

CITY LIMITS: PUSHING BOUNDARIES IN URBAN INFILL DEVELOPMENTS

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Summary

There is increasing recognition that current 'best practice' in the design, construction and management of the built environment is not enough to ensure a sustainable future. Our built environment contributes to some of Australia's most pressing environmental problems. In response, we need to push the limits and move far beyond our current conceptions of best practice. This paper puts forward a principles-based approach to sustainable design in the development industry that incorporates the concepts of ecological limits, systems thinking and responsibility for impacts. In addition, a new framework for setting targets and actions for 'restorative' developments is presented. This paper focuses on the opportunities associated with urban infill projects, examining the kind of targets required to achieve truly 'sustainable' and even 'restorative' development and the principles all developments and retrofits of the future need to embody. This analysis is done in the context of a changing regulatory and economic environment, using examples from precinct-scale Sydney developments that are currently being designed.

1. Background

The built environment contributes to some of Australia's most pressing environmental issues, such as climate change, biodiversity loss, resource depletion, pollution and social inequity. As a nation, Australia is exceeding its ecological footprint, which at 8.1 hectares per capita is 3 times the global average and far greater than the estimated sustainable footprint (1.7 hectares for every person in the world) (Commonwealth of Australia, 2005). This places Australia in the top 5 of consuming nations in the world (GFN et al., 2005) and illustrates the extent of reductions required in order to achieve a sustainable level of resource consumption. Greenhouse gas emissions (GHGE) and material consumption rates in Australia are the highest per capita in the world at 27 and 180 tonnes per capita per year, respectively. Domestic waste production is second only to the United States at 620 kilograms per capita per year. The construction industry contributes to these high statistics as construction and demolition waste is 430 kilograms per capita per year; which constitutes 40% of all solid waste disposed of to landfill (Commonwealth of Australia, 2005).

Currently, average water consumption across Australian cities is 154 kilolitres per capita per year (kL/cap/year) (Beeton et al., 2006), which is the highest national average in the world, with the U.S. falling just below this average (Commonwealth of Australia, 2005). Australia's performance in these indicators shows that vast improvements must be made to secure a sustainable future. An immediate and fundamental shift in thinking and practice is needed. In many of Australia's urban areas, energy supply, water supply and sewage disposal infrastructure is highly centralised, ageing and/or close to its capacity. These centralised systems were designed and built within a paradigm that segregated infrastructure types (e.g. energy and water) and elements within those types (e.g. water separate from wastewater). The unintended result of such systems is unwanted environmental impacts and increased costs. A different way of thinking about our infrastructure is needed, in part because infrastructure has such long life times - of the order of 20-100 years, and in part because infrastructure determines the material intensity of our lifestyles.

Current 'best practice' targets used for design and construction of the built environment have brought some progress towards the goal of sustainability; however, much greater steps need to be taken if we are to address some of the critical issues affecting our urban environment and move towards attaining the ultimate goal of sustainable development. As a highly urbanised nation, the greatest opportunity for Australia to reduce its environmental impact lies in its cities. Two thirds of Australia's population lives in cities and population growth is increasingly concentrated in urban areas. The rapid growth occurring in the inner urban areas of Australia's major cities, notably in Sydney, Melbourne and Perth (Commonwealth of Australia, 2005), presents significant challenges – and significant opportunities – for the sustainability of the built environment. Precinct-scale developments offer a particularly effective opportunity to create change in our built form and infrastructure.

This paper argues that it is time for a paradigm shift in thinking and practice, and that a principles-based approach provides an appropriate framework for this next stage in the development industry's evolution. We draw on principles for sustainability learning, because a deeper level of awareness and knowledge will be fundamental to this paradigm shift. If we are serious about a sustainable future, we need to engage more explicitly with principles such as responsibility, ecological limits and systems thinking.

2. A New Principles-Based Approach in the Development Industry

The Australian development industry has seen a considerable shift towards sustainability over the last decade. Regulatory requirements and the introduction of building rating tools have transformed mainstream

awareness and have in turn resulted in changes within the building industry's supply chain. Despite this, even current leading edge practice falls short of what is needed to ensure a sustainable future. In light of the broader context outlined above, it is clear that significant changes need to be made in order to improve sustainability outcomes. The focus on harm minimisation in the development industry needs to be shifted to focus on creating sustainable and even restorative development. Concurrently, there needs to be a greater level of accountability in the way we describe development, as to date it has been common practice to describe a development as 'sustainable' when it features just a few green elements. This shift might be achieved by focusing on the principles behind sustainability and by using those principles to guide the design process.

A principles framework provides a reference point for sustainability in the development industry, ensuring industry progress towards (and beyond) sustainability is in alignment with the broader national and global picture. It reminds us of ecological limits and how we must stay within them, as well as encouraging a systems approach that will take development to a new level of synergy. A principles framework also opens up possibilities for innovation. It provides context and structure to the discourse about development of the future, whilst allowing sufficient flexibility for lateral thinking and creativity. Importantly, it supports learning for sustainability in the development industry. A deep, transdisciplinary, transformative learning approach to principles-based understanding of sustainability (e.g. Meppem and Gill 1998) empowers industry practitioners to recognise the principles that underpin truly sustainable development and apply them in new and creative ways, rather than 'following the recipe'. This is highly important for the development industry's evolution, and for reaching the long term goal of sustainability.

2.1 Principles for Sustainability Learning

This paper draws on previous research into appropriate principles for sustainability learning. The principles set out below have been drawn from many different fields of sustainability learning (Carew and Mitchell 2001) and adapted for the building and construction industry. The principles are divided into interdependence principles (systems thinking, limits and elasticity, impacts, and uncertainty and complexity) and ethical principles (responsibility, awareness and fairness) (see Figure 1). At the core of relevance to the building and construction industry are understanding limits, systems thinking, and responsibility. These are the focus of this paper.

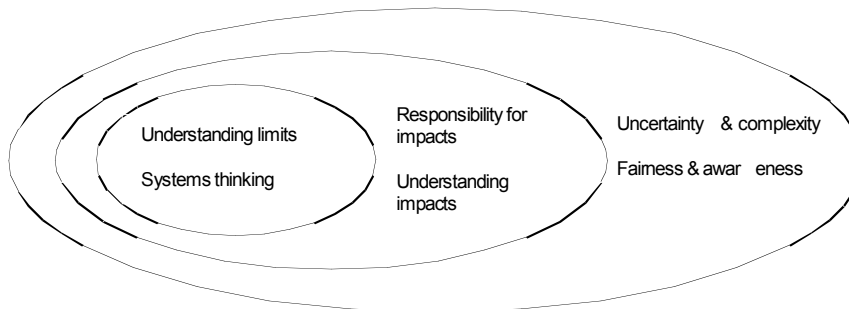


Figure 1: Principles for sustainability learning in the development industry

In the sections that follow, we first outline the principles, then demonstrate their application in various precinct scale developments in Sydney.

2.1.1 Limits

The idea of limits refers to the simple fact that all biophysical resources are limited. The planet has certain amounts of each fundamental building block - the elements - and a finite supply of energy from the sun to drive the processes that change the way those elements are combined in a myriad of ways to produce the biophysical world around us. These natural resources are all we have as potential starting materials for everything we manufacture, construct, use, and dispose. There are physical limits to the scale of these resources, ecological limits to the assimilation potential of the environment, and thermodynamic limits to the rates at which things happen. These limits and the way in which they interact are fundamental to the concept of resilience, which itself is fundamental to sustainability.

As noted earlier, we have already exceeded limits from many perspectives, and from other perspectives are close to it. Our actions have already increased atmospheric concentrations of greenhouse gases, and scientists believe we can only avoid dangerous climate change by urgently making 'deep cuts' in our greenhouse gas emissions. In water, there is a growing call to rehydrate the landscape - to return water to the catchment and source (surface or ground) from whence it was taken (Nelson 2008).

As we can see from the principles above, respecting limits is embodied in the concept of sustainability. Therefore to be considered sustainable, urban development must mirror this principle. It must itself perform within ecological limits. This may be easier to do and measure from some perspectives, such as greenhouse emissions from operational energy use, than from others, such as material intensity. However, the principle of performing within limits needs to be the goal of any sustainable development. Taking climate change as an example, urban development must deliver similar deep cuts in greenhouse emissions to those needed economy-wide to stabilise atmospheric emissions. Whilst sustainable development respects limits from a number of different perspectives, such as resource use, land disturbance and emissions, it also requires systems thinking to explore and optimise the connections between these different areas of ecological impact.

2.1.2 Systems thinking

Systems thinking is embodied in the concept of sustainability (Mitchell, 2000), and recognises we live in a highly interconnected and complex world. It considers the whole and the interrelationship of the many parts, taking into account context and multiple influences and relationships. It also creates awareness of the boundaries and assumptions used to define issues, recognises the influence of world views and perceptions, and embraces uncertainty and complexity. There are myriad examples of systems thinking in nature, yet few in the built environment. Even our approach to green development, perhaps partly as a consequence of traditional disciplinary divisions, tends to focus on one goal at the expense of another, leading to unintended perverse outcomes.

Systems thinking is not reflected in our traditional infrastructure design. Our tendency is to do what we are familiar with, which means that when an existing system is reaching its limits, we augment it with something similar. The economies of scale argument in industrialised systems makes the marginal cost of supplying one more customer look very small. However, a systems understanding of this cost that takes account of their proportion of the large scale infrastructure gives a quite different picture (Mitchell et al., 2007). The extensive economic and environmental advantages of small energy systems (Lovins et al., 2002) and small wastewater systems (Pinkham et al., 2004) are now well documented. The lack of a systems approach in engineering design has also been recently documented in wastewater systems in the USA (Etnier et al., 2007). A systems approach will lead to smaller, distributed infrastructure arrangements, focused on treatment rather than transport of commodities and capturing synergies between infrastructure systems.

Sustainability rating tools for building have played an important role in the 'mainstreaming' of green building, however they can constrain innovation at the cutting edge because they cannot adequately address systems thinking, an inherent limitation of any prescriptive tool. They prompt users to 'follow the formula' (as robust as that formula may be) instead of encouraging broader exploration. Systems thinking encourages creative new connections that allow us to do radically more with less. Emerging interest in the application of 'biomimicry' to buildings is also a recognition of the value of systems thinking. Systems thinking is key to the next paradigm shift in urban development and needs to be built into design and assessment processes.

2.1.3 Responsibility

Whilst the previous two principles are interdependence principles, responsibility is an ethical principle. Business as usual clearly has unacceptable consequences for the future, and in line with this principle all industry sectors, including the development industry, must take responsibility for its actions and accept a greater level of accountability throughout its operations.

For development industry stakeholders and practitioners, responsibility requires a shift in the level of engagement with sustainability principles and with others involved in the process. It means extending the boundaries of responsibility, similar to Covey (1990), by expanding one's area of control as well as taking action within one's influence. The Australian development industry has made significant progress in this regard e.g. It is common for developers to set up partnerships with those who will operate, manage and tenant their developments. However, there is potential for stronger and more extensive connections to be made. New institutional arrangements that facilitate these kinds of relationships will be key (Martin & Verbeek, 2006), particularly through harnessing market capital.

We need to hold ourselves accountable with respect to staying within limits. Some ecological impacts are easier to benchmark and measure than others, allowing us to more easily assess outcomes in relation to limits. For the impacts that are easier to benchmark and measure, targets can be applied as an accountability mechanism e.g. targets for greenhouse gas emission reductions or water use and effluent reductions. We also need to hold ourselves accountable with respect to systems thinking. In this regard, the quality of the outcomes achieved is largely determined by the quality of the process. It is increasingly recognised that traditional design and decision-making processes are no longer appropriate, or the traditional disciplinary roles and divisions. Integrated decision making and implementation processes are now often cited as an important way to optimise outcomes for sustainability. Therefore, it's possible to use process principles as an accountability mechanism for systems thinking.

Building rating tools such as Greenstar and the Australian Building Greenhouse Rating (ABGR) serve as our current accountability mechanism, and have made significant progress in shifting mainstream practice (Davis Langdon, 2008). However, to support the next shift, tools like these will need to be used within a broader principles-based framework that takes limits and systems thinking into account. In a similar vein, sustainability science scholars note the need for transdisciplinary thinking to deal with the issues of our time (Meppem and Gill 1998).

As it is not possible to know 'the right answers' in advance, we must move to the concept of learning, and particularly learning in new, transdisciplinary ways, as key in our planning and accountability mechanisms for sustainability.

3. Towards 'Restorative' Development In Urban Australia

To be truly sustainable, development needs to embody the principles described above. It must stay within ecological limits, and to do this from multiple perspectives a systems approach is required. This definition of sustainability is about a kind of equilibrium – development that uses only its 'sustainable' share of resources and creates only its 'sustainable' share of impacts (such as emissions, waste, effluent, etc). This is the principle of staying within limits. If all our building stock performed like this, we would have an sustainable built environment. However, performance of our existing building stock falls far short of this, and to compensate future development must aim for outcomes that go well beyond sustainability.

This is where the concept of 'restorative' development comes in. Restorative development contributes to the sustainability of the wider area, by using much less than its sustainable share of resources and creating much less than its sustainable share of outputs, or by achieving sustainability 'equilibrium' on the site and reducing the environmental impact of existing development beyond the site through, for example, export of energy with low greenhouse intensity or recycled water.

3.1. The Potential for Precinct Scale Urban Development to Lead in Restoration

Urban redevelopment provides the ideal opportunity for achieving restorative outcomes, particularly precinct scale development that, by nature of its scale and complexity, supports innovation in infrastructure design. This scale lends itself to the cost effective application of decentralised technologies for energy and water that help to minimise environmental impact and maximise efficiency and synergy. Examples include the use of trigeneration for electricity supply, heating and cooling on site, the conversion of organic waste to biogas for use on site, the use of urine separating or vacuum toilets to drastically reduce water use in conveying wastes and energy use in treatment, and improve the local nutrient and energy recovery potential. Use of these decentralised technologies helps a development to meet 'restorative' targets for minimising energy and water use, greenhouse gas emissions and effluent discharge – the principle of staying well within limits. These developments can greatly reduce their reliance on the city's ageing infrastructure, and in some cases be self sufficient and even support other development beyond the site boundaries.

Precinct scale urban development also lends itself well to a systems approach, which is key to restorative development. Developments of this scale are essentially microcosms, with the same spectrum of needs as a normal city, with residential, commercial, retail and community spaces as well as a connecting biological environment. Opportunities exist to apply systems thinking by maximising synergies between the different land and building uses. Buildings can be clustered to maximise symbiotic relationships between them and allow optimal sizing, design and staging of infrastructure.

Development of this scale and complexity provides opportunities to integrate a broader range of issues compared to single building developments, including issues related to transport, connectivity, social access and inclusion as well as the economic aspects of sustainability. This scale of development will naturally involve a larger range and number of stakeholders, meaning that multiple different perspectives and objectives need to be taken into account.

In terms of cost, precinct scale development lends itself to 'doing more with less', through the inherent economies of scale and the ability to optimise infrastructure design. This scale provides ability to bulk-purchase the most efficient products and materials (e.g. "Solaire" in New York). When there is a variety of building types and more uses (commercial, residential, retail), some infrastructure can be designed to better match supply with demand. This is certainly the case with energy, where demand profiles for heat, cooling and electricity can be better matched to supply profiles, effectively reducing the peaks in energy demand (and therefore the need to oversize infrastructure).

In terms of water, precinct scale has advantages over both highly centralised and highly decentralised - the economies of scale in treatment are realised, and the diseconomies of scale in transport are avoided (Pinkham et al 2004). Precinct scale allows potentially more cost effective integration of water cycle elements. Water is heavy, and pumping it around incurs significant energy costs. Therefore local capture, treatment and reuse at a 'cluster' scale is emerging as the means for delivering environmentally, economically, and socially preferable outcomes (Nelson 2008). Precinct scale also offers opportunities to connect effectively to other infrastructure realms. For example, shifting to a resource view of wastewater and collecting the organics in waste and wastewater and recycling those to local energy production. In the future, nutrient recovery will drive wastewater treatment processes, and this is also benefited by a precinct scale approach in terms of collection, storage, avoiding contamination and later transport.

3.2 Creating Restorative Development

In order to create a restorative development, the principles of sustainability need to be translated into specific targets for each aspect of a development, including: water, energy, waste, materials, transport and community. However, the key to restorative development is to meet individual targets and to maximise integration between systems in the built and natural environments. It is often the case that specific targets can be more easily met through synergies between systems and that these synergies can provide the means to "tunnel through the cost barrier".

3.2.1 Staying within limits – sustainable and restorative targets

Defining targets for some development aspects such as energy or water can be easier than for others, such as material intensity and community. For example, the reductions in energy use and greenhouse gas emissions (GHGE) that are required to stay within ecological limits are widely understood and universally applicable. The IPCC 4th Assessment Working Group III report argues that to achieve stabilisation of carbon dioxide at 450ppm CO₂-eq, developed countries such as Australia, must reduce GHGE by 25-40% below 1990 levels by 2020 and by 80-95% below 1990 levels by 2050 (IPCC, 2007). As one of the highest per capita emitters of GHGE (WRI, 2008), Australia should arguably be aiming for the upper limit of this range and for meeting it earlier. Consequently, these society wide targets have been translated into specific targets for the building sector as shown in Table 1 below, in relation to the sustainable – restorative framework.

The sustainable level in Table 1 has been defined as meeting interim targets upfront and building in the flexibility to achieve longer-term targets. This target is derived by assuming that the upper bound of the

IPCC's 2020 target (i.e. a 40% reduction from 1990 levels) needs to be achieved upfront in new developments and that a further reduction of 10% is appropriate to account for the low cost of abatement opportunities in the building sector (Enkvist et al., 2008). The 50% reduction target is then adjusted taking into account growth in energy use in the commercial and residential sectors between 1990 and 2005 to establish reductions from 2005 (current) emissions levels. Table 1 represents an example of sustainable / restorative outcomes for greenhouse gas reductions targets for a mixed use urban renewal precinct, where targets are shown in line with their corresponding ratings in BASIX¹ and ABGR² as well as the measures and infrastructure required to meet these targets. Sustainable and restorative outcomes are compared with what is currently viewed within industry circles as best practice.

Table 1 – Example of Sustainable and Restorative targets for GHGE reductions and likely infrastructure requirements at a mixed use urban renewal site

Rating Tool	Current 'best practice'	Sustainable Case	Restorative Case
Target		40% reduction in GHGE from 1990 levels whole of society = 64% reduction in GHGE from 2005 levels for the building sector	Substantially greater than 64% reduction in GHGE
BASIX (residential)	25% BASIX score	60% BASIX score	substantially > 60% BASIX score
ABGR (commercial)	4.5 star	5 star + 40% additional CO ₂ -eq reductions	5 star + substantially > 40% additional CO ₂ -eq reductions
Measures / Infrastructure	<ol style="list-style-type: none"> 1. Energy efficiency initiatives - average market practice in Australia, and 2. Solar hot water for residential buildings 	<ol style="list-style-type: none"> 1. Best practice energy efficiency, with some leading edge efficiency initiatives 2. Life-cycle embodied energy reductions and <ul style="list-style-type: none"> - Trigeneration or - Large-scale solar hot water system, - Geothermal heat exchange for space heating and cooling, and - Some on-site renewable energy 	<ol style="list-style-type: none"> 1. As for sustainable case (either path) with leading edge energy efficiency 2. Larger contribution from on-site renewable energy 3. Off-site greenhouse gas reduction initiatives

Adhering to ecological limits in the water cycle relates to the use of a sustainable yield of water that can be readily replenished locally as well as mitigating the impacts of stormwater runoff on downstream environments. Sustainability targets set for potable water substitution and stormwater management in general need to be site specific, to take into consideration the physical attributes of the site and surrounding catchment. The ecological limits concept in water extends to considering the resources in the wastewater stream - in particular, phosphorus. Phosphorus is an essential nutrient for all growth, and is currently supplied by mineral deposits that will be depleted in approximately 50-80 years. We need to move from a linear to cyclical approach to phosphorous use, by taking advantage of urine as a concentrated 'source' of phosphorus. The leading water research laboratories in Switzerland recently released a compilation of their technical, social, and economic work in this area (EAWAG 2007), and a trial of 20 urine-separating toilets is underway in Queensland (Beal et al 2008).

With respect to stormwater quality improvements, targets to create a restorative development need to reflect the sensitivities of the receiving environments downstream of the development (Barter, 2005). Natural runoff loads of phosphorous and nitrogen vary from catchment to catchment, as the natural uptake of these nutrients also varies depending on the downstream ecosystem and its condition. The most effective method to reduce adverse impacts on the downstream ecosystem is to design the development's landscape to mimic the natural environment, so that stormwater runoff is slowed and filtered to stay within natural limits of pollutant loads and flow frequency. The Sydney Metropolitan Catchment Management Authority is now recommending that the impervious area in a catchment that is directly connected to a stream by a stormwater drain be less than 2-5% of the catchment, in addition to ensuring that downstream waterways are not affected by erosion or excessive nutrients (SMCMA, 2007). This has significant implications for precinct developments and the integration of water sensitive features into landscape design. Reducing overall site imperviousness will mean an increase in green areas, including green roofs. Minimising the area of hard surfaces directly connected to drainage will mean that all hard surfaces must drain through buffer strips, grassed swales and other water sensitive landscape elements.

3.2.2 Systems thinking – a key attribute of restorative development

Ecological limits need to be respected within a development but also for the surrounding community, as for example, meeting potable water reduction targets at the expense of greater energy use in the community is not a sustainable outcome. This is where the application of the 'systems thinking' principle becomes important. Not only is it important to consider the overall balance of impacts across the different aspects of the development, but in order to make greater advances in sustainability it is vital to assess the potential for

¹ BASIX is the Building Sustainability Index tool used in NSW
<http://www.basix.nsw.gov.au/information/index.jsp>

² ABGR is the Australian Building Greenhouse Rating tool <http://www.abgr.com.au/>

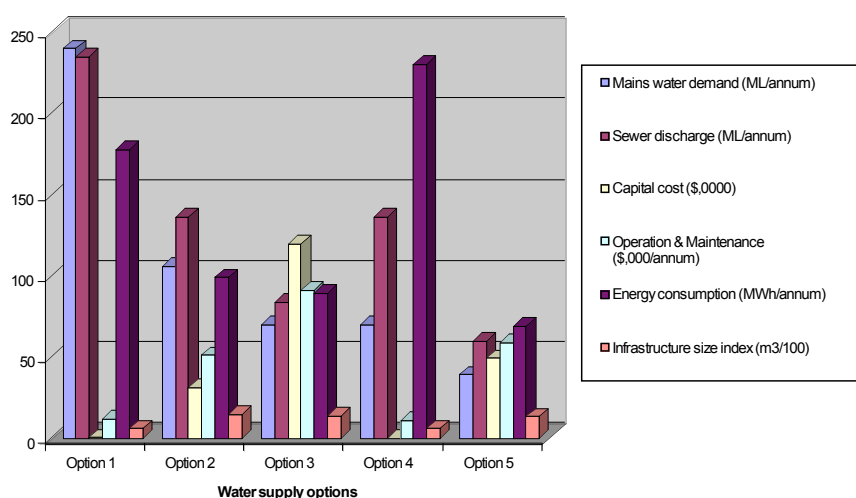
synergies between different parts of the overall system. For example, rainwater can be collected and used to cool an on-site cogeneration or trigeneration plant, which in itself reduces the site's greenhouse gas emissions; but in conjunction, the heat transferred to the rainwater produces a suitable hot water supply source for the development. Further examples of synergies between systems include: recycling biosolids and organic waste in a development for digestion and use as biogas, recycling biosolids/organics for soil conditioner, collecting urine from urine diverting toilets to recover nutrients for use as fertiliser and the use of green roofs to compensate for reduced green areas, improve water quality and provide thermal mass for a building. In this way, available resources can be used more effectively by maximising synergies.

One approach to maximising synergies between systems in a development is to use the principles of biomimicry. Biomimicry takes design inspiration from nature and encourages the incorporation of natural processes into the design of systems in the built environment (Benyus, 2002). Council House 2 is the first Australian urban building to be designed based on the principles of biomimicry (Morris-Nunn, 2007). Features of CH2 include: external sun shades made of recycled timber that pivot in response to the angle of the sun, extraction of warm air through ceiling exhaust and wind powered turbines, shower towers that use falling air and water to cool the lower levels of the building, plantings on the north façade and roof to provide shade, thermal mass in between floors to absorb excess heat as well as solar hot water, photovoltaic cells and a gas-fired co-generation plant to provide electricity (City of Melbourne, 2006).

In Berlin, UFA FABRIK and the Institute of Physics building at the Technical University of Berlin at Adlershof (Schmidt 2005) go further in connecting water and energy cycles with biological systems. Schmidt is interested in the direct connections between rainfall and energy absorption. He suggests that the lack of vegetation in our urban landscape is an insufficiently explored factor in the climate change equation that significantly shifts two variables: the nature of reflected radiation, resulting in shifts in the quantum of energy absorption potential in the atmosphere, and water and energy absorption patterns, significantly impacting heat island effects and thermal performance of buildings. The evaporation of water provides significant cooling potential - up to a theoretical maximum of 680kWh per cubic metre of water. Operational measurements are showing average figures of around 300 kWh/m².a (Schmidt 2005).

The overall balance of sustainability outcomes is highly important when assessing options for a development. In the graph in Figure 2 below, the characteristics of a number of water demand/supply options that have been developed in accordance with the sustainable-restorative framework have been graphed for comparison. The water savings measures used in each option are explained in the key to the right of Figure 2. From left to right, each option provides a greater reduction in potable water demand; however, the associated sewer discharges and energy consumption do not uniformly decrease. In particular, the energy required for treatment and pumping of the externally sourced recycled water in option 4 is much greater than for option 3, which offers similar reductions in potable water use. The capital, operation and maintenance costs of each system and the relative size of the required infrastructure are also shown on this graph (note that capital and operating costs were unavailable for Options 1 and 4). In Option 4, mains water consumption is similar to option 3, however, energy consumption is high and in reality, the cost of this system to the community is likely to be much higher. It is clear from this graph that option 5, which maximizes efficiency, reuse of water, nutrients and biosolids and consequently incorporates synergies with natural systems, provides a more even reduction between potable water use, sewer discharge and energy consumption. This example shows very clearly that the entire system must be considered in order to achieve a balance between environmental impacts. It also shows that appropriate costing of infrastructure needs to be undertaken to reflect the real cost to the community of various options (Mitchell et al., 2007).

Figure 2 – Comparison of water demand-supply options for a precinct scale development



Option 1 - Australian best practice efficiency

Option 2 – Efficiency + rainwater + harvested stormwater

Option 3 – Efficiency + rainwater + on-site wastewater recycled

Option 4 – Efficiency + rainwater + externally sourced recycled water

Option 5 – Greater efficiency + rainwater + greywater + collection of urine and biosolids

The graph in Figure 3 presents an example of the unit costs associated with different water demand-supply options for a precinct development. The infrastructure proposed for each option is explained in the key to the right of the graph. Options 1 to 4 illustrate the rising unit cost associated with increased water savings, however, option 5 is an example where the unit cost of water savings has reduced due to an economy of

scale. This is an example of how innovative strategies and effective sizing can help to “tunnel through the cost barrier”.

In practice, to ensure sustainable outcomes for a development, these sustainability principles (limits, systems thinking, responsibility) must be embedded in the design process. Collaboration between designers, planners and engineers is crucial to ensure that synergies between systems that may be simple to adopt are not overlooked. The application of explicit principles for process in urban development will help to encourage systems thinking and ensure synergies are captured. Figure 4 shows principles that have been developed specifically to guide precinct-scale urban redevelopment. The overarching principle governs outcomes – a development that is at least sustainable and ideally restorative. The other principles govern process and are in place to ensure the first principle is achieved, and in the most effective way. Using these process principles would support restorative outcomes and preclude the choice of design options such as Option 4 in Figure 2.

The examples used in this section of the paper focus on operational impacts that have been modeled for upcoming urban redevelopments in Sydney, however as the development industry moves further towards a systems approach, new concepts will be need to be assimilated. One of the emerging frontiers is the ‘embodied impacts’ of the materials used. These can be far ranging, and include impacts on climate change, biodiversity and other ecological health factors as well as energy and water use.

Figure 3 – Unit costs associated with water savings options for a precinct development

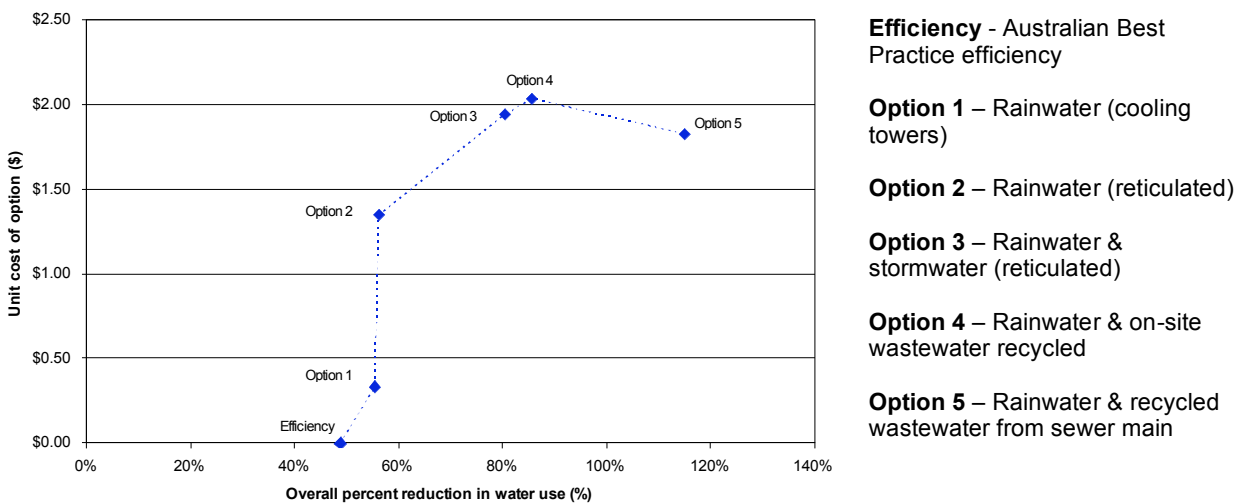
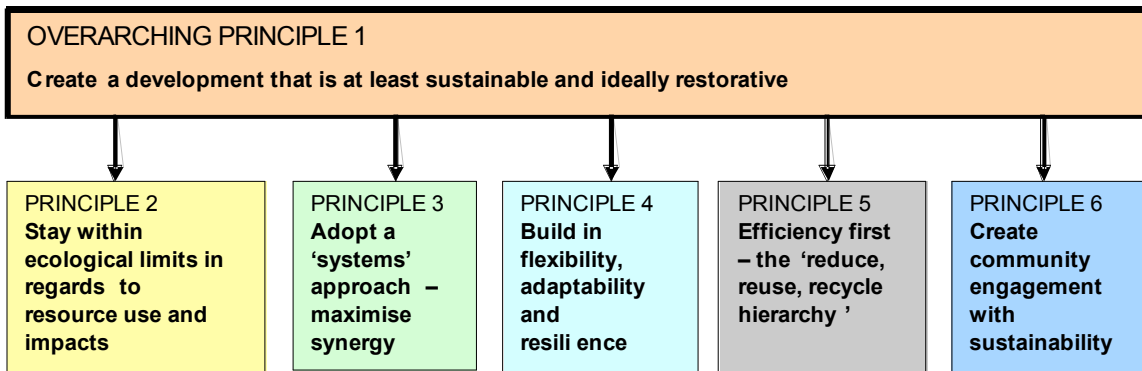


Figure 4 – Sustainability process principles for design of precinct scale developments



4. Conclusion

Despite the increasing popularity of building sustainability rating schemes and the shifts that have been occurring in the building industry, greater changes need to occur in order for developments to become sustainable and respond to the pressing issues of climate change, material waste and water scarcity. Business as usual in the development industry and even current ‘best practice’ is not sufficient to address these problems. It is important that planners, designers and engineers in the industry look beyond current notions of ‘best practice’ and seek to create development that has a net positive impact on the environment and society. By using an overarching principles based framework, all practitioners involved in designing the built environment may be able to rethink their approach and collectively create development worthy of sustainable and even ‘restorative’ status, where the development has a positive impact on its environment. This paper sets out a principles framework that may be used to guide the process and outcomes of ‘restorative’ developments. The sustainable-restorative framework provides a means for identifying the most appropriate option in each development situation. Urban renewal sites present an excellent opportunity to

apply this framework, due to the potential to create synergies between systems and the benefits gained from economies of scale. The creation of restorative developments in Australia will have a significant impact on reducing the ecological impact of urban areas, while still accommodating growth.

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