, and creatively interact with their environment. Physical contact with complex and variable environments provides an important catalyst for creative expression, which forms a foundation of place making (Sennett 1998). By rarefying the rough nuances of the natural terrain into flat planes and vertical walls, benching potentially diminishes constructive phenomenological connections between people and landscapes.



Figure 3. Street-front retaining walls illustrating the disjunction between compact rear-access lots and coastal landform at a suburban development in the City of Joondalup (Author 2015).

To address these adverse consequences, local planning policies adopted since the early 2000s sought to improve urban performance while simultaneously minimising the impact of benching (WAPC 2004a; WAPC 2004b; WAPC 2002). However, the two objectives remain incongruent in practice, whereby the local application of urban design principles developed in Europe and the USA actually coincides with the highest retaining walls found in coastal suburban developments (Kullmann 2014a) (figure 3). More recently, nascent examples of topographically responsive planning and design have begun to emerge in new coastal suburban developments. These innovations are generally premised on the reinterpretation of local vernacular techniques and standards that were systematically displaced from development since the 1960s.

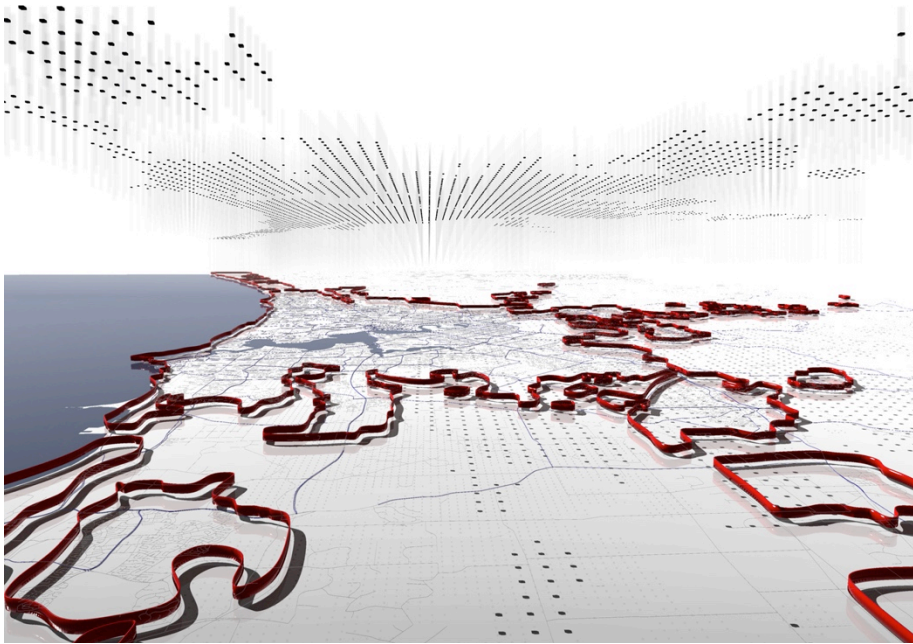


Figure 4. Data visualisation illustrating the challenge of containing Perth's projected 2056 population increase within the existing city footprint (as demarcated by red ribbon). Each hovering data box represents 1,000 infill dwellings (Author 2008).

### Research scope

The article assesses the capacity of recent suburban planning and design innovations to retain and express the topographic character of Perth's northern coastal landscapes. Studying the real-world impacts of planning and design decisions is instructive for future development because the "policy landscape" is only fully actualised in the "real landscape" (Antrop 2013, 19). The research scope is primarily limited to variations on the medium and low-density suburban development that characterises the city's peripheral coastal expansion. To be certain, a substantial corpus of literature identifies both the (environmentally, socially, and economically) unsustainable nature of unrestrained suburbanisation and the fragility of coastal landscapes. For this reason, planning policy and cultural change will ideally slow or halt the coastal suburban expansion of Perth, which since 1970 has

been explicitly endorsed through the Perth Corridor Plan (MRPA 1970) (figure 4).

Nevertheless, despite more recent government mandating of higher densities in new development and transit-oriented densification in older inner-city suburbs (WAPC 2004a; WAPC 2004b), the northern coastal corridor continues to advance at a rate of approximately 1km per year (Author's survey). Prevailing community opposition to coastal densification—and high-rise development in particular—currently limits the effectiveness of these densification strategies (WAPC 2013b). Until such time as this policy and cultural landscape shift, greenfield suburban expansion will remain a planning reality (Gleeson 2006). Therefore, this research takes the position that in parallel to ongoing efforts to improve the effectiveness of urban densification strategies, a need remains for improving current suburban design and planning practices at the site scale. Towards this goal, the research is situated between large-scale planning and conservation mechanisms and lot-scale solutions that address individual situations in isolation from the overall urban structure.

### Literature and models

The specific challenges associated with developing suburbs on steep landform are typically peripheral to the core concerns of international urban design and planning discourse. While the earliest examples of US suburban benching were critiqued as emblematic of environmental wastefulness in industrialised society (See Banham 1971; Bronson 1968; Blake 1964), the practice has more recently been interpreted impassively from the air as type of denatured land art (See Light 2015; Corner and MacLean 1996).

Examination of three key urban models of the twentieth century demonstrates the problematic relationship between urbanism, suburbanism and landform. First, the aspiration of *modern planning* to densify and elevate the city above the ground plane ostensibly allowed the terrain to flow unimpeded beneath and between buildings (Vogt 2000). However, when realised on a large scale in post-war reconstruction in Europe and urban renewal in the USA, decoupling

from the ground inadvertently devalued the landscape. Consequently, the modern pastoral landscape ideal frequently degenerated into placeless environments appropriated by automobiles (Sennett 1990; Jacobs 1961). Second, within *modern landscape planning*, the mapping techniques pioneered by Ian McHarg address these shortcomings by incorporating landform as an important criterion for controlling residential distribution and density at the regional scale (See McHarg 1969). Although these methods have mounted compelling cases for repelling or lowering residential densities in numerous locations in both the USA and Australia, the economic pressures of suburban development often override this reasoning. Third, as illustrated in Andrés Duany's widely adopted Rural-Urban Transect, *traditional urbanism* systematically positions topography as a scenic rural/natural backdrop or as a parkland landmark within the urban zone (See Duany 2002). Although relevant to many inland cities sited on flat river floodplains, this model of urban landform simplifies the multifaceted interaction between topography and suburbanisation in expanding coastal cities (Bosselmann 2011).

In Australian practice, numerous architects continue to pursue the modernist ideal of 'touching the earth lightly' at the lot scale through topographically sensitive architecture (See Paoletta and Quattrone 2008). Nevertheless, despite aspirations to the contrary, these prototypes generally remain as isolated projects for privileged clients on spacious peri-urban lots with limited application to the mass-suburban context. In Australian literature, the multidisciplinary scholar George Seddon provides the most sustained critique of topographic modification in suburban development (Seddon 1979; 1990). Seddon criticises the mass suburbanisation of Perth for extinguishing local character and advises planners to learn from the earliest coastal settlements of Fremantle and Cottesloe (figure 5). Although these examples are relevant, Seddon overlooks the realities of contemporary development that establishes higher suburban densities on steeper topography than either Fremantle or Cottesloe.

## Methods

The research methodology uses case studies to examine and compare the effectiveness of topographically sensitive planning and design innovations under real suburban conditions. Four case-study sites were selected for exhibiting the most extensive—or only—constructed example of a recent innovation in topographically responsive planning. All sites are situated within 1 km of the coast along Perth's northern corridor and reside within the local government jurisdiction of the City of Wanneroo (figure 5). A 400m-diameter circle (five-minute pedestrian-shed) defines the extents of each study area. Analysis draws on cadastre, aerial imagery, original and modified relief data, and eye-level photographs.

Each case-study site is evaluated for the impact of its topographic planning innovation on landform character and surrounding urban design. Landform character is assessed using a subjectivist framework for visual analysis derived from Tveit, Ode and Fry (2006) and Ode, Tveit, and Fry (2008). In contradistinction to typical northern hemisphere temperate regions upon which most landscape assessment rubrics are based, this framework offers a range of criteria adaptable to the particular characteristics of Perth northern coastal environment. Perth's coastal dunes and associated heathland is characterised by: (a) a typically fragmented imageability that does not adhere to imported picturesque landscape traditions; (b) a high degree of vulnerability to anthropomorphic disturbance from a largely natural state; and (c) wide variation in topographic complexity. To apprehend these key characteristics, evaluation emphasises four criteria: (a) *imageability* (contribution of landmarks and other topographic features to a strong visual image); (b) *disturbance* (deviation of topographic elements from the original context); and (c) *complexity* (diversity and richness of topographic element).



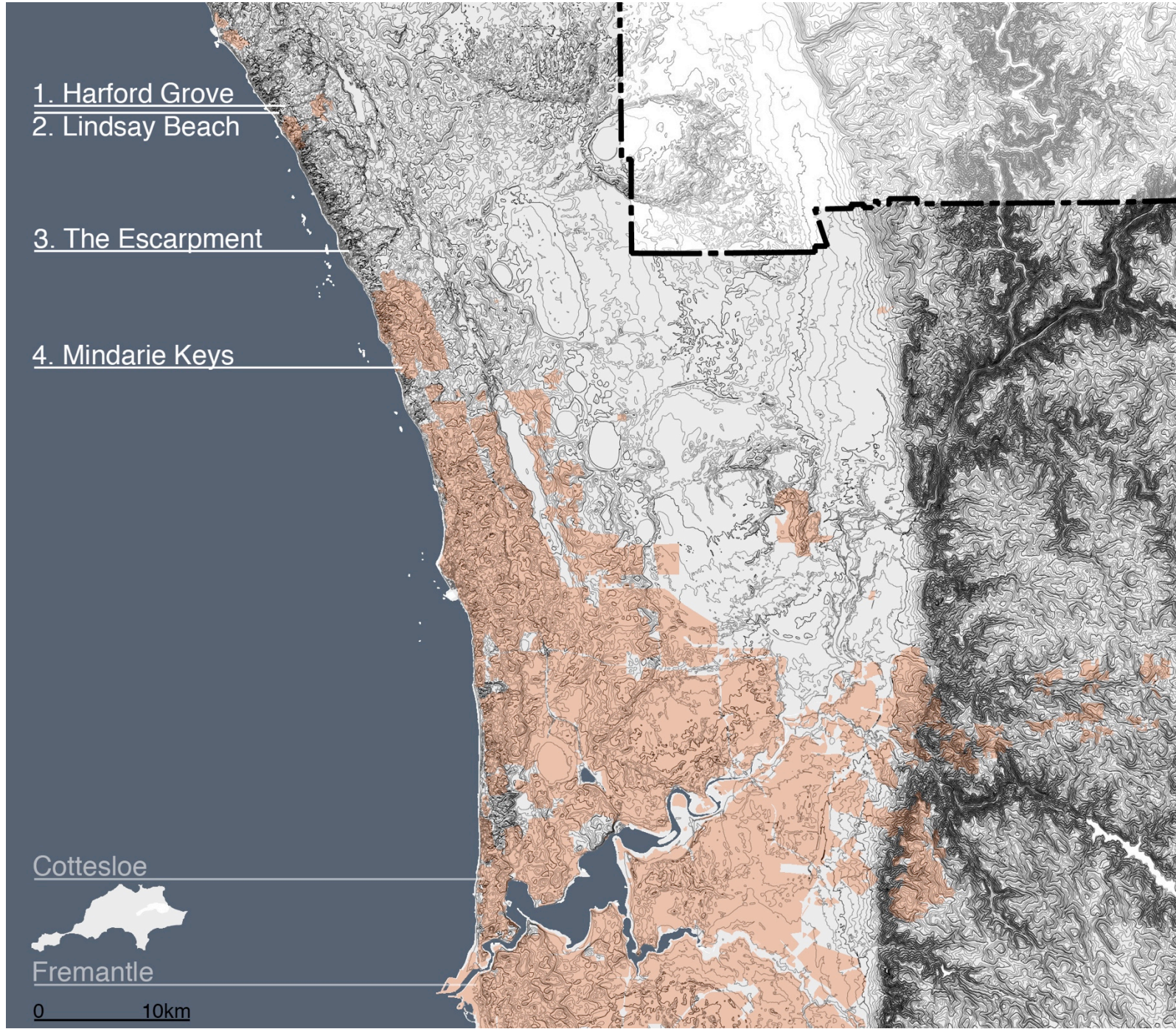


Figure 5. Map of the northern Perth metropolitan area indicating case study locations. Contour interval = 5m (relief data supplied by Landgate, map compiled by Author 2014).



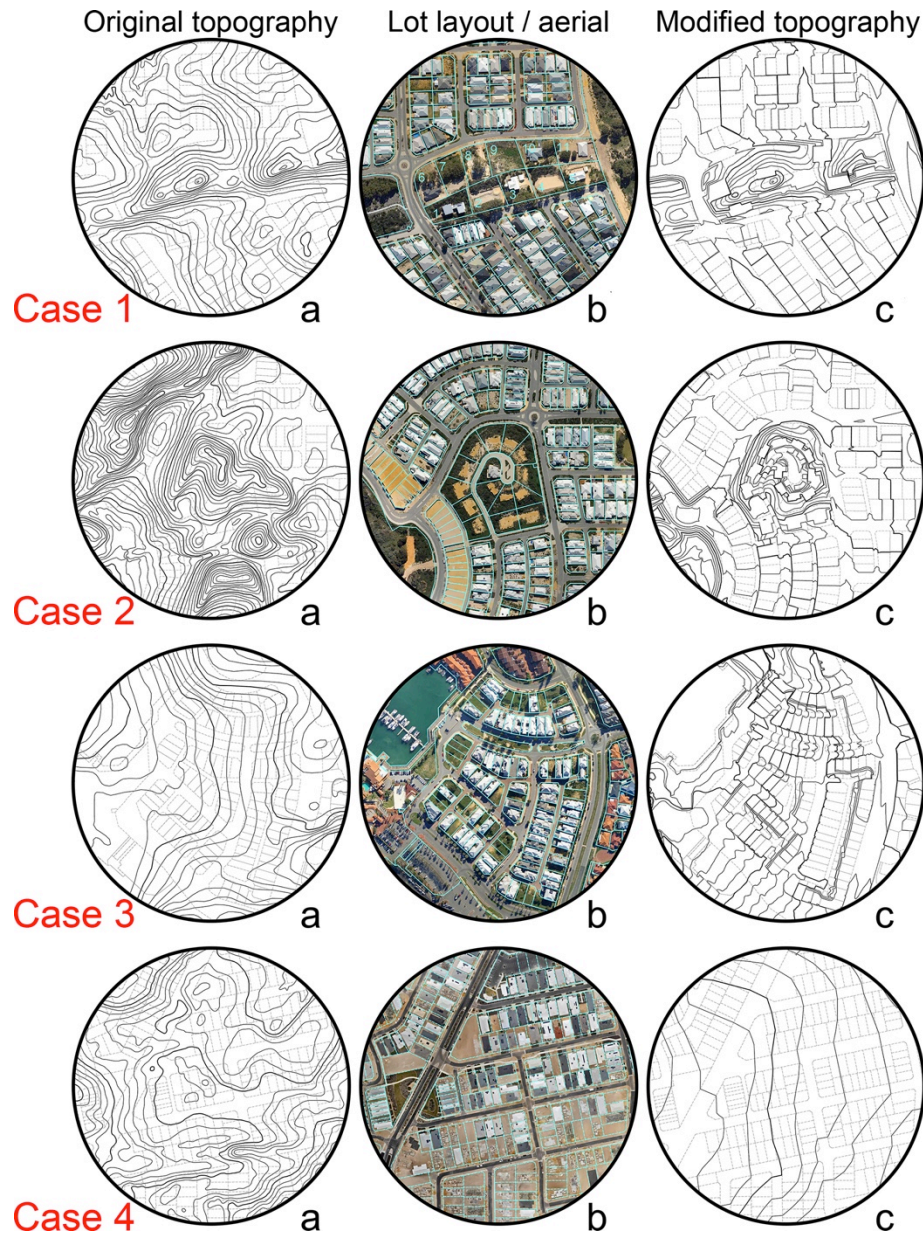


Figure 6. Comparative matrix of all four case studies: 400m diameter study area, depicting (a) pre-development contours, (b) cadastre and post-development aerial photo, and (c) post-development contours. Contour interval = 1m.

## Case studies: site conditions, landform strategies, urban metrics

### Case 1. Hartford Grove, Capricorn Coastal Village

Hartford Grove is one of five precincts that comprise the Capricorn residential development in Yancheep. A low dunal ridge that originally formed part of a larger parabolic blowout system dominates the topographic character of the precinct (figure 6: Case 1.a). The ridge rises at slopes ranging from 15% on the northern side to 35% on the southern side, to a maximum of 10m above the surrounding landscape. As is typical of tertiary dune systems along the Perth coastal plain, the site originally supported stands of Tuart trees (*Eucalyptus gomphocephala*) and understories of Balga (*Xanthorrhoea preissii*) (ATA Environmental 2007).

To achieve the key Structure Plan objective of “greater response to the natural contours and general undulation in landform” (City of Wanneroo 2006, 5), Hartford Grove reintroduces two strategies common in older suburbs. The first strategy retains part of the ridge as a natural public open space (POS) with the landform and native vegetation left mostly intact. The second augments conventional benched medium-density lots with very large ‘bush lots’ sited along the adjacent segment of the ridge. These lots are subject to stringent design guidelines that limit earthworks and clearing of native vegetation (figure 7).

The ridge lots are zoned at 5 dwellings units per hectare (du/ha). The resultant yield of 11 lots averaging 2050m<sup>2</sup> creates lot sizes that are conventionally associated with semi-rural subdivisions (figure 6: Case 1.b). To offset this very low-density area overall, Capricorn contains more areas zoned at 40 and 60 du/ha than the typical density of 30 du/ha found in comparable subdivisions. The resulting high range of housing densities also fulfils the Smart Growth urban design principle of diversifying housing types to accommodate a range of household sizes and needs.

To maximise conservation of the original character of the ridgeline, specific design guidelines govern the 11 lots. Principally, the guidelines establish maximum envelopes for each lot that designate





Figure 7. Case 1 (Hartford Grove): view of retained ridgeline developed with low density 'bush lots' (Author 2015).

the limits of dwellings, ancillary structures, impermeable surfaces, manicured gardens, and associated earthworks. Outside of each envelope, disturbance to the natural landform and vegetation is intended to be limited to essential driveways and firebreaks. To maintain visual permeability, low post-and-wire fencing is required on both street and rear property boundaries. The guidelines also advocate lightweight pole construction techniques to reduce the topographic impact of conventional concrete pad dwellings (Capricorn 2013).

### Case 2. Lindsay Beach, Capricorn Coastal Village

Tertiary dunal ridges frame the topographic character of the Lindsay Beach precinct on three sides, with primary and secondary dunes to the west forming a 300m coastal buffer. Within this frame, a central knoll rises 13m above undulating natural topography at grades ranging from 17% to 35% (figure 6: Case 2.a). As is typical of wind and salt exposed tertiary dunes in the area, the knoll supports open Golden Wattle shrublands (*Acacia saligna*) (ATA Environmental 2007).



Figure 8. Case 2 (Lindsay Beach): view of developed and undeveloped building plinths illustrating retained native vegetation and absence of property fences (Author 2012).

To achieve the Structure Plan objective of topographic conservation while meeting development yield targets (City of Wanneroo 2006), the central knoll is developed with large lots that are subject to extremely prescriptive development conditions that include the provision of building plinths and preclude fences. The 10 du/ha zoning yields 17 'knoll lots' at an average area of 1140m<sup>2</sup>, which is a fraction larger than the traditional post-WWII quarter-acre lot (figure 6: Case 2.b). At nearly double the density of the Hartford Grove bush lots, the knoll lots require less offsetting with higher than typical densities elsewhere in the development.

Highly restrictive development conditions not normally associated with bush lots aim to control the topographic and ecological impact of residential development on the knoll. The most visible of these conditions is the provision of level building pads retained with limestone walls prior to the sale of lots to individual landowners (figure 8). The controlled dimensions of these envelopes are

reminiscent of a building style common until the 1960s, whereby brick houses with suspended timber floors were set above the natural landform on limestone plinths. In addition, garage pads on several lots are set at different levels from the dwelling pads, with boardwalks linking the two levels. This innovation revives a feature common in older suburbs, whereby garages were more likely to match the street or lot levels than the finished floor level of the dwelling.

The design guidelines stipulate that the unbuilt portion of each lot remain as native vegetation. Moreover, the developers of Capricorn intend to revegetate all areas on the private lots that are disturbed during construction. To ensure the integrity and continuity of the native vegetation across the 17 lots, boundary fences are prohibited. Instead, the knoll lots rely on the density of the repatriated coastal heath and the elevation of the building plinths to provide privacy and separation (Capricorn Yanchep 2010).

### Case 3. Harbourside Village, Mindarie Keys

Mindarie Keys was originally developed in the late 1980s as a marina carved into the limestone coastline. Prior to excavation, the study site was situated on the westward side of large sand ridge that rose to a maximum of 20m above sea level at relatively gentle grades ranging from 5–10% (figure 6: Case 3.a). Typical vegetation for the area ranged from Coastal Sword-sedgeland (*Lepidosperma gladiatum*) in the primary swale to Golden Wattle shrublands (*Acacia saligna*) on the exposed hillside. Although the shape of the inlet was loosely based on a large swale near sea level, vast quantities of sand were excavated to create developable slopes between the marina and the sand hills to the east. Where conventional development techniques are used to accommodate this level change, Harbourside Village exhibits some of the tallest front boundary retaining walls in Perth. Several blocks deviate from this practice through the innovative use of rear-access split-level lots.

The split-level lots are zoned at 30 du/ha, which yields 51 lots averaging 370m<sup>2</sup> (figure 6: Case 3.b). Each lot spans a 3m level



Figure 9. Case 3 (Harbourside Village): view of vacant split-level lot with developed split-level dwellings on either side (Author 2015).

variation between the street front and rear right of way (laneway), which equates to one full storey (including the thickness of the structural slab for the second floor). Forty-seven of the lots are graded so that the right of way and rear garages are set one storey below the street level, while the remaining 4 lots invert this relationship. All constructed dwellings are two storeys high, extending to a maximum of three storeys at the rear where the house extends over the garage.

The state Residential Design Codes (WAPC 2013a) primarily govern the layout and dwelling design of individual split-lots, which deem the levels that bulk earthworks establish during subdivision development to be the natural ground level. Once this new ground level is established, the codes restrict significant deviations on individual lots by limiting front boundary retaining wall heights to 0.5m. This provision—in addition to the need to match garage levels to the right-of-way—ensures that the 3m site-level change is accommodated within each dwelling and not at the property boundary (figure 9).



#### Case 4. Escarpment, Alkimos Beach

Escarpment is the first land-release in the South Alkimos district. Undulating dunes that rise and fall between 5m and 15m at grades of 5–10% characterize the original topographic character of the eastern part of the study area. To the south and west, the site encroaches on tertiary dune formations up to 10m high at slopes of 35% (figure 6: Case 4.a). Prior to residential development, the undulating areas of the site were used for livestock grazing, with stands of remnant Balga (*Xanthorrhoea preissii*) punctuating cleared grasslands. The Structure Plan prioritises “reading, understanding and responding to topography and dune systems” to create a strongly grounded sense of place (Darby 2012, 34). To achieve this objective, Escarpment reintroduces 1970s-era site works, whereby the natural landform is cleared of vegetation and smoothed but is not benched (See Kullmann 2014a). Each house is set on a slab of sufficient thickness to accommodate the subtle slopes that remain on individual lots.

The case-study area is generally zoned at 25, 30 and 40 du/ha with some rear-access lots zoned at 60 du/ha. On the ground, this yields 190 single dwelling lots, with front-access lot sizes ranging from 240 to 600m<sup>2</sup> and rear-access lots of 200m<sup>2</sup> (figure 6: Case 4.b). In addition, 5m frontages determine the sizes of nine unzoned rear-access lots, which result in lot sizes of 135m<sup>2</sup>. These small park-frontage lots are significant as the smallest green-titled properties in the northern suburbs and support the Smart Growth principle of diversified housing types that accommodate a range of household sizes and needs.

The Alkimos Beach design guidelines state that spreading the general slope of the landform across many lots establishes a balance between “a traditional coastal village set on the dunes” whilst ensuring that the lots can be economically built on. Dwellings are therefore required to protect what is termed the “natural finished slope” by appearing to sit on the slope rather than be cut into it (Alkimos Beach 2013b, 13). To enforce this objective, dwellings must be set to the pre-established floor level for each lot, and use a firm base or lightweight structure to minimise landform modification (figure 10).



Figure 10. Case 4 (Escarpment): view of dwelling with thickened slab to accommodate site grades (Author 2015).

#### Analysis: topographic assessment criteria

##### Imageability: contribution of landmarks to strong visual image

Distant visual perception of landform is biased towards elevated formations and tends to amplify the impact of steep slopes silhouetted against the sky (O'Shea and Ross 2007). Accordingly, the retained knoll of Case 2 (Lindsay Beach) is first perceived visually from a distance as a highly imageable landmark that is distinct from the surrounding benched landscape (figure 11). Less distinctive, the retained ridge of Case 1 (Hartford Grove) is imaged at the terminus of streets aligned perpendicular to the topographic feature. A line of retained Tuart trees along the front property boundaries also amplifies visual impact of the ridge (figure 12). In both cases, despite occupying relatively small surface areas, the elevated morphologies of the retained knoll and ridge are amplified and disproportionately influential over landform imageability within the precinct. Moreover, in both cases, the higher-than-normal densities that are required elsewhere to offset the ridge lots do not appear to have a more



Figure 11. Case 2 (Lindsay Beach): view of the knoll as a landmark from western approach street (Author 2015).

significant impact on landform imageability than conventional suburban densities.

Although split-level lots improve public-private permeability, topographic imageability of Case 3 (Harbourside Village) is actually obscured due to high site coverage ratios and zero setback walls. With each lot mostly built out, landform is only perceived at close range on staircases within private lots, and on sloping side streets within the public realm. The underlying landform image of Case 4 (Escarpment) is conveyed at the lot scale through the thickened plinths that support each dwelling and the flowing lines of the 1.8m high boundary fences between lots. However, although apparently vivid, this landform image results from the total substitution of the natural terrain with a non-derivative artificial topographic system.

**Disturbance: deviation of topographic elements from original context**

Comparison of the original and modified contours of Case 2 (Lindsay Beach) indicates that the lower and middle slopes remain relatively



Figure 12. Case 1 (Hartford Grove): view of the ridgeline from perpendicular side street (Author 2015).

intact with very little disturbance outside of the road works and building plinths (figure 6: Case 2.a and 2.c). However, the contour signatures also indicate significant disturbance at the summit of the knoll, where the top 2m of the dune has been levelled off to accommodate the access road turn-around and car parking. The more bimodal landform disturbance of Case 1 (Hartford Grove) is heavily contingent on dwelling construction methods. Lots using pole framed single-level dwellings generally exhibit minimal topographic disturbance (lots 2, 3, 5), although additional site levelling and clearing negate these benefits in at least one instance (lot 5) (figure 6: Case 1.b). Lots reverting to conventional concrete slab construction exhibit more significant degrees of topographic disturbance. In the most severe examples, lots are mostly de-vegetated and excavated to create a level building pad larger than the slab (lots 6, 11) (figure 13). Lots with level building pads retained with limestone walls (located at the maximum extents of the allowable building envelope) exhibit less extensive disturbance (lots 8, 10).





Figure 13. Case 1 (Hartford Grove): view of topographic disturbance caused by cut and fill for concrete slab construction (Author 2013).

Given their highly modified landforms, topographic disturbance for the remaining case studies is more difficult to evaluate. Although incorporating topographic variation into the development, comparison of the original and modified contours of Case 4 (Escarpment) demonstrates a highly disturbed landform (figure 6: Case 4.a and 4.c). At several locations, the developed levels deviate 8m from the level of the original sand dunes. The scale of disturbance is vividly expressed in the dissected dunes that temporarily remain at the edges of the case study area but will be eliminated in future development phases (figure 14). In Case 3 (Harbourside Village), the topography of the whole village was extensively disturbed prior to subdivision to accommodate the excavated marina, with some areas excavated as far as 10m below the natural contour. Within the development, the very high degree of topographic disturbance is camouflaged by built up urban form and heavily reshaped POSs (figure 6: Case 3.a and 3.c).



Figure 14. Case 4 (Escarpment): view across subdivision illustrating smoothed landform and dissected sand dunes in background (Author 2015).

#### **Complexity: diversity and richness of topographic element**

Although clearly visible in the aerial photograph of Case 1 (Hartford Grove), variation in landform complexity between the north and south sides of the ridge is not as apparent in the comparison of contour signatures from before and after development (figure 6: Case 1.a, 1.b and 1.c). This indicates that in addition to the disturbance of earth from its natural state, other characteristics of the landscape also impact topographic complexity. The most variable feature on the ridgeline is the extent of residual natural vegetation. Remnant vegetation enhances the sense of landform complexity, even where up to 50% of a lot is disturbed to accommodate a dwelling and associated facilities. In Case 2 (Lindsay Beach), the relatively intact cloak of native vegetation on the knoll contributes a high degree of complexity to the relatively simple underlying landform morphology. Importantly, the building plinths appear to be set within this contiguous landscape, as opposed to the natural topography appearing as fragments amongst a mostly constructed scene.

In the heavily modified topography of Case 3 (Harbourside Village), perception of landform complexity is significantly diminished in the development, with slope variation incorporated within dwellings that are built out to the lot boundaries. In this highly architectural environment, the short steep side lanes that mediate 3m level variations between street fronts and rear lanes are the only significant registries of topographic variation. In the totally transformed topography of Case 4 (Escarpment), landform complexity is eliminated altogether. Whereas the natural landform undulates in a complex manner between knolls and depressions at grades of 5–10%, the modified landform falls to the west at relatively consistent grades of 1–3%.

### **Comparison against the status quo**

The four case studies apply three distinct historically derived approaches to conserving landform in current suburban development on coastal sand dunes. Cases 1 and 2 both demonstrate the targeted use of below average densities on prominent topographical features, which are offset elsewhere in the development with conventional benched lots of above average densities. Whereas Case 1 (Hartford Grove) applies densities equal to some semi-rural lots, Case 2 (Lindsay Beach) exerts tightly restricted guidelines to enable lots that approximate the traditional suburban quarter acre. Case 3 (Harbourside Village) exhibits the strategic use of split-level lots that absorb level changes within individual lots rather than as walls at the boundary. Case 4 (Escarpment) demonstrates undulating lots that result from site works undertaken without the use of retaining walls.

The effectiveness with which each innovation conveys landform character is tied to the specific topographic conditions of each case study site. The strategy of locating low density on high points suits the prominent landform features of both the Case 1 and 2 sites. The numerous steep linear ridgelines that dune blowouts create characterise this morphology, which is common at the northern extents of the Perth coastal corridor. The strategy of splitting lot levels suits the Case 3 site, where the need to reconcile disparate levels within a relatively compact area results in grades that are too steep for

conventional development practices. This situation is likely to be repeated in the development of new marinas and other urban nodes that are planned for Perth's northern coast. The strategy of smoothing out smaller topographical features suits the gently undulating setting of Case 4. This landscape type commonly occurs in between the dune ridge systems of the northern corridor.

Due to the unique topographic circumstances of each site, it is instructive to evaluate the alternative future of each case study if developed using conventional practices. Using this criterion, the topographic features of Cases 1 and 2 would either be graded level and eliminated, or remain as benched formations capped at 4m high once access and retaining wall engineering is factored in. From this assessment, the retained legibility of the topographic features in the as-constructed version conveys improved landform character over conventional practices. Developing Case 3 without the use of split-level lots would result in extremely high street-front retaining walls. In this regard, the as-constructed version significantly improves urban permeability, while landform character is more subtly expressed on side streets. Of the studies, the land smoothing of Case 4 presents the least equivocal evidence for improved landform character over conventional development practices. Although benching would also extensively disturb the natural landform, evidence in other northern coastal suburbs suggests that retaining walls may actually conserve more of the general morphology of the natural terrain than unrestricted smoothing of the entire development site.

### **Evaluation: effectiveness of topographic conservation strategies**

#### **Strategy 1. Conserved ridge with large bush lots (Hartford Grove)**

Lot 1 most fully expresses the intent of the guidelines governing the topographically sensitive development of the ridge, with the dwelling split into two multi-storey pavilions set on different levels, and native vegetation repatriated right up to the edge of the building. However, elsewhere in the development, the design guidelines are followed and enforced less stringently. Disregarded guidelines include using lightweight construction techniques, and limiting clearing, manicured



gardens, impermeable surfaces, and ancillary structures to within the building envelope.

That the topographic character of the ridge is already susceptible to the actions of individual landowners calls into question the robustness of this strategy over a longer timeframe. Incremental changes to a residential property are an integral part of home ownership, and while local governments do pursue major building code breaches, they are less likely to follow up on small-scale breaches of the developers' detailed design guidelines. Consequently, the capacity for the ridge to continue to function as a designated wildlife corridor is likely to be eroded over time. Nonetheless, even with incremental changes in defiance or ignorance of the design guidelines, the topography at the property boundaries will remain at their natural contours. For this reason (assuming no lot amalgamation or coordinated levelling between adjacent properties), the overall silhouette of the ridge within the suburb is likely to remain intact.

Although ridge-top bush lots prevent the ridge being eliminated through benching, this strategy does effectively privatise a prime landscape type. This results in direct experience of landform being limited to a small percentage of privileged residents, while the majority interact only indirectly with the conserved ridge when traveling along the arterial roads that bisect it. The inclusion of path easements between bush lots that link into the existing paths along adjacent POS would provide all residents with the opportunity to traverse and experience of the ridge, whilst negligibly impacting lot sizes.

### **Strategy 2. Conserved hill with limestone house plinths (Lindsay Beach)**

Since being released in the late 2000s, the very slow uptake of housing construction on the Lindsay Beach knoll lots is instructive. The extremely prescriptive design guidelines that aim for dwellings that "sit lightly in the landscape" (Capricorn Yanchep 2010, 4) necessitate the interpretation of an architect or building designer and challenge conventional building site practices. In addition, the spatially limiting

building pads, and caveats that restrict some dwellings to a single storey, curtail the suburban culture of future dwelling expansion. That some of these provisions are already being tested in local government development applications attests to the novelty of the knoll's development model (City of Wanneroo 2011).

As per Hartford Grove, there is no guarantee that the landscape-focussed guidelines for the knoll will be adhered to or enforced. Individual landowners will inevitably seek to 'improve' their lot by establishing exotic planting, fenced-off play areas and ancillary structures. To be certain, whereas some of the Hartford Grove bush lots are hidden from public view, it is possible that the visual exposure of the knoll and absence of fences will make it more difficult for landowners to incrementally erode the provisions of the design guidelines. Moreover, the limestone plinths create a distinct separation between building floor levels and the surrounding landscape. This separation has been evaluated elsewhere as the best method for reducing the degradation that results from human land use activities creeping into remnant vegetation (Studio LFA 2013). Nonetheless, once the Capricorn development corporation is disbanded, the local government is likely to be less proactive at revegetating areas of private lots that are disturbed during building construction. Given that the privacy and security of the knoll lots are contingent on dense native shrubland, its degradation risks provoking a feedback-loop of fence building and additional clearing.

### **Strategy 3. Terraced hillside with small split-level lots (Harbourside Village)**

At Harbourside Village, split-level lots were planned more as a site engineering necessity than as a mechanism for accommodating landform. The use of split-level lots enables the rear-access street layout to be calibrated to steeper slope grades than conventional practices permit. Whereas the level difference between parallel streets in conventional flat rear-access lots is limited in practice to approximately 3m, frontage street levels can be set 6m apart under the split lot arrangement. By locating site-level differences within each lot, the front and rear boundaries interface at grade with the street

and laneway respectively. Had the site been developed conventionally, building orientations would be reversed, with 3m high retaining walls at the street frontage, and rear lane garages set at-grade. As is evident elsewhere in Mindarie, even 2m high frontage retaining walls create blind frontages that result in poor visual permeability and necessitate rarely used staircases for street access.

Historically, split-level dwellings occurred incrementally through the addition and incorporation of ancillary structures over time. To save on costly earthworks and modifications to existing rooflines, home extensions tended to step up or down with the lay of the land. Intentionally designed split-level houses became popular in the 1970s, although the step-down tended to be used more to designate lifestyle zones within the house than in response to site levels. By extending the split to full storeys on lots developed at very high coverage ratios, Harbourside Village deviates from historic suburban examples. By effectively architecturalising each entire lot, the practice necessitates a high degree of precision and integration between site engineering and building design and construction.

#### **Strategy 4. Topographic smoothing with thick house slabs (Escarpment)**

The marketing strategy for Escarpment focuses specifically on topographically responsive design to differentiate the character of the development from other subdivisions. Lots that are free of limestone retaining walls are promoted as enabling “homes to be built on the natural contours of the land,” creating “a coastal community more like Cottesloe” whilst protecting “landform that’s over 10,000 years old” (Alkimos Beach 2013a, 4). Although appealing in theory, it is difficult to reconcile claims of landform protection and comparisons with Cottesloe with the constructed reality. Instead, smoothing out the dunes substitutes the natural landform with a pastoral fabrication of naturalness that is more palatable to the lifestyle brand that the developers seek to convey.

Consequently, the smoothing development model extensively transformed the landform of the Escarpment, despite the suburb exhibiting the gentlest topography of the four case studies. If this

model were extended to the steeper dunal topography that predominates in future development zones along the northern corridor, the disturbance is likely to equal or surpass the impacts of conventional benching practices. Indeed, the narrative behind smoothing may be used to justify completely levelling entire suburban sites, rather than just individual lots. Recalibrating the method to accommodate steeper undulations requires accepting more complex site works and taller building plinths that are likely to compromise the functionality of private outdoor space. However, spare engineering capacity for facilitating steeper undulations exists in the form of steeper street grades. Roads at the Escarpment do not exceed 4%, despite the provision in the Structure Plan for roads to be graded up to the accepted engineering standard of 10%.

#### **Discussion: impediments to innovation**

Although innovations in lot layout, lot diversity, design guidelines and dwelling design and construction are evident in the case studies, established engineering standards, societal values and planning policies continue to limit topographic conservation.

#### **Engineering**

In all four cases, civil engineering standards remain largely unchanged from conventional benched developments. For example, most street grades—which are tied to traffic speeds and impacted by sewage and storm-water standards—remain bound to the current 10% limit. While most streets in the case study areas fall well under this limit, the access road to the knoll (Case 1) is the one exception. Here, an average grade of 12.5% minimises the topographic impact of the access road while appearing to have no impact on road functionality or infrastructure performance. Moreover, precedents for far steeper road grades are located in older suburbs with demonstrated topographic character. The 1960s coastal suburb of Quinns Rocks includes numerous 16% road grades, while the 1940s grids of Scarborough and North Beach include 20% and 25% grades respectively. Recalibrating road standards to permit steeper road grades and slower, tighter road curves will enable suburban street networks to respond more closely to natural variations in topography.



## Value systems

Early in Perth's development the coast was considered a harsh and difficult environment to access, with little value placed on elevated building sites and ocean views. With the post-WWII reorientation of the city towards car-based coastal suburbanisation, elevated lots, and the views that they offer became desirable. Facilitating ocean views is now a highly influential factor in suburb layout design and site engineering, with benching often constructed in a grandstand formation to maximize premium lots with views.

While avoiding this highly modified arrangement, all case studies perpetuate the relationship between topographic features and exclusivity. Cases 1 and 2 most overtly propagate economic hierarchy, with the large knoll and ridge-top lots worth more than double adjacent conventional lots. Although not as apparent, Case 3 also places an economic premium on split-level lots through increased construction costs. Similarly, marketing material for Case 4 distinguishes between "flat, almost flat, sloping and steep lots," noting that there is a "lot for every home and budget" (Alkimos Beach 2013a, 4). This implies a landform-based economic hierarchy, whereby steep lots are the most expensive to purchase and develop. Ensuring direct community access to topographic character cannot be left to market forces and may require alternative housing types and more extensive and varied provision of POS.

## Policy

Planning policies of the past decade have demonstrated intent to improve the conservation and expression of topographic character in Perth suburban development (WAPC 2004a; WAPC 2004b; WAPC 2002). Nevertheless, several embedded policy elements continue to restrict topographically responsive design innovation. The first relates to the *Residential Design Codes* (WAPC 2013a), which control residential development in Western Australia. While the codes effectively limit landform modification on individual lot developments in established residential areas, these provisions do not control bulk earthworks in new subdivisions. In new development, the levels created through bulk earthworks are deemed the "natural ground

level," even where this ground is entirely constituted with artificial terraces (WAPC 2013a, 55).

The second restrictive policy is the provision of POS, which remains set at 10% of the development area, despite considerable changes to suburban environments and lifestyles over the past half-century (Grose 2007). Moreover, POS has traditionally taken the form of large sports fields, even though just 5% of the population currently play the sports for which they are designed (Giles-Corti et al. 2005). The additional need to accommodate stormwater infiltration has resulted in parks being generally sited in low-lying areas, leaving little space for capturing elevated topographic features with the public realm. Third, retained topographic character remains difficult to objectively assess with current planning mechanisms. While the Smart Grown Assessment Tool that has been adopted local government does include natural landform conservation as a criterion, other more development-focussed urban performance criteria can be used to offset the overall score (City of Wanneroo 2005).

## Conclusion: site-specific sub/urbanism

The topographic conservation strategies for each of the four case studies attempt to adapt historic suburban practices to current development standards. Overall, these strategies encompass (a) density offsets tied to topographic features, (b) modification of conventional benching by placing retaining walls within lots, and (c) thickened dwelling slabs to accommodate smoothed topography within lots. Each topographic conservation strategy is targeted to the particular dunal topographic features of that site, which range across the case studies from (a) ridgelines and knolls, (b) artificial steep slopes, and (c) undulating landforms. This integral relationship between strategies and site conditions limits the cross-comparison and transferability of strategies between case studies. Rather, when analysed internally, each innovation demonstrates moderately improved expression of topographic character in comparison with conventional development practices on the same site. The one exception is the suburb-wide smoothing strategy of Case 4, which demonstrates both the vulnerability of sand-dune systems to

extensive regrading and the potential for topographic character to be caricaturized and subverted for lifestyle marketing.

Given that plot ratios doubled in the quarter century since benching was introduced to suburban development, adapting old practices presents significant planning challenges. For this reason, except for Case 4, the topographic strategies evident in the case studies remain contained to relatively small areas of each overall suburban development. More comprehensive integration of topographically responsive strategies into new suburban development evidently requires further evolution of industry conventions and urban design policy. First, significantly increased diversity of lot and dwelling sizes improves opportunities for suburban form to respond to topographic variation. Second, by extension, the suburban monoculture of similarly sized houses requires reinvention with smaller and larger dwellings, which have the added benefit of accommodating increasing demographic diversity (ABS 2010). Households unsuited to conventional fully detached four-bedroom suburban houses are likely to be better served with alternative housing options scaled to their needs (Wuff, Healy and Reynolds 2004). Third, alternative housing construction techniques enable lots to be developed without first being levelled. And fourth, looser urban structures enable street networks to react to natural landform more effectively.

Given the intricacies of complex sand dune topography, more site-specific approaches to urban development are likely to challenge established principles of urban design. These principles—which are generally imported into Australia with little modification from their northern hemisphere origins—prioritise urban order, hierarchy, legibility, and connectivity as established from a two-dimensional plan viewpoint. Adapting and loosening these principles do not imply a *laissez faire* approach to suburban form, but a recognition that the three-dimensionality of landform contributes significantly to urban legibility and experience. The looser form that results from taking a topographically based approach to suburban design potentially



Figure 15. View of typical terrain zoned for future suburban expansion. Topography ranges from gentle undulations to steep ridgelines (Author 2015).

revives the dune-based vernacular layouts of the earliest coastal settlements. This local vernacular suggests a west coast variety of the “scruffiness” that Brendon Gleeson (2006, 13) identifies as a positive defining character that differentiates Australian (sub)urbanism from imported urban templates.

Although this research demonstrates that improved topographically responsive planning practices are achievable and beneficial to the current generation of suburban developments, the longer-term sustainability of rediscovering local vernaculars through incremental improvements in coastal suburban development is highly uncertain. With Perth’s population projected to increase by 2 million people over the next four decades—and local jurisdictions thus far failing to achieve densification targets for the existing urban fabric (WAPC 2010)—any topographic improvements are likely to be negated in practice by the sheer geographic extent of suburban expansion. The morphology of the northern coastal areas gazetted for future development—which are characterised by steeper dune systems than



comparable coastal areas closer to the city centre—compound this reality (figure 15). In this demographic and topographic context, future research and design experimentation will benefit from a wider scope that extends beyond established low-to-medium suburban densities. Innovative configurations of higher densities and atypical dwelling arrangements suggest further opportunity for robust topographic expression and wider community acceptance of alternatives to current suburbanisation practices.

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