

REFORMULATING PLANNING TOOLS TO PROMOTE LOW IMPACT URBAN DESIGN AND DEVELOPMENT

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Paper presented at (and in the Proceedings of) the New Zealand Water and Waste Association 4th South Pacific Conference on Stormwater and Aquatic Resource Protection, Carlton Hotel, Auckland, New Zealand, 4 – 6 May, 2005.

ABSTRACT

Low impact urban design and development (LIUDD) is a rapidly evolving field that is benefiting from the inclusion of disciplines beyond those traditionally involved in stormwater management. It is expanding to incorporate an integrated approach to design and development practices. The paper reports on work undertaken as part of a six-year research programme, aimed at improving the uptake of LIUDD in New Zealand. The programme is driven by a strong recognition that successful implementation of LIUDD rests with the willingness of stakeholders to implement new techniques and practices and that it is important to develop a range of tools to assist their uptake.

This paper reports on progress with development of tools and processes to assist councils and other stakeholders. The paper presents a selection of key LIUDD principles currently under development. These principles are preliminary and have been informed, in part, by lessons from overseas and New Zealand experience. The paper identifies some relevant planning tools and processes that can be used by councils and communities as well as acknowledging some barriers that need to be overcome. The paper concludes that uptake would be assisted by improved capacity-building and the adoption of multi-disciplinary and multi-skilled approaches by practitioners.

KEYWORDS

Low impact development, catchment, imperviousness, ecology, natural cycles, CUES, LIRRDD

ACRONYMS

CUES Centre for Urban Ecosystems Sustainability
ICMP Integrated catchment management plan
LID Low impact development
LIRRDD Low impact rural residential design and development
LIUDD Low impact urban design and development
WSUD Water sensitive urban design

1 INTRODUCTION

Low Impact Urban Design and Development (LIUDD) is a six-year FRST-funded programme, aimed at improving the uptake of low impact design and development practices in New Zealand. It has a particular, but not exclusive, focus on the built environment. Led by Landcare Research Ltd, the research team is drawn from several public institutions and private companies encompassing researchers with expertise in environmental sciences, engineering, social sciences, economics and planning. The programme represents the first major funded research for the newly created Centre for Urban Ecosystem Sustainability (CUES), a joint centre of Landcare Research Ltd and the University of Auckland.

The research methodology has been underpinned by an interdisciplinary approach that recognises the need to not only integrate knowledge of natural environmental systems, technologies, physical infrastructure, social sciences and planning but also that successful implementation and outcomes rest with the willingness of stakeholders to implement new techniques and practices. Thus, the programme is intended to draw together understandings of

environmental science, public policy and practice and disseminate this in readily accessible ways to achieve practical outcomes. The programme has four key themes:

- **Getting buy-in: the human and social dimension** – identifying ways of overcoming social and institutional barriers to LIUDD.
- **Innovative science and design** – integrating natural features and treatment processes in urban development and catchment management to reduce stormwater impacts and enhance biodiversity.
- **Economic tools for LIUDD** – comparing cost-benefits of different approaches to underpin rational choices.
- **Changing plans and practices: making it happen** – improving processes and guidelines for council plans, codes and developing incentives for implementation.

The research activities focus on metropolitan Auckland, Taupo and Christchurch. There are also close links to Australian and North American case-studies. The context for our work ranges from development sites to catchments and includes both greenfield and brownfield applications. We have established six case study sites in urban and rural locations with varying spatial scales that we are drawing on to develop and apply concepts, techniques and processes. Consistent with this approach, there is a strong emphasis on interaction with a large number of stakeholders in councils, private sector, iwi, consumers, other organisations and the public.

Our programme has several features that we consider constitute an integrated approach to the research. First, as noted, it draws on a range of disciplines beyond those traditionally involved in this field to examine how the uptake of LIUDD can be enhanced and increased. Second, it is collaborative where we work alongside partners in the public and private sectors over a period of some years. In turn, this collaboration assists to disseminate knowledge of the programme and its findings, as well as informing the researchers. Third, the programme is strongly oriented, through participatory research and the use of demonstration projects, towards the transfer of research findings to practitioners and residents/consumers, thus encouraging the uptake of new practices. Finally, the researchers have a strong commitment to the integration of data across programme objectives and disciplines, so that results will be presented in forms that are easily accessible for residents as well as practitioners.

One of the four components of the research programme is exploring how plans and practices can be changed to assist the implementation of LIUDD. The uptake of LIUDD is of course influenced directly by a raft of instruments, such as statutory and non-statutory plans, strategies and codes of practice, largely administered by regional, city and district councils. Currently, there is a variety of approaches taken by councils that could be construed as constituting low impact development, usually with a focus on managing the quality and quantity of stormwater. However, our brief is wider than that, as we explain below. There are also few incentives to encourage developers to change traditional land development practices and take on board innovations (Heslop et al., 2003). In fact there are barriers to change. As part of changing practices, we have established a national taskforce of practitioners to assist with influencing the uptake and implementation of LIUDD. This group is overseeing the development of guidelines on how council plans and everyday development practices can be modified to accelerate the uptake of LIUDD. These guidelines, including the provision of economic incentives for the development industry, will be drawn from research now underway across the programme. The taskforce will also be considering ways that the guidelines can be implemented readily by stakeholders.

The paper reports on some initial work completed to date on changing plans and practices. Our involvement in the Taupo West Structure Plan process, undertaken recently by Taupo District Council with stakeholder participation, has been invaluable for the articulation and refinement of key LIUDD principles (CUES, 2004; Taupo District Council, 2004). Having outlined a brief explanation of the programme, the paper looks next at the definitions of LIUDD and presents some of these principles. Following that, the paper summarises some lessons learned from overseas and New Zealand. Tools and processes for influencing change will then be identified and discussed, along with barriers perceived by stakeholders and ourselves. The paper concludes with some reflections on lessons to date and issues yet to be addressed in the implementation of LIUDD.

2 WHAT IS LIUDD AND ITS RURAL-RESIDENTIAL SUBSET LIRRDD?

Every set of practices that is given a label requires clear definition including acknowledgement of inclusions and exclusions. We are currently refining what we believe LIUDD is and what it is not. LIUDD evolved in New Zealand from its origins in Low Impact Development (LID, Shaver 2000) as an alternative approach to stormwater management in North America and from Water Sensitive Urban Design (WSUD, Lloyd et al., 2001) in Australia. In New Zealand (Eason et al., 2004; van Roon, 2005) these practices, have been evolving since the late 1990s, and are reaching beyond alternative stormwater management to an integrated urban design and development process now uniquely labelled by the research team as LIUDD and LIRRDD (Low Impact Rural Residential Design and Development) in the rural-residential context. The overall objective of LIUDD is:

To avoid, or secondarily reduce, a wide range of adverse effects of a physiochemical, biodiversity, social, economic and amenity nature resulting from conventional urban development, protecting aquatic and terrestrial ecological integrity while allowing urbanisation at all densities.

(van Roon, 2005, page 4)

An essential step towards encouraging uptake of LIUDD is providing clarity to all stakeholders on what the principles of LIUDD are and the methods that can be used to implement those principles. We are, at present, reviewing a draft list of principles and recommended implementation methods before engaging other stakeholders in the process. A small sample of this list is presented by way of example in Table 1. Within this sample are included the overarching primary and secondary principles and the stormwater principles relevant to the theme of this conference. As can be seen from the sample in Table 1, we anticipate providing a coded listing of principles, sub-principles and actions that will enable stakeholders to assess the degree to which their planning documents, policies, guidelines, codes of practice, and actual practices incorporate LIUDD. For example, each principle is extended further in the relevant implementation section, and numbered accordingly. A stakeholder will then be able to create a checklist of implementation achievements using the codes from the CUES table. We need to ensure that the list is comprehensive, itemises all the issues and identifies the topics that the CUES team should focus on. The list will be regularly reviewed and updated during the research period. There are still gaps. For example, it is yet to incorporate Maori perspectives of LIUDD. Not all of the

CUES Programme's work begins with the urban environment. Case studies in locations particularly under pressure for peri-urban growth, for example Taupo, Manukau and Waiheke, have provided stimulus for development of LIRRDD principles and practices, some of which are reported in Appendix 4 of the Proposed Taupo West Rural Structure Plan (Taupo District Council, 2004). LIRRDD, using catchments as a design and management context, takes advantage of the landuse transition from rural to rural-residential to protect environmentally sensitive areas and most importantly to restore terrestrial and aquatic ecosystems if these have been degraded by pastoral and other land uses. Biophysical and amenity improvements achieved at this stage should then be protected permanently during any future intensification of urban uses on such sites.

The LIUDD approach is evolving rapidly and as research results become available and the nature of interactive systems are better understood, the emphasis in the CUES Programme, its articulated principles and means of implementation are adjusted. As the programme proceeds we do not anticipate major changes in key principles, however the range of implementation methods will increase, as stakeholders seek innovative alternative ways of achieving key objectives. Some existing implementation methods are already well known whilst others are under development. Good practice will be conveyed through revised codes of practice, guidelines and demonstration models some of which are under design or construction in collaboration with councils.

3 SOME LESSONS TO DATE FROM OVERSEAS AND NZ EXPERIENCE

An important consideration in developing a set of principles is to look at what lessons can be gleaned from overseas experience. However, it should be noted that the LIUDD (plus LIRRDD) approach has been developed in New Zealand and does not appear to have an exact parallel overseas. As such, lessons from selected locations overseas (Table 2) can be assessed on a partial systems basis only, taking aspects which fit the low impact approach appropriate to New Zealand conditions and underlying causal factors. As a result of our early focus on LID there may be a bias in Table 2 towards stormwater related lessons. It is expected that this will balance out as the CUES programme progresses. Several lessons in Table 2 are deserving of further explanation whereas others are generously supported by the references supplied.

Table 1: A sample only, showing part of the draft checklist of LIUDD and LIRRDD principles for assessment of planning, policy and development outcomes (van Roon, M and van Roon, H., 2005)

	Sub-principles	Description	Rationale	Implementation
<p>Primary principle</p> <p>1 Work with nature's cycles on a catchment basis</p>	<p>1A Support cyclical processes.</p> <p>1B Use catchment context as design & management framework.</p>	<p>Manage cyclical processes that determine distribution & influence of water, soil, plant nutrients, contaminants, organisms & energy.</p>	<p>Functionality of cyclical processes is essential for internalisation of effects & reduction of resource demands, that together make urban or rural-residential developments 'low impact'. Design within catchment context to support natural cycles (van Roon & Knight, 2004).</p>	<p>Encourage recycling of water, wastes, materials & energy through co-location of complementary activities (1.1), innovative infrastructure (1.2) & technologies (1.3). Use catchment context for design & management (1.4).</p>
<p>Secondary principle:</p> <p>2: Site selection achieves effect/impact minimisation</p>	<p>Spatial/Strategic Planning Approaches</p> <p>2A Optimize development through location & site selection, to avoid /minimize negative impacts (van Roon & Knight, 2004 p92).</p>	<p>Select areas for development & screen out inappropriate areas. Catchments & subcatchments used as the primary basis for planning & assessment.</p>	<p>Avoidance of sensitive areas/ sites to minimize environmental / economic costs as this is more effective then remedial work.</p>	<p>Prior to development or re-development identify & delineate sensitive areas & limitations or constraints at a regional scale (2.1). Develop criteria for assessment & basis for decision-making in selection of development areas & convert to Regional Plan provisions (2.2) or District Plan provisions (2.3).</p>
<p>Tertiary (3⁰) principle:</p> <p>3.1: Encourage alternative development forms that retain or create natural space & increase infrastructure efficiency</p>	<p>Structure Planning approaches in catchment context</p> <p>3.1A Cluster activities & permanently disallow intensification on "balance" land</p>	<p>Cluster compatible activities or land uses to minimise overall servicing costs & impacts</p>	<p>Clustering of activities provides for reduced capital expenditure & lower ongoing maintenance & operating costs, whilst allowing for increased densities overall.</p>	<p>Prior to development or re-development identify & delineate sensitive areas & limitations or constraints within catchment (3.1.1). Develop criteria for assessment & basis for decision-making in selection of development areas (3.1.2) & convert to District plan provisions (3.1.3) & covenanting (3.1.4).</p>
<p>3⁰ principle</p> <p>3.2: Localisation & naturalisation of water, soil & nutrient cycles.</p> <p>Optimise recycling, minimise external demand & discharges.</p> <p>Optimise 'integrated three waters management' within local catchment.</p>	<p>Stormwater</p> <p>3.2A Minimise generation of stormwater & localize at source.</p> <p>3.2B As a long-term goal reduce 'effective' impervious surface area to less than 15% of catchment.</p> <p>3.2C Maintain/ re-create catchment flow characteristics as if under previous "natural vegetation" (hydrological neutrality).</p> <p>3.2D Utilise stormwater wherever possible as a secondary water supply</p> <p>3.2E Maximise groundwater recharge with stormwater following contaminant removal.</p>	<p>No development on upper & riparian catchment areas so as to ensure maintenance of the environment & water quality.</p> <p>15% effective imperviousness recognised as practical in greenfield sites. Difficult to achieve in brownfields.</p> <p>Minimisation of runoff from catchment headwaters.</p> <p>Aim at zero discharge from properties.</p>	<p>To ensure maintenance of the environment & water quality, avoiding nutrient enrichment & pollution.</p> <p>Avoid capital costs & maintenance of reticulated systems. Minimize downstream surge & scour effects as well as trap contaminants & nutrients.</p> <p>Upper catchments act as reservoir for species to allow ongoing re-colonisations of habitat affected by development.</p>	<p>Use " natural processes" streams & wetlands as infrastructure (3.2.1). Avoid curb & channel storm water reticulation systems (3.2.2) & provide pipes only for overflows, not for base flow (3.2.3).</p> <p>Protection (3.2.4) & re-vegetation (3.2.5) of the riparian corridors. Identification , protection &/or re-creation of indigenous habitats, including wetlands, forests, springs, & streams - both perennial & ephemeral (3.2.6). Provide financial, rating or other incentives to encourage developers & land owners to retain or create these natural features (3.2.7).</p> <p>Re-vegetate upper catchments (3.2.8) & all erosion prone areas (3.2.9). Encourage high biomass vegetation systems to intercept rain & species with high evapo –transpiration capability (3.2.10).</p> <p>Adopt narrow roads (3.2.11), swales (3.2.12), rain gardens (3.2.13), biofiltration (3.2.14), porous paving (3.2.15), onsite detention tanks (3.2.16), ecoroofs (3.2.17). Provide for ongoing maintenance of stormwater control devices (3.2.18). Camber all impervious surfaces, including roads, to direct run-off to above devices or to natural vegetation areas on pervious soils (3.2.19). Use organic soils & compost to optimise function of raingardens (3.2.20).</p>

Table 2. Some lessons to date for the CUES project from overseas and the New Zealand experience

Some lessons learned	Selected geographical locations that collectively demonstrate lesson.
1. LIUDD cannot be achieved without integration of the urban water cycle into the urban design process (van Roon and Knight, 2004). The range of professional disciplines contributing to design should reflect this.	Canada, USA, NZ, Australia, Netherlands
2. Countries with high-density populations, or with acute and chronic groundwater and drainage challenges will provide water cycle management lessons for spacious NZ, Australia, Canada and USA as population pressure and city intensification occurs.	Netherlands
3. The most effective spatial unit for low impact design is the catchment. Design and development at smaller scales should consider the catchment context (NSCC, 2002; MCC, 2002).	Taupo, Long Bay–North Shore City, Flat Bush–Manukau City in NZ; Olympia -USA
4. Community initiated catchment management processes are a sound foundation for stakeholder involvement in LIUDD and LIRRDD. (ACAP, 1998; Whangamata Community, 2001). Council initiated catchment management with strong community participation is the next best alternative.	ACAP project, Nova Scotia; ICM projects Australia and NZ e.g. Whangamata Community Plan process;; Long Bay Structure Plan; Taupo West (not initially catchment based)
5. LIUDD practices can be adapted to improve sustainability within residential developments at all population densities, topographies and spatial scales (TDC, 2004; Seattle City, 2005; Liptan and Murace, 2002; Tauw, 2002; City of Hannover, 2002). See Photos 1 – 4.	Taupo West, NZ; Sea Street Project, Seattle, USA; Westminster Woods, Guelph, Ontario; Chilliwack and Simon Fraser in Vancouver; Buckman Heights, Portland, USA; Kronsberg, Germany; Enschede and Nijmegen, Netherlands
6. Alternative development forms such as clustering retain or create spacious natural habitat & increase infrastructural efficiency.	Tapiola, Helsinki, Finland; The Island Co-housing project, Martha’s Vineyard, Massachusetts, USA; Village Homes, Davis, California, USA; Long Bay, North Shore City, NZ, Figure 1; Taupo West, NZ;
7. Integrated ‘three waters management’ is an essential part of LIUDD. This includes recycling of wastewater and stormwater for dual non-potable water supply. This reduces water withdrawals from waterways, water treatment costs, chlorine use and effluent discharges (Sydney Water, 2005; Mudd et al., 2004; Lim, 2003).	Countries with arid conditions lead by example: Australia including Rouse Hill in Sydney, Mawsons Lakes in Adelaide, Aurora in Melbourne; Oman; California; Israel; S. Africa.
8. The integration of ‘three waters management’ and water recycling will be associated with changing costs and the redistribution of those costs among different stakeholders.	Australia: Aurora in Melbourne; Mawsons Lakes in Adelaide.
9. Financial and health risk assessment and reduction are paramount for local authorities and water service industries contemplating the uptake of LIUDD technologies and practices. If risks cannot be quantified and lowered or underwritten, uptake will be impeded (McBride, 2003).	Yarra Valley Water and plumbing industry in Melbourne; Lynbrook Estate in Melbourne; Flat Bush, Manukau City, NZ; Auckland chose Waikato River for additional water supply instead of dual supply options e.g. rain water tanks.
10. The landscaping, re-vegetation and street narrowing (resulting in traffic calming) associated with at-source stormwater management increases amenity and neighbourhood real estate values (Seattle Post Intelligencer, 2002). See Photo 5, Seattle and Photo 6, Taupo East.	‘Sea Streets’ project, Seattle, USA; Westminster Woods, Guelph, Canada; Taupo East Riparian corridors, NZ; Lynbrook Estate parks & streetscapes, Melbourne.
11. On-site greywater and stormwater recycling sustainably enhances landscaping in arid regions (Coulhurst et al., 2003, 2004; Tan pers.comm., 2005). See Photo 7.	Inkermann Oasis, Melbourne; Docklands, Melbourne; Israel; periphery of Cape Town, South Africa; Muscat, Oman.
12. Urban ground water recharge using LIUDD techniques for contaminant removal has been successfully demonstrated (Tauw, 2002; Mudd et al., 2004).	Randstad conurbation, Netherlands; Westminster Woods, Guelph, Ontario, Canada; Parafields, Adelaide, Australia.
13. Existing narrow streets carrying high traffic flows can practically be retrofitted with LID stormwater technologies (Islam, 2003). See Photos 5 and 8.	Cremorne Street, Melbourne, Australia.
14. The most effective means of achieving hydrological neutrality (a primary	Long Bay NZ, Figure 1; Vancouver (Canada) and

objective of LIUDD) is via attention to urban layout and the proportion of structures and vegetation contributing to site coverage (van Roon, 2005).	Seattle (USA) subcatchments of Puget Sound; Olympia, Washington, USA
15. Diverse international statutory models exist for communal land ownership and management of residential village open space where at-source stormwater management and biodiversity enhancement is focussed (Dixon and van Roon, this conference).	CUES members anticipate transferable lessons from a comparison of models in Ontario, Canada and northern NZ (see Dixon, van Roon and Dupuis– this conference).
16. Cost effective, energy efficient examples of commercial, institutional and residential ‘green buildings’ that demonstrate reduced demand on centrally provided infrastructural services (TGBP, 2004; Landcare Research Ltd, 2005; Dunster, 2005; Institute of Asian Research, 2005; Jansen, 1994).	Choi Bldg, University British Columbia; Ecolonia, Alphen aan den Rijn, Netherlands; Bedzed, U.K.; 60L Building, Melbourne; Landcare Bldg, Tamaki, Auckland; Earthsong, Ranui, Waitakere; Waitakere Ecohouse, Waikumete, Waitakere, NZ.

Countries like New Zealand, faced for the first time with water cycle disturbances from urban intensification on a significant scale, have much to learn from other nations like the Netherlands which has very high population density, compact cities, vulnerability to flooding and groundwater dependence for potable water supply (Lesson 2). For centuries the Netherlands, much of which is below sea level, has dealt with these issues. Global climate change provides an additional challenge. The Netherlands demonstrates how stormwater infiltration devices can be artistically designed and retrofitted into very compact pedestrianised streetscapes many of which are in brownfield restoration areas. Similar lessons are demonstrated in Cromorne Street, Melbourne (Lesson 13). Wherever stormwater is infiltrated for aquifer recharge (Lesson 12) ‘low impact’ stormwater technologies are employed to remove contaminants prior to infiltration.

Higher density residential areas in other parts of Europe, such as Kronsberg, Germany, and also Portland, Oregon, United States of America and in the Simon Fraser University residential village in Vancouver, Canada have demonstrated the feasibility of incorporating many low impact stormwater and energy saving technologies in compact brownfield and greenfield situations the equivalent of which have not yet been constructed in New Zealand. By contrast of scale, the ‘Sea Streets’ project in Seattle, Washington, U.S.A. has demonstrated successful brownfield low impact stormwater retrofitting of a low density residential neighbourhood not unlike that of New Zealand suburbia before 1980 (Lesson 5). In the process of addressing stormwater issues other improvements to livability and sustainability have occurred, such as increased visual amenity, a feeling of closure and ‘traffic calming’. This is appreciated by the residents and is reflected in higher property prices. These ‘by products’ of the process may in fact be a major factor in encouraging LIUDD uptake by the public.

The catchment context for low impact design (Lessons 3 and 4) is further discussed under Integrated Catchment Management in the Tools and Processes section below. Many New Zealand lessons in ‘integrated three waters management’ come from arid countries or regions such as Oman, Israel, California, South Africa and, most conveniently, Australia (Lessons 7, 8 and 11). There is no doubt that water shortage has been a major stimulus to innovative research and technological developments in water recycling in these nations.

Many of the lessons of Table 2 can and have been applied at a microscale in individual green buildings that minimise and recycle both water and energy, not just within the building but by also utilising the immediate landscaped grounds and building roofs to optimise natural cyclical processes (Lesson 16).

Photograph 1. Buckman Heights Courtyard
raingarden, Portland, Oregon, U.S.A.



Photograph 4. Simon Fraser University, Vancouver,
Canada. Installation of infiltration galleries in
streetscape.



Photograph 2 Chilliwack, Vancouver with Low
Impact Stormwater Technolgies.



Photograph 5 Sea Street Project, Seattle,
Washington, U.S.A



Photograph 3 Chilliwack, Vancouver, stormwater
infiltration gallery



Photograph 6 Kiddle Drive, Taupo East, dry pond
series adjacent to street.



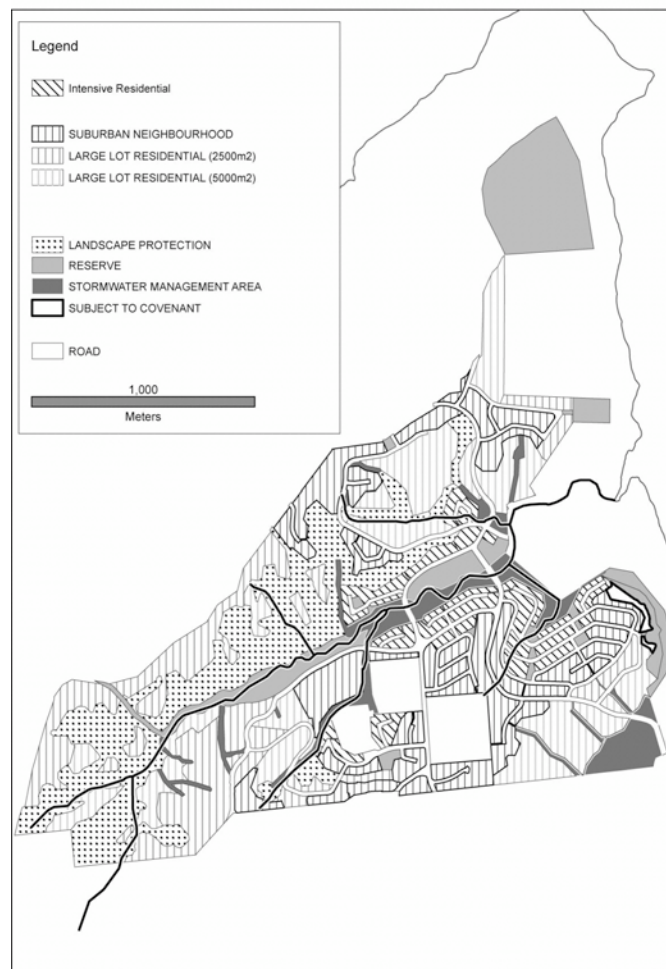
Photograph 7 Inkermann Estate, City of Port Phillip, Melbourne, Australia. Landscaping supported by greywater irrigation.



Photograph 8 Cremorne Street, Melbourne. Retrofitted biofiltration beds in brownfield street.



Figure 1 An example of urban design that is based on Integrated Catchment Management. The Plan was adapted to black and white from a Draft Landuse Strategy for Long Bay catchment (North Shore City Council, 2002). Some zones have been merged to simplify production. The Plan does not show operative zones, but gives an indication of how development of the area could be achieved in the future. Note the increasing intensity of housing with distance from catchment headwaters to river mouth.



4 TOOLS AND PROCESSES

A key element for encouraging the uptake of LIUDD relies on responsive local government processes that will encourage innovation. Table 3 provides an overview of the most significant planning, process and implementation documents through which LIUDD can be implemented. The interaction of these is critical to the success or otherwise of the LIUDD process. To an extent it is a hierarchical system where the higher level provides the context for the lower level tools. The absence of national policy (e.g. National Policy Statements) has been and continues to be a major gap in implementing LIUDD principles. For example, policy statements on energy and mandatory insulation standards would greatly facilitate the uptake of energy efficient buildings. Similarly, the concept of dual water supplies may require revision of current policies and practices in the public health sector. A recent amendment to the Resource Management Act requiring councils to consider the efficiency of the end use of energy, effects of climate change, and the benefits to be derived from the use and

development of renewable energy is a step forward in this regard. In some cases national strategies provide policy guidance, as is the case with the Biodiversity Strategy (Department of Conservation and Ministry for the Environment, 2000) which promotes the scale of protection and restoration of ecosystems promoted as part of this LIUDD programme. The CUES group will over the duration of this FRST programme explore the role which many of these tools and processes can play in the uptake of LIUDD and the interaction between these processes.

Table 3 Some planning tools and processes for implementation of LIUDD principles and subprinciples

Tool or process	Description and legal standing	Role with respect to implementation of LIUDD principles and subprinciples
National Policy Statement (NPS)	Top of the Resource Management Act (RMA, 1991) hierarchy of plans. Other RMA plans are required not to be inconsistent with NPS/s,	Key opportunity to influence LIUDD implementation nationwide. One or several NPS could be used. The National Coastal Policy Statement is the only NPS to date.
National Environmental Standards	An instrument provided for in the Act but not developed until more recently.	Key opportunity to influence LIUDD implementation nationwide. Preparation of NESs now underway.
National Strategies	Strategies are developed to deal systematically, on a long-term basis, with issues of national concern.	Such strategies, in the absence of NPSs derived there from, provide support and direction to LIUDD principles concerned with for example both biodiversity protection and restoration, and energy use efficiency.
Urban Design Protocol	A new instrument designed to promote improved awareness of urban design issues throughout the country	Implementation of the strategy by stakeholders is voluntary but provides opportunities to link environmental science, planning policies and design guidelines in ways that can give effect to LIUDD principles.
Regional Policy Statement	Key RMA (1991) policy document for each region beneath NPSs. RPS gives some direction to District Plans.	Opportunity to include policies that will influence uptake and implementation of LIUDD by Districts in the region.
Regional Plan	Non mandatory plans (except Regional Coastal Plan) under RMA (1991) formulated by regions to manage specific resource issues over the whole region or part e.g. a catchment.	Regional Plans also give policy guidance to District Plans. Opportunity to include policies and rules aligned with LIUDD principles for earthworks and stormwater management within catchment context. Provides framework for granting of comprehensive catchment consents for stormwater.
Regional Coastal Plan (RCP)	Mandatory regional plan under RMA (1991) sets policies and rules for Coastal Marine Area that receives stormwater and effluent under conventional development scenario. Some RCPs have policy influence over the landward extent of the coastal environment.	Influences the degree to which the marine environment is the assumed recipient of unlimited piped stormwater and sewage effluent discharges. May therefore exert pressure to control these at source on land. Identifies and sets rules for coastal protection areas. Provides context for resource consents in the CMA. Resource consent approach will influence the pressure put on other parties to provide cyclical processes in infrastructure design and thereby minimise demands for resources and impact of discharges.

District Plan	Mandatory plan under RMA (1991) controls granting of subdivision consents. Also sets rules with which development form must comply. Must not be inconsistent with higher level plans in RMA hierarchy.	District Plan determines whether subdivision layout can meet requirements of LIUDD principles. DP may either facilitate or create barriers to LIUDD implementation through rules for street, lot, or infrastructural standards. District Plan can control percentage of catchment or site that may be in impervious surfaces. DP sets rules that influence granting and conditions on resource consents to subdivide.
Iwi Management Plan	Plans prepared by Iwi for their area (rohe). Must be considered during preparation of plans under RMA.	May give guidance for the protection of biophysical resources and sensitive areas of natural and cultural importance to the Iwi. May show where the aspirations of an Iwi align or are contrary to LIUDD principles.
Strategic Plan	Sometimes also termed Area Plan. Non-mandatory plan to give long-term over-view to resource management of a region or district.	Suitable tool for identifying the 'least impact', most suitable areas/sites in a region/district for eventual urbanisation and for permanent resource protection. This is therefore a key tool for implementation of Principle 2 in Table 1 above.
Structure Plan	Non-mandatory plan process by District Councils.	A flexible tool for conceptualising the balance and layout of development versus protection areas for a specific location. Its flexibility enables use of the catchment as a design unit (Principle 1, Table 1 above) and the opportunity for community participation. The CUES team has already participated in a community-council working party to develop such a structure plan.
Long Term Council Community Plan (LTCCP)	Mandatory Plan (under the Local Government Act 2002) outlines community-council agreed aspirations for the future of the district. Prepared at beginning of term of new council.	Provides an opportunity for citizens to express to councils their aspirations or opposition to the incorporation of LIUDD designs and technologies in the local district or region. LTCCP provides the long-term planning context within which a community may foresee the gradual replacement of conventional design and infrastructure with LIUDD equivalents.
Local Community Plan (LCP)	Voluntary plan prepared by residents to express their priorities for protection, management, rehabilitation or development.	Good examples are already available where such planning has been carried out in a catchment context. LCPs can form input to LTCCP. Local Community Plan processes provide an opportunity for gaining the support of residents for the LIUDD approach.
Annual Plan	Mandatory Plan (under the Local Government Act 2002) formulated by Regional and District Councils. Forms part of the LTCCP when it is prepared every 3 years.	Annual financial allocations that will enable the financing of LIUDD uptake. Higher initial capital allocations may be required for LIUDD infrastructure with gradual payback over decades.
Asset Management Plan	Mandatory Plan (under the Local Government Act 2002) guides management of properties and infrastructure of regional or district council.	Successful LIUDD depends upon sympathetic management of local authority owned open space, streetscapes and infrastructure for stormwater, waste and water services. In particular to accept different amortisation approaches especially in redevelopment situations.
Integrated Catchment Management Plan	Non-mandatory process used by councils to either design infrastructural networks, or by communities and councils to prioritise actions to resolve resource management conflicts.	Both types of ICMPs are key tools for ensuring implementation of LIUDD in a catchment context. Stormwater engineers will continue to use ICMPs to design comprehensive catchment based networks regardless of whether these are based on conventional piped systems or dominated by onsite stormwater treatment technologies with storm overflow provision. The second type of ICMP is the ideal framework for Local Community Plans (see above).
Best Practice Guidelines	Non mandatory guidelines written often by councils to encourage sound practice.	Such guidelines can be highly influential for education of stakeholders. A good example is the Low Impact Development guidelines prepared by the Auckland Regional Council which are used nationwide by engineers from both public and private sectors.
Codes of Practice	Guidance given to development and construction sectors on standards to be met during construction	Relevant codes deal with practices such as subdivision, roading and building construction. These codes are highly influential in determining whether LIUDD will be put into practice by the construction industry.
Resource Consent Conditions	Conditions placed on resource consents granted by regional and district councils under the RMA (1991).	Conditions set at the time of the granting of resource consents will influence the degree to which LIUDD principles are implemented. This will particularly influence those principles concerned with the containment of water, nutrient and contaminant cycles. Monitoring conditions are particularly important to assess LIUDD effectiveness.

Differential rating	Practice of district or regional council in providing rating incentives for property owners.	Differential rating systems can be used to encourage property owners to install technologies or design site layout in a manner which favours good LIUDD practices such as reduction in site coverage in impervious surfaces, planting of trees, installation of rain water tanks or insulation in buildings.
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There are instruments under other statutes which could also be considered in terms of LIUDD relevance, such as building codes and regulations prepared under the Building Act 2004, environmental health requirements and voluntary codes of practice prepared by sector. However, at this point in the research programme, we are focusing first on influencing local government processes and development industry practices.

Three types of plans noted above are worthy of some additional explanation in terms of their utility in promoting LIUDD principles.

4.1 STRATEGIC PLANS

An emerging feature in planning practice in recent years has been the increased frequency of preparation of strategic and structure plans by councils in consultation with communities for the management of urban growth. This is undertaken at least initially outside statutory planning processes. A useful example is the strategic approach taken by Christchurch City Council in planning the urbanisation of an area of 8,400 hectares in the south west of the city, the outcome of which will assist the Council in providing a framework for the integrated use, development and protection of natural resources (Christchurch City Council, 2003). The development of South West Christchurch has been selected as one of the six case studies in the LIUDD research programme.

Rapid urban growth in Christchurch began during the early 1990s. Although work on the City Plan was undertaken during the 1990s, by 2001, there was an urgent need to provide more residential land to accommodate increasing demand in the city's fastest growing area and to rethink the approach to storm-water disposal, a critical issue in the south western part of the city. The South West Area Plan will lead to the development of more detailed structure plans, as necessary, together with changes which will be made to the City Plan through the formal statutory processes.

Phase 1 in the preparation of the Area Plan comprises technical studies which inform the development of three documents in Phase 2, an integrated catchment management plan, a 'greenprint' and a statement of issues. A greenprint is defined as the minimum area needed to be kept free from development in order to protect important natural, cultural, spiritual and heritage values (Christchurch City Council, 2003). It will identify non-negotiable areas for development and other constraints and assist in generating land use options. Phase 3 reviews and analyses the investigations and studies with a view to producing the Area Plan, which will present a preferred land use option, in Phase 4. Similarly, the structure plans developed as part of implementation will be derived by testing the alternative concepts arising out of the preferred land use option identified in the Area Plan. Structure plans in this context will show physical features such as roads, reserves, other land use features, surface water management requirements and cost share information for stakeholders.

What is of interest for LIUDD implementation is that a particular form of local tiering is emerging which combines both statutory and non-statutory plans, meeting requirements under the Resource Management 1991 and Local Government Act 2002. The tiering reflects a partial hierarchy of purpose that informs policy making and implementation to meet a range of council functions and requirements, moving from the strategic overview to more detailed land use planning and implementation as required (Dixon, 2005). While the Area Plan sits effectively above a raft of specific-purpose or functional plans, these plans will be developed sequentially and inform several dimensions of the development process in a complementary, rather than hierarchical way, assisting integration across the Council.

4.2 STRUCTURE PLANS

As noted above, while not mandatory, structure plans are a tool increasingly used by councils to assist with detailed planning of greenfield sites. In part they are a direct response to the effects-based nature of the statutory landuse planning system, with its focus on managing effects rather than prescribing land use patterns. There is no standard methodology so that format and outcomes are not prescribed by statute or customary practice which might stifle LIUDD innovation. As a planning tool they can be quite flexible, issue-specific or comprehensive, depending on local circumstances. Community participation can be readily incorporated in the development of

the structure plan and is usually provided for by councils. Indeed, communities can have a second opportunity to become involved if the structure plan becomes part of a plan change which is publicly notified. These plans have considerable potential to incorporate LIUDD principles on a catchment basis. They do, however, need to be developed within a strategic context, as demonstrated by the experience of developing the Proposed Taupo West Structure Plan. Further development of this plan has now been delayed by the Taupo District Council pending the preparation of a 'district-wide growth management strategy'.

On the one hand, the proliferation of terms such as 'structure plans' and 'neighbourhood plans' being used in different ways around the country can be confusing for the professional and development communities. On the other hand, these documents may well add considerable clarity and justification for more targeted intervention in an effects-based context where councils wish to be more proactive in shaping the long term development of their city or district.

4.3 INTEGRATED CATCHMENT MANAGEMENT PLANS (ICMP)

A third type of plan which has significant potential for LIUDD implementation is the Integrated Catchment Plan. Two types of integrated catchment management plans are typically used and are sometimes mistaken for each other. The engineering profession uses ICMPs as a framework for comprehensive stormwater or wastewater network design. Communities and resource management professionals develop ICMPs as a means of identifying resource management conflicts within a catchment, followed by prioritisation of actions to resolve these. The catchment context for low impact design cannot be overemphasised. For LIUDD (and LIRRDD) to succeed in incorporating the water cycle into urban design, professionals other than engineers and environmental scientists, particularly planners, must learn to design and manage in this context. The community typically finds the catchment an easy concept to understand and work with. In New Zealand, the wave of successful community initiated coastal catchment management projects, particularly over the last eight years, has been largely patterned on the Atlantic Coastal Action Programme in Nova Scotia, Canada (ACAP, 1998) and Landcare Trust initiatives in both Australia and New Zealand.

5 BARRIERS TO UPTAKE AND IMPLEMENTATION

The implementation of LIUDD is a complex matter and requires input from a range of disciplines. Thus no one individual has the skill base to address all the issues required and in consequence a team approach is needed. This team approach is rarely adequately resourced in respect of time, skills and funding to carry out the task. For example, developers proposing more innovative projects can find it difficult to obtain the necessary input from staff in district councils. Similarly, small consultancies may not always have the necessary design expertise. Further the issue can be compounded by jurisdictional boundaries and different functions of regional and district councils which can easily deter integrated approaches to environmental management at a strategic level, unless there is commitment on the part of councils and staff to implement agreed strategies. There are several issues that we have identified as potential barriers to the uptake of LIUDD practices (Eason et al., 2004). Some of these are being addressed through our research programme.

First, there is often a short-term planning horizon adopted by councils in response to strong pressures from the development sector and demands by communities for more residential housing opportunities. Unless there is an agreed growth strategy in place, this approach can result in decisions and actions which can make the adoption of integrated environmental management and innovative practices problematic. The process adopted by Christchurch City Council and current implementation of the Auckland Regional Growth Strategy are examples of where strategies are or will be embedded in council statutory and non-statutory plans to guide future growth. Thus, development of greenfield sites at local levels will take place within a context of key decisions on strategic issues such as protection of environmentally sensitive areas, integration with transportation and other infrastructure considerations, and so on.

Second, the adoption of alternative approaches to development requires strong advocacy and promotion on the part of professionals and councils along with acceptance by the development industry. The process of changing practices requires education of key participants through upskilling of practitioners along with greater awareness on the part of the developers. A pilot study exploring developers' understanding of sustainable design demonstrated a wide variation in their appreciation of principles and practices (Heslop et al., 2003). Influencing tertiary education programmes is critical for influencing new generations of professionals, such as engineers and

planners, along with the provision of professional development training for those already in practice. Demonstration projects where councils and developers work together can also be effective ways of encouraging uptake of new practices, as well as providing opportunities to trial and improve implementation of new techniques.

Third, attention needs to be given to the raft of requirements in place within councils. These can relate to the content of plans, provision of incentives, as well as tackling risk and liability issues. For example, developers report with some frustration that it is easier to meet district plan requirements than to put up proposals for more innovative approaches (Heslop et al., 2003). Proposing developments that do not totally conform with council requirements is likely to create delays in processing and obtaining necessary consents, and in turn, have adverse implications for the financing of projects. An inherent tension lies in the often poor fit between relatively simplistic plan provisions and the complexity and diversity of ecological processes. Solving this tension requires flexibility on the part of councils which cannot always be achieved given the content of plans.

Fourth, the provision of incentives by councils would also assist the uptake of new approaches, for example the use of rainwater as part of a dual water supply to implement LIUDD principles. This would reduce the demand for treated water as well as acting to detain stormwater. Currently, North Shore City Council is trialling the retrofitting of tanks in an established residential street. A fifth issue is that the avoidance of risk and liability possibilities has created an attitude where innovation is stifled. New systems for stormwater management, disposal of human wastes (clivus multrum) and re-use of greywater are often held back because of fear by local government of being sued or faced with major public health problems.

Finally, a major barrier to implementation of alternative stormwater management devices is limited information on the effectiveness and long-term maintenance costs of these devices, along with consideration of how these costs might be apportioned to councils and homeowners. This forms one of the key research themes for the CUES group and research results will provide some answers on the economics and ongoing effectiveness of alternative approaches.

6 CONCLUSION

LIUDD is very much a work in progress and is rapidly evolving. The inclusion of fields such as urban design signals significant new steps in the broadening of LIUDD to become an integrated design and development process (van Roon, 2005). The recent publication of the New Zealand Urban Design Protocol (Ministry for the Environment, 2005) adds a new incentive to strengthen the relationships of LIUDD with urban design, sustainable design and planning. Most importantly, the uptake of LIUDD principles and practices requires greater awareness of ecological processes and their temporal dimensions by practitioners along with an appreciation of the importance of catchments as an appropriate unit for planning and assessment purposes. A key driver for LIUDD in New Zealand is the need to improve the quality of receiving waters, thereby meeting increasing community expectations for high standards of life sustaining resources.

An important issue in respect of changing plans and practices is the need to improve the capacity of practitioners in understanding the complexity and diversity of ecological processes, as well as the effects of human activities on natural systems. The checklist that is being developed in the course of the research will assist to draw attention to some critical principles. A key challenge will then be to ensure that LIUDD becomes fully integrated in local government planning processes through the rafts of plans and practices as noted in Table 3. This will require strong advocacy by key influencers and implementers. In addition, we observe that capacity-building and advocacy is contingent on adequate staffing and support which, in many councils, is already stretched and under-resourced.

The next stage of the research will focus on the further development and refinement of LIUDD principles, identifying any gaps and inconsistencies, and seeking feedback. There is need for input from Tangata Whenua in refining the principles. In addition, the translation of the scientific, economic and technical data from the research programme into readily understood policies and practices will be assisted by our national task force and group of stakeholders. Attention will also be given to how the uptake of LIUDD principles might be monitored. While the programme is now well underway, it will be some time before the impact of our research findings can be comprehensively determined. However, we can already cite examples of where our recommendations have influenced council practices and processes through the adoption of new concepts, approaches and tools.

ACKNOWLEDGEMENTS

We would like to warmly acknowledge the support of Taupo District Council in enabling us to participate in the development of the Proposed Taupo West Structure Plan. We are also grateful for the support of the New Zealand Foundation for Research, Science and Technology in funding the LIUDD programme.

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