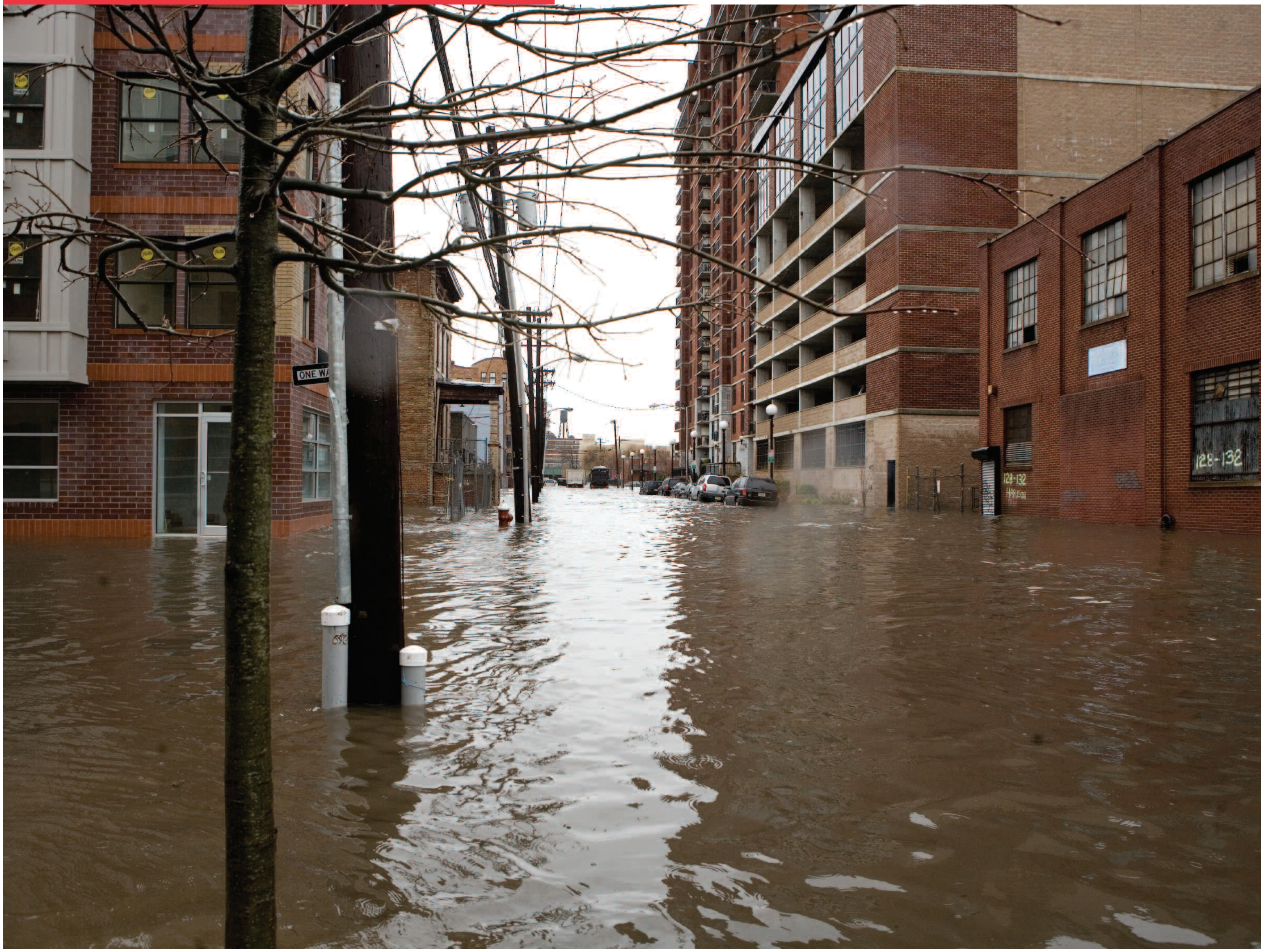

Photo: David Pfeffer

Urban Flooding, Homeowner Hazard Perceptions, and Climate Change

BY DAN SANDINK

Urban flooding has become one of the most substantial threats to property and health safety in many Canadian municipalities, and several recent events have exemplified the seriousness of this problem. In August 2005, a severe rainfall event in southern Ontario caused extensive overland flood and sewer backup damages, resulting in the most costly insured storm damage in Ontario's history. In 2004, 2005, 2006 and this past summer, the City of Hamilton experienced heavy rainfall events that resulted in significant urban flooding damages. The cities of Ottawa, Sarnia, Thunder Bay, Peterborough, Saskatoon, Montréal, Edmonton, Calgary and Moncton, as well as many others, have also experienced damaging urban flooding events over the past few decades.

> However, the barrier of low public awareness will have to be overcome to effectively engage homeowners in urban flood risk reduction.

Insured damages from the southern Ontario storm of 2005 were estimated at $500 million, second only to the 1998 Ontario-Québec Ice Storm as the most expensive catastrophe in the Canadian insurance industry's history. Of the $500 million total, approximately $247 million was directly attributed to sewer backup damages. Flooding events in 2005 in southern Alberta resulted in $300 million in insured damages, $144 million of which was attributed to sewer backup.[1]

Frustrations associated with urban flooding for homeowners are compounded by the fact that damages caused by infiltration and overland flooding are uninsurable. While sewer backup coverage is available, it must often be specifically requested by homeowners and provided as an optional endorsement at an additional cost. In some cities, homeowners may find it difficult to retain coverage for sewer backup damages, as insurers are discovering that costs associated with this peril are unsustainable, and are limiting or withdrawing coverage.

Climate change will increase the frequency and intensity of heavy rainfall events, thereby increasing the risk of urban flooding. While addressing infrastructure issues is a necessary component of reducing urban flood risk, individual homeowners can have a significant role in reducing risk through protecting their own homes and reducing their contributions of stormwater to municipal sanitary sewers and stormwater management systems. However, the barrier of low public awareness will have to be overcome to effectively engage homeowners in urban flood risk reduction. Some cities have been working to improve homeowner knowledge and risk-reducing behaviour through education and financial assistance programs.

I.
URBAN AND BASEMENT FLOODING

Urban flooding occurs in urban areas, where the impacts of extreme rainfall and snowmelt are exacerbated by high concentrations of impervious surfaces, infrastructure, buildings, property and people. Urban flooding can have serious implications for both buildings and infrastructure, as extreme flows of water during heavy rainfall events can damage both overland and underground stormwater management infrastructure. Basement flooding is a specific impact of urban flood events, and is largely caused by overland flows, sewer backup and infiltration flooding.

TYPES OF URBAN FLOODING

When extreme rainfall exceeds the capacity of underground storm sewer systems and above-ground overland flow routes, overland flooding can occur. In Canada, underground storm sewer systems are sometimes designed to handle 1 in 25 year rainfall events, (or events that, based on historical records, occurred on average once every 25 years) but more frequently 1 in 5 year standards are used for storm sewer design. Overland flow routes have been incorporated into new developments since the 1970s and are designed to handle excess stormwater flows when rainfall exceeds the capacity of underground pipes. Overland flow routes have commonly been designed to handle 1 in 100 year flows. However, many older areas in Canadian municipalities may be serviced by underground pipes designed to handle only 1 in 2 year events, and older areas often do not have well defined overland flow routes. When an extreme event occurs that is greater than a 1 in 100 year event, or when overland flow routes have not been incorporated into a development, overland flows can run over private property and sometimes into basements.

Sewer backup results from overloaded underground storm and sanitary sewer pipes, and can be exacerbated by excess stormwater contributions from private buildings. Sanitary sewer systems can overload and surcharge as a result of inflow and infiltration, where ground and stormwater enter sanitary sewers through cracks in pipes or cross-connections with the storm sewer system. Several cities in Canada have identified private eavestrough downspout and foundation drain connections to the sanitary sewer as significant contributors of unwanted water to these systems.

Infiltration occurs when groundwater levels rise above basement floors. When the groundwater level is higher than the lowest level of the basement, it can enter basements through cracks in foundation walls and basement floors. Infiltration flooding can also occur when heavy rainfalls infiltrate into the soil beside foundation walls, where it can then enter the basements through cracks in walls.

II.
CLIMATE CHANGE AND URBAN FLOODING

Under a changing climate, we will experience an increase in the frequency of drought, extreme rainfall, high temperatures, wind events and we can expect an exacerbation of the health impacts associated with these events. It has been argued that extreme events that currently have return frequencies of 1 in 100 years could have return frequencies of 1 in 15 or 1 in 10 years by 2070 under climate change conditions.[2]

As temperatures increase, evaporation will also increase and the atmosphere will be able to hold more moisture. Higher amounts of moisture in the atmosphere will result in more severe precipitation events in many parts of the world, including Canada.[3] A research study in the City of London revealed that a "wet" climate change scenario would result in significant increases in

[1] Insurance Bureau of Canada
[2] Lehner, B., Doll, P., Alcamo, J., Henrichs, T., & Kaspert, F. (2006). Estimating the impact of global change on flood and drought risks in Europe: A continental, integrated analysis. Climatic Change, 27, 273-299.
[3] Madsen, T., & Figdor, E. (2007). When It Rains, It Pours: Global Warming and the Rising Frequency of Extreme Precipitation in the United States. Environment America.

> Stormwater management infrastructure in Canada has traditionally been designed with the assumption that weather and climate conditions are static, and historical climate conditions can be used to accurately predict the future climate.

short-duration rainfall magnitude and intensity, which has serious implications for stormwater management infrastructure.[4] Although the precise impacts of climate change will differ depending on the climatic and environmental characteristics of specific regions, it is often thought that extreme precipitation events could increase in severity by approximately 15 percent.[5] Under this type of scenario, events that are currently considered to have 1 in 20 year return frequencies could occur once every 10 years.[6]

Stormwater management infrastructure in Canada has traditionally been designed with the assumption that weather and climate conditions are static, and historical climate conditions can be used to accurately predict the future climate.[7] As discussed above, underground stormwater management infrastructure has often been designed to handle 1 in 5 year events and overland infrastructure has been designed to handle 1 in 100 year events. Increasing frequencies of extreme rainfall events caused by climate change will mean that stormwater management infrastructure design standards will be less reflective of the frequency and intensity of events that we will experience in the future.

Aside from increased damages caused by basement flooding, increasing severity of extreme rainfall can have numerous negative impacts, including increased urban stormwater runoff, increased frequency of combined sewer overflows (CSOs)[8], and infrastructure damage.

III.
URBAN FLOOD MITIGATION: THE ROLE OF THE HOMEOWNER

There are several actions private homeowners can adopt to reduce both their own urban flood vulnerability, and the vulnerability of others in their community. These measures are outlined in a recent ICLR publication entitled the *Handbook for Reducing Basement Flooding*,[9] and includes both measures to keep water out of the home and measures that reduce the home's contribution of water to municipal infrastructure.

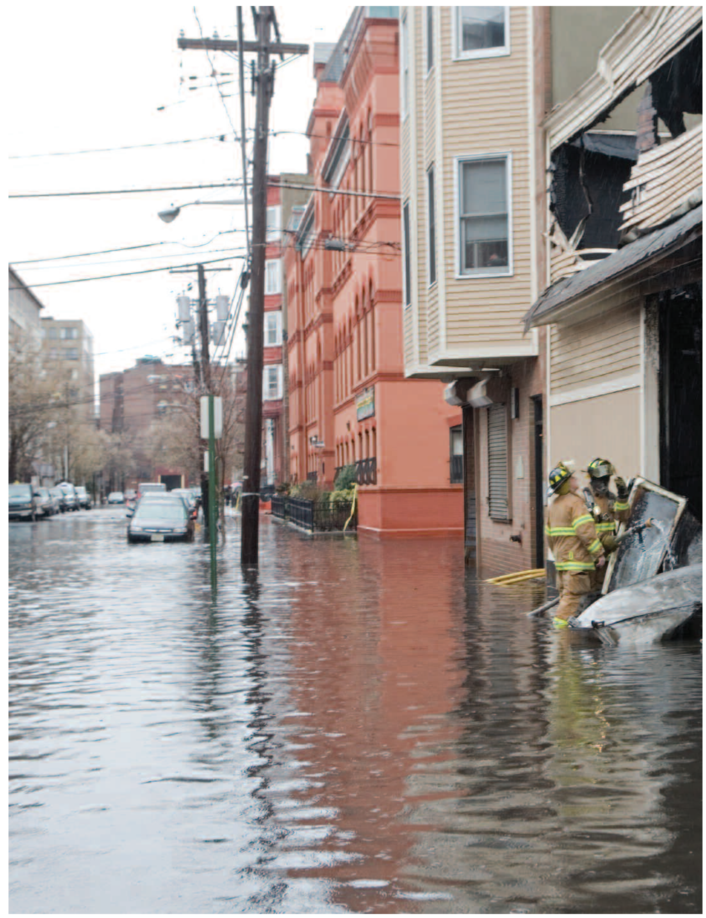

Photo: David Pfeffer

To reduce excess water contributions to the municipal storm and sanitary sewer systems, homeowners can disconnect downspouts from the municipal sewer system. Disconnection of foundation drains from the municipal sewer system and installation of a sump-pump to pump foundation drainage water to the surface of the lot rather than into the sewer system can also help to reduce overloading of the sewer system. These measures are especially imperative if downspouts and foundation drains are connected into the sanitary sewer or if the homeowner is serviced by a combined sewer system.

Options to protect homes from flooding include installation of a backwater valve, which serves to reduce the chances that sewer backup will enter the home, and proper lot grading that directs

[4] Predrag, P., & Simonovic, S. (2007). Development of Rainfall Intensity Duration Frequency Curves for the City of London under the Changing Climate. University of Western Ontario Department of Civil and Environmental Engineering, Water Resources Research Report #58.

[5] Waters, D., Watt, W.E., Marsalek, J., & Anderson, B. (2003). Adaptation of a storm drainage system to accommodate increased rainfall resulting from climate change. Journal of Environmental Planning and Management, 46, 755-770; Kharin, V., & Zwiers, F. (2000). Changes in the extremes in an ensemble of transient climate simulations with a coupled atmosphere-ocean GCM. Journal of Climate, 13, 3760-3788.

[6] Kharin, V., & Zwiers, F. (2000). Changes in the extremes in an ensemble of transient climate simulations with a coupled atmosphere-ocean GCM. Journal of Climate, 13, 3760-3788.

[7] Kije Sipe Ltd. (2001). Impacts and Adaptation of Drainage Systems, Drainage Methods and Policies. Climate Change Impacts and Adaptation Program, Natural Resources Canada: Ottawa.

[8] Combined sewers convey both sanitary and storm sewage, and are common in older areas of many Canadian cities. When these systems receive excess stormwater flows, they are designed to automatically re-route sewage flows to surface water. While this practice reduces the risk sewer backup and damage to sewage treatment facilities, it results in significant pollution of surface water.

[9] Available from www.iclr.org

> Studies have also revealed a high reliance on the government for flood protection, and that often the blame for damages caused by natural hazards is placed on governments, rather than extreme natural events or on those who choose to occupy hazard prone areas.

water away from the home. Homeowners can also reduce flood risk in their neighbourhoods by clearing clogged sewer grates, or reporting continuously clogged sewer grates to their municipal government. As well, by avoiding pouring fats, oils and grease (FOGs) down their drains, homeowners can reduce the chances that their own sewer connections and the municipal sewer system will become clogged with residue, which can increase sewer backup risk.

Reverse slope driveways have been identified as a common culprit in the exacerbation of urban flood impacts. This type of driveway directs water into the home, and can increase the risk of basement flooding for neighbours, as excess water can enter the municipal sanitary sewer system through basement floor drains. For this reason, some municipalities have taken steps to prevent construction of new reverse slope driveways.

Homeowners should also be encouraged to review their insurance policies and talk to their insurance providers or brokers about basement flooding coverage, and should be informed that insurance companies in Canada do not insure damages caused by overland flooding or infiltration flooding. As well, homeowners should be encouraged to talk to their insurance provider or broker after they have made a claim for sewer backup to see if making a claim has affected their insurance coverage for future events.

Isolated cases of sewer backup may often be attributed to problems with the home's sewer lateral, the underground pipe that connects a home's sanitary plumbing system to the municipal underground sewer system. Sewer laterals that have been clogged with FOGs or with tree routs can result in isolated sewer backup events. Older pipes may be cracked, which allows groundwater to enter the pipe, increasing sewer backup risk. Cracked or damaged pipes also allow excess groundwater to enter the municipal sewer system, thereby increasing risk of sewer backup for both the homeowner and the neighbourhood.

It is important to note that measures taken at the homeowner level reduce, but do not eliminate basement flood risk. As well, appropriate flood reduction measures are not "one size fits all", and should reflect the specific characteristics of each home. All plumbing fixtures must be regularly maintained, and in circumstances of extremely severe urban flooding, there is little that homeowners or municipalities can do to eliminate risk.

IV.
PERCEPTION RESEARCH

Understanding public perceptions of natural hazards is an important part of non-structural hazard management. In comparison to structural approaches to hazard management, which attempt to alter the hazard to reduce risks to population (e.g., building dams and levees to control flooding), non-structural approaches attempt to alter human behaviour to reduce vulnerability. A commonly applied non-structural measure in Canada has been the use of floodplain maps to steer development away from flood prone areas. Non-structural measures also include education programs and actions designed to increase the awareness and risk-reducing actions of the individuals who are exposed to hazard risk.

Hazard perception studies were first conducted in the 1960s, and throughout this time, a few findings have generally remained constant in the literature. First, people who live in areas subject to hazards are largely unaware that they could sustain damages, personal injury, or death. In most cases, less than half are aware of their exposure to natural hazards. People deny their exposure, denigrate the potential for a recurrence of the hazard or misinterpret hazard recurrence statistics ("It happened here last year, so we aren't due for another 99 years."), or denigrate the seriousness of a potential hazard ("I came out alright after the last hurricane, so why should I worry about the next one?"). In terms of urban flooding, a particular manifestation of this characteristic is people's tendency to refinish their basements after they have experienced flooding without taking appropriate risk-reduction measures.

Second, people who live in hazard prone areas rarely take actions to protect themselves. Many studies have revealed that less than 15 percent of individuals exposed to hazards take actions to reduce their risk of sustaining damages. When people do take action, they generally take inexpensive and less effective actions such as evacuating at the last minute, or moving valuable items to a higher level in their home during a flood event.

Finally, perception studies have frequently revealed that people with property prone to flooding rely highly on government built structural mitigation mechanisms, such as dams, levees and floodwalls, to protect them from damages. Studies have also revealed a high reliance on the government for flood protection, and that often the blame for damages caused by natural hazards is placed on governments rather than extreme natural events or on those who choose to occupy hazard prone areas.

Research undertaken on perceptions of urban flooding revealed that those affected by sewer backup are unlikely to undertake risk reducing activities, including installing backwater valves and disconnecting foundation drains from municipal sewer systems, despite their past experience. As well, homeowners are more likely

[10] Sandink. D. (2007). Sewer Backup: Homeowner Perception and Mitigative Behaviour in Edmonton and Toronto. Institute for Catastrophic Loss Reduction, ICLR Research Paper Series #44.
[11] Ibid.

MUNICIPALITY	MAXIMUM AMOUNT	DESCRIPTION
CITY OF TORONTO	$3,200	• 80% up to $1,250 for backwater valve installation • 80% up to $1,750 for sump pump • 80% up to $2,800 for backwater valve and sump pump • Up to $400 for disconnection of foundation drain from the municipal sewer • Property must have disconnected eavestrough downspouts where possible
HALTON REGION	$2,725	• ½ of cost up to $1,800 for foundation drain disconnection, sump pump installation • ½ of costs up to $250 for downspout disconnection • ½ of costs up to $675 for backwater valve installation • Household drainage survey must be conducted by a regional representative
CITY OF ST. CATHARINES	$3,000	• Up to $3,000 in assistance for installation of a backwater valve, sump pump with a battery backup, disconnection of foundation drain
CITY OF WELLAND	$3,000	• Up to $3,000 in assistance for installation of a backwater valve, sump pit and sump pump with a battery backup, foundation drain and downspout disconnections

to attribute responsibility to their municipalities than to take action themselves to reduce urban flood risk.[10] These findings have serious implications for how hazards are managed, specifically highlighting the importance of public awareness through effective hazard education.

V.
METHODS TO ENCOURAGE PUBLIC HAZARD MITIGATION

Several municipalities across Canada have developed homeowner-level flood mitigation programs, which include education components as well as financial assistance through partial subsidies for homeowner-level urban flood reduction. Education components may include brochure mailings, information open houses, public meetings and websites devoted to homeowner flood information. Subsidy programs have been developed by some municipalities, with the goals of increasing homeowner uptake of measures including downspout and foundation drain disconnection, backwater valve installation, and repairing sewer laterals.

The City of Edmonton has offered an assistance program to homeowners affected by flooding since 1991, which provides $975 for the installation of a backwater valve, and up to $1,400 for sump pump installation, if necessary.[11] The City of London's program provides 75 percent of the costs of installation of plumbing devices or alteration of plumbing, and includes, for example, up to $1,875 for disconnection of foundation drains when the connection is inside of the home, and up to $575 for a backwater valve.[12] The City of Ottawa's program provides up to $4,000 for the installation of protective plumbing devices when the home was flooded by a sewer backup, and 50 percent of the cost of installation of protective plumbing up to $2,500 if measures are installed in a home that has not experienced flooding, but is in an area that is considered at risk of flooding.[13] The City of Saskatoon has also provided up to $2,500 for protective plumbing to homeowners who have been affected by past flooding events.[14] Table 1 provides a description of the flood subsidy programs in Toronto, Halton Region, St. Catharines and Welland, Ontario.

Subsidy programs may be available to everyone in the City, such as in Toronto, to individuals who have experienced basement flooding, such as in St. Catharines, or to homeowners who are in an area that may be vulnerable to basement flooding, such as in London and Ottawa. Grant programs are often directed to properties that have experienced flooding from sewer backup caused by the City sewer system, rather than flooding associated with infiltration or overland flows.

Some cities have gone as far as to require backwater valves in all new homes. For example, the City of Edmonton has required backwater valves since 1989 and the City of Winnipeg has required backwater valves since 1979. This may serve as a more cost efficient method of reducing flood risk, as the cost of installing a backwater valve during construction of a home is considerably less than retrofitting a valve, which may cost thousands of dollars and result in inconvenience for homeowners.

Urban flooding has been an increasing cause of damage in Canadian municipalities, and is likely to increase as a result of climate change. While updating and improving stormwater and sanitary sewer infrastructure will be necessary to reduce urban flooding risk, individual homeowners can play a role in reducing risk by protecting their own homes and reducing their contribution of stormwater to the municipal sewer system. Some municipalities in Canada, recognizing the importance of homeowner actions, have undertaken education and subsidy programs to reduce risk, and in some cases, have applied bylaws to require basement flood protection devices. These programs and measures serve to counteract the limited knowledge and low risk perceptions individuals who are prone to hazards tend to have.

DAN SANDINK joined the Institute for Catastrophic Loss Reduction (ICLR), an insurance backed research organization associated with the University of Western Ontario, in 2006. At ICLR, Dan's work has focussed on urban flood mitigation, hazard perceptions, disaster mitigation at the municipal level, and climate change adaptation. Dan is a graduate of the University of Guelph and the University of Western Ontario.

[12] City of London: http://www.london.ca/d.aspx?s=/Sewer_and_Wastewater/sump_subsidy.htm.
[13] City of Ottawa: http://www.ottawa.ca/residents/funding/protective_plumbing_en.html.
[14] City of Saskatoon: http://www.saskatoon.ca/DEPARTMENTS/Infrastructure%20Services/Public%20Works/Water%20and%20Sewer/Basement%20Flooding/Pages/FloodProtectionProgram.aspx.