A NEW ERA FOR STORMWATER MANAGEMENT – NZS 4404:2010

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ABSTRACT

The revised NZ Standard NZS4404:2010 "Land Development and Subdivision Infrastructure" now includes formal provision for Low Impact Design (LID) for stormwater, stormwater treatment and requires climate change impacts to be taken into account.

LID and the need to consider climate change impacts into stormwater design brings new responsibilities and accountabilities for all involved with stormwater management. Important questions include what is current best practice and what are the preferred sustainable solutions for robust, outcomes in this age of increasing uncertainty, and pressure for acceptance of "non-proven" alternative solutions?

The paper focuses on the changes to NZS4404 Section 4 "Stormwater". The associated implications of these changes, the need for much earlier consultation by developers on stormwater management options and an even greater need for integrated catchment management planning along with the consequential implications for managing stormwater infrastructure in the long term are considered.

While some local guidance on LID is available in New Zealand, best practice national guidelines for LID stormwater alternatives, climate change adaptation design procedures have yet to be developed. The need for more enabling concepts for low impact design in planning documents, for NZS4404 to be supported by sound design guidelines and improved coordination between the planning, design and implementation phases of land development is discussed.

KEYWORDS

Stormwater, climate change, low impact design, stormwater treatment

PRESENTER PROFILE

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Brian is on the NZS4404 review committee representing ACENZ. In 2009 he undertook a study of potential climate change impacts on the Asian Development Bank Central Region Water Resources Project in Vietnam. Brian recently completed a mid-term review for a major European Union funded project "Reducing Vulnerability" across 15 Pacific countries. As part of a Transfund research project, Brian co-authored the publication "Integrated Stormwater Management Guidelines for the New Zealand Roading Network" which he presented at the Sustainable Land Transport Conference in 2004.

Brian was the technical reviewer for the book “Keeper of the Longer View” - History of 20 years of the Office of the PCE and also lead case study presenter for the 2007 and 2008 IPENZ seminar series “Incorporating Climate Change Predictions into Engineering Design”. He presented a paper at the NZWWA 50th anniversary conference in 2008 on “Engineering Best Practice. Where are we at? Climate Change in Context”.

1 INTRODUCTION

Some principles of Low Impact Design (LID) and the need to consider climate change have been incorporated into a number of territorial authorities planning documents and design processes for over ten years. However, the specific introduction of LID and climate change impacts into the revision of NZS4404 “Land Subdivision and Development” (‘the Standard’) truly marks the advent of a “new era” in land development and stormwater management for New Zealand.

Low Impact Design is a development approach that utilises natural systems and processes for the management of erosion and stormwater (Lewis, 2009). It is both a design approach and a range of structural techniques. This approach to development has been adopted internationally and is termed and defined slightly differently depending on core objectives. Similar approaches include Water Sensitive Urban Design (Australia), Sustainable Urban Drainage Systems (UK) and Low Impact Design (USA). A research project in New Zealand also developed the concept Low Impact Urban Design and Development that seeks to integrate water management and urban design principles.

The combination of the release of the revised NZS4404 standard, planning, design and operational experiences along with release of the latest Ministry for the Environment (MfE) guidelines on climate change impacts makes it timely for a review of performance and identification of issues and additional responsibilities for planners and engineers in relation to sustainable stormwater management in New Zealand. This paper considers legislative requirements, planning and consenting issues, engineering design and construction aspects along with the added operational, maintenance and monitoring needs of the “new era” stormwater management systems.

The “new era” of stormwater management inherently involves more coordination and integration of thinking between respective divisions and departments within a TA (policy, planning, infrastructure management, construction monitoring, operation and maintenance divisions) along with additional responsibilities at all levels to ensure a “sustainable” future for stormwater management in New Zealand.

2 BACKGROUND

In relatively recent times, stormwater management planning and design has been affected three ways by demands of various new drivers associated with low impact urban design and development. These are :

a. Stormwater collection and disposal (concepts of off-site and on-site retention and various disposal systems by infiltration and soakage) (Stormwater quantity)
b. Stormwater treatment (sensitive receiving environments) (Stormwater quality)
c. Climate change (changing design parameters)

In the past, most emphasis has been placed on the management of water quantity. There has been an emerging consideration of water quality over the past 20 years, however, rarely are the three key criteria for stormwater management considered together or in an integrated and consistent way within a TA or across New Zealand. LID introduces alternative options to address these key elements of stormwater management, further challenging to traditional approaches.

The standard stormwater infrastructure has a designated Level of Service (LoS) within the TA's Asset Management Plan (AMP), typically a design return period and sometimes some water quality criteria. Under the "new era" the level of service concept will remain but will be described differently and involve different concepts.

The design of future stormwater systems will need to consider all three criteria outlined above, align with objectives set out in regional and local planning documents and requirements of consent conditions. Stormwater quantity and quality are currently key factors in most regional plans. As such, stormwater quantity and quality management approaches have already become a standard element in the stormwater system design process. There is an increasing need to also consider the potential implications of a changing climate on stormwater infrastructure over its operational life, and integrate this in the design process.

The inclusion of climate change factors in stormwater design may or may not be formally part of a Councils' policies. From here on it is considered that climate change impacts on stormwater systems need to be assessed and incorporated into the stormwater system design. Consideration of climate change effects is now incorporated into New Zealand Standard 4404:2010.

TAs will be impacted, if not already, by additional responsibility and skill requirements through consent processes, consent compliance, health and safety, inspection requirements, system performance in terms of LoS and "State of the Environment" reporting along with potentially an increase operation and maintenance costs compared to a conventional piped stormwater system.

In addition to experience with many TA stormwater management systems, from policy development and plans through to design and construction my most recent experience on the NZS4404 review committee highlighted the added responsibilities that will need to go hand in hand with fully integrating LIUDD, SUDS and climate change factors into their policies, plans, consenting procedures, design processes and associated operation and maintenance contracts.

The Standard introduces and provides for the concepts to be standard stormwater/management planning and design tools, however, it does not provide for specific design procedures or guidelines or procedures for incorporating the "new era" of stormwater management approaches into urban design protocols.

It will be up to each TA to develop these to fit local contexts and organisational circumstances. It is noted that a number of the New Zealand cities already have codes, guidelines and procedures that provide guidance on LID and climate change integration into stormwater planning and design. However there are still challenges in converting high level policies and concepts of LID and climate change into effective design procedures and implementation practices. The paper "Roadblocks in the Land Development Process and the Uptake of Low Impact Urban Design and Development" (Feeny 2006) identified such issues, including the need for co-ordination and consistency in the development approval process.

3 THE "NEW ERA" FACTORS

Traditional approaches to stormwater collection and disposal has been driven by the need to provide urban drainage and prevent flooding for development. The responsibility of individual lot stormwater disposal was by and large taken away from individual lot owners by the local authority for the benefit of the greater good. As with other infrastructure to manage the other two waters (water supply and wastewater), the effective method for community acceptance of delivering a stormwater service was through a piped system with disposal to the nearest water course. In the case of stormwater, the collection system is usually from gutters with the conveyance through pipes and disposal through outlets into natural environments such as rivers, streams or the coast. Scott (2008) makes some excellent points about private control of stormwater and the conflict with the common good. Her paper concludes with "Rather than supporting adaptive governance where by citizens have a greater role in environmental management, to date existing power relations have been reinforced. Risks of flooding, rather than water quality, continue to take precedence. Nevertheless, new spaces have been created for sustainable water management, and the process of implementation has only just begun."

Up until recently, many urban TA's have held 'global stormwater discharge consents' that approve approaches to stormwater management within a TAs boundary. Stormwater reticulation from individual lots was typically a "poor cousin" compared to the other two waters and formal stormwater reticulation from individual lots was developed on a priority basis as a matter of need, such as separation from the wastewater system or to address local flooding or drainage issues. The track record of stormwater management in New Zealand is not good when compared to the other two waters. It tended to be the last of the three waters to be dealt with in earlier years of development. More recently stormwater management has become an integral part of an infrastructure development plan and includes consideration of environmental and public health and safety drivers similar to those in wastewater and water supply infrastructure.

Along with alternative means of collection and disposal, stormwater treatment and climate change factors have come to the fore in the past ten years. These are the "new era" factors which need to be integrated into urban planning at an early stage of development and also require specific attention and responsibility by TA's to deliver long term sustainable water management.

Scott (2008) identifies the dilemma about achieving multiple objectives and outcomes that emerge "… in relation to low impact approaches to water management, also aimed at protecting the common good: while trying to enhance ecological values, low impact approaches also promote collective, private and public 'ownership' of the problem of stormwater".

The 'new era' factors that are critical for the future sustainable management of stormwater management are described below.

a) Collection and Disposal :

Interestingly stormwater having generally been the last of the three waters to be reticulated is the first to come under scrutiny to be "unreticulated " with a whole range of options available from storage/attenuation, evapotranspiration concepts, to soakage and infiltration schemes to development of or reversion to open and natural water courses. All of these are great concepts in the right setting and correct design. Inherent with all of these is the handling of the greater than design event and the concept of developing and maintaining secondary flow paths. The "new era" options all have

different characteristics and where the responsibility of individual lot collection and disposal has been devolved to the individual, responsibility for operation and maintenance needs to be clearly documented and regularly monitored by the TA.

b) Treatment :

In recent years there has been a growing concern about stormwater quality. Codes of practice have not generally been prescriptive on stormwater treatment. The concept of low impact design embraces stormwater quality issues and aims to minimize environmental impacts by:

- Preventing and minimising stormwater runoff through source control and infiltration practices
- Improving water quality by filtration
- Installing detention devices for water reuse

NZS4404 now formally introduces these concepts of treatment which need to be integrated into the overall stormwater management system. The design response is to understand and limit contaminant sources, control contaminant movements in water, trap and treat contaminants before leaving the urban setting, in a manner similar to urban wastewater treatment and disposal.

c) Climate change

Climate change factors now need to be incorporated into all stormwater management systems. The Ministry for the Environment has prepared climate change guidelines for local government (MfE (2008)) and these are recognised as a useful resource and basis for stormwater design and management in the NZS4404 revision. However wider risk factors need to be taken into account and further guidance on approach needs to be taken from the regional council and TA. For example, testing the sensitivity of the range sea level rise given in the guidance manual upon any land development proposal. In considering protection standards, a risk based precautionary design approach is recommended.

The incorporation of climate change factors into the stormwater system design implies building in flexibility and redundancy into design so that future generations of authorities can cope with and respond to changes over long term timescales.

4 REGIONAL AND DISTRICT POLICY AND PLANS

Regional and district plans are two key policy instruments to support implementation of LID principles. Policy and rules on LID and climate change vary throughout the country and play a key role in enabling, encouraging or impeding the uptake of LID in practice. . Puddephat and Heslop (2007) discuss policy instruments that have been used internationally to promote the uptake of sustainable water management practices and discuss their transferability to the New Zealand context. Their paper highlighted the importance of the role that local context plays in determining the correct mix of policy instruments and the importance of enabling factors for successful implementation of low LID.

As part of the Transfund Research Project Kouvelis and Armstrong (2004) undertook a review of all district and regional plans to assess extent and consistency of policies and rules about stormwater management in NZ with a focus on roadside drainage. The lack

of consistency and diversity of rules and regulations was truly noteworthy for such a small country.

Snapshots of experience indicates the same applies to the overall stormwater management within TAs. This is confirmed Feeny (2006) where similar issues for overall LIUDD are identified in the Auckland area. The clear message here is that for sustainable "new era" stormwater management there is an urgent need for better communication and coherent policy development between regional and district planning documents. In relation to development of policy and rules there is room for better communication and liaison between the planners and engineers.

Feeny (2006) indicated that as one of the road blocks to low impact urban design and development " ….related to the issues already listed, …the issue of poor coordination that regulators faced in relation to structure plans and related regulations. This results in a lack of integration of the main instruments such as water and sanitary services assessments, asset and catchment management plans … etc".

The clear message here is that for sustainable "new era" stormwater management to be successful, there is an urgent need for better communication and integrated policy development between regional and district councils and their planning documents. There is considerable room for better communication and liaison between planners and engineers in the development of policies and rules.

The need to link engineering standards and codes of practice to the district plan but retain the flexibility to revise the technical specifications without a plan review needs to be resolved. Areas of specific requirements where special rules associated with the "new era" factors need to be identified. The lead time for (sometimes 5 years or longer) effective implementation of policies needs to be recognised and acknowledged.

All in all, many district and regional plans are currently not enabling in terms of the "new era" stormwater management factors.

5 CONSENTING

The consenting processes for LIUDD, SUDS and discharge analyses incorporating climate change factors have a range of additional degrees of difficulty for all participants in the process :

- Developers
- Developers' advisers
- Councils' planners and consent processing staff
- Councils' technical advisers
- Contractors
- Council's supervising staff
- Monitoring and compliance staff

The primary reason for the additional degrees of difficulty is that many concepts are new, sometimes untried, there are typically no design guidelines and often councils are uncertain of their own requirements.

These new factors need to be integrated into the development and approval process to ensure robust consenting procedures involve all three of the "new era" stormwater factors :

- collection and disposal mechanisms (often site specific, with success factors buried in the design and construction details)
- selection of appropriate treatment processes
- application of the correct climate change impact factors

These additional degrees of difficulty apply over all aspects of the consenting process from the standard of the application, the selection of the stormwater management technique, the design details, the setting of consent conditions, construction implementation and the monitoring and compliance aspects of any conditions.

In the first instance the “new era“ stormwater factors need to take into account district and regional plan objectives policies and rules - once again reinforcing the need for these to be clear, concise and understandable. There are some examples and experiences around now in both policy areas and implementation that provide evidence of what works and what does not work.

Because the introduction of these “new era” factors are in fact often new to both the developer and councils and often untested in some areas it is highly recommended that early consultation takes place between the developers and respective councils to at least agree in principle to the approach taken and the design detail and support documentation to be submitted with application.

An important factor here is the understanding of development levies and the way an incentive for rebate on LID might apply. The council needs to be sure, for example, that a policy promoting stormwater neutrality is in fact sustainable and that they will not be picking up the costs of reworking a sustainable solution in five years time because of a poorly presented and /or assessed application. The solution is not easy, given that for many options there are still no “best practice” solutions available and details need to be context specific.

Morgan (2009) p68 cites an example from Auckland City with its incentives levies for LID with a rates rebate for the installation of rainwater attenuation tanks.

There appears to be room for more collaboration between TAs to compare design solutions that have worked to date and certainly to identify solutions where problems have emerged within a few months or years of installation. Issues can then be considered and addressed early and lessons learned from previous experience. There is a need for capacity building in relation to staff skills to undertake assessments of consent applications incorporating LID or climate change factors. Consent conditions need to be clear, practical and able to be implemented successfully. Factors that need to be considered when setting consent conditions for “new era” stormwater developments include :

- asset ownership
- access for maintenance activities incorporated in the design
- long term maintenance issues procedures and responsibilities
- operation maintenance and compliance issues for on-site disposal consents
- consent holder responsibilities
- concepts of identifying and maintaining into perpetuity secondary flow paths
- setting development levy that include consideration of life cycle costs of treatment
- operation and maintenance of the stormwater management system
- performance monitoring

6 DESIGN APPROACHES

As with consent applications the design approach and concept design for stormwater management systems involve not only knowledge on the micro level but requires an understanding of the macro level bigger picture and where the development sits within an integrated catchment management plan.

The lack of best practice procedures including redundancy in design and robustness consideration for long term sustainability means there is room for differing opinions on appropriate stormwater management techniques between the designer, the consent authority and technical reviewer. The definition of sustainability is often at the heart of the issue.

Other aspects which need to be considered and may impact on the implementation of low impact design approaches include:

- matching stormwater design solutions with objectives of existing integrated catchment management plans,
- tight construction specifications that reflect design details and assumptions
- conflict of technical design detailing between on-site disposal and road sub-base integrity
- tension and conflict by other geotechnical stability requirements
- process to ensure design details are in fact incorporated into the construction phase.

7 DESIGN PROCEDURES

NZS 4400:2010 provides for the “new era” stormwater management factors for all three issues:

- collection and disposal
- stormwater treatment
- climate change

NZS4404 does not provide design procedures for these three factors. The previous NZS4404 did give some guidance on standard design solutions. However, because of the extent and complexity of potential solutions it was not possible to give design solution for each of the potential LID techniques. Instead, a design process that aims to understand and respond to the local context and development objectives is encouraged.

Several TAs have developed some excellent guidance material as well as design guidelines and procedures for LID and the consideration of climate change in stormwater management. Best practice across New Zealand incorporating design procedures for LID and climate change, however has yet to be established.

There are a number of success stories. There are a few major developments incorporating SUDS and LID that are currently under “test” or have yet to be tested under design conditions. There is also some evidence some systems are not performing according to design and therefore not providing sustainable solutions. A significant number of case studies that include examples of policy, design and implementation of

LID have been prepared as part of the Low Impact Urban Design and Development research programme (LIUDD – case study portal).

For example the design life for soakage or infiltration system needs to be carefully assessed. In my view and based on experience traditional soak holes correctly designed are likely to have an operational life of around 20 years or less. The cost of refurbishment needs to be acknowledged and design life identified in Asset Management Plans.

Design for long term sustainability will need some redundancy and robustness built in. This could be by way of reserve areas for soakage and infiltration concepts or conservative loadings in the design assumptions. Peer review of designs is highly recommended. Similarly peer review of staff assessments are considered necessary to ensure the design has covered all aspects.

Some aspects that need particular scrutiny when considering the "new era" factors for stormwater management are listed below:

a) Collection and Disposal

- levels of service (there is a wide range used across New Zealand)
- design life
- on-site designs
- rainwater attenuation tank capacities
- open channel designs
- secondary flow path considerations
- long term sustainable solutions that will need to make provision for stormwater pumping
- life cycle costings

b) Treatment

- selection of the correct process to suit local conditions (conditions vary substantially across New Zealand)
- maintenance issues
- monitoring requirements

c) Climate Change

- NZS4404:2010 identifies the MfE guidelines as a useful resource or basis for the incorporation of climate change factors into stormwater management design
- major stormwater systems need to use a risk management approach using different climate change scenarios
- a precautionary design approach is recommended
- climate change factors affect both a) and b) above.

8 OPERATION

Historic operation of standard gravity stormwater systems has not attracted much attention through the consenting or implementation of a stormwater system. The operation is typically clearly defined in technical standards, very straightforward and has involved flap gates and outlet structures.

The “new era” stormwater systems require a range of different operational requirements depending on the system selected.

Such aspects include :

a) Collection and disposal

- monitoring of performance for LOS and consent requirements

- increased stormwater pumping where sea level rise is a factor

b) Treatment

- treatment process operations

- consent compliance issues

These increased operational requirements need to be taken into account during the assessment of the design and life cycle costs in relation to setting development levies.

9 MAINTENANCE

Maintenance of stormwater systems has historically been relatively straightforward typically involving

- inlets
- grates
- sumps
- flap gates
- outlets
- pipelines

The management of the “new era” stormwater systems involve a whole range of alternative maintenance requirements due to the integration of natural processes in the stormwater management process. These can significantly overlap with the type of services often provided by Parks Departments within TAs. System maintenance requirements need to be taken into account when selecting and assessing stormwater management options and in the design detailing.

The alternative maintenance activities for LID treatment devices include:

- maintenance of vegetation and filtration media
- safe disposal of waste from treatment
- stormwater attenuation tanks
- detention system maintenance requirements
- soakage and infiltration systems

All of these need documented maintenance guidelines as part of the consent procedure.

Puddephat and Heslop (2008) provide an excellent checklist for designing maintenance smart systems.

Young (2008) highlights the challenges that are faced with on-going pond maintenance and summarises possible solutions for a more sustainable future.

10 CONCLUSIONS

The “new era” of stormwater management provides exciting times for planners, engineers, councils, developers and their advisors.

The enabling of alternative stormwater methods of collection and disposal and associated requirements for treatment with the incorporation of climate change factors in designing stormwater systems are all welcomed and in fact necessary for long term sustainability of modern day stormwater systems.

However until the additional responsibilities for all involved are clearly recognized the three additional “new era” factors in stormwater management, collection and disposal, treatment and climate change factors, there are many challenges ahead for planners, designer and operators.

Additional responsibilities involve all aspects of the stormwater system and catchment management.

While NZS4404:2010 now formally enables LID in a New Zealand standard there is still a lot of work to be done by implementing agencies. This includes:

a. Development of clear and coherent objectives, policies, plans and rules in the regional and district plans. These are essential for successful implementation of low impact design stormwater systems

b. Improving skills and enhancing capability across the stormwater industry to support the integration of “new era” factors in stormwater planning and design. Capacity building is required across the following professions :
   - Planners
   - Engineers
   - Surveyors
   - Design Professionals
   - Consenting staff
   - Design teams
   - Construction

c. Revision and modification of development approval processes to encourage early discussions during concept design, integrated assessments of consent applications, efficient consent processing and appropriate implementation and monitoring.

d. Establishment of best practice across New Zealand

e. Development of design guidelines

f. Requirements that operation, maintenance and monitoring plans to be mandatory for all LID systems.

Collaboration between TAs, industry and other agencies and innovation is encouraged to support the evolution of the industry and work towards a nationally recognised framework for the "new era" of stormwater management.

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