Applying Low Impact (Water Sensitive) Design in Nelson Tasman

Envirolink Advice Grant:
CO9X1518, 1665-TSDC125

Applying Low Impact (Water Sensitive) design – in Nelson Tasman

Robyn Simcock

Landcare Research

Jan Heijs

Morphum Environmental Ltd

Prepared for:

Tasman District Council and Nelson City Council

189 Queen Street
Private Bag 4
Richmond, Nelson 7050
New Zealand

June 2016

Landcare Research, 231 Morrin Road, St Johns, Private Bag 92170, Auckland 1142, New Zealand, Ph +64 9 574 4100, www.landcareresearch.co.nz

Morphum Environmental Ltd., 3 Wensley Road, Richmond, PO Box 3681, Richmond 7050, New Zealand. Ph +64 21 354782, +64 9 377 9779 (Auckland Landline), www.morphum.com

Reviewed by:	*Approved for release by:*
Ian Lynn Scientist Landcare Research	Suzie Greenhalgh Portfolio Leader – Supporting Business & Policy Landcare Research
Landcare Research Contract Report:	LC2606

Disclaimer

This report has been prepared by Landcare Research for Nelson City Council and Tasman District Council. If used by other parties, no warranty or representation is given as to its accuracy and no liability is accepted for loss or damage arising directly or indirectly from reliance on the information in it.

Contents

Summary

Project and Client

- Nelson City and Tasman District Councils are developing a joint Land Development Manual (LDM). This Manual is increasing the emphasis on Low Impact Design[1] (LID) to ensure post-development water flows do not exacerbate flooding risk, help protect local waterways (quantity and quality), and reduce the risk of non-compliance with new freshwater limits.

Objectives

- Present LID advice based on assessment of the Councils' current LDMs and on-the-ground installed LID practices, supported by interviews. This included looking for areas that inhibit the application of LID and to provide recommendations for the best opportunities for step changes.
- Provide LID advice to the joint council LDM Steering Group through a report, presentation, and site field visits.

Methods

- Review current LDMs, assess a range of LID devices identified by Council, interview staff from Council, contractors and stakeholders, and present LID overview and findings to LDM Steering Group.

Results

- The Nelson and Tasman area has had a relatively wide range of individual LID stormwater devices installed over the last decade. Most of the devices are designed to reduce flows in areas where the existing primary stormwater system has limited capacity. They therefore reduce additional flood risk by slowing the rate at which runoff enters the network and reducing the total volume of stormwater runoff. Many of the devices also improve water quality and provide amenity through 'greening' as an additional benefit. The most common devices are swales, with either mown grass or native plantings, treating runoff from roads and carparks. Dry infiltration basins are also relatively common; most of these are also mown grass but some include areas of native wetland plants. Some issues were seen related to design and constructions errors and maintenance that have compromised the effectivity of these devices. Relatively small changes in design and maintenance would enhance the performance

---

[1] Low Impact Design is similar in concept and detail to a range of other methodologies that have developed in different parts of the world such as Water Sensitive Urban Design (WSUD), Sustainable Urban Drainage Systems (SuDS), Low Impact Design and Development (LIDD), "Green", "sustainable" or "natural" infrastructure etc.

of swales and wetland infiltration basins. For example, increasing swale depth, infiltration rate, and plant height and altering plant species would increase initial abstraction volume, infiltration and retention (and probably evapotranspiration losses).

- The location of devices in roadsides and public space allows efficient monitoring and increases the certainty of consistent maintenance approach because parks contractors maintain plants in public devices. Parks staff generally support public green space that manages stormwater as long as outcomes do not compromise parks/reserve objectives (aesthetic, ecological and/or recreational). They seek specific guidance on plant choice and maintenance practices for stormwater performance. For example, specific inlet maintenance, suitable mulching materials and mowing heights. Parks staff can inform the design and plant species specific for stormwater devices vested to Councils to achieve agreed (usually low) levels of maintenance and specific stormwater requirements. A second design priority is to ensure road devices can be maintained without closing traffic lanes or requiring road controls, given traffic controls inflate maintenance costs, particularly for regular mowing. Roading engineers are most concerned about maintenance costs, avoiding water or vegetation roots impacting road subgrades, and practicalities of driveway crossings. Developers are concerned about the delays and uncertainties experienced in consenting subdivisions with LID, and risks associated with their implementation relative to competitors who may not be faced with the same requirements, e.g. avoiding constraints on titles requiring private devices.
- The Nelson and Tasman area has examples of stormwater management using riparian green fingers (riparian overland flow paths) that receive dispersed flow from adjacent roads. In many cases stormwater quality performance in such areas could be enhanced by altering vegetation and ensuring more even dispersion of flow across these zones, and increasing retention within these public recreational spaces.
- Few examples of green landscaping, raingarden planter boxes, tree pits, and wetlands are present in the region. However, there are several established, relatively large, living roofs of tussock and pasture sod on commercial buildings near Mapua and in Golden Bay.

Conclusions and Recommendations

- The Nelson and Tasman areas have high-quality examples of the main individual LID devices using native plant species and green-fingers riparian overland flow paths. These can form the base for consultation, training, monitoring, and promotion.
- The Councils want a dual approach that achieves a 'least regrets' and small interim steps approach. The recommended approach is first to build on the LID principles in existing Nelson guidance, and include the rationale for strengthening the use of LID in the region through the new joint LDM. Second, we recommend focusing on a few devices that:
    - can build on existing implemented practices and installed devices (i.e. an incremental change with local sites people can visit for community/business acceptability)

  - are future proof for impending freshwater changes by providing stormwater quality treatment at low cost
  - can be designed to achieve low to medium maintenance costs with existing equipment, with minimum additional training, and
  - have flexibility for retrofitting at lower cost in cases where higher stormwater quality and or quality is needed in future.
- The recommended devices for **greenfields** are 'green fingers' of enhanced riparian overland flow paths fed by swales and level spreaders. In these areas stormwater volume can be attenuated with infiltration wetlands adjacent to the riparian zones and/or raingardens beside roads to enhance amenity of recreation and transport corridors. Wetlands and swales suit areas with high water tables or low subsoil permeability and low slope; lined raingardens are more suited to freely draining and more steeply sloping sites.
- The recommended devices for **brownfields** retrofits and redevelopments are bioretention devices in public spaces, allowing maintenance to an agreed standard:
  - Along roads – swales linked to lined/unlined exfiltration tree pits /raingardens, especially maximising the enhanced evapotranspiration performance provided by retaining existing tree canopy along streets (this makes existing road verge work for dual uses)
  - For carparks and large impervious surfaces (industrial/big box) – raingardens with exfiltration where conditions allow (this allows reduced area footprint)
  - In highly impervious urban spaces (and high water tables) – planter boxes fed from roof water (smallest area footprint, multiple use of edging for traffic separation, physical tree protection)
  - Private spaces – dual-purpose rain tanks and green roofs can also make a significant contribution in private spaces. Unlike permeable paving and rain tanks, green roofs are less vulnerable to removal by people.
  - General landscaping – the contribution of general landscaping for stormwater mitigation can be enhanced across the brownfields areas by lowering surfaces so they are below footpaths and carparks and using roof water for passive irrigation.
- The devices should be supported with codes of practice using existing examples to demonstrate and build local best practice including plant species selection and maintenance methods. The constraints (and opportunities) imposed by steep slopes, high water tables, and zones with sensitive soils need to be detailed with geotechnical requirements.

There is some local evidence of water quality concerns related to urban impacts on receiving water and sediment quality. There is relevant national evidence (from Christchurch and Auckland) of the impact on runoff quality of moderate-volume roads, larger carparks, and roofing materials containing copper and zinc. There is no evidence for the performance of devices in Nelson. However, there is little justification for monitoring the performance of water quality/volume outcomes of stormwater devices in Nelson, given the very high expense and overwhelming national and international literature demonstrating performance if inlets, adequate soil infiltration/permeability rates, and dense vegetation cover are maintained. A summary of the recommendations and their priority (S=short-term, M=medium-term, L=long-term) are listed in table 1.

Table 1: Recommendations to create step change in the implementation of LID in Nelson City and Tasman District

#	Recommendation	Priority (S/M/L
1	Change the order of sections in the future manual so that LID is at the front as the first tool/method to manage stormwater.	S
2	Improve wording so that it is clear LID is to be considered first, and how it is to be considered, i.e. before other more traditional stormwater management practices are allowed. A decision tree/method and a relate checklist would assist this.	S/M
3	Clearly explain what LID is in the future manual.	S
4	Align local RMA plans and the engineering standards over time.	M
5	Develop an operation and maintenance manual for LID devices.	M – adapt guides from other regions
6	Develop a plan to improve the performance and reduce maintenance costs on existing LID devices.	M
7	Provide a list of preferred plants for a range of stormwater devices, specific to this area and the location specifics as well as related maintenance instructions (as part of the O&M manual).	S
8	Design landscaped areas to receive stormwater runoff to the extent possible without compromising the objectives of the reserve (aesthetic, recreational, etc.) and to include this in the manual at the appropriate location.	M
9	Provide a Design and Construction Checklist for constructed wetlands.	M – adapt guides from other regions
10	Include water quality requirements in the LDM to protect / enhance the existing natural environment and to assist in meeting future NPS-FM requirements under a no-regrets approach.	S
11	Undertake specific investigations into local gross pollutants and implement appropriate mitigation measures.	M to L
12	Review the links between objectives, priorities and the requirements in the future LDM to achieve fit-for-purpose LID for Nelson City and Tasman District.	S to M
13	Establish a register of pre-accepted devices and their applications.	M
14	Create checklists for developers and consenting staff to help the design review, construction and 224C process to ensure good outcomes and effective processing and to reduce uncertainty for developers.	M
15	Provide for upskilling of staff and industry including training, checklists and practice notes.	S & M & L
16	Develop a planting choice document specific for a range of stormwater treatment devices in this region, and the location where applied = #7.	S & L, update as sites increase
17	Initiate a cost optimisation project considering local knowledge and (international) best practice for the maintenance of stormwater treatment devices.	M
18	Capture the costs of the maintenance activities for public devices.	M
19	Develop a spatial tool to help select fit-for-purpose LID applications, taking into account local constraints and objectives. The same tool can later also be used to justify any future plan requirements.	M to L

20	Further explore and detail the opportunity to use LID and soakage in tandem, in part to reduce flood risk.	M
21	Review the detailed LDM text and calculation rules after LID devices and tools have been confirmed.	M
22	Develop practice notes and standard approved engineering diagrams, aligned with #13.	M
23	Develop a good-practice example tour of LID devices.	S & M

1 Background

The Nelson and Tasman District Councils are developing a joint Land Development Manual (LDM) to standardise and streamline the development rules across the wider region. The manual is combining best practice from the existing engineering standards from both regions to inform and guide a regional approach across catchments and communities. To bring about improved stormwater management outcomes and behaviours, the credibility of existing best practice examples and science findings is needed to support proposed change from existing provisions that (only) encourage Low Impact Design (LID) to more definite LID requirements in suitable sites. These requirements are needed to manage post-development flows and avoid or mitigate increases in stormwater temperature and contaminants. LID will enable national directions like the National Policy Statement for Freshwater Management (NPS-FM) to be given effect in a logical and constructive way by those on the ground.

The region has suffered major urban flooding in recent years, and has some 'D' grade streams[2] (which is unacceptable under the current NPS-FM grading system) in urban and rural catchments. Some streams and rivers have been impacted by discrete pollution events, such as spills and discharged into the conventional pipe network. The Nelson and Tasman region has relatively high rainfall intensities, variable soil characteristics and dispersed populations. Recommended LID techniques need to take account of these regional factors, including local capacity and likely capital and operational costs.

The project builds on limited previous Envirolink work for Nelson City Council, including the potential for street sweeping as a Best Management Practice for improving water quality. Street sweeping is not likely to occur in all areas and is unlikely to achieve desired outcomes (e.g. temperature mitigation) in others. The work will also build on a 2006 Envirolink report for Nelson City Council on Implementation of LID, a time when few LID devices had been constructed.

A small, no regrets step change is sought, based on local experiences of a variety of LID devices now installed. These experiences will help Council identify which LID techniques they want to see installed, own, and maintain in the region. A larger, more comprehensive review of LID requirements is programmed for the next review in about 3 years.

---

[2] For example, Nelson City Council 2015 'River and stream health report' shows grades at monitored sites http://nelson.govt.nz/assets/Environment/Downloads/scorecards/2014/River-Stream-Health-Scorecard-2014-15.pdf. The Parliamentary Commissioner for the Environment (2015) released an analysis of the 2014 NPS on Freshwater Reforms and its 'bottom lines' for water quality http://www.pce.parliament.nz/media/pdfs/Managing-water-quality-web.pdf

2 Objectives

The Nelson City Council (NCC) and the Tasman District Council (TDC) requested Low Impact Design advice based on international best practice to support the development of a Joint Nelson Tasman Land Development Manual. This Envirolink project had four specific deliverables:

- Review the current engineering requirements in the area. Document areas that inhibit LID and opportunities for a step change in requirements.
- Use interviews and field visits to confirm and capture local LID priorities, limitations, and opportunities within the area. A joint Council LDM Steering Group presentation was followed by a Council-sponsored field tour of local LID sites.
- Develop recommendations for the 2016 LDM section on LID, and stormwater engineering requirements/objectives. Identify supporting material required so any changes to the manual are well justified.
- Provide information for Council (staff and Steering Group) on the national and international LID best practice.

3 Methods

Current engineering requirements in Nelson (Chapter 5 of LDM Nelson City Council, 2010) and Tasman (Chapter 7 of Engineering Standards and Policies, Tasman District Council 2013) were reviewed. Technical drawings were *not* reviewed, nor were the design criteria for individual devices reviewed, as this was beyond the scope of the medium-Envirolink project.

Interviews with Council staff were conducted in April and May 2016 in Council offices and at field LID sites. A list of sites with LID features, and in many cases engineering diagrams, was provided by the Councils. Each field site was visited by the authors, and in many cases also with Council staff. This included follow-up visits with Nelson Council Horticultural Supervisor and staff to specifically unpack issues about the maintenance and aesthetics of extensive road-side raingardens at three sites.

A draft report and matrix of devices and assessment criteria was presented at Joint LDM Steering Group. The presentation (Appendix 4) was supported by brief sheets describing each of the suggested priority LID devices (Appendix 3). Feedback was gained following the meeting and supplemented during a field trip with Joint LDM Steering Group at which key sites in Nelson and Tasman that represent a gradient from 'conventional' to intensive LID practices were visited. Four Councillors attended, as did about 20 staff from across relevant departments of both Councils, and people associated with the development industry. Specific written feedback on draft was received from stakeholders and council staff.

Information on national and international LID best practice was delivered, including by referencing recent changes and developments within LID/WSD in Auckland, particularly changes to TP10 (Appendix 7), with recent underpinning technical reports, as this guidance document is currently referenced in local LDM guidance.

Stoke riparian green finger with stream, overland flow path, plantings and public footpaths, 2011

4 Results

4.1 What is Low Impact Design?

Tasman District Council's 'Stormwater and Drainage', section 7.10.1 (pp. 28 and 29) defines 'Low Impact Design' (LID) as an approach to land development and stormwater management that recognises the value of natural systems in order to mitigate environmental impacts and enhance local amenity and ecological values. The approach promotes the use of stormwater management methods and solutions which protect, incorporate and mimic natural drainage processes of a given site or catchment[3]. This definition aligns with what is also called 'Water Sensitive Design' in New Zealand and internationally. The Council document further identifies that a Low Impact Design approach should include:

> *'a) Integrating stormwater design into the early stages of design and planning of development proposals;*
> *b) Understanding existing drainage patterns within the catchment;*
> *c) Retaining or enhancing natural drainage systems where possible;*
> *d) Minimising impervious surface cover within developments;*
> *e) Avoiding, rather than mitigating, adverse effects by managing stormwater at source (on site)*
> *f) Using natural systems and processes, such as soil infiltration and vegetation, in the management of flow and quality treatment of stormwater.*
> *g) Integrating stormwater management and disposal with other urban values, such as open-space retention and ecological, recreation and amenity benefits'*

This definition can be improved and strengthened. For example, in addition to this definition, LID should also include:

- avoiding contaminant generating surfaces by avoiding building materials with high copper and zinc concentrations
- taking opportunities to disconnect impervious areas from pipes and extend flow paths (e.g. by replacing pipes with swales, rain tanks)
- minimising earthworks and avoiding compaction where possible
- identifying and protecting permanent and intermittent streams including their riparian margins and avoiding development in floodplains (no-go-zones).

One of the main technical objectives of an LID approach can be summarized as replacing or supplementing 'peak flow control' with volume control, often expressed as controlling a 'water quality volume that limits changes in flow rate and flow duration in receiving waters.

[3] For a detailed description see Auckland Council (2015) Design Manual, General Guidance 1 'Water Sensitive Design' that includes case studies from across New Zealand http://content.aucklanddesignmanual.co.nz/design-thinking/wsd/Documents/20032015%20GD04%20WSD%20Guideline%20Document.pdf

The effects of stormwater on receiving water quality are minimised by maintaining stream channel stability, reducing runoff pollution, reducing combined sewer overflows and mimicking the pre-development runoff hydrograph (Fassman-Beck et al. 2013). Fassman-Beck et al. (2013) review international stormwater guidelines, finding jurisdictions are now addressing runoff volumes, groundwater recharge, evapotranspiration, and hydrograph timing in the post-development condition as well as peak flow mitigation. This is being achieved practically by specifying on-site retention of the 90^{th}–95^{th} percentile design storm event in addition to peak flow controls for 2 yr, 24 hr ARI and larger storm events (as was required in the old TP10, Auckland Council 2003). Stormwater mitigation requirements vary with the type of receiving water, for example: areas feeding a constrained pipe system or combined sewer would have the most stringent controls – to minimise flooding and sewer overflows; areas discharging to streams would have peak flow and quality requirements; areas discharging direct to harbours would only have quality controls. LID may also control total, or effective, impermeable surface areas – in this case a roof may be made permeable by installing a greenroof (living, planted system with minimum water retention or depth), and a carpark made permeable by installing a permeable surface with minimum subsurface water storage zone.

Where soils are permeable and stable (low erosion or slumping risk), LID generally maximises water infiltration to achieve groundwater and stream recharge. In areas with soils that have limited subsoil permeability, high water table, or unstable soils, devices are typically lined and under-drains installed to prevent infiltration and maximise evapotranspiration opportunities (e.g. incorporate trees and green or living roofs). The installation of underdrainage can be a significant capital cost component, and requires maintenance inspection. Rainwater harvesting and reuse are volume and peak flow control methods that can be used regardless of ground conditions.

4.2 LID and the Current Land Development Manual Review

LID is provided for in both current Nelson (2010) and Tasman (2013) Land Development Manual (LDM)s; however, both use the term 'stormwater disposal'. The LDM also infers a piped network rather than use of natural assets for stormwater management. Using 'disposal' and 'pipes' means stormwater is treated as a problem to remove from site, not as a resource that can be used to support stream base flow, sustain wetlands and vegetation, and reduce demands on potable water.

The current LID words in the LDM are reasonable but too weak to drive effective action. This lack of 'imperative', combined with lack of objectives in Nelson LDM 7.1.1 justifying why LID and protection of natural stormwater assets (floodplains, streams, wetlands) are impediment to uptake of LID. Much of TDC (2013) reads as if LID is introduced as an afterthought. Uptake is voluntary. Similarly, although the LID section in Nelson LDM is generally very good, its location towards the back of one of the documents makes it look like a 'nice to have' option. See also section 5.1 and Appendix 6.

Recommendation 1. **Change the order of sections in the future manual so that LID is at the front as the first tool/method to manage stormwater.**

Recommendation 2. **Improve wording so that it is clear LID is to be considered first, and how it is to be considered, before other more traditional stormwater management practices are allowed. A decision tree/method and a relate checklist would assist this. Treatment devices are only part of this process.**

The following two objectives would make a difference, if introduced to the equivalent of 7.1.1 (TDC 2013):

‘a) Because a large part of stormwater runoff (quality and quantity) is determined by land use, and because it is much more expensive to retrospectively mitigate, the following are to be considered first, starting at the planning stage 1) avoiding increases in flood flows and volumes, 2) avoiding generating contaminated stormwater, then 3) treatment at source.

b) The retention, use and enhancement4 of natural assets such as streams and wetlands, floodplains and overland flow paths is preferred’

Not having objectives such as a) and b) indirectly inhibits the application of LID because it provides for an easy way to apply traditional solutions. Similarly, including references in the introduction of Nelson City Council (NCC) development manual, Section 5.1 to flooding, stream erosion, loss of streams and degraded stream health/swim-ability, and key sources of pollution would be useful to justify stormwater management objectives and requirements by the use of LID practices.

The understanding of what is, and is not, LID varies widely. Clarification would be very helpful (Fig. 1).

Figure 1: What LID includes (extract from LDM Steering Group presentation, Appendix 4).

[4] Enhancement does not mean extensive earthworks to create in-stream engineered topography; it means amending soils and vegetation with limited earthworks

Recommendation 3. Clearly explain what LID is in the future manual.

The range of devices and overall approach in both LDMs is limited. TDC (2013) lists just rain tanks and raingardens. Many other LID tools are available at the different stages of the planning and design process, particularly those related to site-layout/design, retained overland flow paths and retained stream/riparian areas. Examples of how LID can be applied at every stage in the design process can be shown in the flow diagram shown in Figure 2 (from Lewis et al. 2015).

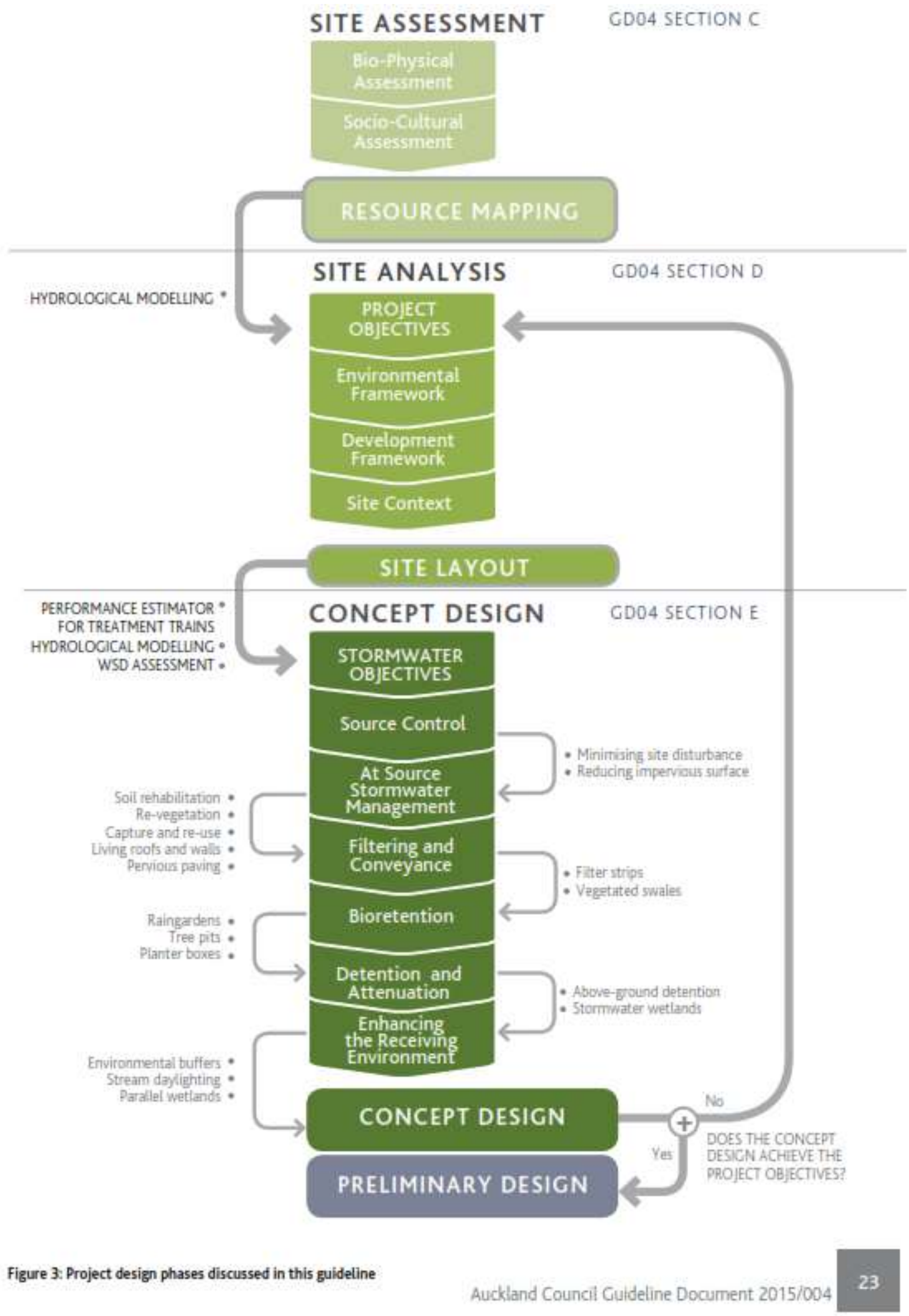


Figure 2: How LID 'devices' fit into an overall LID design process.

It is important that the local RMA plans and the engineering standards get aligned over time because most of the controls to manage potential effects from stormwater runoff effectively are related to the use of the land and human activities, before stormwater reaches the reticulation, as illustrated in Figure 3. These are (in part) governed by land-use requirements. Therefore LID requirements need to be applied throughout the entire design process and aim to use stormwater as a valuable resource.

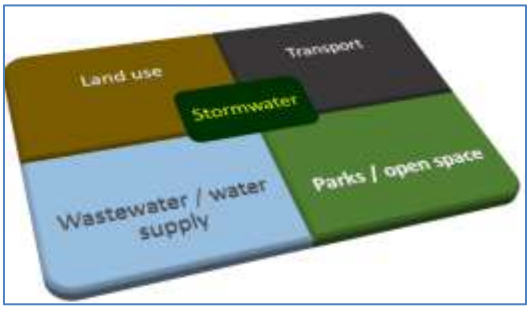


Figure 3: Stormwater network management can't manage stormwater alone (extract from extract from LDM Steering Group presentation, Appendix 4).

Recommendation 4. Align local RMA plans and the engineering standards over time.

Detailed comments on the existing standards, Chapter 7 of Tasman LDM 2013 and Nelson City Council 2010 are provided in Appendix 6.

4.3 Current LID practices in Nelson – Tasman

The Nelson and Tasman area has a relatively wide range of individual LID stormwater devices or 'green infrastructure' installed over the last decade. Most of the devices are designed to reduce flows in areas where the existing primary stormwater system has limited capacity. The devices therefore reduce additional flood risk by slowing the rate and total volume of storm runoff. Many of the devices also improve water quality and provide amenity through 'greening' as an additional benefit. The most common devices are swales[5] (mown or planted with variable soil depth) and bioretention devices that treat runoff from roads and carparks, and infiltration basins.

Effective, large-scale swales that are well-established with dense filtering plant cover include the main road, Stoke (Fig. 4) and Frenchay Drive. Conventional grass swales are installed at Saddleback Road, Todds Valley, Richmond pool complex, and beside the riparian strip on Sanctuary Drive. However, the grass is mown too short in most cases, as the minimum design height is usually 100 mm. The attractiveness and function of some of the grassed swales are enhanced with specimen trees. Relatively small changes in design and

[5] One page descriptions of these devices written for the Nelson City Council and the Tasman District Council are provided in Appendix Two as 'Bioretention Device Introduction Sheets'

maintenance would further enhance the performance of some swales (see recommendation 6 below), for example, by increasing the infiltration rate, raising the mowing height or replacing grass with unmown groundcovers to slow stormwater velocity and boost the volume infiltrated, retained, and detained (and evapotranspiration). An operation and maintenance manual for stormwater treatment devices that can also be referred to in a 'specification for maintenance contract' and upskilling of regulatory and operational staff and the industry is expected to improve the functionality and appearance of existing and future devices.

Figure 4. Planted swale on high-capacity road in Stoke (April 2016). The dense cover of native sedges and small flaxes avoids the traffic disruption of frequent mowing and is a more effective buffer against traffic for pedestrians.

Recommendation 5. Develop an operation and maintenance manual for LID devices.

Bioretention devices are called a variety of names in engineering diagrams including raingardens, planted gabion baskets, planted gardens, and landscaped drains. Large raingardens with native plantings that to the uninformed or casual view appear little different from conventional landscaping can be seen at Harvey Norman Nelson, NMIT Nelson, and Sundial Square in Richmond.

A common failing on the sites visited was kerb-inlets just before the entry into the treatment devices (Fig. 5). This largely prevents devices receive runoff. Other common failings included soil levels being at or above the surrounding hard surfaces, which also prevents runoff entering the device (Fig. 6). Lack of ponding depth in raingardens and/or outlets, or overflows at a too low a level results in reduced storage and loss of valuable flood mitigation potential. Most if not all of these failings can be easily rectified at relatively low cost.

Figure 5: A design defect kerb inlet just before inlet to device.

Figure 6: A construction defect. Ground level in device higher then surrounding hard surfaces impeding inflow.

Recommendation 6. **Develop a plan to improve the performance and reduce maintenance costs on existing LID devices.**

Another area of concern at some sites is the choice of plants and consequent reduced aesthetics and increased maintenance requirement where plantings (and mulches) were unable to supress weeds. In some cases this led to groundcovers being sprayed out and replaced with rock mulch (e.g. Brambley Estate central swales and the edges of the older Sanctuary Drive raingardens). Plant size and location within devices also needed to be more carefully matched to reduce the need for frequent trimming to maintain road and footpath space.

Recommendation 7. **Provide a list of preferred plants for a range of stormwater devices, specific to this area and the location specifics as well as related maintenance instructions (as part of the O&M manual suggested before).**

Most Nelson and Tasman LID devices are in roadsides and public space (Figs. 4 to 6, Appendix 3). This location allows efficient (visual) monitoring and this can reduce the risk of poor performance of the device. Parks contractors maintain public devices and other road side reserves. Often landscaped areas are designed with ground levels well above surrounding hard surfaces. While this approach assists drainage in wet areas, and allows space for imported soil in degraded urban areas, it also increases the need for irrigation. Parks staff generally support creating public green space that also benefits stormwater management, if the area is designed with agreed maintenance to the forefront, and achieves acceptable aesthetics and ecological outcomes. They seek specific guidance on effective practices to enhance stormwater performance (i.e. over and above aesthetics). For example, specific inlet maintenance, suitable mulching materials and mowing heights. Parks experience can inform design and plant species that help ensure devices vested to Councils have agreed (usually preferably low) levels of maintenance.

Recommendation 8. **Design landscaped areas to receive stormwater runoff to the extent possible without compromising the objectives of the reserve (aesthetic, recreational, etc.) and to include this in the manual at the appropriate location.**

Although these areas are not specific LID devices, they can contribute to reduced flooding risks and protecting stream health.

Dry ponds or detention basins are relatively common. Some only receive stormwater from events of a minimum size, and are valuable public playing fields (formal recreational spaces). Other areas have been converted from boggy grass that was difficult to maintain, to native sedge and wetland species. In a few cases, wetlands have been created, a notable example being the Richmond Pool Complex. This wetland does not include a sediment forebay, as a grass swale provides initial treatment.

Recommendation 9. Provide a Design and Construction Checklist for constructed wetlands.

4.4 Nelson–Tasman priorities, limitations and opportunities

There are three stormwater priorities in the Nelson–Tasman area:

- managing peak flow and volume
- minimising stream removal, and
- protecting or enhancing water quality.

Priority 1

Managing peak flows and volumes is the primary priority because there are significant zones where the current primary network has insufficient capacity, along with loss or blockage of secondary overland flow paths/existing floodplains and new development upstream of existing urban areas. These factors have combined with rainfall variability to create increased flooding risks. Intensification and greenfield development leading to increased impermeable areas means the volume discharged needs to be reduced and the rate of discharge slowed in these areas to avoid further exacerbating flooding.

> *'Higher runoff post development can directly lead to flooding of downstream properties within flow paths. Traditional mitigation of flow rate by matching pre-and post-development peak flowrates avoids this direct flood risk but fails to achieve stream protection during to the extended duration of the high flow. Therefore, the correct solution to this is to limit the post development flowrate to the level that the in-stream environment can withstand without damage.' (LDM Draft May 16)*

We agree with this wording – LID will significantly help avoid and reduce flood risks.

Priority 2

Avoid stream removal, stream piping, and wetland removal, and retain overland flow paths and flood plains.

Piping of streams often increases flooding risk, as the natural hydraulic capacity of the stream is often reduced. Stream removal (including first order headwater streams), piping and channeling also leads to reduced health of the remaining streams. Not protecting (natural) overland flow paths also leads to increased flooding risks. Increased flows as referred to under priority 1 are also responsible for stream erosion and poor stream health.

Protecting streams and their riparian margins, protecting overland flow paths, and not building in floodplains is an essential part of the LID approach and underpins protection of the Nelson and Tasman natural environment.

Priority 3

Maintaining and improving water quality, especially in streams already compromised by urban development and/or not reaching national freshwater standards. This includes protection of streams from acute (spill) events through direct discharges from the piped stormwater network by disconnecting source areas. High temperature is a contaminant in summer, with small streams receiving runoff from urban areas (particularly carparks and unshaded streets) being most vulnerable.

Although the NPS FM is not yet translated in specific planning rules and other actions in the Nelson Tasman area, the application of LID is highly consistent with the intent of the NPS. Retrospective mitigation at a later stage will be much more expensive than applying LID now. Applying LID now is therefore consistent with a 'least-regrets' approach.

Recommendation 10. **Include water quality requirements in the LDM to protect / enhance the existing natural environment and to assist in meeting future NPS-FM requirements under a no-regrets approach.**

Urban areas and roads are also sources of gross stormwater pollutants, defined as particles >5 mm diameter (Fitzgerald and Bird 2010). The majority of gross pollutants is typically vegetation, although this fluctuates seasonally, being higher in autumn. Australian research on urban gross pollutants by Allison et al. (1998a, b) is generally consistent with New Zealand studies quantifying catchpit and street sweepings across New Zealand (Depree 2008; Pennington and Kennedy 2008, Mayson et al. 2010). The Allison et al. study also reports that about 30% of the gross pollutant load entering the drainage network in commercial urban areas were food and drink refuse from fast-food outlets, and cigarettes. Concentrations of these gross pollutants were highest during 'first flush' but most load was transported in floods. Further intensification is proposed for both Nelson and Richmond and this could lead to higher gross pollutants. However, waste management education may be the prime response.

Recommendation 11. **Undertake specific investigations into local gross pollutants and implement appropriate mitigation measures.**

Although an assessment of water quality in Nelson and Tasman was out of scope of this report, some sources include a River Water Quality Report (TDC[6], pp. 60–62, 76–78, and 116–118 as an example of urban streams) and a committee report: "Impact of Discharges from Stormwater Systems on Streams and Estuary Margins in Richmond: 2010 - Report Rep10-07-07". This further justifies the need to include quality treatment in addition to the need to control quantity to mitigate flood risk (see recommendation 10).

Recommendation 12. **Review the links between issues, objectives, priorities and the requirements in the future LD manual to achieve fit-for-purpose LID for the Nelson and Tasman Councils.**

4.5 National and international LID practice

In general, LID is increasingly promoted and required across the world (Dietz and Clausen 2008). Over the last 10 years more and more authorities in the UK, China, the USA, and many other areas are requiring LID. Although LID was often related to improving environmental outcomes, they are now also required to help address flooding risk often in response to major flooding events. There is also an increasing call for more green-infrastructure, providing many benefits not just for stormwater (Morgan et al. 2013, EPA 2016, Loci Environment and Place Inc 2016, Wong 2006). LID is a subset of green infrastructure (Ahiablame et al. 2012, Lewis et al. 2015).

Within New Zealand, in addition to the design objectives listed in section 4.1, there are four key changes in LID practice.

- A strong move towards use of wetlands with high plant cover, labyrinthine (tortuous) water flow paths, and varied depth (bathymetry), including areas with permanent water. This is associated with a move away from ponds (at least in Auckland). Wet ponds have many undesirable side effects where water quality and stream erosion are important to protect. Ponds are associated with high temperature, provide only peak flow control, little to no volume reductions, and have proved only limited use in reducing stream erosion. Wetlands have lower public risk (due to densely vegetated, wide margins, and shallow water). Both ponds and wetlands should be off-line and both should have easily accessible sediment forebays to extend longevity.
- Nationally, there is a move in Christchurch and Auckland to prioritising targeted source control by identifying and reducing where possible contaminant generating areas where possible. In Auckland, the proposed Unitary Plan targets roads with >5000 vehicles per day, structures with copper and zinc cladding, and carparks with more than 50 vehicle movements per day. Within a site, this means placing devices near areas generating the highest contaminants (e.g. corners or roads where tyre wear, accelerating and braking and load spills are highest).

[6] http://www.tasman.govt.nz/document/serve/StateoftheEnvironmentRiverWaterQualityinTasmanDistrict2015December.pdf?path=/EDMS/Public/Other/Environment/EnvironmentalMonitoring/WaterMonitoring/SurfaceWater/RiverWater/StateOfEnvironmentReports/2015/000000432260

- Multiple use of public open space by creating parks that receive and treat stormwater but also contribute to aesthetics and human health through passive recreation or biodiversity.
- A focus on using LID treatment suites rather than individual devices. Using a variety of devices provides resilience and takes advantage of the strengths of different devices and receiving environments (see Fig. 7).

	CONTAMINANT				TREATMENT RESPONSE						
Contaminants	Particle size	Associated sediments		Treatment process	Gross pollutant trapping	Sedimentation (pond & basins)	Filtration (swale & filter strips)	Constructed wetlands	Bioretention	Infiltration	Subsurface wetland
Sediment litter organics	>5 mm	**Particulates**	Gravels	Screening							
Fine sediment Suspended sediment Particulate metals Hydrocarbons Organic films	125 µm - 5 mm		Fine gravel to sand	Sedimentation							
	10 - 125 µm		Sand to fine silt	Sedimentation							
				Filtration and adhesion							
	0.45 - 10 µm	**Soluble**	Fine silt to fine clays								
Soluble organics Nutrients Pesticides Pathogens	<0.45 µm		Very fine clays	Micro-biological and chemical							

Figure 7: Targeted treatment of stormwater contaminants (Figure 38 in GD04 Auckland Council 2015).

Existing Nelson and Tasman (and other) guidance refers to Auckland Council 'TP10', design guidance for stormwater treatment devices. Changes to TP10 are being issued in 2016/17 as General Guidance 1 (GD01, see Appendix 7 for a summary of changes). GD01 will be a live electronic document. The design guidance takes into account Auckland and international research over the 10^{+} years since TP10 was published, and the change in focus from 75% Total Suspended Solids removal to include temperature and heavy metals. Nutrients are contaminants of freshwater in Nelson and Tasman, but not specifically considered in Auckland design guidance. The bioretention guidance allows a reduced depth of media – where matching to specific outcomes and plants – and inclusion of an Internal Water Storage below the root zone to improve volume mitigation and infiltration to underlying, low-permeability soils.

An international practice not seen in New Zealand, is an emphasis on trees for stormwater mitigation, both individually and as part of conventional stormwater devices. Mitigation is based on providing a minimum root volume/depth and quality for new trees, and on protecting the minimum spread and height of canopy for older trees. In some cities a 'treebate' is provided, being a discount on annual general rates, or specific stormwater rates, based on tree properties. This may be also be linked with city-wide tree canopy cover targets designed to enhance urban liveability and/or moderate peak summer temperatures, e.g. Portland, Oregon (Fig. 8) and Vancouver.

Figure 8: Raingardens with trees used to separate cycle storage areas and pedestrians and create pleasant urban spaces in Portland, Oregon.

4.6 Issues that inhibit the application of LID in Nelson / Tasman

The Nelson and Tasman Councils want a dual approach that achieves a 'least regrets' and small interim steps approach. The recommended approach is first to build on the LID principles in existing Nelson guidance, and include the rationale for strengthening the use of LID in the region through the new joint LDM.

The current LID words in the existing engineering requirements are reasonable but ultimately too weak to drive effective action. The range of devices and overall approach is limited, particularly in the Tasman District Council. In addition, many other tools are available at the different stages of the planning and design process. LID therefore needs to be mandated, but this needs to be supported with the following:

- detailed rationale for LID (see recommendation 1, recommendation 2, recommendation 3).
- a pre-approved list of acceptable, i.e. Council 'approved option, including planting suggestions[7]
- check lists for Council approval at design, construction, and at 224C sign-off that cover critical design features influencing performance and long-term maintenance/renewal. A design check list would help ensure the safety and long term maintenance costs of public devices are carefully considered.

A second block to LID uptake in some cases is increased Council approval time processing consents that contain LID features. Delays in consenting developments with LID (requests for additional information, etc.), and the uncertainty whether or not the proposals will be approved, substantially increase risk of developers, especially in a competitive market. Overseas, LID has been deliberately advantaged by allowing developments with LID to be fast-tracked and prioritised. Use of pre-accepted devices may help reduce delays. Other solutions include staff training, clear checklists, and clarity of stormwater requirements to minimise requests for additional information.

Recommendation 13. **Establish a register of pre-accepted devices and their applications.**

Recommendation 14. **Create checklists for developers and consenting staff to assist in the design review, construction and 224C process, to ensure good outcomes, effective processing and to reduce uncertainty for developers.**

Recommendation 15. **Provide for upskilling of staff and industry including training, checklists and practice notes.**

[7] 'Living Heritage' was published in August 2003 by the Department of Conservation and Nelson City Council. It describes eight ecosystems in the Nelson city area and provides advice on species and planting. The 'fresh water wetlands' and 'coastal flats and alluvial terraces' ecosystems have many plants suitable for LID devices. http://nelson.govt.nz/environment/biodiversity-2/nelson-nature/resources/living-heritage-plant-guide

A third major blockage is concern about the maintenance costs for council-vested devices and, in some cases, poor aesthetic results, especially where they trigger community complaints. This can be addressed to some extent by examining costs of existing mature devices, and by applying knowledge of local parks and engineering staff in the context of local sites to develop checklists for design, installation, and a transparent signoff procedure for vested council assets that includes inspections during construction. The Nelson and Tasman districts have high-quality examples of the main individual LID devices using native plant species and green-fingers riparian overland flow paths. These can form the base for LID design checklists, consultation, training, monitoring and promotion.

Recommendation 16. **Develop a planting choice document specific for a range of stormwater treatment devices in this region, and the location where applied.**

Recommendation 17. **Initiate a cost optimisation project considering local knowledge and (international) best practice for the maintenance of stormwater treatment devices.**

5 Overall LID design process and Preferred treatment devices

5.1 Overall design process

A matrix has been developed to help guide decisions to select treatment devices. The matrix focuses on devices. However, a developer should investigate **site-wide approaches** (e.g. source control, retention of natural areas, as suggested in Table 2 and Appendix 8) before diving into **device selection**. This approach helps set the scene for a greater move towards LID and is recommended even though many developers work backwards from a yield-maximising design, i.e. consider LID very late in design (recommendations 2 and 3 are intended to address this need).

It is also useful to require a design process using a decision-tree-type-flowchart that can be used by the developer/designer and consent staff to check whether LID opportunities have been adequately considered and maximised. The process provides certainty and reduces time consuming iterative processes (an overview and an example of a check list approach are given in Appendix 8[8]).

Table 2: Components of WSUD following the planning to implementation cycle

WSUD includes the following (from planning to design to construction to operation)	
– Develop / intensify in areas that are already compromised rather than developing in new areas (Smart Growth) – Identify natural assets such as streams, flood plains and overland flow paths, permanent and intermittent streams and their riparian margins – Identify other natural features such as the natural landform and vegetation – Protect the above identified areas when locating areas for development. – Minimise the extent (volume and footprint) of earthworks and change in contours, minimise soil compaction, topsoil removal. – Minimise the use of heavy machinery in riparian margins and other natural and open space areas to avoid (unintended) compaction. – Cluster housing and maximise (permeable) open spaces – Restore/enhance streams where required – Use vegetation and other natural features to manage and reduce runoff – Rehabilitate soil by improving infiltration capability after completion of earthworks and/or building activities	– Avoid building in floodplains and compromising overland flow paths – Minimise impervious areas on sites and roads – Minimise concentration of flows and acceleration of runoff – Minimise stream crossings and use bridges where possible, minimise stream piping for land development purposes (reclamation) – Protect Stormwater management areas, streams, riparian margins and overland flow paths in perpetuity – Provide access to natural features and watercourses – Use appropriate streetscape including minimising impervious area, maximise the use of Green Infrastructure and treat stormwater runoff using vegetated treatment devices – Avoid the use of contaminant generating construction materials – Use stormwater treatment devices as close to the source as possible such as bioretention devices – Put in place effective operation and maintenance practices for all stormwater assets (man-made and natural assets)
Note: A bunch of treatment devices is not WSUD. This is not an exhaustive list.	

[8] Even though the focus of this report is on individual devices to achieve an incremental step

5.2 A Matrix of devices

The matrix in the attached excel spreadsheet has 'devices' in rows and characteristics in columns. Columns are arranged in draft order of priority; characteristics are colour coded into green (good) and red (not contributing or not recommended). This should help more quickly identify what is not worth pursuing at a specific development; for example, where underlying soils prevent infiltration devices being used. The disadvantage of this approach is that it encourages 'cherry-picking' of devices rather than an integrated whole-site and/or treatment train approach.

Each of the devices considered most suitable for immediate use in the Nelson and Tasman area is supported by a one-pager describing the key features, with photos using local examples (Appendix 2). The aim of this is to reduce confusion across device names, given the terminology used to describe bioretention devices visited in the area varied. The case studies themselves are provided in Appendix 4. These case study sites formed the prompts for interviews and identification of design, implementation, and maintenance issues relevant for the area. In each case study particularly effective features are identified. In some cases, what would make these areas function better for stormwater volume or quality or transport are also identified, with issues that arose during construction or maintenance and how they have been or could be resolved.

Stormwater devices are only part of the LID toolkit. The devices listed in the matrix are broader than currently in the TDC document (raingardens and rain tanks). However, most of the devices have a case study field site in the Nelson and Tasman areas (Appendix 4). The core devices are bioretention swales, raingardens, vegetated overland flow paths, wetlands, and infiltration basins.

Planted swales and filter strips

Swales and filter strips primarily act to slow flow and convey water but can be designed to provide significant detention and retention by specifying infiltration rate, rooting depth, and subsurface drainage (exfiltration). They are suited to providing pre-treatment for raingardens or wetlands. Key differences to raingardens are that most swales/filter strips only pond while conveying water (an exception is wet swales, not common in NZ) and soil is usually only 200–300 mm deep.

Raingardens, planter boxes and tree pits

These devices do not transport water, but are ideally integrated into flatter areas fed by swales, or terraces on steeper slopes. These devices allow short-term (2–24 hour) ponding and drawdown of stormwater and are efficient at reducing peak flow and delivering water quality benefits. They may be designed to drain to a piped network and / or ex-filtrate into underlying gravels/soils. Internal water storage below the root zone enhances water detention volume and evapotranspiration. This group of devices is often called bio-retention.

Vegetated overland flow paths

These may be considered a particular subset of swales, although these are specifically designed to take high flows. They include riparian floodplains. In general these can be designed to increase surface roughness and allow for some detention (they are generally very smooth if a conventional mown surface). Overland flow paths may be a combination of planting or mown areas; the frequency and height of mowing can influences their performance. Including pruned trees usually decreases the frequency of mowing maintenance.

Stormwater Wetlands and Infiltration basins

Onsite, private devices

The most common devices are living roofs (green roofs) or green walls, rain tanks (dual and single purpose) or pervious paving[9]. The rationale is to focus on devices that will be maintained by public agencies, in public spaces, so have a high certainty of adequate performance:

- Living roof guidance has been developed that is broadly relevant; however, the area has a dominance of natural turf or grass-sod roofs. Living roofs are very effective at peak flow reduction and annual volume control, but not large event mitigation
- Pervious paving is not recommended for private sites at this stage unless certain 'management' criteria are met. The recording of such devices on titles and council database is needed to enable inspections, provide advice on maintenance to successive owners and detect conversions to impervious surfaces.

Other devices

The following devices are not recommended at this stage as stand-alone devices:

- Subsurface wetlands. Expensive, uncommon, used for removal of specific dissolved contaminants, require specific design and maintenance expertise and pre-treatment to reduce potential for clogging
- Sand filters, French drains, and non-vegetated infiltration trenches are not LID devices on their own as they do not include vegetation

---

[9] Pervious paving also has application in suitable public areas, typically low-weight-loading car parks and pedestrian areas, particularly near or over tree pits. Pervious paving in public spaces is useful where appropriate maintenance equipment and methods are available. In particular, permeable concrete and bonded-resin blocks may require specific suction equipment to remove sediment that may not be available in the region

- Ponds. Not favoured as provide little water treatment and in future likely to need conversion to wetlands to mitigate temperature and faecal coliforms / Enterococci

'Non constructed', non-engineered devices

The use of non-constructed, non-engineered devices is fundamental to catchment-wide LID but typically not consented as devices, and includes the following:

- Reserves (ecological and recreational)
- Trees (used in places with stormwater rate rebates linked to tree canopy)
- Rehabilitation of pervious areas to maximise retention of stormwater and vegetation health[10] (hence interception and evapotranspiration)
- Disconnection of downpipes, informal raingardens
- Landscape areas that receive stormwater flows where:
  - primary function is not compromised (e.g. active recreation)
  - level is lower than surrounding impervious areas
  - drainage is adequate

Characteristics against which devices are rated in the matrix

The following characteristics are useful to rate device suitability. Costs have not been included as they are highly case and scale specific. Ira et al. (2016) note that higher costs of treatment associated with LID devices may be attributed to the relatively recent nature of LID and lack of usable quality data, but also the under-utilisation as an integrated part of design. This lack of integration typically leads to inefficient duplication of LID practices with conventional piped systems or a reduction in 'avoided costs'. COSTnz[11] provides an approach for calculating life-cycle costs using individual construction elements, and is most useful for comparing the relative capital costs of different devices. Note also that unquantifiable benefits are easily lost in a cost-only presentation.

- Performance – hydrology: peak flow, volume (annual) for specific design events

---

[10] for example, see Toronto's 2012 'Soil Management best Practices for Urban Construction at http://www.sustainabletechnologies.ca/wp/wp-content/uploads/2015/02/Land-and-Water_2014-Jan_Feb_pg33-37.pdf and http://www.sustainabletechnologies.ca/wp/home/healthy-soils/preserving-and-restoring-healthy-soil-best-practices-for-urban-construction/

[11] The 2009 User manual can be downloaded from http://www.costnz.co.nz/COSTnz_User_Manual.pdf . S. Ira et al. presented a useful paper at the 2016 stormwater conference on factors determining the cost of long term maintenance and resilience of LID devices stating '*green infrastructure solutions are likely to be more robust and resilient than traditional (piped) solutions… are more economical to construct, but maintenance costs of diffuse green infrastructure such as raingardens and swales can be more expensive than traditional approaches*'

- Performance – contaminant removal: gross solids, particulates, dissolved contaminants, temperature
- Maintenance frequency. Note that devices along roads need to be designed to allow safe maintenance with minimal traffic controls (especially for busy roads). However, this can be achieved by set-backs using foot path location or ‘pop outs’ such as tree pits/planters
- Device longevity and cost of replacement or renovation (including disposal of media)
- Performance risk profile, taking into account:
    - availability of locally relevant guidelines, standards and checklists
    - availability of local exemplars (local materials, local experience)
    - availability of maintenance guides/checklists; match to current practices (especially for publically-maintained devices); barriers to enhanced maintenance
    - ease of identifying and fixing common implementation faults at ‘council handover’
    - relevance of device performance data to the Councils, given no local devices have data on hydrological or contaminant removal performance
- Suitability for carparks, road margins, riparian margins/green fingers
- Suitable for greenfields – brownfields (impervious areas)
- Suitable for areas with high water tables (<1 m depth, or fluctuating to <0.6 m depth)
- Suitable for low permeability soils with low exfiltration
- Suitable for areas with erosion limitations (slope, soils)
- Non-stormwater benefits delivered or potentially delivered
    - Safety of pedestrians and adjacent users
    - Aesthetics and landscape
    - Ecology and biodiversity

Recommendation 18. Capture the costs of the maintenance activities for public devices

5.3 Identifying areas for mandatory and fit-for-purpose LID

It would be useful to identify sites where LID should be mandatory in the Nelson and Tasman area, subject to acceptable site conditions (although noting that some LID techniques are available for any site) and in response to issues specific to the local catchment area. For example:

1. Quantity driven: Flooding/stormwater capacity

- Sites where there are known downstream flooding issues where no plans (improvement works) exist to remove the flooding risks.

- Sites where receiving primary stormwater system has no (or limited) capacity to take more flows (and hence will increase flooding risks if more impervious surfaces are added to the area, and/or existing impervious surfaces are efficiently connected with pipes to Council network).
- Runoff-constrained sites with limited overland flow paths (cross-reference to a map of these places and local definitions).

2. Stream health and retention

- Sites upstream of unstable, eroding streams, to reduce frequency erosion-producing events.
- These include areas where stream channels have been narrowed or diverted during development, and banks are unstable. An observation in the Nelson and Tasman area is that retrospective bank stabilisation is expensive, especially in areas with limited space available, and is also likely to result in compromised stream health.
- Sites in catchments with streams/freshwater that require protection/improvement of summer low flow or water quality and suitable infiltration/aquifer recharge zones.

3. Quality benefits

- Sites that discharge to existing streams/freshwater/estuarine environments if 'high contaminating activity' (use NZ Transport Agency or region-specific definition).
    - e.g. roads with >5000 or >10 000 vehicles per day
    - roads in industrial areas with transport of potentially acute contamination from spills (fertiliser plants)
    - higher use carparks (>50 vehicles?)
    - surfaces with high zinc or copper concentrations (roofs, guttering)[12]
- LID for these areas would be mandatory because LID *disconnects* source and receiving environments and improves water quality.

  LID principles and some devices are suitable to reduce peak flows and enhance water quality for the following:[13]

    - *urban areas with a high percentage of impervious surface cover and, where the existing stormwater systems rely on piped infrastructure;*
    - *land that has poor natural drainage and/or a high water table or naturally occurring ground surface has poor permeability, preventing infiltration*

[12] Given stream and estuary receiving environments are susceptible to these contaminants

[13] In contrast to current TDC guidance, as these are listed as exclusions in 7.10.1, page 29 Tasman District Council "the 2013 Engineering Standards and Policies", chapter 7- Stormwater and Drainage. (http://www.tasman.govt.nz/document/serve/Chapter7StormwaterandDrainage20140401.pdf?path=/EDMS/Public/Other/Policy/Policies/EngineeringStandards/000000278677

By mapping and overlaying areas with information related to flooding, constrains in the primary network, stream erosion, pollution, etc., it would be relatively easy to identify the type of LID / water management required to achieve all local objectives and address local constraints. This has been done before in other areas in NZ such as North Shore City.

Recommendation 19. **Develop a spatial tool to assist selection of fit-for-purpose LID applications, taking into account local constrains and objectives. The same tool can later also be used to justify any future plan requirements**

5.4 Where and how does soakage fit in?

The schematic in Figure 9 shows the ideal design process incorporating LID where conditions allow soakage. Soakage is supported by both NCC and TDC where conditions are appropriate. Soakage has a number of benefits such as reducing flood risks, groundwater recharge and contribution to, often reduced, base-flows in streams.

We suggest first, treat and reduce peak flows and volume using LID. A LID device can be designed to store up to 2 yr event; rainfall statistics for a site near Stoke (Table 3) show this can be about 40% of a 100-yr event volume, providing significant attenuation. Bioretention devices such as raingardens, planters and tree pits are usually sized to meet a water quality volume; large flows (e.g. more than 2 year ARI) should be bypassed to avoid potentially harmful impacts to plants, erosion of surface, scouring at inflows/overflows. Second, encourage soakage where ground conditions allow, further assisting in reducing food risks. The residual Stormwater then flows into the primary system directly or as overland flow.

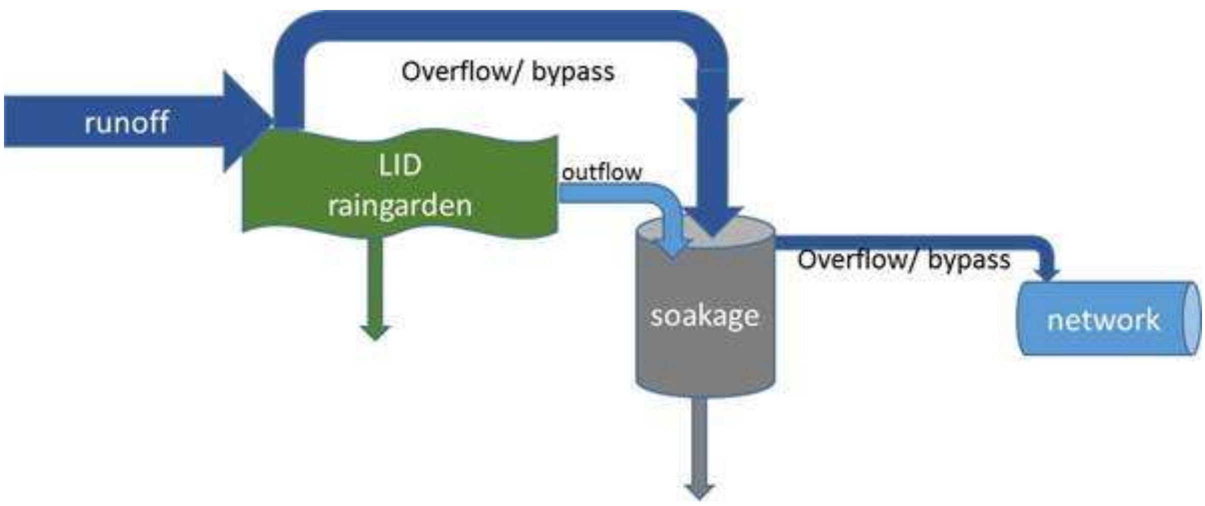


Figure 9: Ideal design process that incorporates LID where site conditions favour soakage.

Table 3: Rainfall statistics for Ngawhatu show the relative storm sizes with increasing return periods

Orphanage at Ngawhatu Rainfall Statistics				
Return	Storm Total (mm)			Drought Total (mm) **
Period	1 hr	6 hr	24 hr	28 day
2 year	22.0	47.0	84.5	1.8
5 year	29.0	60.0	106.5	0.5
10 year	34.5	71.0	124.0	0.0
20 year	40.5	82.5	143.5	0.0
50 year	50.5	101.5	173.5	0.0
100 year	59.5	118.0	200.5	0.0
Extremes Recorded **	98.2 21/04/13	144.0 21/04/13	200.0 14/12/11	0.0 06/02/2013
Storm totals are from HIRDS analysis based on site location. ** Drought totals and extremes are from analysis based on data collected on site.				

Recommendation 20. **Further explore and detail the opportunity to use LID and soakage in tandem, in part to reduce flood risk.**

5.5 Additional detail to support LID in Nelson City and Tasman District

The following detailed information was beyond the scope of this report. It is recommended to underpin and support broader and more cost-effective application of LID in the joint LDM, particularly by delivering devices with high pubic acceptance and low ongoing maintenance.

Recommendation 21. **Review the detailed LDM text and calculation rules after LID devices and tools have been confirmed.**

This should include updating reference to Auckland Council publications, but ensuring the new standards on which these are based are applicable to Nelson-Tasman (see Appendix 7).

Recommendation 22. **Develop practice notes and standard approved engineering diagrams.**

Have available documents that show complying solutions meeting TRMP as well as engineering requirements. While these have been very successful in other regions, they do, however, need to provide adequate engineering detail so the engineering consultants understand what is required. The process from there on is straightforward and (almost) guarantees a ‘rubber stamp’ approval.

Recommendation 23. **Develop a good-practice example tour of LID devices.**

Information on field sites to visit that demonstrates LID approaches and devices, with supporting website information and/or pamphlets. This could complement the pamphlets of walking tours/public park orchard tours created by Nelson, because most people do not recognise that some landscaping is actually protecting stream quality by managing stormwater, or appreciate the special design and maintenance requirements. The basis for such a tour is already present, as in July 2015, a draft document pulled together 19 examples of sites with LID devices in NCC. Each site is shown in one page with photos and very brief description (e.g. Figure 10). Most of these sites were visited as part of this Envirolink report. Expanding the draft by including plant species, maintenance notes and critical success features (and flaws to avoid), would create a valuable council, developer and community resource.

Catalogue of Low Impact Design (LID) features in Nelson City

In accordance with the Long Term Council Community Plan (LTCCP)

Examples of LID

Placemakers **52 Saxton Road West, Stoke**	Run off from carparks draining into Gabion Baskets
Construction date	February 2005
Engineering Plan Number / Building Consent No.	BC 051262, A896734 (pages 313, 342, 345)
Notes / Photos	

Figure 10: Cover of Nelson City Council draft of examples of local LID sites.

Another potential model is a self-drive tour of exemplar homes designed to show technologies at work (Fig.11). The tour was organised by the Superhome Movement in partnership with Christchurch City Council through its Build Back Smarter service (www.superhome.co.nz). Tony Moore is the Christchurch City Council contact; but note that no LID was included in this tour.

Figure 11: Pamphlet for self-drive tour, as an example for public information.

6 Summary and recommendations

The following actions are recommended, supplemented with a proposed priority rating (short, medium, long term) and explanatory comment where relevant.

#	Recommendation	Priority (S/M/
1	Change the order of sections in the future manual so that LID is at the front as the first tool/method to manage stormwater.	S
2	Improve wording so that it is clear LID is to be considered first, and how it is to be considered, before other more traditional stormwater management practices are allowed. A decision tree/method and a relate checklist would assist this.	S/M
3	Clearly explain what LID is in the future manual.	S
4	Align local RMA plans and the engineering standards over time.	M
5	Develop an operation and maintenance manual for LID devices.	M – adapt guides from other regions
6	Develop a plan to improve the performance and reduce maintenance costs on existing LID devices.	M
7	Provide a list of preferred plants for a range of stormwater devices, specific to this area and the location specifics as well as related maintenance instructions (as part of the O&M manual).	S
8	Design landscaped areas to receive stormwater runoff to the extent possible without compromising the objectives of the reserve (aesthetic, recreational, etc.) and to include this in the manual at the appropriate location.	M
9	Provide a Design and Construction Checklist for constructed wetlands.	M – adapt guides from other regions
10	Include water quality requirements in the LDM to protect / enhance the existing natural environment and to assist in meeting future NPS-FM requirements under a no-regrets approach.	S
11	Undertake specific investigations into local gross pollutants and implement appropriate mitigation measures.	M/L
12	Review the links between objectives, priorities and the requirements in the future LD manual to achieve fit-for-purpose LID for Nelson Tasman.	S/M
13	Establish a register of pre-accepted devices and their applications.	M
14	Create checklists for developers and consenting staff to help the design review, construction and 224C process, to ensure good outcomes and effective processing, and to reduce uncertainty for developers.	M
15	Provide for upskilling of staff and industry including training, checklists and practice notes.	S & M & L
16	Develop a planting choice document specific for a range of stormwater treatment devices in this region, and the location where applied = #7.	S & L, update as sites increase
17	Initiate a cost optimisation project considering local knowledge and (international) best practice for the maintenance of stormwater treatment devices.	M
18	Capture the costs of the maintenance activities for public devices.	M
19	Develop a spatial tool to help select fit-for-purpose LID applications, taking into account local constraints and objectives. The same tool can later also be used to justify any future plan requirements.	M L

20	Further explore and detail the opportunity to use LID and soakage in tandem, in part to reduce flood risk.	M
21	Review the detailed LDM text and calculation rules after LID devices and tools have been confirmed.	M
22	Develop practice notes and standard approved engineering diagrams, aligned with #13.	M
23	Develop a good-practice example tour of LID devices.	S & M

7 Acknowledgements

This project has benefitted greatly from support and input of council staff across stormwater, planning and parks at Nelson and Tasman Councils. The opportunity to present the concepts of LID/WSD to the Joint Nelson/Tasman Land Development Committee was core. Support from this committee in resourcing a subsequent field visit to Nelson and Tasman sites for staff and councillors was invaluable, as it allowed more in depth discussions across a broad range of issues. Particular thanks to Nelson City Council's Peter Grundy, Phil Ruffell, and to Tasman District Council's Ian McComb and Robert Workman. Thanks to the following Council staff for their time and engagement in interviews: Gary Clark, Tania Bray, Lisa McGlinchey, Phil Ruffell, Shane Overend, 'Roy Miles', Chris Pawson, Matt Mazzucchelli, Eddie Powick, Jeff Cuthbertson, Glenn Thorn, Stephen Richards, Anna Gerraty, Michael Croxford, Andrew Petheram, Lindsay Barber, Rosalind Square, Breyl Wilkes, Robert Workman, and Lisa Gibellini. Paul Newton for his helpful field input at Sanctuary Drive and comments.

The authors thank Robert Workman and Ian McComb (Councils), and Ian Lynn (Landcare Research) for helpful peer review comments, and Anne Austin (Landcare Research for editorial assistance). This project has also benefitted from Envirolink coordination provided by Helene Kingsley-Smith and Cynthia Cripps (Landcare Research).

8 References

Ahiablame L, Engel B, Chaubey I 2012. Effectiveness of low impact development practices: literature review and suggestions for future research. Water, Air and Soil Pollution 223(7):4253-4273

Allison R, Chiew FHS, McMahon T 1998a. A decision support system for determining effective trapping efficiencies for gross pollutants. In: Water sensitive urban design technical manual for the Greater Adelaide Region, 2010. Adelaide, South Australia, Department of Planning and Local Government, Government of South Australia.

Allison RA, Walker TA, Chiew FHS, O'Neil IC, McMahon TA 1998b. From roads to rivers: gross pollutant removal from urban motorways. Technical report 98/6. Melbourne, Victoria, Australia, Cooperative Research Centre for Catchment Hydrology.

Auckland Council 2003. Stormwater management devices: design guidelines manual. Technical Publication 10. Auckland, Auckland Council

Buchanan K, Clarke C, Voyde E 2013. Hydraulic energy management: inlet and outlet design for treatment devices. Prepared by Morphum Environmental Limited for Auckland Council. Auckland

Council Technical Report 2013/018. http://www.aucklandcouncil.govt.nz/SiteCollectionDocuments/aboutcouncil/planspoliciespublications/technicalpublications/tr2013018hydraulicenergymanagementinletoutletdesignfortreatmentdevices.pdf

Dietz M and Clausen J 2008 Stormwater runoff and export changes with development in a traditional and low impact subdivision. Journal of Environmental Management 87(4):560-566

Depree C 2008. Contaminant characterisation and toxicity of road sweepings and catchpit sediments: Towards more sustainable reuse options. Land Transport NZ Research Report 345.

EPA 2016 City green: Innovative green infrastructure solutions for downtowns and infill locations. United States Environmental Protection Agency EPA 230R16001. https://www.epa.gov/sites/production/files/2016-06/documents/city_green_0.pdf

Fassman EA, Simcock R, Wang S 2013. Media specification for stormwater bioretention devices, Prepared by Auckland UniServices for Auckland Council. Auckland Council Technical

Report 2013/011. http://www.aucklandcouncil.govt.nz/EN/planspoliciesprojects/reports/technicalpublications/Documents/tr2013011mediaspecificationforstormwaterbioretentiondevices.pdf

Fitzgerald B, Bird W 2010. Literature review: gross pollutant traps as a stormwater management practice. Auckland Council Technical Report 2011/006. http://www.aucklandcouncil.govt.nz/SiteCollectionDocuments/aboutcouncil/planspoliciespublications/technicalpublications/tr2011006grosspollutanttrapsasastormwatermanagementpracticeliteraturereview.pdf

Ira SJT, Roa A, Carter R 2016. Understanding and determining the cost of long term maintenance and resilience of WSD. Water NZ Stormwater Conference 2016, Nelson, New Zealand

Lewis, M., James, J., Shaver, E., Blackbourn, S., Leahy, A., Seyb, R., Simcock, R., Wihongi, P., Sides, E., & Coste, C. 2015. Water sensitive design for stormwater. Auckland Council Guideline Document GD2015/004. Prepared by Boffa Miskell for Auckland Council. http://www.aucklanddesignmanual.co.nz/design-thinking/wsd/gd04

Lewis M, Simcock R, Davidson G, Bull L 2010. *Landscape and ecology values within stormwater management.* Prepared by Boffa Miskell for the Auckland Regional Council: Auckland Regional Council Technical Report 2009/083

Loci Environment and Place Inc 2016 Green Infrastructure Evidence Base. Designed for local government and enabling organisations. http://loci.melbourne/data/documents/Green-Infrastructure-Evidence-Base.pdf

Mayson A, Depree C, Simcock R 2010. Road Derived Sediments (RDS) and vegetative material reuse feasibility study. Auckland Motorway. Auckland, NZ, NZ Transport Agency.

Morgan C, Bevington C, Levin D, Robinson P, Davis P, Abbott, J, Simkins P. 2013. Water sensitive urban design in the UK. Publication C723 CIRIA London

Nelson City Council 2010. Land Development Manual 2010 – chapter 5 – stormwater. http://nelson.govt.nz/assets/Environment/Downloads/land-development-manual-2010/LDM-2010-Section-5-Stormwater.pdf (accessed April 2016).

Nelson City Council 2015 'River and stream health report' shows grades at monitored sites http://nelson.govt.nz/assets/Environment/Downloads/scorecards/2014/River-Stream-Health-Scorecard-2014-15.pdf.

Parliamentary Commissioner for the Environment 2015. Managing water quality: examining the 2014 National Policy Statement. June 2015. http://www.pce.parliament.nz/media/pdfs/Managing-water-quality-web.pdf

Pennington S, Kennedy P, 2008. Quantification of catchpit sediments and contaminants. Prepared by Golder Associates (NZ) Ltd for Auckland Regional Council. Auckland Regional Council Technical Publication 2009/122.

Tasman District Council. 2013. The 2013 Engineering Standards and Policies, chapter 7 – Stormwater and Drainage. (http://www.tasman.govt.nz/document/serve/Chapter7StormwaterandDrainage20140401.pdf?path=/EDMS/Public/Other/Policy/Policies/EngineeringStandards/000000278677) (accessed April 2016).

Wong T 2006. An overview of water sensitive urban design practices in Australia. Water Practice and Technology.1 (1):

Appendix 1 – LID Device Matrix

Treatment Device	Stormwater process and description	Pros summary	Cons summary	New Zealand reference	True LID? subjective scale 1 = no / low 5 = yes
Gross pollutant trap	Physical screening of gross pollutants (> 5mm diameter). Include screens in catchpits and gutters or booms and floating traps inside channels.	Can be effective primary treatment and first step in treatment train to improve performance, decrease maintenance of other devices	Devices vary greatly in performance (trapping efficiency) and mechanism. Regular maintenance and matching to flood capacity/litter storage is critical for performance; maintenance costs often underestimated	Fitzgerald and Bird 2010.	1
Road catch pit or sump	Sedimentation collects larger, heavier debris (>0.5 mm, sand to gravel) preventing blockages in downstream pipes	Known 'minimum treatment' technology (~30 to 50% sediment capture). Efficiency depends on turbulence, inflow velocity and 'empty' volume. Can insert bags (nets) to improve removal of floatables and insert filters	May adversely affect water quality, through sediment flushing and chemical changes in catchpit. Negligible volume control; difficult to inspect; inserts can be difficult to clean; minimal mitigation of acute events (spills); impacted by autumn leaves	Pennington and Kennedy 2008	2
Planted bioretention swales and filter strips					
All swales	Designed for flow conveyance and contaminant removal where minimum residence time is 9 minutes	Low capital costs, especially if not under drained. Maintains open space for later retrofit of more effective devices (raingardens) if curbs and inlets are adequate	Limited to sites with suitable (gentle) slopes unless terraced. Limited to sites with adequate stability. Hydrological benefits occur but there is no accepted method for quantifying this	Lewis et al 2010	2 to 3
Mown grass swale with no underdrainage or exfiltration	Sedimentation and peak flow reduction; all these devices rely on surface roughness to slow water movement from impervious surface to another device or overland surface path; contribution to water quality depends on infiltration rate, root zone depth, vegetation height and any exfiltration	Low capital cost; maintenance uses unspecialised equipment (mowers)	Moderate maintenance cost; mowing height needs to change, mowing increases vulnerability to compaction, scalping, erosion and sediment mobilisation; road safety issues (traffic, slopes, etc.)		2
Planted swale / filter strip 300 mm depth with underdrainage	Sedimentation and peak flow reduction, some infiltration through root zone provides initial abstraction	Broader hydrological and water quality benefits due to greater contact time and slowing of velocities; small volumes of imported or amended soils	Higher capital cost but lower maintenance costs if established with low weed invasion and suitable plants		3
Planted swale with formal exfiltration to underlying permeable material	Sedimentation and peak flow reduction, Infiltration through root zone, aquifer recharge	Broader hydrological benefits; aquifer recharge, temperature mitigation	Limited to sites with subsoils and geology that allow exfiltration without triggering erosion or structural vulnerability	Lewis et al 2010	3
Level spreader discharges sheet flow to gently-sloping, vegetated filter strip in riparian zone / overland flow path	Stormwater is evenly spread over a large, grassed or planted surface area using a concrete channel and/or distribution box before entering a wetland or stream. Achieves sedimentation and peak flow reduction	Suitable for retrofit in older areas alongside riparian areas	Limited to sites with suitable space, stable soils (not slip- or erosion-prone); installation must ensure even flow distribution and avoiding channels or preferential flow paths developing. Soils should not be vulnerable to compaction if area is mown.	Buchanan et al 2013, section 3.2	3
Raingardens	Stormwater ponds then seeps through engineered soil with prescribed infiltration rate before discharging to primary system or infiltrate	Can be used in many locations instead of conventional landscaping. Achieve stormwater quality and significant volume treatment in a small footprint, volume attenuation enhanced with Internal Water Storage and exfiltration; add amenity value	Relatively expensive due to depth and pipe work and level of design detail (so useful to have pre-permitted devices)	Lewis et al 2010; Fassman et al 2011	5
Planter boxes	The surface level of the device (and ponding) is above the ground and sides are usually impervious	Suited for small, urban spaces receiving roof runoff where conventional planter boxes might otherwise be used; edges often combined with seating or walls; reduce need to irrigate gardens in summer	Usually small volumes. Where planters are integrated with buildings an impervious liner will be needed; if above ground, additional structural loading may be needed	Lewis et al 2010	5

Treatment Device	Stormwater process and description	Pros summary	Cons summary	New Zealand reference	True LID? subjective scale 1 = no / low 5 = yes
Tree pits	Usually 1 by 1 m or 1 by 2 m pits; with 1 m depth of media minimum; ideally under planted with ground cover to keep surface open but sometimes combined with pervious paving	Suited for intensely urban areas with high impervious surfaces by using cantilevered covers; medium and large trees boost aesthetic and hydrological benefits (interception and water uptake). Tree health can be increased by allowing paths for roots to extend outside tree pit	Require a sufficient soil volume to support a tree to maturity or tree life, size and species are limited.		5
Vegetated overland flow paths and secondary flow paths, riparian areas	Green fingers' designed to transport events in excess of the piped network capacity	Provide space for other community benefits (walking, cycling) and large trees	Often proposed very small (1 to 2 m^3) in concrete boxes with no root exits; these may have low medium-term aesthetics		3
Infiltration basins	Planted or turf basins that are usually dry and fill with runoff in larger storms, not day to day events. Usually designed to drain within 1 to 2 days so provide sediment and dissolved contaminant removal, aquifer recharge. Could be designed to be very large raingardens when receiving 'every day' events, depending on the ponding depth and infiltration rate.	Provide flood attenuation and aquifer recharge. Can be combined with large open park spaces providing community amenity, recreational and/or biodiversity benefits	May have difficulty achieving design infiltration and drainage rates due to compaction, high sediment, surface sealing or inadequate subsoil permeability. Design return period and remediation of effects of inundation (and budget) with parks; community must buy into a dual amenity/recreation and stormwater function		4
Constructed wetlands	As above but generally with standing water over part of their surface	Greater nitrogen attenuation, allow reduced maintenance by avoiding mowing	Can look 'messy' if initial maintenance allows weed growth, cue for cares absent, or not linked to riparian area	Lewis et al 2010	5
Permeable paving	Stormwater infiltrates through paving or between large gaps in paving, then through specific foundation substrate (where it may be stored) before discharge to primary system or exfiltration	Can efficiently retard peak flows and provide for recharge. Volume retention can be achieved using specific base course depth. Very wide variety of options available and increasing.	Some are highly vulnerable to sedimentation and 'blinding' depending adjacent land use; highly specialised construction and material needs for some paving options; many do not have plants, so don't provide plant-related benefits or 'recharge' through evapotranspiration	Worth and Blackbourn 2013 (draft)	4
Pond	Sedimentation with effective forebay. Detention (volume control)	Peak flow reduction	Likely to increase water temperature; very expensive to renovate when silt needs removal (need forebay to extend life); open water with mown grass edge increases attractiveness to ducks and geese (water fouling); old on-line ponds can block fish passage ~ no volume reduction	Lewis et al 2010	2
Public planted areas (e.g. reserves, road reserves, etc.)	use adjacent planted areas to take stormwater as 'free' opportunity / additional benefit	opportunity based multi-functional use depending on size/design can contribute to flood mitigations and SW treatment	might compromise recreational use (but can be avoided with good design) might pond / look muddy after event		3
Private Devices					
private rain tank (single purpose)	Sizing and design allows mitigation of multiple stormwater objectives through use of multiple outlets, e.g., extended detention, peak flow attenuation of 2 and 10 yr ARI, retention and reuse of rain				2
private rain tank (dual purpose)					3
private green roof					5
private rain garden					5
Private infiltration device (gravel base, non-vegetated)					2
Private sand filter					2

Treatment Device	Flooding1 Peak flow reduction	Flooding2 Volume reduction	Pollution1 Gross solids reduction	Pollution2 TSS (Solids) reduction	Pollution3 Temperature reduction
Gross pollutant trap	no	no	yes	nil	no
Road catch pit or sump	no	no	yes	partial, especially coarser sediment	no
Planted bioretention swales and filter strips					
All swales	some	Initial abstraction volume; evapotranspiration not considered in calculations	yes	significant	some, where vegetation is taller
Mown grass swale with no underdrainage or exfiltration	some	no	yes	some	some
Planted swale / filter strip 300 mm depth with underdrainage	yes	yes	yes	yes	yes assuming outlet/overflow 300mm above soil
Planted swale with formal exfiltration to underlying permeable material	yes	yes	yes	yes	yes assuming outlet/overflow 300mm above soil
Level spreader discharges sheet flow to gently-sloping, vegetated filter strip in riparian zone / overland flow path	some	no	some	some	some
Raingardens	yes using ponding area and storage in soil	yes up to 50% aided by Internal Water Storage	yes	yes	yes
Planter boxes	yes using ponding area and storage in soil	yes up to 50% but usually smaller	yes	yes	yes
Tree pits	yes using storage in soil	depends on volume of device and Internal Water Storage Zone	yes	yes	yes
Vegetated overland flow paths and secondary flow paths, riparian areas	some	no - as designed to transport and convey water	yes	some	n/a as operate when flows are high
Infiltration basins	yes	yes	yes	yes	yes
Constructed wetlands	yes using ponding area and storage in soil	yes	yes	yes	yes
Permeable paving	yes using storage foundation	yes with base water storage zone up to 50%	yes	yes	yes
Pond	yes	negligible unless has high vegetation cover	yes	some	negative
Public planted areas (e.g. reserves, road reserves, etc.)	yes	yes	yes	some	some
Private Devices					
private rain tank (single purpose)	yes	some	na	na	na
private rain tank (dual purpose)	yes	yes	na	na	na
private green roof	yes using ponding area and storage in soil	yes up to 50%	yes	yes	yes
private rain garden	yes using ponding area and storage in soil	yes up to 50%	yes	yes	yes
Private infiltration device (gravel base, non-vegetated)					
Private sand filter					

Treatment Device	Amenity / Green value (amenity)	Maintenance frequency	Typical Contributing Catchment Area	Typical Device Footprint (space)	Risks1 Design and Construction	Risks2 Maintenance	Risks3 Local cases
Gross pollutant trap	negative	low to high (site and device specific)	small to large	very small	low if matched to site	low if budgeted	yes
Road catch pit or sump	no	at least annual; depends on site espec. leaf fall and road use	small	very small	low - new designs and inserts available to improve	traffic controls needed (safety); difficult to inspect capacity	abundant; BAU
Planted bioretention swales and filter strips							
All swales		Influenced by inlet design and plants. If under-drains are used they must be checked	small	moderate	low if slopes, profile, capacity, subsoils follow guidance	low to moderate	yes
Mown grass swale with no underdrainage or exfiltration	similar to mown road verges - increase using trees	high - regular mowing required	small	moderate	low	high - usually mown too low; compaction risk; traffic safety controls	abundant
Planted swale / filter strip 300 mm depth with underdrainage	yes	low once established	small	moderate	moderate (plant species)	moderate during establishment, then low	yes - some very effective examples
Planted swale with formal exfiltration to underlying permeable material	yes	low once established	small	moderate	as above	as above	yes - some very effective examples
Level spreader discharges sheet flow to gently-sloping, vegetated filter strip in riparian zone / overland flow path	marginal	medium to high if mown	small	high	medium	medium if mown	yes, using curbs not level spreader to create sheet flow into riparian area
Raingardens	yes	medium (depending on inlets and trees)	small to medium	low to moderate	moderate (ponding depth, inlets)	moderate (until guidance produced)	yes, but few have ponding depths >100 mm
Planter boxes	yes	medium to high	small	low	low	low	no
Tree pits	yes	low once established, trees pruned if volume is adequate	small	low to moderate	low if adequate depth and volume	moderate (until guidance produced)	yes
Vegetated overland flow paths and secondary flow paths, riparian areas	marginal	depends on mowing frequency and landscaping	medium to large	high but land may not be 'usable' for structures, so lower value	low	low	yes
Infiltration basins	possible	medium	medium to large	high	moderate	low (with adequate mowing height and ground bearing pressure)	yes
Constructed wetlands	yes	low once established	medium to large	moderate to high	moderate	low to medium	yes
Permeable paving	yes	high	small	nil	moderate	medium to high; may need specialist suction equipment	a narrow range
Pond	varies depending on shape, planting, perception of danger/fencing	Depends on capacity of sediment fore bay	medium to large	moderate	low to medium	low if access designed	present
Public planted areas (e.g. reserves, road reserves, etc.)	yes	varies	small to medium	low to moderate	low to moderate	medium until guidance delivered	yes
Private Devices							
private rain tank (single purpose)	Nil to negative	low	small	high if small sections and not underground or under decks	low	risk of inadequate maintenance high, espec. with ownership change for all private devices	yes
private rain tank (dual purpose)	Nil to negative	low	small	high if small sections and not placed under ground or decks	low	risk high	yes
private green roof	yes	low to high depending on design	any size	nil	medium	low to medium	yes
private rain garden	yes	medium	small	low	low	low to medium	yes
Private infiltration device (gravel base, non-vegetated)		low	small	low	low	low	yes
Private sand filter		medium	small	low	low	Low	?

Treatment Device	Suitability Carparks	Suitability Greenfield	Suitability High water tables	Suitability Low permeable soils	3-waters Yes / No	Other Benefits
Gross pollutant trap	yes	yes	yes	yes	No	nil unless first step in treatment train
Road catch pit or sump	yes	yes	maybe	yes	No	nil
Planted bioretention swales and filter strips						
All swales	yes	yes	yes	yes	No	
Mown grass swale with no underdrainage or exfiltration	yes	yes	yes - because shallow	yes - because infiltration is not needed	No	
Planted swale / filter strip 300 mm depth with underdrainage	yes	yes	yes	yes	No	
Planted swale with formal exfiltration to underlying permeable material	yes	yes	not usually, unless peat soils or fluctuating water table	no	No	
Level spreader discharges sheet flow to gently-sloping, vegetated filter strip in riparian zone / overland flow path	yes	yes	yes	yes	No	
Raingardens	yes	yes	no	yes	No	
Planter boxes	not usually	yes	yes	yes	No	
Tree pits	yes	yes	no	yes	No	
Vegetated overland flow paths and secondary flow paths, riparian areas	not usually	yes	yes	yes	No	
Infiltration basins	yes	yes	not usually, would convert to wetland	with amended design	No	
Constructed wetlands	yes	yes	yes	yes	No	
Permeable paving	yes	yes	yes	yes	No	
Pond	no - use wet swale	yes	yes	yes	No	
Public planted areas (e.g. reserves, road reserves, etc.)	yes	yes	yes with exclusion of high traffic/frequently mown areas	yes with exclusion of high traffic/frequently mown areas	No	
Private Devices						
private rain tank (single purpose)	if tank is underground	yes	yes if above ground	yes	Yes	
private rain tank (dual purpose)	if tank is underground	yes	yes	yes	Yes	
private green roof	no	yes	yes	yes - if does not use local soils	No	
private rain garden	yes	yes	yes	yes - if does not use local soils	No	
Private infiltration device (gravel base, non-vegetated)	yes	yes	No	No	No	
Private sand filter	yes	yes	No	No	No	

Appendix 2 – Bioretention Device Introduction Sheets

Planted swales and filter strips

- Vegetated channels that convey and filter stormwater. A filter strip is a planted slope that filters stormwater with a dispersed (or laminar) flow
- The most common device internationally and in Nelson as they are simple and water has to be conveyed anyway. Mature examples present in Nelson/Tasman (planted and grassed)
- Primary functions: Slow the velocity of flows, increase time of concentration, filter coarse sediment to reduce sediment load (TSS). Convey and pre-treat water from impervious surfaces to storage or treatment areas (often raingardens or wetlands or infiltration basins)
- Other functions: oil and grease removal, moderate (particulate) metals removal, some temperature reduction
- Defining features: Generally pond only while conveying water (an exception is wetland swales, not common in NZ). Shallow soil /media (200-300 mm), often not specialised
- Suitable for primary treatment of runoff from roads, drive ways, parking areas, small-sites

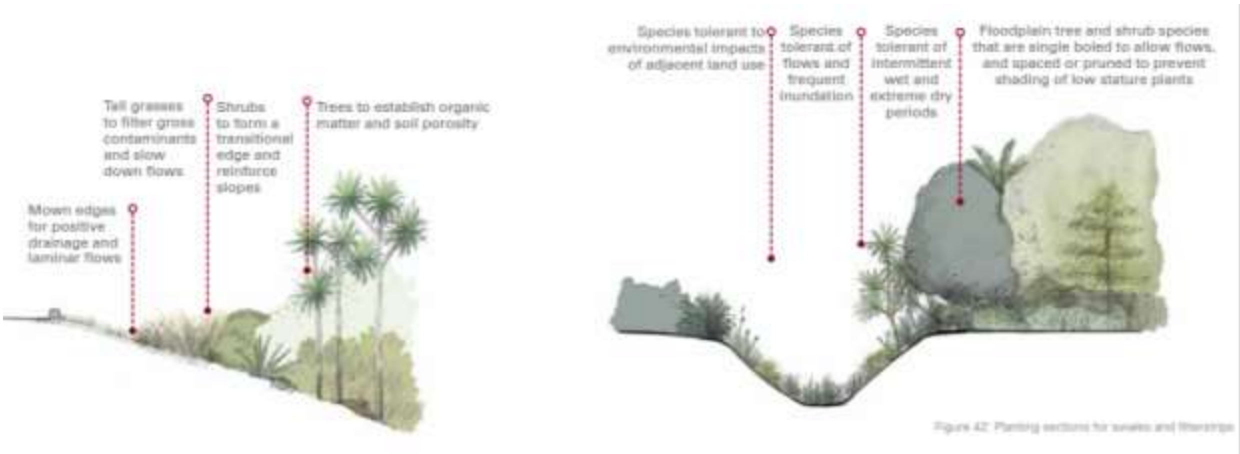


Figure 12: Cross-sections of a filter strip (left) and swale (right) (Lewis et al. 2009).

Four 'types' of filter strip and swale

- Mown grass swales / filter strips with no underdrainage. May have above features but need additional design input to ensure grass height is maintained at 50–150 mm and potential compaction damage from machinery is mitigated
- Planted with under-drainage (minimises exfiltration in to adjacent soils where exfiltration is not desirable, e.g. fill slopes or unsuitable geology)
- Planted with exfiltration into underlying gravels/soils, may use a basal infiltration trench backfilled with gravels if underlying conditions are suitable

- Filter strip with or without a level spreader dispersing water across riparian zone

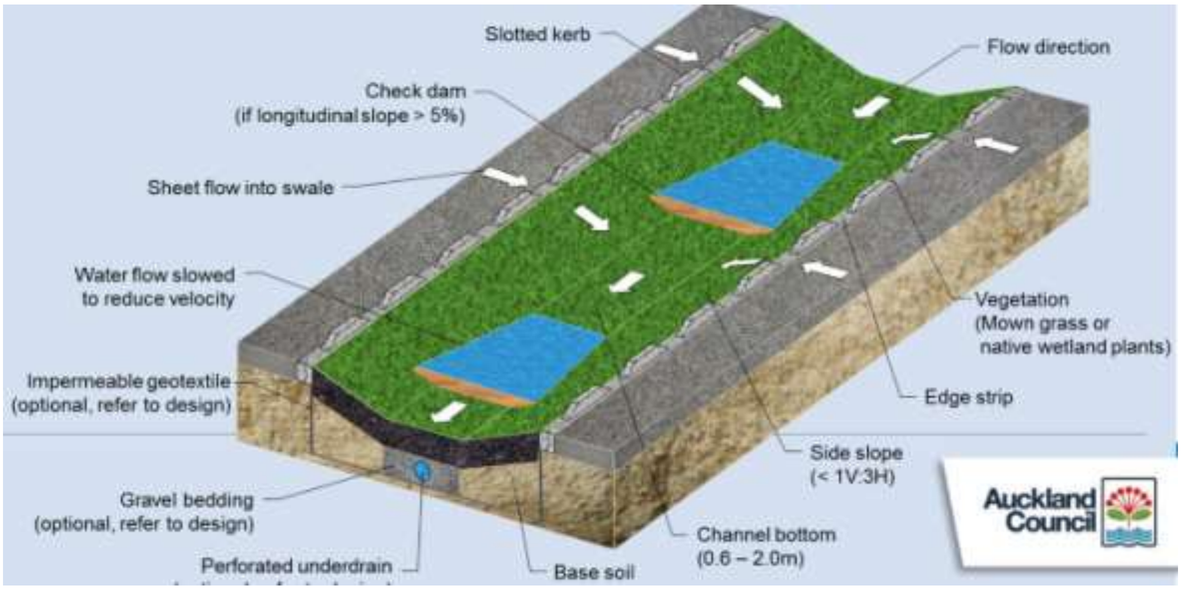


Figure 13: Cross-section of a swale with underdrainage (Auckland Council draft).

Key issues for Nelson/Tasman based on site visits

- Effective inlet and outlet design to ensure inlets are self-cleaning, that sediment is accumulated in places where it can be removed easily (where relevant)
- Driveway and footpath/pedestrians crossings (concrete reinforcement for driveways, frequency)
- Excluding people and vehicles (adequate road parking, crossing points, defined edges and drops)
- Ensuring minimum width and side slopes to support dense plant cover (reduce heat, physical damage, water stress)
- Plant selection to minimise maintenance, especially trimming against roads or footpaths
- Safety and cost of maintenance within 1 m of active road way on arterial roads (especially mowing grass swales)
- Mown swales are vulnerable to degradation that shortens life, especially compaction / rutting and scalping by mowers

Figure 14: Filter strip: Saddleback Road, Todds Valley with street tree located for efficient maintenance and protection from mowers.

Figure 15: Swales at aquatic centre, Richmond.

Raingardens, planter boxes and tree pits

- Densely planted, free-draining area where water ponds for up to 24 hours and infiltrates media.
- Self-watering, self-fertilising perennial landscaping that may be 'naturalistic' revegetation. Can be used instead of conventional landscaping in many situations
- Primary function: improve stormwater quality, especially dissolved contaminants, provide peak flow control and contribute to volume control (e.g. 2-yr event = 40% of 100-yr Richmond event)
- Defining Features: Stormwater ponds to between 50 and 300 mm depth and is filtered through 0.5 to 1 m of free-draining media (typically 50–300 mm/hr). Usually receive runoff directly from impervious surfaces, filter strips or integrated with swales. Underdrainage usually connected to primary stormwater network; large rainfall volumes are events overflow or are bypassed. Plants maintain infiltration/conductivity and recharge stormwater storage volume
- Typically 2–10% of impervious area. Suited to carparks and road runoff for gently sloping or level sites. Not suited for stormwater with high sediment loads. Do not transport water

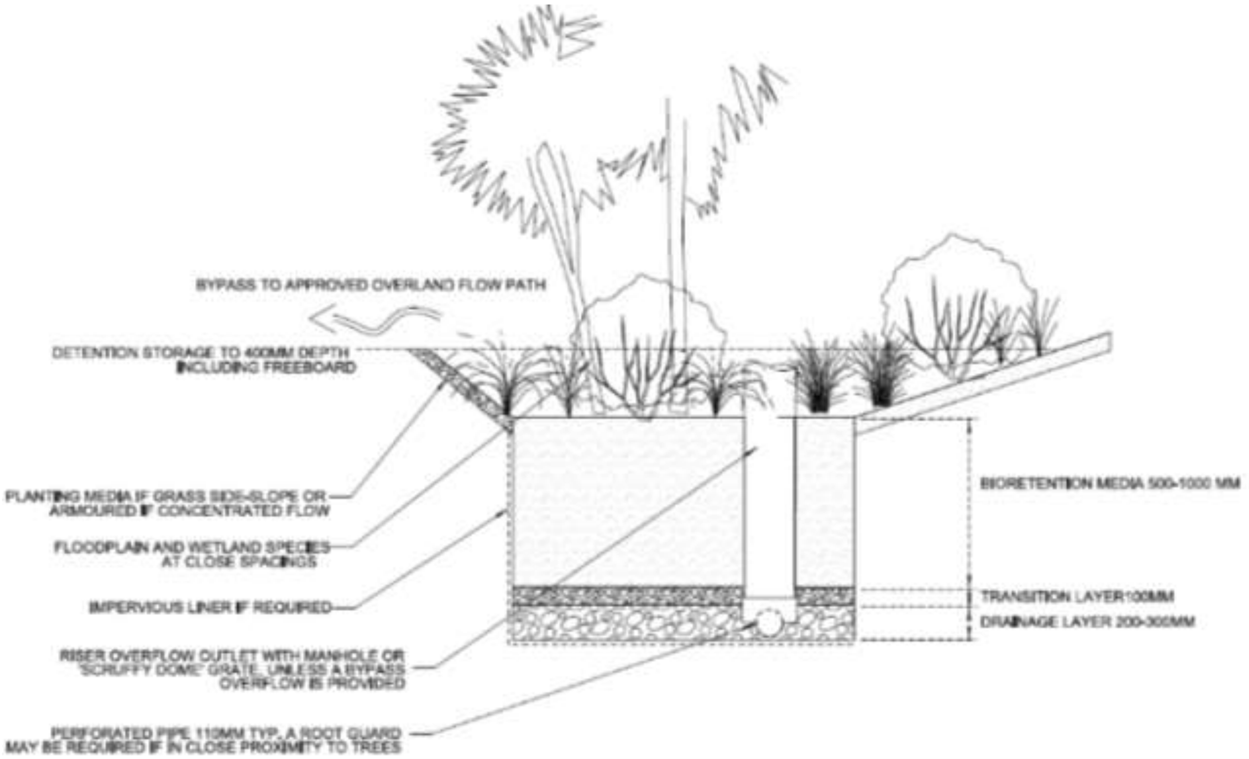


Figure 16: Raingarden components – without internal water storage zone (North Shore City standard design) http://www.northshorecity.govt.nz/services/environment/stormwater/documents/bioretention-guidelines.pdf

Special Types

- Stormwater planters/planter boxes. Above-ground or partly-sunk concrete/gabion unit receiving water from a downpipe (bubble up or surface discharge); ideal where space is limited as can be adjacent to buildings; used to provide seating and security (physical separation)
- Tree pits. Trees are planted into devices with or without groundcover

Figure 17: Bioswale in Sanctuary Drive (left photo). Raingarden in Sundial Square has attractive planting but the small, narrow inlets are prone to blocking and difficult to maintain (Right photo).

Key issues in Nelson

- Effective inlet design to ensure self-cleaning, and that sediment is accumulated in places where it can be removed easily (no sediment fore bays were seen; stones impede sediment removal)
- Lack of ponding depth in many sites due to improper construction or overfilling during maintenance (with mulch)
- Inadequate width leading to plant/tree damage and death, bare areas
- Reinforcing options/setbacks for roads need to be standardised and agreed with road engineers
- Plant selection to minimise maintenance, especially along edges, to minimise or avoid trimming against roads or footpaths (within 1 m of active road way)
- Use of mulch that floats (anecdotal)
- Cost of unique engineering designs. A solution is to use modular, pre-approved designs.
- Documentation refers to TP10 guidance. TP10 will be changed in 2016: media specifications, reduced depth and design modifications to enhance volume mitigation and exfiltration where conditions are suitable (see Appendix 7). These will help reduce cost and footprint of raingardens but a minimum footprint is suggested to reduce risk of clogging and extend device life.

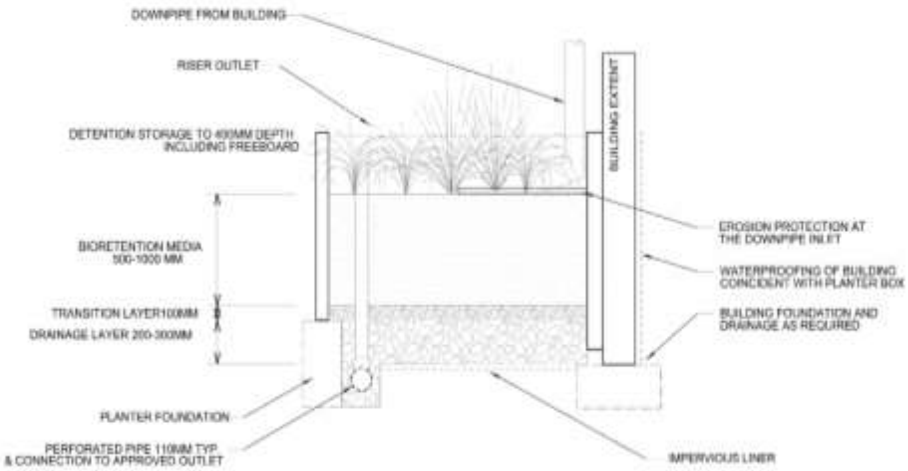


Figure 18: Stormwater planter cross section, North Shore City Council.

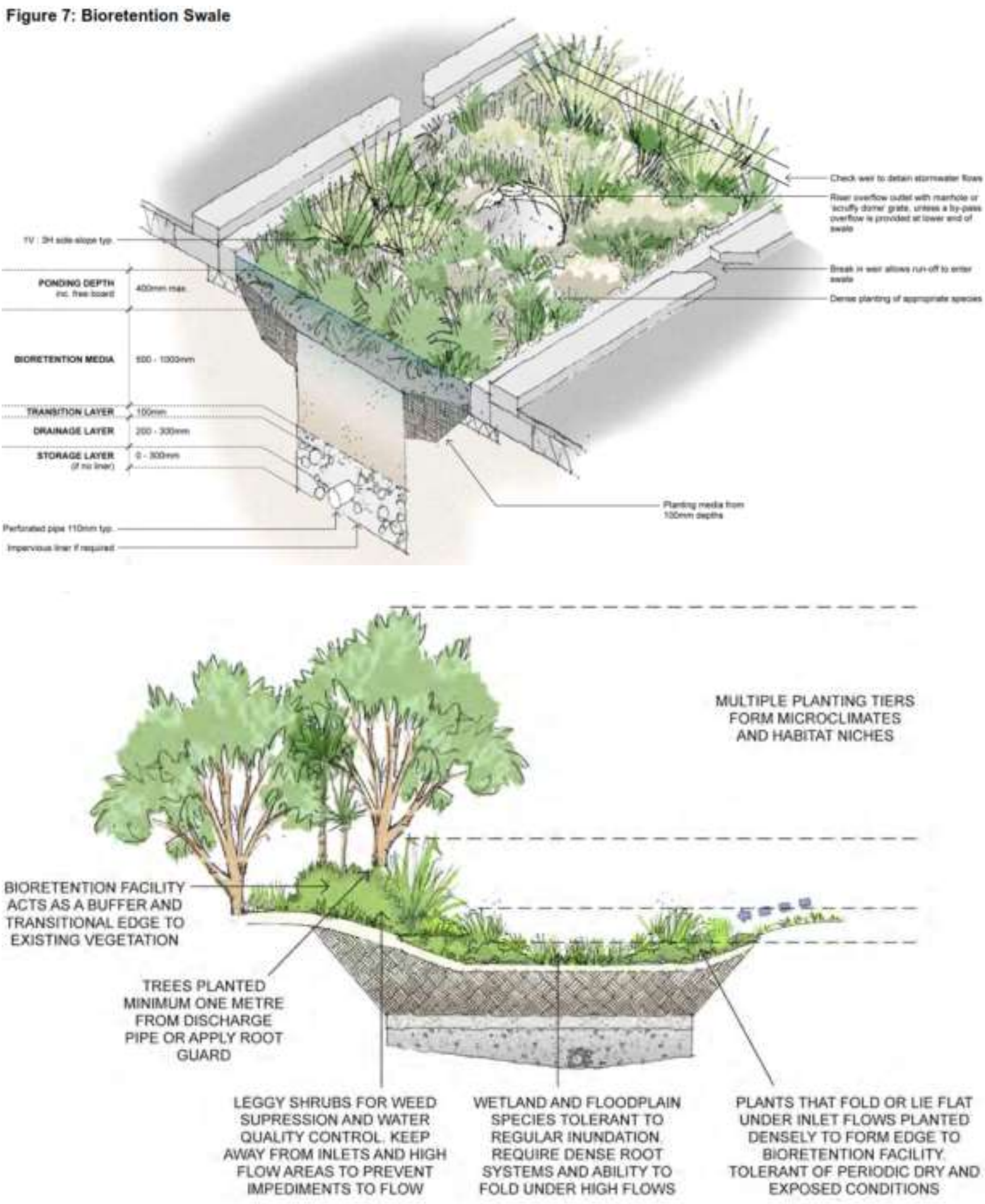


Figure 19: Examples of Bioretention Swales, North Shore City Council

Stormwater Wetlands

- Areas with water-loving plants that retain permanent water in places and carefully engineered to ensure 'labyrinth' water movement and a variety of water depths
- Primary Function: volume control, detention and fine filtration of contaminants by allowing sediment to settle and filter through plants
- Defining features: A forebay at the inlet where coarse sediment and gross contaminants are captured to allow efficient maintenance and long life; a large, planted area manages water quality (in particular sediment and temperature mitigation) and detention of peak flows; high flows are bypassed
- Suited to greenfields and passive recreational areas where a permanent water table is present with relatively flat land over a large area. Successful in Nelson/Tasman where they have replaced boggy mown ground within detention basins and also where adjacent to riparian zones

Figure 20: Stormwater wetland near Richmond Aquatic Centre

Special types

- Surface-flow wetland, including wet swales. Water flows across alternating zones of deeper water (pools) and shallow planted areas
- Subsurface flow wetland. Stormwater passes through the root zones of wetland plants below the surface. Requires water with low sediment concentrations and uniform flow
- Floating treatment wetland/island. A raft supporting wetland plants that is tethered within a stormwater pond. Mainly used as a retrofit to enhance performance by shading open water (decrease temperature) and increase sediment removal in root curtain and biofilms

Key issues in Nelson

- Limited design experience and implementation in Nelson/Tasman
- Maintenance costs (mitigate by ensuring effective vegetation establishment, and using fore bays to capture gross pollutants and coarse sediments
- Faecal matter from wetland birds creating water contamination (mitigate by reducing loafing areas, avoiding mown grass adjacent to open water, tall planting to limit flight lines)
- Public concern about safety around open water (mitigate using wide, dense edge planting and shallow slopes) and mosquitos/stagnant water (mitigate by avoiding short circuiting, allow shallow and deep water)

Figure 21: Wetland basin in Saddleback Road, no permanent water or deep ponded areas.

Table 4: Stormwater quantity and quality treatment provided by Wet ponds and constructed wetlands

	Quantity control				Quality control								
Key ● effective ○ partially effective - not effective	Flood attenuation (>2 year ARI)	Groundwater recharge	Volume reduction (retention)	Detention (95%ile event)	Sediment	Gross pollutants	Metals removal	Oils and grease	Nutrient removal	Organics	Hydrocarbons	Indicator bacteria	Temperature
Wet pond	●	-	-	●	●	●	○	○	○	○	○	○	-
Constructed wetland	●	-	-	●	●	●	●	●	●	●	●	○	-

Appendix 3 – Field case study sites in Nelson and Tasman

The following sites were discussed in meetings with Nelson and Tasman engineers, and formed the prompts for interviews, particularly when discussing implementation and maintenance. Engineering diagrams are available for many of the sites. The full list of sites is given below; this is followed by one-page case studies that list 1) effective features 2) what would make these areas function better for stormwater volume or quality or transport and 3) issues that arose during consenting/construction/maintenance and how they have been or could be resolved. These sites inform the selection of 'most suitable devices' for Nelson/Tasman in the short term and key design features for 'approved devices' for Nelson/Tasman. These most suitable devices build on what has already proven to work well in the area, or that can be confidently 'tweaked' to offer improved level of stormwater treatment and acceptable maintenance costs/frequency.

Living, or 'green' roofs were not visited although there are several relatively thin roofs on commercial buildings in the region, for example, Mahana Estates (Fig 22, photo below from 2011) near Mapua, have three sloping tussock roofs covering an art gallery/café and winery, and Sans Souci in Golden Bay has turf on flat roofs over accommodation blocks. No modern lightweight roofs designed specifically for stormwater mitigation have been identified.

Figure 22: Tussock on roofs at Mahana Estate, Mapua**.**

Harvey Norman, Nelson

- Below road level with drop protected and disguised by dense cover of a range of native species
- Maintenance achieves a clean edge that does not impede pedestrians, however the occasional large lowland flax (*Phormium tenax*) may be better replaced with the lower mountain/coastal flax (*P. cookianum*)
- Could enhance by adding patches of taller trees to provide shade for pedestrians/cyclists along this straight, busy, boring street
- Soil appears higher then asphalt in places – maybe because mulch has been added or rushes have allowed sediment to build up; some of the oioi rushes are very desirable growth form, being upright and therefore not needing regular trimming)
- A better edge would be L-shaped and allow a 50-mm drop onto a concrete strip in the device

Figure 23: Harvey Norman site, Nelson.

Saddleback Road, Todds Valley

Bollards with rope connections were constructed initially, and then removed because the risk of damage to grass was assessed as low; the road is a cul-de-sac and road width allows parking on bitumen road edge, not on the grass.

- Filter Strip receives runoff over berm. No kerbs
- Funny that the only bit of kerb is around the trees (A novel way to protect from traffic, both grass mower and cars? Also makes mowing simpler/faster as don't need to go around trees. Tree roots should be able to exploit swale for moisture if soil conditions allows root exploration)
- Flow into small stream. Very little flow at the time of visit
- Off-line detention basin planted as a wetland as the ground was very hard to maintain in grass (too soft and wet to mow and keep looking acceptable); was very dry and appeared overgrown with weeds but overall looks green (i.e. functioning for bioretention)
- Spillway into culvert under access driveway. Can't see OLFP

Figure 24: Saddleback Road, Todds Valley.

- Could improve detention and WQ by increasing grass height in mown area

Reduce sediment build-up along edge and extend life before renovation is needed by enhancing self-cleaning either 1) increase slope and breadth of concrete edge or 2) create L-shape (i.e. a 50-mm drop over concrete edge strip; maybe enhancing tree numbers

Frenchay Drive

- Road side swale, undulating width adds interest and slows traffic by creating visually ‘narrow’ areas
- However narrow areas are vulnerable to poor plant health if plants can’t tolerate trampling (people sort-cut through the narrowest and least-vegetated areas) or heat (having hot surfaces on both sides)
- No kerbs. Planted swale with gravel/metal mulch. Species are hebe, flaxes and sedges (Carex). Flaxes and Hebes are healthy; sedges have thinned /failed to thrive in some places – this might be exacerbated by foot traffic short cuts through the swale? Few weeds but gravel cover is too high for a mature bioretention device, as vegetation underpins stormwater volume and quality mitigation
- Effective underpasses to the stream; large capacity that are well armoured with rock; their purpose is obvious for public and inlets are easy to see and check efficiently

Figure 25: Frenchay Drive.

Frenchay Drive Playground – dry pond

- Not sure about hydraulics (see picture). Probably intended to take extra flows from area to the East
- Inlet/outlet at lowest point. Probably using limited capacity to throttle the flows (?) rather than an overflow device (scruffy dome)
- Including edible fruiting plants, citrus and feijoa, provides additional community benefit. Well-placed on edge of detention area where they can access both well-drained and wetter soils as all fruit trees require reasonable rooting depth and produce best where stress is low

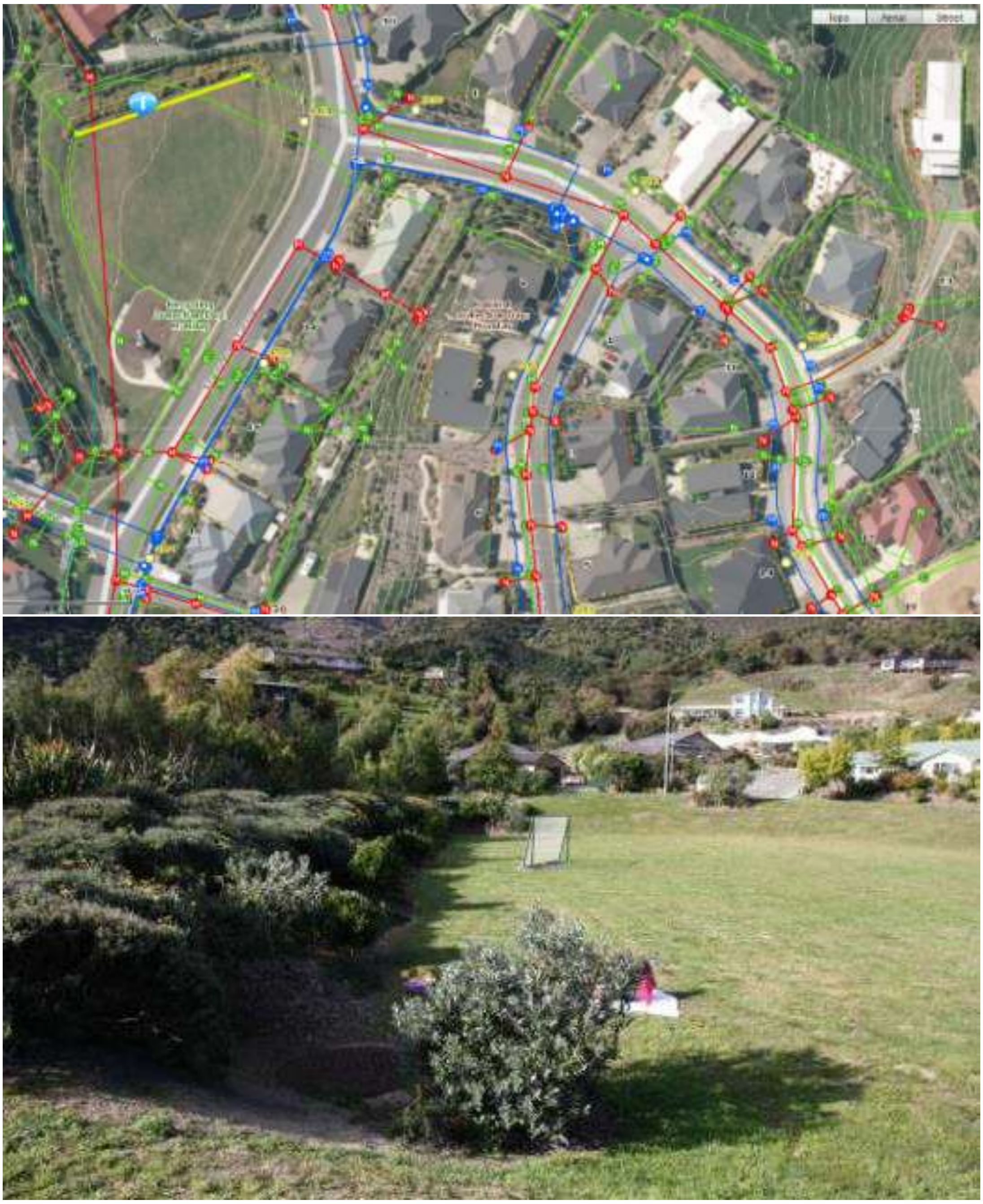


Figure 26: Frenchay Drive Playground – dry pond.

Halifax Street East

- Old area. No kerbs.
- Sheet flow across street into reserve into Maitai River with some preferential flow paths –concrete spreaders with drop zones would improve evenness of flow and remove flow from steep areas that have higher erosion potential
- Could be better planted to achieve full plant cover over all areas, and particularly any preferential flow paths, weed control to remove pampas, raise tree canopy to encourage denser grass sward; Full plant cover in highly trafficked areas may require board walks
- Could reduce peak flow and volume by creating undulating swales /micro-detention areas. Undulations would help mower to leave a taller sward (minimum 100 mm) with increased surface roughness; or add formal areas of sedges (these can be useful to define paths). Paths can be used to create edges for micro-detention areas if overflows are board-walked.

Figure 27: Halifax Street East.

15 Alton Street (Nelson Marlborough Institute of Technology NMIT)

- Strip bordering the street (upper photo)
    - Older area with wider beds and inlets (each with a double-slit that helps self-clean) and with healthier, dense vegetation (mainly small flax, *Phormium cookianum*) with small deciduous trees (flax not impacted by leaf fall as trees are small, flax is bulky)
    - Outlet at lowest point but limited ponding depth. May be designed to provide exfiltration into underlying gravels
- Beds within the carpark (bottom photo) are very narrow; below recommended width. Beds should be at least 1 m width to reduce ongoing damage from intruding car bumpers damage makes the bioretention look messy, and lowers plant cover and health. Most of the remaining groundcovers (Astelia species) look healthy; useful to have at least 2 species (3 would have been even better). An uncommon species for mass planting in raingardens as they don't tolerate wetness or trampling
- No outlet seen in these narrow strips – so check infiltration to permeable underlying gravels; in large events overflow to larger raingarden grate
- Design fault –cess pit next to kerb inlets in places (bottom photo)
- Construction or maintenance issue: soil/mulch level appears higher than asphalt – overfilling means water can't get into the device and ponding depth is removed

Figure 28: NMIT bioretention; the circle shows the overflow height which allows only minimal ponding depth; the arrow shows how runoff can bypass the swale directly to the catchpit.

Sanctuary Drive

Swale takes road runoff. Road reserve includes underground infiltration trenches for treatment of private stormwater from houses, avoiding private on-site devices. Check swale maintenance –some street owners want rushes trimmed very low and frequently (as a lawn), some have been removed – public complaints are a key issue for councillors/council. A site for road engineers and landscape architects (for plant selection) to see; interesting combination design of bioswale and adjacent infiltration trench

- Impressive suite of LID; placement on one side of road reduces impacts on carparking
- Heathy planting; few weeds as just maintained; gravel mulch retrofit to reduce weeds in low groundcovers that were initially established; well-defined edges;
- No signs of any primary road drainage. All sheet flow so no concentrated flow into swales (preferred practice)
- See map: subsoil drains have been used: so intended as raingardens, not swales

Figure 29: Sanctuary Drive raingardens.

Sunningdale Drive

- Dense healthy vegetation with mountain flax in centre and low sedges along edges to reduce maintenance trimming ; flaxes may become too large in future
- Soil higher than surrounding hard surfaces prevents effective functioning; dropping soil level would provide volume and water quality advantages and reduce flax maintenance

- Easy to repair – flaxes are tolerant of replanting
- Cess pits just in front of swale inlets (bottom photo) means high proportion of flow can short circuit and avoid stormwater treatment device
- Could enhance detention by running raingarden outflow through filter strip to stream

Figure 30: Sunningdale Drive.

Saxton wetland and playing fields

- Some improvement works underway
- Scope not clear (visually)
- Big pipe coming out indicates probable piped stream
- Check final slopes (steep slopes are a common design fault. Steep slopes have elevated risk of poor vegetation growth and erosion as plant stress is high via compaction and reduced rainfall; if they are long, they are also more difficult to maintain safely – especially if grassed)
- Review inlets from road, or if the grass strip to the right is creating sheet flow into drain
- If this is a perennial stream, consider potential to create or enhance habitat by creating a slight 'meander' low flow and/or variation in depth

Figure 31: Saxton wetland and playing fields.

Figure 32: Saxton Field swale and overland flow path, 2011 (very short – usually minimum 100 mm height for swales – discuss with Parks implementing different mowing standards within playing grounds, including potential for planting up).

Hammill road

- Very narrow street, which is great from an impervious area point of view
- No further useful stormwater features; normal kerb-and-channelling
- The pop-out gardens could be set below grade to receive stormwater runoff

Figure 33: Hammill Road.

Main Road Stoke swale

- Planted from a grass swale – two long swales with no crossings. Densely vegetated except at small areas around inlets. Effective buffer for pedestrian traffic; would be enhanced with trees.

Figure 34: Main Road Stoke swale.

Sundial Square

- Intensive urban area, town centre
- Raingardens take water from adjacent carpark and footpaths
- Lots of storage volume (good). About 300–400 mm deep but inlets flush with soil level of raingardens, so storage will not be activated
- Attractive, dense vegetation (Apodasmia = oioi) will probably need 6-monthly edge-trim to maintain clear edge and footpath width unless fertility of substrate is low or upright cultivar is used
- Small square pipes are used to transfer stormwater from carpark to raingardens; poor design as easily block (some were clogged). Replace with wider curb cuts overlain with removable grate, ensuring slope and drop into pipe and into raingarden is sufficient to flush rubbish/reduce blockage
- Use of trees provide increased street and environmental benefits; check maintenance schedule around leaf fall to maintain open inlets
- Improve function with some easy / cheap improvements (raise overflow grate)

Figure 35: Sundial Square.

Richmond Pool Complex

- Carpark, grass swales and wetland
- Grass swales are mown very short; very wide, plenty of space with trees well positioned to side of swale
- The wetland was very dry; function is improved and stress decreased by maintaining areas of permanent water; now low maintenance

Figure 36: Richmond Pool complex.

Adjoining NZTA deviation (highway) swales, Richmond

- Wide grass swales
- Receiving open drain/swale base looked herbicided (because mowing too difficult?)
- Some of the swale seems to drain into the same wetland (above)
- The earth bund to the left is intended as a noise barrier. It acted like a dam during the big 2013 rain event causing the development behind to flood. So work is being masterminded to fix the issue (opportunity?)

Figure 37: Highway swales, Richmond.

Forget-Me-Not Lane

- Small residential street. Very narrow grass swales in between kerbs
- Grass mown far too short. Short grass, highly exposed scrumpy domes, and herbicide edges means this has low aesthetics. Adding trees might help distract from the swale

Figure 38: Forget-Me-Not Lane.

Brambly Estate

- Wide central swale/raingarden divides carriage way; initial groundcover plants were replaced with rocks to make maintenance easier – but this undermined the intent, and reduces resilience of infiltration to sediment and compaction. Find out what original plants were and if a mulch was used – as a common reason for such outcomes is lack of mulching and/or weedy media allowing weeds to establish combined with herbicide-vulnerable groundcovers
- Concrete edges prevent vehicles entering swale; drop into swale will extend life and help keep entry points open
- Trees (totara?) are looking healthy
- Drains into heavily modified stream
- This design make vehicle and trailer/boat access to sections difficult

Figure 39: Brambly Estate.

Placemakers, Stoke

- Device cannot work as stormwater cannot enter – the soil and mulch level is higher than the asphalt surface that generates stormwater

Figure 40: Placemakers, Stoke.

Opportunities for LID devices

Mapua wharf

- Potential Bioretention in planter boxes. Missed opportunity as planters could have been fed from downspouts; alternatively runoff could enter into subsoil to boost water supply to lower root zone and save on irrigation (planters are irrigated)
- Show examples where planters are used, and edges are incorporated into public seating. Including stormwater helps support larger trees needed for shading to mitigate UV and heat of paved/concrete surfaces in summer. An alternative used overseas have been columns of vines such as hops or male kiwifruit (because they are deciduous)

Figure 41: Mapua wharf development

Figure 42: Potential stormwater mitigation area – high capacity to receive and slow inflows (review drive ways and whether the area receives footpath or house runoff) (2011 photo**).**

Figure 43: Port Nelson 2011 – this should be receiving runoff from footpath if not the road, which would benefit tree health and trap coarse litter.

Appendix 4 – Presentation to the Joint Land Development Steering Group (powerpoint)

presentation to Steering Group 16 May 2016

Low Impact Urban Design Advice

to support the development of a joint (Nelson / Tasman) Land Development Manual

Robyn Simcock (Landcare Research)

Jan Heijs (Morphum Environmental Ltd.)

LANDCARE RESEARCH
MANAAKI WHENUA

MORPHUM
Engineers & Consultants
The union of engineering design and nature

16 May 2016 Low Impact Urban design Advice for TDC and NCC 1

Outline

- Scope of Envirolink project
- Wider context of LID
  - National and international findings and practice
  - Low Impact Design – wider understanding
- Draft results
  - Current versions of manuals
  - Current practices
- Next step and future steps
  - Next set of agreed / approved devices

This presentation: part of consultation

Need your feedback

Deadline June 2016

Now or email

16 May 2016 Low Impact Urban design Advice for TDC and NCC 2

Scope of Project

- **Review of Land Development Manuals (LDM)**
  - Areas that inhibit application of LID
  - Opportunities for step changes
- **Local priorities, limitations, opportunities**
  - Through interviews and field visits
- **Develop recommendations**
  - Decision matrix
- **National and International Best Practice**
  - overview

16 May 2016 Low Impact Urban design Advice for TDC and NCC 3

Why change? - Why LID?

- **Traditional SW management unsuccessful:**
  - in protecting against flooding
  - In protecting natural environment
    - Streams (ecological health, erosion)
    - Marine environment
  - Triggering huge investments to fix problems
    - If at all practicable
    - Some effects are irreversible (too late)
- **Overwhelming international evidence / literature**

'We' replace a stream shaped over 0000's years with a pipe .... and wonder why there is flooding

Conclusion: pipe and forget didn't work

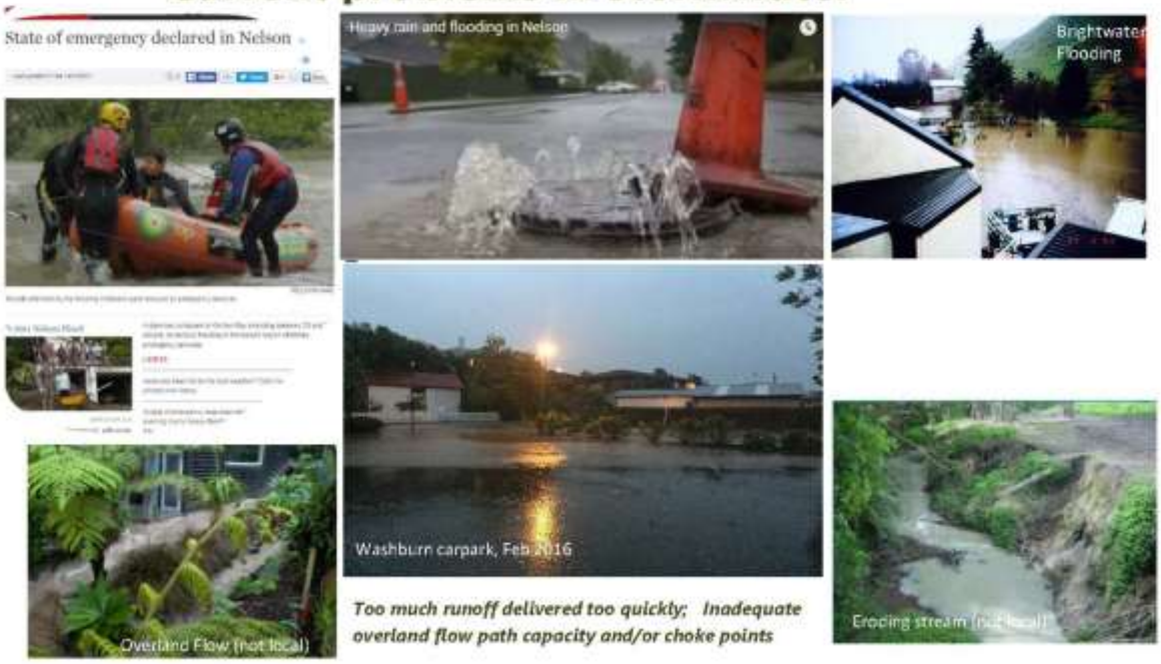
Solution: Change to prevention and at source → LID

- closest to mimic natural processes
- Lots of other benefits including costs (long term)
- Very good results

'We' develop in easy accessible / low lying land: floodplains .... and wonder why there is flooding

16 May 2016 Low Impact Urban design Advice for TDC and NCC 4

Tasman / Nelson different?
Flooding: NO
Current problems in stormwater



Too much runoff delivered too quickly; Inadequate overland flow path capacity and/or choke points

Tasman / Nelson different?
Water Quality: No

- **Point raised in stakeholder meetings:**
  - LID needed in TDC/NCC? – any water quality problems?
- **Although out-of-scope for this project did a quick search:**
  - Some sampling assessment undertaken in the past
    - Local: 2010 TDC report to Environment and Planning Committee (H505, S750)
      - Elevated levels of Zinc downstream of residential and commercial areas. Lead and copper levels increasing over time indicative of increased pollution from urban areas
      - Very poor ecological condition in parts of Jimmy-Lee Creek
    - Waimea Inlet sediment (2007) report
      - Some quotes:
        - *No surface fauna visible, not even crab holes. Surface had a yellow / orange tinge"*
        - *The study site had values higher than the estuary reference sites for all parameters.*
        - *Zinc values were especially high.*
        - *Enrichment was evident.*
        - *There was a significant reduction in species diversity.*
    - 2012 and 2003 Nelson reports on sediment quality
      - elevated levels related to residential and commercial use; Some exceeding criteria
- **TDC / NDC not very different from elsewhere**
  - Impact of urban activities on Water quality very well documented around the world
  - No reason that TDC/NCC different
  - Lots of pollutants accumulate – only possible difference is rate of decline
- **And NPS Freshwater Management will require a more stricter approach.**
- **No regrets approach for anything 'new'**
  - New developments, new roads, major redevelopments, major road renewals
    - Much more expensive later

Pre and post
90's and 00's ponds limited success

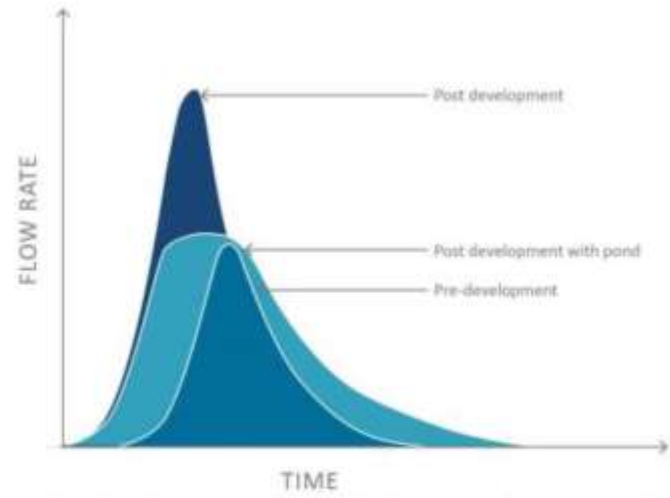
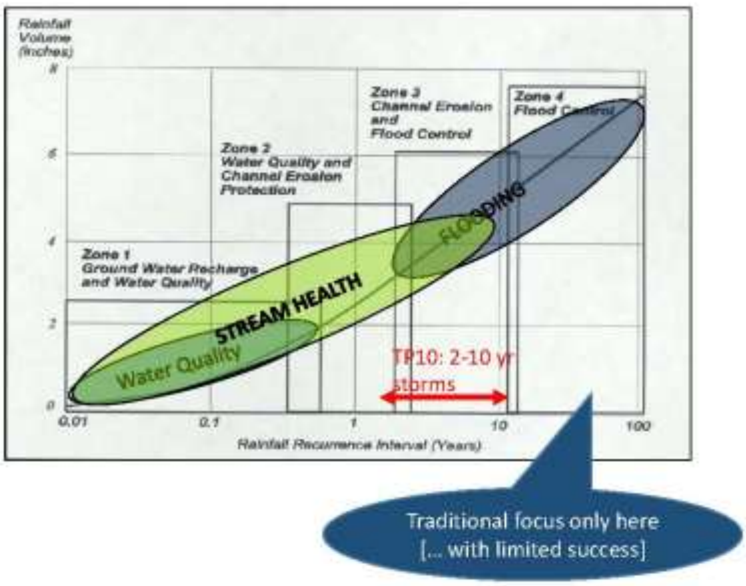


Figure 8: Typical post-development hydrograph with detention (adapted from Shaver, 2000)

Source: Auckland Council GD04

16 May 2016 | Low Impact Urban design Advice for TDC and NCC | 7

Change in Looking Large Events Only to Whole Hydrograph



16 May 2016 | Low Impact Urban design Advice for TDC and NCC | 8

Stream Protection: Need to Look After Both:

- The stream habitat

  stream management
  - riparian margin
  - barriers to fish
  - general geomorphology
  - etc
- Discharges

  avoid, reduce
  - quantity (full hydrograph)
  - quality (sediment, contaminants, temperature, food-sources etc)

16 May 2016 Low Impact Urban design Advice for TDC and NCC 9

Stormwater managers can't manage stormwater alone

16 May 2016 Low Impact Urban design Advice for TDC and NCC 10

Understanding LID

- **Not just**
  - Treatment Devices
  - 2 and 10 year storms
  - Stormwater
- **Low impact design = District Plan**
  - Land use
  - Protecting headwaters
  - Riparian margins
  - Limiting earth works footprint / compaction
    - And soil reconditioning?
  - Limiting impervious areas
  - Discharge and Stream management
  - Devices
    - Rain gardens, Permeable paving, Roof gardens, Etc
  - Treatment train

"wider LID"

D.P tools

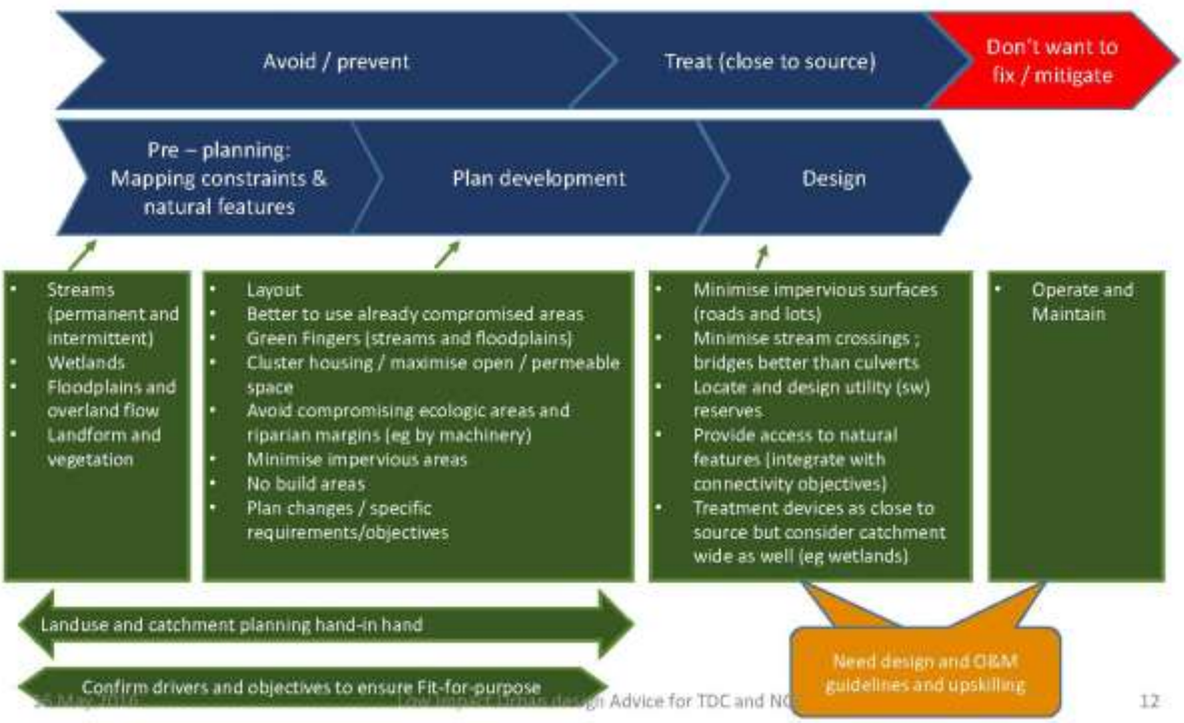
SW tools

The network manager

- **Fit for purpose!**
  - Look at drivers:
  - Streams (quantity and quality)? Marine? Flooding? Contaminants?
- **Tools**
  - Prevention
  - At source treatment
  - Treatment train
- **Other Benefits**
  - Amenity
  - Insulation (green roofs)
  - Greening
  - Bio diversity
  - See also cost/benefits

16 May 2016 Low Impact Urban design Advice for TDC and NCC 11

Phases



16 May 2016 Low Impact Urban design Advice for TDC and NCC 12

Drivers (not always all 3)

Quantity	Stream Health	Water Quality (incl sediments)

• **Flooding**
• **Overland flow**
• **Limited network capacity**
	• **Stream loss**
	  • Permanent and
	  • Intermittent
	• **Riparian margins**
	• **Stream erosion**
	  • Erosion
	  • Related to flow and volumes
	• **Fish passage**
		• **Stream and marine pollution**
		  • Sediments
		  • Nutrients, oxygen, etc
		  • temperature
		  • Heavy metals / pah's / etc
		• **Focus on highest risk**
		  • Busy roads
		  • Carparks
		  • Commercial / industrial

Would be great of we would know (map) what drivers apply where.

16 May 2016 Low Impact Urban design Advice for TDC and NCC 13

LID devices often work better than assumed but need to be designed, built and maintained properly!

16 May 2016 Low Impact Urban design Advice for TDC and NCC 14

Example Seattle – High Point Redevelopment

- Brownfield project (high density – social housing)
- Great Urban design
  - Streets look much wider
  - but aren't
  - no use of fences
  - Lots of walke-able spaces
  - Tree protection
- Great stormwater management : LID
  - Raingardens,
  - engineered soil,
  - permeable paving
  - Signage
  - Participative community
- a great place to be







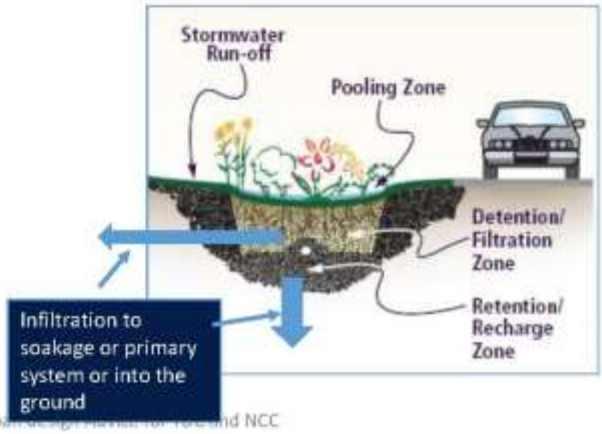

16 May 2016 Low Impact Urban design Advice for TDC and NCC 15

Bioretention is core to LID

- Uses natural processes; mimic nature to:
  - mitigate hydrology:
    - reduce runoff volume and peak discharge rate
    - delay runoff, extend flow duration
    - can design to recharge aquifers
  - reduce concentration and loads of contaminants

Includes:

- *Raingardens*
- *Bioretention Swales*
- *Stormwater Planters*
- *Tree Pits*
- *Green Roofs*



16 May 2016 Low Impact Urban design Advice for TDC and NCC 16

Other possible benefits of raingardens / bioretention

- cool water (small streams)
- cool air, adjacent structures, people
- enhance vegetation (self-irrigating and self-fertilising)
- visual screening, glare reduction, security
- biodiversity/habitat creation,
- sense of place
- enrich play areas and educate regarding stormwater
- ....

16 May 2016 Low Impact Urban design Advice for TDC and NCC 17

The Matrix

- List of devices
- List of scoring criteria
- Intend:
    - Pick the next few devices or device types
        - Easy implementable
            - Most acceptable / least controversioal
    - Full comprehensive review in 3 years

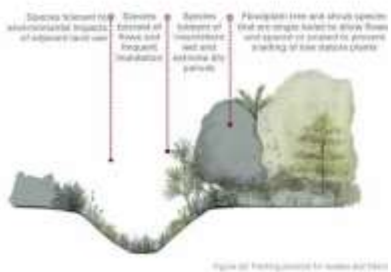
16 May 2016 Low Impact Urban design Advice for TDC and NCC 18

Device category: Swale

Figure: Cross-sections of a swale (Auckland Council draft)

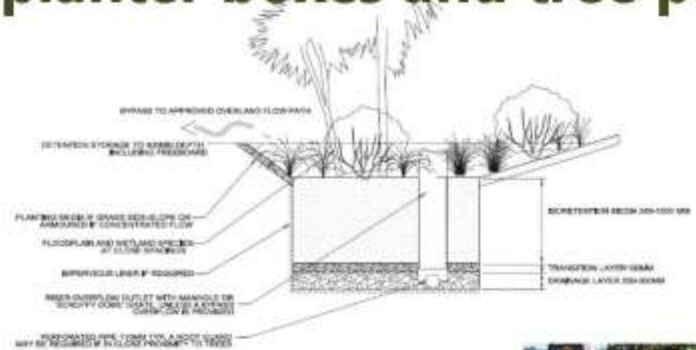
- Conveyance
- Slow down runoff
- Filter course sediment and
- some pollutant removal
- Sometimes used in combination with raingardens (get the water to the raingarden)

Saddleback Road



16 May 2016 — Low Impact Urban design Advice for TDC and NCC — 19

Device category: Raingardens, planter boxes and tree pits



- Densely planted
- Peak and volume control
  - Ponding area 50-300mm
  - up to 24 hrs, 2 yr storm
- Filtering and biochemical treatment (sediments,
- Filter course sediment and
- some pollutant removal
- Sometimes used in combination with raingardens (get the water to the raingarden)

Sanctuary drive, Stoke

Sundial Square, Richmond

16 May 2016 — Low Impact Urban design Advice for TDC and NCC — 20

Device category: Wetlands

- Densely planted with water loving plants
- Carefully design to achieve labyrinth of water movement
  - Maximise residence and contact time)
- Peak and volume control
- Forbay to catch sediments / gross pollutants
- High flows are bypassed
- Suited in greenfields, could be in floodplains / riprarian strips.
- Passive recreation

Aquatic Centre

Saddleback Road

16 May 2016 Low Impact Urban design Advice for TDC and NCC 21

Scoring

- **Used**
  - Flooding
  - Pollution
  - Amenity
  - Maintenance
  - Footprint
  - Risk
  - Suitability
- **Used traffic light**
  - Focussed on positives
  - Not possible to calculate cost
    - Note: economy of scale can significant reduce costs incl O&M
- **No weighting**
  - Some columns more important then others
- **Need you feedback on**
  - Setup
    - Anything else you want us to look at?
  - contents

16 May 2016 Low Impact Urban design Advice for TDC and NCC 22

Matrix - see handout

Current Manual review findings

- **Good intend**
  - Some sections show good intend
  - indicating political / strategic support for LID
  - Need clearly spelled out objectives and staged performance criteria (decision tree)
- **But: no teeth**
  - Only application when there was limited capacity in downstream primary network
  - Use of words like 'where appropriate' , where practicable', where possible, should be considered', are weak
- **Put in as an afterthought**
  - Lots of text suggest it is the piped network that is the focus
  - LID to be considered FIRST (see previous slides)
- **Alignment with TRMP and NRMP?**
  - Not part of scope but important to follow up
- **Design detail**
  - Seen some design errors in the field: maybe guidelines rather then part of manual to enable easy updating: 'pre-approved designs'

Field visit

- **Lots of LID devices**
  - Most / all triggered by insufficient capacity of downstream network
- **Swales easily improved to boost flood mitigation and quality**
- **Likes**
  - Sheet-flow common,
  - Good amenity with native species
  - Roadside bioretention (raingardens / swales)
  - Attractive parks also providing storm water function
- **Improvements on existing devices (easy to do)**
  - Swale width and bank slopes
  - Overfilling removing ponding depth / storage volume
  - Inlet and outlet arrangements to avoid short-circuiting
  - Few trees and few wetlands (with wet areas)

16 May 2016 Low Impact Urban design Advice for TDC and NCC 25

Draft recommendations

Being selective is very subjective

- **But based on matrix and experience**
  - Bioretention
    - Already applied but improve design Maybe have 'pre-approved designs'
      - Certainty to get consent
      - Efficient
    - Maintenance
      - Better choice of plants
      - Upskilling maintenance staff
  - Raintanks?
    - Quantity only
  - Allow stormwater to enter landscaped areas
  - Wetlands in new greenfields
  - Green fingers
- **Other (not part of current scope)**
  - Manual: bring LID to the front and include decision tree process
  - Alignment of planning documents
  - Practice notes
  - O&M instructions
    - Incl upskilling
- **Optimise LID and soakage**
  - Could work well together to minimise flooding

Need your Feedback

16 May 2016 Low Impact Urban design Advice for TDC and NCC 26

Appendix 5 – Field itinerary for LID-LDM Steering Group site visit

The LDM Working group endorsed this stormwater site visit for the Steering Group and Nelson City Council / Tasman District Council staff.

1:00 – Bus leaves Tasman District Council, Richmond (Cr Noriss, Cr Bryant, Paul Newton, Robyn Sc, Gary C, Lisa M, Jeff C, Steve M, Anna G, Beryl W, Tania B, Ros S, Phil D

1:15 – Bus arrives at Rutherford Hotel (Robyn Si, Jan H, Dugald L, Ian M, Shane J, Robert W, Trevor J)

1:30 – Bus arrives at Nelson City Council (Cr McGurk, Cr Ward, Lisa G, Shane O, Phil R, Chris P)

1:45- 3:45 – Site visits

- Harvey Norman, Nelson – extensive raingardens between street and carpark, almost indistinguishable conventional landscaping

- Panorama Drive, the Ridgeway Detention

- Sanctuary Drive rain gardens and riparian strip 'green finger' (photo above)

- Main Road Stoke Swale (drive past)

- Richmond Aquatic Centre car park and wetland

- Sundial Square raingarden (drive past)

4:00 – Bus arrives Tasman District Council Richmond

4:30 – Bus arrives Nelson City Council

Appendix 6 – Comments on text TDC 2013 and NCC (2010) standards

The scope does not include a detailed review of the text, calculation rules, and suggestion for changes to the text. It is recommended that this be done after LID tools have been selected. Review comments are generally to take the opportunity to improve the text**.**

TDC 2013 standards

It is not clear (not part of the scope) to see whether the engineering standards are aligned with council strategies and legal requirements, including network consent requirements. Alignment is important to justify objectives and subsequent requirements in engineering standards. Some objectives and design principles do include LID. Unfortunately the following text has very little teeth.

LID is to be considered at many stages throughout the development process across the following stages:

1. Pre-design (mapping constrains) to
2. Plan development (structure plan/development layout, aiming to protect/enhance natural assets such as stream and wetlands, minimise earthworks and compaction, minimise hard surfaces as well as space for future LID solutions such as wetlands, bioretention
3. Specific design of public and private land including LID devices
4. Design of individual lots, including rules, covenants to ensure LID is used on private lots.

It is recommended to include a design process using a decision-tree-type flowchart that is mandatory and clear and can be used by both the developer/designer and the consent staff to check whether LID opportunities have been adequately considered and maximised. It provides certainty and reduced time-consuming iterative processes, which developers look for.

LID tools and methods: Only a very limited number of treatment devices are suggested in the document – rain tanks and raingardens. There are many other tools available at the different stages of the planning and design process.

Need for practice notes: Documents that show complying solutions meeting Tasman Resource Management Plan (TRMP) as well as engineering requirements. Having these available has proved very successful. They do, however, need to provide adequate engineering detail so the engineering consultants understand what is required and the process from there on is easy and (almost) guarantees a 'rubber stamp' approval.

Standards and TRMP need to be aligned, with TRMP includes LID requirements. It is recommended that the TRMP-text is reviewed as well because these standards need to be aligned with the TRMP and use the next opportunity to tidy up and misalignments.

Below are detailed comments on the existing 2013 standards – chapter 7 only. Some go beyond LID but have been included as suggestions.

Reference	Subject	Comment
General	Use of 'where appropriate', 'where practicable', 'where possible', should be considered', etc.	Should be avoided because it provides a way out.
General	Alignment with District Plan / RMA-plan	Standards and TRMP need to be aligned. I'm assuming the TRMP has LID requirements. Would be good the review TRMP text as well because these standards need to be aligned with it
General	Pdf file	Made more notes and suggestions in pdf file to further improve the text. Key comments are included in this table.
Disposal	Avoid the use of the word 'disposal'	Stormwater should be seen as a resource. Disposal of stormwater as used in some sections has some negative connotations. I would suggest discharge, infiltrate, convey, etc.
7.1.1	Missing objectives	Suggest including two objectives at the start: a) Because a large part of stormwater runoff (quality and quantity) is determined by land use, and because it is much more expensive to mitigate retrospectively, 1) avoidance then 2) treatment at source is to be considered first, starting at the planning stage. This would include to identification of natural assets such as streams and wetlands, floodplains and overland flow. b) The use of natural assets such as streams and wetlands is preferred. Not having these will indirectly inhibit the application of LID because it provides an easy way to apply traditional solutions.
7.1.1. a)	OLFP objective	OLFP only to cater for flows in addition to 1:50 storm event. Primary reticulation often blocks (partially) during large storms. Good practice is to design OLFP for 100% of the flows (not just the additional). Mostly up to 1:100 yr but I would suggest consider more where additional costs/implications are not significant. Also wording to be improved. It reads as flows in access of 1:50yr and objective b) talks about primary system designed for flows <= 1:20 yr. Not clear about 20–50 yr. Note table 7.2 states 1:100 yr. Not strictly LID
7.1.1 c)	Stormwater infrastructure	Text suggests a piped network to the reader. It does not encourage use of (existing) natural assets such as streams for conveyance. Suggest make this explicit by adding *"the use of existing natural assets such as stream should be considered first"*.
7.1.1. d) – f)	Use of natural assets	Suggest making the preference to use natural assets more clear.
7.1.1 j)	Reference to resource consent	I suggest also include reference to the TRMP??? This is important because an individual consent, for example, also includes permitted activities. I'm assuming the TRMP has LID requirements. Would be good the review TRMP text as well because these standards need to be aligned with the TRMP.

Reference	Subject	Comment
7.1.2	Design methods	Although NZ4404 does include LID, from experience the use of LID is not often proposed by developers and their consultants. This section provides an opportunity to express the consideration of LID during design (and planning). Suggest adding a 2nd paragraph with the words: *"For the benefit of doubt, LID (Structure planning, Avoidance and treatment at source) is to be considered first before other, more traditional stormwater solutions are proposed. This needs to be well documented and justified.* *Whether or not this process is followed will be tested during the resource consent and/or 224 approval process."* See also review comments suggesting a decision-tree method.
7.1.3 **7.10.5**	Reference to Auckland Technical Publications	Many (or all?) of these TPs have been superseded. Suggest update. TP124 has been replaced.
7.2.1 a)	LID expectation	Suggest explicitly state that LID solutions are preferred, must be considered. … and that only when can be proved that this is not possible alternative more traditional solutions can be proposed.
7.2.1 d) i) j)	OLFP	As above; to be 100% of 100-yr event flow.
7.2.1 g)	Reliance on soakage	This suggests the reliance on soakage. Not sure about this; often soakage is considered an additional benefit but should not be relied upon because during these design storms soakage often doesn't perform as assumed. On the other hand, soakage is a great asset when applying LID treatment devices (but is not a must).
7.2.1.k)	Life cycle maintenance requirements	Maintenance manual – yes. Costs – not so sure. This type of knowledge generally doesn't sit with developers and most of their consultants and is often overstated. Good understanding of the (often over-stated) O&M requirements should be with council.
7.2.1 g) h)	Development scenario	Suggest use a maximum probable development scenario when considering floodplains and when designing LID devices.
7.2.2	Climate change	Suggest include climate change in rainfall and sea level calculations (i.e. not change to ARI to accommodate). Although the trend is clear and generally accepted, predictions are continuously updated and by referring to an adjusted ARI any change would require a change of the standards.
7.2.3	Table 7-2	Not all LID at 5% AEP. Many treatment devices only up to 2-yr ARI. Can seek up-to-date advice is desired.
7.5.2	Sea level prediction	Have been updated since 2007. Most recent report was from the Parliamentary Commissioner for the Environment (supported by work undertaken by NIWA). 7.5.2.f: to include (changes to) groundwater tables.

Reference	Subject	Comment
7.7	Accepted methods	LID and other are all included. Suggest separate LID as a first option because it makes it more explicit; also because design requirements for LID are often different to other stormwater management methods. Alternatively, clearly state which methods are LID and which are not.
7.7.1	When to use LID	LID preferred is too weak. Suggest stringer wording as indicated before. Need to quality 'is preferred'. Too easy out. Suggest something like: *"LID is to be used unless proven not possible and practical* *This will be tested during resource consent process as well as the 224 approval process.* *When proposed not to use LID the test is at the discretion of council whether or not LID is / is not proposed"*. See also review comments suggesting a decision tree method. Also suggest move LID requirements to the front as the first part of the process.
7.7.2	Soakbeds and soakage trenches	Suggest limit use to LID treatment. Hesitant to use for design storm intensities (e.g. flooding).
7.7.2 c)	Soakage capacity	For LID emptying in 24 hours is adequate. Note soakage trench is not commonly used as a term from LID. Typically swales or raingardens (bio retention) is used. Suggest say soakage (excl. LID) and have a separate section for swales and a separate one for bioretention. NOTE it would be a great opportunity to design all soakage trenches to include LID / stormwater treatment. Might need a /bypass for flows >2 yr ARI? For conveyance of design storm flows – see earlier comments.
7.7.2 e)	Privately owned systems	Suggest a register for all privately owned soakage and LID treatment systems. In this section include the requirement to provide details to be entered into a register.
7.7.3	Open channel design	To include Use of natural stream (permanent and intermittent) for stormwater conveyance is preferred Manmade channels are a 2^{nd} option but only of 1) is not possible Piped stormwater is 3^{rd} choice Agree with all >900 mm should use open channel. Maybe smaller??
7.7.3	Open channel design	Use of natural streams: need to stress that a natural channel should keep its natural habitat and appearance. So no straightening and hard engineering structures. Most working already there. Might need some strengthening. Often an opportunity to enhance / undertake stream restoration. Could require this as a resource consent condition (?) which reduces cost to council.

Reference	Subject	Comment
7.7.3. h)	Waterways in private ownership	Suggest add wording to the effect that any structures / obstructions (houses, garages, sheds, fences, etc.) should not be built in these floodways/streams/margins. Note this also needs to be secured in the TRMP.
7.7.4 and 7.7.7	Piping of watercourses	Keeping and enhancing streams is an important part of the LID process. Recommend distinguishing between piping and reclamation. Suggest clarify when to use culvert and when to use 'piping' A definition: Piping is to provide access to the other side. Pipe length (culvert) should not be wider then needed to provide for this access. Reclamation is when to pipe is designed to increase useable land (developable land). The sentence "*In some infill and brownfield circumstances retention of open channels is not possible due to the ongoing maintenance requirements and access restrictions."* Reads like an open door to pipe streams.
7.7.9 a)	On site retention of stormwater	Wording is weak and at odds with the requirement to have post-development flows the same as pre-development flows (?) Note that this requirement might apply at development level allowing for the use of catchment wide devices such as wetlands.
7.7.10 7.8.1	Sizing of devices and piped network	Suggest ensure, at the discretion of council, devices be sized to include future upstream developments. I guess in these cases a contribution from council (recoverable through development contributions) would be appropriate.
7.8	Piped system	The use of underground stormwater infrastructure should be avoided where possible and where the absence doesn't cause nuisance, ground instability and other issues. Benefits: This would in its own right encourage the use of LID principles It would also reduce initial capex as well as future asset management costs and liabilities It would reduce the likelihood of cross connections to wastewater network
7.10.4 Drawing 725	Site suitability	Worth noting in this section that when some or all of the (treated) stormwater cannot be 'disposed' on site, alternative options are possible. Refer to section where this is explained. Happy to provide guidance. In essence, you can have a drain pipe at the bottom of any LID device and hook this up to the primary stormwater system, avoiding the need for infiltration. (Done in Long Bay). Infiltration Is preferred, aiming for recharge groundwater and stream (base) flow and getting closer to pre-development hydraulic conditions. Drawing 725 is a bit confusing. It looks like all raingardens have to be drained and cannot be used as infiltration.
Drawing 725	LID concepts	Drawings are confusing. Suggest have different drawing for different concepts and show multiple options for discharge/overflow.
Drawing 724	Channel lining	Methods such as hard engineered solutions should be avoided. Often created an unnatural look (e.g. use of rock riprap).

NCC 2010 Chapter 5 (only)

It is not clear (not part of the scope) to see whether the engineering standards are aligned with council strategies and legal requirements, including network consent requirements. Alignment is important to justify objectives and subsequent requirements in engineering standards.

The document reads as if LID is introduced as an afterthought. Some objectives and design principles do include LID. LID is to be considered at many stages throughout the development process across the following stages:

1. Pre-design (mapping constrains) to
2. Plan development (structure plan/development layout, aiming to protect/enhance natural assets such as stream and wetlands, minimise earthworks and compaction, minimise hard surfaces as well as space for future LID solutions such as wetlands, bio retention
3. Specific design of public and private land including LID devices
4. Design of individual lots, including rules, covenants to ensure LID is used on private lots.

It is recommended to include a design process using a decision-tree-type flowchart that is clear and can be used by both the developer/designer and the consent staff to check whether LID opportunities have been adequately considered and maximised.

Need for practice notes: Document that show complying solutions meeting TRMP as well as engineering requirements. Having these available has proved very successful. They do, however, need to provide adequate engineering detail so the engineering consultants understand what is required; the process from there on is easy and (almost) guarantees a ‘rubber stamp’ approval.

Standards and DP need to be aligned: I’m assuming the DP has LID requirements. It is recommended that the NRMP-text is also reviewed because these standards need to be aligned with the DP; also use the next opportunity to tidy up and for misalignments.

Reference	Subject	Comment
General	Use of 'where appropriate' , where practicable', where possible, should be considered', etc.	Should be avoided because it provides a way out.
General	Alignment with District Plan / RMA-plan	Standards and DP need to be aligned. I'm assuming the DP has LID requirements. Would be good the review DP text as well because these standards need to be aligned with the DP.
General	Pdf file	Made more notes and suggestions in pdf file to further improve the text. Key comments in this table. Many sections have not been commented on because the scope was limited to LID.
Disposal	Avoid the use of the word 'disposal'	Stormwater should be seen as a resource. Disposal of stormwater as used in some section has some negative connotations. I would suggest discharge, infiltrate, convey, etc.
5.1	Introduction	Very limited. Reference to issues such as flooding, stream erosions, loss of streams and stream health, major source of pollution. would be appropriate in an introduction to justify stormwater management objectives and requirements later in the document. Also reference to a 'stormwater strategy' would be appropriate.
5.3	LID in performance criteria	It reads as if LID is optional and brought in as an afterthought. Suggest require LID and use of natural systems such as suggested in e), f), g), and j) as a 1^{st} option, and only if that is not possible move to more traditional methods. See suggestion for decision tree as proposed when reviewing the TDC document.
5.3 a)	Development potential	Definition appears to be limited to what the Strategic City Development Plan is providing. These documents generally don't look beyond 10–20 years. Assets last much longer. See also comments on the TDC standards. I suggest the introduction of /maximum probable' which is increasingly used in other councils in NZ
5.3. b) 5.10 a) and many more sections	Capacity primary and secondary systems	OLFP only to cater for the balance of the design flow (based on a 1:50 storm event) and the capacity of the primary system. Primary reticulation often blocks (partially) during large storms. Good practice is to design OLFP for 100% of the design flow (not just the additional). Mostly up to 1:100 yr but I would suggest consider more where additional costs/implications are not significant and the implications are significant (needs risk assessment).
5.5.2 a)	Climate change	Good to see climate change being included into the document. Maybe take the detail out to allow any updates to be automatically included and simply refer to best practice stormwater calculation specifications for calculations and modelling in an attachment or other document.

Reference	Subject	Comment
5.5.3.1	Soakage	In general, good. Suggest review soakage when used in combination with LID. Not sure whether it is best to rely on soakage when suggesting. Because of the soil-issues in Nelson it is suggested to consider soakage as an additional benefit. Also LID devices are typically design for up to a 1-in-2-yr event. On the other hand, soakage is a great asset when applying LID treatment devices (but is not a must).
5.5.3.4	Discharge to council reserve	Great to see allowance to discharge into council reserve. Next step / opportunity would be to encourage doing this as along as reserve objectives are met (e.g. active recreation). Maybe also add some supporting text / justification: Stormwater and road reserves provide a great opportunity to attenuate and treat stormwater before discharging. Ground levels of any planted area should be lower compared to the surrounding hard surfaces so it can receive stormwater runoff. Whether or not the receiving planted areas are fully designed as an LID device (preferable) or just provide a natural function similar to pre-development is to be decided by using the 'decision tree' as proposed before. Any landscaped area can still have drainage which could be connected to a stream or a primary system.
5.5.4	Capacity	Suggest to clarify and separate rows for piped system, OLFP and streams: Don't understand the distinction between minor and major streams. Probably missing some background knowledge. All streams should provide at least up to 1:100-yr flow and also a risk assessment is required to assess what the consequences are for flows >100 yr ARI Also suggest to distinguish between top of bank flow and full flow which as likely to require space above the bank-full flow, including the allowance for (substantial) storage LID device capacity is unclear. LID devices typically designed for up to 2-yr flow. Not sure what is intended with 'overall capacity'
5.5.10	High ground water levels	Suggest include reference to recent NIWA report talking about elevated ground water levels as a result of climate change and the related increased drainage and flooding risks.
5.6.1	Datums	Climate change / Sea level rise included??
5.11.3	Piping of watercourses	Keeping and enhancing streams is an important part of the LID process. Recommend distinguishing between piping (culverting) and reclamation. Suggest clarifying when to use culvert and when to use 'piping'. My definition: Piping/culverting is to provide access to the other side. Pipe length (culvert) should not be wider then strictly needed to provide for this access. Reclamation is when pipe is proposed to increase useable land (developable land).

Reference	Subject	Comment
5.16	LID	Contents generally very good. Some comments to improve further: See proposal for decision tree, e.g. should have section 5.1.6.1 g) towards the start of the list Having a LID section is great but having it towards the back of the documents makes it look like a nice-to-have Some of the TP documents are dated and have been superseded by other documents Suggest qualify some proprietary devices (see 5.16.1.1. b) as 'last option' because of high maintenance costs (including O&M, depreciation, etc.) Include roads, the main and major contributor to stormwater pollution and increased runoff
5.16.4	Ponds	Wet ponds have many undesirable side effects. Examples: temperature, only peak flow control, no volume reductions, proven only limited successful in reducing stream erosion). If ponds are proposed, they should be off-line. Suggest include wetlands.

Appendix 7 – Summary of feedback

Discussions with roading council staff

Issues (negative) include:

- Additional cost of maintenance given local community to mowing of verges at present (voluntarily), cost of renewal (and timeframe / frequency)
- Clogging of gravel often used as mulch; floating of bark mulches
- Need to secure budgets for maintenance
- Safety – especially elderly falling into devices with vertical sides (sundial Square)
- Lack of apparent justification for impacts of urban Stormwater in Nelson/Tasman and hence need to mitigate adverse water quality; lack of requirement to treat until National Policy Statement on freshwater forced change
- Planted vs grassed bioretention/stormwater treatment varies

Discussions with Parks staff

- Support LID, particularly where they provide for amenity values (therefore complement parks objectives). Not enough consideration of amenity to date in such multi-functional areas (too many look scruffy)
- Need to have clear maintenance arrangements with utilities, including agreed standards and practical guidance on how to do the stormwater specific maintenance, training
- Need to be properly designed and constructed to avoid poor outcomes and to have O&M at the forefront of design considerations, species lists
- Support tree pits and generally lowering landscaping areas so they can passively receive Stormwater as long as functionality of reserve (playing surface/recreation) is not compromised
- Looking for cost/benefit ratio
- Good example was Aquatic Centre, low maintenance thus far and worked well in large events

Others

- What are non-regulatory measures to encourage and persuade?
- What measures cover impermeable surfaces on private land?
- Can LID on private land be considered a mitigation measure for the impacts of increasing density/imperviousness?

- What is the evidence for medium- and long-term efficacy of LID?
- In a Mediterranean climate[14] such as ours would it be wise to specify wetlands where there is a constant flow of water from springs streams, etc.?
- How do capital and operational costs of LIDS and traditional approach compare?
- Can we factor in the environmental, traffic calming, and aesthetic benefits?
- Can we illustrate a range of attractive options before and after neighbourhood retrofitting or reconfiguring?
- Pictures and or design detail diagrams will be very useful for getting the message across to potential users.
- I think the message also needs to be put out to architects and even home owners. When people design landscaping on new Commercial or even down to existing residential properties it is an opportunity to consider low impact solutions to reduce the overall run-off and improve the quality of the run-off.
- Perhaps this needs to be a separate guideline outside the LDM so it is referenced by more than just surveyors and engineers???
- I note that the matrix does list private devices. I think there are cross-overs between solutions suitable for private or public installations. Maybe have a separate matrix for suitability in each land use? Residential; Infill residential subdivision; green field subdivision with new roads; Commercial development (on site – Harvey Norman); Commercial / CPD subdivision or upgrade (Queen Street, Sundial square); Industrial (on site); Industrial Subdivision.
- Robyn made the comment that we have a great local pallet here already. It would be useful to note the local examples as part of the background description/reference material for each treatment device.
- I like the Matrix concept. It presents a lot of information in a small space. It may be able to be re-ordered I was a bit unsure of the purpose of the matrix but from my perspective as a Subdivision designer wanting to assess options to be able to provide recommendations to a developer.
- I would like to see a few more Suitability items: Infill subdivision, hillside development, flat to undulating topography development, residential development, commercial development, industrial development. I understand that the rating is a bit subjective but would still value it.
- I would like to see an assessment of the typical footprint each device would take up compared to the amount of detention, rather than just the high to small rating. Developers are interested in yield and cost. If they are bound by a consent condition that required neutral SW flows then LID will be part of the project budget so it comes down to how many sections a detention solution will take up. The other factor will be

[14] Nelson-Tasman not really a Mediterranean climate, 'a climate distinguished by warm, wet winters under prevailing westerly winds and calm, hot, dry summers, as is characteristic of the Mediterranean region and parts of California, Chile, South Africa, and SW Australia"!.

if a LID can be used to enhance a subdivision and provide a point of difference while at the same time reduce downstream pipe sizes a developer will listen to possible solutions presented even if it is not a consent requirement.

- Jan mentioned that he had lots of examples of the various devices listed. I would like to see those listed for the reader's further reference. Maybe this could be instead of the brief description column that seems to have overshadowed the Stormwater process assessment in that column.
- Maybe instead of Flooding (a bit emotive) use Quantity for columns 6 and 7. Similarly, maybe use Quality for columns 8, 9 and 10. I note that colours have been used to rate from green – good to red – bad; LID properties. Maybe put this in a key.
- I was a bit unsure what the 3-waters benefits referred to? 3 waters benefits means things like if you catch rainwater in a tank and reuse it you can potentially reduce flooding and inflow into wastewater networks and save potable water
- Based on our conversation on Friday, and seeing the list of LID projects that are on the ground in Nelson/Tasman, the main focus is to identify the 'easy wins', i.e. devices or practices that are likely to be acceptable as this interim small step. And those devices will:
- Contribute to flood mitigation – through lowering peak flow and retarding peak flow, also by reducing volume. Because flooding is the main driver, especially as far as public/politicians are concerned
- Receive road and/or carpark runoff (these being the main types of impervious surface being mitigated) for greenfields and brownfields
- Have sites that look good in Nelson/Tasman and are therefore can be seen/visited
- For which we know implementation and maintenance issues (and how they're being/have been overcome – e.g. roads subgrade protection, swale protection from traffic, maintenance, local reaction)
- Are 'least-regrets' approaches – so provide some water quality and low-flow benefit given Freshwater Reforms pressures
- Work for sites where water exfiltration/recharge is low or not wanted (clay, high water tables, subsurface erosion)
- Have design guides/practice checklists / assessment points that we can easily apply from elsewhere

Appendix 7 – Auckland Council TP10, TP90 and TP124 update, 2016

In places, the Councils' codes cross-reference Technical Publications produced by Auckland Regional Council, known as TPs. These have been reviewed over the last 2–5 years, taking into account new information and new regulatory drivers, particularly the Proposed Auckland Unitary Plan (Table below, TSS = Total Suspended Sediment, HCGAs = High Contaminant Generating Areas, PAUP = Proposed Auckland Unitary Plan, ALWP = Air Land and Water Plan).

	TP10	GD01
Regulatory driver	Air Land and Water Plan + 9 District Plans	(Proposed) Auckland Unitary Plan
Combined management approach	Treatment train – focus on primary, secondary and tertiary	Treatment suite – integrated approach with innovation and flexibility
Water quality volume	1/3rd of 2-year 24 hour API (approx. 25 mm)	90th%ile (approx. 25 mm)
Water quality management	ALWP: 75% TSS removal	PAUP: TSS, copper, zinc and temperature. UP: design performance
Water quality target areas	None identified	HCGAs
Sizing	Extended detention volume	Detention and retention, pre and post development
Susceptible areas	None identified	SMAF1 and SMAF 2

TP124 has been replaced by GD04 Water Sensitive Design – Auckland Design Manual (2015). GD04 covers site assessment, analysis and concept design. TP10 is being replaced by GD01 'stormwater management devices' in 2016. Three volumes cover design, construction, and operation & maintenance. Construction and O&M are largely based on TR2010/052 and TR2010/053, with some sections being updated. For design, TR2013/018 'Hydraulic Energy management inlet and outlet design' cuts across all devices, as does a new 'Plants and Soils' chapter that contains media specifications for different devices and suggested plant species lists. The following chapters are affected

- Revised **Ponds** chapter (wet ponds with permanent pool & detention ponds)
- Revised **Wetlands** chapter focusing on constructed surface flow wetlands with simplified sizing method, and labyrinth and banded bathymetry design
- Revised **Infiltration** chapter to include underground gravel trench, perforated pipe, on-site soakage and rain crates
- Revised **Swales** chapter
- Revised **Living roof** chapter based on TR2013/045 that exceeds SMAF requirements

- Revised **Rain tanks** chapter based on TR2009/083 Landscape and ecology values in Stormwater management with simplified sizing method (similar to North Shore City Council) for use as detention device or allowing a portion for reuse
- New **Bioretention** chapter for raingardens, planter boxes and tree pits replaces the TP10 filtration chapter
- New **Pervious Paving** chapter (with base course providing temporary storage)

TP90 is being replaced by GD05 'Erosion and sediment control'; TP58 is being replaced by GD06 'On site waste water' in 2016.

Opportunities to improve:	Social & cultural values						Environmental values (in addition to water quality)				
• High potential ○ Some potential - Not a value	Alignment with Māori cultural values	Incorporating Te Aranga Design Principles	Improved amenity	Improved community connectedness	Improved public safety	Education	Habitat improvement	Connecting green corridors	Plant diversity	Bird, insect and reptile diversity	Plant ecosourcing
Pervious pavement - unlined	•	○	○	•	•	•	-	-	-	-	-
Living roof	•	•	•	•	○	•	○	○	•	•	•
Rain tank	•	○	•	○	○	•	-	-	-	-	-
Infiltration trench	○	○	-	○	○	•	-	-	-	-	-
Retention/irrigation	○	○	○	○	○	•	-	-	-	-	-
Vegetated swale	•	•	○	○	○	•	○	○	○	○	•
Raingardens	•	•	○	•	•	•	○	○	•	•	•
Tree pits	○	•	○	•	•	•	○	-	○	○	•
Planter boxes	○	•	○	•	•	•	○	-	○	○	○
Wet pond	○	○	•	•	○	•	•	•	•	•	•
Constructed wetland	•	•	•	•	○	•	•	•	•	•	•
Extended detention basin (dry pond)	○	○	•	•	•	•	○	○	○	○	○

Appendix 8 – Water Sensitive Design draft checklist of considerations

WSD Element	Structure/ Framework Plan Greenfield land	Structure/ Framework Plan Existing Urban	Small multi-unit/site development / single site	Rural/ country side living
Intensifying previously developed areas in preference to new areas where possible	✓	✓		
Identifying natural features including natural drainage patterns, overland flow, intermittent and permanent streams and vegetation	✓	✓	✓	✓
Identifying wider environment values, features and considerations	✓			
Protecting existing vegetation and streams (including margins) during development	✓	✓	✓	✓
Minimising the use of heavy machinery in riparian corridors and other natural / open space areas	✓			✓
Minimising the extent of earthworks and change in contours , soil compaction, topsoil removal and modification of natural drainage patterns	✓			✓
Re-establishing and enhancing streams, vegetation and riparian margins including connectivity	✓	✓	✓	✓
Using vegetation and natural features in management and reduction of runoff	✓	✓	✓	✓
Rehabilitating soil infiltration properties following completion of earthworks	✓	✓	✓	✓
Reconciling site layout with natural drainage patterns and site features	✓			✓
Protecting flood plains and overland flow paths from development	✓	✓	✓	✓
Minimising impervious area footprints, including roads	✓	✓	✓	✓
Clustering development and impervious areas and creation of coherent open space/vegetated areas	✓	✓	✓ (multi-unit)	
Minimising aggregation and concentration of stormwater flows	✓	✓		✓
Maximising infiltration of stormwater and use of permeable surfaces	✓	✓	✓	✓
Diverting runoff away from stormwater networks to vegetated areas	✓	✓	✓	✓
Using open space/grass areas for temporary stormwater detention and/or stormwater treatment	✓	✓		
Avoiding the use of high contaminant generating building materials	✓	✓	✓	✓

Identifying stormwater management areas to be set aside from development as Green Infrastructure Zones	✓	✓		
Designing road layouts to provide for efficient traffic movements and multiple values including amenity and stormwater management by the use of trees and other green infrastructure features	✓	✓		
Minimising requirements for stream crossings and other structures within streams	✓	✓		✓
Using stormwater for non-potable use, including passive irrigation of landscaped areas and vegetation, car washing, toilet flushing	✓	✓	✓	✓
Using vegetation for shading to reduce thermal impact	✓	✓		
Providing public access to natural features and watercourses	✓	✓		
Designing and managing areas that may be prone to litter generation (public congregation and other activities) to minimise litter discharge	✓	✓		
Considering sequential design and mitigation elements when discharging into sensitive receiving environments	✓	✓		
Using green infrastructure for stormwater management including bio-retention devices and similar for stormwater treatment	✓	✓	✓	✓
Identifying communal stormwater management devices and infrastructure and provision for their lifelong ownership and cost effective maintenance and operation	✓	✓		