Sustainable Infrastructure Planning:
Using Development Charges for Stormwater Management

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ABSTRACT

This research explored the use of development charges (DCs) as a sustainable planning policy implementation tool to address integrated urban water management (IUWM) principles through the implementation of water sensitive urban design (WSUD) practices. This was accomplished by focusing on whether and how development charges can be used in Canadian slow-growth city regions to provide incentives for sustainable urban infrastructure practices through facilitating the decentralisation of stormwater management. The forms of stormwater management explored included structural landscape- and building- based strategies encompassing bioretention, infiltration, and dispersion. Potential implications were explored from the perspective of planning through semi-structured interviews, to the on-the-ground site design level within development projects through a review of the literature and case study analysis. Findings from the National Capital Region (Ottawa and environs) case study were synthesised into a series of best management practices for implementation of an IUWM DC strategy for the Manitoba Capital Region.

KEY WORDS

Canada, development charge, development finance, environmental price reform, green infrastructure, integrated urban water management, IUWM, Manitoba Capital Region, municipal finance, National Capital Region, planning, policy, stormwater management, sustainability, sustainable development, sustainable water management, urban design, urban planning, urban water, water infrastructure, WSUD.

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I would also like to formally acknowledge the support I have received through the University of Manitoba Graduate Fellowship, G. Clarence Elliott Fellowship, and the Dean David Witty Urban Design Scholarship. This support has allowed me to dedicate more time to my research which has (I hope) established a body of work synthesising academic perspectives of sustainable planning and urban design with the real-world perspectives of municipal officials related to regional planning and infrastructure financing.

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LIST OF ACRONYMS AND ABBREVIATIONS USED

DC	Development Charge
DP	Development Plan (loosely equivalent to Official Community Plan)
GI	Green Infrastructure
GIC	Government Imposed Charge (e.g., building permit processing fee)
IUWM	Integrated Urban Water Management
IWRM	Integrated Water Resources Management
LID	Low Impact Development
LIUDD	Low Impact Urban Design and Development
MCR	Manitoba Capital Region
MDG	Millennium Development Goal(s)
MMAH	Ministry of Municipal Affairs and Housing (Province of Ontario)
MOE	Ministry of Environment (Province of Ontario)
NCC	National Capital Commission
NCR	National Capital Region
OCP	Official Community Plan (loosely equivalent to Development Plan)
PMCR	Partnership of the Manitoba Capital Region
RPAC	Regional Planning Advisory Committee (precursor to PMCR)
SP	Secondary Plan
SUDS	Sustainable Urban Drainage Systems
SWITCH	Sustainable Water Management Improves Tomorrow's Cities' Health (see 'Theoretical Framework' for more on this subject)
SWM	Sustainable Water Management (encompasses IUWM)
UN	United Nations
UNDP	United Nations Development Programme
UNESCO - IHP	United Nations Educational, Scientific and Cultural Organisation - International Hydrological Programme
WSUD	Water Sensitive Urban Design; *please note use of "WSUD" in this research is holistic and includes other localised responses such as LID, LIUDD, SUDS, and WSUD unless otherwise indicated.*

1.0 INTRODUCTION

This research was concerned with if, when, and how development charges could be used as a policy instrument to apply integrated urban water management strategies in Canadian slow-growth regions. The Municipality of Ottawa was used as a case study for this research. The Manitoba Capital Region (MCR), a voluntary partnership of approximately sixteen urban and rural municipalities, was used as the focus area for implementation of this research for four reasons.

C. Kotak, July 2013. "Context Map of the Manitoba Capital Region and Municipality of Ottawa." Map produced using data provided by GeoGratis, the Manitoba Land Initiative, and Land Information Ontario.

Figure 1: Context Map of the Manitoba Capital Region and Municipality of Ottawa.

First, at the time of this research, the MCR did not have an extensive legislative framework for regional stormwater management, growth management, or development finance, leaving a relatively ‘clear slate’ to establish related protocols. Second, the MCR is a voluntary political partnership with no ability to draft formal regional legislative and/or regulatory criteria at the point of writing this thesis, and therefore member municipalities must comply with Provincially established guidelines. Third, the portion of the MCR excluding the City of Winnipeg experienced a 6.6% population growth between 2006 and 2011, proportionately higher net growth by 137% than the City of Winnipeg itself, which experienced 4.8%, or Manitoba as a whole, which experienced 5.2% (Statistics Canada 2012a; Statistics Canada 2012b; Statistics Canada 2012c; Statistics Canada 2012d; Statistics Canada 2012e; and Statistics Canada 2012f).

Finally, the geographic area of the MCR would be valuable to the implementation of a provincial and/or national water strategy to reduce human-induced eutrophication of Lake Winnipeg, the internationally recognised “Threatened Lake of the Year” for 2013 (Global Nature Fund, 2013a). Although the Red River accounts for only 16% of the annual inflow to Lake Winnipeg (Environment Canada & Manitoba Water Stewardship, 2011, p.3), 68% of the total Phosphorus and 34% of the the total Nitrogen loads in the lake from 1997-2007 were due to nutrients measured in the water of the Red River north of the City of Selkirk (“Average annual percentage contribution of rivers, atmospheric deposition and fixation to the total phosphorous and nitrogen load in Lake Winnipeg from 1994 to 2007” in *State of Lake Winnipeg: 1999 to 2007 Highlights*, 2011, Environment Canada & Manitoba Water Stewardship, p.8).

1.1 Disclosure of Related Employment

The Master of City Planning program at the University of Manitoba requires a planning-related internship term to be completed for fulfilment of degree requirements. In September 2011, I completed my formal internship with the Community Planning and Development (CPD) Division of Manitoba Local Government (renamed Manitoba Municipal Government in the fall of 2013). My duties were to examine and review provincial and municipal development charge (DC) policy and legislation across Canada and in the United States, as well as complete an inventory of current development/lot charge practices as they occur in Manitoban municipalities and planning districts. I briefly examined academic literature regarding DCs to supplement the final report. No formal literature review was written.

This research in this thesis is designed to go above and beyond the work I completed with CPD. It is not intended in any way to be a replication of my prior work. The particulars of the report I produced are property of CPD, and remain confidential. Any reference made to information within this Major Degree Project is based only upon information drawn from publicly accessible sources.

To summarise, the content of this research differs from the work I completed with CPD in the following ways:

1. Internship work was focused only on review of basic enabling components of existing Provincial and Municipal DC policy and legislation across Canada and the United States, and on what the possible implications of enabling legislation would be for Manitoban legislation. Basic enabling Provincial DC legislation is

assumed to be complete and is therefore not a concern in the production of this research.

2. No formal academic literature review was completed.
3. Internship work did not relate to sustainable design guidelines for DC program structuring, nor did it formally address implications related to sustainable design or sustainable water management options related to DCs.

1.2 Problem Statement

This research describes DCs as a planning policy tool that bridges the gap between planning for sustainable water management and financial incentives for green infrastructure. It focused on whether and how planning policy could structure development charge programs in Canadian slow-growth city regions to foster the establishment of green infrastructure for stormwater management.

1.3 Purpose and Scope

Both land use planning and residential water consumption habits have a direct impact on the landscape and its lotic (moving water, e.g., river or stream) and lentic (still water, e.g., lake) systems (Environment Canada, 2013b, ¶9). Canada, a country with 7% of the global supply of fresh water (Environment Canada, 2013b, ¶2), had a stable freshwater quality indicator rate of 41% ‘good’ or ‘excellent’ between 2007 and 2009 (Environment Canada, 2013c, ¶1). Ratings used in the scale were ‘poor,’ ‘marginal,’ ‘fair, ‘good,’ and ‘excellent’ (Environment Canada, 2013b, ¶10). Higher quality fresh water (‘good’ or ‘excellent’ ratings) was typically found in remote areas, while areas where one or more human-based land use existed (e.g., agriculture) on the land were more likely to result in 'poor' or 'marginal' readings (Environment Canada, 2013b, ¶10).

Consider this in another context: industrial and wastewater (including stormwater) treatment effluents are "the primary sources of toxic substances released to water in Canada" (Environment Canada, 2013b, ¶5). Roughly 85% of Canadians live within 300 kilometres of the international border between Canada and the United States of America (Environment Canada, 2013b, ¶7) and, in 2011, 81% of Canadians lived in 'urban' areas, defined as areas with a minimum population of 1,000 and minimum population density of 400 persons per square kilometre (Human Resources and Skills Development Canada, 2013, ¶4). As approximately 60% of Canada's fresh water drains in a northerly direction (Environment Canada, 2013b, ¶7), effluents produced by the majority of the Canadian population flow through much of the country's land base before being released into the oceans. Both urban-area and agricultural stormwater runoff streams are of particular concern: uninfiltrated surface water is a substantial carrier of previously localised pollution that can overwhelm both lotic and lentic ecosystems (Roy, Wenger, Fletcher, Walsh, Ladson, Shuster, Thurston & Brown, 2008).

Improving the sustainability of urban and peri-urban stormwater infrastructure will not be seen as a priority until there are both financial incentives for the private sector and legal responsibility for the public sector to innovate. The application of development charges, defined as cost-offsetting charges for infrastructure applied to developers by local planning authorities (Province of Manitoba, n.d. a), is explored here as a potential means of establishing this connection.

The forms of green infrastructure explored in this research address decentralised stormwater management through reduction, retention and re-use strategies at two scales: first, the building and area-based scale, including strategies that could be implemented on a single residential lot such as green roofs, rain gardens and the capture of greywater; and second, at the neighbourhood scale, including strategies that could be implemented on a series of adjacent residential lots such as bioretention and biodetention, infiltration and dispersion, and water-sensitive planting strategies.

The literature review and case study analysis contrasted practices of the National Capital Region (Ottawa and environs) with specific demonstration projects abroad to show the effectiveness of sustainability-driven development charges as part of planning policy in slow-growth city regions that have experienced considerable sprawling development. Winnipeg, Manitoba and its surrounding capital region municipalities served as the illustration for recommendations derived from research findings.

1.4 Research Methods

This research was undertaken in four stages:

First, a methodology was developed to assess the relationship between development charge and green infrastructure (GI) programs at the provincial and municipal levels in slow-growth capital regions in Canada. DC and GI programming was examined in relation to urban and peri-urban sustainable water management (SWM) planning programs, strategies, and initiatives; this stage was completed through archival research only.

Second, planning implications associated with SWM, DC, and GI at the provincial and municipal levels were assessed in a case study area: the National Capital Region (NCR). Implications were addressed from the perspective of policy planning as well as the on-the-ground site design level within development projects through a semi-structured key informant interview process.

Third, preliminary program recommendations were synthesised from the NCR case to provide a potential 'best practice' framework for implementation in the Manitoba Capital Region (MCR). Finally, program recommendations were made for a best-fit SWM DC and GI strategy in the MCR.

1.4.1 Semi-structured key informant interviews

Semi-structured interviews were used to complement literature, policy, and legislative review undertaken as part of case study analysis. This mixed approach to research provided a more comprehensive understanding of the many implicit factors involved in harmonising sustainable water management and planning policy, via development charges, in slow-growth city regions. The three major objectives of the semi-structured interviews were as follows:

- confirm literature, policy, and legislative findings as accurate;
- elicit information from participants regarding their experience of development charges (DCs) and any influences DCs may have had on area development; and
- elicit information from participants regarding their experience of DCs and any potential influences DCs may have had on the sustainability of area development.

1.4.2 Ethical considerations

A copy of the materials submitted for human ethics approval to the University of Manitoba's Joint Faculty Ethics Review Board can be found in Appendix A.

Representatives from the public and private sectors were contacted based on their public involvement with related research found while reviewing case study documentation. Participants were recruited based on their involvement with planning policy, development, and stormwater management within the NCR. Due to small staffing complements a maximum of three municipal officials and three developers from the geographic area were to be included in the interview component of the research.

The majority of case study documentation reviewed contained individuals' names, emails, and organisational telephone numbers to use for more information. These individuals, when approached to become project participants, often created situations where snowball sampling developed as an alternative method of finding participants.

Participants were provided with an overview of the research intentions, an interview or focus group guide (as applicable) as well as the informed consent form package at least two weeks in advance of the occurrence of any interview or focus group. Participants were also provided with the researcher's and research advisor's contact information should they have any questions before the interview is to take place. Interviews did not begin without confirmation of consent granted through the return of the completed informed consent form package.

A short debriefing took place after completion of the formal component of the interview with each participant to ensure that the information collected by the researcher matched the intent of the responses given by the participant. A summary of interview findings was transmitted digitally in a secured document format to each participant in the week following the interview. Participants were able to follow up with the researcher to confirm the data collected.

Deception was not used in this research. Contact with minors, individuals that cannot grant their own consent, and other high risk groups did not occur due to the nature of the subject matter of the research, as well as the targeted interviewee selection process.

1.5 Significance

This research sought to use existing institutionalised planning frameworks from slow-growth city regions in Canada to harmonise development charges, a form of development finance guided by specific legislative/regulatory provisions, and innovation in stormwater management implemented through decentralisation and increase in the ecological function of infrastructure. This research was inspired equally by the recent impacts of climate change on prairie hydrology (increased severity and frequency of flood, drought, and large-scale storm events), and massive public sector infrastructure deficits for infrastructure networks reaching the end of their useable lifespans. These factors have resulted in an increasingly critical call for more resilient — more sustainable: or, by necessity inherently interdisciplinary and cross-jurisdictional —

methods of water management for Canada's slow-growth city regions to be able to weather the forecasted changes and prosper into the future.

Fortunately there has been considerable development in the recent past regarding the next paradigm of sustainable water management abroad. Interdisciplinary projects such as SWITCH (see Section 1.7) can effect positive social, environmental, and economic change through co-operation between the public and private sectors when local planning frameworks are open to adaptation.

Opt-in projects do not accurately address the massive role economics plays in innovation, nor do they contribute effectively to watershed-scale water quality improvements (Roy et al., 2008, pp. 355). This has been addressed in the research but may be a structural flaw of local implementation, as case studies and demonstration projects tend to be public sector driven operations where financial, legislative and regulatory blockades to innovative development are diminished. The additional costs of development resulting from delayed approval and liens applied against uncertain results may discourage the private sector such that innovation is largely avoided. More importantly, slow-growth jurisdictions in Canada have not typically used development finance mechanisms to meet current planning and planning policy goals. This has resulted in uncoordinated and generally ineffective attempts at improving the sustainability of local development projects' stormwater management.

However, should planning frameworks establish a means by which innovation is subsidised, or where charges are levied at true cost, the perceived and real economic barriers to innovation may be greatly reduced. Provincial planning frameworks (policy and legislation, including building codes) provide planning authorities (districts and individual municipalities) with the structure (development plans and zoning by-laws) and mode (development finance) of controlling local development. Should these provincial frameworks take a clear supportive stance on sustainable development, it is more likely that planning authorities and planning support tools would become intrinsically more coordinated in addressing sustainable development on a regional level.

This coordination is particularly relevant when addressing sustainable water management in Manitoba. Integrated watershed management planning is undertaken at the scale of the watershed, not at the scale of a basin or a municipality. The Manitoba Capital Region (see chapter 4) contains 16 municipalities (Manitoba Local Government, n.d., a) and 5 different watersheds (Water Stewardship Division, n.d. a). With cohesive provincial policy and legislation on sustainable development, planning authorities are provincially (as well as regionally) supported and better prepared to address applications from the private sector for innovative development.

The coordination and support network provided by the province and other public sector entities should ideally encompass a wide range of technical fields. This could be done by adopting an existing third-party sustainable development evaluation framework such as Leadership in Energy and Environmental Design (LEED) - however, it has been recommended that LEED-based criteria be extended to encapsulate macro-level global environmental goals and supplemented with additional localised micro-level parameters (Novotny, 2009, pp.21-22). LEED standards for development in the United States have already been adapted to Canadian climates and endorsed by the Canada Green Building Council [CaGBC] (CaGBC, n.d.). The adoption of a third-party framework, however, leaves the public sector vulnerable to future shifts in that framework that may not correspond with provincial mandates or municipal goals.

1.6 Assumptions and Limitations

This thesis is intended to explore the connection of development charges and stormwater management in Canadian slow-growth city regions. The two slow-growth regions in this thesis, the Manitoba Capital Region and National Capital Region (Ottawa side), are discussed in Chapter Three. Both of these cases were selected due to their similar levels of residential development pressure (e.g., similar housing starts and typologies) and differing political responses to a lack of significant development pressures. Ottawa has also progressed significantly further than Winnipeg on many stormwater management initiatives. This creates opportunities for this thesis to build upon 'lessons learned' and past successes to develop a potential implementation framework for the Manitoba Capital Region. Similar development considerations, demographics and population growth, as well as the lack of geographic constraints to limit growth, and risks for overland flooding make Ottawa and environs a comparable case study for the Winnipeg city region.

Unlike fast-growth regions such as greater Toronto and Vancouver, there is an implicit fear that additional costs will 'scare developers away' from developing in slow-growth regions. This belief has held far more sway over Winnipeg politicians and policy makers than their counterparts in Ottawa over the last thirty years, and the results of this are evident today: unlike Ottawa, Winnipeg's charges for development are not enshrined in legislation or by-law. They are entirely negotiated on a private, case-by-case basis. A number of recent high-profile scandals discussed in the media have made Winnipeg residents aware of the 'backroom deals' and 'strong-arming' conducted by prominent development firms to pressure the City into providing servicing and/or amenities for costs far less than the cost of actual service provision.

Addressing concerns across the entirety of municipal/regional infrastructure networks and a comprehensive approach to water management is simply beyond the scope of this document. This research addresses stormwater-based design solutions that:

A) are possible to implement at different scales of residential development, from the construction of a single building to a new suburban neighbourhood within Canadian climactic zones;

B) generate site-specific quantitative and qualitative feedback within a relatively short time following development; and

C) require the fewest amendments to existing legislative and regulatory design and development standards (e.g., building codes, sanitation guidelines) for implementation.

This thesis forms only one of many possible policy approaches to an area of planning and design with great breadth and depth. Case Studies are individual in nature and particular results may not be generalisable towards the whole. The findings of this thesis were from a small sample size and the extrapolation of broader themes is more appropriate than interpolation of specific issues in the case study that may or may not be outliers.

Stormwater management has often fallen under the historical umbrella of wastewater management, and may, therefore, have both a different philosophical approach as well as distinct institutional and regulatory requirements. Stormwater infrastructure was selected as an appropriate form of infrastructure for this thesis because the relationship between overland flows and infrastructure designed to contain those flows is relatively simple to determine at both site-specific and regional scales. There has also been considerable innovation in stormwater-based green infrastructure over the past twenty years. Both of these factors are relevant when compared against other forms of core infrastructure, such as roads and related transportation infrastructure, and potable water supply networks.

This approach, unlike other research approaches involving DCs, does not specifically address housing affordability (for example, Nelson, Bowles, Juergensmeyer, & Nicholas (2008)). Most research on DCs does not consider sustainability and sustainable development. Most research of development charge impacts on physical development only addresses rudimentary ramifications such as the establishment of ‘zones’ of development inversely proportional to the local charges: zones with higher charges typically see less development, and areas with lower charges see more development. This thesis examines the relationship between specific installations of green infrastructure for stormwater management, but may relate to this other work in that lower fees foster development at some level. Whether this is geographically-based or form-based will be discussed later in Chapter Two.

This thesis is designed to complement existing work on development charges by addressing policy gaps. This thesis is intended to begin the conversation of establishing a connection, or rational nexus (see Section 3.3), between charges applied against developments, and the impacts those developments have on both the landscape and municipalities' infrastructure networks. This research is preliminary in nature and, in the event of consideration for related legislation, a considerable amount of additional examination would be required.

1.7 Theoretical Approach

This research sought to amalgamate theoretical approaches in urban water planning, sustainable design, and development finance by applying the approach and methodology established as Integrated Urban Water Management (IUWM), which has been used in high-profile projects such as Sustainable Water Management Improves Tomorrow's Cities' Health (SWITCH). SWITCH was a collaborative research undertaking by 15 countries in Europe, Asia, Africa and South America, with 33 member organisations that included urban planning representatives of municipalities, governmental and non-governmental research organisations such as UNESCO-IHE, consultants, and 17 universities across the globe. SWITCH ran from 2006 to 2011 and was supported by the European Commission (a branch of the European Union) at a cost of over €20 million ("SWITCH - Managing water for the city of the future," n.d. a).

The IUWM SWITCH approach was complimentary to many other contemporary research initiatives undertaken within the framework established by the United Nations (UN) to meet the Millennium Development Goals (MDP). SWITCH sought to produce a holistic framework for sustainable urban water management using demand-led research that focused on "sustainable, robust and flexible technologies" (SWITCH, 2011, p.7). This research was guided by the principles of doing more with less, and adaptability in the face of future uncertainties (SWITCH, 2011, p.7).

> A key outcome for the SWITCH project was to move a city towards an [integrated urban water management] paradigm using the model of stakeholder engagement that actively encouraged experimenting with new innovations and methodologies. Movement towards the new paradigm would happen more quickly if [stakeholder groups] made progress towards delivery of the key SWITCH objectives. The SWITCH approach of 'learning by doing and doing by learning' is an approach in which investigation and learning take place at the same time. The support of knowledge flows between key stakeholders and between the stages of a process are key factors to facilitating the uptake of sustainable practices (SWITCH, 2011, p.17).

The findings from SWITCH are respected by international researchers and the project has gained quite a high profile; major scientific events such as the World Water Forum, ICLEI World Congress, and international Water Weeks in Singapore and Stockholm have dedicated significant portions of programming to reviewing and learning from

SWITCH (SWITCH, 2011, p.19). Further academic interests in the findings established through SWITCH have led to the establishment of the International Research School for Urban Water Management by UNESCO-IHP, an academic forum for the exchange and expansion of water-related research between developed and developing countries (SWITCH, 2011, p.19).

The SWITCH project established nine broad objectives related to integrated urban water management (IUWM) / sustainable urban water management (SUWM). They are as follows, with emphasis added to highlight objectives relevant to this thesis:

1. Improve the scientific basis of IUWM/SUWM globally;
2. **Move demonstration cities' water systems towards sustainability;**
3. **Develop a strategic IUWM/SUWM approach for the future;**
4. Increase the impact and visibility of IUWM/SUWM through stakeholder awareness and initiatives;
5. **Develop city- and river basin- scale IUWM/SUWM options with an awareness of the larger contexts of hydrology and the water cycle;**
6. Provide water services with minimum impact on water and environmental resources;
7. Develop alternatives in waste and sanitation based on clean production;
8. **Integrate ecological functions into water systems at the city- and river basin- scales; and,**
9. **Develop innovative arrangements with public bodies addressing SUWM at the city- and river basin- scales with an awareness of the larger contexts of hydrology and the water cycle**
   (SWITCH, 2011, p.7).

As North American jurisdictions were excluded from the SWITCH project, the present applies SWITCH findings to potential Canadian approaches to implementation. This research is similar to other research addressing popular American (‘low impact development’), Australian (‘water sensitive urban design’), British (‘sustainable urban drainage systems’) Danish, Dutch, and Swedish philosophies to sustainable water management that are tailored to meet local climactic, social, and economic environments that are often considerably different than those found in Canadian slow-growth regions.

This research investigated SWITCH objectives 2 and 3 (through a broad focus on planning as a means of improved local and regional sustainability); 5 (articulation of stormwater management techniques); 8 (increased ecological function in stormwater management); and 9 (shifted institutional planning frameworks to incorporate incentives for IUWM/SUWM). Objectives 8 and 9 were the most relevant to this research.

1.8 Chapter Outline

Chapter One has provided the overarching framework of this research: its goals; scope; significance; assumptions; limitations; and theoretical approach. Chapter Two provides an outline of the research areas of sustainability, water planning, and public-sector finance mechanisms for infrastructure. This was done by following the approach (philosophy), method (broad principles), and strategy (specific directives) methodology. Chapter Three explored the Canadian case study of the National Capital Region to synthesise a series of emergent best practices for the establishment of a surface water management-oriented development charge framework in the Manitoba Capital Region. Chapter Four provides suggestions for 'next steps' for both real-world implementation and related academic research. Following the main document, Appendix B provides an overview of a potential implementation framework based on the findings of this thesis.

2.0 LITERATURE

The literature review supporting this research is divided into three major thematic sections: first, an overview of *sustainability* and *development control* addressing the principles of sustainability, current Canadian federal and provincial legislative frameworks, and structural sustainability achieved through integrated design; second, an examination of integrated urban water management (IUWM) including operational planning frameworks and locally responsive green infrastructure strategies; and third, a summary of development and development finance controls used in planning frameworks followed by a discussion exploring how to create linkages between these controls and IUWM.

2.1 Sustainability and Development Control

This section provides an overview of the principles of sustainability and sustainability-driven development control. First, origins of the terms *sustainable* and *sustainable development* as used in this research are explored briefly, and the related Canadian legislative frameworks are introduced. The following sub-section describes how the different segments of sustainability can be connected through the notion of water *Footprints*[1] and explores the impacts of domestic water usage on municipal and/or regional energy expenditures required to support the related infrastructure networks. The

[1] A Footprint or *Ecological Footprint,* is a representation of the number of hectares of ecologically active land and/or water required to produce and offset the ecosystem services an individual or organisation consumes (Global Footprint Network, 2012).

final sub-section discussed the concept of structural[2] sustainability, which could be achieved through integrated design processes such as those from the Hammarby Model.

2.1.1 Principles of sustainability and sustainable development

The impetus of the international sustainable development movement was the 1972 United Nations [UN] Conference on the Human Environment held in Stockholm (Stoddart & Cruikshank, 2012, p.8). This conference led to the formation of the United Nations Environment Programme (UNEP) and marked the beginning of an ever-expanding series of multilateral environmental agreements between member nations of the UN (Stoddart & Cruikshank, 2012, pp.6-8). A decade and a half later the United Nations World Commission on Environment and Development [WCED] led by the then Prime Minister of Norway published the Brundtland Report *Our Common Future* (WCED, 1987). It established the three-pillar approach to sustainability and sustainable development commonly accepted today - addressing economic, environmental, and social wellbeing of sustainability and sustainable development as it is known today (Stoddart & Cruikshank, 2012).

Our Common Future (WCED, 1987) broadly defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (p. 41). This definition is by its nature

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[2] *Structural sustainability*, i.e., physical installations in a building or landscape that function in some way to increase the sustainability of building operations or landscape processes without requiring consistent and direct input from residents or other operators. See Figure 2 for an example of structural sustainability in a landscape.

inclusive of economic, environmental, and social 'needs,' which implicitly states that concepts of social equity and environmental stewardship are critical to the success of future generations (Millennium Ecosystem Assessment, 2005). It also does not present a stance regarding environmental sustainability dependent on politically-based geographic constraints such as municipal or federal borders, or the degree of industrialisation a nations has undergone. This definition has survived the past quarter of a century due to its continued applicability to sustainable development at macro- as well as micro- scales. It is highly relevant to this thesis for two reasons: 1) the philosophy of the definition encompasses both the research frameworks used in this project; as well as 2) the practical economic, environmental, and social implications in the implementation of policy, legislation, and development control in related technical fields.

The Department of Environment was established 16 years prior to the publication of the WCED report, the year after the *Canada Water Act* (Canada Water Act. R.S.C., 1985, c.C-11) was first passed in 1970 ("Environment Canada - Water - Federal Policy and Legislation", 2006, June 13). Coinciding with the release of *Our Common Future* (1897), Canada's Department of Environment (now Environment Canada) published the *Federal Water Policy*. Five years later, in Rio de Janeiro, the United Nations adopted a call to action through *Agenda 21* (United Nations [UN], 1992). Chapter 28 of *Agenda 21* in particular outlines local authorities' "vital role in educating, mobilising and responding to the public to promote sustainable development" (Paragraph 28.1).

Since the *Agenda 21* (UN, 1992) call to action, national-level action in Canada has lagged considerably. Though it was once considered a leader in sustainability, the federal government has lost significant momentum and has achieved a considerably lower than anticipated level in policy, legislative and regulatory initiatives in driving sustainable development priorities at the sub-national level (Toner, 2000, pp. 53-54). Because of this, it is inappropriate to establish an accurate average ranking of provincial progress at the national level (Toner, 2000, p.53). It is possible, however, to more closely compare the jurisdictions relevant to this research in particular: the geographically adjacent, but politically and planning policy stance-disparate provinces of Manitoba and Ontario.

A legislative framework for sustainable development was established in Manitoba (through the *Environment Act* (*The Environment Act* C.C.S.M. c. E125) in 1987 with the passing of *The Sustainable Development Act* (*The Sustainable Development Act* C.C.S.M. c. S270), and the *Water Rights Act* (*The Water Rights Act* C.C.S.M. c. W80)). In the same year, Ontario proclaimed the *Clean Water Act* (*Clean Water* Act S.O. 2006, c. 22) and related Regulations 284/07 and 288/07 (outlining member municipalities within each sourcewater protection area designated by a Conservation Authority, and their operating procedures, respectively), and the *Drainage Act* (*Drainage Act* R.S.O. 1990, c. D17) in particular). These pieces of legislation and regulation have assisted the establishment of Provincial planning frameworks within which water management could be implemented.

Legislative management of water resources is generally distinct from the planning and development finance controls established through *The Planning Act* (*The Planning Act* C.C.S.M. c.P80) in Manitoba, and Ontario's *Planning Act* (*The Planning Act* R.S.O. 1990 c. P13) and *Development Charges Act* (*The Development Cost Charges Act* S.O. 1997 c. 27). However, both of these streams of regulatory instruments function more effectively by building a stronger (linear) transition from vision to objective to implementation, with the use of quantitative information and quality controls. This is largely due to the inefficient use of qualitative information: without a very clear framework and delineation of a specific encompassing project process, qualitative information often leaves room for legal interpretation, potentially rendering considerable debate and patchy implementation.

Although it lacked coordinated initiatives prior to the new millennium (Toner, 2000), Canada's federal government is now interested in the use of firm quantitative indicators. For example, in the fall of 2010 the Province of Manitoba signed a five year memorandum of understanding with the Government of Canada regarding the management of Lake Winnipeg (Environment Canada, 2013a, ¶2). This memorandum, driven largely by the Province, has led to the formal establishment of nutrient level targets including a reduction in Lake Winnipeg's phosphorus load by 50%, which would bring the lake to pre-1990 figures (Environment Canada, 2013a, ¶2). In 2012, the Government of Canada committed to supporting the next five year phase (2012-2017) of provincially driven restoration, deemed the "Lake Winnipeg Basin Initiative" (Environment Canada, 2013a, ¶3).

These quantitative federal targets were supported by qualitative actions from the Province of Manitoba. Prior to and in conjunction with the federal recommitment, Bill 46, the *Save Lake Winnipeg Act*, received Royal Assent and became provincial law. This act amended four pre-existing Provincial Acts including *The Planning Act* to require drinking water and waste water management planning to be undertaken by capital region municipalities, and *The Environment Act* to prohibit on-site wastewater management (e.g., septic fields) in new rural residential subdivisions (*Save Lake Winnipeg Act*, 2011).

2.1.2 Integrated segments of sustainability

National and international goals such as those established for the Lake Winnipeg Basin Initiative or the UN's Millennium Development Goals establish both quantitative (hard) and qualitative (soft) targets in an effort to develop tangible and well-rounded approaches to environmental issues. Unfortunately, "the sanitation target of the Millennium Development Goals is proving a greater challenge than expected and universal sewerage is thought to be an unattainable goal, even in the long term" (Bahri, 2012, p.19). Nevertheless, in an effort to maintain relevant quantitative baseline data UNESCO-IHE commissioned Mekonnen and Hoekstra (2011) to complete a global inventory of national-level water use on a per-capita basis. This inventory was the third of its kind commissioned (following Hoekstra & Hung, 2002 and Hoekstra & Chapagain, 2008), and provided a significantly more comprehensive exploration and calculation of the global water Footprint than its predecessors.

A water Footprint, similar in nature to a carbon Footprint, is a representation of the total per capita water use needed to maintain a certain standard of living over a certain period of time. In Mekonnen and Hoekstra's 2011 report, the Footprint was a numerical representation of the cubic metres of water impacted (consumed or polluted) by an average individual, over the course of a year (p.11). This Footprint was broken down into three component uses: blue; green; and grey. To somewhat simplify the accounting used in this approach for the purposes of this research, *blue* uses refer to direct consumption of surface- and ground- water; *green* refers to the use of stormwater, largely for agricultural purposes; and *grey* refers to the amount of additional (environmental) water that was required to offset the pollution entering the natural environment as a result of blue and green uses (Mekonnen & Hoekstra, 2011a, pp. 11-15).

For the period of 1996-2005, Mekonnen and Hoekstra (2011a) found the global per capita average water Footprint was 1385 m^3: approximately 92% was the result of agricultural production[3], 5% was a result of industrial goods and operations, and 4% was due to domestic use (Mekonnen & Hoekstra, 2011a, p.5). Canada's per capita average water Footprint was 2333 m^3, nearly 170% of the global average (Mekonnen & Hoekstra, 2011b, p.22). Canadian domestic water use accounted for 6.1% of this number, 80% (4.8%, or 112.89 m^3 of total per capita consumption) of which was grey use, and 20% (1.1%, or 29.10 m^3) blue (Mekonnen & Hoekstra, 2011b, p.22). When compared with nations such as Denmark (1635 m^3, with a domestic contribution of

[3] see World Water Assessment Programme (2012) for more on the concept of *virtual* or *embodied* water

1.5%), Germany (1426 m^3, with a domestic contribution of 1.9%), Sweden (1428 m^3, with a domestic contribution of 3.0%), and the United Kingdom (1258 m^3, with a domestic contribution of 0.6%), it is clear that Canada as an aggregate had a considerably higher total level per capita, as well as a proportionately higher level of domestic water use than many of its sister nations with existing water management programs (Mekonnen & Hoekstra, 2011b, pp.22-24).

These Footprint measurements also have inherent energy implications. Not only do higher per capita levels of water usage necessitate more distribution infrastructure, they also increase the gross capacity requirements of municipal and regional water and wastewater treatment facilities. Larger facilities and larger pipes almost always generate higher costs, both fiscally and environmentally: in Sweden, for example, up to 20% of the total energy used in a municipality is for wastewater treatment - and wastewater treatment is only a fraction of the entire regional water system (Grön, 2011, sl. 5 & 7). Municipalities have to build, operate, and maintain infrastructure to: transport and store source water for treatment; treat source water to create potable water; transport potable water to communities; transport stormwater and wastewater to treatment facilities; treat stormwater and wastewater; and transport resulting treated water for discharge.

Ageing water and wastewater distribution infrastructure can lose up to 50% of water within the network, resulting in a reduced economy of scale for the production of potable water, and potential health and safety issues related to the potential leaching of wastewater into groundwater sources (Bahri, 2012, p.58; Grön, 2011, sl. 5-7). Separate land drainage systems were designed for the express removal of stormwater and snowmelt runoff from urban areas but, by design, do not provide opportunities for infiltration or dispersion of stormwater, which are the favoured forms of stormwater management internationally (Rauch, Seggelke, Brown, & Krebs, 2005, pp. 398-399).

Alternatively, combined sewers allow comparatively clean stormwater runoff to enter the wastewater treatment system. This greatly increases the amount of water requiring treatment annually, and, therefore, increases the size of treatment plant required by another factor level (Rauch et al., 2005, pp. 397-398). Following storm events, even 'oversized' treatment plants in areas with combined sewers occasionally have to release partially treated or untreated wastewater to maintain a water level at their internal capacity: this is a particular area of concern for both urban centres discussed later in this thesis.

These factors, among others, contribute directly to water-related municipal costs and ultimately end-user fee schedules, as well as increasing energy requirements. These energy requirements are additional indicators of system efficiency, whether or not individual consumers currently strive to conserve water. By reducing such systemic inefficiencies in local water infrastructure combined with incremental shifts in end-user behaviour, significant changes in the efficiency and health of municipal water systems could reliably allow less 'oversizing' to occur at a network-wide level. Long-term visioning for structural change directed through planning policy and implementation through fiscal measures are required to move towards the principles of integrated sustainability and ensure the continued affordable provision of potable municipal water.

2.1.3 Structural sustainability through integrated design

Examples drawn from European planning practices can help develop a better understanding of the innovation of structural sustainability through integrated design. This section first discusses the Swedish co-ordinated approach and resulting model for international sustainable design-development. Second, to establish a complement with Sweden's governmental process, a case study discussion of the design-centric Hammarby Model followed. Third, a series of suggestions from the case studies intended to move Canadian slow-growth city regions towards structural sustainability were introduced.

The fundamental difference between Swedish and Canadian sustainability policy at all levels of government has been the integration applied within the approach itself: Nelson (2005) defined the three main objectives of Swedish planning as "democratic and decentralised decision-making; competing interests are balanced; [and] ecological and social needs and values are taken into account" (p. 2). Vision statements are supported by policies and objectives, which in turn generate clear, measurable targets (Organization for Economic Co-operation and Development [OECD], 2001, pp. 130-131). Of particular relevance to this research as a framework for future consideration, Sweden has also continued to structure sustainable development practices using economic instruments (OECD, 2001, p.132).

All levels of Swedish government have engaged in public education, maintained open channels for consultation, and regularly (meaningfully) engaged third-sector organisations (OECD, 2001, pp.127-134). Though Sweden has struggled with both vertical and horizontal 'silos' in government, headway has been made through the development of public-public and public-private approaches using local and international guidelines for sustainable development (e.g., Agenda 21 and UN) (Rowe & Fudge, 2003, pp. 128-130, 134, 137). Many of these approaches are used by individual municipalities: in many ways, the regulatory capabilities of Swedish municipalities are comparable to Canada's provincial governments due to the substantial delegation of power from upper levels of government (Nelson, 2005; Rowe & Fudge, 2003). Research activity about environmental, economic, and joint enviro-economic initiatives has remained high and supported due to Sweden's continued role in innovative development (OECD, 2001, p. 134). Like other Nordic countries, since the mid-1990s Sweden has been ahead of much of Europe on taxation practice as well: tax and tax-incentive reforms have shifted the basis of calculations from labour market forces to environmental impacts such as energy use and 'green accounting', which has resulted in both real environmental and economic gains (OECD, 2001, p.131, 133-134).

The egalitarian view that sustainable housing should be available for all regardless of social status, asserted in the 1960s by the Swedish Social Democrats, has also remained a core component of the state's mandate (Nelson, 2005, p.2). This vision is reflected in all stages of planning from policy and objective development, to the resulting design-planning (Rowe & Fudge, 2003, pp. 127-128). Up to half of all housing units remain publicly owned, and until recently this has allowed a continued impact in sustainable housing development to occur (OECD, 2001). However, the implementation of the *Right to Buy* housing policy that has increased the amount of private ownership, means that a policy-objective-target restructuring such as the Hammarby Model, as discussed below, needed to occur to ensure patterns of housing development were not to be significantly impacted in the future (Rowe & Fudge, 2003; p.131).

Through the nationally integrated approach, guidance of federal policy, and protection of federal legislation, municipal and regional governments can establish aggressive qualitative and quantitative criteria for the physical form of development at many different scales (Rowe & Fudge, 2003; p.129). The six goals included in the City of Stockholm's planning programme, for example, are: environmentally efficient transport; goods and buildings free of dangerous substances; suitable energy use; suitable use of land and water; waste treatment with minimal environmental impact; and, a healthy indoor environment (City of Stockholm Executive Office, 2008, pg. 5). A prime example of what can be achieved within this operational framework is the Hammarby Model, a prototype established to guide the redevelopment of a large brownfield site in central Stockholm. Now known as Hammarby Sjöstad, it has become *the* international template for sustainable neighbourhood development (Hammarby Sjöstad 2011a; Notaras, 2010).

According to Miller (2011), planning for Hammarby began as the City of Stockholm explored the site's development potential in a bid for the 2004 Olympic Games. Once the bid was dismissed, the City decided to hold the site's redevelopment which ultimately began almost ten years later (Miller, 2011). The Hammarby Model emerged through collaboration between Fortum (the local energy provider), the Stockholm Water Company, and the Stockholm Waste Management Administration

(Hammarbysjostad.se, 2011, ¶2). This model provides an excellent springboard to explore smaller, unrelated projects focusing on only a particular component of energy savings as a piece within the larger network of sustainable development. GlashusEtt (2007), Hammarby Sjöstad's environmental learning centre, explains "[t]he City of Stockholm imposed stringent environmental requirements... [that] demanded completely new environmental solutions" (p.5). Hammarby Sjöstad was seen as a chance to be very adventurous in achieving more sustainable living: the ultimate goal was to reduce the environmental load to half of what a typical Swedish town would have imposed in the 1990s (GlashusEtt, 2007; Grontmij AB, 2008). This resulted in a series of strict requirements needing cross-sectoral solutions, such as the mandate that 80% of local trips must be by foot, bicycle, or public transit (GlashusEtt, 2007, p.4-6).

Five specific water-related goals are integral to Hammarby Sjöstad: reduced consumption amounting to 100 litres per person per day; re-use of 95% of wastewater phosphorus for agricultural applications; a 50% reduction in water-borne environmentally harmful substances; local primary treatment of stormwater; and, treatment of stormwater from streets with vehicle counts of over 8,000 per day (Hammarby Sjöstad, 2011b, sidebar ¶1). As identified by GrontmijAB (2008), the independent consulting firm responsible for the assessment of Hammarby, criteria such as these allowed the complete closed-loop districts in the Hammarby Sjöstad development, as of 2008, to reduce total measurable environmental impacts (discharges into the air, soil, and water) by 32-39% (p. 3): "[t]he activities that have produced the biggest reduction in environmental impact are water, sewage and heating, the technical services…and the construction materials for the production of the buildings" (Grontmij AB, 2008, p.6).

Hammarby was chosen as the site for four innovative wastewater treatment plant pilots (GlashusEtt, 2007, p. 5): the four chemical, physical and biological techniques used in the onsite Sjöstadsverket plant were expanded upon and favourably evaluated by Pâques (2003) based on the high-achieving criteria of 95% phosphorus removal, 50% reduction in heavy metals and other harmful elements, and a (low) nitrogen content of maximum 6 mg/l (p.5). Treated wastewater from Sjöstadsverket is sent to the district heating/cooling plants where it is stripped of its excess heat energy. If there is a surplus or a deficit of heat energy for the neighbourhood, the extra is shared between the Högdalen heat and power plant and the Hammarby heat plant in the adjacent pre-developed Stockholm area (GlashusEtt, 2007, p.7). This method of securing heat from alternative sources has been "[t]he biggest reduction in the environmental impact from the buildings" in both construction and operational phases (Grontmij AB, 2008, p.5).

The biosolids and separated phosphorus resulting from the plant's extraction processes, safe to use on agricultural land, are used for agricultural processes including the production of biomass for supplementary heating needs (Hammarby Sjöstad, 2011a). The biogas resulting from the process is used to power approximately 1,000 stoves in the neighbourhood, as well as district buses and other vehicles (GlashusEtt, 2007, p.6). This approach to water treatment resulted in a 2008 reduction of 67-70% of building-based over-fertilisation in the district, leading to massive positive impacts in the

Figure 2: Wetland retention area and stormwater channel in Augustenborg, a densely developed 1950s social housing project in Malmö, Sweden. Augustenborg was renovated in 1999-2000 and retrofits redirect approximately 70% of total stormwater flows away from the local sewer system using stormwater channels (pictured above), wetland retention areas, and green roofs (Villarreal, Semadeni-Davies & Bengtsson, 2004). (Photo by author, 2008.)

eutrophication process and ecological resiliency of nearby water bodies (Grontmij AB, 2008, p.4).

Stormwater in Hammarby Sjöstad is used as an asset and is completely managed on-site (Hammarby Sjöstad 2011a; Hammarby Sjöstad 2011b). Rainwater collected from roofs and courtyards is not treated; rather it is drained into the harbour via interconnected gutters, rainwater ladders, and canals. Stormwater from high-volume streets is collected in tanks where sedimentation occurs before the remaining water is ultimately drained into the harbour via canals and channels similar to those seen in *Figure 2* from Malmö, Sweden. This stormwater strategy not only allows considerable amounts of water to be diverted from energy-heavy wastewater treatment facilities, but is also a largely passive process, reducing required energy inputs to near zero (GlashusEtt, 2007; Hammarby Sjöstad 2011b).

Half of the annual energy requirements for domestic hot water in a typical residential block of Hammarby are met by a 390m^2 solar array (Notaras, 2010; GlashusEtt, 2007, pp.6-7). Fuel cells linked to this array, the first in any commercial building in Sweden, are housed in GlashusEtt for the neighbourhood (GlashusEtt, 2007, p.7). The development goal of reducing per capita daily water consumption from 180 litres (note that this is already only approximately a third of the average North American's consumption per capita) to 100 litres has been partially met: the 2007 average determined was 150 litres (GlashusEtt, 2007, p.6).

Karlsson of GlashusEtt stated in an interview with Notaras (2010) that the integration of sustainable planning and design processes was fundamental to the applicability and success of the Hammarby Model (¶5).

> “Seventy-five percent of the environmental goals are built into the buildings,” Karlsson recounted… “In contrast with more bottom-up approaches, where environmentally conscious citizens band together to live sustainably, Hammarby doesn’t rely on the environmental awareness of its citizens….. We have a holistic approach and do not just focus on carbon alone. We have green areas for biodiversity and well-being,” Karlsson said. (Notaras, 2010, ¶7-8, 15)

Grontmij AB (2008) determined the water consumption for 23 blocks of residential units to be in the neighbourhood of 85m^3 per unit or approximately 230 litres per day (p. 4). This represents what they have calculated to be a 41-46% decrease in total consumption relative to the 1990s benchmark set when Hammarby was in the early stages of planning (Grontmij AB, 2008, pp. 2-4). This is a strong result – particularly when considered in context: the desire to develop a full(er) environmental cost accounting system in Hammarby has led to the water figures calculated by Grontmij AB (2008) including both potable water, as well as the amount of wastewater processed per person, per day (p.2).

These efforts towards a full-cost system to assess the higher-level operational sustainability of Hammarby Sjöstad have been formalised in the Environmental Impact Profile (EIP) developed by the City of Stockholm and Grontmij AB (2008). The local EIP has been structured to work within the environmental frameworks set municipally and federally. The federal framework consists of sixteen goals to be accomplished by 2020, each of which is directly attributable to at least one department of government

(Swedish Environmental Protection Agency [SEPA], 2011). The National Board of Housing, Building and Planning is responsible for the overarching goal addressed in this project, “a good built environment” (SEPA, 2011, ¶15), described as follows:

> Cities, towns and other built-up areas must provide a good, healthy living environment and contribute to a good regional and global environment. Natural and cultural assets must be protected and developed. Buildings and amenities must be located and designed in accordance with sound environmental principles and in such a way as to promote sustainable management of land, water and other resources.
> (Miljömål, n.d. p.23)

Adoption of the Hammarby Model and the integrated approach used by Sweden in general should not be seen as a panacea to water quality issues. The Baltic Sea Region, according to BalticSTERN (2013), is one of the most polluted seas on earth (p. 15). Similar to Lake Winnipeg, the water body is experiencing blue-green algal blooms of increasing intensity and duration, low oxygen levels, and concerning rates of eutrophication (BalticSTERN, 2013 pp.5-6), which has become the “predominant water quality concern worldwide” (Bahri, 2012, p.21). The Baltic, however, unlike Lake Winnipeg, is directly shared between nine different countries (including Sweden) and has, like Lake Winnipeg, primarily suffered from a lack of collective governance from member states to establish a consistent approach (BalticSTERN, 2013). Project timescale is also a consideration when coordinating multiple governments due to election cycles. Work on the HELCOM Baltic Sea Action Plan officially began in 2005 and the preliminary strategy was passed in late 2007 with goals reaching to 2021 (Helsinki Commission, 2009, ¶3-16).

BalticSTERN (2013), the research network representing the nine Baltic Sea countries, continues to work towards the largest international regional cost-benefit analysis of cost-effective solutions established to meet an environmental policy statement (pp.15-16). This illustrates why region-wide buy-in is so critical in environmental issues: without it, a comprehensive approach likely could not be maintained.

2.2 Integrated Urban Water Management

This section provides a summary of the formation and principles established within the emergent paradigm of Integrated Urban Water Management (IUWM). IUWM constitutes a 'multiple bottom line' approach and was originally conceived to bridge the gaps between social, economic, environmental, and cultural factors of urban and peri-urban water management (Gabe, Trowsdale & Vale, 2009, pp. 2000-2002); in other words, the macro-level goal of IUWM is to

> provide socially acceptable, economically viable and environmental sustainable water supply, wastewater and stormwater services in urban areas by considering interdependencies between water/wastewater/stormwater, energy, urban design and the surrounding environment (Burn, Maheepala & Sharma, 2012, p.113).

This approach supports community and economic development, as well as mitigation of negative environmental impacts due to resource consumption and the generation of pollution (Burn, Maheepala & Sharma, 2012, p. 115).

IUWM was first established as a collaborative research initiative and operationalised framework for water resource planning in urbanised areas that functions within the context of entire drainage basins (Novotny & Brown (Eds.), 2007; Novotny, V. & E.V., 2011). Core IUWM principles recognise that water resource management efforts should be made holistically with consideration for both landscape processes and human inputs: in other words, landscapes and nutrient cycles (environments and ecosystems) should be considered in addition to human needs when water systems are being planned and designed (Brown, 2005; Dietz, 2007; Mitchell, 2006; Novotny, 2008;

Novotny, 2009; and SWITCH 2011). More specifically, IUWM intends to unify urban and regional planning frameworks with sustainable water management principles through the establishment of comprehensive sustainability-oriented land use and development policy controls to guide the drafting of planning document-level controls. This policy-level connection fosters the integration of stronger water-sensitive criteria in specific implementation of WSUD/LID programs such as land development (e.g., subdivision) and design control (e.g., construction permit, district or site drainage plan) approvals within the scope of an entire watershed (Bahri, 2012; Roy et al., 2008). For more detail regarding the process and activities required for on-the-ground implementation of IUWM at a city- or region- scale, see Burn et al., (2012).

IUWM is very clear regarding the uses of different types of water as discussed in the previous section; specific purposes and constraints in the use of water resources from both fresh water (stormwater, groundwater, and surface water) and wastewater (mainly grey- and black- water, though other more detailed forms are also classified) sources (Bahri, 2012, p.6). In an effort to constrain the scope of this thesis, IUWM includes practices specifically related to the integrated design-planning principles of stormwater management approaches such as Water Sensitive Urban Design (WSUD) and Low Impact Development (LID) that are relevant to this research. The first sub-section following discusses founding ideas and decision-supporting tools from related fields generally to provide a context for urban stormwater issues, IUWM, and WSUD/LID. The second sub-section details the planning and operational framework established to provide guidance for implementation through WSUD/LID under IUWM guidance.

The final sub-section discusses the role of green infrastructure within WSUD/LID. Both ‘high’ and ‘low’ design approaches are discussed.

2.2.1 Context

“Water issues often remain disconnected from broader urban planning processes” (Bahri, 2012, p. 36). Stormwater management issues, for example, were historically motivated by public health concerns: the express expulsion of stormwater from urban areas provided protection from the spread of cholera and typhoid while reducing the immediate risks of overland flooding (Novotny, 2009; Novotny & Brown (Eds), 2007; Mitchell, 2006, p. 589; Rauch et al., 2005, p. 397). This approach of expedited drainage continued until the 1960s when impacts on the health of aquatic environments were becoming more and more noticeable, so policy makers began to debate issues of drainage quality (Braga, 2001; Heaney, Pitt, &Field, 2000, p. 1-2; and Roy et al., 2008, pp. 346-347).

International attention garnered by the World Commission on Environment and Development (WCED)’s *Brundtland Report* in 1987 led many researchers to adopt a sustainability-driven approach to stormwater management. Though this ecological focus remained segregated from typical public-sector practices in North America until the late 1990s, many jurisdictions have now developed and implemented interdisciplinary planning practices in IUWM — many modelled on the principles of LID and WSUD (Brown, 2005, pp. 456-460; Heaney, Pitt, & Field, 2000, pp. 1-2, 2-19; Heaney, Wright, & Sample, 2000; Novotny, 2008; Roy et al., 2008, pp. 344-345;).

According to Rauch et al. (2005), the comparatively high concentration of human populations, water infrastructure, and water pollution in urban regions makes their participation in water resource planning frameworks like IUWM absolutely critical. To address the complexities associated with importing resources from surrounding regions, Brown (2005) argues that IUWM takes a transdiciplinary approach to the urban water cycle by addressing "conservation, pollution prevention...ecological restoration...urban improvement...[and] reduction of drainage investments" (p.456). In WSUD/LID, Mitchell (2006) notes that each form of water infrastructure – where the term *infrastructure* is not limited to pipes and chemical/mechanical treatment plants – should be addressed holistically within the interconnected sectors of the regional water system and landscape collectively (p.589). In short, WSUD/LID both constitute a discrete site design-based means of addressing indiscrete landscape-scale problems.

As IUWM approaches respond intrinsically to local environmental, social, and economic circumstances, researchers and practitioners have developed a plethora of specialised frameworks have developed over the last twenty years (Brown, 2005; Dietz, 2007; Mitchell, 2006; and SWITCH 2011). Localised design and planning approaches include WSUD in Australia (Brown, 2005, p.461), low impact urban design and development (LIUDD) in New Zealand (Elliott & Trowsdale, 2006), sustainable urban drainage systems (SuDS) in the United Kingdom (British Geological Survey, 2013), and LID in the United States of America (Dietz, 2007, p.351). These localised IUWM practices were developed to build resiliency into the governance and operations of urban water management networks by replacing existing reactionary urban and regional water systems with proactive source controls, storage, and treatment mechanisms (Heaney, Pitt, & Field, 2000; Novotny, 2009, p.24). Ongoing WSUD efforts to decentralise the handling of stormwater decentralisation in Australia, for example, have highlighted the fragmentation of current public policy and lack of organisation/capacity in the current planning/governance structure (Sharma et al. 2012, p. 343) as well as the need for legislative reform at the IUWM level to provide a “holistic approach for providing urban water services to residential developments” (Burn et al., 2012, p. 119). In short, IUWM works at a macro scale to address water issues holistically and enables WSUD to work at a micro scale to replace ‘hard’ (non-resilient / centralised) infrastructures with ‘soft’ (resilient / decentralised) infrastructures. IUWM cannot address stormwater management without WSUD techniques, and WSUD techniques cannot be implemented effectively without the guidance of IUWM planning.

The establishment of resilient infrastructure does not necessarily entail a return to a pre-development conditions, rather it calls for a form of reconciliation ecology - a healthy synthesis of *urban environment plus sustainable water management*. Resilient systems foster the establishment and continued operation of ecological processes to protect, preserve, and repair water resources for the future (Novotny, 2008, p.5; Roy et al., 2008). As in the localised IUWM strategies mentioned previously, resilient infrastructure varies considerably by locale. There are, however, a number of common principles about soft infrastructure within the range of WSUD/LID approaches: first, they focus on decentralised means of managing water on a landscape basis (e.g. pervious on-site controls managed by stakeholders instead of impervious end-of-pipe solutions managed by local utilities); second, an inter- and intra- governmental collaborative approach of building, interior, and landscape -based strategies (e.g., water-saving fixtures, green roofs, and bioswales that work together to manage specific site loads); and third, they are cross-sectoral and addresses energy in all forms (e.g., wastewater heat recovery, as discussed in the Hammarby model previously) (Dietz, 2007; GlashusEtt, 2007; Hammarby Sjöstad 2011b; Heaney, Pitt, & Field, 2000, pp. 1-2; Novotny, V. & E.V., 2011, pp.5-9; and Roy et al., 2008).

2.2.2 Planning and operational framework

Scientific approach. The key strength and weakness of IUWM and local implementation initiatives such as WSUD is that the processes involved in establishing the operational framework have emerged to combat 'wicked' problems. This term was first used by Rittel and Webber (1973) to address socially-oriented professions such as planning, as "the classical paradigm of science and engineering – the paradigm that has underlain modern professionalism – is not applicable to the problems of open societal systems" (p. 160).

Wicked problems, unlike the rational, cause-and-effect problems encountered in conventional science- or engineering- based disciplines, do not have a definitive structure. This fundamental lack of structure makes it difficult to establish a discrete solution: as the root cause(s) of the issue at hand are not eminently known, a solution can only attempt to address the symptoms. This results in an ongoing, evolving problem-solving process that may never actually completely solve the problem itself as solutions fall within a spectrum of better to worse and, by nature, the problem itself will never truly ‘go away’ (Rittel & Webber, 1973, pp. 160-166). These problems may also be somewhat hidden in societal day-to-day routines and the status quo: consider the work of Milesi, Running, Elvidge, Dietz, Tuttle, and Nemani (2005), that determined that the most prevalent irrigated crop by land area in the United States is turf grass (p. 436).

Non-point source pollution of water sources is another good example of a wicked problem: issues arising can be mitigated through many different approaches such as source control or remediation, but the nature of society means that pollution itself will almost always exist in some capacity. When viewed holistically pollution in much of the industrialised world can also be considered to be a byproduct of a linear consumption pattern, which is another wicked problem in and of itself. Water quality issues such as waterborne pollution are best addressed at the watershed scale. This captures a sufficient field of contiguous system inputs and outputs to address the ‘wickedness’ at a scale where demonstrable results may occur. Solutions at a basin-wide scale can engage land areas large enough to require intra-governmental and even international cooperation (McCann, 2013, p.255).

The ramifications of wicked problems for the planning profession are threefold: first, the modern profession of planning emerged as a means to address the wicked problems of public health and transportation through the regulation of land uses (Fainstein, 2013); second, individual planners have ethical and professional obligations to pursue the improvement of social, environmental, and economic circumstances for the public good (Canadian Institute of Planners, n.d., "Appendix A – Code of Ethics"); and third, the profession of planning will be expected to play a stewardship role for environmental resources in the uncertain future (Witty, 2002). These circumstances are not exclusive to the profession of planning: in fact, an entire scientific field dedicated to the management of wicked problems has begun to emerge in recent years.

The conventional or 'linear' scientific approach to solving a problem involves scientists within a particular discipline analysing a distinct input which has generated a discrete output, which is then ultimately converted into a product or system of greater societal benefit (Batie, 2008, pp.1177-1180). This approach has been recognised as ineffective at addressing wicked problems for one major reason: a linear, single-disciplinary focus that is intended to yield the solution will not present a resilient solution to address an adaptive wicked problem in which the cause is not entirely known (Batie, 2008). To address this shortcoming in relation to environmental issues such as water quality, the field of sustainability science began to develop "a direct focus on wicked problems (e.g., sustainable development) and includes [sic] engagement with stakeholders..." shortly before the new millennium (Batie, 2008, p.1182).

Sustainability science defines itself based on the overarching problems it attempts to mitigate rather than the professions involved in the mitigation. For many recent initiatives, Batie (2008) argues that it is appropriate to consider sustainability science as an endeavour concerned with furthering sustainability in social and environmental capital through the strategic use of incentives (p.1182). Sustainability science uses several experimental multi-pronged problem-solving methods including stakeholder engagement in the development of policy instruments. These may, for example, drive small-scale initiatives such as pilot projects or scenario analysis in risk-averse jurisdictions for the incremental improvement of social and environmental quality (Batie, 2008, pp.1182-1185). This view of sustainability and policy is both intuitive and heuristic in nature, and distinct from the traditional scientific approach (Klauer, Manstetten, Petersen & Schiller, 2013). However, this relationship is further complicated when the political sphere is considered.

Approaches to policy formation. Different approaches to sustainability policy formation have been developed internationally, nationally, and at the state- or provincial- level over the past two decades (Happaerts, 2012; Lafferty & Meadowcroft, 2004; Lafferty & Meadowcroft, 2000a; Lafferty & Meadowcroft, 2000b). Bruyninckx, Happaerts and Van den Brande (2012) analysed sustainability policy in twelve countries and found that policy-planning approaches that address sustainability are rooted in one of four governance models: the holistic; the ecological interpretation of sustainable development; the policy principles; or the environmental integration model (p.50).

The holistic governance model, like *Our Common Future* (WCED, 1987), gives equal weight to social, environmental, and economic considerations in sustainability (Happaerts, 2012, p.555). In this model Bruyninckx, Happaerts and Van den Brande suggest that policies for sustainability are integrated horizontally throughout (restructured) government departments and operations, creating a new collective interdepartmental approach with departmental autonomy in implementation (pp. 50-51).

They note that this model can produce a robust and accountable strategic approach that weathers political and cultural shifts (p.51). This model is closest to the applied principles and development of the Hammarby Sjöstad area (see Section 2.1.3).

To implement the ecological interpretation of sustainable development as Sweden strove to do, a state could increase the rigour of sustainable initiatives beyond the holistic governance model by establishing sustainability and sustainable development as the highest policy priorities and requiring all other policy to directly support them (Bruyninckx, Happaerts & Van den Brande, 2012, pp.551-556). In this thesis, this model is closest to the approach taken for the Hammarby Model[4]. British Columbia's Dockside Green development appears to be the strongest (and largest) candidate in Canada for this model at the site level. However significant commitment by government would be required before broader implementation of the ecological interpretation of sustainable development model could be considered.

The policy principles model establishes a series of principles that form the entire basis of autonomous departmental policy direction, decision-making, and operations (Happaerts, 2012, p.555). This model is most similar to the approach taken in Manitoba in which a series of policies (*The Provincial Planning Regulation, C.C.S.M. 2005, c.39 81/2011*) guide the planning and development of land across the province. Followers of the environmental integration model choose to address sustainability and sustainable development by integrating concerns into existing policy areas such as planning,

[4] Note the Hammarby Model (as a representation of the ecological interpretation of sustainable development model) is distinct from the applied principles of the Hammarby development area (a representation of the holistic governance model) as the Hammarby Model advocates for a new form of governance *for* development through a re-imagination of energy stream management, and not just a new form *of* development that fits within the parameters of existing policies and regulations.

agriculture, and infrastructure (Happaerts, 2012, p.555). The approach undertaken in Ottawa most closely resembles this model.

The main difference, for the purposes of this thesis, between the policy principles and ecological interpretation models is that effective implementation of the policy principles model establishes a legislated inter- and intra- departmental policy hierarchy in which certain concerns are usurped by others considered to be more valuable (e.g., the development of prime agricultural land for the expansion of an urban centre) (Bruyninckx, Happaerts & Van den Brande, 2012; Happaerts, 2012). Authors concur that the largest differences between the four policy models are related to national economics and politics: countries with “sound economic performance” (Bruyninckx, Happaerts & Van den Brande, 2012, p.556), supportive political will, and policy entrepreneurs (generally either elected officials or public servants) were found to have a more concentrated attention towards sustainable development (Bomburg, 2004; Bruyninckx, Happaerts & Van den Brande, 2012).

Bruyninckx, Happaerts and Van den Brande (2012) argued that the establishment of a strong federally-directed governance system (as currently exists in Canada) creates a regulatory structure that affords opportunities to establish innovative sustainability and sustainable development policy both at the national and sub-national (i.e. provincial) levels (p.556). Lafferty and Meadowcroft (2004) argue that, in many ways, provincial authorities are best-suited to the development and implementation of sustainable development controls. Within provincial jurisdictions, sustainability policy can be operationalised through regulation: agriculture; education; energy; mining;

transportation; and, most relevant to this thesis, planning and land use controls. The extent of and means by which a provincial body establishes sustainability policy is directly linked with its political purview (see also Bruyninckx, Happaerts & Van den Brande 2012; Happaerts, 2012).

Method: IUWM and WSUD. Authors such as Rauch, Seggelke, Brown, and Krebs (2005) argue that public-sector planning *and* socially-based controls "are required for addressing contemporary drainage issues.…[and] can be grouped into intervention types base on land-use management practices, such as planning, regulative- [sic]… and financial-offset initiatives" (p. 403). In other words, has meant that both top-down (regulatory) and bottom-up (operational) integrated and transdiscplinary approaches are needed to successfully transform current water management frameworks (Rauch et al., 2005, p. 404; Urrrutiaguer, Lloyd, & Lamshed, 2010). The most effective cases of WSUD implementation in Australia and the United States have occurred when governmental regulations have been coupled with participatory processes involving other governmental and citizens' advocacy groups (Roy et al., 2008, p. 354). Note that while this thesis acknowledges the importance of non-structural controls in stormwater management, its primary concern is with the implications of built interventions such as swales, green roofs, ponds, or alternative surfacings.

Urrrutiaguer et al. (2010) noted a particular strength in separating cross-jurisdictional collaborations with grant-based funding in the Melbourne area (p. 2235). Melbourne Water, as they note, established environmental (40%) and economic (30%)

criteria as weighted criteria for stormwater management projects, while governmental and community-based capacity building constitute the remaining 30% (*Table 10: Weighting of the three categories of assessment criteria and the associated indicators*). Environmental criteria including ongoing nitrogen loading in the local bay, are being monitored to evaluate planned stormwater management projects for their effectiveness (p. 2236). While accurate forecasting of project costs remains difficult due to design uncertainty, a consistent approach towards the scope, scale, and design of stormwater management interventions is expected to increase the reliability of cost forecasting substantially (Urrrutiaguer et al., 2010, pp. 2337-8).

While IUWM as an approach to stormwater management is relatively new to land use and policy planning, similar approaches have existed in natural resource and environmental management for decades (Geldof & Stahre, 2004). Heaney (2000), for example, advocated for an approach that specifically integrated land use, development, and policy planning. He called for 1) reduction of demand through a combination of technologies that allow the re-use of greywater/stormwater; 2) on-site stormwater management by using both infiltration and detention systems to eliminate or reduce overland flows; 3) established flow- and pollutant- based stormwater charges and credits directly related to site permeability (pervious surfacing) and retention, as well as the capacity of the existing land use to generate potential pollutants, and; 4) full-cost accounting for local infrastructure, where all development pays in full for both its on-site and off-site infrastructure and related soft services (p. 2-17).

The philosophy of IUWM seeks "to overcome fragmentation in public policy formation and decision-making" (Bahri, 2012, p.5) and falls within the spectrum between the policy principles and holistic models of governance depending on local conditions. The key differences between conventional stormwater management and emergent IUWM approaches are that under an IUWM framework, (1) all streams of water (source-, storm-, and waste- waters) are seen as resources instead of burdens, and; (2) the interactions between social, environmental, economic, and political factors are recognised (Bahri, 2012; Global Water Partnership, 2013; Rauch et al., 2005).

Recognising that water in all forms is a resource and that urban planners are stewards of that resource, allows for a complete re-conceptualisation of how urban and peri-urban water management functions (Bahri, 2012; Brown, 2005). This is illustrated by Bahri's (2012) *Table 2: Comparison of urban water management and IUWM,* that lists innovative processes and water management techniques that can establish linkages between different streams of water (qualities and quantities), other disciplines (including ecology, engineering, and economics) as well as a complement of high-tech, low-tech, and natural approaches to stormwater management (pp.37, 55-56): "[t]he systems approach is not limited to the physical characteristics of the urban water cycle, but also includes institutional, financial and policy structures" (Bahri, 2012, p.38). Based on this structure, IUWM practices are defined according to the hydrological, environmental, social (political will and lifestyle choices), and economic needs of the locale in question.

IUWM functions by providing local governments (e.g., municipalities and regional bodies) with policy and legislative frameworks in which to act (Global Water

Partnership, 2013, pp. 41, 43-44). IUWM cannot be successfully implemented by cities alone and requires coordination and cooperation with upper levels of government (Bahri, 2012, p. 43). This relationship building, which functions by bringing both upstream and downstream municipalities and diverse stakeholder groups together, may need to overcome significant political roadblocks to establish and maintain regional approaches to water management (Bahri, 2012, pp. 44, 50). This can be a challenge to granting administrative and planning controls to lower levels of government (Bahri, 2012, p. 46) when impediments to the widespread implementation of IUWM and WSUD practice are “social and institutional rather than technical” (Sharma, Cook, Tjandraatmadja & Gregory, 2012, p. 342).

Bahri (2012) views fostering ecological function in urban and peri-urban environments as a means of both improving resiliency to droughts and flooding and improving economic bottom line (Bahri, 2012, pp. 30-34). Under an IUWM approach government-imposed charges are structured to “reflect the true costs” for water use, treatment, distribution, and infrastructure (Bahri, 2012, p.6). She notes that ecosystem services approaches, within which individuals’ or organisations’ land use impacts are tied to proportionate financial contributions, have become increasingly popular as means of encouraging up-stream users’ equitable use of resources (p.67). IUWM-based incentives are generally used in concert with directed legislation/regulation and full-cost accounting to foster private-sector participation and innovation (pp.46-47).

The core goal of regionally emergent approaches such as WSUD, LID, LIUDD, and SuDS has always been a minimisation of impermeable surfacing to maximise stormwater infiltration (Roy et al., 2008, p.345). While this is a simplification of these four similar-but-distinct practices of sustainable water management, this viewpoint is sufficient for considerations discussed in this thesis. The important consideration of regionally emergent approaches such as WSUD, LID, LIUDD, and SuDs is the consistency of application of IUWM methods when using site-based stormwater management techniques — which, as discussed later in this section, include on-site retention and reuse (e.g., rainwater harvesting) as well as naturalised treatment systems (e.g., constructed wetlands) (Global Water Partnership, 2013; Bahri, 2012; SWITCH, 2011; Roy et al., 2008; Elliott & Trowsdale, 2006; Brown, 2005).

WSUD approaches use both planning and design tools to manage water holistically in the landscape by "integrating the built form (including our urban landscapes) and the urban water cycle" (Donofrio, Kuhn, McWalter, & Winsor, 2009, p. 180). The key critical control points for WSUD are: principles for site design (e.g., requirements at the designation and zoning stages of planning processes); source control guidelines (e.g., requirements enforced at the zoning and subdivision approval stages of planning and design processes), and; specific controls for on-site management/treatment (i.e., design guidelines for the building and/or site development approval stages of the *design* process) (Carmon & Shamir, 2010, pp. 184-186; Donofrino et al., 2009, pp. 182-183).

Decentralised stormwater management strategies such as WSUD form a significant strategic support for the implementation of IUWM-level concepts. If strategic WSUD programs are implemented within the scope of an intra- or interwatershed-wide IUWM framework, they may provide a more effective means of addressing both site-specific and watershed-wide stormwater management in relation to both lotic and lentic health (Roy et al., 2008). Carmon and Shamir (2010) advocate for legislative/regulatory and economic reform to foster water sensitive planning principles and support the transition into a new paradigm of water management (p. 187). The creation of a mutually supportive IUWM/WSUD strategic framework may also directly support improved health in downstream ecosystems (Roy et al., 2008, p.357).

> The planning of [WSUD] developments differs from conventional systems by taking a total urban water cycle perspective in planning services…which may include the adoption of decentralised technologies. [WSUD] developments also consider the environmental impacts of urban water services on the larger ecosystem and catchment. …. [WSUD] developments can include structural and non-structural measures for source control of stormwater and other measures to minimise the impact of urban development on ecological and hydrological processes. (Sharma et al., 2012, p.341.)

WSUD functions through the use of three major strategies: source control; retention and detention, including at least primary treatment, and; infiltration (Novotny, 2009, p.24; Roy et al, 2008, p. 345). These methods of managing stormwater quantifiably reduce overland runoff and bolster local flood resiliency by increasing both the permeability and storage capacity of sites, and by cleaning runoff by using natural and mechanical infiltration processes (Brown, 2008; Roy et al., 2008). Authors such as Novotny (2008) have argued that the best practice mimicry of natural processes through "ecological engineering" (such as biotic rain gardens instead of abiotic sewer pipes) improve system function while generating amenity value and removing pollutants. In a later publication, Novotny (2009) goes farther to state that the next generation of best management practices (BMPs) in stormwater management - naturalised swales, permeable surfacing, green roofs, and wetland and rain garden networks - "can become the drainage system itself" (p. 25).

Eventually, Novotny (2009) argues, regular surface-based stormwater management infrastructure could replace local storm sewers; larger clusters of decentralised infrastructure may even render regional infrastructure obsolete (p. 26). Roy et al. (2008) concur and anticipate massive cost savings, though they also stress the need for additional research on factors such as weather, climate, and other changing conditions (p. 348). Roy et al. (2008) define seven characteristics slowing the implementation of WSUD principles at a watershed-scale in America and Australia:

(1) ongoing uncertainties regarding cost and performance;
(2) a lack of funding or market-based incentive programs;
(3) low levels of leadership;
(4) fragmented responsibilities;
(5) lack of legislative mandate;
(6) ineffective implementation related to reduced institutional capacity, and;
(7) conflicting design/engineering guidelines (pp. 347-350).

Roy et al. (2008) present a three-fold approach to address these issues: 1) education of professional and public stakeholder groups with engagement tools ranging from seminars and public open houses to demonstration projects; 2) research regarding real-world costs and potential incentives; 3) a commitment to establish clear policy-level guiding principles to address institutional, legislative, and design-based shortcomings throughout both the public and private sectors. Risk-sharing (including financial risk), community engagement, regulatory management and maintenance, and ongoing monitoring were also highlighted by Sharma et al. (2012) as important factors for robust implementation. They suggest that public authorities may need to subsidise decentralised systems on a trial basis to share the risk in their development, as well as ensure that systems function as desired: "in some [WSUD] case study developments it was highlighted that WSUD elements reduced demand for centralised services, but there was no discount given for [local development charges]" (p. 349).

Sharma et al. (2012) also highlighted governance, financial, performance, and social acceptability as barriers to implementation of WSUD (p. 345). Sharma et al. (2013) and Roy et al. (2008) have indicated potential for cost savings in conditions where WSUD interventions replace traditional hard infrastructure alternatives, however, Roy et al. (2008) also note that existing legislative and/or policy guidelines have often forced the construction of both green (see the following Section) and hard infrastructure systems at increased costs due to a knowledge gap between engineering and site design guidelines for stormwater management (p. 348). Sharma et al (2013) clarify that cost savings are more likely to occur in relation to deferred network expansion and/or reduced capacity and treatment needs (p. 2099).

2.2.3 Green infrastructure

Broadly speaking, the term green infrastructure (GI) refers to any built or naturally occurring landscape intervention that intercepts stormwater before it enters conventional infrastructure (Benedict & McMahon, 2001). However, the specifics of systems vary based on the scope of different projects (Naumann, Davis, Kaphengst, Pieterse, & Rayment, 2011, p. 14). GI installations do not always need to be connected to a piped infrastructure network (Sharma et al., 2013). For the purposes of this thesis, GI installations, including ponds, wetlands, green roofs, cisterns, and combined storm/greywater interventions address the stormwater (bio)retention and (bio)detention functions of WSUD. Infiltration solutions including permeable surfacing, modified (permeable) tree planters, rain gardens, and alternative roadway designs address the increased permeability of sites; dispersion solutions like bioswales act as a means of on-site dispersal of stormwater in intense rainfall and/or melt events, and finally; xeriscaping/lawn reduction and use of native plant species reduce or eliminate irrigation requirements.

GI installations are typically at one of three different scales: on-site, or within a single property (e.g., a rain garden in the yard of a single-family home or a green roof on a multi-family apartment building); cluster or development scale (e.g., a small pond and series of connected bioswales serving a single cul-de-sac); or a distributed system (e.g., a large-scale retention pond and connected systems - which may or may not be fed by multiple cluster systems - that functions at a small neighbourhood scale) (Sharma et al., 2013, p. 2093). The larger the installation, the more likely it is to be managed by the local infrastructure authority (i.e., municipality), which may provide residents with a higher level of comfort regarding the ongoing maintenance and beautification of stormwater GI installations as landscape amenities (Sharma et al., 2013).

GI emphasises networks and connectivity between natural and built systems. GI in urban areas may be built systems (e.g., green roofs, rain gardens, or permeable surfacing), as well as protected, undeveloped, or restored natural areas such as woodlands, wetlands, marshes, or prairie remnants (Novotny & Brown (Eds.), 2007; SWITCH, 2011). These systems fall into either source or treatment control categories. Interventions such as green roofs and rainwater cisterns fall into the source control category while the remainder of the built systems this research is concerned with (e.g., bioswales, tree planters, and bioretention ponds or treatment wetlands) are classified within the treatment category (Donofrio et al., 2009, p.182).

Peak performance biofilters such as those that may be constructed within streetscapes or greenspaces (e.g. bioswales, rain gardens, and tree planters), as well as less accessible features such as artificial wetlands and intensive green roofs (as media required a minimum depth of only 20 cm), for example, were found to be highly effective at addressing nitrogen, phosphorus, and suspended solids in stormwater (Hurley & Forman, 2011): laboratory trials found removal rates of up to 70%, up to 85%, and over 95% respectively (Bratieres, Fletcher, Deletic, & Zinger 2008, pp.3930, 3939). Trials conducted by Bratieres et. al. (2008) found peak nitrogen and phosphorus removal depended on three considerations: careful selection of plant species with high surface-area root networks; use of mature plants and sandy loam soil medium, and; avoidance of organic matter or chemical fertiliser supplements (pp.3933-9). Studies also found that surface area has a strong positive correlation with the removal of both total nitrogen and phosphorus: in Melbourne, for example, which has an average annual rainfall of just over 650 mm (note: ~100mm more than the Manitoba Capital Region) bioswales or other biofilters such as those seen in Figures 3 and 4 would only need a surface area equivalent to only 2% of the total land area (Bratieres et al., 2008, pp. 3931, 3935, & 3939; Environment Canada, 2013d).

Figure 3: Incomplete naturalised retention pond in the Sage Creek neighbourhood development in Winnipeg, Manitoba. (Photo by author, 2009.)

Figure 4: Mature naturalised retention pond in the Royal wood neighbourhood development in Winnipeg, Manitoba. (Photo by author, 2009.)

Hurley and Forman (2011) found that in the Boston area, where the local lakes were experiencing algal blooms and eutrophication, designing bioretention facilities to capture as much stormwater as possible was more important than increasing the amount of land area used for retention structures[5] (pp. 858-9). Findings indicated it was possible to consistently remove a minimum of 65% of phosphorus from stormwater on an industrial site if all of the stormwater was treated with a biofilter system covering 5% of the site's total area (Hurley & Forman, 2011, pp. 860-1). Considering Manitoba's development control legislation, The Planning Act (C.C.S.M. 2006 c.P80), outlines land contributions, among others, of up to 10% for public reserve purposes in addition to land for 'municipal services,' "required for sourcewater protection," or any land subject to the conditions of a development agreement (§135 s.6 & 7), a 5% target is attainable.

In the last decade a considerable amount of research regarding roof runoff reduction potential through the use of plantings has also been conducted.[6] From reviewing German and Belgian case study research, Mentens, Raes, and Hermy (2005) found that between 45-75% of annual runoff landing on the roof can be absorbed: from a stormwater perspective alone the authors equated this to approximately a 2.7% reduction in total runoff (p. 224). These findings are not isolated to European environments. When also considered broadly for improved building insulation, reduced urban heat island effect, social/amenity value, and the potential reduction of space

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[5] For a recent review of the shifting ecological roles of (bioretention) ponds, see Tixier, Lafont, Grapentine, Rochfort, and Marsalek (2011).

[6] See VanWoert, Rowe, Andresen, Rugh, Fernandez, and Xiao (2005) for a detailed evaluation of physical characteristics.

required for stormwater infrastructure at grade, green roofs may become an increasingly accepted option as metropolitan regions continue to lose at-grade opportunities for stormwater management (VanWoert, et al., 2005, p.1036).

Controls determining the size, scope, and form of public infrastructure are established through federal/provincial legislation and regulations; federal codes and standards (e.g., national building codes); provincial codes and standards (e.g., effluent standards for stormwater and wastewater disposals); and, regional and/or municipal guidelines and specifications (e.g., planning/capacity standards by-laws). Infrastructure for stormwater management, unlike many other forms of infrastructure (e.g., all-weather roadways; water and wastewater treatment facilities) is a strong candidate for innovation as it has largely municipally-imposed design and management controls. The flexibility of these control criteria allow more discretion on the parts of the professionals designing the infrastructure itself, and any municipalities or regions that may impose additional standards or guidelines (Engineers Canada, 2012, pp.10-12).

Evaluation of Infrastructure. The first ever national-level report card evaluating Canadian water and road infrastructure was based on data from 123 participating municipalities in the 2009-10 period (Federation of Canadian Municipalities [FCM], Canadian Society for Civil Engineering [CSCE], Canadian Public Works Association [CPWA], & Canadian Construction Association [CCA], 2012). Using the ranking system of “very good,” (adequate for current needs and in good repair) “good,” (meets current needs but may require significant repair) “fair,” (requires attention) "poor," (below standard, and/or at the end of usable life) and "very poor," (unacceptable and/or imminently failing) municipal respondents rated 30% of all water and road infrastructure between fair and very poor (p.2). The current replacement cost of just the bottom 30%, applied nationally based on this representative sample, is $171.8B (p.2).

Wastewater infrastructure (plants, pumping stations, and storage facilities) generally fell into fair to very poor categories (40%), while 30% of linear wastewater infrastructure (pipe networks, including combined sewer servicing) fell into fair to very poor categories (FCM, CSCE, CPWA, & CCA, 2012, p.2). Implementation of recent, stricter federal regulations will likely result in lower grades being assigned to facilities falling within very good and good conditions as well (FCM, CSCE, CPWA, & CCA, 2012, p.2). Stormwater infrastructure was rated highest of all infrastructure types studied, with only 13% of facilities (pumping stations, reservoirs, et cetera), and 24% of dedicated stormwater pipe networks below a rating of good (FCM, CSCE, CPWA, & CCA, 2012, p.2).

There are weaknesses in the quality of data presented in these measurements, however. Stormwater infrastructure was the smallest category of infrastructure in this study (FCM, CSCE, CPWA, & CCA, 2012, p.1): only half of respondents declared any form of asset management or quality assurance practice in the evaluation of stormwater infrastructure, while dedicated infrastructure review practices for drinking water and roads were present in 90% and 86% of respondent municipalities respectively (p.19). Only 68 of 123 respondents (55%) provided data on local stormwater infrastructure: 55% of those respondents did not have any data on their stormwater facilities and 54%

did not have any data on their non-linear infrastructure (e.g., ponds), while 49.5% did not have a system for managing and/or collecting data on local infrastructure at all (p.14, 40). Over half of respondents had no regular inspection interval for linear infrastructure, 28% had over a decade-long interval, and less than 6% stated linear stormwater infrastructure was inspected at an interval of less than five years (p.40).

This is not restricted to stormwater infrastructure alone: over 40% of municipal respondents declared no data on any linear infrastructure whatsoever, and, though federally mandated, low levels of water treatment facility data were present in 30% of respondent municipalities (FCM, CSCE, CPWA, & CCA, 2012, p.3). Of the stormwater infrastructure evaluated in the report, an average of 33% of assessments were based on "complete and reliable data" (FCM, CSCE, CPWA, & CCA, 2012, *Figure 30 – Source of physical condition information*) while an average of 49% of assessments were based on the "opinion of qualified individuals" (FCM, CSCE, CPWA, & CCA, 2012, *Figure 30 – Source of physical condition information*).

When considered more broadly against the average lifespan of stormwater infrastructure components – 80-100 years for pipes and 30-50 years for pond facilities (FCM, CSCE, CPWA, & CCA, 2012, *Figure 1 – Typical service lives of infrastructure components.*) – and the onset of dedicated linear infrastructure (storm sewers) in the 1960s (Braga, 2001; Brown, 2005), the comparatively higher scores allotted to stormwater infrastructure by municipal respondents may not necessarily be indicative of a stronger system, but instead a newer system. Consider southwest Winnipeg for example, which experienced a surge in the use of retention ponds by the 1980s. If a

30-50 year timescale (FCM, CSCE, CPWA, & CCA, 2012, *Figure 1 – Typical service lives of infrastructure components.*) is accurate, end of lifespan concerns for the infrastructure, such as overland flooding and storm sewer backups caused by excess sedimentation in retention ponds, should only be beginning to emerge in the present day.

Strategy: Stormwater management via green infrastructure. Authors such as Roy et al. (2008, p. 345) and Dietz and Clausen (2008, pp. 560-561) corroborate the argument that there is almost always a strong positive correlation between the imperviousness of an area of land and resulting damage to local water systems. Marsalek and Schreier (2009) conclude that a holistic, multi-pronged approach of runoff prevention through retention, infiltration, and detention strategies "is the best strategy for adaptation to the increasing storm events and the increasing pollution from increased traffic and urban activities" (p. ix). While Dietz and Clausen (2008) explain it is difficult to determine a discrete value where imperviousness begins to have a severe impact on a watershed, in principle the correlation is strong enough that imperviousness may provide a good exponential indicator of the levels of nutrient transmission (indicating the potential damage to downstream lentic health) as well as anticipated stormwater runoff (pp. 561-565). These findings were further corroborated in 2011, for example, when Pyke et al. (2011) found that three variables were key in determining land use impacts to stormwater runoff: in decreasing order of importance, these were "amount of impervious cover, precipitation volume, and event intensity" (p. 170-162).

Dietz and Clausen (2008) and Pyke et al. (2011) suggest that developments integrating LID (WSUD in this thesis) principles can evade the exponential pollutant increases related to runoff and combined sewer overflow events: "annual stormwater runoff volume in the LID [WSUD] subdivision did not change as watershed impervious coverage increased…pollutant export from the LID [WSUD] subdivision was more consistent with export from forested watersheds" (Dietz & Clausen, 2008, pp. 564-565).

Dietz and Clausen (2008) studied two of the three core WSUD program areas outlined previously in this thesis: bioretention or detention, and infiltration. The case – a residential subdivision developed with 21% impermeable surface area – involved the use of rain gardens, reduced and permeable pavings, bioswales, bioretention, and reduced lawn areas with corresponding increases of 'natural' areas (Dietz & Clausen, 2008, p. 561). In contrast to Dietz and Clausen's (2008) real-word study, Pyke et al. (2011) produced a simulation that modelled and evaluated both stormwater quantity and quality changes for three development proposals for a single site: 'undeveloped' (open grasses, or 0% impervious by land area), 'low-density suburban' (car-centric) development (25% impervious by land area), and a higher-density 'transit-oriented' mixed-use development with ecological reserves (16% impervious by land area) (p. 168). The higher-density residential/mixed-use area was found to have the best overall results; as residential density increased, the stormwater pollutants, per capita, decreased from 60 kg/yr to 12 kg/yr - a factor of *five* times (Pyke et al., 2011, p. 172). Three of the 'suburban' sites would have to be developed to accommodate the population housed in one ‘transit-oriented’ site, which could triple area stormwater pollutants (Pyke et al., 2011, p.172).

While green infrastructure concepts may demonstrate positive momentum towards broader IUWM goals of overland flow and pollution reduction, Gabe, Trowsdale and Vale (2009) argue that it is absolutely critical for any financial incentives to be tied to actual performance via a series of indicators based on macro-level program goals (p. 2001). Without this level of evaluation and connection to financial incentives, there are no means of attributing local stormwater quality improvements to GI.

According to Roy et al. (2008), seven major roadblocks are hindering widespread implementation of WSUD, and these fall into three major categories: leadership (i.e., legislated and political directives); financial supports, and; design specifications. They argue that the right combination of financial incentives for managing stormwater using WSUD techniques (i.e., bioretention/detention, infiltration/dispersion) and supporting public sector investment could theoretically generate significant change within watersheds (pp.349-350). Stormwater rebates in particular were reviewed favourably in principle, but reviewed fees were not connected to the actual amount of runoff generated by the sites and “too low to encourage implementation of WSUD” (Roy et al., 2008, p. 350).

2.3 Development and Finance Controls

"Economic aspects play a major role in urban water management" (Rauch, et al., 2005, p.397). Development and infrastructure financing are particularly relevant to IUWM for a number of reasons. Bahri (2012) argues that the lateral integration of water management with planning, infrastructure, housing, and other public sector divisions of mandate create opportunities for two forms of price correction. First, IUWM emphasises the need for full-cost accounting, which results in true cost service provision and establishes a price signal for users to evaluate their water consumption within their service networks. Second, IUWM advocates for broader sustainability-driven water pricing through interconnected taxation, subsidisation, and tariff systems to promote both waterbody and broader environmental protection, restoration, and judicious use of resources; as well as offset further environmental damage to water systems resulting from pollution through targeted polluter-pay based charges (Bahri, 2012).

This section provides a summary of relevant development and finance controls available to Canadian planning bodies. The first sub-section clarifies the context of development and finance control operations: the relationship between urban form and infrastructure development. The second sub-section discusses some of the mechanisms currently used in public-sector infrastructure financing and funding. It also provides a brief overview of development charges including: legislative and regulatory requirements; program structure; implementation; and, administration. The final sub-section establishes links between development charge programs and sustainable planning initiatives such as IUWM.

2.3.1 Context

When addressing sustainable development and infrastructure finance collectively, the relevance of urban sprawl to stormwater management becomes apparent. The infrastructure constructed to support the auto-centric forms of development common to North America since the mid-twentieth century have resulted in large amounts of previously pervious land being paved, dramatically reducing stormwater infiltration and fostering the production of oversized wastewater treatment systems (Heaney, 2000, pp. 2-25 – 2-59). The roots of this research are drawn from the planning and design professions' continuing explorations of sprawl, sprawling development, and sprawl mitigation. Ewing, Pendall, & Chen (2002) found many of today's definitions of *sprawl* describe four physical characteristics: low physical density; a lack of neighbourhood centres; firm segregation of land uses, and auto-centric, non-pedestrian development patterns. Sprawl, in their research, was considered to be a landscape process equivalent to the majority of North American suburban development occurring since the mid twentieth century "in which the spread of development across the landscape far outpaces population growth" (p. 3). Burchell, Downs, McCann, and Mukherji (2005) frame the underlying cause of the sprawling development dilemma as such:

> [w]hile sprawl is typically believed to be a result of market forces expressing consumer preferences, in fact a web of local zoning ordinances, state policies, and federal laws and programs has [sic] encouraged sprawl to such a degree that it is often difficult to build anything else (p. 15).

Publicly managed infrastructure networks are routinely expanded into previously un- or less- developed areas and processing capacities are increased in order to provide services to greenfield developments. The increased operating costs of servicing and network maintenance, generally understood to be significantly more than the one-time construction costs, are borne by the tax base as a whole throughout the usable life of the network. Sprawling development, whether considered in urban or rural contexts, raises the same overarching planning concern: when these forms of development occur, it is probable that there will be either an increase in sustainability *or* short-term affordability, but not both.

Planning and design initiatives addressing sprawl in Canada include New Urbanism and New Pedestrianism approaches, which combine physical design characteristics such as street-front densification and the reassertion of the pedestrian scale in developments, SmartCode or form-based zoning, and transect development (see Duany, Speck, & Lydon's (2009) *The Smart Growth Manual* for a succinct overview) – to specific development typologies such as compact neighbourhoods or transit-oriented developments, to broader planning policies such as Smart Growth. *Smart Growth*, as an approach to taming sprawling development, has two overall features described by Nelson: a focus on non-greenfield development, and diversification into more accessible modes of transit (paraphrased in Blais, 2010, p. 23).

New Urbanism, New Pedestrianism, and to a lesser extent Smart Growth, are not discussed in detail as the focus of this thesis underpins these urban design methodologies. The major sprawl-related issue that this thesis addresses is the overextension of municipal and regional infrastructure networks. In order to understand just how overextended these networks are requires calculating the long-term costs (both internal and external) associated with sprawl – a tremendously difficult process.

Existing extensive mis-pricing through under-pricing and subsidisation of land and infrastructure services for new development, combined with density-reducing land-use policies, have helped create and perpetuate the massive environmental, social, and economic problem of sprawl (Blais, 2010; Blais 2011; Curran, 2008). While changing the processes that inform land use policies can take many years, changing the cost of development by correcting the subsidisation of new infrastructure can be done in the significantly shorter term. Tomalty and Skaburskis (2003) argue that the ability to establish reduced high-density development charges, and therefore provide incentives for denser forms of development, is compromised by the levying of charges that are far too low against conventional low-density development (p. 156).

2.3.2 Planning-driven financial controls

Municipal and regional funding arrangements vary across Canada, but for the purposes of this research revenues are assumed to come from three broad categories: (1) grants from upper levels of government; (2) municipal taxes (e.g., property and sales taxes), and (3) user fees and charges (e.g., development charges, land dedications, and utility bills) (Canada Mortgage and Housing Corporation [CMHC], 2009). This thesis is concerned with the latter category.

Existing upper-level funding arrangements. Canadian financial supports for infrastructure are split between the three levels of government. Financial contributions for priority projects have generally been split into thirds between each level of government (Canada-Manitoba Infrastructure Secretariat, 2010A): in order for a municipality or a region to access federal-level funding, a financial commitment from, or collaboration with, the provincial government for the specific project in question is often required (Government of Canada, 2013). In the province of Manitoba for example, development within a region is constrained by existing infrastructure through *The Provincial Planning Regulation* (the Provincial Land Use Policies or PLUPs) (Reg. 81/2011 C.C.S.M. c.P80) under *The Planning Act* (C.C.S.M. c. P80). If a municipality lacks capacity for additional wastewater treatment within its boundaries, for example, it will not receive approval for plans for further development from the Province. Aside from regional service-sharing or construction of un-serviced development as discussed in the *Provincial Planning Regulation*, thereis no pragmatic or sustainable means of supporting ongoing development without expanding existing treatment services (Reg. 81/2011).

The $1B Green Infrastructure Fund (GIF), established by Infrastructure Canada for 2009-2014 to support projects that “promote cleaner air, reduced greenhouse gas emissions and cleaner water” (Infrastructure Canada, 2012a, ¶2) was fully committed by July 2011 (Infrastructure Canada, 2012a, ¶4). There was no specific consideration in the GIF to address stormwater management, which instead focused on ‘hard’ (conventional) infrastructure specifically for waste and wastewater (often combined sewage and stormwater) treatment, as well as carbon and energy storage and transmission (Infrastructure Canada, 2012a, ¶2; Canada-Manitoba Infrastructure Secretariat, 2010b).

According to Infrastructure Canada (2012b), since 2007, public sector GIF-leveraged contributions in Ontario have contributed over $2.3B for 270 green infrastructure (including wastewater) projects, which represented 17% of the total infrastructure funding of $13.8B (¶2). The majority of funds (60%, or ~$8.4B) were used for public transportation and transportation infrastructure projects, while 5% ($660M) was dedicated to projects addressing drinking water infrastructure (¶2). The Communities Component arm of the Building Canada Fund, a national –level program funded by the federal gas tax, has been developed to work with the GIF to improve effluent quality in and around the Great Lakes and St. Lawrence through wastewater treatment facility improvements (¶29-30).

The GIF, together with the Building Canada Fund and Infrastructure Stimulus Fund, have provided a total of $629M in infrastructure funding to Manitoba since 2007 (Infrastructure Canada 2012c, ¶2). Green infrastructure (including wastewater) projects represented 15% of the total funding at $94M and transportation 46%, or $285M, and drinking water infrastructure 15% or $91M (¶11). Since 2005 an additional $665M of half federal, half provincial funds were dedicated to expansion and upgrading of the Red

River Floodway: this upgrade raised protection for the City of Winnipeg and much of the Manitoba Capital Region from a 1-in-90 year to a 1-in-700 year level (¶22-23).

Existing municipal funding arrangements. CMHC (2009) found that in 2006 government-imposed charges (GICs) made up 10.7% or $25,783 of the purchase price ($240,000) of average single-detached dwellings in Winnipeg, and 15.5% or $54,334 in Ottawa (of $350,000) (Figure 1 – Total GICs on single-detached dwellings, 2006; Figure 2 – Total GICs as percent of price on single-detached dwellings, 2006). The percentage share of GICs has not changed significantly since CMHC's evaluation of 1996-2002 data, where average costs were 13.5% of purchase prices (CMHC, 2005a; CMHC, 2009).

Municipal components of total 2006 GICs were 48.8% in Ottawa and 27.4% in Winnipeg (CMHC, 2009, Table 2 – GICs on single-detached dwellings, 2006). In Ottawa, infrastructure charges constituted 39.8% of all GICs and 6.2% of the purchase price, while land dedications were 3.9% of GICs and 2.5% of the price (CMHC, 2009, Table 2 – GICs on single-detached dwellings, 2006). In Winnipeg, infrastructure charges constituted 14.5% of all GICs and 1.6% of the purchase price, while land dedications were 8.3% of GICs and 0.9% of the price (CMHC, 2009, Table 2 – GICs on single-detached dwellings, 2006). The only other significant municipally-imposed charge levied by the Cities was for building permits (at 10.8% of Ottawa's municipal GICs, and 10.6% of Winnipeg's municipal GICs) (CMHC, 2009, Table 2 – GICs on single-detached dwellings, 2006). While Ottawa's infrastructure and land dedication charges were 81.7% and 5.2% of municipal charges respectively, and Winnipeg's infrastructure charges were 53% and land dedications 30.6%, both jurisdictions had a very similar overall percentage share of municipal GICs between the two categories at approximately 85% (CMHC, 2009, Table 2 – GICs on single-detached dwellings, 2006).

Development charges. Development charges (DCs) are defined as fees obtained by a Municipality from land developers to offset the infrastructure costs incurred by new development, redevelopment, or the intensification of existing land uses – in other words, DCs are designed to make growth pay for growth (Province of Manitoba, n.d. a, ¶32; Ministry of Community Services [MOCS], 2005, p. v; Slack, 2002, p.14). DCs are one-time fees that function as a cost recovery tool. They are not application or administration fees, nor are they recurring taxes (Province of Manitoba, n.d. a, ¶32.). DCs have many different names in jurisdictions across Canada including: capital cost charges; development charges; development cost charges; development levies; growth development charges; growth fees; growth related capital fees; impact levies; impact fees; infrastructure charges; servicing agreement charges; and service levies. There is no difference between development *cost* charges and development charges, or any of the other terms included above: these terms may be used synonymously. For the sake of ease of discussion in this thesis the term *development charge* has been used as it has been adopted in the ensuing case study of the City of Ottawa, National Capital Region, and Province of Ontario.

Provincial legislation provides Canadian local governments with the authority to levy formal development charges. Ontario is the only province that has an entire act dedicated to DCs alone; other provinces including British Columbia (BC) and Saskatchewan have included a Part, and sections, respectively, within other acts. To proceed with DCs, a local government in Ontario or BC must complete an application and conduct a background study process as directed through enabling provisions of the Acts before a local DC by-law may be passed. In Ontario, once the by-law is passed and conditions such as public reporting and confirmation of review period have been met, the local government may implement DCs (*The Development Charges Act*, R.S.O. 1997, c. 27). In most Canadian jurisdictions, DCs are typically levied at the point of subdivision or building permit approvals, along with land dedications, connection fees, and other development agreement charges, at which point DC funds are then deposited separately into a protected reserve account held by the Municipality.

Canadian DCs have typically been used for offsite hard infrastructure (e.g., sewers and roads), though they may also be used to assist in the provision of soft infrastructure (e.g.,police and fire servicing or transit supports). In Ontario, for example, where DCs have been used to assist with the provision of soft infrastructure including libraries, recreational amenities, safety services, and cultural facilities for the last two decades (British Columbia Ministry of Municipal Affairs [MOMA], 2000; Slack, 1994, pp. VIII, 12, 31; City of Ottawa, 2013k; CMHC 2005a, p. 2). DC fee schedules may be established at the scale of an entire municipality or region (referred to as a "municipality wide DC") may be structured to be applied to specific neighbourhoods within an urban area (an "area specific DC") (Slack, 2002, p. 15). All monies collected under a specific fee schedule must be placed into a dedicated reserve fund that may only be used within the geographic boundary of the fee schedule's constraints and only for the levied purpose – an area specific stormwater drainage DC for the west end of a city cannot be used for road construction in the west end, nor may it be used for stormwater drainage improvements in the east end of the city unless specified in the fee schedule (Slack, 2002, pp. 16-17).

There are four possible charge structures for geographically-based DCs as identified by Slack (1994; 2002) and Tomalty and Skaburskis (2003, p. 145):

1. municipality wide charges (MWCs), where all development within the municipality is charged equally regardless of where it is located;
2. area-specific charges (ASCs), where development within a specific area of the municipality is charged a specific amount. Under this approach not every area of the municipality is subject to DCs;
3. ASCs where development within the entire municipality is broken into segments and each segment is charged a specific amount. Under this approach every area of the municipality has DCs applied; and
4. a combination of overlapping MWCs and ASCs split between the different types of DCs. For example, a certain area of a municipality may be charged MWCs for road development, and an ASC for stormwater management or wastewater infrastructure.

DC fees themselves can be calculated to reflect a number of factors including the proximity to major network facilities (e.g. pipe distance to water treatment plants or lift stations), whether the development is infill or occurring on a greenfield site, whether or not neighbourhood services are pre-installed, and by the servicing standard to be applied to the site and/or intended site use (e.g., industrial development may not be in an area serviced by the infrastructure network, and well users such as residential or commercial units would not contribute to water treatment costs unless the network was capable of servicing their location) (Slack, 2002, p. 16).

For Slack (2002): “If the development charge reflects the full costs and benefits…then developers are more likely to make efficient location choices” (p. 16). In short, by levying charges based on factors local governments would like to discourage, the local government can establish a disincentive to help ameliorate the factor. For example, the location of development charges under option one could foster sprawling development through cross-subsidisation (as discussed in the following section), while charges under option two could foster development in areas without applicable DCs. Charges under option three and four foster development in the least expensive DC areas (Slack, 2002; Skaburskis & Tomalty, 2000). In the Greater Toronto Area, for example, residential DCs structured to reflect the reduced per-capita costs of higher density development would be significantly less than their low density counterparts:

> …[m]ore than 70% of the savings are public, attributable to increased density, which spreads costs over more units and to increase in land-use mix, which reduces the residential share of the costs. The largest savings are for roads, followed by stormwater management, transit, water, policing, and

> sanitary sewers. Environmental and congestion [transportation] costs are also lower (Slack, 2002, pp. 6-7).

DCs are only one alternative among many other widely used tools available to planning authorities for the financing and provision of local infrastructure (Slack, 2002; MOMA, 2000; Slack, 1994) including comprehensive development agreements (DAs); local improvement zones; public-sector borrowing; public-private or public-public partnerships; user fees; and taxation revenues. While both DCs and DAs are implemented at a site-by-site development level within a municipality, there are three key differentiating factors: first, specific DC costs are articulated in local by-laws (i.e., charges are publicly available and non-negotiable) and therefore DCs provide a more consistent basis for developers' cost expectations than DAs; second, DC by-laws are reviewed and approved by a provincial government while under development to ensure consistent and appropriate infrastructure need/cost forecasts are used to set charges; and third, as established DCs apply to all eligible forms of development, the consistent approach established by the program could have the capacity to support local planning goals such as densification and the orderly expansion (or redevelopment) of priority neighbourhoods such as the city centre (Blais, 2011; Blais, 2010; Curran, 2008; MOMA, 2000; Slack, 2002; Slack, 1994), or, directly relevant to this thesis, goals related to drainage management (Barbosa, Fernandes & David, 2012, p. 6792).

Tomalty and Skaburskis (2003) argue that, depending on the method of implementation, DCs could function on a cost-recovery basis and have little ability to direct growth. Further, implementation methods may also limit the possibilities of combining planning objectives with more comprehensive programs of infrastructure charge mechanisms that might result in both more efficient networks and reduced planning-based concerns in new or re-development areas. Currently, DCs by and large function as a retroactive municipal finance tool for the development-induced expansion of infrastructure networks in Canada (Blais, 2010; Blais, 2011; Curran, 2008; Slack, 2002; MOMA, 2000; Slack, 1994). The disconnection between local (municipal, regional, provincial) planning objectives is often the outcome of basing DC fees on non planning-based servicing concerns (e.g., a municipality-wide unilateral "per unit" fee does not provide an incentive to develop smaller residential lots - and therefore higher gross urban density - nor does it foster infill development or the production of multi-family housing, as costs are tied to the number of units and not their interior size, their lot size, or their location) (Curran, 2008; Slack, 2002; Slack, 1994).

Many authors including Tomalty and Skaburskis (2003) concur that “a well designed development charge system can reinforce planning goals” (p. 144). More specifically, they state that DCs must be reflective of the specific costs resulting from each specific development proposed or they will be contrary to local planning objectives:

> The development charges that would help attain planning goals would differentiate the fee according to the proposed project’s attributes that directly affect the next external costs that it creates. ….However, most municipalities do not design their development charge schedules to reflect these planning goals (p. 144).

A consequence of this (often inadvertent) disconnection is the cross-subsidisation of development, which occurs when the true cost of a particular development within a region is hidden (subsidised) by other developments throughout the region: this results from an average cost pricing approach, in which the total costs of development are shared over the total number of developments, instead of a marginal cost approach in which incremental developments are charged incrementally appropriate fees (Slack, 2002, pp.3, 5-6, 8-12). The main goal of most Canadian DC programs has been infrastructure cost management, though they often fail to do even this (Tomalty & Skaburskis, 2003). However, some writers argue that DCs may be structured to form an effective planning support tool that directs development through strategic financial incentives (Blais, 2010; Lee et al., 2008; Slack, 2002; Slack, 1994; Sustainable Prosperity, 2014).

2.3.3 Linking development finance and sustainability

The concept of tying financial penalties to undesirable activities originated with Pigouvian charges: Pigou (1920) was the first to identify a means of market correction through government-imposed taxation to address negative externalities such as pollution generated by a factory, or, as a more recent example, automobile trips generated by a commercial entity such as a fast food outlet (Clinch & O'Neill, 2010, p.2150). The structure of the Pigouvian charge provided regulators with a framework and rationale to levy funds from a business owner or developer to offset the tertiary costs of their activities incurred by third parties such as area residents, governments, and the environment. An often-cited example of this is a paper mill: the paper maker pollutes the river by making his product, which he then sells to customers. Neither the paper maker nor his customers are required to pay for the increased cost of cleaning the water downstream to keep the village's drinking water safe. In this case, a Pigouvian charge could be levied against the paper maker for the increased cost of cleaning the village's drinking water (Clinch & O'Neill, 2010; Pigou, 1920).

Nearly a century later, many academics including Slack (Sustainable Prosperity, 2014; Slack, 2002; Slack, 1994) as well as Tomalty and Skaburskis (Tomalty, 2007; Tomalty & Skaburskis, 2003; Skaburskis & Tomalty, 2000) continue to build on Pigou's argument as a means of addressing planning concerns by stating that DCs need to be structured to reflect the direct external costs of the particular development project (Tomalty & Skaburskis, 2003, p. 144). This argument can be extended to property taxes, user fees, and DCs: by harmonising the public-sector cost components of developments, a consistent price signal can help direct developers to make efficient development choices regarding locations, densities, and servicing needs of developments - and water infrastructures in particular (Skaburskis & Tomalty, 2000, pp. 303-4; Sustainable Prosperity, 2014, 10:14, 15:09, 16:19).

This argument is not limited to municipal issues. The *Rio Declaration* Principle 16, the "polluter pays" principle, was developed to ensure that anyone undertaking activities that generate negative environmental externalities should be required to mitigate those externalities in an appropriate fashion (Stoddart & Cruikshank, 2012, footnote 52). The principle serves as a directive of sorts to foster public-sector (national, provincial, and municipal) stewardship of environmental resources, including stormwater, through the development of legislative, regulatory, and supporting economic penalty frameworks: by "making environmentally damaging activities more costly, it is suggested that there would be a strong incentive to invest in more sustainable modes of production" (Stoddart & Cruikshank, 2012, p. 27). The polluter pays principle is by no means intended to be limited to development charges; however as the development, redevelopment, and intensification of land uses may have massive impacts on local and regional environmental conditions, this thesis takes the view that development fees could be used as a price signal to influence development patterns and their impacts on local and regional ecosystems.

DC programs are not intended to generate a profit for local governments; instead they work to ensure that growth pays for growth and that the existing municipal tax base (e.g., local homeowners) are not responsible for subsidising growth through the property tax system (Skasburskis & Tomalty, 2000, p. 308). CMHC (2005b), for example, found that slow-growth municipalities do not typically implement development charges, and that in municipalities that *do* implement charges, there has never been an ongoing surplus for infrastructure provision (p. 6). In the same survey, CMHC found that DCs funding off-site infrastructure work in combination with other charges levied under subdivision agreements, such as DAs, that dictate on-site infrastructure (p. 2). When infrastructure cost management is split between DCs and DAs, and externalities are taken into account, the following argument could be made: as stormwater concerns are based on the amount of infrastructure required to mitigate the stormwater (and pollutants using the stormwater as a vector) leaving a site, it is fair to assume that, should a developer be able to maintain all stormwater flows (and therefore pollutants) within their site, there is no pressure applied to the local infrastructure network and therefore no legitimate means of levying a charge to accommodate the end-user. This is an example of a rational nexus.

A *rational nexus* is a legal concept developed through case law that established two factors to confirm charges – including development charges – are fair (Rappa, 2002): first, the servicing need must be generated by the development. In the case of a stormwater charge, this means that there must be stormwater leaving the site in a greater volume than before the development occurred, and that the stormwater requires some form of infrastructure to direct, capture, treat and/or otherwise mitigate it. Second, the charge applied against the developer must reflect only their portion of the total cost of the infrastructure network. This means that each lot within a neighbourhood development cannot be charged more than the amount that it has contributed to the total infrastructure need.

This argument is why charges based on lot area, or unit size (i.e., marginal costs) are often seen to be more equitable than other methods (i.e., MWCs or even large ASCs) by developers and local governments (Sustainable Prosperity, 2014, 7:12; CMHC, 2005b; Blais, 2010; Tomalty, 2007; Tomalty & Skaburskis, 2003; Skaburskis & Tomalty, 2000). If stormwater charge programs' fees were calculated at a marginal level instead of a municipality-wide or area-specific level, levied charges would more accurately reflect the true costs of a development. However, when developers are allowed to provide an equivalent amount of land instead of cash-in-lieu in a DA or other subdivision agreement, this approach is cause for significant concern as planning goals such as density, as well as efficient use of infrastructure, are often undermined (Skaburskis & Tomalty, 2000, pp. 306, 308). Based on the literature reviewed, it is reasonable to conclude that if a ‘true cost’ price signal were to be established for stormwater management on a site-by-site basis, developers and property owners may start to make choices based on stormwater quantity and quality, that are harmonised with local planning goals (Sustainable Prosperity, 2014, 5:00, 7:32, 10:14).

3.0 CURRENT PRACTICE: THE MANITOBA CAPITAL REGION AND NATIONAL CAPITAL REGION

To this point, this document has outlined some of the bigger picture of sustainability and sustainable development, reviewed the tenets of integrated urban water management, and discussed the state of infrastructure in Canada while introducing potential ‘greener’ alternatives. This chapter compares the presented theory to the current planning practices of the National Capital Region (NCR) and Manitoba Capital Region (MCR). The first sub-section highlights the planning context of the MCR and NCR, in particular, water-related issues and opportunities; population and geography; and the local development market. The second sub-section provides an overview of the Region’s planning frameworks by reviewing Regional land use, development, and development finance controls in relation to opportunities for integrating IUWM innovations for sustainable development. The third and final sub-section summarises both case study analysis and semi-structured interviews undertaken with key stakeholders in the regional planning and development process.

In the following chapters: “Ottawa” is used when describing the municipality in its entirety; “city proper” is used when describing the designated urban area within the Greenbelt; and “City,” or “City of Ottawa” are used when addressing the formal organisation responsible for governance of the urban and rural areas within the municipality.

3.1 Research Framework

This section of the research also used a mixed approach to explore existing conditions for IUWM-inspired development charge implementation in Canadian jurisdictions. Case study analysis was undertaken through the study of existing planning framework for, and materials produced by, the NCR, City of Ottawa, MCR, and City of Winnipeg.

The intent of this stage of the research was to develop the researcher's awareness of any existing policy-level barriers to implementation of IUWM and development charges in the MCR, and, ultimately, to move towards a consideration of possible solutions. The findings from the case study analysis, and semi-structured interviews were used to adjudicate both the academic literature and preliminary case study 'best management practices' (BMPs) to synthesise a tailored approach for the MCR.

3.1.1 Approach and methods

A mixed-methods approach to research was used to explore existing conditions for IUWM-inspired development charge implementation in Canadian jurisdictions. Case study analysis was undertaken in two stages: first, through a study of the existing planning framework for the NCR and City of Ottawa based on document review and through semi-structured key informant interviews.

The intent of this aspect of the thesis work was to expand the researcher's understanding of existing IUWM and development charge strategies and experiences; confirm existing findings as accurate; as well as to explore successes and pitfalls experienced by those involved in the real-world implementation of the academic propositions explored previously in Chapter Two. The findings from the case study analysis and semi-structured interviews were used to synthesise a potential BMP framework identified in Chapter Three of this document.

The review of case study materials suggested a number of potential interview participants. In the majority of cases, contact with individuals led to snowball sampling as a secondary method of participant selection. Potential participants were provided with both a general interview guide suggesting major themes to be discussed, as well as a list of specific questions and an informed consent form prior to the actual interview (see Appendix 1). Each interview lasted approximately 60 minutes and followed a semi-structured format. The format allowed the researcher to glean further information about unanticipated related topics as they arose in conversation, as well as probe for greater detail regarding specific issues.

3.1.2 Application and analysis

Key informant interviews with municipal and development sector respondents were excluded from this thesis. Multiple points of contact were established within the intended municipal and development informants' networks, and considerable efforts were made to confirm times and dates of prospective interviews during a site visit. Key informants from the development sector were ultimately excluded as informants from the municipal sector were unavailable. The researcher believes representation from both municipal and development representatives is required to reduce bias in the data and establish a more fulsome perspective. Therefore, the researcher was not able to complete scheduled key informant interviews with development sector representatives as municipal representatives did not participate. The researcher believes this is likely due to the political nature of development charges and the timing of this research coinciding with the review of the local development charges by-law.

These unintended shifts in scope led to an amended approach placing greater emphasis on the implementation framework and its implications to and from regional and provincial perspectives of the public sector. Partially due to the absence of municipal respondents and developer representatives, the total key informant sample size (reduced from the intended six to two) for semi-structured interviews under this research was significantly smaller than originally outlined through the formal ethics review process.

When scheduling interviews and discussing organisational roles with key informants, consistent efforts were made to extend the sample size. Participants confirmed that there were few other sources within their respective work areas (and few other relevant potential interviewees in other departments), and that staff within their immediate work areas were of consistent view/opinion (through internal directive and central policy direction) regarding the subject matter of the distributed interview questions (as well as this research's broader themes). This was stated by both participants separately and without prompting of the researcher, as each identified discussions with colleagues regarding the question topics distributed prior to the scheduled interviews as per the informed consent process.

The combination of the targeted nature of this research and the small scale of the target groups (i.e., comparatively small planning and planning policy staff complements in the relevant departments of the Province of Ontario and National Capital Commission) meant that findings are likely to be representative of the jurisdictions in which they work. Findings, as discussed in Section 3.3, were mutually supportive and as were respondents' statements. They were also in alignment with findings from the literature and case study materials.

3.1.3 Analysis methodology

Prior to formal analysis a number of themes emerged very clearly. However, qualitative analysis was used to evaluate interview responses to ensure that these themes were properly understood and appropriately representative. While qualitative analysis is subjective in nature, a series of principles introduced by Gray (2009) were followed: broadly speaking, first interviews were transcribed; second, those documents were then coded in multiple passes based on themes apparent in the transcriptions; third, a macro-level comparison was made between themes and individual responses to confirm the apparent themes and merge similar sub-categories; and finally, a series of overarching principles were drawn from the themes identified through the review process.

The first and all subsequent coding passes involved the differentiation (i.e., highlighting, colour-coding, and reorganisation) of key words, industry-specific jargon, and recurrent themes for each family of questions. Passes were completed following the principles of open (e.g., thematic/concept-based), axial (e.g., organisation of open themes/concepts), and selective coding (generalisation towards ‘big-picture’ concepts) as described by Neuman (2003, pp. 442-444) and Gray (2009, pp. 500-511). Some themes were primarily identified through review of the literature, while others emerged predominantly through interview responses. All thematic categories generated through this research were mutually supportive in nature. Findings from the semi-structured interviews provided a degree of richness of information not seen in the academic literature and review of case study materials; this was anticipated through the design of this research (where the ‘real-world’ perspective was relied upon to validate text-based findings).

3.2 Background

This sub-section provides an overview of Winnipeg and the MCR, and Ottawa and the NCR. First, it explores each broader regional context, examining physical, social, and economic characteristics by looking at water-related opportunities and constraints, regional demographics, and the regional development market. Second, it examines local planning and development controls to understand their roles in strategies for regional sustainability, as well as how links are, and could be, made to IUWM practices. Finally, it examines each regional infrastructure and development finance framework to understand its role in regional sustainability and relation to IUWM.

3.2.1 Regional contexts

Governance in MCR.

Municipalities in the Winnipeg region have been formally working together through organisations such as the "Mayors and Reeves of the Capital Region" to develop collective responses to regional planning issues since 1999 (Regional Planning Advisory Committee [RPAC], 2003; Partnership of the Manitoba Capital Region, 2007, p.27). The Partnership of the Manitoba Capital Region (PMCR) was formally established by the Province of Manitoba in 2006 (*Capital Region Partnership Act,* C.C.S.M. c. 23) following the recommendations of the 2003 RPAC report *A Partnership for the Future: Putting the Pieces Together in the Manitoba Capital Region* as a means to address functions related to both planning governance and collective municipal administration.

The legislation does not provide the PMCR with the authority required to function as a separate level of government similar to upper-tier municipalities in Ontario, and instead established an organisation that may determine formalised recommendations for the Minister of Municipal Government regarding regional issues such as: planning; infrastructure and service delivery; environmental management; and economic development (*Capital Region Partnership Act,* C.C.S.M. c.23). This means that the big-picture planning activities and operations related to development plans and regional strategies still require provincial approval. The 16 PMCR municipalities are represented by 9 different planning authorities, 4 of which are planning districts encompassing 11 municipalities, while the remaining 5 authorities are individual municipalities (Province of Manitoba, 2007). This illustrates some of the fragmentation that has occurred historically in the region due to differing perspectives regarding planning, development, and politics.

The PMCR was formalised six months prior to the proclamation of *The Planning Act* (C.C.S.M. 2006 c.P80), which established a revised provincial planning framework for municipalities outside of the City of Winnipeg. Since the PMCR was formed, it has established priorities in four major areas: collaborative regional development; environment and water quality; transportation and shared services; and economic development (PMCR, 2009a; PMCR n.d.). The collaborative regional development focus declares a need for ongoing development to increase in density and occur in existing service centres (e.g., cities and towns) (PMCR, 2009b, p.11). The environment and water focus establishes a responsibility and need to keep the water quality of regional watercourses high, as well as a desire by the PMCR to identify and protect ecologically significant areas (PMCR, 2012). This focus area also expresses a desire to develop and adopt environmental strategies throughout capital region municipalities to address natural area, waterway, and drinking water protection; and controls as needed to protect "rivers and streams or Lake Winnipeg" from further environmental degradation (PMCR, 2012, ¶3-5).

Curiously, there is no explicit mention of flood mitigation or planning for flood areas in particular in the environment and water priority area in the latest PMCR priorities even though a large amount of the land area within the existing capital region has been subject to considerable flooding concern (PMCR, 2012). There have also not been public discussions of either infrastructure finance or environmental degradation stemming from low-density development since the 2003 RPAC report, which acknowledged the issue as a "worrisome aspect of the existing patterns of residential and commercial industrial development" (*A partnership for the future: Putting the pieces together in Manitoba's capital region,* p.121).

This is likely due to the political nature of the current PMCR's committee, as the 2003 report was the last authored by co-chairs representing both the region's and the provincial government's interests. The 2003 report went as far as to explicitly state that low-density residential developments: 1) constitute an ongoing public sector tax burden because developers pass infrastructure maintenance and life-cycle replacement costs not typically factored into development fees to both development residents and municipalities; 2) often occur where existing infrastructure is not at capacity, so further servicing and financing inefficiencies may occur, creating even higher costs for municipalities; and 3) increase property taxes for both development residents and municipal residents as larger infrastructure networks generate higher costs (RPAC, 2003, pp.121-123).

Governance in NCR.

Because it is located in the heart of the Canadian capital region, governance and other administrative controls in Ottawa are somewhat different from those found in capital regions of the provinces (see Figure 5 on the following page). The precursor to the

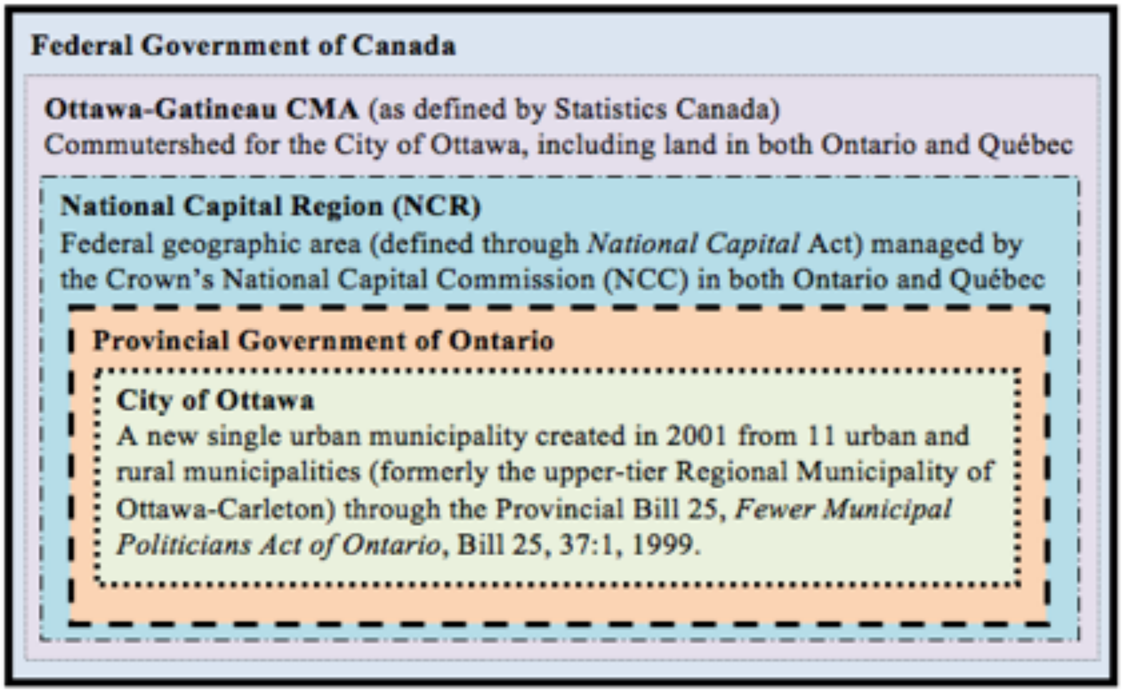

Figure 5: Governance Structure of the Ottawa Area. (Image by author 2013.)

current City of Ottawa, the upper-tier municipality of the Region of Ottawa-Carleton was established in 1969, and became the first true regional-level government in Ontario (City of Ottawa, 2009, p.15). The current National Capital Region (NCR), a ±4715 square kilometre (471,500 hectare) federal area was formally redesignated in 2002 following the Ontario municipal amalgamation initiative. It encompasses the current City of Ottawa and surrounding communities (*National Capital Act,* R.S.C. 1985, c.N-4 Schedule 2 c.17 s.20). The NCR is administrated by the National Capital Commission (NCC), a Crown corporation established in 1959 to provide additional guidance to the nationally significant region (NCC, n.d. ¶2). While the NCR designation does not provide another formal political jurisdiction, the NCC does have the ability to intervene in nationally significant land designation, zoning, expropriation, and other related development matters (*Munro v. National Capital Commission,* 1966).

Geography and Demographics in the MCR.

The City of Winnipeg has developed outwards from the junction of the Red and Assiniboine Rivers in the south central segment of the province of Manitoba. The average elevation is 239 metres above sea level; the average temperature is 2.4 degrees Celsius; and the average annual rainfall is 404 millimetres, while the snowfall reaches an additional average of 114.8 centimetres annually (Manitoba Land Initiative, 2012; Environment Canada, 2013d). The capital region of Manitoba had a 2011 total land area of ±7841 square kilometres, ±464 square kilometres of which was within the City of Winnipeg (Statistics Canada 2012a; Statistics Canada 2012b; Statistics Canada 2012c; Statistics Canada 2012d; Statistics Canada 2012e; and Statistics Canada 2012f).

Statistics Canada (2012a; 2012b) determined that the Winnipeg CMA population as a whole grew by 5.1% between 2006 and 2011 to reach 730,018 persons or nearly two thirds of the population of the province of Manitoba, while the City of Winnipeg in particular experienced a slightly lower growth rate of 4.8% for a total 2011 population of 663,617 or nearly 91% of the CMA population. However growth in the CMA is not entirely representative of growth within the MCR: when all capital region municipalities excluding Winnipeg are included in the growth calculation, the exurban area of the MCR is revealed to have a net growth of 6.6%, significantly higher than Winnipeg as well as the province as a whole, which experienced 5.2% growth over the same period (Statistics Canada 2012a; Statistics Canada 2012b; Statistics Canada 2012c; Statistics Canada 2012d; Statistics Canada 2012e; and Statistics Canada 2012f).

Geography and Demographics in the NCR.

The City of Ottawa is located south of the junction of the Ottawa and Rideau Rivers in the easternmost corner of the province of Ontario. The average elevation is 114 metres above sea level; the average annual temperature is 6 degrees Celsius; and the average annual rainfall is 732 millimetres, while snowfall reaches an additional average of 235.7 centimetres annually (City of Ottawa, 2013a, Table 55).

The Municipality of Ottawa covers 288,800 hectares of land and water (Land Information Ontario, 2013); 20,000 hectares within the municipality form a rural Greenbelt of forested, farm-, and park- land around the city proper (Brown, Mitchell, & Beresford, 2005, p.195). Three quarters of the land within the Greenbelt is owned by the National Capital Commission, while the balance of the land is owned by other federal institutions (Brown, Mitchell, & Beresford, 2005, p.195). The NCC and other institutions have established partnerships with public and private tenants using the land to foster conservation, preservation, and sustainable management practices (Brown, Mitchell, & Beresford, 2005, p.195).

The land within the municipality covers 279,600 hectares (2,796 square kilometres), 7.9% of which (~22,000 hectares) was urbanised as of 2006 (City of Ottawa, 2013a, Table 55). The Ottawa region, including all Ontario municipalities that share a common border with the City of Ottawa, constitutes 799,600 hectares (7,996 square kilometres), while the Greater Ottawa-Gatineau area (distinct from Census Metropolitan Area requirements) constitutes 1,186,800 hectares (11,868 square kilometres) (City of Ottawa, 2013a, Table 55). The City of Ottawa is therefore 23.6% of the land area within the Greater Ottawa-Gatineau area.

Statistics Canada (2012g) determined that the Ottawa-Gatineau census metropolitan area (CMA) had a 2011 population of 1,236,324 and the City of Ottawa itself had a population of 883,391. The Ontario portion of the CMA had a population of 921,823 in 2011, up 8.9% from 2006 figures (Statistics Canada, 2012h). The populations of the city proper and region grew similarly increasing by 8.8% and 9.1% respectively (Statistics Canada, 2012g).

Just over half, or 52% (3287 square kilometres) of the total 2011 CMA land area (6287 square kilometres) was within the province of Ontario, as well as 73% (384,358) of the region's total private dwellings (526,627) (Statistics Canada, 2012h). The population densities of the Québec and Ontario portions of the Ottawa-Gatineau CMA were considerably different, at 197 and 280 persons per square kilometre, respectively (Statistics Canada, 2012h). The 2011 percentage of Ottawa's population residing within the Greenbelt declined slightly to 57.2% (or ~433,000 individuals), while urban centres outside the Greenbelt had grown to 32.9%, with an approximate population of 305,000 (City of Ottawa, 2012, p.5-6). The downtown core (10.5% or ~97,000 persons) and rural areas (9.9%, or ~92,000) did not experience significant change within the period of 2006 to 2011 (City of Ottawa, 2012, p.5; City of Ottawa, 2012, Table 5: Population and household estimates by sub-area, 2007-2011). The 2011 average individual income across the CMA was high for Canada, at $43,595, with 60% of all employment found in the private sector (City of Ottawa, 2012, p.IV).

Development Market in the MCR.

In 2011 the City of Winnipeg had 280,489 dwellings, resulting in an average of 2.4 persons per dwelling unit (Statistics Canada, 2013b). Both the province of Manitoba and Winnipeg CMA also had a 2011 average dwelling occupancy of 2.4 persons per unit with 24,290 dwellings in the CMA outside of the City of Winnipeg boundary (Statistics Canada, 2013a; Statistics Canada, 2013b). Overall housing starts in Winnipeg have grown 8.2% between 2002 and 2012 to 4,065 per year, comprising 56% of total housing starts in Manitoba (Economic Development Winnipeg, 2013 May, Table: "Starts, dwelling units, Winnipeg, Manitoba and Canada").

Of the 4,065 units constructed in the CMA in 2012: 86% (3482) were within the City of Winnipeg; 3.6% (148) were in the Rural Municipality [RM] of Springfield; 2.8% (114) were in each of the RMs of Taché and Ritchot; while the RMs of Headingley, Macdonald, St. Clements, West St. Paul, East St. Paul, St. Francois-Xavier, and Rosser shared decreasing portions of the remaining 5.1% (207) of 2012 CMA starts (CMHC, 2013a, Table 2.1: Starts by Submarket and by Dwelling Type - January - December 2012). CMHC (2013b) has estimated 2013 and 2014 single- and multi- family unit starts will remain high at forecasted rates of 4,250 and 2,050 units respectively (CMHC, 2013, pp.9, 27).

Development Market in the NCR.

While Ottawa has continued to experience sustained population growth, it has also experienced a gradual trend of decreasing household size (City of Ottawa, n.d., p. 2-1). This led the City to a establish a residential demand forecast for 145,000 new units between 2011 and 2031 to accommodate workforce growth of 170,000 and overall population growth of 213,000, which constitutes a 23% increase over the municipality's 2011 population (City of Ottawa, n.d., pp. 2-1, 2-2). To meet the new unit target (145,000) for the next 20 years, with a 26-year average of 5,431 unit starts per year, the development of residential units within the City of Ottawa will require an annual increase of 33% (City of Ottawa, 2013b, Table 36). Other than in 2002, development levels at this intensity have not been seen since the mid-1980s (City of Ottawa, 2013b, ¶1-2).

From 1971 to 2006, home ownership in Ottawa increased from 50% to 66% of occupied dwellings (City of Ottawa, 2013c, Table 26). In 2006, 43% of residential units within the city proper were single detached units, while semi-detached and row housing units constituted 6% and 19% respectively (City of Ottawa, 2013d, Table 31). Low-rise apartments provided 11% of units, while high-rise apartments provided 19% (City of Ottawa, 2013d, Table 31). Ottawa has since experienced more modest shares of detached residential units than its surrounding municipalities, with detached dwellings comprising 37% of housing starts from 2006-2011 (City of Ottawa, 2013e, Figure 71: Share of new dwellings by type). By 2031, new market-produced residential units are anticipated to constitute 27% detached units, 5% semi-detached units, 28% rowhome units, and 40% apartment-style units (City of Ottawa, 2013e, Figure 71: Share of new dwellings by type). Ontario and Québec municipalities adjacent to Ottawa are anticipated to hold a significantly larger share of single detached units in the 2031 residential market, with figures between 46% and 94% (City of Ottawa, 2013e, Figure 71: Share of new dwellings by market type).

The City of Ottawa (2013f) commissioned Hemson Consulting Ltd. to complete a cost and revenue-based analysis of four major forms of residential development occurring within the municipality. "[H]igher density urban; lower-density urban greenfield; low density villages and scattered estate and low-density residential" (City of Ottawa, 2013f, ¶1) were evaluated based on rate-based charges, development charges, as well as long and short-term marginal servicing costs based on thirteen recent comparable developments (City of Ottawa, 2013f, ¶2-6). The results showed that higher-density urban residential development generated the only per-capita surplus at over $455, while lower-density development (-$409), low-density rural development (-$357) and low-density village and scattered estate (-$199) all generated noticeable per-capita deficits (City of Ottawa, 2013f, ¶7).

Local Water-Related Services and Programming in the MCR.

Winnipeg neighbourhoods constructed prior to the 1960s, approximately 8700 hectares of urban land, use 'combined' (both storm- and waste- water conveyance) pipe networks, while 22300 hectares of urban land have separate land drainage and waste sewers (City of Winnipeg, 2008). The City of Winnipeg operates one water treatment plant and three wastewater treatment plants (City of Winnipeg, 2013a; City of Winnipeg 2013d). The City of Winnipeg anticipates an average of 18 overflow events annually (City of Winnipeg, 2013c) even though only approximately 30% of the city's land area is serviced by a combined sewer system (City of Winnipeg, 2008).

Unlike in the Ottawa region, the City of Winnipeg cannot provide water supply services to other municipalities within the MCR due to a 1913 agreement between the Greater Winnipeg Water District and the Government of Canada permitting the municipality to withdraw water from Shoal Lake (International Joint Commission, 1914). The City can, however, accept wastewater (including stormwater) from other municipalities for treatment and has recently signed an agreement to do so for the first time with West St. Paul, an RM directly north of Winnipeg (City of Winnipeg, 2013b).

Minor drainage works began in southern Manitoba in the 1840s led by the Manitoba Department of Public Works in an effort to increase the amount of fertile cropland through draining swamps, sloughs, and other wet areas of land (Warkentin, 1973, ¶5). As Manitoba Public Works experienced limited success draining the area of land between the Red River and the Manitoba Escarpment (a remnant of glacial Lake

Agassiz), the Province of Manitoba stepped in and replaced *The Drainage Act* (S.M. 1880, c.2) with *The Land Drainage Act* (S.M. 1895, c.11), allowing widespread installation of engineered drainage solutions to take over. Decades later, in 1919, the Manitoba Drainage Commission was formalised and given a series of tasks including the reassessment and redistribution of the existing taxation inequalities for land drainage systems (Griffiths, 1952, as cited in Elliott, 1978). These inequalities were still present in 2001, when Manitoba Conservation (2001) stated the following in *Building a sustainable future: Water: A proposed strategic plan for Manitoba*:

> Land drainage is not well coordinated amongst landowners, municipalities, conservation districts, and the provincial government…The drainage system has deteriorated over the years and resources are declining to the point where many municipalities are requesting increased provincial assistance (p.12).

Local Water-Related Services and Programming in the NCR.

The City of Ottawa owns and operates two major water treatment facilities and one wastewater treatment facility within the urban area inside the Greenbelt and controls an additional eight facilities in rural villages (City of Ottawa, n.d., p.2-26). Residences are billed bimonthly for metered water and wastewater usage. The City is not responsible for the provision of water and wastewater services outside of the urban area as land outside of the Greenbelt is intended for agricultural, environmental, and rural residential uses; however the City does have the ability to designate and service areas in which it deems urban servicing viable and has done so in eight villages (City of Ottawa, n.d., p. 2-26).

The establishment or expansion of any treatment facility requires the City of Ottawa to undertake a detailed cost-benefit analysis, comprehensive servicing study, and favourable financing plan before construction can occur: in rural areas, treatment facilities are typically reserved for locations with a sufficiently dense settlement areas, a valuable source of economic development, or where an existing and prevalent water-related health concern can only be mitigated by municipal treatment (City of Ottawa, n.d., pp.2-26-2-28). Costs, benefits, and lifespans of these urban and exurban infrastructure networks, including the component pipes, pumps, and other equipment necessary for operation, are detailed within the *Infrastructure Master Plan* (2012) component of Ottawa 20/20, the umbrella of planning documents for the City.

Ottawa experiences periodic overland and high water table flooding related to three major variables: river flooding; spring runoff; and overloaded municipal sewer systems (City of Ottawa, 2013g). Serious river flooding is the urban area is relatively rare as river ice is cleared annually prior to the major snowmelt (City of Ottawa, 2013g); however basement flooding and sewer backups are quite common to the region when snowmelt overwhelms local wastewater network capacity (CBC, 2011).

All of the neighbourhoods within the city proper that were constructed prior to 1951 have combined wastewater infrastructure networks, while some areas built in the 1950s began to have partially separated stormwater and wastewater systems (City of

Ottawa, 2009, pp.76, 108). In addition to combined sewer networks, homes in the older areas of Ottawa typically do not have weeping tiles or other means of ‘off-grid’ drainage management, which increases stormwater runoff and significantly contributes to wastewater overflows following rain and snowmelt events (City of Ottawa, 2009, pp. 76-77). In 1961 Ottawa attempted to resolve the overflow problem by shifting to partially separated stormwater and wastewater systems; the City also passed a by-law prohibiting both roof drainage and weeping tile from connecting directly to wastewater infrastructure (City of Ottawa, 2009, p.77). Over the last five years, in an effort to combat ongoing combined sewer backups and overflows within neighbourhoods, the City of Ottawa (2009) ramped up installation of back flow valves in the existing combined sewer systems and has implemented a funding program to support homeowners’ installation of sump pumps in flood-prone areas (p.77).

The City of Ottawa (2009) has determined that peak annual water demand typically occurs in early evenings in the summer months due to residents watering their lawns (p.28). The City has assessed that “the magnitude of those peaks is such that the opportunity for peak demand reduction from many other demand management measures may be insignificant in comparison” (City of Ottawa, 2009, p.28). Understanding and mitigating outdoor water use through regulation, outright bans, and/or public education opportunities, however, is not a simple endeavour and further study has to be undertaken to explore targeted outdoor water demand management before infrastructure costs can reliably be reduced (p.28).

However, the City has established a series of municipal programs to increase resident involvement in the overall management of local water resources. For example, the *High Volume User Program* provides consumption-based rebates for the installation of water-saving appliances in multi-unit residential, commercial, and institutional properties (City of Ottawa, 2013h), and the *Rural Clean Water Grants Program* provides mitigation-based grants for the establishment of buffer strips in rural and farming areas to reduce erosion and other environmental impacts of agricultural activities to water bodies, courses, and groundwater (City of Ottawa, 2013i). The City of Ottawa (2013j) has also developed a reforestation program to aid in air and water purification and carbon fixation called *Green Acres*, where rural landowners are able to 50/50 cost share reforesting (including planning, planting, and maintaining) their properties. Prior to the implementation of these programs, the City explored the widespread use of rain barrels, and supported xeriscaping as opportunities for water conservation (City of Ottawa, 2009, p.28).

3.2.2 Planning and sustainability

Manitoba Capital Region.

The most recent *Provincial Sustainability Report for Manitoba* (2009) was drafted by the Province under direction from *The Sustainable Development Act* (C.C.S.M. c. S270). The report outlines 45 indicators split into environmental, economic, and social factors; a full chapter is also dedicated to the interactions between sustainability and land use planning (Province of Manitoba, 2009). Both water indicators (quality, as well as allocation and consumption) were ranked as “stable,” while at-risk ecosystem and wildlife species are ranked as “inconclusive” (Province of Manitoba, 2009, pp.13-14, 29-31).

Surface water was evaluated based on the nationally-established Water Quality Index, but groundwater had not been fully analysed due to a lack of data (Province of Manitoba, 2009, pp.29-33). However, closer examination of presented data in *Figure 1-13: Water quality index values for the shield, plains and prairie ecozones in Manitoba from 1992 to 2007* (Province of Manitoba, 2009, p. 30) shows a gradual decline for prairie ecozones from a high ‘fair’ ranking to a significantly lower position within the ‘fair’ range; plains rankings have remained highly variable and generally in the lower range of the ‘good’ ranking, while shield rankings have remained relatively constant hovering on the border between ‘excellent’ and ‘good’ rankings.

While the Province of Manitoba (2009) considered itself a leader in sustainable forestry practices including ecosystem monitoring, these same rigour of practice was not applied to surface water management or water withdrawals in 2009 (pp. 23, 25, 29-33). Ecosystem concerns were primarily discussed in relation to biodiversity, protection of endangered species, habitat conservation, and continuation of commercial fishing practices (Province of Manitoba, 2009, pp. 13-18). Perennial streams in southern Manitoba range widely in their allocation[7]: the Red River, of particular importance to this research and the health of Lake Winnipeg, is only 10% allocated by

[7] allocation, referring to the volume of water in the watercourse permitted for private withdrawal/use

volume, while smaller rivers such as the Assiniboine (80%), Boyne (99%), and Souris (95%) are very close to their maximum allocation capacities (Province of Manitoba, 2009, *Figure 1-14 B: Amount allocated for perennial streams*, p. 32). As of 2009, Manitoba had 17 integrated watershed management plans either completed or in progress. Water infrastructure is not given any specific indicators throughout the report.

The PMCR has not implemented a comprehensive surface water management strategy to address drainage concerns in the Manitoba Capital Region. Until the recent *Manitoba Surface Water Management Strategy* (2014) was passed, the regulation of drainage-related matters was based on a combination of piecemeal provincial policy and individual development approvals. *The Manitoba Water Strategy* (2003), the active framework throughout the drafting of this thesis, contains a number of policies relevant to development within the province: water quality policy 1.4 commits the province to improve the quality of both wastewater discharge and reduce non-point source pollution, conservation policy 2.4 promotes water retention, and education policy 7.2 fosters the development of demonstration projects (p.27). While other policies apply to the province as a whole, the drainage-specific policy area is constrained to agro-Manitoba. Conservation policy 2.2, applicable to the entire province, promotes arrangements such as those explored through this research, stating

> [s]oil conservation, wetland retention, and the application of appropriate land use practices shall be promoted primarily by the provision of incentives, but with regulation where required, not only as essential elements of water conservation and protection, but also as key measures to reduce siltation impacts, downstream flooding, and non-point source pollution.

Manitoba Conservation, 2003, p.27

The Province of Manitoba (2014a) recognises the complexity of Canadian water management processes, as jurisdictional controls are spread between all three levels of government (p. 22). Since the drafting of this thesis, the Province has established an umbrella strategy for integrated water management across most departments and agencies. The Province passed *Manitoba's Surface Water Management Strategy* in 2014 as part of the *TomorrowNow* series. The Strategy has fifty actions that fall under three main goals to be achieved by 2020: improving and protecting water quality; preparing for extreme events; and coordination and awareness (p. 3). Under the improving and protecting water quality goal the Province of Manitoba (2014a) has set strong statements towards reducing eutrophication by removing excess nitrogen and phosphorus from our systems, promoting urban stormwater management, and partnering to develop alternative options to stormwater retention (pp.8-14). The Strategy supports development of Integrated Watershed Management Plans, which have a geographic basis following the boundaries of conservation districts, which function at a watershed scale, and not planning districts, which follow municipal (and therefore political as well as development control) boundaries (p. 21).

The Province of Manitoba also published *Towards sustainable drainage: A proposed new regulatory approach* in June 2014 to support consultation regarding regulatory changes proposed by the new Strategy. The document identifies a specific Class for urban and rural subdivisions with at least ten lots. The proposed Class would require an engineering certification for drainage and retention infrastructure, detailed site plans, and compliance with all federal, provincial, and municipal requirements (Province of Manitoba, 2014b, p. 12). This approach begins to reduce impediments to the implementation of WSUD techniques discussed in Chapter Two; however this approach does not address the regulatory framework that currently prohibits cost-effective installation of many forms of GI because duplication/redundancy of services (e.g., construction of a bioswale network and full-size piped sewer system on the same site) is not addressed; and the classification of stormwater remains under the wastewater and sewage body of regulations. The ten-lot threshold assumed for the residential Class would also exempt most multi-family residential developments, as well as many condominium developments.

National Capital Region.

The City of Ottawa's latest Official Plan was specifically prepared as one of five major documents within the growth management and sustainable development framework of the Ottawa 20/20 initiative begun in 2002 (City of Ottawa, n.d., p.1-3). The overarching goal of the City that guides the formation of planning principles in each of the five major planning documents is "sustainable development and accommodation of growth and change without undermining the environmental or social systems on which we depend" (City of Ottawa, 2009, p.17). The other four plans under Ottawa 20/20 address social services (e.g., housing provision and employment); heritage, arts, and culture;

economics; and the environment (City of Ottawa, n.d., p.1-4). After the completion of the other four major strategies, Ottawa's 2003 Official Plan was used to articulate more detailed land use planning, design, and infrastructure strategies for the next twenty years of development (City of Ottawa, n.d., p.1-5; City of Ottawa, 2009, p.7). The Official Plan also established the overarching strategies for a series of three supportive planning documents addressing more detailed planning and policy at the city-wide level for infrastructure; greenspace; and transportation (City of Ottawa, n.d., p.1-5).

The seven principles of Ottawa 20/20 used to steer the development of the entire local planning framework are: "a caring and inclusive city;" "a creative city rich in heritage," "unique in identity;" "a green and environmentally sensitive city;" "a city of distinct," "liveable communities;" "an innovative city where prosperity is shared among all;" "a responsible and responsive city;" and, "a healthy and active city" (City of Ottawa, n.d., p.1-3). Within the environmental principle, Ottawa indicates direction to protect and preserve natural resources including habitat, green spaces, trees, and agricultural lands; curb sprawl through wise land use and preservation of the existing urban development boundary; and foster active and public forms of transportation (City of Ottawa, n.d., p.1-3). The City acknowledges that these principles cannot be achieved without co-operation with both the provincial and federal governments, as well as other partners for projects related to infrastructure, sourcewater protection, and water quality management (City of Ottawa, 2009, pp. 11-13).

Ottawa has been actively involved in the promotion of growth management and sustainable development since the early 1990s, when the region was still composed of multiple municipalities (City of Ottawa, n.d., p.2-8). Urban concentration, densification, and greening opportunities resulting from a holistic planning process have been seen as a means of achieving social, economic, and environmental goals including the reduction of greenhouse gas emissions in the development sector (City of Ottawa, n.d., p.2-33). Considering the goal of concentration, new residential development has been tied to minimum density targets; accepts alternative infrastructure design standard, such as those for road right of ways; and reduces or waives parking requirements in areas with high accessibility to public transit (City of Ottawa, n.d., pp.2-10-2-13).

In addition to establishing a minimum density standard of 34 units per net hectare (~14 units per acre, excluding streets and other right-of-ways), the City has instigated a no-net-loss of density clause: any development application requesting a reduction of parcel density in one area is required to increase density in another area to assure there is no net loss of density within the municipality (City of Ottawa, n.d., p. 2-14). New and redeveloped neighbourhoods are expected to use density gradients to integrate within the existing built form, while single detached dwellings are simultaneously restricted to a maximum of between 45% and 55% of each development area's total units (City of Ottawa, n.d., p.2-14). If the findings established by Dietz and Clausen (2008) and Pyke et al. (2011) in Chapter Two of this thesis hold true, the City's system of density gradients and no-net-loss clause should have a net positive impact on the quality of local stormwater and health of area watersheds.

Broad policy guidance for implementation of the water-related elements of the environmental principles provide for "planning on the basis of natural systems to protect and enhance natural processes and ecological functions (e.g., watershed planning, groundwater and surface water protection, and greenspace policies)" (City of Ottawa, n.d., p.1-9). Policy guidance for infrastructure broadly suggests more effective use of existing resources and the ongoing containment and compaction of development to facilitate more sustainable development (City of Ottawa, n.d., p.1-10).

The overarching perspective of Ottawa's 2009 Infrastructure Plan was significantly different in scope than that of previous plans. The City transitioned from a focus on expenditures and demand- and asset- based management to a more holistic approach seeking to integrate communal components of municipal infrastructure systems (City of Ottawa, 2009, p.8). The Infrastructure Master Plan (2009), like the Official Plan, lays out the integrative and sustainability-oriented components of water, wastewater, and stormwater infrastructure and planning projects for the next two decades under the Ottawa 20/20 scope (p.8) which "recognised that infrastructure assets include not only "pipes", but also the natural, fiscal, and people assets important to the success and sustainability of infrastructure services" (City of Ottawa, 2009, p.16). This shift to address the holistic social, economic, and environmental accounting of public services (City of Ottawa, 2009, p.17) integrated newer, more progressive stormwater management policies that were adopted by Council in 2007 (City of Ottawa, 2009, p.8).

The City of Ottawa (n.d. a.) goes further to tie the roles of infrastructure provision and land use planning together, stating:

> [l]and use and infrastructure issues are strongly inter-related and together form a cornerstone of the City's growth management program.... the

> provision of urban infrastructure – such as drinking water, wastewater disposal and drainage – shapes development patterns by making more intense use of the land base possible. Thus, policies for governing the extension and upgrade of infrastructure can provide key levers for managing urban growth. If the city is to grow in an efficient manner and achieve the vision set out in this Plan, it is essential that land use and infrastructure policies be "pulling" in the same direction (2-18).

The City's Official Plan states that development and the development review process must conform to municipality-wide stormwater management as detailed in the Infrastructure Master Plan; requirements as defined through a Master Drainage Plan (i.e., a district-wide series of controls specific to stormwater concerns in that particular area); setbacks and other development restrictions as defined through watershed, sub-watershed, environmental management, and community design plans; site-specific management plans addressing focus areas such as drainage infrastructure, environmental protection, and stormwater management, as required; and any interim, improved, or alternative measures as defined by either or both of the municipality and local conservation authority (City of Ottawa, n.d., pp.2-30–2-31).

Waterbodies, watercourses, woodlands, wetlands (including those not deemed 'provincially significant'), and other key ecological, habitat, and natural resource areas have been protected through formal planning designation as Natural Environment Areas or Rural Natural Features (City of Ottawa, n.d., p.2-33). Local watershed and sub-watershed plans work in conjunction with environmental management and community design plans to establish a series of additional development restrictions to protect and foster the natural systems and land within these environmental designations (City of Ottawa, n.d., pp.2-33, 2-36–2-37).

Environmental Management Plans in particular provide the ability to establish sub-watershed-wide setback requirements as well as site-specific stormwater management requirements, such as those discussed in Chapter Two of this thesis, to be considered at the subdivision stage of development (City of Ottawa, n.d., p.2-37). This site-specific focus is placed on overall runoff reduction and retrofit procedures for less developed areas but also apply to areas that developed prior to the implementation of comprehensive stormwater management controls (City of Ottawa, n.d., p.2-30). The City encourages the protection of natural resources, as well as green building and landscaping techniques including permeable surfacing, tree planting, green roofing, and the construction of living walls (City of Ottawa, n.d., pp.2-30, 2-33). Stormwater infrastructure is recognised as “fundamentally different” from water and wastewater infrastructure for two major reasons (City of Ottawa, 2009, p.22): stormwater infrastructure is designed as a local system in response to site-specific needs; and stormwater management is achieved through a hybridisation of engineered solutions (pipes and pumps) and natural systems (ecological treatment, waterbodies, and watercourses) (City of Ottawa, 2009, p.22).

The City of Ottawa (2009) acknowledges that stormwater drainage is integrated into the wastewater transport and treatment process, and states “[r]eduction in drainage flows as a wastewater demand...is achieved primarily through capital works to provide an alternate location for drainage flows” where stormwater systems are entirely disconnected from the wastewater collection system (p.29). Peak volume wastewater flows, like peak stormwater flows, occur with rainfall and snowmelt events (City of Ottawa, 2009, p.29). The City's economic position on wastewater and stormwater management is clearly indicated in the *Infrastructure Master Plan* (2009):

> [i]t is considered more cost effective to undertake to limit and prevent extraneous flows in new systems than to remediate excess extraneous flows in the future....The magnitude of the peaks during wet weather events indicates that the primary opportunity for peak demand reduction is through the control of drainage flows and extraneous flows.....A wet weather strategy focused on extraneous flow removal from existing systems and control of future extraneous flows has previously been identified as the most effective means to achieve meaningful demand reduction and realise possible benefits of reduced or deferred infrastructure costs and increased reliability of service levels. (p.29)

In the above statement, the City of Ottawa (2009) has established three major ideas: (1) stormwater management has a significant impact on and ability to mitigate concerns related to local wastewater infrastructure capacity; (2) the most economically effective strategy regarding limited capacity concerns in wastewater and stormwater infrastructure networks is pre-development mitigation; and (3) using pre-development mitigation techniques may result in both economic and broader savings for the municipality (p.29). These ideas support Ottawa's broader stance that planning and finance are inextricably linked, and therefore development charges need to reflect "current actual costs of projects" (City of Ottawa, 2009, p.38). As Ottawa has both development approval and infrastructure management duties, a high degree of responsibility and a certain degree of flexibility are afforded to the City regarding local infrastructure specifications.

3.2.3 Infrastructure planning and finance framework

Manitoba Capital Region.

In Manitoba, inter-municipal planning involving the City of Winnipeg has, at times, been made difficult by the division of the legislated planning framework. In addition to infrastructure conflicts regarding water services, City of Winnipeg operations – including planning guidance – are almost entirely established through *The City of Winnipeg Charter* (C.C.S.M. 2002, c.39) (Regional Planning Advisory Committee [RPAC], 2003, p.70). All other Manitoban municipalities' (and planning districts') planning and development operations are essentially governed through *The Planning Act* (C.C.S.M. 2005, c.P80) and *The Municipal Act* (C.C.S.M. 1996, c.M225). This has been an ongoing issue with impacts to both the PMCR and individual planning authorities' working relationships(RPAC, 2003, pp. 18, 48, 81-82).

Like all other Manitoban municipalities the City of Winnipeg's own established planning framework should comply with the *Provincial Planning Regulation* (Reg. 81/2011, C.C.S.M. 2005, c.P80), which outlines the Provincial Land Use Policies (PLUPs) (RPAC, 2003, p.18). Once a municipality has adopted a development plan by-law that complies with the PLUPs, planning and development decisions are then deferred to the policies established within that local development plan and any accompanying secondary plan by-laws (RPAC, 2003; Manitoba Local Government, n.d. b; Manitoba Conservation, 2009, pp.120-121). All development plan by-laws and ensuing amendments must be approved by the provincial planning body to ensure compliance with the PLUPs: however, once a development plan by-law has been approved, a municipality or planning district may adopt or amend any number of secondary plan by-laws without provincial approval (RPAC, 2003; Manitoba Local Government, n.d. b). While development plans address holistic intents through vision statements as well as broad policy and land use guidance for landowners, developers, and residents, secondary plans allow a finer level of control - allowing inputs such as site runoff controls and design guidelines for stormwater infrastructure - to be established for designated areas.

Public consultation is conducted prior to the drafting of a development or secondary plan to ensure that the vision statements and implementation strategies are reflective of local needs. Development plan by-laws function by binding planning authorities and stakeholders including landowners, developers, and residents to the policies. The City of Winnipeg in particular has managed to evade much of the binding nature of this framework for sustainability- and water- related planning concerns with its last development plan by-law approved and adopted in the summer of 2011: by adopting both the *Sustainable Water and Waste Directional Strategy* and *A Sustainable Winnipeg Directional Strategy* as strategies, as opposed to by-laws, policies have become suggested guidelines instead of requirements (City of Winnipeg, 2013e).

This concept is very similar to the City's current methods of securing developer contributions for the cost of infrastructure and community amenities. Under *The City of Winnipeg Charter* (C.C.S.M. 2002, c.39), the City has established development agreement parameters that govern the scope and structure of developer contributions (City of Winnipeg, 2002, p. 4). The City can require a development agreement to be established as a condition of approval for any application for a re-designation, rezoning, conditional use, or subdivision - but not a building permit (C.C.S.M. 2002, c.39). Other capital region municipalities can apply the same conditions through *The Planning Act* (C.C.S.M. 2005, c.P80). Set charges or charge formulas for infrastructure necessitated by different types of developments can be established through by-law, as established in the municipalities of Cartier, East St. Paul, Macdonald, Ritchot, Rockwood, St. Andrews, St. Clements, St. François-Xavier, Selkirk, Springfield, Stonewall, Taché, and West St. Paul (but not Headingley, Rosser, or Winnipeg); however the majority of infrastructure servicing provisions and costs remain governed through individually negotiated development agreements (*Fees and Services By-Law 1616-11; By-Law 2008-08; By-Law 03-04; By-Law 6-2006; By-Law #21/11; Capital Development Fees By-Law 4148; By-Law 14-2009; By-Law 7-2013; By-Law No. 5195; By-Law No. 11-21; By-Law 7/10; By-Law No. 18-2009 and By-Law No. 6-2010;By-Law No. 2012-01*).

Winnipeg's development agreement parameters are designed to work in concert with cost recoveries (re: oversizing provisions) and local improvement charges as established by Council (City of Winnipeg, 2002, p.4). Most drainage-based infrastructure fees are calculated using the area-based Trunk Service Rate value established by the City (City of Winnipeg, 2006, p.15); however these fees are somewhat open to negotiation based on the structure of the development agreement process itself. Development agreements are secured through either the requirement of an up-front performance lien from the developer, or the establishment of a development control strip (where the City assumes title to a narrow parcel of land that splits the rest of the developer's landholding from existing city infrastructure such as roads and water pipes) (City of Winnipeg, 2002, pp.7-8).

In a development agreement, stormwater management is addressed through: the basic grading plan; preservation of City access to stormwater management ponds for maintenance; and cost-recovery for oversized infrastructure (City of Winnipeg, 2002). Development agreements traditionally require a master site grading plan (City of Winnipeg, 2002, p. 11). Site grading plan requirements, as defined by the City of Winnipeg (2012), are distinct from those found in specific stormwater management and drainage plans such as those required by the City of Ottawa (n.d. b). Winnipeg guidelines establish requirements for the direction and flow of surface water within sites: development proposals with sites of over 1,000m^2 are required to maintain internal drainage to accommodate a 1-in-25 year storm (City of Winnipeg, 2012, p.4). The structure of the development agreement process leads to a site-by-site, development-by-development approach to stormwater management. This could be quite a strong approach if linked to more detailed stormwater management criteria; however this does not appear to be the case in Winnipeg or other capital region municipalities today.

National Capital Region.

The *Provincial Policy Statement* (2005), a series of guiding principles for Ontario municipalities produced under Section 3 of the *Planning Act* (*Planning Act*, R.S.O 1990, c.P.13), that predate Ottawa 20/20 requires planning authorities including the City of Ottawa to: plan at the watershed level and identify locally and cross-jurisdictionally significant water bodies, courses, and natural features; ensure efficient and sustainable use of local water resources; use development controls to protect and/or improve the ecological functioning of vulnerable areas and natural features including those related to surface- and ground- water; and, use alternative approaches of development to protect, improve, and/or restore ecological and hydrologic function in surface- and ground-water features (Section 2.2).

The Province of Ontario passed *The Sustainable Water and Sewage Systems Act* (*The Sustainable Water and Sewer Systems Act*, S.O. 2002, c.29) in an effort to ameliorate financial strains related to municipal water infrastructure; however, by proxy the nature of the subject matter in the act also addressed some environmental water quality measures. The act was intended to force municipalities providing water and wastewater services to develop fully cost-recoverable servicing plans, which were to be confirmed by a municipal auditor and approved by the Minister of the Environment (*The Sustainable Water and Sewage Systems Act,* Sections 3, 4). The costs to be covered under this act were to include not only traditional service provisions (operations, maintenance, and financing) but also source(water) protection (*The Sustainable Water and Sewage Systems Act,* Section 7). *The Sustainable Water and Sewage Systems Act* was passed by the province in 2002; however it was never proclaimed and thus was automatically repealed in December 2012 as it had not come into force within the required time frame for legislative and/or regulatory instruments.

A significant proportion of the City of Ottawa's financial resources and staff expertise is consumed by infrastructure planning and management. The City of Ottawa (2009) has forecasted it will require $1.58B, or 25% of capital spending, for water and wastewater infrastructure capital projects until 2020: 79% of funding is to be used in the repair and upgrade of existing systems, 17% for new infrastructure, and 3% to meet ongoing regulatory requirements (p.19). The City of Ottawa's *Infrastructure Master Plan* (2009) provides guidance for planning and engineering studies, facility and operations studies, design guidelines, and construction standards (Figure 2.1 Infrastructure Planning Process). These resulting documents feed into completed Community Infrastructure Plans, which combine infrastructure requirements with policy guidance from the Official Plan via Community Design Plans and other secondary documents (City of Ottawa, 2009, Figure 2.1 Infrastructure Planning Process).

A high level of importance is placed on stewardship of the City's infrastructure. Policies of the Infrastructure Master Plan (2009) direct Ottawa to consider the broader planning framework (the seven principles of Ottawa 20/20 as well as the additional four planning areas with dedicated planning documents) in addition to more conventional infrastructure planning tools such as asset management, financial modelling, risk assessment, and technological improvements (pp.39-42. 45-63). Ottawa 20/20 directly identified green infrastructure and natural resource management as key assets for the future (p.42). To reflect this priority, the City of Ottawa formally established the desire to complete an environmental strategy to provide more detail regarding valuation of green infrastructure and natural capital, as well as to formulate benchmarks for local infrastructure (pp.42-43).

A cornerstone to the integration of infrastructure and land use planning in the City plans is "consideration of impacts on the natural environment" (City of Ottawa, 2009, p.45). The framework for integration, which includes more conventional considerations of network optimisation and rehabilitation, is strongly financially motivated: the City recognises that without consideration of "[t]he relationship between infrastructure and the environment [that] extends well beyond the planned use of surface and groundwater for water supply and wastewater disposal" (p.46), it will be extremely difficult to continue to provide affordable water and wastewater services. Further, the City recognises intense rain and snow melt events contribute to higher flows at local wastewater treatment facilities, localised flooding, and ongoing seasonal problems with septic systems in rural areas (p.46). Overflow events, localised flooding, and groundwater contamination often result in significant burden on residents and provincial and/or federal fines, in addition to the broader problem of environmental degradation in both local and downstream water bodies (p.46). The overarching shift in the planning framework required to facilitate all of these practices requires strong integration of the City's ongoing sub-watershed planning, community design planning (secondary planning), and development control procedures as directed in the *Provincial Policy*

Statement (2005) under Section 3 of the *Planning Act (Planning Act,* R.S.O. 1990, c.P. 13).

Local innovation in stormwater management is fostered through the *Infrastructure Master Plan* (2009) policy area 6.2, which discusses, among other initiatives, the City's intent to work with local home builders' associations and building owners' associations on a voluntary basis to credit the organisations in a means proportional to "the flow removed through a compensation project and the benefit for the system (e.g., flow removed upstream in the system would have more benefit than the same flow removed downstream in the system)" (p.79). These 'compensation projects' include most of what this research seeks to address directly through a restructured development charge framework: parking lot retention and pervious pavings, on-site water storage, construction of green roofs and/or disconnection of flat roofs from the local stormwater infrastructure network (City of Ottawa, 2009, p.79).

The Ampersand neighbourhood development in South Nepean, Ottawa, for example (see Figures 6 and 7 on the following page), is a mixed-use (primarily residential) development with green roofs, permeable surfacing, and storm- and grey-water capture, treatment, and reuse; the developer also integrated a series of other energy considerations into the design with support from CMHC and Natural Resources Canada through Canada's ecoAction Plan (CMHC, 2011).

Credits earned through this program can be applied to other drainage requirements within the same development or exchanged with another developer for

Figure 6: Greenspace in the Ampersand neighbourhood development in Ottawa, Ontario. (Photo by R. Kotak, 2013, used with permission.)

Figure 7: Rainwater capture in the Ampersand neighbourhood development in Ottawa, Ontario. (Photo by R. Kotak, 2013, used with permission.)

application to a separate development, but must remain within the original stormwater management area (City of Ottawa, 2009, p.80). The City of Ottawa inspects the oversees the modifications made on the particular site for projects in this program(pp. 79-80). In addition to the agreement with the developer, the credit is registered to the official title of the property in question (City of Ottawa, 2009, p.80).

Two other initiatives of the *Infrastructure Master Plan* (2009) policy area 6.2 are active discouragement of design features that may contribute negatively to flooding concerns (pp.80-81), and active fostering of green building practices to reduce growth-related network use requirements (pp.81-82). Through work with the local homebuilders' associations and building owners' associations, as well as the Ottawa Construction Association and Ottawa Housing Corporation, the City of Ottawa (2009) has committed to establishing a targeted suite of green building tools for the local development industry (p.82). The City of Ottawa (2009) has stated a desire to pursue green infrastructure opportunities in relation to potable water, wastewater, and drainage systems with both developers and inhabitants of projects. The City also supports stormwater management in intensification areas with combined sanitary-storm sewers with a program for voluntary disconnection of stormwater sources from the network, a scheme that is conceptually identical to the 'compensation projects' discussed above (pp.82-83).

To relate the atypical infrastructure management practices of demand-side reduction and decentralised stormwater management to the local development charge framework, the City of Ottawa (2009) explicitly stated that

> [w]hile flow removal and water efficiency projects do result in the reduction of flows entering the sewer system and, thus, allow future room for flows generated by growth, they are not often specifically growth-related capital projects. The *Development Charges Act*, in effect, encourages the City to build new larger pipes rather than pursuing measures (operating and capital) that would result in similar benefits at a much lower cost...Once capacity-building projects under the water efficiency, water loss, green infrastructure and flow removal programs are identified, the City should consult with representatives of the development community so that the financial benefits of these works in place of more costly traditional capital projects can be fully understood. If the financial benefits are fully explained and illustrated, developers may be amenable to the voluntary pursuit of funding these less-costly projects (p.86).

Prior to the 5-year renewal of the City of Ottawa's DC by-law, Schepers (2009) prepared a policy paper for city Council and the Planning and Environment Committee. This report outlined the recommended policy framework for local development charges to 2014. To move towards implementation of what are essentially stormwater management development charges, the City of Ottawa (2009) created three options for the local development community to consider: (1) the use of DCs for stormwater management, as a formal recognition that this support to create additional capacity within the existing infrastructure networks which would be needed to accommodate the growth; (2) disregard option (1) and continue the status quo; and (3) develop a voluntary development charge contribution program where developers can elect to participate in option (1) for their region. In the latter case, their contribution would exempt them from the component of the charge levied under option (2) (p.87). Any of the three options of this DC framework would be expected to work in conjunction with discretionary exemptions, provincial and federal program funding (particularly FCM's Green

Infrastructure Fund), and the pursuit of other (voluntary and mandatory) means of achieving network management and per-capita increases in regional network capacity (City of Ottawa, 2009, pp.88-89).

Under *The Development Charges Act* (*The Development Charges Act*, S.O. 1997, c.27) Ontario municipalities including the City of Ottawa are required to: (1) prepare a background study detailing eligible services, forecasting local development (location, form, and quantity), and relating anticipated capital and operating costs to forecasted development servicing requirements; to establish eligibility to (2) pass a local by-law within one year of completion of the background study; which requires (3) public consultation (Sections 10-12).

Background work completed by the City of Ottawa (2013k) indicates an infrastructure program value of $6.67B. Of this, the City predicts that $2.65B could be cost-recoverable through DCs over the next two decades – nearly two thirds of which is intended to be recouped from residential development (¶16). The Development Charges By-law *No. 2009 - 216* identified stormwater infrastructure as a designated service under the DC program. It also designated three major areas for the application of DCs: inside the Greenbelt; outside the Greenbelt; and rural areas (Sections 2, 3; Schedule A). Under By-law 2009 - 216, the DCs levied depend on the class of each development: residential development, specifically by dwelling type differentiating between single- and semi- detached, apartment (either 0-1 or 2+ bedrooms), multiple, row, and mobile home dwellings; commercial; limited or general industrial; institutional; and non-residential generally (Section 4).

Overall City of Ottawa (2014a) rates for municipality-wide DCs for residential units within the Greenbelt in 2014 ranged from $9,610 per unit for studio and one bedroom apartments, to $22,173 per unit for single detached and duplex units. Outside the Greenbelt, DCs for the same units ranged from $11,865 to $30,362. Rural rates for serviced and unserviced areas in 2014 were equal, ranging from $3,601 to $8,519. Municipality-wide components of stormwater charges for residential units within the Greenbelt in 2014 ranged from $18 per unit ($11 in 2013), for studio and one bedroom

Area Name	**Relation to Greenbelt**	**Area-Specific Stormwater DC per Single Detached Unit**
Inner Greenbelt Ponds	Inside	$1,077 per unit
Riverside	Inside	$5,066 per unit
Cardinal Creek	Within	$1,718 per unit
Leitrim South Urban Centre	Within	$5,798 per unit
Gloucester Urban Centre	Outside	$4,248 per unit
Monahan Drain	Outside	$1,429 per unit, or sub-areas $3,319 - 4,356 per unit
N5 Channelization	Outside	$6,942 per unit
Nepean Ponds	Outside	$744 per unit
Nepean South Urban Centre	Outside	$4,471 per unit
Shirley's Brook	Outside	$4,052 per unit
Overall Average Area-Specific Stormwater DC:		$3,580 per unit
Average Charge Plus Municipality-Wide DCs for a Single Detached Residential Unit Inside the Greenbelt		$25,753 per unit (Area-Specific Stormwater DC 13.9% of total)
Average Charge Plus Municipality-Wide DCs for a Single Detached Residential Unit Outside the Greenbelt		$33,942 per unit (Area-Specific Stormwater DC 10.5% of total)

Figure 8: Area-specific stormwater development charges in Ottawa. Image by author, adapted from City of Ottawa (2014a; 2014b).

apartments, to $42 per unit ($28 in 2013), for single detached and semi-detached (duplex) units (City of Ottawa, 2013n; City of Ottawa, 2014a). Municipality-wide rates for inside Greenbelt properties were comparable to outside Greenbelt and rural (serviced and unserviced) rates.

Stormwater DCs for municipality-wide stormwater infrastructure are levied against all serviced development types within the three major areas (City of Ottawa, 2013l). In addition to these general charges, smaller area charges are also applied to building permits in eleven catchment areas for dedicated district improvements such as erosion controls, channellisations, and retention ponds (City of Ottawa, 2013m). See Figure 8 for more detail regarding 2014 area-specific residential rates. While serviced area stormwater/drainage DC rates did not change between 2013 and 2014, at $0.02/SF for industrial developments (total DC of $8.41/SF) and $0.04/SF for commercial developments (total DC $19.55/SF), total charges for industrial uses increased by less than $0.25/SF, while commercial development charges increased over $5.00/SF (City of Ottawa, 2013n; City of Ottawa 2014a).

3.3 Linking NCR Planning, IUWM, and Development Finance

This section provides a comparison between interview responses and the previously discussed academic and case study literature. Both interviews added value to the above research: the vast majority of respondent feedback directly supported or dovetailed the discussions of the previous chapters.

Both respondents held senior planning roles with public-sector institutions. Respondents were able to provide information regarding the planning, development, and approvals systems of the City of Ottawa, the Province of Ontario, and the National Capital Commission. Their scope of duties as discussed was varied and included planning provisions directly related to land use, infrastructure, greenbelt, and environmental concerns. They both saw legislation as a driving force for their organisational mandates and they both referred frequently to four Acts: *The Planning Act* (R.S.O. 1990, c. P13); *The Development Charges Act* (R.S.O. 1997, c.27); *The Environmental Assessment Act* (R.S.O. 1990, c. E18); and the *National Capital Act* (R.S.C. 1985, c. N-4). They viewed these four Acts as working in concert with each other to provide a comprehensive framework to address planning, servicing, and environmental issues in the NCR as well as the broader province of Ontario.

3.3.1 Roles and responsibilities

The interviewees both noted the division of land use and development planning from environmental assessment was both an impediment and an asset. While planning documents are housed under the Ministry of Municipal Affairs and Housing (MMAH), the statutory division of labour identifies the Ministry of Environment (MOE) as the Ministry responsible for environmental approvals. They indicated that their respective organisations both work to avoid “overstepping” the MOE’s stormwater management approaches. The environmental assessment and approval process runs in parallel to the broader planning and development approvals process: though development (e.g., subdivision) approval is issued through MMAH or its delegate, approval is often conditional upon the provision of an environmental license through the MOE's separate process. This is a critical distinction as the MOE does not currently allow planning authorities to require developers to build green infrastructure. Recently, however, there has been movement towards revisions for this process to allow GI requirements in extenuating circumstances.

Green infrastructure used in stormwater management was split into two broad categories by respondents: 'man-made', referring to features such as swales, basins, and roofs; and 'natural' (or 'ecological') infrastructure, which primarily includes natural and naturalised features that are valued for their flood-mitigating capacities. As the MOE also establishes detailed design standards/guidelines for man-made stormwater management infrastructure, much of the control regarding green infrastructure in general is inherent to the Ministry. Limited authority over infrastructure approvals for features such as retention ponds has been delegated to some municipalities. However, this only occurs after the municipalities have provided adequate background study materials to the Province to ensure appropriate servicing capacity is maintained.

One respondent identified other organisations outside of the Province that are currently in the process of developing SWM policies for their planning materials. The NCC, for example, works internally with conservation authorities and individual developers to implement stormwater runoff standards equivalent to pre-development figures – even if it requires use of NCC-held lands to achieve such targets. A growing number of upper- and lower- tier municipalities are also implementing SWM-oriented downspout disconnection programs like those initiated by the City of Toronto. At first, the Respondent explained, that program provided partial funding support to property owners to develop on-site stormwater management. With changes in political will, property owners were required to comply with the disconnection directive without municipal funding support. Interestingly, a Respondent noted, Ontario is in the midst of renewed public concern about water quality at beach and swimming venues. This echoes similar concerns that spawned the original widespread movement of the mid-twentieth century that brought stormwater management to the fore.

3.3.2 Research and decision-making support

Both Respondents stated that, in their experience, programs such as those for downspout disconnections or development charges have significant clout when supported with up-to-date information. By undertaking extensive and/or intensive background studies, planning authorities can establish support for the establishment and defence of increased standards. Standards relating to the ecological health of watercourses, for example, are not as tangible as standards related to common law considerations (e.g., impacts to neighbouring lands and landholder rights). The latter, one Respondent explained, identifies criteria such as erosion standards. These criteria have significantly more ability to ensure compliance with proposed standards: particularly since study materials can be presented to landowners during the development approvals process to substantiate the claims of approval authorities.

Respondents discussed the roles of on-site approaches to mitigation intended to address criteria such as erosion thresholds. Both identified required or recommended approaches as a means of generating positive impacts on the health of downstream watercourses. One Respondent provided the example of Green's Creek, where the City of Ottawa was able to require increased infrastructure standards for the retention, detention, and infiltration of stormwater in properties abutting the creek. This occurred because the appropriate supporting infrastructure and stormwater studies were available, and partners from both higher levels of government (i.e. the NCC and Province) worked collaboratively with the municipality to establish a joint process for development approvals within a defined area. However, the Respondent noted, most other ongoing SWM GI interventions are entirely ad-hoc and only very loosely coordinated by area approval authorities. Without the NCC and/or Province playing coordinating and consistent roles, there are very few means by which concentrated impacts may be evaluated.

3.3.3 Economics

Development charges are, in the words of one respondent, "very much a development control mechanism - but it depends on how the municipality elects to implement them."

Respondents highlighted, for example, area-specific charges as a key means of alleviating cross-subsidies in relation to water and wastewater infrastructure. They saw municipality-wide charges, in contrast, as a means of crippling planning objectives through unintended disconnects between planning policy and price signal design. Both of these arguments are well reflected in the reviewed literature.

The MMAH, the Ministry responsible for DC legislation, reviews background studies for infrastructure capacity before approving municipal DC programs. Respondents indicated an overall shift in low-density, large-lot developments since the onset of DC legislation in the late 1990s: as charges rose, prices followed and the pool of buyers has been reduced. This has reduced sprawling development.

An unanticipated direction related to political campaign financing arose when discussing broader implications of DCs. A respondent revealed that development firms fund many municipal politicians' campaigns. This may have significant ramifications for the development of political will to establish a rational nexus for charges related to green infrastructure. If there is no political will at the provincial and/or municipal levels to establish charges and to build technical capacities, there is no benchmark to which local developers can be held.

The MOE currently requires developers to provide additional contingencies, such as increased easements, when installing GI in projects. If further research demonstrating the efficiencies and impacts of GI is undertaken on behalf of the MOE, Respondents suggest there is potential for contingencies to be waived. The resulting cost reductions may spur the adoption of GI by more area developers. If a sliding scale were to be developed for a GI-based DC program, developments with certain characteristics aligning with planning goals could be eligible for reduced charges or exempted entirely from stormwater-related DCs.

While focusing on tangible criteria for charges (e.g., erosion thresholds and retention of overland flows), Respondents argued that water quality improvements can be made on land use and development control bases in statutory planning documents and the development approvals process. However, development controls only address changes to the status of sites: this approach does not consider the ongoing maintenance of on-site works. Respondents were clear that in order to address stormwater management and GI holistically in a long-term and sustainable manner, the "whole gamut" of municipal tools are required to fill the gaps in existing regulatory processes.

One Respondent raised the example of Kitchener, Ontario as a potential best practice under existing legislation: funding for stormwater works has shifted from property tax revenues to a stormwater utility fee and credit system. Set fees are levied based on each property's use and lot size, while credits are applied against fees for all on-site stormwater management installations. The formal rationale for Kitchener's stormwater utility fee structure, as presented by the Respondent, was that cost savings inspire retrofits to existing properties: installations such as green roofs, living walls, bioswales, rain gardens, infiltration trenches, cisterns, and permeable pavings – all things discussed in this research previously – are used to reduce established fees based on a handful of relatively simple volumetric calculations. This results in a 'user-pay' approach to stormwater management that has generated considerable interest in, and completion of, widespread GI retrofits. Both residential and commercial land uses have demonstrated stormwater improvements, although the latter has shown more innovation.

Respondents also identified other, broader sustainability-oriented uses of municipal finance tools that have recently been permitted through legislation. Municipalities can now engage in bulk purchasing of materials for sustainability-driven retrofits through the use of local improvement charges. For example, a municipality could purchase a large number of solar panels at discount, provide the panels to homeowners, and then finance their costs over a 10-year period. Top-down political leadership is a driving factor in the use of these sorts of interventions. However, Respondents also recognise citizens' rights to petition council for local improvements as a means to generate bottom-up changes in neighbourhoods that are progressive and organised in nature. The clarity of calculations and concrete basis upon which they are levied make development charges, as one Respondent put it, "less difficult to fudge." Using the structure inherent to DC programs as a template to provide clear, articulated criteria for GI for areas undergoing (re)development may help provide GI with a more accurate price signal as discussed in Chapter Two. When combined with a suite of other supportive funding instruments, GI may, in the words of a Respondent, "make it into the mainstream" sooner rather than later.

Best-case visioning. Respondents were open to establishing a coordinated, watershed-based GI approvals system guided by a DC framework and involving the local conservation authority(ies). They also noted a high degree of potential for a coordinated multi-stakeholder approach to generate measurable positive results. With an accurate price signal established by a tiered or sliding-scale DC system and modernised pro-GI legislation and approvals processes from the MOE, municipalities and conservation authorities would, in the eyes of the Respondents, be able to require developers to consistently implement uniform best practices across their jurisdictions.

Within such a framework, Respondents indicated long-term cost-effectiveness could overcome (potentially) higher up-front costs through sustainable stormwater management principles supported by both planning policy and financial directives. Respondents also cautioned that stormwater sewers would still be required for municipal liability protection under any new approach to infrastructure. However, one Respondent also noted, there has already been movement towards reducing infrastructure standards from the 100-year storm threshold in pilot projects. Widespread implementation of the pilot approach could result in piped services with reduced overall capacity and cost.

Overall, Respondents were very positive about GI in particular and had favourable views of existing land use controls and planning policies regarding stormwater management. Respondents saw strong benefits for proactive stormwater management in their day-to-day work, and supported the continued research and development of implementation tools such as design standards and resource handbooks. Respondents were also clear that more performance-based research is needed to reduce approval authorities' uncertainty of GI and, ultimately, the overreaching safeguards they currently require (e.g., development areas with bioswales, retention ponds, full sewer systems, and additional protective buffer strip easements).

Respondents noted that significant improvements could be made to financial frameworks to bring them in line with planning policy statements. The horizontal integration of planning-related tasks – environmental assessments in particular – was raised as an area with potential for future work. The political system was highlighted by Respondents as the critical source for advocacy of further work in stormwater management and the use of sustainability-driven development finance tools. Without continued political support, Respondents were not confident that the current system of GI and stormwater management policy could build upon or maintain its' momentum.

3.4 Building an IUWM-based Finance Framework

To efficiently address existing shortfalls, the literature and case study review suggest a series of steps need to occur. First, following SWITCH (2011) objectives discussed in Chapter One, a series of interdepartmental, intergovernmental, and inter-sectoral policy-level discussions should be held to determine the most constructive approach to solving this wicked problem (Rittel & Weber, 1973). Stakeholders including planning authorities, water-oriented organisations/coalitions/foundations such as the Lake Winnipeg Foundation and the public at large could coordinate a campaign to overcome any insufficient political will at the Provincial level.

Second, the policy-level multi-stakeholder discussions would need to identify appropriate regulatory directives and policy commitments to be established. This, as

Sharma et al. (2012) and Burn et al. (2012) discuss, can reduce the disconnect (i.e., inadvertent or direct conflicts and gaps) between departmental policies to establish a more holistic policy environment capable of enduring political shifts and generated paradigm shifts in the tools and procedures used in 'on the ground' implementation.

During the establishment and outlining of directive indicators, policy and technical support materials need to be produced. Water management, Bahri (2012) states, has been systemically disconnected from planning processes in many jurisdictions. It is critical that implementation tools and guiding materials are produced to support the transition from provincial policy statement to integrated planning, design, and water management approvals at the municipal level. These materials must provide specific and measurable financial, environmental, and procedural information related to both policy-level development and technical skills for the planning, inspection, construction, and maintenance of on-site works. Throughout this process, the coordinating organisation (i.e., provincial planning) would need to host ongoing consultations with local industry stakeholders regarding both shortfalls and insights into future trends for design standards, costs/financing, inspections/maintenance, and approvals processes.

Municipally speaking, WSUD-based stormwater management approaches are outlined in the City of Winnipeg's *Sustainable Water and Waste*, a "Direction Strategy" for implementation support that accompanies the City's current development plan by-law. This Direction Strategy outlines the use of GI identified throughout this research including "elements such as green roofs, pocket parks, vegetated bio-retention ditches or swales, bio-retention cells, modified tree pits, rain gardens, permeable paving" (City of Winnipeg, 2011, p.53). These techniques are examples of growth towards integrated sustainability, which was demonstrated in all phases of planning Hammarby Sjöstad and, ultimately, the development of the Hammarby Model (Miller, 2011). In agreement with authors such as Mitchell (2006), Policies 4 to 6 of the City's stormwater management and flood protection section focus on the integration of on-site GI to reduce site runoff, reduce impacts to local watercourses, and develop strategies for on-site retention using naturalised solutions such as artificial wetlands and other ecological solutions to support improved flood resiliency (City of Winnipeg, 2011, pp.37-55). However, these approaches are suggested – not required – guidelines for developers.

In order to make a consistent and concerted effort, this progress at the municipal level needs to be reinforced at the provincial and regional levels to allow local governments to move from 'requesting' developer participation to 'requiring' developer participation. If all municipalities within a region (as, in this case, represented by the Manitoba Capital Region) committed to establishing the same or similar requirements and series of incentives, competition for development amongst the local governments would be equalised and developers would not be able to effectively bargain one municipality's requirements against another's. Fees paid for GI-related 'offsets' could be placed into a dedicated reserve fund, as any other infrastructure-specific levy would be (Slack, 1994). This funding could be accessed for both regional improvements and the development of stronger support tools such as highly detailed background studies to forecast costs, as well as publicly accessible technical design guidelines to facilitate the construction processes - and ultimate "bottom line" costs - of said GI. The use of DC reserve funds for specific infrastructure planning purposes (e.g., studies and supporting administration) is not new: Ontario has permitted this through its *Development Charges Act* (*The Development Cost Charges Act* S.O. 1997 c.27) for over a decade.

In both the literature review and key informant interviews regulatory directives were viewed as critical pieces in the establishment of municipal and regional (e..g, conservation authority-based) implementation of both green infrastructure and broader sustainability-oriented development charges. Infrastructure financing tools structured to provide accurate price signals to stakeholders were seen as instrumental to the successful implementation of both green infrastructure and related stormwater management goals by authors such as Bahri (2012), Blais (2011), Roy et al. (2008), Slack (1994), and Tomalty and Skaburskis (2003). They concur that price signals *must* support planning objectives, and this requires strong political will and dedicated policy development at all levels of government: clear directives need to be established at the provincial and federal levels identifying which concerns (e.g., development and water quality) usurp others, with specifics in relation to both when and how.

Further research is absolutely paramount to the implementation of GI. The development of detailed background studies, for example, supports both the development of internal capacity for public servants to establish new requirements as well as linked charges with a defensible rational nexus. By building expertise, providing training, and disseminating understanding, increased capacity and trust can be established across the public and building sectors. This, plus sustained homeowner education and marketing, is absolutely critical to the successful and widespread implementation of GI and was emphasised heavily by both interview Respondents.

The use of development charges to foster a baseline level of on-site stormwater management was supported by both case study evidence and the academic literature, but for effective implementation broad-reaching price signals must also be used: as discussed by one Respondent, DCs bolstered by continued program-based price signals such as those established by Kitchener's stormwater utility may have the potential to get GI-based systems built *and* maintained properly, even in jurisdictions without provincial-level regulatory directives for sustainable water management. Approaches such as this one have been both publicly and politically palatable in Ontario. They have resulted in both real-world changes to existing developed areas, and increased municipal financial capacity for service provision. With a use-based fee and credit system such as those established by Kitchener's stormwater utility, a Respondent asserts that cross-subsidisation is no longer of significant concern.

The Respondent described a system in which individual property owners "pay their way" in a use more, pay more system that has been publicly accepted to a surprisingly high degree in a reasonably short period of time. Both respondents clarified that commercial users are, and are more likely to, engage credit systems more than residential users as they quickly recognise the benefit of long-term savings. Alternatively, one Respondent noted, Kitchener schools have been unable to amass the financial capital required to implement stormwater management infrastructure on-site or pay the fees required for sites without GI. In these cases, the municipality and schools have taken to establishing joint use agreements for on-site improvements. This has resulted in schools obtaining utility credits/offsets, and the municipality being able to reduce their portion of easements otherwise required between roadways and school sites. This sort of approach is both welcomed and fostered through the SWITCH (2011) principles discussed earlier in this thesis.

While Kitchener has demonstrated success in the implementation of a stormwater utility, there is consensus among authors and Respondents that a considerable amount of research and development is still required for widespread implementation of GI- or stormwater- based DCs. Most importantly, a planning policy framework needs to be developed to ensure that adequate price signals are established and that costs - environmental and otherwise - are actually covered. The framework must establish clear and articulate principles to ensure that planning and (green) infrastructure goals are both prioritised in a co-development approach. Authors and Respondents note minimum thresholds (e.g., pre-development levels or better) need to be established, and strong mandatory penalty and appeals processes need to be established for shortfalls. These may include provisions similar to DC-based "oversizing" needs, where the costs of off-site improvements are levied against developments not capable of meeting needs on-site. Penalties must be significant enough to deter the alternative; however approval authorities should be accommodating regarding the use of public/municipal reserves to meet local stormwater management needs to incent change in site-based physical interventions for GI instead of simply inflating the costs of ‘business as usual.’

4.0 BROADER PERSPECTIVES: CONNECTING IUWM & PLANNING DCS

This chapter contains a summary of findings, recommendations for implementation, and opportunities for future research. The first sub-section provides with a summary of the related academic literature, case study findings, and addresses recommendations as derived from this research. The second sub-section provides suggestions for a potential series of 'next steps' beyond the scope of this research.

4.1 Research Summary

4.1.1 Key Findings from the Reviewed Literature

The three segments of literature review (sustainability and sustainably designed developments; integrated urban water management; and, development finance controls) have revealed a number of overarching themes. First, there is no panacea for sustainability, sustainable development, nor water management: planning problems are 'wicked' (Rittel & Webber, 1973) in nature and embedded into the socio-economic, cultural routines, and governance models of society. Both the concepts of 'wicked' problems and integrated solutions are not new: the philosophy of integrated planning for water management has existed under different names for decades (Heaney, 2000). However, through continued work in the fields of stormwater-sensitive urban design (collectively referred to as WSUD in this research) and related green infrastructure (GI) approaches (authors including Bahri (2012), Brown (2008), and Roy et al. (2008)), as well as through projects such as SWITCH (2011), many more research-driven *and* hands-on infrastructure design, management, and planning approaches have begun to emerge with the potential to facilitate incremental shifts towards sustainability in local, sub-national, and national governance models. If WSUD programs are implemented within the scope of an intra- or inter- watershed-wide IUWM framework, they may provide a more effective means of addressing both site-specific and watershed-wide stormwater management in relation to both lotic and lentic health (Roy et al., 2008). Carmon and Shamir (2010) advocate for legislative/regulatory and economic reform to foster water sensitive planning principles and support the transition into a new paradigm of water management (p. 187). The creation of a mutually supportive IUWM/WSUD strategic framework may also directly support improved health in downstream ecosystems (Roy et al., 2008, p.357). While both of these arguments are relevant to a joint IUWM/WSUD approach, the latter may be of great (and timely) interest to restoration efforts focused on Lake Winnipeg.

Second, to build towards positive impacts in environmental health and sustainability, academic research could advocate for the development of practical, multi-disciplinary, cross-sectoral, and integrated alternatives. One such alternative for the interim may be the stronger alignment of planning objectives of water management (e.g., ‘improved water quality in downstream waterbodies’ or ‘reduced number of combined sewer overflows’) with tangible, discrete quantitative benchmarks such as ‘no net runoff’ that can be both demonstrated and carefully measured at further stages of implementation. However, insufficient data still exists for sufficient governmental ‘comfort’ with implementation: GI projects in particular have many unknown design factors related to impacts from extreme climactic conditions such as those experienced in the Manitoba Capital Region (Engineers Canada, 2012; FCM, CSCE, CPWA & CCA, 2012).

Many jurisdictions that have adopted GI targets have done so through optional enabling provisions and still require traditional infrastructure with sufficient capacity to service the site regardless of the potential capability of the green infrastructure (GI) system (Roy et al., 2008). Demonstration and/or pilot projects undertaken jointly by academic, governmental, and development groups using GI - including bio-mimicry or "ecological engineering" in particular - may be a means of establishing a more detailed understanding of differing needs and developing appropriate performance targets that are responsive to local climactic conditions, substrates, and landforms (Novotny, 2008).

Third, reviewed literature suggests a considerable disconnect between planning objectives and development charges (DCs), a popular finance tool used by many local governments (i.e., municipalities and regions) under the guidance of enabling provincial legislation to assist in the provision of infrastructure necessitated by growth. While "[e]conomics play a major role in urban water management" (Rauch et al., 2005, p.397), the importance of other land use planning decisions related to density (including sprawling development), and the physical provision and expansion of infrastructure networks cannot be underscored enough (Skaburskis & Tomalty, 2000). The literature review found that authors including Slack (1994; 2002), Tomalty & Skaburskis (2003), and Blais (2010; 2011) noted that the implicit and explicit impacts to land use regulation - including those related to stormwater management - caused by these planning policy decisions correspond to the current structure of many development charge programs: in other words, DCs often incent development with physical characteristics in flagrant opposition to sound planning principles. In addition to often failing to support planning, DC programs are also currently not structured to recuperate appropriate shares of true infrastructure servicing costs (Sustainable Prosperity, 2014).

Full-cost accounting is not typically used to set fees, and established fee schedules do not typically utilise marginal cost pricing (Slack, 2002; Blais 2011). Using average cost pricing over large areas of land can establish significant cross-subsidies, where developments that generate lower levels of need (e.g., urban densification through infill developments) subsidise developments with higher infrastructure needs (e.g., large-lot greenfield developments) (Slack, 1994; Sustainable Prosperity, 2014). Barbosa, Fernandes, and David (2012) suggest that legislative reform can begin to move fees including DCs from cost-recovery items in budgets, with little or no support of planning principles, to pro-active means of ensuring planning policies are reflected holistically at multiple stages of land use control (i.e., via policies and regulations drafted under legislative Acts, development and secondary plans, zoning by-laws, and the development approvals process). In addition to cross-subsidisation, established DC programs examined in the reviewed literature did not provide any support for valuation or affiliated charge mechanisms for environmental externalities or ecological goods and services (Stoddart & Cruikshank, 2012). Some credits were established for “green” buildings outside of the jurisdictions examined in the case study component of this research; however the uptake of these programs has been limited at best and little to no established criteria outside of the green building certification process have been implemented in the DC rebate evaluation process (CMHC, 2005b).

4.1.2 Key Findings from the Case Study

Overall case study findings supported arguments made in the reviewed literature. Fragmentation of governance was seen as a root cause of weak connections between development and environmental approvals processes. The importance of provincial leadership cannot be underscored enough. Legislative and regulatory processes take time to update, and consequently lag behind best practice development; this causes incremental implementation of innovative planning and environmental management tools including GI. Two particular stopping points in the current process were identified: first, inaccurate price signals that do not reflect the long-term impacts of development decisions on the landscape; and second, overly cautious redundancies, which are currently implemented in the development approvals process to protect municipal liability and require significantly more research and design support before standards can be amended.

In light of these issues, respondents are positive that innovation is occurring and that research initiatives are underway to support the widespread implementation of more sustainable forms of stormwater management. Respondents indicated that multi-pronged, holistic approaches are required to overcome institutional gaps and address sustainable development and (storm)water quality issues. The two key levers identified as "the legitimate way forward" for widespread implementation of GI for stormwater management were the establishment of regulatory directives and production of accompanying support materials (including accurate price signals). Three key actions were outlined under these two levers: building expertise; providing training; and disseminating understanding. This research has confirmed that clear, consistent, and well-communicated approaches to stormwater management are key for the public sector to generate significant 'on the ground' improvements.

4.1.3 Implementation Discussion

Three things are critical for the widespread implementation of sustainable stormwater management principles within an IUWM/WSUD approach:

- regulatory directives, preferably established through legislation;
- appropriate use of supporting infrastructure finance tools to establish appropriate and accurate price signals implemented at all stages of the planning, development, and maintenance processes; and,
- widespread dissemination of educational resources including both technical, builder-specific documents, as well as homeowner-oriented marketing and maintenance materials.

While development charges can play a strong role in the establishment of green infrastructure at the point of (re)development, it is crucial that continued municipal, regional (e.g., upper-tier governments or conservation authorities), and provincial efforts foster maintenance by ensuring incentives to sustain the works as originally designed.

From a municipal perspective, the first step towards implementation of an IUWM-based development finance framework would involve a firm understanding of existing infrastructure costs. Completion of a detailed background study is essential to the development of an IUWM-based program for a single municipality, or the entire Manitoba Capital Region. A grounded exploration of the technical, financial, and social considerations for implementation of specific forms of GI would follow next. Following stakeholder consultations, draft by-laws could be established outlining alternative development standards (i.e., site design 'codes', much like building codes, but for landscapes) for implementation in pilot areas, and, ultimately all municipalities within a region. Because GI standards would be presented as alternatives, members of the development community would be free to elect to participate in the design and implementation of GI, or opt out entirely at their discretion. This establishes an approach suitable for implementation in a constrained fiscal environment such as that experienced by politicians in slow-growth regions - yet the approach is also transferrable to politically volatile fast-growth regions due to its 'give-and-take' perspective.

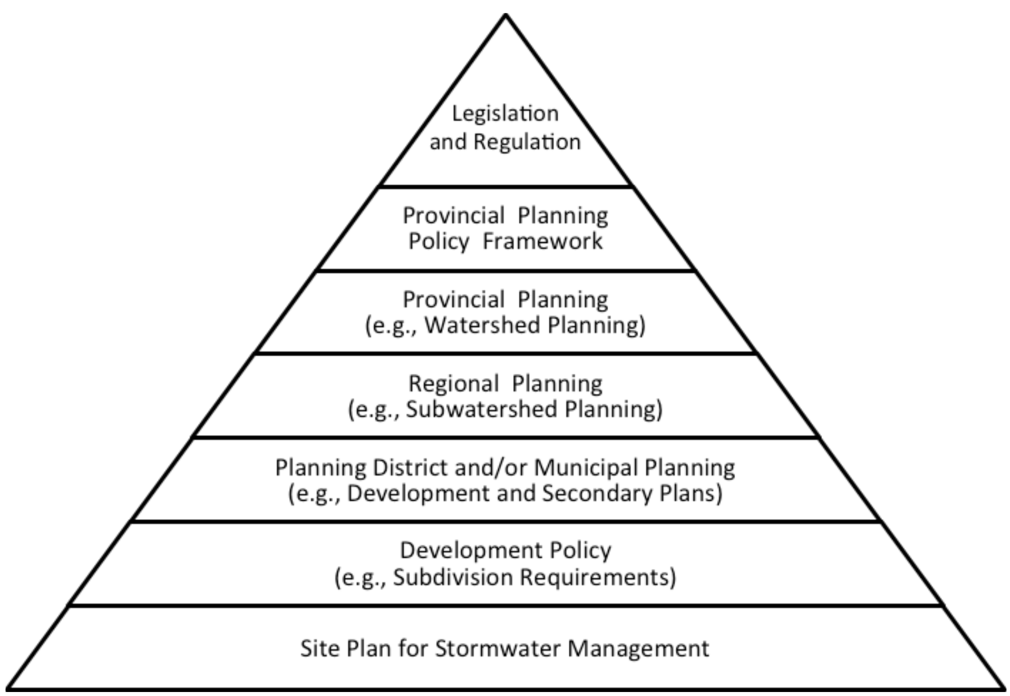

Figure 9: Steps in the planning and development process. Image by author (2013).

4.2 Opportunities for Further Research

As discussed briefly earlier in this chapter, an opportunity exists for further hands-on research into the development of Canadian extreme continental climactic (i.e., Manitoban) design specifications for green infrastructure. Some work regarding GI standards is already being undertaken by various faculties at the University of Manitoba, but that work needs to be expanded to include alternative standards and detailed cost estimates for multiple scales of implementation. Impacts related to green infrastructure for stormwater management in the areas of: flood resilience; building code modernisation and infrastructure equivalencies; construction and life cycle cost estimates; combined network (i.e., traditional 'piped' infrastructures plus GI) capacity; nutrient reduction; and re-examination of sanitation/pathogen standards for stormwater within the wastewater umbrella also have significant potential for further work in both the public and private sectors. Establishing a series of baseline data points regarding the costs and benefits of stormwater infrastructure in particular would greatly facilitate the establishment of (and governmental 'comfort' for) more holistic development charge systems that integrate environmental externalities into their cost calculations.

An environmental valuation approach may also facilitate stakeholder discussion and soothe public opinions regarding the distinct political shifts necessary for the implementation of environmentally-cognisant charge mechanisms. Further exploration of the similarities and differences in sustainability and sustainable development controls between provincially-governed and federally-governed jurisdictions may provide additional insight into the use and effectiveness of public administration as a means of driving sustainability policy across Canada.

4.3 Closing Remarks

Fortunately or unfortunately, much of the driving force behind establishing sustainable planning policy priorities including fostering innovation in stormwater management rests with Canada's provincial and municipal governments. Policy change in these bodies relies on political leadership, which seeks to represent the views of their electorate. As such, the onus for that shift rests with local stakeholders and may take a long time to occur.

However, the reviewed academic literature, case study materials, and interview respondents all confirm that, while incremental, change *is* occurring. Price signals and stakeholder demands are driving municipal and provincial governments towards more sustainable modes of planning for development. With mutual understanding between the public and private sectors, clear provincial direction, municipalities' participation in - and individual alignment with - collective sustainability-driven provincial and regional planning objectives, the researcher is optimistic that continued positive change can be made.

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APPENDIX A: ETHICS PROTOCOL

Submission Contents:

1. Summary of Project
2. Research Instruments
3. Participants
4. Informed Consent
5. Deception
6. Feedback / Debriefing
7. Risks and Benefits
8. Anonymity or Confidentiality
9. Compensation
10. Dissemination

Original Submission Attachments:

- Ethics Protocol Submission Package (question section, form, and checklist)
- Research Instruments:
  - Participant Recruitment E-mail
  - Participant Guides (3)
  - Question List for Semi-structured Interviews (2)
  - Informed Consent Form
- Certificate of Completion – TCPS 2 Program

1. **Summary of Project:**
This thesis explores the use of development charges (DCs) as a sustainable planning policy tool through establishing a framework to address sustainable water management. This will be accomplished by focusing on whether and how development charges can be used in Canadian slow-growth city regions to provide incentives for sustainable urban infrastructure practices through facilitating the decentralisation of water management. The forms of sustainable water management explored in this thesis address stormwater in particular and include both landscape- and building-based strategies such as bioretention, infiltration, and dispersion.

This thesis work will be undertaken in four stages: First, I have developed a methodology by which to assess the relationship between development charge and green infrastructure (GI) programs at the provincial and municipal levels in slow-growth capital regions in Canada. DC and GI programming was examined in relation to urban and peri-urban surface water management (SWM) planning programs, strategies, and initiatives. This stage has been completed through archival research only; Second, I will assess the planning implications associated with SWM, DC, and GI at the provincial and municipal levels in the City of Ottawa and the broader National Capital Region (NCR). Implications will be addressed at the policy planning level as well as the on-the-ground site design level within development projects through a semi-structured key informant interview process; Third, preliminary program recommendations will be synthesised from the City of Ottawa and NCR cases to provide a potential 'best practices' framework for implementation in the Manitoba Capital Region (MCR). These recommendations will be adjudicated by a focus group consisting of provincial, municipal, and development project staff; and, finally, concrete program recommendations will be made for a best-fit SWM DC and GI strategy in the MCR.

Key informant participants from the public and private sectors of Ottawa and the NCR will be asked to engage in semi-structured interviews to:

- confirm local planning policy and legislative findings as accurate;
- share information regarding their experience of development charges and any potential influences they may have had on area water infrastructure; and,
- share information regarding their experience of development charges

and any potential influences they may have had on the overall sustainability of area development.

Focus group participants from the public and private sectors of the MCR area will be asked to:

- confirm local planning policy and legislative findings on the MCR as accurate;
- share information regarding their experience of sustainability-driven development charges;
- provide comments regarding the proposed 'best practices' implementation framework established through the first three stages of this thesis work.

2. **Research Instruments**

Semi-structured interviews and a focus group will be used to complement literature, policy, and legislative review undertaken as part of case study analysis. This mixed approach to research will provide a more comprehensive understanding of the many implicit factors involved in harmonising sustainable water management and planning policy, via development charges, in slow-growth city regions.

The objectives of the semi-structured interviews are as follows:

- confirm literature, policy and legislative findings as accurate;
- elicit information from participants regarding their experience of development charges and any potential influences they may have had on area development; and
- elicit information from participants regarding their experience of development charges and any potential influences they may have had on the sustainability of area development.

The objectives of the focus group are as follows:

- confirm local planning policy and legislative findings on the MCR as accurate;
- gather professional opinions regarding expected successes and pitfalls of implementation of sustainability-driven development charges in the MCR specifically; and
- obtain comments regarding the proposed 'best practices' implementation framework established through the first three stages of this thesis work.

Participants of this research will not experience any personal or professional risk greater than those incurred in typical day-to-day employment or life. If desired, participants may remain anonymous in the research and accompanying final thesis.

A copy of all questions to be used within interviews is attached at the end of this document.

3. **Participants**

Municipal, regional and/or provincial employees and private-sector developers will be contacted based on their public involvement with related research found while reviewing case study documentation. Participants will be recruited based on their involvement within the City of Ottawa, the NCR, and the MCR. A maximum of three public sector officials and three developers from each geographic area will be included in the interview component of the research. The focus group will include a maximum of four public sector officials and four developers, yielding a maximum of 20 participants for the entire research project.

The majority of case study documentation already reviewed contains individuals' names, emails, and organisational telephone numbers to use for more information. These individuals, when approached to become project participants, may also create situations where snowball sampling develops as an alternative method of finding participants.

As these potential participants (and/or the referral parties) already have their information presented publicly for further information regarding the documents used in the researcher's case study research, there does not appear to be any particular characteristics rendering them especially vulnerable, nor requiring any additional precautions.

A copy of the recruitment letter (e-mail) to be used is attached at the end of this document.

4. **Informed Consent**

Participants will be provided with an overview of the thesis' intentions, an interview or focus group guide (as applicable) as well as the informed consent form package at least two weeks in advance of any interview or focus group occurring. Participants will be provided with the researcher's and research advisor's contact information should they have any questions before the interview is to take place. Interviews will not begin without confirmation of consent granted through the return of the completed informed consent form package.

Contact with minors, individuals that cannot grant their own consent, and/or other high risk groups is not expected to occur due to the nature of the subject matter of the thesis itself.

A copy of the informed consent package to be used is attached at the end of this document.

5. **Deception**
   Deception will not be used in this thesis research.

6. **Feedback/Debriefing**
   A short discussion (approximately a quarter of the length of time of the formal interview) will take place after completion of the formal component of the interview with each participant to ensure that the information collected by the researcher matches the intent of the responses given by the participant.

   A summary of interview findings will be transmitted digitally in a secured document format or mailed in a confidential envelope via registered mail to each participant in the month following the interview. Participants will, if desired, be able to follow up with the researcher to confirm the data collected.

7. **Risks and Benefits**
   This research does not entail any personal or professional risk greater than participants would incur in typical day-to-day employment or life.

   Participating in this research will expand knowledge regarding the viability of surface water management achieved through the unification of municipal development charge programs with regional planning practices in Canadian slow-growth city regions.

8. **Anonymity or Confidentiality**
   Participants may elect to remain anonymous in the research.

Quotations of transcribed interview material, if used, will not be attributed by name, job title, or any other identifying characteristics.

Shall participants withdraw from the research, all physical and digital records pertaining to their involvement will be promptly and securely disposed of.

Interviews and focus groups, with prior consent granted by each individual participating in the event in question, may be digitally recorded, transcribed, and stored in password-protected files on the researcher's password protected personal computer. Files will not provide or be named with any identifying characteristics such as names, titles or positions of employment. All related files will be encrypted and password protected as per University of Manitoba standards, and will be permanently deleted one year from the calendar date of the researcher's thesis defence.

9. **Compensation**
   Participants will be formally notified in the informed consent package that they will not receive any credit or remuneration for participating in this research.

10. **Dissemination**
    In accordance with requirements of the Government of Canada and the University of Manitoba, research findings will be published in the final thesis document, which will be available in hard-copy at the University of Manitoba, and online through MSpace and Library Archives Canada.

    Participants may request (through the informed consent process) that a secured digital copy of the document be sent to them upon completion.

Participant Recruitment E-mail

For focus group and interview participants

Hello,

I am a graduate student in the Department of City Planning at the University of Manitoba. While preparing the materials for my thesis research I came across _______________ *(document name)* where you were listed as *(a contact / an author).* I would like to invite you to participate in my thesis research exploring the use of development charges as a means of implementing regional stormwater management at the site level.

My thesis explores the use of development charges (DCs) as a sustainable planning policy tool through the establishment of a framework to address sustainable water management. This will be accomplished by focusing on whether and how development charges can be used in Canadian slow-growth city regions to provide incentives for sustainable urban infrastructure practices through facilitating the decentralisation of water management. The forms of sustainable water management explored in this thesis address stormwater in particular and include both landscape- and building- based strategies such as bioretention, infiltration, and dispersion.

To complete my research I will be conducting semi-structured interviews with public-sector employees and developers with experience within the City of Ottawa and the National Capital Region (NCR). These interviews will provide me with the material needed to establish preliminary 'best practices' for implementation of surface water management oriented development charge programs in other urban regions. Following these interviews, I will host a separate focus group with public-sector employees and developers from the Manitoba Capital Region (MCR). This focus group will assist in refining the preliminary 'best practices' to streamline potential implementation.

A maximum of twenty participants will be involved in this entire research process, with up to three public-sector and development industry interviews in each the City of Ottawa and the NCR, and up to eight participants in the MCR focus group. Interviews, including debriefing, are expected to be sixty minutes in duration, and the focus group is expected to be three hours in duration.

As a participant, you will not be compensated for your participation. You are not anticipated to experience any risk greater than that experienced in day-to-day employment. You will also have the option of remaining anonymous in the final document.

If you would like to participate in this research, please reply to this email for further instructions. If you have any questions, please contact me at [REDACTED]; you may also contact my thesis advisor, Dr. Richard Milgrom, at [REDACTED].

Thank you for your consideration.

Caitlin Kotak
Master of City Planning Program Student
Department of City Planning, University of Manitoba

Participant Guide (1/3)
For semi-structured interview participants from the public sector

Introduction	Description of interview length and goals. Confirmation of informed consent.
Background	Confirmation of interviewee's role/duties associated with: development charges; green infrastructure; water and/or urban regional planning.
Planning & Design for Green Infrastructure (GI)	Local history of GI (i.e., enabling legislative and/or planning processes); formal and/or informal connections to the local planning framework.
Development Charges (DC) & Green Infrastructure	Local DC program establishment (i.e., legislation and/or planning processes); program link (if any) to green infrastructure. Structure of implementation program, and level of relative success.
Urban/Regional Planning & Water-Related Site Design	Connection of local planning framework (e.g., subdivision approvals process, and local zoning by-laws) to on-site stormwater management practices.
Outcomes	What does and doesn't work in the existing process; potential and realised outcomes of linking DCs and GI through an urban/regional planning framework.
Recommendations	Recommendations.
Debriefing	Confirmation of information collected throughout the interview.

Participant Guide (2/3)

For semi-structured interview participants from the development industry

Introduction	Description of interview length and goals. Confirmation of informed consent.
Background	Confirmation of interviewee's experience/duties associated with: development charges; green infrastructure; water and/or urban regional planning.
Green Infrastructure (GI) & Water-Related Site Design Framework	GI and the regulatory process (e.g., subdivision and development applications, zoning by-laws); planning and/or design-related hurdles; consistency of process and public sector expectations.
Development Charges (DC) & Green Infrastructure	Local DC program establishment (i.e., legislation and/or planning processes); program link (if any) to green infrastructure. Structure of implementation program, and level of relative success.
Outcomes	What does and doesn't work in the existing process; potential and realised outcomes of linking DCs and GI through an urban/regional planning framework.
Recommendations	Recommendations.
Debriefing	Confirmation of information collected throughout the interview.

Participant Guide (3/3)
For focus group participants

Introduction	Description of focus group length and goals. Confirmation of informed consent.
Background	Confirmation of participants' roles/duties associated with: development charges; green infrastructure; water and/or urban regional planning.
Findings: Green Infrastructure (GI) & Water- Related Site Design Framework	GI and the regulatory process (e.g., subdivision and development applications, zoning by-laws); planning and/or design-related hurdles; consistency of process and public sector expectations.
Findings: Development Charges (DCs) & Green Infrastructure	Local DC program establishment (i.e., legislation and/ or planning processes); program link (if any) to green infrastructure. Structure of implementation program, and level of relative success.
Findings: Outcomes	What did and didn't work; potential and realised outcomes of linking DCs and GI through an urban/ regional planning framework.
Recommendations for an Implementation Framework	Recommendations. Discussion of recommendations and feasibility.
Debriefing	Confirmation of information collected throughout the focus group.

Participant Questions for Semi-Structured Interviews (1/2)

For public sector participants (municipal, regional, and provincial employees)

Background:

- Please tell me about your department's formal and informal roles, if any, in relation to the following:
  - [green and/or conventional] water infrastructure;
  - development charges; and
  - urban and/or regional planning.
- What is your experience of the above on a day-to-day basis?

Planning & Design for Green Infrastructure:

- What is your department's formal position (e.g., legislative framework) on green water infrastructure?
- What is your department's informal position (e.g., planning policy and internal operations) on green water infrastructure?
- How does your overall planning framework support the development of green water infrastructure?
- How does the existing development charge framework function in collaboration with the planning and development approvals process?

Development Charges & Green Infrastructure:

- How does your existing development charge framework support the development of green water infrastructure at the regional and site-specific scales?
- How successful do you believe the existing development charge framework has been at addressing the development of water infrastructure at the regional and site-specific scales?
- What component(s) of the structure of the existing development charge framework do you believe are the most and least successful at supporting the development of green water infrastructure at any scale?
- How could the existing development charge framework be restructured to better address the development of green water infrastructure at any scale?

Urban / Regional Planning & Water-Related Site Design:

- How are planning considerations for green water infrastructure integrated into the existing development approvals process?

- How are planning considerations for on-site stormwater management integrated into the existing development approvals process?

- How could the existing development charge framework be modified to help the development approvals process better address the development of green water infrastructure for on-site stormwater management at the regional and site-based scales?

Outcomes:

- What changes would you suggest to the existing development charge framework to increase local impacts on the sustainability of development?

- In relation to green infrastructure and on-site water management, what is/are the key feature(s) of the existing development approvals process and development charge framework that you would suggest to other jurisdictions for implementation? Are there any unsuccessful features that you would suggest other jurisdictions avoid?

- What, key components would you suggest to connect regional planning and development charge frameworks to better support the development of green water infrastructure?

- Is there anything else you would like to add?

Participant Questions for Semi-Structured Interviews (2/2)
For participants from the development industry

Background:

- Please tell me about your and your organisation's formal and informal roles, if any, in relation to the following:
    - [green and/or conventional] water infrastructure;
    - development charges; and
    - urban and/or regional planning.
- What is your experience of the above on a day-to-day basis?
- What is your organisation's position (e.g., company policy or mandate) on green water infrastructure?

Green Infrastructure & Water-Related Site Design Framework:

- How are planning considerations for on-site stormwater management integrated into the existing development approvals process?
- How are planning considerations for green water infrastructure as a whole integrated into the existing development approvals process? Into the development charge framework?
- How successful do you believe the existing development charge framework has been at addressing the development of water infrastructure at the regional and site-specific scales?

Development Charges & Green Infrastructure:

- In your experience, how does the existing development charge framework function in collaboration with the planning and development approvals process?
- What component(s) of the structure of the existing development charge framework do you believe are the most and least successful at supporting the development of green water infrastructure at any scale?
- How could the existing development charge framework be restructured to better address the development of green water infrastructure at any scale?
- How could the existing development charge framework be modified to help the development approvals process better address the development of green

water infrastructure for on-site stormwater management at the regional and site-based scales?

Outcomes:

- What changes would you suggest to the existing development charge framework to increase local impacts on the sustainability of development?
- In relation to green infrastructure and on-site water management, what is/are the key feature(s) of the existing development approvals process and development charge framework that you would suggest to other jurisdictions for implementation? Are there any unsuccessful features that you would suggest other jurisdictions avoid?
- What, key components would you suggest to connect regional planning and development charge frameworks to better support the development of green water infrastructure?
- Is there anything else you would like to add?

Informed Consent Form

For focus group and interview participants

THE FOLLOWING SECTION WAS PRINTED ON OFFICIAL DEPARTMENT OF CITY PLANNING LETTERHEAD ONCE IT ATTAINED FORMAL APPROVAL FROM THE UNIVERSITY OF MANITOBA JOINT--FACULTY REB.

Research Program Title

Sustainable Infrastructure Planning in Slow-Growth City Regions:
Using Development Charges for Stormwater Management

Researcher and Contact Information

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Graduate Student, Master of City Planning Program
University of Manitoba
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Research Advisor and Contact Information

Dr. Richard Milgrom
Department Head and Associate Professor, City Planning
University of Manitoba
Telephone : [REDACTED]
Email : [REDACTED]

Background

This consent form, a copy of which will be left with you for your records and reference, is only part of the process of informed consent. It should give you the basic idea of what the research is about and what your participation will involve. If you would like more detail about something here, or information not included here, you should feel free to ask. Please take the time to read this carefully and to understand any accompanying information.

This thesis seeks to provide a broader view of development charges as a planning policy tool through bridging the gap between sustainable water management planning and financial incentives for green infrastructure. This is accomplished through focusing on whether and how planning policy can structure development charge programs in slow--growth city regions to foster the establishment of green infrastructure for sustainable water management.

Literature, policy and legislative review, key informant interviews and case study analysis examining practices of the City of Ottawa and the National Capital Region will shed light on the effectiveness of sustainability-- driven development charges as part of planning policy in slow--growth city regions that have experienced considerable sprawling development. The Manitoba Capital Region will serve as the illustration for recommendations derived from research findings.

Your participation in this research will provide otherwise unattainable insights and opinions regarding the effectiveness of real--world implementation strategies related to the above research.

Research Procedures

You are being asked to participate in this research. If you agree to participate, you will be invited to participate in: A) an interview of approximately 45 minutes in length, or B) a focus group of approximately 3 hours in length. You may also be contacted at a later date to provide follow--up comments. Follow--up commentaries should not exceed 30 minutes in length. A short debriefing will follow each interview and the focus group, and is expected to be approximately 15 minutes in duration. The time frame for this project is August 2013 to October 2013.

Risk

This project does not entail any personal or professional risk greater than you would incur in typical day--to--day employment or life. Participating in this research will aid in expanding knowledge regarding the viability of surface water management achieved through the unification of municipal development charge programs with regional planning practices in Canadian slow--growth city regions.

Confidentiality

Your privacy is of utmost concern. Interviews and focus groups, with prior consent of all participants, may be digitally recorded, transcribed, and stored in password--protected files on the researcher's password protected personal computer. Files will not provide or be named with any identifying characteristics such as names, or titles of positions of employment. All related files will be encrypted and password protected, and will be permanently deleted one year from the calendar date of the researcher's thesis defence expected to occur in March 2013. Quotations of transcribed interview material, if used, will not be attributed to interviewees by name or job title. If desired, you will have the choice of being fully anonymous by checking the relevant box on the following form.

Due to the limited pool of participants eligible to participate in this research there is a chance that even anonymous participants' identities may be inferred from the resulting publication.

Remuneration

You will not be provided with any credit or remuneration for participating in this research. You may receive a copy of the final thesis if desired.

Withdrawal

Should you change your mind following commencement or completion of the interview and wish to withdraw from the research, you may do so without any negative consequences. Should you wish to have a recording device turned off for all or a portion of your participation in an interview or focus group, you may tell the researcher to do so without any negative consequences. All physical and digital records pertaining to your involvement will be promptly and securely disposed of.

Dissemination of Findings

Research findings will be published in the final thesis document, which will be available in hard--copy at the University of Manitoba, and online through MSpace as required by the Federal Government of Canada. Interviewees declaring a desire for anonymity on the following form will retain such status, and no personal or employment--based identifiers will be provided in the published document.

Feedback

A brief summary of interview findings will be distributed to you in the month directly following your interview for your confirmation. You may indicate your preferred method of correspondence on the following form. Should you desire, a copy of the final thesis may be sent to you. If you would like to receive a secured PDF format copy, please check the relevant box on the following form.

Your signature on this form indicates that you have understood to your satisfaction the information regarding participation in the research project and agree to participate as a subject. In no way does this waive your legal rights nor release the researchers, sponsors, or involved institutions from their legal and professional responsibilities. You are free to withdraw from the study at any time, and/or refrain from answering any questions you prefer to omit, without prejudice or consequence. Your continued participation should be as informed as your initial consent, so you should feel free to ask for clarification or new information throughout your participation. The University of Manitoba Research Ethics Board(s) and a representative(s) of the University of Manitoba Research Quality Management/Assurance Office may also require access to your research records for safety and quality assurance purposes.

This research has been approved by Joint Faculty Research Ethics Board (JFREB). If you have any concerns or complaints about this project you may contact any of the above-named persons or the Human Ethics Coordinator (HEC) at [REDACTED]. A copy of this consent form has been given to you to keep for your records and reference.

Please select which of the following research activities you will be participating in:

- □ Interview participant
- □ Focus group participant

I ___________________________________(print name), consent to the dissemination of material provided to the Researcher for use in the development of the project outlined above.

I understand that the information I provide will be incorporated into a publicly disseminated thesis prepared by the Researcher. I understand all material I provide to the Researcher will be treated as confidential, stored privately and securely, and subsequently destroyed by one year following the calendar date of the Researcher's thesis defence.

- □ I would like to remain anonymous in the final thesis document
  or
- □ I consent to having my name released in the final thesis document

- □ I would like to receive a copy of the final thesis document.
  My contact information is:
  ____
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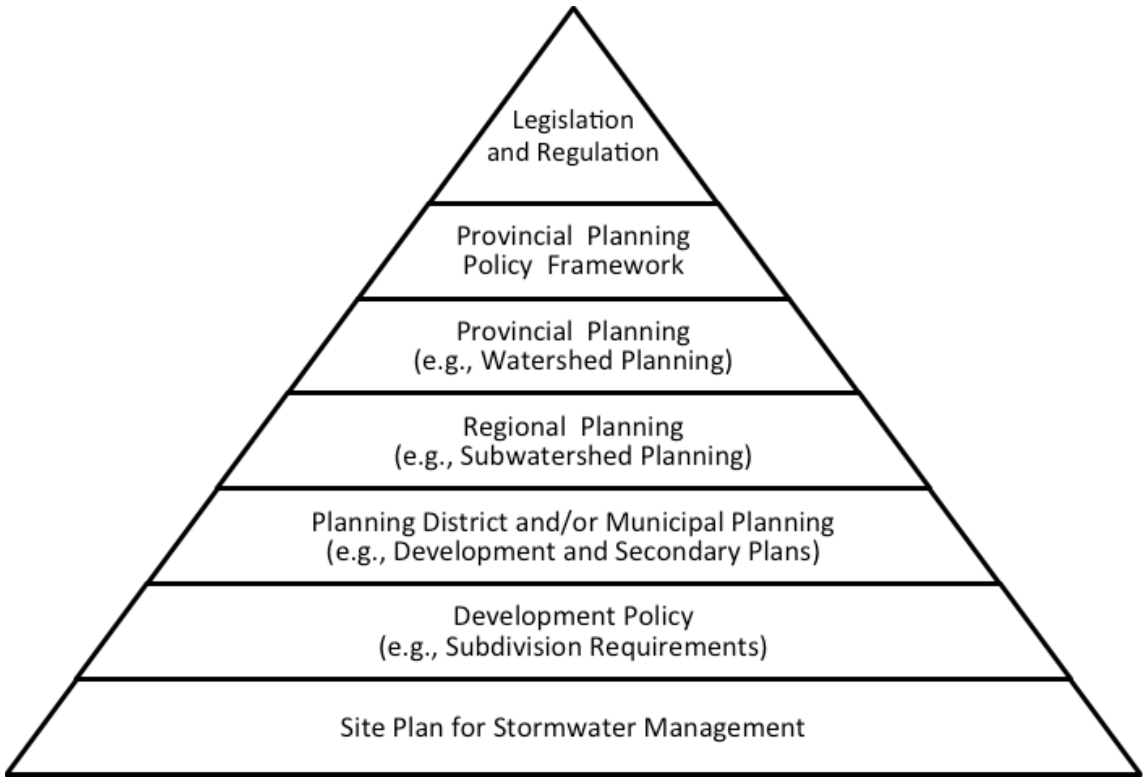
_______________________	_______________________	_______________
Participant's Name (please print)	Participant's Signature	Date
	_______________________	_______________
	Researcher's Signature	Date

APPENDIX B: PROPOSED IMPLEMENTATION FRAMEWORK

The following proposed implementation framework for the Manitoba Capital Region is based on the findings from the academic literature, case study analysis, and key-informant interviews conducted in the preparation of the attached thesis.



Legislation and Regulation

- Amend existing planning and municipal administration legislation to phase-in implementation of stormwater management-based municipality-wide and area-specific development charges (DCs) through municipal by-laws. This will establish amendments to, at a minimum, the following Manitoban statutes:
  - *The Planning Act* (significant / consequential amendments);
  - *The City of Winnipeg Charter* (significant / consequential amendments); and
  - *The Municipal Act* (alignment / inconsequential amendments).
- The statute amendments should ensure that the DC process is transparent and equitable, similar to those implemented in Ontario and British Columbia, is supported by requiring:
  - background studies to be completed for all forms of planned infrastructure DCs, including hard and soft infrastructures for green infrastructure and related supports for stormwater management.

  - detailed guidelines for financial controls including the establishment of municipality-wide and area-specific reserve funds for each form of charge levied.

  - detailed guidelines about eligible expenses for DCs collected, limiting use to:
    - infrastructure materials and installation;
    - background studies required for local and/or regional infrastructure needs (e.g., development, phasing, maintenance, and monitoring), as well as DC implementation and monitoring; and
    - secondary planning studies to inform the establishment of area-specific DCs.

  - requirement for annual public reporting about all funds collected and spent, as well as the balances of each reserve account.

  - the completion of stormwater management plans for all 'at-risk' planning authorities (i.e., municipalities and planning districts) such as those within the floodplain, along major flood/erosion channels, and those fronting onto Lakes Winnipeg and Manitoba (at risk of overland flows contributing to eutrophication);

  - periodic DC reviews triggered by mandatory maximum by-law lifespans; and

  - consultation and appeals processes for by-law development (note: Ontario has a significantly shorter time period for DC by-law appeals than the period established for other by-laws).

- To soften and support the transition to a DC system, amend existing legislation in the interim to allow development agreements to be applied against specific variance applications as well as building and site development permits in cases where development has a substantive impact on stormwater infrastructure (not, for example, basement renovations or construction of porous/raised fences).
  - This creates a transitional means for building-based and landscape-based stormwater management techniques (or contributions to costs in lieu) to be implemented.

  - Support this interim action by establishing more stringent development agreement parameters for building and site permit applications through a policy position and formal guidebook distributed to planning authorities (i.e., municipalities and planning districts) across Manitoba.

- Optionally, establish a mandatory minimum per-lot levy development cost or additional surcharge for municipalities or Conservation Districts that:

- will be used to fund initial background and infrastructure studies for DCs; and,
- will be carried into the future in lieu of DCs for planning authorities that are not considered 'at-risk' and, therefore, are not required to implement local DC by-laws, (provided no formal DC program is implemented).

- The Provinces of Alberta and Ontario have given municipalities the power to levy DCs on behalf of another municipality when costs are incurred outside of the municipality of development. This may only occur in special cases where a rational nexus can be proved. Establish similar provisions to address environmental and economic implications of DC programs with sensitivity to operations of, and Statutes governing, the following:
    - Conservation Districts;
    - Planning Districts; and
    - the Manitoba Capital Region.

<u>Provincial Planning Policy Framework</u>

- Amend *The Provincial Planning Regulation* to require planning authorities to consult with utilities, conservation authorities, municipal finance administrators, academic/research institutions (e.g., University of Manitoba and/or Ducks Unlimited), as well as local developers and/or design and engineering firms when establishing development standards, contribution thresholds, and alternative approvals processes for green infrastructure and related stormwater management techniques/processes.

- Require planning authorities with at-risk geographies to develop Integrated Urban Water Management Plans that address water-sensitive urban design techniques and/or green infrastructure installations to foster increased resilience for local economic, environmental, and social conditions.

- Provide guidelines to planning authorities regarding appropriate infrastructure scope/detail, development forecasting, fee formulae, climate/hydrology, and mapping considerations for completing background study materials.
    - Following in the footsteps of Kitchener, Ontario, support the establishment of stormwater-based charges with a formula/rational nexus connecting impervious site cover to the amount owing.

<u>Regional Planning: Planning District and/or Municipal Planning</u>

<u>Development Plans</u>

- Establish explicit policy statements:
    - about the protection of local watercourses and stormwater channels, as well as the mitigation of overland flows throughout the region.

    - supportive of the development of on-site green infrastructure (GI). Specify broad designation types or districts that are suitable for innovation (e.g., residential, commercial, institutional 'campus'), pending municipal review.

    - broadly outlining the varied levels of risk for overland flooding or other affiliated stormwater concerns (e.g., eutrophication of a waterbody, or complete lack of drainage) in the region.

    - tying local DC by-laws to planning goals outlined in the previous two points.

- Tie all development charges to planning goals outlined in development plan policy areas. Indicate that area-specific charges under local DC by-laws are to be applied to areas with approved Secondary Plans.

Secondary Plans

- Outline segments of local development areas/districts and designate the levels of stormwater management required for each.

- Outline district risk levels on a more detailed basis than in the Development Plan, and define appropriate means of management for each district.
    - For example, eutrophication may be addressed through an emphasis on bioretention for added filtration benefits, while a lack of drainage could be addressed through the development of a network of connected swales and ponds, or by fostering the development of on-site cisterns.

    - Suggested forms of infrastructure could be fostered through a greater discount rate in area-specific charge structures; however these should also be considered against the intended land use.

Development Approvals Policy (e.g., Subdivision Requirements)

- Ensure informational materials for development approvals (e.g., subdivisions, conditional uses, variances) contain a section outlining Development Plan and specific Secondary Planning area policy statements for development. Ensure policies are illustrated by breaking them down by intended land use, and demonstrate specific examples of appropriate development applications.
    - The publication (or limited distribution) of Manitoba-specific design standards, such as those being developed by academic institutions and non-governmental organisations such as Ducks Unlimited, would help facilitate this process.

    - Similarly, the development of a series of small-scale pilot projects involving a representative sample of stakeholders can be used to build knowledge in local industries, generate acceptance, and test the efficiency and design of future standards for green infrastructure and development typologies.

Site Planning and Inspection

- Ensure planners, engineers, development finance officers, permit approvals staff, and building and site inspectors are trained to evaluate green infrastructure effectively.

Related Processes

Municipal

- Consider implementing a complementary utility fee similar to the process undertaken by Kitchener, Ontario to ensure that stormwater management infrastructure is maintained or improved over time.

- Consider implementation of programs like those used by the City of Ottawa to foster downspout disconnections. Other programs fostering features for new development or redevelopment projects such as stormwater cisterns or greywater retention systems (e.g., dual plumbing in commercial buildings for toilet use) would also complement planning goals.

Federal/Provincial

- De-classification of stormwater as a form of wastewater would have a significant impact on municipalities' financial abilities and design capacities to develop alternative infrastructure to address stormwater management.

- Implementation of a provincial stormwater management utility, or consent for large municipalities and/or regions to develop local utilities, would ultimately foster the development of complementary fee processes in a more effective way than above.

- Building and site design code equivalencies for green infrastructure in new and existing construction would greatly facilitate municipal development approvals processes.