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Centre for Freshwater Management

Behaviour change programmes for prevention of urban stormwater contamination: A literature review

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TITLE: **Behaviour change programmes for prevention of urban stormwater contamination: A literature review**

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1. Introduction

Environmental quality is inextricably linked to human behaviour patterns (Steg & Vlek, 2009). The numerous problems – global warming, water and air pollution, loss of biodiversity – that pose a threat to environmental sustainability are the result of human behaviours (Vlek & Steg, 2007). It is therefore argued that these problems can be addressed by changing behaviour patterns (Steg & Vlek, 2009), though there is increasing debate about whether this is best achieved by focusing on the individual, or on the structures and systems that influence individuals to behave in certain ways (e.g. Shove 2010). Behaviour and behaviour change have emerged as key areas of interest for national and local governments (Morris, Marzano, Dandy, & O'Brien, 2012b), and Christchurch City Council has commissioned this review of the international literature to ascertain what behaviour change approaches have been applied in New Zealand and beyond in the area of stormwater, how these have been evaluated and assessed, and how effective they have been.

A key focus of this review is therefore on the effectiveness of sustainable behaviour change programmes, especially in relation to preventing stormwater contamination within urban settings. Following this introduction and an explanation of the method employed, section three provides an overview of behaviour and behavioural change theories from their inception to recent times – particularly in relation to 'pro-environmental' and 'sustainable' behaviour change. While the term 'behaviour' can refer to an individual's behaviour, this review is interested in identifying a step-change that can drive behaviour change across Christchurch, New Zealand, at the scale of neighbourhoods and the wider urban environment. If new strategies and solutions are to take hold, they need to become embedded within people's daily lives. A systemic approach that can introduce and roll out new frameworks for all urban residents – those in government organisations, businesses, households, and community groups – will help to reorder societal priorities and practices, and induce the changes required to protect our urban waterways and associated natural ecosystems.

Section Four briefly outlines various common issues of urban stormwater management to determine whether or not there may be appropriate behaviour change theories that can be aligned to mitigate the problems. By identifying management pressures and issues, and the types of contaminants stormwater managers are dealing with this paper aims to align possible approaches and solutions for Christchurch City Council. Section Five examines studies that have investigated behavioural changes specifically in relation to stormwater contamination, or closely related topics around water sensitive urban design, sustainable urban water management, green infrastructure, and green stormwater infrastructure. Technology and innovation, social marketing and education are explored as potentially complementary approaches to reducing and preventing stormwater contamination. Social practice is also explored as a possible conceptual model for behaviour change. Examples of how community groups have been supported in different contexts – through provision of a mixture of

resources, incentives, education, opportunities for involvement and consultation, and experimentation and adaptation – are also discussed.

A key assumption underpinning much of the work reviewed here, is that in the medium term, with assistance from local authorities towards enabling and facilitating pro-environmental values and awareness, behaviour can change throughout the wider community – eventually achieving a 'critical mass' of pro-environmental behaviour. Essentially, the adoption of new behaviours, and changing social norms and values, are seen as mutually reinforcing (Harre, 2011).

2. Literature review method

This literature review draws on various resources, including both peer-reviewed academic studies, and grey literature in the form of reports and other documents produced by authorities and consultants engaged in stormwater management and urban environmental management more broadly. We consulted:

- Online scientific databases, through the Lincoln University and University of Canterbury subscriptions, to access peer-reviewed, academic journal articles and conference proceedings;
- Online sources of relevant grey literature, including Australian and New Zealand Stormwater Conference websites (2017 and 2018); New Zealand and Australian local government websites; Australian Capital Territory (ACT) government website; Auckland Regional and District Council websites; various other regional and local government websites where the literature pointed to relevant developments or programmes.

Texts were screened for their relevance to behaviour change in relation to stormwater management, as well as sustainable or environmental behaviour change more generally.

We did not find any official accounts of behaviour change programmes to prevent stormwater contamination on any of the New Zealand regional and local council websites accessed for this review. While local authorities do provide a lot of information on stormwater management, this is varied in content and volume, and mainly focused on current regulations governing stormwater systems, and technical measures for stormwater infrastructure and management. Very little material was found on water sensitive urban design, sustainable urban water management, green infrastructure or green stormwater infrastructure – let alone behaviour change approaches. In terms of ratepayer education and awareness raising around stormwater connectivity and infrastructure, Auckland City Council's *Our Auckland* magazine (2018 editions), for example, do provide information of the various upgrades and projects that had been carried out over recent years by the council's contractor, Watercare (see infographics in Appendices 1 & 2). No information regarding new technology, green

infrastructure, sustainable urban stormwater management, or water sensitive urban design was found on those sites, however. Therefore, our search suggests that in the information made available by the local authorities responsible for stormwater planning and management in New Zealand, there remains a focus on technical solutions and municipal infrastructure, rather than non-structural approaches (such as awareness raising and behaviour change) or decentralised green infrastructure.

The review therefore draws primarily on international experience as reported in the literature. Section 3 provides a brief discussion of key behaviour change theories, before Section 4 outlines the aspects of stormwater that pose challenges for management. Section 5 then reviews studies of behaviour change programmes related to urban stormwater from the international literature. Section 6 summarises the key findings of this review that might inform management in the New Zealand and Christchurch contexts, before Section 7 concludes the report.

3. Overview of environmental behaviour change theories

There are numerous theoretical frameworks that have been developed over recent decades to explain the connections (or lack of connections) between environmental awareness or knowledge, and pro-environmental behaviours. Yet others are more widely concerned with how to induce sustainable behaviour change. Kollmuss and Agyeman (2002) provide a description of some of the most commonly applied analytical frameworks – linear progression models; altruism, empathy and pro-social behaviour models; and various sociological and social-psychological models – all of which they deem to have some validity in certain circumstances. Pro-environmental behaviour models apply a more holistic focus than earlier linear models, by considering context and complexities; whereas social practice models are based on the theory of 'structuration', which recognises that individual actions are shaped by (and in turn also shape) social structures and norms (Giddens, 1984).

3.1. Linear models

Early environmental behaviour change theories began to emerge in the early 1970s. These were soon subjected to critique (Kollmuss and Agyeman, 2002) due to their foundation on simplistic assumptions of a uni-linear progression, which maintained that environmental knowledge would lead to awareness and concern for the environment (environmental attitudes), which in turn would lead to pro-environmental behaviours. As rationalist models, such approaches tended to treat people as more-or-less independent individuals who decide what they want to do, and are then free to act on their intentions, given sets of identifiable constraints or barriers (Chatterton, 2011). Essentially it was assumed that educating people

about environmental issues would result in pro-environmental behaviour (Kollmuss and Agyeman, 2002).

Ajzen and Fishbein (1980) argued, however, that there is no necessary relation between an environmental attitude and an actual pro-environmental behaviour, especially when the attitude is not closely linked to the behaviour (e.g. views on climate change vs. driving a car). They asserted that attitudes do not directly determine behaviour; rather they influence behavioural intentions, which in turn shape people's actions – see Figure1 below.

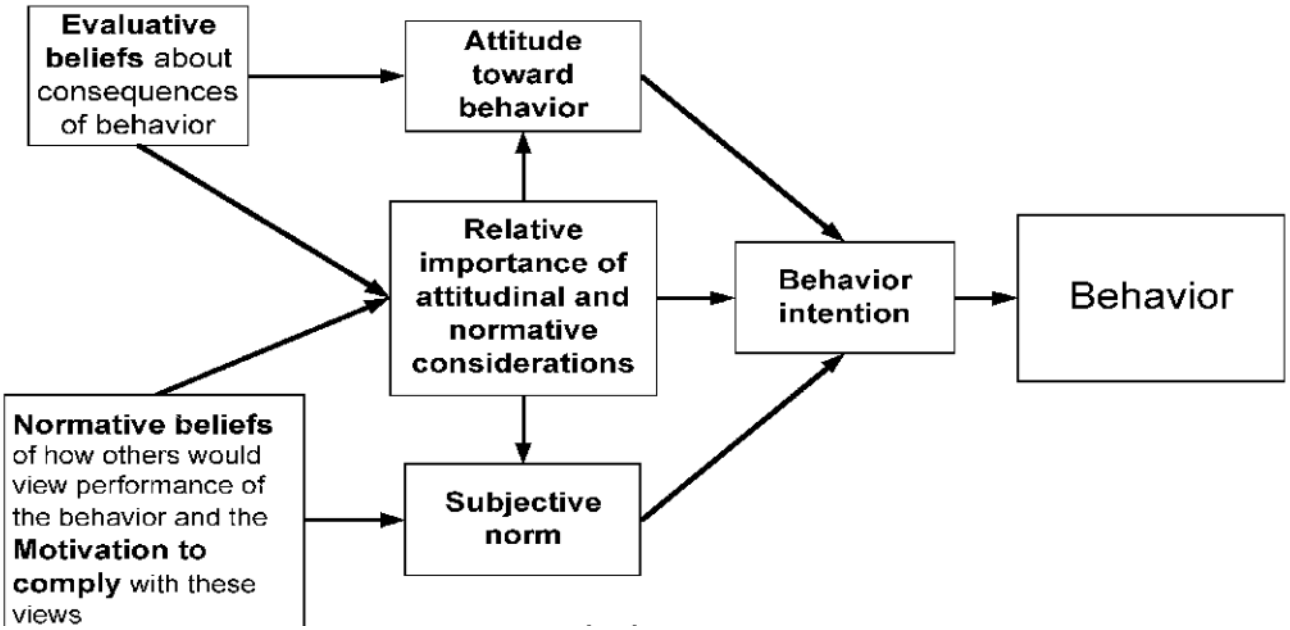


Figure 1. Theory of reasoned action

Source: Ajzen & Fishbein (1980), in Kollmuss & Agyeman (2002, p. 243).

The way people receive and process information is also a factor in whether or not they are open to changing their behaviour. In a 2019 public audience interview with Sam Harris[1] Daniel Kahneman summarised his work on System 1 and System 2 thinking. He explained that System 1 thinking is rapid, unconscious, effortless and automatic in order to assess situation, deliver updates to the brain and comprises 97 percent of human thinking; whereas System 2 is slow, deliberative, conscious, requires effort and requires rational thinking in order to find new or missing information and make decisions, and makes up 3 percent of our thinking. People therefore make most decisions in System 1, which is relatively more instinctive and less rational. Kahneman warns that when trying to influence others we tend to forget that they are also working in System 1 thinking, so trying to convince someone with rational arguments

[1] American neuroscientist, philosopher, and author. See www.samharris.org.

or facts is not necessarily going to convince them or change their behaviour (Kahneman, 2019b). In System 1 we deal with moral understandings through stories and emotions. In order to move people's thinking processes from System 1 to System 2, Kahneman (2019a) asserts that policymakers need to be making societal level decisions, "we hire people to think about numbers and best practice […] the handover from System 1 to System 2 must also be made by policymakers". Kahneman (2019a) states that if people are to be convinced to change their behaviour the way to convince them is by telling them the stories of individuals and their experiences, stories that they can relate to.

Altruism, empathy and pro-social behaviour models are frameworks through which to analyse pro-environmental behaviour, all of which are linked to individuals' value systems (Bierhoff, 2003). Peoples' values, beliefs, attitudes, feelings, fears, and emotional attachments are all contributors to their degree of engagement in pro-environmental behaviour (Harre, 2011; Kollmuss & Agyeman, 2002).

- **Altruism** is defined by Bierhoff (2003) as "prosocial behaviour [where] the helper's motivation is characterised by perspective taking and empathy" (p. 9).
- **Empathy:** Hoffman (1978) distinguishes between two broad concepts of empathy, one is the "awareness of another person's feelings, thoughts, intentions, self-evaluations", while the other refers to "vicarious affective response to others" (quoted in Bierhoff, 2003, p. 111).
- **Pro-social behaviour** is defined by Eisenberg and Miller (1987) as "voluntary intentional behaviour that results in benefits for another: The motive is unspecified and may be positive, negative, or both" (quoted in Kollmuss & Agyeman, p. 244).

Environmental behavioural models generally rest on these basic concepts in order to understand motivations of pro-environmental behaviour on the basis of people's perspectives, perceptions and actions as individuals and/or community groups. However, they do not thoroughly examine the overall context, wider environment, and underlying paradigms within which individuals and groups are operating.

External factors are arguably as important as internal factors in determining pro-environmental behaviour. Kollmuss & Agyeman (2002) identify institutions, economics, demographics, and social and cultural factors as influential contributors to the many conflicting and competing drivers of people's daily decisions and actions in relation to the environment. While these factors are complex, and not fully understood, they are nevertheless considered important when designing new policies and strategies for change (Kollmuss & Agyeman, 2002).

Economists assert that economic stimuli can *encourage* people to act in a pro-environmental manner; however there is no assurance that people *will actually act* in an economically rational way (Kollmuss & Agyeman, 2002). This is because economic decision-making does not play out in isolation, but is inevitably intertwined with social, cultural, practical, and

structural factors (Gifford, 200; Kollmuss & Agyeman, 2002). Factors such as the availability/accessibility of public transport systems and recycling facilities, for example, can either constrain or enable pro-environmental behaviour. Various influences interact to shape the outcome of any given project, programme or initiative. Time and resources invested in education may extend people's knowledge of environmental issues, but this does not necessarily result in an increase in pro-environmental behaviour (Gifford, 2011). In Kollmuss & Agyeman's (2002) conceptual model (see Figure 2, below), the arrows indicate how different factors are assumed to interact, and the black rectangles represent barriers to change towards pro-environmental behaviour.

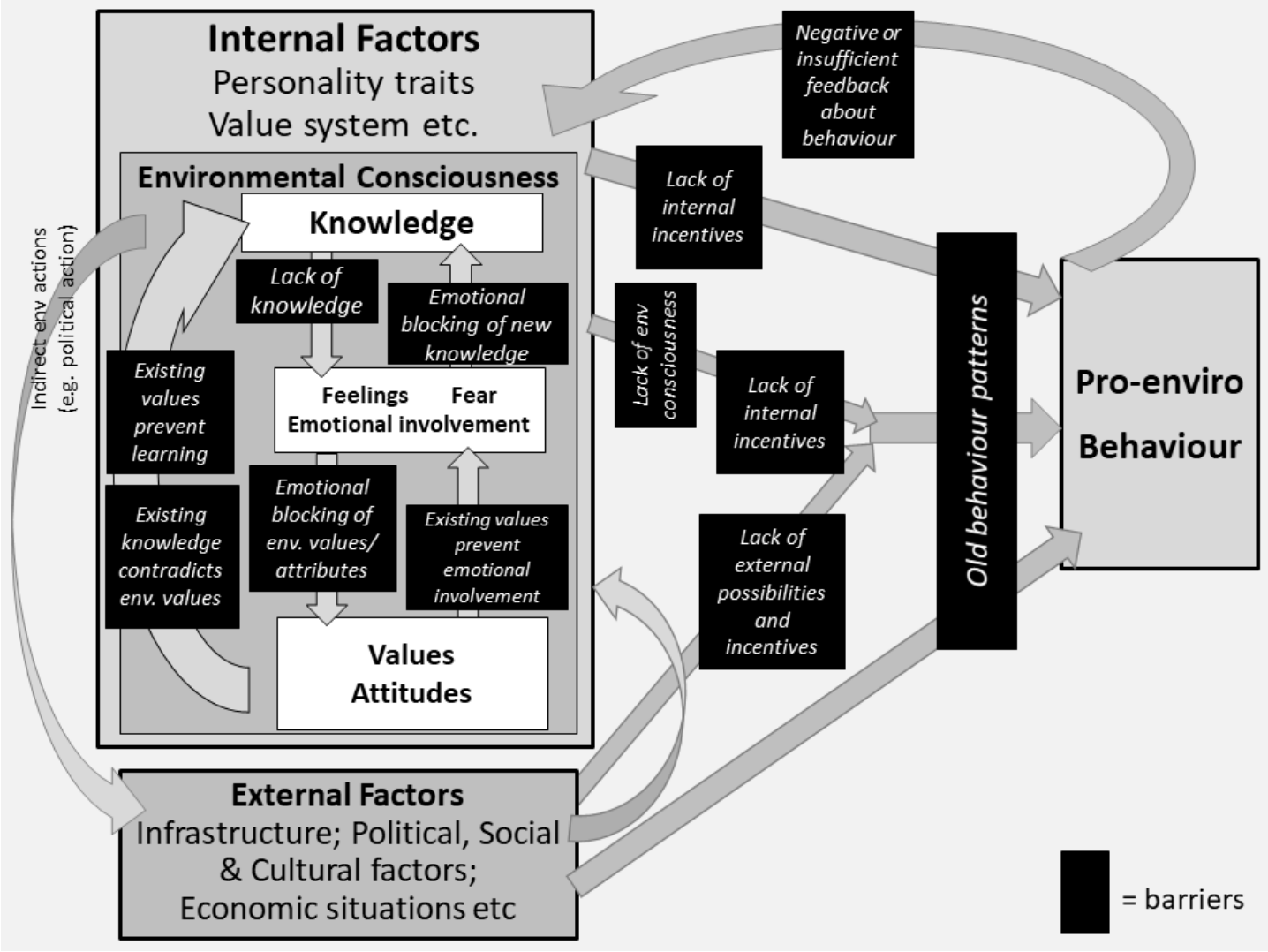


Figure 2. Model of pro-environmental behaviour

Source: Kollmuss and Agyeman (2002, p. 257).

Research based on pro-social, altruism and empathy models, as well as linear models, shows that in most cases an increase in knowledge and awareness, and attempts to change attitudes, do not necessarily lead to pro-environmental behaviour (Kollmuss & Agyeman, 2002). According to Shove (2010), these models and their associated concepts of social change are confined to a simplistic but dominant 'ABC' paradigm – wherein *attitude*, *behaviour*, and *choice* of individuals are seen as deterministic of behaviour change, while the institutions and systems that shape and perpetuate behaviours are largely neglected. Shove states that a focus on trying to change behaviour and attitudes creates blind spots for those looking to actually change behaviour, and restricts the field of governance options or interventions to achieve behaviour change. As an example, Shove (2010) asserts that laying all responsibility at the feet of individual 'addicts' of CO_2 deflects attention away from the many institutions and companies that establish, develop and structure the provision of fuel and combustion engines in the first place. Shove (2010) reminds us that policy interventions across the board do have significant effects – whether by design or inadvertently – on shaping future ways of life. It is not just individual human weakness or lack of willpower that drives consumption or unsustainable behaviour: "Trying to persuade people to consume and waste less through behaviour change programmes will not address the larger and more significant problems concerning the ways under which people need or think they need to live and consume" (Uzzell, p.4, cited in Shove 2010, p. 1277).

3.2. Pro-environmentalism theories

Stern (2000) presented a conceptual framework for pro-environmental behaviour that identified several distinct environmentally significant behaviours, and different *combinations of factors* that determine different behaviour types. He asserted it was necessary to define environmentally significant behaviour in the context of an intent-oriented focus on people's beliefs, ethics and motives, in order to understand and change target behaviours (Stern, 2000). He developed the value-belief-norm (VBN) theory of environmentalism, which builds on earlier linear theories, but links theories of values and norms to 'New Environmental Paradigm' (NEP) (Dunlap & Van Liere, 1978) perspectives. Stern (2000) proposes a causal chain of five variables that he asserts leads to environmentally significant behaviour (see Figure 3 below). Figure 3 outlines Stern's five variables – personal values (especially altruistic values); NEP (awareness of 'limits to growth' and 'balance of nature', etc.); awareness that particular conditions pose a threat; perceived ability to avert adverse consequences, and personal norms for pro-environmental action (sense of obligation to act pro-environmentally) (Stern, 2000).

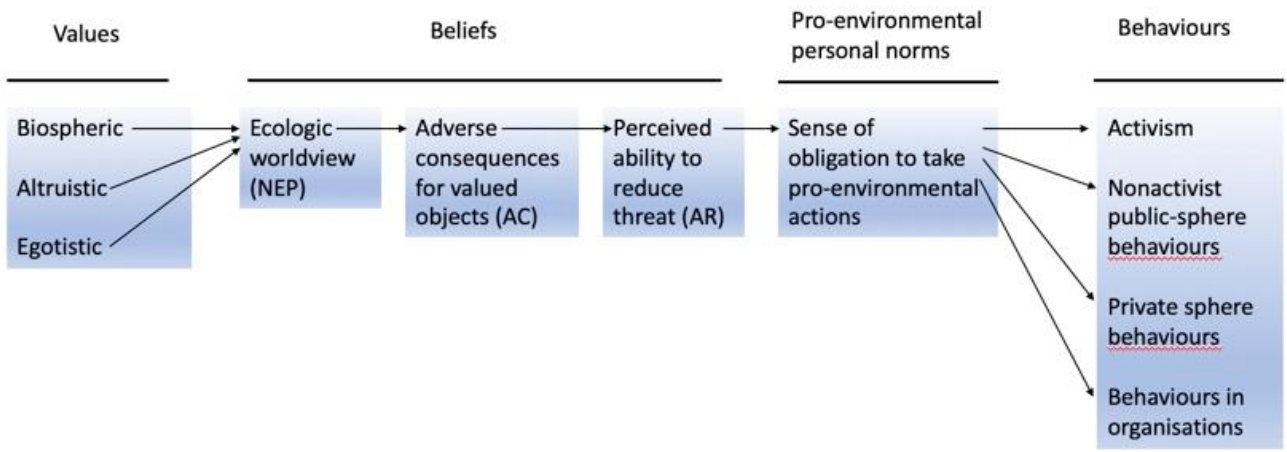


Figure 3. Stern's value-belief-norm theory of environmentalism
Source: Stern (2000, p. 412).

This causal chain is seen as depicting a transition from relatively stable elements of beliefs and personality traits, to more focused beliefs about human-environment relations (NEP) and their consequences, and the level of responsibility an individual accepts for taking corrective action.

Drawing on Stern's work, Lee, Kim, Kim, and Choi (2014) developed a definition of pro-environmental behaviour based on three different types of values – altruistic value orientation, perceived consumer efficacy or effectiveness (PCE), and environmental concern. Writing in the field of business studies, they argued that understanding the variations, relationships and interactions among these broadly positive values is helpful in the development of meaningful business policies and the establishment of effective marketing and communication strategies (Lee et al., 2014).

Further extensions of Stern (2000) and Kollmass & Agyeman (2002) are evident in the work of Gifford and Nilsson (2014), who detailed complex personal and contextual social factors that influence pro-environmental behaviour. Childhood experiences, knowledge and education, personality and self-construal, sense of control, values, political views and worldviews, personal goals, sense of responsibility, place attachment, age, gender and chosen activities are all deemed to potentially shape individuals' concern for the environment. While social influencers (religion, rural/urban residence, norms, class, cultural/ethnic identity) are considered to shape long-term behaviours, Gifford & Nilsson (2014) also acknowledge volatility (passing fads, changing friendships or relationships) as important.

Recently, Schirmer and Dyer (2018) identified four specific factors influencing individuals' pro-environmental behaviours – values norms; awareness and knowledge of issues; people's proximity and place-based identity; and lifestyle and life-stage factors. Their values/norms, awareness, identity and lifestyle framework (see Figure 4, below) is intended to provide a

context for understanding and addressing specific water-quality problems within communities. The framework also builds on Stern's (2000) model in terms of incorporating values and environmental awareness, but it additionally encompasses people's connectivity to nature, and the life stages they are experiencing, as determinants of positive pro-environmental behaviours.

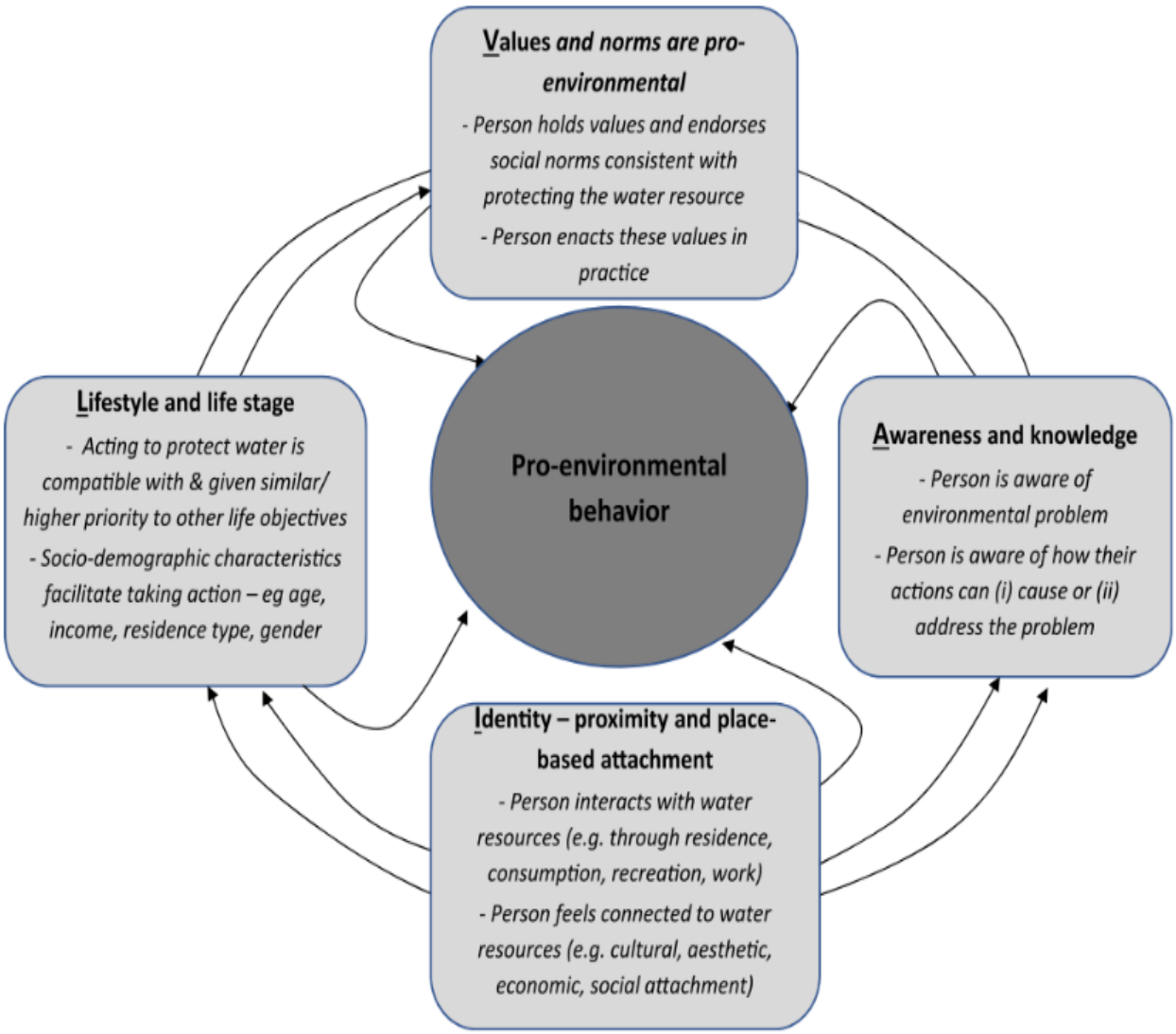


Figure 4. VAIL framework for adoption of pro-environmental behaviours
Source: Schirmer and Dyer (2018, p. E7692).

3.3. Sustainable behaviour change models and organisations

Miller and Buys (2008) sought to understand how environmentally sustainable behaviours could be normalised to support collective action in communities. They studied the Nerang River Catchment, on the Gold Coast of Australia, with the aim of identifying ways in which different societal norms could be simultaneously changed. Their findings identified the potential role of social capital[2] in engaging and educating people, and in devising environmental sustainability strategies, interventions and initiatives. Their study links social capital to more environmentally friendly water use behaviour, but also suggests that negative norms can be cultivated and reinforced within social networks. They assert that levels of social capital, environmental responsibility, and socio-demographic lifestyle factors are important in determining acceptance (or lack of acceptance) of sustainable and environmental practices.

According to Miller and Buys (2008) social norms and standards must also be considered, because norms significantly influence environmental behaviours. Social capital – or social connectedness – while it may produce widespread positive consequences for community well-being and sustainability, is not straightforward, and societal interaction with environmental sustainability plays out in complex ways. Miller and Buys (2008) argue that people usually do not understand the environmental impact of many of their everyday behaviours, but elements of social capital may help understand levels of engagement in environmentally sustainable behaviours.

The application of psychology and psychological perspectives to sustainability has also been advanced by practitioners and consultants. For example, *Awake,* an Australian consultancy in the fields of environmental and organisational psychology, has developed a model of enablers toward a culture of sustainability for application at the organisation scale (Cotter, 2019). The model proposes elements required for sustainability to become embedded in organisational decisions and actions. These elements have been identified through Cotter's research (2013) into the determinants of sustainable outcomes within organisations and communities. The model highlights that successful change is more likely when both individual enablers

[2] Defined as the social connectedness of a community or the glue that enables people, organisations, communities and nations to work together collaboratively for mutual benefit (Putnam, 2000).

(attitudinal/psychological factors) and organisational enablers (support mechanisms) are in place, see Figure 5 below.

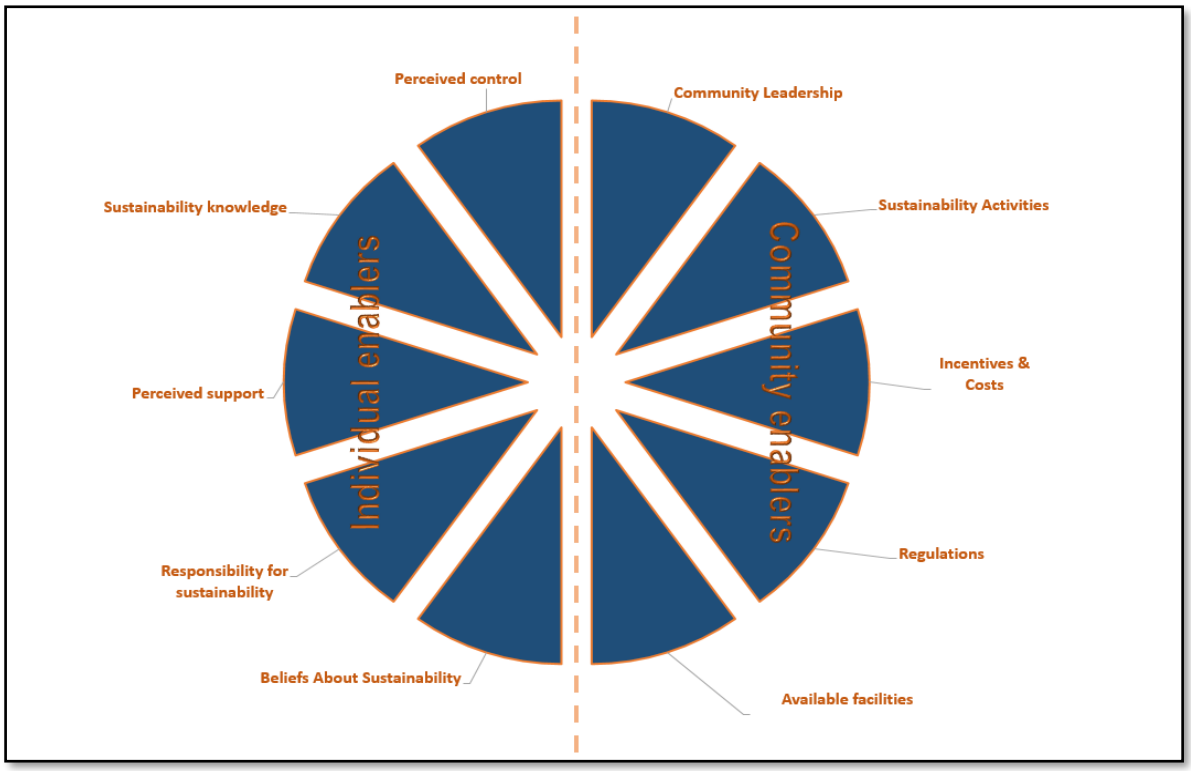


Figure 5. Sustainability Culture Model: Enablers of a culture of sustainability for communities

Source: AWAKE (2019), http://awake.com.au/sustainability-culture-model/

Another Australian behaviour change consortium, BehaviourWorks Australia, provides research around behavioural change in regards to environmental and social issues. Linked to the Monash University Sustainable Development Institute, BehaviourWorks has developed the 'BWA Method', which explores an environmental problem, 'deep dives' into behaviours, and seeks to apply interventions. The central premise of the BWA is that most problems can be partially solved by influencing the behaviours that underpin the problems. Given the complexity of individuals' behaviours, BWA provides behavioural science insights to assist organisations to influence behaviours and the types of interventions that are likely to provide positive outcomes.

3.4. Social practice theories

Rather than focus on individuals and seek to identify and influence their attitudes and behaviours, a practice perspective focuses on what people actually do, and how what they do shapes and is shaped by conventions, norms, and objects. More specifically, social practice theory (SPT) is interested in what people do, how what they do changes over time, and what

values, institutions, standards, technologies and management imperatives influence those changes (Shove, 2003a, 2003b, 2010; Shove et al., 2012). SPT is increasingly recognised as a way to navigate between individualist renditions of change that are unable to account for institutional structures that frame, facilitate and constrain what people do, and structural accounts of change that are unable to account for the agency of the individual within structures (Everett & Lamond, 2016; Geels et al., 2015; Greene, 2018; Shove et al., 2012; Spaargaren, 2011; Kadibadiba et al., 2018).

Shove et al. (2012) and Shove and Spurling (2013) have derived a framework that focuses on three elements of a practice – materials, meanings, and competences. Material objects include technologies, infrastructure, apparatus, tools and hardware. Material objects enable, shape, entrench or constrain practices. Competence involves knowledge, know-how, practical skill and technique. Meanings are defined by Shove et al. (2012, p. 23) as "the social and symbolic significance of participation [in a practice] at any one moment", while Reckwitz (2002, p. 243) describes them as "mental activities, states of emotion and motivational knowledge". A practice may shift or evolve through a change in one of the three elements, but occasionally a completely new practice will emerge involving a shift in all three. For example, the recent arrival of new material objects (electric scooters) in Christchurch has enabled a completely new mobility practice in the city, associated with new meanings (fun and freedom?) and requiring (for some users) new competencies (both in managing the software and the scooter). Meanings are an element of a practice rather than a single motivating factor (Shove et al., 2012), but they can be quite an important element. Delaney and Fam (2015) found that the historical, emotional and cultural dimensions of meanings associated with rainwater tanks in Australia strongly influenced their uptake, and the skills householders have or are willing to develop in using them.

Theories of social practice are a relatively recent inclusion in studies of sustainability, and only recently has the focus shifted to exploring how social practice theory can contribute to facilitating the adoption and spread of more sustainable practices (Strengers & Maller, 2015). If socio-technical change is conceptualised as an outcome of long term and often cross-cutting processes of linking and unlinking the elements of both sustainable and unsustainable practices (Shove et al., 2012; Walker et al., 2014), then interventions aimed at speeding a shift to more sustainable practices need to begin with an understanding of the elements and linkages that are sustaining current practices (e.g. around stormwater).

To understand why people consume or dispose of resources in a particular way, it is necessary to view the practices within the context of people's varied daily lives, what materials they have access to, what meanings are associated with particular practices, what competences they have or need for particular practices, and how these materials, meanings and competences interconnect, shape and influence each other. If new strategies and solutions are to take hold, they have to become embedded in the details of daily life, and that embedding will consequentially develop the order of society (Shove, et al., 2012). If more

sustainable patterns of consumption are to emerge, then it is not individual behaviour change that is required, but a reconfiguring of the shared cultural, political and technological elements that shape everyday activity to support less resource-intensive routines (Hoolohan et al., 2018a).

In the context of water, SPT has been used to explore how daily water practices have changed across successive generations of Australian migrants, and in times of plenty and times of shortage, and to highlight the role of infrastructure (and the institutions that enable and maintain it) in generating unsustainable water use (Strengers, 2011; Strengers & Maller, 2012; Browne, 2015; Kadibadiba et al, 2018; Hoolohan & Browne, 2018b). Hoolohan et al. (2018a) have developed a useful social practice toolkit that policy-makers and practitioners can use in workshop situations to develop and implement policies and/or intervention programmes. The purpose is to enable users to explore the complexity of everyday life and develop innovative policies and interventions that benefit sustainability objectives. The workshop exercises first open-up the problem space and explore everyday action, before identifying possible routes to intervene and then selecting and refining a number of these into practical action (Hoolohan et al., 2018a).

In summary, social practice theory recognises that what people do and how they do it emerges through the way materials, meanings and competences interconnect, shape and influence each other. The practices that lead to healthy or contaminated stormwater can be evaluated through the analysis of these elements to understand how such practices are integrated into people's daily lives, what linkages maintain them, and what intervention points might lead to their adaptation or redirection towards sustainability.

3.5. Summary of environmental behaviours and behaviour change

Research in the disciplines of geography, anthropology, sociology and social psychology (framed in terms such as socio-technical systems and social practice theory) has focused on behaviour as a result of complex inter-relationships and shared social practices (Morris, Marzano, Dandy, & O'Brien, 2012c). According to such theoretical perspectives, individuals reproduce or perform behaviours that are themselves a product of the relationships between people, their environments and the technologies that mediate these practices (Morris et al., 2012c). In this way, relationships, environments and even objects become relevant determinants of how behaviour is produced; individuals do not act and make decisions independent of their environment and their relationships within communities and wider societal practices (Morris et al., 2012c). For example, business people have 'domestic' lives, and many 'domestic' people work within businesses and companies. Both of these settings, and the relationships within them, influence individuals' behaviours and decision-making. Traditionally, policy instruments in the environmental space have comprised tools such as legislation, regulation, and financial incentives/disincentives (i.e. a 'carrot and stick'

approach). Increasingly, behaviour change approaches provide extra breadth to the mix of policy options (Morris, Marzano, Dandy, & O'Brien, 2012a).

Morris et al. (2012c) assert that the most successful behaviour interventions are those that:

- are based on *good understanding* of individuals' and groups' values, motivations and perceptions;
- target the wider social environment of individuals and their *community groupings;*
- adopt a *multi-faceted* approach; and
- facilitate *active involvement by participants* in project design and delivery.

They caution that behaviour change approaches can be controversial, and the right balance needs to be found between the role of government and citizens (Morris et al., 2012). Accusations of public interference in private lives may arise where government policy encroaches on individuals' rights to make their own choices (Morris et al., 2012). As such, there are important ethical issues around policies that focus on behaviour. Collier et al. (2010) assert that successful changes in behaviour require organisations to:

- be specific as to what the actual behaviour change policies are;
- be clear on the short, medium, and long-term aim/s; and
- ensure key themes are identified and well communicated.

4. Overview of stormwater issues

Stormwater management challenges sit at the intersection of society and the natural and built environments. As such, numerous actors, activities, and systems can affect stormwater, and policies and programmes designed to address stormwater contamination need to consider these carefully. Within this, it is important to understand how behaviour change theories might be applied to reduce stormwater contamination and, ultimately, improve urban water quality and the urban environment. In order for urban populations to be able to use and enjoy our urban waterbodies, maintain and restore ecosystems, and nurture sustainable urban environments, awareness of the human effects on stormwater needs to increase. Although it is not necessarily *sufficient on its own* to achieve behaviour change, urban residents' understanding of where their actions intersect with local stormwater systems is crucial. This, of course, will vary from place to place depending on context. We draw here on international literature, as well as studies from New Zealand, to identify aspects that might be of relevance to Christchurch City Council in the management of its stormwater and urban waterways.

Cities consist of large areas of impervious surfaces – rooftops, roads, carparks, and paving – which generate enormous volumes of runoff as stormwater. Urban infrastructure and built

environments receive, divert and channel millions of litres of stormwater away from city centres, business parks, and residential areas via rooftops, spouting systems, gutters, pipes and drains, and urban streams. The difference between natural land cover and impervious surfaces in terms of runoff generation is shown in Figure 6 below.

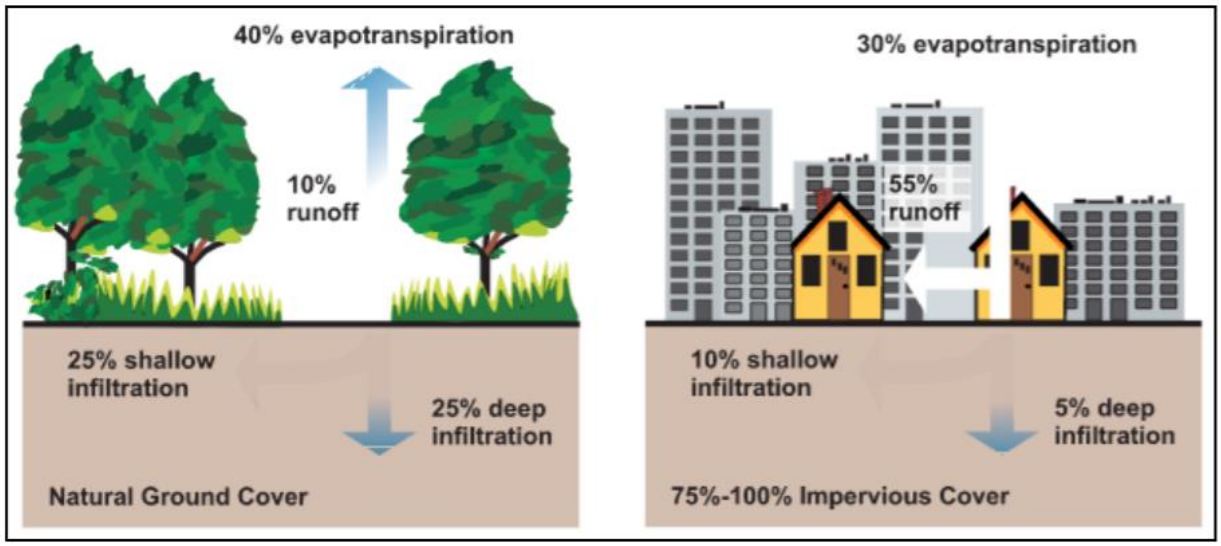


Figure 6. Relationship between impervious cover and surface runoff.
Source: USEPA (2003, p. 1.)

In the interests of public hygiene and flood protection, stormwater is usually conveyed and discharged untreated to a nearby natural waterbody (wetland, lake, river, or the sea). Insofar as stormwater comprises mainly rainwater, there is potential for some degree of recovery at different points in the system particularly if contamination can be mitigated and reduced. Such uses in the urban environment could include irrigation for parks and gardens, visual amenity, fleet vehicle washing, sewage treatment, topping up wetlands etc. (see Figure 7 below).

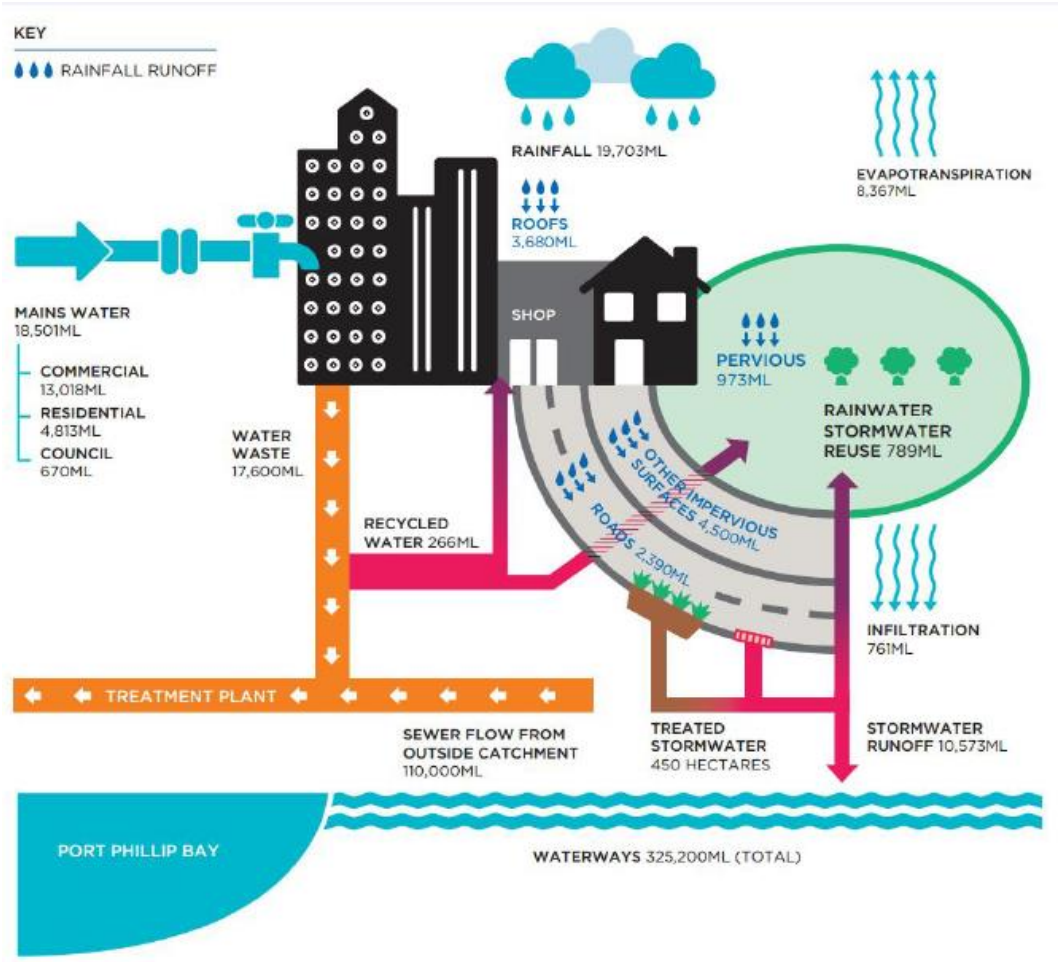


Figure 7. City of Melbourne's water cycle

Source: Commonwealth of Australia (2015, p. 5).

However, as urban environments and impervious surfaces continue to expand over rural landscapes, stormwater volumes increase and contaminants accumulate significantly in receiving environments. Increased inputs of heavy metals, sediment, nutrients, hydrocarbons, organics, and pathogens are all added to the stormwater flow, which becomes hazardous to humans and the environment. The effects of stormwater pollution on communities, on natural systems, and on surrounding environments, is now increasingly recognised as a threat to the sustainability of our water systems. The issues related to urban development, which drives stormwater contamination, are inter-connected, complex and multi-layered as illustrated by Chocat et al. (2007) in Figure 8 below.

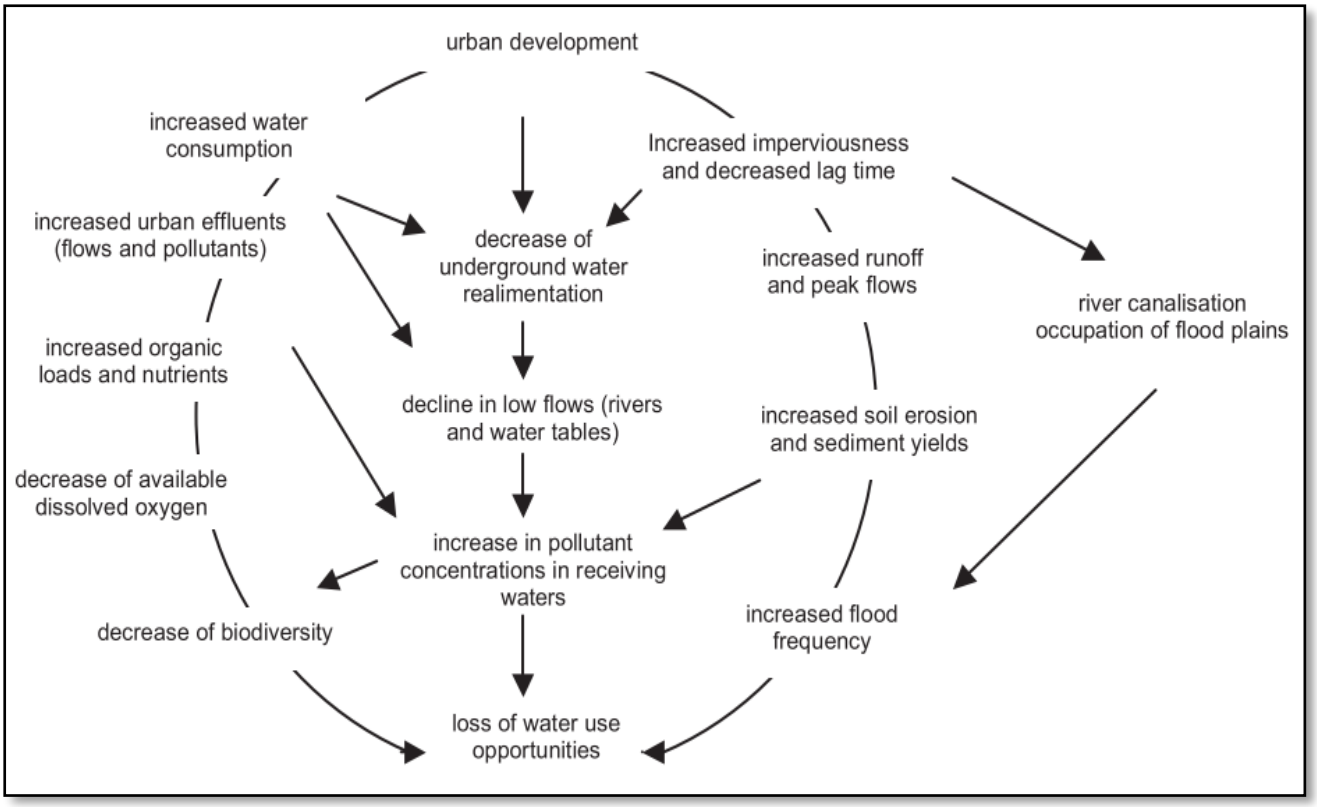


Figure 8. Complexity of current urban drainage issues
Source: Chocat et al. (2007, p. 274).

For the purposes of discussion we draw here on the Australian Senate's Parliamentary Stormwater Management Report (2015), which provides a short summary of key stormwater issues that identify key aspects of future stormwater management. While the report is focused on Australian cities, the key points are deemed relevant and applicable to New Zealand and Christchurch, and most 'developed' countries.

The Australian Senate identified the following critical aspects of stormwater management and research:

a) the quantum of stormwater resources and their impacts;
b) the potential of optimal management practices in areas of flooding, environmental impacts, waterway management and water resource planning;
c) the role of scientific advances in improving stormwater management outcomes and integrating these into policy at all levels of government to unlock the full suite of economic benefits;
d) the role of stormwater as a positive contributor to resilient and desirable communities into the future, including 'public good' and productivity outcomes;
e) modelling stormwater frameworks to develop economic and policy incentives for stormwater management;

f) modelling of land use planning and building controls to maximise benefits and minimise impacts in both new and legacy situations;
g) funding models and incentives to support strategic planning and investment in desirable stormwater management, including local prioritisation;
h) asset management and operations to encourage efficient investments over appropriate timeframes;
i) the role of stormwater innovation in supporting desirable outcomes and transparent decision-making, including access to information and novel technologies for planning, design and implementation.

Not only does contaminated stormwater cause significant environmental damage, it also represents a wasted potential resource. The Australian Senate Inquiry acknowledged that increased utilisation of stormwater could deliver various environmental benefits, as well as potentially securing economic and social benefits. Unfortunately, the Inquiry made no mention of behaviour, behaviour change, or adoption of fundamentally different stormwater models.

In 2014, Christchurch City Council passed a water supply, wastewater and stormwater by-law to: (a) manage, regulate and protect from misuse or damage the Council's water supply, wastewater and stormwater systems; and (b) protect the public from nuisance and maintain public health and safety. The Council's water supply and wastewater systems are almost completely closed off and securely isolated from all public interactions; however the stormwater system is not. As is the case in many other countries where municipalities manage, regulate and protect urban stormwater systems, the public's accessibility to, and subsequent contamination of, these systems causes significant problems for natural ecosystems (particularly freshwater, coastal, and marine ecosystems) and human uses of the environment.

A key challenge for policy makers is therefore to devise ways in which these urban water issues can best be addressed, especially in light of the complexities and sensitivities around engaging with a wide range of individuals, stakeholders, societies and cultures. Regulation and legislation has been passed, and rules are in place, but this has not prevented people, businesses or industries from continuing to contaminate stormwater. Environment Canterbury data on contamination incidents citywide during 2018 shows that of the total number of 395 reported incidents, 153 were for sediment; 150 were classified as chemical, cement or 'other' contaminant; 78 were classed as oil/fuel; and the remaining eleven involved effluent. Seventy five percent of reported incidents involved contaminated stormwater from industrial sites. In a 2018 *Waterways Survey* of Christchurch residents commissioned by Christchurch City Council, 45 percent of respondents either did not know where stormwater flowed to, or thought it went to a wastewater treatment plant.

Historically, interventions to address issues such as stormwater contamination have been largely limited to legislation, regulation, and financial incentives (or disincentives), such as fines or taxes. The effectiveness of such approaches has proved questionable overall, and

new, alternative approaches are being developed to provide a wider mix of policy options and tools for policy makers (Australian Capital Territory, 2017; Clark, 2018; Horbuckle, 2018; Johnson & Schaltegger, 2016; Morris et al., 2012a; Searle-Bell, 2016; Voraakhom, 2018). Important among these is a range of approaches to inducing behaviour change.

5. Urban stormwater behaviour change programmes

5.1. International urban stormwater studies

Studies of urban stormwater management have evolved through time as approaches to stormwater management have changed. The literature addressing behaviour change approaches to stormwater management began to expand from the late 2000s. We review here key contributions to the literature derived from a comprehensive database search.

In their study of the adoption of green stormwater infrastructure[3] Chini et al., (2017) assert that change is required to move away from grey infrastructure systems rooted in 20th century sociotechnical regimes, and to advance to more long-term policies that facilitate a sustainable future. "A transition from a grey stormwater system to an integrated green-grey hybrid system is required to move towards the goal of urban stormwater sustainability" (Chini et al., 2017, p.2). By greening the urban environment with the addition of vegetation, Chini et al. (2017) suggest that opportunities to reduce the volume of urban runoff and improve stormwater quality will emerge. Increased amounts of green infrastructure will increase the number and coverage of green spaces, which will provide social benefits that promote a sense of community and enhance public health and mental health (Chini et al., 2017; Elmqvist et al., 2015; Tzoulas et al., 2017).

Change in stormwater management has also been widely advocated in order to protect and restore urban streams and receiving environments. Roy et al. (2008) advised adoption of distributed, bespoke source-control technologies for stormwater management throughout catchments. Synthesising research from Australia and the United States, they found that while effective technologies do exist to protect freshwater ecosystems in urban environments, water sensitive urban design projects only existed as scattered, small-scale demonstrations within traditional stormwater and drainage systems.

Roy et al. (2008) make the key observation that every catchment location is different, so stormwater management should also be treated differently across catchments. They argue that acknowledging and working with the particular institutional structures within a catchment, and formulating an integrated socio-technical approach, is necessary. However,

[3] Green stormwater infrastructure aims to mimic natural ecosystems functions to provide water storage and water quality regulation by promoting infiltration, treatment and enviro-transpiration using vegetation, soils, and other elements (UNEP, 2014; USEPA, 2015).

equally important is allowing sufficient time and space to test and adapt novel water sensitive urban design approaches. Roy et al. (2008) identified numerous water sensitive urban design demonstrations, but few explicitly aimed to protect or restore receiving streams, and even fewer were implemented at a catchment scale.

Roy et al. (2008) highlighted two progressive Australian exemplars – the Victorian Stormwater Initiative targeting Port Phillip Bay, and the Healthy Waterways Partnership at Moreton Bay (reduction of annual nitrogen loads); and four examples in the United States – the Etowah Habitat Conservation Plan Stormwater Management policy (reduction of impacts on endangered species); Portland's Downspout Disconnection programme along the Willamette River, Oregon (reduction in combined sewer overflows and incentivised disconnection of household downpipes); the Nine Mile Run Rain Barrel Initiative in Pennsylvania (supply of free rain barrel, installation and technical support); and Kansas City's 10,000 Rain Gardens Initiative in Missouri (education campaign). Based on these case studies Roy et al. (2008) insist that catchment based actions to encourage water sensitive urban design rollouts require an experimental and adaptive approach to enable relevant technological solutions. While technological solutions are critical towards developing appropriate guidelines for urban stream restoration and protection, so too are community support and engagement – particularly through local champions (Roy et al., 2008).

In their study of green stormwater infrastructure and sustainability, Chini et al. (2017) identified 'urban experimentation' as a mechanism to create space and time to implement and observe various forms of green stormwater infrastructure in a flexible and adaptable manner. To eliminate contaminants and human derived pollution from stormwater drains, stormwater management plans need to incorporate community involvement and communications from the outset (Chini et al., 2017), and combine economic, social and environmental goals and benefits.

In addition to advocating for community-based, experimental frameworks for implementation of green stormwater infrastructure, Chini et al. (2017) recommend that project evaluation be based on participant motivation and constant feedback processes that produce local, relevant knowledge. They identified three important requirements for green infrastructure experimentation, if it is to contribute to sustainable urban stormwater management:

- a fluid definition of green infrastructure in policy;
- the inclusion of maintenance and evaluation in sustainable urban stormwater management/green infrastructure programs; and
- constant communication of the plan or programme within the community.

Urban experimentation is a tool that is increasingly applied by authorities in the United Kingdom, Germany, and India to promote community change to enable adaptable frameworks that break from the norm of grey infrastructure "through its requirement of new

forms of governance, maintenance, and citizen participation" (Chini, et al., 2017, p.5). 'Urban laboratories' are seen as a way to experiment with and evaluate city programs in a systematic way so as to inform cycles of policy development (see Figure 9 below): "Urban experiments are sites of knowledge production that – when combined with a continuous feedback loop – create a recursive process of learning and data collection" (Chini, et al., 2017, p.5).

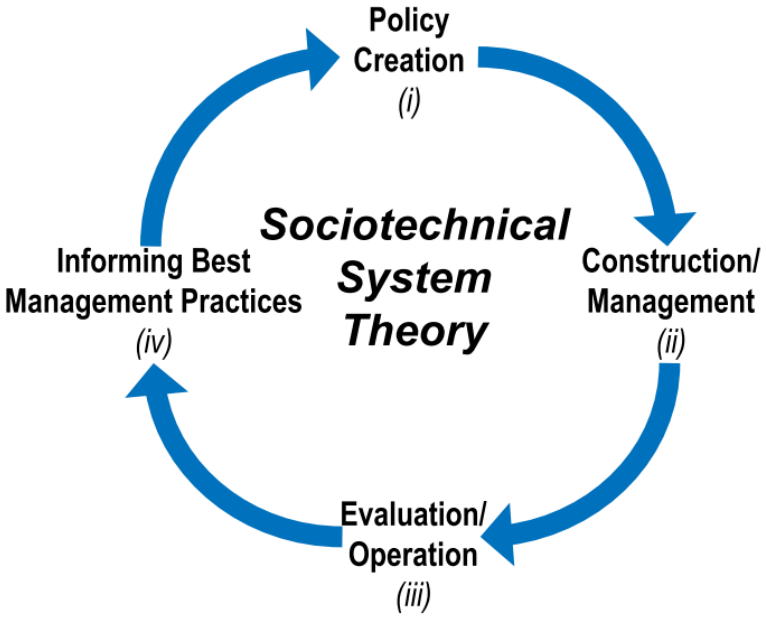


Figure 9. A generalised policy feedback cycle seen from a sociotechnical perspective
Source: Chini et al. (2017, p. 6).

Chini et al. (2017) formulated nine key questions[4] which they applied to twenty-seven United States cities. They analysed websites and other online material from city authorities to identify the main drivers for adoption of green infrastructure at the city scale. Cleaning up local waterways, compliance with consent conditions, addressing flooding, and creating aesthetically pleasing green spaces were the main reasons given.

Gao et al. (2018) conducted a ten-year, catchment-wide study in Tippecanoe County, Indiana, USA to examine public perspectives and individuals' perceptions of urban stormwater management plans relating to public and private infrastructure. Drawing on county surveys, they concluded that residents' water quality awareness and sense of personal responsibility

[4] (1) Does the city have a green infrastructure plan? (2) What motivates the city to adopt such a plan? (3) What green infrastructure installations are included in the plan? (4) Is the plan physically implemented by the city (i.e., public vs. private construction)? (5) Is there a maintenance plan/budget? (6) Are there plans for evaluation of the built infrastructure performance? (7) Does the plan have a success point? (8) Are there opportunities to revise the plan following evaluation? (9) Who are the key players in the plans (e.g., departments, knowledge brokers, etc.)?

had increased over the ten-year period. Those residents who had adopted rain gardens during this time were found to have a higher appreciation of the local Wabash River, and a sense of personal responsibility for the natural functions of the river. In urban areas, residents supported the integration of rain barrels and rain gardens into public spaces. When it came to private property, people's perceptions of the benefits of urban stormwater management plans were related to their functionality rather than their environmental benefits. Increasing public awareness of urban stormwater management plans, promotion of public involvement in wider catchment activities, and emphasising the functional benefits of stormwater management practices, were all deemed to have been effective in motivating the adoption of stormwater infrastructure. The effectiveness of stormwater management practices was found to be dependent on: community adoption rates reaching a critical mass, gaining an early understanding of individuals' perceptions of what urban stormwater management is, and the long-term perceptions individuals' had about the river.

5.1.1. Individual behaviours

Most models of individual behaviour are strongly intuitive, straightforward, and explicit, whereas social reality, and the diffuse impacts of social structures and technologies, is highly complex and often difficult to anticipate (Morris et al., 2012a).

From their study of Canberra, Australia, Schirmer and Dyer (2018) developed a framework of factors that influence individuals' pro-environmental behaviours regarding water-sensitive urban design. They found that technical solutions, which are often readily available and most quickly rolled out, are usually the most expensive. They suggest that it may be preferable to invest in the promotion of human behaviours that protect water quality within water sensitive urban design initiatives. Drawing on a review of past pro-environmental behaviour studies, the authors developed the values/norms, attitudes, identity and lifestyles framework (see page: 9 above), which they contend explains pro-environmental behaviours via four common domains (Shirmer & Dyer, 2018):

- values and norms (V);
- awareness and knowledge (A);
- proximity and place-based identity (I);
- life-stage and lifestyle (L).

Building on these four domains, the authors developed 22 indicators to understand urban residents' engagement in four 'water-friendly gardening behaviours' that help improve water quality in the local lake. They surveyed 3,334 residents, and found a significant degree of variance in the adoption of water-friendly gardening/pro-environmental behaviours. They recommend that explicitly engaging with values/norms, awareness, identity and lifestyle factors is very relevant in the context of individual behaviour change (Schirmer & Dyer, 2018).

Schirmer and Dyer (2018) concluded that all four of the VAIL framework elements should be engaged with to increase awareness of, and the sense of connection with, people's local waterways. Their study also found that the two strongest predictors of water-sensitive gardening practices were age (i.e. being older) and home ownership, which led them to conclude that "the greatest gains in water quality could result from behaviour change among younger residents who rent their residence" (Schirmer & Dyer, 2018, p. E7696). However, how to realise those gains through behaviour change within this particular target group was not discussed.

Schirmer and Dyer (2018) did suggest various other approaches for encouraging pro-environmental behaviours. The first was to target groups that are already aware of and practicing sustainable lifestyles (i.e. the existing active gardeners), and to try to inform, educate and enhance their current practices. Secondly, they recommended the promotion of functional outcomes, focusing on the benefits that behaviour change can bring to the individual, rather than the benefits to the environment (Schirmer & Dyer, 2018). In relation to this, they suggest that authorities raise awareness of the long-term consequences of pollution entering storm drains in functional, economic and, to a lesser degree, environmental terms. Presenting individuals with the long-term outcomes of their actions in both a negative and positive light was also perceived as useful (Schirmer & Dyer, 2018). People who spent their time recreating around local waterways and lakes had a greater awareness of the water-quality problems and likely a stronger motivation to adapt their gardening practices and behaviour. Finally, Schirmer and Dyer (2018) encourage the further development of awareness-raising campaigns that increase individuals' confidence and let them know that their actions can make a difference.

5.1.2. Education for individual behaviour change

The link between education or understanding and behaviour change is seen as tenuous (Stenekes, Colebatch, Waite, & Ashbolt, 2006). This is because the issues related to changing people's behaviour are extremely complex and include a mix of factors such as gender, age, culture, income, prior awareness, contextual issues, demographics, practical imperatives etc. (Stenekes et al., 2006).

Taylor, Curnow, Fletcher and Lewis (2007) studied business parks in Australia and the United States, and explored whether education campaigns reduced stormwater pollution. They set out to determine whether a low-cost, eight month education campaign within a small commercial district was successful in changing people's behaviour and reducing stormwater litter loads. Their monitoring and evaluation program consisted of six different styles of evaluation and tested new guidelines on best management practices (BMPs). They evaluated the extent and quality of the campaigns and their implementation, the degree to which these changed people's awareness, attitudes, self-reported behaviour, and actual behaviour, and

the nature of the changes on stormwater litter loads. Their results were mixed – the campaigns were unsuccessful at influencing the behaviour of merchants and the public, and only modestly successful at reducing litter loads entering the stormwater system. Methodologically, the project highlighted how using different styles of evaluation can help build a more complete picture of the actual performance of educational initiatives, guidelines and advice in relation to good practice around environmental behaviour and stormwater management.

Their recommendations for educational campaigns were as follows:

- It is important to have clear organisational responsibilities, including a detailed and regularly updated project plan to co-ordinate activities involving both monitoring and implementation of non-structural stormwater improvements (e.g. educational campaigns).
- There is value in taking a paired catchment approach to monitoring in order to increase explanatory power of monitoring results (i.e. using a control site).
- There is value in taking a statistical and multi-faceted approach when seeking to determine subtle changes in monitoring parameters.
- Information collected during pre-campaign monitoring should be used when designing education campaigns.

In their study of residents' attitudes towards, and acceptance of, green stormwater infrastructure investments in Syracuse, United States, Baptiste (2014) found there was a high level of acceptance among residents due to a common shared experience (of overflowing sewers). Residents supported the City's implementation of green infrastructure due to their experience of this problem, rather than any formal education or awareness of the wider issues and outcomes. There was also no relationship between the socio-demographic characteristics of those study participants, and their knowledge of green infrastructure. Citizens' knowledge of the technology, its efficacy, aesthetics and costs all influenced their acceptance of green infrastructure as a stormwater management technology in their neighbourhood. Baptiste (2014) concluded that lived experience was a key driver of high levels of green infrastructure knowledge in this community. Citizens' acceptance is essential for the effective implementation of policy on green stormwater infrastructure, and widespread acceptance should allow authorities to take a targeted approach to green infrastructure investment (Baptiste, 2014). According to Baptiste (2014), the most likely targets for success include low-income neighbourhoods, where there may be demand to improve the overall aesthetic of the area and public spaces. If authorities do intend to pursue an educational and regulatory approach to changing individuals' behaviour, then they must communicate clearly and openly with communities (Baptiste 2014).

Persaud et al. (2016) investigated whether an educational approach, combined with a regulatory framework, changed residents' behaviours around non-point source stormwater pollution management in Manatee County, Florida, USA. In order to reduce nutrient-laden runoff, local and state governments passed different regulatory mechanisms on best

management practices (BMPs) regarding fertiliser and pesticide applications, and introduced a fertiliser black out period. However, the study found that 69 percent of residents had not seen any promotional or educational materials related to the imposed blackout period, and they had limited awareness of the issue of nutrient pollution in general. The study also revealed that while social dimensions are important in sustainable stormwater management, certain areas need to be targeted to strengthen the link between social norms and environmental stewardship (Persaud et al., 2016). The study found that the known consequences of pollutants can often take second place to stronger social pressures, whereby neighbours and friends may hold influence and sway over positive and negative pro-environmental behaviours. Persaud et al. (2016) recommend that environmental managers utilise various homeowner associations to research attitudes and existing behaviours that appropriate norms and desired behaviour changes over the long-term.

Interestingly, residents had a strong desire to access data about local water quality, which Persaud et al. (2016) saw as a useful opportunity for engagement, and 'proof' for residents that deterioration was occurring in local water bodies. Residents requested more information on the changes and happenings impacting on their landscapes so 'Lunch and Learns' were implemented to inform them about the non-point source pollution mitigation practices they could engage in. 'Walkabouts' with environmental officers were also offered, where questions regarding landscaping issues could be asked. The study found that residents placed a high value on aesthetics over environmental function, so outreach and educational initiatives should start with the most environmentally aware neighbourhoods first.

Gao et al. (2018) found that in order to motivate individuals' adoption of sustainable urban stormwater management initiatives, it is essential to make resources such as skills, education, equipment, and funding accessible to the public. However, it must be remembered that these resources do not necessarily encourage people to adopt pro-environmental behaviours. According to Gao et al. (2018), the most likely ways to motivate people's adoption of sustainable urban stormwater management leadership is through their involvement in catchment wide activities, their increased awareness of urban stormwater management practices, and emphasis on the functional benefits for themselves and their communities.

Individuals' behaviour regarding stormwater will not change solely through the implementation of education programmes and workshops. People also need to be engaged with a project that is meaningful to them within their community, provides a shared common experience, is not just driven by benefits for the environment, is adequately funded and resourced, and has pleasing aesthetic outcomes for everyone to enjoy.

5.1.3. Technology and individual behaviour change

Many studies have found that particular technical or infrastructure solutions can improve stormwater quality in urban catchments. However, it is often the case that the level of business and community uptake, or 'buy-in', of the new technology is a major factor in whether or not community wide installation occurs (Brown et al., 2016; Roy et al., 2008). New technologies such as bio-retention systems (rain-gardens), infiltration systems, permeable pavements, green roofs, and stormwater harvesting systems, are all available for people to use. Roy et al., (2008) note that an increasing number of stormwater policies are being integrated and implemented within communities, however they argue that fragmented responsibilities, lack of capacity, lack of legal mandate and above-the-norm costs can impede the programmes. Collins et al. (2011) call for a socio-ecological perspective in the implementation of sustainable stormwater technology, while Brown et al. (2016) suggest that efforts to protect and restore local streams and rivers should recognise that these are located within wider socio-ecological systems.

In an online survey, Wu et al. (2012) sought to gauge the attitudes of residents in Salisbury, Australia, towards using treated stormwater in a managed aquifer recharge (MAR) scheme. South Australia has been considered a leader in large-scale urban stormwater harvesting schemes over the last 50 years. In particular, Salisbury Local Government Area is considered a worldwide leader in utilising treated stormwater in MAR, having twenty strategic stormwater harvesting sites and wetlands in their area. Companies with high water demand can access treated stormwater at cheaper rates than standard mains water, and 16,000 homes are also linked to the scheme, as are community facilities, and parks and sports ovals (for irrigation).

Wu et al. (2012) examined residents' attitudes toward other water use options, involving close personal contact with treated stormwater – e.g. personal washing, pets, clothes, fruit, vegetables, flowers, lawns, gardens, parks, flushing toilets and washing cars. They found that the Salisbury community had a generally positive attitude toward using treated stormwater for non-potable uses. Survey respondents considered that using stormwater treated through the MAR process was not likely to lead to a health risk, particularly for water uses that do not entail bodily contact. In this case, the technical interventions were enough for people to use the stormwater in certain, no-skin-contact, situations.

Ward and Winter (2016) studied urban flood mitigation by local authorities in Cape Town, South Africa, where poor stormwater quality has led to the deterioration of the urban rivers. The study highlighted how urban waterways and water quality are shaped by interactions between people, drainage systems, flood protection, and ecological systems. The authors found that residents had a poor understanding of the linkages between land uses/behaviours, and the consequential impacts in their urban rivers (Ward & Winter, 2016). The predominant focus by authorities on technological solutions for flood prevention did not lead citizens to account for their own actions, which contributed to the continued deterioration of their local waterways. As Ward and Winter (2016) noted, traditionally 'hidden' drainage infrastructure

fails to connect citizens with the downstream impacts of their behaviour on environmental systems and services. Although societal and ecological processes are inextricably linked (Grimm et al., 2000) urban residents often 'miss the link' in their ability to influence social patterns and processes to bring about environmental change (Grimm et al., 2000). Furthermore, conventional stormwater infrastructure also hides changes in the physical and ecological condition of the stormwater itself, so residents' perceptions of the state of the water remain the same (Grimm et al., 2000).

In Vermont, USA, Coleman, Hurley, Rizzo, Koliba, and Zia (2018), conducted a state-wide survey to evaluate the influence of interacting spatial, social and physical factors on residents' motivations to adopt green stormwater infrastructure. The study focused on infrastructure solutions such as rain gardens (bio-retention), infiltration trenches, and active diversion of roof run-off to a rain barrel/lawn/garden (as opposed to street or sewer). Coleman et al. (2018) found that adoption of diversion of roof run-off was more likely to be part of a larger assembly of green behaviours, and that private landowners may tend toward infiltration trenches rather than rain gardens. Rain gardens were seen as serving larger areas (i.e. for civic uses) rather than private properties (Coleman et al., 2018). They found that improved stormwater management outcomes at watershed, town, neighbourhood and household levels were not just dependent on technological advances, but also on local governments' adaptive approaches. Another key finding was that stormwater strategies need to be tailored on a catchment-by-catchment basis. While technical innovation is crucial, contextual factors are key to environmental behaviour (Steg & Vlek, 2009), and these factors will be important to recognise in efforts to recruit private landowners in stormwater management, and to promote their adoption of new technologies (Coleman et al., 2018).

In a study of household uptake of stormwater tanks in Melbourne, Australia, Brown, Bos, Walsh, Fletcher, and RossRakesh (2016) concluded that a blend of technological measures and education could foster a 'civic environmentalism' conducive to addressing stormwater contamination. The study involved incentivising households in Little Stringybark Creek (LSC) catchment, on the outskirts of Melbourne, to apply for a subsidy to install a stormwater tank on their property. The study found that an approach combining education (to encourage the examination of subjective norms and attitudes) and incentives (to mitigate behavioural controls), can help transform public behaviour towards decentralised sustainable stormwater management. Brown et al. (2016) suggested that the success of the behaviour change initiative in this study was attributable to their use of an integrated suite of incentive- and regulation-based mechanisms, alongside technological and educational applications, to ensure maximum participation.

Brown et al. (2016) acknowledged the complex relationships between cognitive processes, external factors, and human behaviour and attitudes. In order to maximise household participation in installing sustainable stormwater technology they recommend the following:

a) Manage people's motivations and expectations – financial incentives worked.

b) Be aware that trust, risk and social networks are important – the aims of the project attracted some residents but were a disincentive for others; scepticism and distrust of environmental communication and information do exist.

c) Understand the role of values, attitudes and perceptions in decision-making – personal values and attitudes interact with individual motivations and decision-making. The growth in privately-owned rain-gardens increased others' understanding of, familiarity with, and uptake of rain-gardens during the project.

d) Know that there were barriers and constraints for participants because they were all affected by household income, inadequate size or layout of a property, and whether or not they owned their own home. Environmental issues were seen as a low priority relative to their daily responsibilities.

Brown et al. (2016) suggest that a 'civic environmentalism approach', whereby mobilising resources from within local government and community-level organisations, to serve local goals, could help. Furthermore, they advocate an experimental and adaptive approach, stating that achieving high levels of participation and uptake takes time. These considerations should inform the design and funding of both incentive and regulation-based programmes.

In summary the technological aspects of green stormwater infrastructure are a significant factor in individuals' attitudes and behaviour toward stormwater management on private property, but technological solutions alone will not solve urban stormwater issues. People's sense of ownership of the problems and solutions, social norms and values, and the ease of use of various alternatives are all crucial to the success of green stormwater infrastructure and related technological and infrastructure solutions.

5.1.4. Financial incentives for behaviour change

Proft (2018) provided recommendations for the design of stormwater credit policies to create appropriate incentives for property owners to adapt their property to better manage polluted runoff and realise financial benefits. These recommendations are based on a synthesis of the research of existing stormwater management districts across the northeast of Rhode Island, USA, and are as follows:

- Make the financial investments work for property owners by financially assisting them with the installation of stormwater infrastructure that is 'above the minimum requirements';
- Identify priority properties and develop an outreach program to work with them individually – while telling others about it;
- Allow property owners to earn additional credits (not just monetary) if they manage runoff from neighbours;
- Enable property owners to take responsibility for maintenance, and support them in this.

However, Proft (2018) concluded that in their study area, property owners who built a stormwater control measure for credit would not find the exercise economically viable. Additionally, the degree of official outreach and promotion of the credit scheme system was very limited across the districts because council staff recognised the potential loss in revenue as a result of reduced stormwater management fees, so they did not actively encourage private management of stormwater by property owners.

5.1.5. Community focused behaviour change

A number of authors have observed that people who are more connected to each other are more likely to connect with their natural environment, and that this connectedness, and a sense of caring for other people, other species and the environment, is associated with greater wellbeing (Carlisle et al, 2009; Christopher, 1999; Kellert & Wilson, 1993; Ferrer-i-Carbonell & Gowdy, 2007; Roberts, et al., 2015). Roberts et al. (2015) argue that there is abundant anecdotal evidence that youthful shared experiences in natural environments can be the foundation of lifelong friendships. Being involved in activities and sharing particular experiences with others develops ties within society, propagates opportunities to enhance the quality of life for all members, enhances connectedness, trust, mutual sense of obligation, and creates a safety net for difficult times ahead (Bos & Brown, 2015; Roberts et al., 2015).

Miller and Buys (2008, p. 244) also assert that "fostering social capital may encourage people to work together on environmental and sustainable initiatives". Their study explored whether social capital, environmental responsibility, and socio-demographic lifestyle factors might predict environmentally friendly or unfriendly home water use behaviours (specifically gardening and car-washing), in a drought-prone Australian community. Study participants who reported a higher degree of 'neighbourhood connection' were more likely to wash their car in an environmentally friendly manner. However, these residents were also more likely to engage in the potentially harmful gardening practice of using weed-killers, pesticides and herbicides. Miller and Buys (2008) conclude that the real challenge is to keep building social capital while identifying ways to simultaneously change societal norms so that environmentally sustainable behaviour becomes standard. In this way, individuals and community groups should become motivated to act.

Selman, Carter, Lawrence, and Morgan (2010) discuss how rivers and other waterbodies have traditionally provided a range of nature-based activities and shared experiences to communities that have lived near them. Waterbodies have provided a social and economic focus for communities, and being in close proximity to waterways enabled communities to become accustomed to, and familiar with, their vagaries. Now in many urban areas, however, the idiosyncrasies of local waterways have virtually been forgotten (Selman, et al., 2010). Water pollution and the increased frequency of flood events call for communities to reconnect with their local water bodies, so they can take responsibility for and improve those

natural environments (Selman, et al., 2010). However, urban residents are inclined to disregard the values and significance of stormwater because urban water infrastructure establishes cognitive and behavioural barriers, which in turn contribute to dissociation between urban aquatic ecosystems and people (Selman, et al., 2010).

Based on a ten-year study of urban stormwater management practices, Gao et al. (2018) observed that the adoption of sustainable stormwater practices by individuals depends on them identifying with a wider group who share an interest in sustainability. Their longitudinal study identified individuals' perceptions of urban stormwater management practices (SMPs) in the public and private realms. Gao et al. (2018) found that over the study period, and at the level of the individual, residents' awareness of water quality and their sense of personal responsibility increased. Those who had installed rain gardens had a higher appreciation of the local Wabash River, and came to understand more about how the river functions. Residents supported the integration of rain barrels on private properties in the urban area, and the study found that people appreciated these primarily for their functional benefits, rather than environmental benefits. Similarly, respondents valued rain gardens in public spaces primarily for functional benefits. In order to successfully bring about behaviour change in domestic water use, it was essential to make resources, such as skills, knowledge, equipment, and funding, accessible to the public. However, Gao et al. (2018) found that it does not necessarily follow that *individual* people, operating in isolation, will adopt pro-environmental behaviours. The promotion of wider public involvement in watershed activities, an increased public awareness of urban stormwater management in general, and an emphasis on functional benefits, increased people's motivation to actually adopt pro-environmental practices.

Boulet, Ghafoori, Jorgensen, and Smith (2017) studied stormwater pollution prevention among small and medium sized enterprises (SMEs) that were based in the outer east suburbs of Melbourne, Australia. They utilised a combination of different behaviour change strategies – capacity building, social norms, and commitment – to change stormwater pollution behaviours. The authors noted that non-structural, behaviour change approaches to stormwater management are relatively inexpensive, flexible, and broadly applicable, yet they remain under-researched compared to structural measures, particularly in the case of SMEs. Boulet et al. (2017) drew on five categories of BMPs in relation to non-structural stormwater management (following Taylor et al. 2007):

- Town planning controls (e.g. requiring low-impact development designs);
- Strategic planning and institutional controls (e.g. city-wide stormwater quality management plans);
- Pollution prevention practices (e.g. street sweeping);
- Education and participation programs (e.g. awareness raising and behaviour change campaigns); and
- Regulatory controls (e.g. local laws that reduce erosion on building sites).

The behaviour change interventions studied by Boulet et al. (2017) did not result in a change of water quality in the stormwater systems – this was later attributed to already low pollution rates prior to the study. However, there were encouraging signs that SMEs did positively increase their stormwater pollution prevention practices over the course of the study. The key recommendation from the study was for authorities to foster the development of social norms (through communication campaigns and behavioural influencers), relationships, and face-to-face engagement with target groups when attempting to change behaviour.

In their study in the twin cities of Minneapolis-St Paul, USA, Pradhananga and Davenport (2017) examined the direct and indirect influences of community attachment on people's feelings of collective efficacy in relation to environmental concerns, and on civic engagement. A postal survey of 1,000 residents showed that residents who were attached to their neighbourhood through social ties and ties to the natural environment, were also driven in their engagement with water resource protection. Further, residents' in their study perceived collective efficacy and concern for stormwater as significant predictors of civic engagement in water-related issues. Pradhananga and Davenport (2017) assert that programs aimed at increasing civic partnership around water resource issues will benefit from understanding the role the natural environment plays in enhancing people's attachment to their community. Their conceptual model is presented in Figure 10, below. They claim that it is important for local authorities, when developing civic engagement programs, to understand the number of different ways people can become attached to their community. Pradhananga and Davenport (2017) recognise that large scale strategies aimed at strengthening community attachment, and engagement in stormwater management, may prove difficult. They advise that social networks to encourage engagement and pro-environmental behaviour changes may be more effectively built in smaller geographic areas.

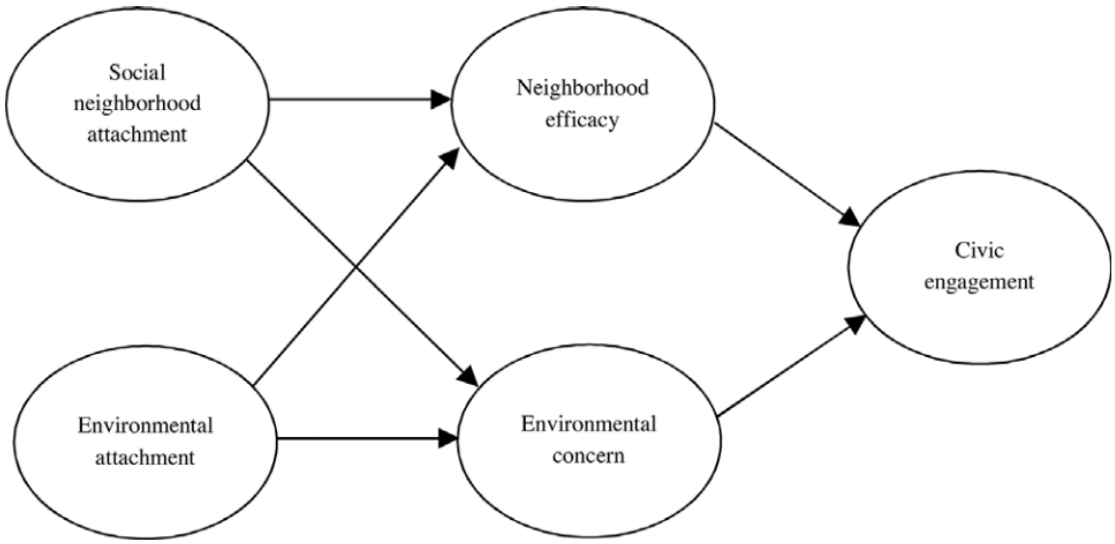


Figure 10. Conceptual model of factors fostering civic partnership
Source: Pradhananga and Davenport (2017, p. 4).

Investigating green infrastructure in Ontario, Canada, McWilliam, Brown, Eagles, and Seasons (2015) concluded that where local government authorities are seeking to drive pro-environmental behaviour change, it is important that they establish policy goals around long-term protection, measurable policy objectives, and effective policy tools, so as to limit any anticipated negative impacts. McWilliam et al. (2015) also assert that adaptive management policies are necessary to protect essential ecosystem services from unanticipated long-term impacts, particularly those caused by climate change.

Selman, et al. (2010) conducted and analysed a series of creative writing workshops that aimed to foster pro-environmental attitudes among local people in northern England in an effort to help 'recover' the River Dearne. Within the research context of social practice, Selman et al. (2010) focussed on meaning, competence and materials. The outcome was that participants found the process a positive experience and discussed changes in their knowledge, attitudes, and actions about the use and management of river environments locally and in general (Selman et al., 2010). As participants engaged in the practical workshops their 'catchment consciousness' appeared to increase, and their increased interest levels led them to spend time researching the geography and history of the river (Selman et al., 2010). Through the practice of sharing stories, local wisdom, hopes and fears in a personal and engaged manner participants showed variable effects on their behaviours, and a more consistent effect on emotional, physical and cognitive engagement with rivers (Selman et al., 2010).

The examples provided in this community focused section illustrate that by applying a holistic, strategic approach across numerous urban community groups, it is possible to demonstrate to individuals that their individual and community roles and responsibilities fit into a bigger picture, and contribute toward the improvement and maintenance of healthy ecosystems and urban waterways (EPSRC Research Consortium, 2016-2019).

5.2. New Zealand urban stormwater projects

While there have been numerous New Zealand-based studies of the technical aspects of stormwater management, no literature was found specifically focused on behaviour change to prevent stormwater contamination. However, a forthcoming Waterways Centre Master's thesis addresses "The barriers to and opportunities for building-scale Water Sensitive Urban Design in Christchurch, NZ" (Southworth, forthcoming 2019). This work does consider aspects of behaviour and behaviour change in relation to the urban built environment.

While not a specific behaviour change study, the relatively small-scale, Mariner Rise housing development, on the Whangaparoa Peninsula, Northland, New Zealand, is an example of a New Zealand local authority, hoping to foster pro-environmental behaviours by creating

shared spaces for youth, an ecological wetland, and stormwater overflow infrastructure (Whittaker, 2018). Given the marked increase of high density housing developments in the region, the local community requested the provision of recreational amenities, while still being mindful of ecological imperatives. Auckland Council Property requested environmental mitigation measures with the housing developer to create a 2,700m^2 open area for an ecological recreation area. Local children have been playing beside the native and biodiverse wetland (also used as a stormwater retention basin during flood events), complete with boardwalks, climbing rocks and logs, stepping stones and a more traditional playground. The research of Roberts et al. (2015) suggests that these youthful shared experiences within nature will provide lifelong friendships and a likelihood that young people will connect with their natural environment in the future.

Another New Zealand stormwater project, recorded in the magazine *Local Government* (Moore, 2018), focuses on the implementation and technical aspects of water sensitive urban design. It discusses the increasing motivation of consultancies, and the willingness of councils and engineers, to begin to adopt water sensitive urban design. Unfortunately there is no mention of working with communities and the public in the installation of the infrastructure.

An example of a fully developed water sensitive urban design sub-division exists in Wanaka at a subdivision known as Kirimoko Park (Ira, Simcock, Moores, & Batstone, 2018). The developers have achieved 23 percent and 17 percent construction cost savings for stages two and three, respectively. The use of existing natural drainage patterns and hydrology, swales and raingardens, as opposed to catchpits and pipes, significantly reduced earthworks. Integration across architecture and the landscape has enabled a resilient and sustainable system. Lakes District Council have stated that they are not prepared to vest the subdivision back in the Council, but have made a note to review the subdivision in ten years' time, to see if there are any benefits they could learn from.

6. Key findings

- Behaviours are complex, and changing individual and community behaviours is even more complex, due to the large number of variables.
- Theories around behaviour change towards more pro-environmental behaviours have transitioned over the years, from linear, individual-focused models, to a recognition that abilities to change and trajectories of change are far more organic and influenced by policy, infrastructure, economics, social norms and lifestyle, place identity, and life stages.
- Instead of a traditional, narrow approach to roll out region-wide education programmes pro-environmental change programmes need to shift their focus to include engagement with numerous groups within various catchment communities. Understanding is required in terms of how people perceive:

- stormwater pollution issues;
- the legislation around green stormwater infrastructure/water sensitive urban design;
- performance, costs and savings benefits of green stormwater infrastructure/water sensitive urban design infrastructure; and
- the level of engineering guidance available for green stormwater infrastructure/water sensitive urban design.

- Local authorities should work with a range of already established community groups – start with already committed pro-environmental groups and expand from there. Where possible, involve established groups in the planning, and perhaps even the roll out, of stormwater infrastructure solutions. Interest groups within the community have significant social reach within households, neighbourhoods, businesses they work in or own, and educational institutions they may be associated with (preschools through to tertiary institutions).

- Local authorities need to establish genuine relationships and conduct face-to-face engagement with target groups when attempting to change behaviour – i.e. not just carry out online surveys.

- Local authorities should explore 'experimenting' with infrastructure projects and programmes, that facilitate medium- to long-term adaptive frameworks and feedback loops. Not only would such 'community-based experiments' provide useful technical feedback and knowledge for adaptability specific to a particular catchment, they would also create civic partnerships between councils and ratepayers, as well as social ties within the community that will ultimately drive engagement toward stormwater protection.

7. Conclusions

This literature review has explored international scholarship on behaviour and behaviour change; provided a brief overview of stormwater issues; discussed findings from the international literature on stormwater management through education programmes, technological initiatives, and community-focused behaviour change specific to stormwater projects; and provided some examples of urban stormwater projects within New Zealand.

The international literature contains examples of recent and fairly successful efforts by local authorities to facilitate the uptake of green stormwater infrastructure/SWUD – e.g. through infrastructure installation incentives and improved functionality, education, recognition of societal differences, fostering community engagement and involvement, consultation, experimentation, establishing feedback loops, and supporting adaptations – amongst different urban communities. There are thousands of community groups worldwide that have formed out of concern for the quality and quantity of their local surface waterbodies. And these groups might be harnessed in tackling stormwater contamination.

In Christchurch, for example, the Avon-Heathcote Estuary Ihutai Trust is a non-profit organisation formed in 2002 by members of the public working together for clean water, open

spaces, safe recreation and healthy ecosystems for Christchurch, New Zealand people to enjoy. They host a Facebook page to interact with people there and via their website. They are supported by Christchurch City Council, Environment Canterbury and Canterbury Community Trust and facilitate riparian planting events, maintenance of plantings, restoration projects, and the annual 'mother of all clean ups'. They are an established pro-environmental group who, as individuals, live in households and neighbourhoods and work in various businesses throughout the city – they have numerous social networks that could be tapped into.

Over the last decade, Christchurch City Council has formally established many connections to community and business groups within the city and surrounds. The 'Target Sustainability' programme, for example, provides free support and online resources to assist Christchurch businesses to become more efficient around their natural resources – particularly in regards to water and energy efficiency and waste reduction. Consequently, there is a pre-existing connection to a network of environmentally aware local business owners who want to change their own behaviour as well as influence others. Council's Target Sustainability programme might, like community groups such as the Avon-Heathcote Estuary Ihutai Trust, also be a beneficial starting point from which to build behaviour change initiatives. It is hoped that the cases and findings presented here will, over the medium to long term, be able to inform programs for pro-environmental behaviour change that might address the drivers of stormwater contamination in Christchurch.

References

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs: Prentice-Hall.

Australian Capital Territory. (2017). ACT healthy waterways basin project: Consultation report. Canberra, Australia: Retrieved from https://www.environment.act.gov.au/__data/assets/pdf_file/0011/1030043/ACT-Healthy-Waterways-Consultation-report-ACCESS.pdf

Avon-Heathcote Estuary Ihutai Trust. (2019). Avon-Heathcote Estuary Ihutai Trust website. Retrieved 15 April 2019, from http://www.estuary.org.nz/

Baptiste, A. (2014). "Experience is a great teacher": citizens' reception of a proposal for the implementation of green infrastructure as stormwater management technology. *Community Development, 45*(4), 337-352. https://doi.org/10.1080/15575330.2014.934255

BehaviourWorks Australia. (2019). Behaviour Works Australia. Retrieved from https://www.behaviourworksaustralia.org/about/

Bierhoff, H. (2003). *Prosocial Behaviour*. London: Psychology Press.

Bos, D., & Brown, H. (2015). Overcoming barriers to community participation in a catchment-scale experiment: Building trust and changing behavior. *Freshwater Science, 34*(3), 1169-1175. https://doi.org/10.1086/682421

Boulet, M., Ghafoori, E., Jorgensen, B. S., & Smith, L. D. G. (2017). Behaviour change: Trialling a novel approach to reduce industrial stormwater pollution. *Journal of Environmental Management, 204*, 272-281. https://doi.org/https://doi.org/10.1016/j.jenvman.2017.09.003

Bradford's Beck Community Group. (2019). Bradford's-Becks.org. Retrieved 15 April 2019, from https://bradford-beck.org/

Brown, H., Bos, D., Walsh, C., Fletcher, T., & Ross Rakesh, S. (2016). More than money: how multiple factors influence householder participation in at-source stormwater management. *Journal of Environmental Planning and Management, 59*(1), 79-97. https://doi.org/10.1080/09640568.2014.984017

Browne, A. L. (2015). Insights from the everyday: Implications of reframing the governance of water supply and demand from 'people'to 'practice'*. Wiley Interdisciplinary Reviews: Water*, 2(4), 415-424.

Carlisle, S.; Henderson, G.; Hanlon, P.W. 2009: 'Wellbeing': a collateral casualty of modernity? *Social Science & Medicine 69(10)*: 1556–1560.

Chatterton, T. (2011). An introduction to thinking about 'energy behaviour': A multi-model approach. . Bristol, UK.: University of the West of England Retrieved from http://eprints.uwe.ac.uk/17873

Chini, C., Canning, J., Schreiber, K., Peschel, J., & Stillwell, A. (2017). The green experiment: Cities, green stormwater infrastructure, and sustainability. *Sustainability, 9*(105), 21.

Chocat, B., Ashley, R., Marsalek, J., Matos, M. R., Rauch, W., Schilling, W., & Urbonas, B. (2007). Toward the Sustainable Management of Urban Storm-Water. *Indoor and Built Environment, 16*(3), 273-285. https://doi.org/10.1177/1420326x07078854

Christchurch City Council. (2019). Target Sustainability. Retrieved 14 April 2019, from https://www.ccc.govt.nz/environment/sustainability/target-sustainability/target/target-water/

Christopher, J. 1999: Situating psychological well-being: exploring the cultural roots of its theory and research. *Journal of Counseling and Development 77(2)*: 141–152.

Clark, G. (2018). The crisis lurking in Australia's stormwater drains. Retrieved 13th August, 2018, from https://www.governmentnews.com.au/the-crisis-lurking-in-australias-stormwater-drains/

Coleman, S., Hurley, S., Rizzo, D., Koliba, C., & Zia, A. (2018). From the household to watershed: A cross-scale analysis of residential intention to adopt green stormwater infrastructure. *Landscape and Urban Planning, 180*, 195-206. https://doi.org/https://doi.org/10.1016/j.landurbplan.2018.09.005

Collier, A., Cotterill, A., Everett, T., Muckle, R., Pike, T., & Vanstone, A. (2010). Understanding and influencing behaviours: A review of social research, economics and policy making in DEFRA. DEFRA, London.

Collins, S., Carpenter, S., Swinton, S., Orenstein, D., Childers, D., Gragson, T., . . . Whitmer, A. (2011). An integrated conceptual framework for long-term social–ecological research. *Frontiers in Ecology and the Environment, 9*(6), 351-357. https://doi.org/doi:10.1890/100068

Commonwealth of Australia. (2015). *Stormwater management in Australia*. Parliament House, Canberra, Australia: The Senate Printing Unit.

Cotter, T. (2013). Defining and building a culture of sustainability: An overview of the determinants and enablers or a culture of sustainability. AWAKE.

Cotter, T. (2019). Awake: applying psychology to sustainability. Retrieved January 2019, from www.awake.com.au

Delaney, C., & Fam, D. (2015). The 'meaning' behind household rainwater use: An Australian case study. *Technology in Society, 42*, 179-186. https://doi.org/https://doi.org/10.1016/j.techsoc.2015.05.009

Dunlap, R. E., & Van Liere, K. D. (1978). The "new environmental paradigm". *The Journal of Environmental Education, 9*(4), 10-19.

Eisenberg, N., & Miller, P. (1987). The relation of empathy to prosocial and related behaviours. *Psychological Bulletin, 101*, 91-119.

Elmqvist, T., Setälä, H., Handel, S. N., van der Ploeg, S., Aronson, J., Blignaut, J. N., . . . de Groot, R. (2015). Benefits of restoring ecosystem services in urban areas. *Current Opinion in Environmental Sustainability, 14*, 101-108. https://doi.org/https://doi.org/10.1016/j.cosust.2015.05.001

EPSRC Research Consortium. (2016-2019). Achieving urban flood resilience in an uncertain future. United Kingdom: Engineering and Physical Sciences Research Council.

Everett, G., & Lamond, J. (2016). SuDS and human behaviour: Co-developing solutions to encourage sustainable behaviour. . E3S Web of Conferences, 7.

Ferrer-i-Carbonell, A.; Gowdy, J.M. 2007: Environmental degradation and happiness. *Ecological Economics 60*: 509–516.

Gao, Y., Church, S., Peel, S., & Prokopy, L. (2018). Public perception towards river and water conservation practices: Opportunities for implementing urban stormwater management practices. *Journal of Environmental Management, 223*, 478-488. https://doi.org/https://doi.org/10.1016/j.jenvman.2018.06.059

Geels, F.W., McMeekin, A., Mylan, J., & Southerton, D. (2015). A critical appraisal of Sustainable Consumption and Production research: the reformist, revolutionary and reconfiguration positions. *Global Environmental Change* 34, 1–12.

Greene, M., 2018. Socio-technical transitions and dynamics in everyday consumption practice. *Global Environmental Change* 52, 1–9.

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist, 66*(4), 290-302.

Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology, 49*(3), 141-157. https://doi.org/doi:10.1002/ijop.12034

Grimm, N. B., J, M. G., , Pickett, S. T. A., & Redman, C. L. (2000). Integrated approaches to long-term studies of urban ecological systems. *Bioscience, 50*(7), 571-584.

Harre, N. (2011). Psychology for a better world: Strategies to inspire sustainability. Auckland: University of Auckland.

Hoolohan, C., & Browne, A. (2018a). Change points: A toolkit for designing interventions that unlock unsustainable practices.

Hoolohan, C., & Browne, A. (2018b). Reimagining spaces of innovation for water efficiency and demand management: An exploration of professional practices in the English water sector. *Water Alternatives, 11*(3), 957-978.

Horbuckle, A. (2018, 8th June, 2018). The future of stormwater – solution unveiled? Paper presented at the 2018 National Local Government: Infrastructure & Asset Management, Melbourne.

Ira, S., Simcock, R., Moores, J., & Batstone, C. (2018). Activating water sensitive design in New Zeland: Understanding the costs and values. Paper presented at the New Zealand Associaton for Impact Assessment, Havelock North, Hawkes Bay.

Johnson, M. P., & Schaltegger, S. (2016). Two Decades of Sustainability Management Tools for SMEs: How Far Have We Come? *Journal of Small Business Management, 54*(2), 481-505. https://doi.org/10.1111/jsbm.12154

Kadibadiba, T., Roberts, L., & Duncan, R. (2018). Living in a city without water: A social practice theory analysis of resource disruption in Gaborone, Botswana. *Global Environmental Change, 53*, 273-285. https://doi.org/https://doi.org/10.1016/j.gloenvcha.2018.10.005

Kahneman, D. (2019a). #150 - The map of misunderstanding: A conversation with Daniel Kahneman (S. Harris, Interviewer). Retrieved from https://samharris.org/podcasts/150-map-misunderstanding/

Kahneman, D. (2019b). The power of your subconscious mind (E. Schurenberg, Interviewer). Retrieved from https://behaviouraldesignacademy.com/kahneman-fast-slow-thinking/

Kellert, S.R.; Wilson, E.O. 1993: *The biophilia hypothesis*. Island Press, Washington, DC.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: Why do people act environmentally and what are the barriers to pro-environmental behaviour? *Environmental Education Research, 8*(3), 22.

Lee, Y., Kim, S., Kim, M., & Choi, J. (2014). Antecedents and interrelationships of three types of pro-environmental behavior. *Journal of Business Research, 67*(10), 2097-2105. https://doi.org/https://doi.org/10.1016/j.jbusres.2014.04.018

McWilliam, W., Brown, R., Eagles, P., & Seasons, M. (2015). Evaluation of planning policy for protecting green infrastructure from loss and degradation due to residential encroachment. *Land Use Policy, 47*, 459-467. https://doi.org/https://doi.org/10.1016/j.landusepol.2015.05.006

Miller, E., & Buys, L. (2008, 2008/02/15). The impact of social capital on residential water-affecting behaviors in a drought-prone Australian community. *Society & Natural Resources, 21*(3), 244-257. https://doi.org/10.1080/08941920701818258

Moore, P. (2018). Smart solutions - stormwater management. Retrieved 15 April 2019, from https://localgovernmentmag.co.nz/lg-magazine/3-waters/stormwater-management/

Morris, J., Marzano, M., Dandy, N., & O'Brien, L. (2012a). Forestry, sustainable behaviours and behaviour change: Policy context. United Kingdom: Forestry Commission.

Morris, J., Marzano, M., Dandy, N., & O'Brien, L. (2012b). Summary report: Forestry, sustainable behaviours and behaviour change - setting the scene. United Kingdom: The Research Agency of the Forestry Commission. Retrieved from https://www.forestresearch.gov.uk/research/literature-review-behaviour-and-behavioural-change/

Morris, J., Marzano, M., Dandy, N., & O'Brien, L. (2012c). Theories and models: Behaviour change. United Kingdom: The Research Agency of the Forestry Commission.

Persaud, A., Alsharif, K., Monaghan, P., Akiwumi, F., Morera, M., & Ott, E. (2016). Landscaping practices, community perceptions, and social indicators for stormwater nonpoint source pollution management. *Sustainable Cities and Society, 27*, 377-385. https://doi.org/https://doi.org/10.1016/j.scs.2016.08.017

Pradhananga, A., & Davenport, M. (2017). Community attachment, beliefs and residents' civic engagement in stormwater management. *Landscape and Urban Planning, 168*, 1-8. https://doi.org/https://doi.org/10.1016/j.landurbplan.2017.10.001

Proft, K. (2018). Incentivizing property owners to reduce runoff via stormwater management district credit programs (Masters, University of Rhode Island, Rhode Island, United States).

Reckwitz, A. (2002). Toward a theory of social practices: A development in culturalist theorizing. *European Journal of Social Theory, 5*(2), 243-263.

Roberts, L., Brower, A., Kerr, G., Lambert, S., McWilliam, W., Moore, K., . . . Wratten, S. (2015). *The nature of wellbeing: how nature's ecosystem services contribute to the wellbeing of New Zealand and New Zealanders* [Report].Department of Conservation. Retrieved from www.doc.govt.nz.

Schirmer, J., & Dyer, F. (2018). A framework to diagnose factors influencing pro-environmental behaviors in water-sensitive urban design. *Proceedings of the National Academy of Sciences, 115*(33), E7690-E7699. https://doi.org/10.1073/pnas.1802293115

Searle-Bell, M. (2016). The future of stomwater management. Retrieved 20 July 2016, from https://localgovernmentmag.co.nz/lg-magazine/special-feature-lg/future-stormwater-management/

Selman, P., Carter, C., Lawrence, A., & Morgan, C. (2010). Re-connecting with a recovering river through imaginative engagement. *Ecology and Society, 15*(3).

Shove, E. (2003a). *Comfort, cleanliness and convenience: The social organization of normality*. Oxford, U.K: Bloomsbury Publishing Plc.

Shove, E. (2003b). Converging conventions of comfort, cleanliness and convenience. *Journal of Consumer Policy*, 26(4), 395-418.

Shove, E. (2003c). Users, technologies and expectations of comfort, cleanliness and convenience. Innovation: *The European Journal of Social Science Research*, 16(2), 193-206.

Shove, E. (2010). Beyond the ABC: climate change policy and theories of social change. *Environment and Planning, 42*, 1273-1285.

Shove, E., Pantzar, M., & Watson, M. (2012). *The dynamics of social practice: Everyday life* and how it changes. London: SAGE.

Shove, E., Spurling, N. (eds.), (2013). *Sustainable Practices: Social Theory and Climate Change* Vol. 95. London: Routledge.

Spaargaren, G. (2011). Theories of practices: Agency, technology, and culture: Exploring the relevance of practice theories for the governance of sustainable consumption practices in the new world-order. *Global Environmental Change, 21*(3), 813-882.

Steg, L., & Vlek, C. (2009). Encouraging pro-environmental behaviour: An integrative review and research agenda. *Journal of Environmental Psychology, 29*(3), 309-317. https://doi.org/https://doi.org/10.1016/j.jenvp.2008.10.004

Stenekes, N., Colebatch, H., Waite, D., & Ashbolt, N. (2006). Risk and governance in water recycling: Public acceptance revisited. *Science, Technology, & Human Values, 31*(2), 107-134.

Stern, P. (2000). Toward a coherent theory of environmentally significant behaviour. *Journal of Social Issues, 56*(3), 407-424.

Strengers, Y. (2011). Beyond demand management: co-managing energy and water practices with Australian households, *Policy Studies*, 32:1, 35-58.

Strengers, Y., & Maller, C. (2012). Materialising energy and water resources in everyday practices: Insights for securing supply systems. *Global Environmental Change*, 22(3), 754-763.

Strengers, Y. & Maller, C. (2015). *Social Practices, Intervention and Sustainability: Beyond Behaviour Change*. Routledge, Abingdon.

Taylor, A., Curnow, R., Fletcher, T., & Lewis, J. (2007). Education campaigns to reduce stormwater pollution in commercial areas: Do they work? *Journal of Environmental Management, 84*(3), 323-335. https://doi.org/https://doi.org/10.1016/j.jenvman.2006.06.002

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Ka´zmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and Urban Planning, 81*, 167-178.

UNEP. (2014). Green infrastructure: guide for water management. Retrieved from http://wedocs.unep.org/handle/20.500.11822/9291

USEPA. (2003) Protecting Water Quality from Urban Runoff. Retreived 15 April 2019 from: https://www.epa.gov/

USEPA. (2015). What is Green Infrastructure? Retrieved 10.1.18, from https://www.epa.gov/green-infrastructure/what-green-infrastructure

Uzzell, D. (2008). Challenging assumptions in the psychology of climate change. *InPsych: The Bulletin of the Australian Psychological Society Ltd, 30*(4), 10.

Vlek, C., & Steg, L. (2007). Human behavior and environmental sustainability: Problems, driving forces, and research topics. *Journal of Social Issues, 63*(1), 1-19. https://doi.org/doi:10.1111/j.1540-4560.2007.00493.x

Voraakhom, K. (2018). How to transform sinking cities into landscapes that fight floods. *Ideas worth spreading.* Retrieved 2019, from https://www.ted.com/talks/kotchakorn_voraakhom_how_to_transform_sinking_cities_into_landscapes_that_fight_floods?utm_source=linkedin.com&utm_medium=social&utm_campaign=tedspread

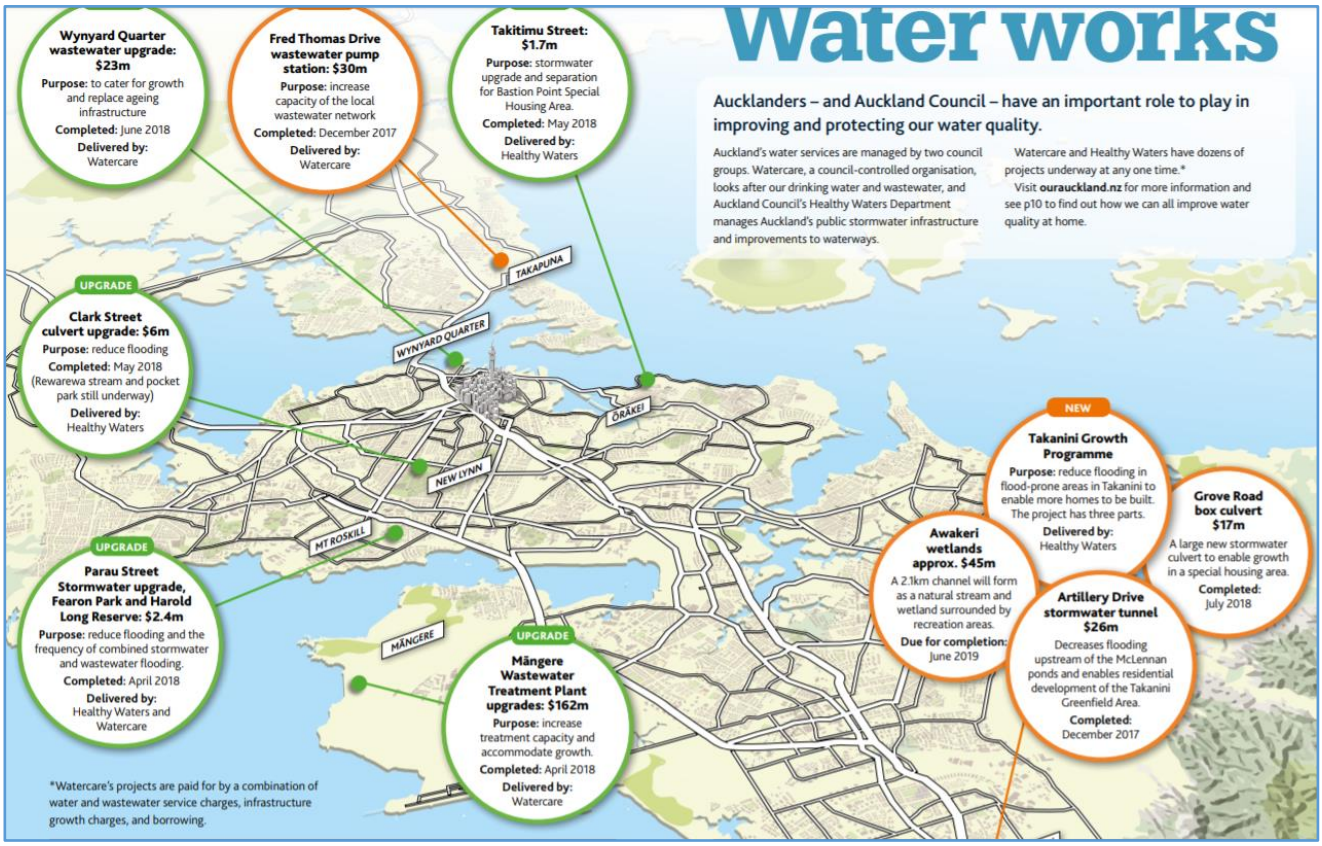
Walker, G., Shove, E., & Brown, S. (2014). How does air conditioning become 'needed'? A case study of routes, rationales and dynamics. *Energy Research & Social Science* 4, 1-9.

Ward, E. W., & Winter, K. (2016). Missing the link: Urban stormwater quality and resident behaviour. *Water S. A., 42*(4), 571-576.

Whittaker, J. (2018, 11th May 2018,). Mariner Rise – Where ecology, children and stormwater meet. *Local Government Magazine*. Retrieved from https://localgovernmentmag.co.nz/lg-magazine/3-waters/mariner-rise-whangaparaoa-peninsula/

Appendix A

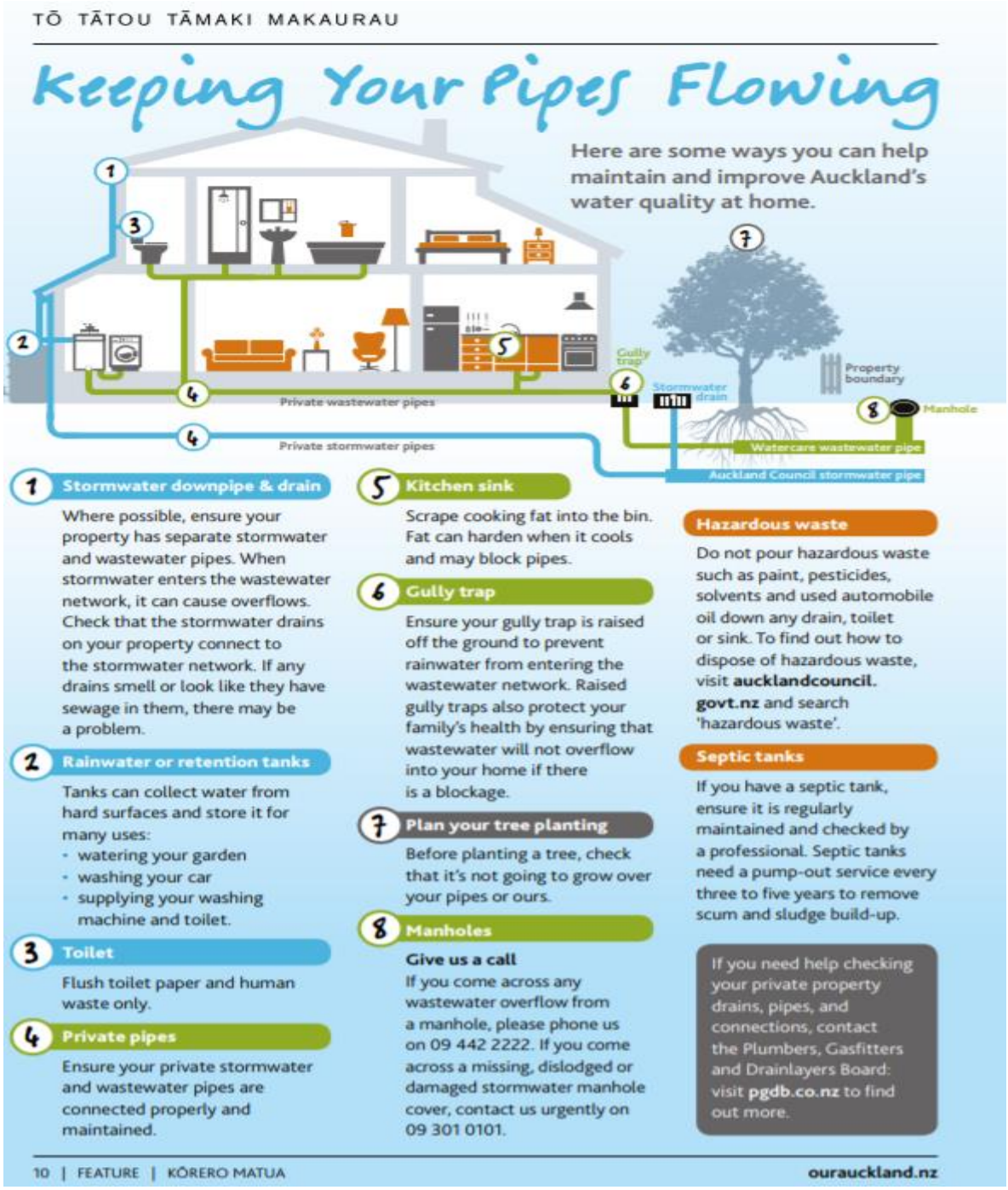
Infographic from Auckland City Council informing residents of recent wastewater and stormwater upgrades and new installations in various city suburbs



Source: Auckland City Council (2018, pp. 8-9).

Appendix B

Infographic from Auckland City Council on ways for residents to keep their residential storm and waste water infrastructure flowing



Source: Auckland City Council (2018, p. 10).

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