Mitigating Impacts of Stormwater, Wastewater and Pharmaceuticals in the Environment

Final Report

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Ecology Action Centre
40 YEARS OF ACTION

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Contents

Introduction

In order to raise awareness of the issues of stormwater and wastewater management, as well as the emerging issue of pharmaceuticals in the environment, the Ecology Action Centre (EAC), in partnership with Bay of Fundy Ecosystem Partnership (BoFEP), hosted two workshops for municipalities around the Bay of Fundy in February 2012. The 'Stormwater and Wastewater Management' workshops were part of a larger BoFEP project titled 'Utilizing a Comprehensive Approach for Addressing Toxic Chemical Concerns Affecting Sustainable Use of the Bay of Fundy'. The workshops were designed to help planners, municipal officials and other interested stakeholders effectively manage stormwater while also raising awareness on the impacts of pharmaceuticals in the marine environment. This report will present research findings on the impacts of pharmaceuticals in the aquatic environment and available treatment and mitigation options, as well as a summary of the 'Stormwater and Wastewater Management Workshops'.

Water quality in the Bay of Fundy can be impacted by contaminants found in both stormwater and wastewater. Stormwater, which is often untreated, can enter the natural environment directly through storm drains. In areas serviced by combined systems, both stormwater and wastewater are treated in sewage treatment plants before being released into the environment. In times of heavy rain fall events, the high volumes of stormwater and wastewater can exceed capacity of wastewater treatment plants and result in the direct release of untreated sewage into the environment. These events, known as combined sewage overflows, directly impact water quality causing environmental and economic impacts.

The impacts of stormwater runoff resulting from more severe and more frequent storm events are felt primarily in urban landscapes where the high area of impervious surface cover (roofs, roads, parking lots) prevents precipitation from being retained in the ground. In urbanized areas like many cities and towns around the Bay of Fundy, water instead moves quickly over the hardened landscape, collecting contaminants along the way, and flows directly into the drainage system which can lead to combined sewage overflows, infrastructure damage from flooding, erosion and degradation of water quality. Changes in the amounts and intensity of precipitation associated with climate change along with problems associated with aging infrastructure and an ever expanding area of impervious surfaces in most municipalities make managing stormwater a critical issue.

Sewage treatment plants use physical, biological and chemical processes to remove contaminants from wastewater before releasing it into the environment. Various levels of sewage treatment exist around the Bay of Fundy. An emerging issue in wastewater treatment is the discharge of pharmaceuticals and the impacts they are having on the aquatic environment. Pharmaceuticals are designed to be biologically active, which means they have the potential to impact organisms living in the aquatic environment once they are released into freshwater and marine systems, even at very low concentrations. The impacts of pharmaceuticals on the health of the aquatic environment may be of particularly significance in urban and industrial areas where organisms are already stressed by degraded water quality.

A wider issue that exists is the lack of general knowledge on the connection between what enters our wastewater systems and the health of our streams, rivers and coastal waters. Many people are not aware that what goes down the drain eventually ends up in the natural environment – nor are they aware of the potential impacts of disposed pharmaceuticals on the environment. The combined

significance/impact of direct individual discharge of chemicals to the environment from household wastewater (EPA 2010; Hinch 1990) and stormwater disposal has been largely unrecognized (EPA 2010).

The workshops took place on February 22nd (Digby, NS) and February 23rd (Saint John, New Brunswick). The workshops targeted a broad range of stakeholders interested in the health of the Bay of Fundy including municipal planners, councillors, public works officials, provincial government, consultants and non-government organizations. The purpose of the workshops was to increase capacity of municipalities to 1.) Select and implement tools to reduce the impacts of stormwater runoff through a range of innovative, cost-effective Best Management Practices in order to improve water quality in the Bay of Fundy and reduce infrastructure and property damage caused by heavy rainfall events, and 2.) Increase awareness of the emerging issue of pharmaceuticals in the marine environment. The workshop was an excellent opportunity to bring people from various backgrounds together to network, talk about issues, share information and discuss ways to move forward to improve the health of the Bay of Fundy. All workshop presentations are available online at: http://www.ecologyaction.ca/content/stormwater-workshop-presentations-march-2012

This project built on recommendations that emerged from three 'Tools for Healthy Watersheds' workshops that were hosted by the EAC in partnership with BoFEP in March 2011. Water quality and land-use practices and specifically, stormwater management, emerged as priority issues at these workshops. To build on the success of the 2011 workshops, the EAC hosted follow up workshops to provide municipalities with the tools to better manage stormwater and other emerging water contamination issues, such as pharmaceuticals. The workshops also built on BoFEP's efforts to engage a range of stakeholders and partners in dialogue on sustainability of Bay of Fundy.

The Ecology Action Centre has worked towards sustainability for Nova Scotia's communities and environment for 40 years and is known for offering well–researched, cost-effective, solutions to environmental challenges facing Nova Scotia's communities. The EAC has been involved in many research and capacity building projects, both with community partners and in collaboration with government and academic institutions. We have considerable expertise in climate change adaptation research and education. The EAC recently created a stormwater management blog (www.stormwatercentral.com) to share innovative stormwater Best Management Practices and encourage dialogue on reducing the impacts of stormwater runoff. The lead contractor on this project was Ashley Sprague, EAC's Restoration Coordinator.

BoFEP promotes the vitality, biodiversity and productivity of the Bay of Fundy ecosystem, as well as the social well-being and economic sustainability of its coastal communities. BoFEP facilitates communication and co-operation among individuals and organizations interested in the Bay of Fundy. A project advisory committee was established and included BoFEP representatives Pat Hinch and Barry Jones.

The Insurance Bureau of Canada (IBC) was also involved in this project. IBC reviewed the workshop agenda and had a representative present at both workshops. IBC is the national industry association representing Canada's private home, car and business insurers. IBC is well aware of the costly effects of severe weather events, and are actively engaged in developing, promoting and implementing adaption measures for homeowners and municipalities. The funding to develop these workshops and resource materials came from Environment Canada.

Section I: Pharmaceuticals

Overview

An emerging issue in wastewater treatment is the discharge of pharmaceuticals and the impacts they have on the aquatic environment. Pharmaceuticals are designed to be biologically active, which means they have the potential to impact organisms living in the aquatic environment once they are released into freshwater and marine systems, even at very low concentrations. The impacts of pharmaceuticals on the health of the aquatic environment may be of particularly significance in urban and industrial areas where organisms are already stressed by degraded water quality. It is important to note that because this is an emerging issue, not much is known about the effectiveness of current and future treatment options or the impacts that these drugs are having to wildlife populations in the natural environment.

Methodology

A literature search was conducted to locate general information on the impacts of pharmaceuticals in the marine environment and possible mitigation and treatment methods that municipalities should consider. This information was compiled into a fact sheet that was distributed to all workshop participants (Appendix I) and as an article for Fundy Tidings (Appendix II). A regional expert, UNBSJ post-doctoral fellow Jen Ings, was contacted to present more in-depth information at the workshops as well as review workshop background material. Dr. Jen Ings' research focused on the effects of municipal effluent and pharmaceuticals on fish. Numerous communications were held with the ERA Subcontractors, Angella Mercer and Dr. Karen Kidd through email and phone, and staff from Environment Canada (Burlington office) were consulted for information on pharmaceutical and wastewater monitoring programs.

Research

a) Pharmaceuticals in the Environment

Humans use a wide-range of pharmaceuticals to control disease and improve health conditions. After we take these drugs, they are used and then excreted by our bodies and enter the wastewater system. Drugs also enter the wastewater system when unused medications are flushed down the toilet. Many pharmaceuticals, along with other personal care products such as shampoos and cosmetics, have been detected in municipal wastewater, and most are only partially removed using current sewage treatment processes, leading to their presence in wastewater effluents entering rivers, lakes and coastal waters. A nationwide study done in 1999 and 2000 by the United States Geological Survey (Kolpin et al. 2002) found low levels of drugs such as antibiotics, hormones, anti-depressants and beta-blockers in 80% of the rivers and streams tested (USGS 2002) and a number of studies conducted in Canada have also found a high prevalence of these compounds in the aquatic environment (Crouse et al. 2012; Metcalfe et al. 2003).

The measurement of pharmaceuticals and other chemicals in municipal wastewaters is difficult because the low levels present are often close to analytical detection limits of the measurement devices and most studies measure only a few of the hundreds of chemicals that are likely to be present in the environment (Mercer and Kidd, 2012). Very little data is available on levels of pharmaceuticals found in

freshwater and marine environments around Atlantic Canada. The few studies that have been conducted detected levels of the anti-inflammatories Naproxen and Salicyclic Acid, blood cholesterol/lipid regulator Gemfibrozil and anti-epileptic Carbamazepine (Brun et al. 2006; Comeau et al. 2008).

Environment Canada operated a Pharmaceutical and Personal Care Product Surveillance Network (Environment Canada 2011) from 2008-2011 which monitored 18 freshwater systems across Canada including the Napan River and Little Sackville River in Nova Scotia. Numerous acidic drugs, neutral drugs, antibiotics and antibacterial drugs were monitored. A preliminary report should be produced by the end of 2012 (Backus, S. Environment Canada, Burlington, Ontario, personal communication, May 15, 2012). This will provide some much needed baseline data on presence, distribution, and behaviour of pharmaceuticals in aquatic environments locally.

b) Environmental Concerns

Studies have linked pharmaceutical exposure to effects on reproduction, stress, bioenergetics and other endocrine system functions in fish as well as growth of invertebrates and algae (Table 1). Of particular concern is the synthetic estrogen, ethinylestradiol, used in oral contraceptive medications. Laboratory studies on small minnow species, including mummichugs found in the estuaries of the Bay of Fundy, have shown that exposure to this chemical causes a significant decrease in egg production and changes in hormone levels (Parrot and Blunt, 2005; Peters et al. 2007). Recent studies are starting to identify other drugs, such as anti-depressants and beta-blockers, which have the potential to reduce fertility or affect spawning in certain aquatic organisms, as well as affect other parameters that may impact long-term health and survival. Often the greatest environmental impacts are seen near wastewater treatment plants.

Table 1. Observed effects in fish of pharmaceuticals. Pharmaceuticals listed are the most commonly studied and reported on in published literature. (Created by Jen Ings, 2012)

Pharmaceutical	Class	Observed effect(s) in fish
17α-ethinylestradiol	Hormone	Reproduction
Fluoxetine (Prozac®)	SSRI	Neuroendocrine, metabolic
Venlafaxine (Effexor®)	SSNRI	Neuroendocrine, metabolic
Ibuprofen (Advil®)	NSAID	Neuroendocrine
Naproxen (Aleve®)	NSAID	Neuroendocrine
Salicylate (Aspirin®)	Analgesic	Neuroendocrine
Gemfibrozil	Lipid regulator	Metabolic
Carbamazepine	Anti-epileptic	Reproduction
Sulfonamide	Antibiotic	Growth

c) Mitigation

The focus in the United States and Canada to date has remained on how to best dispose of unused drugs, as opposed to addressing the root problem of pollution prevention, or the need to eliminate the occurrence of leftover medical waste. The most common method used to encourage proper disposal of unused pharmaceuticals are collection events often known as 'takebacks' or 'returns'. These programs are relatively new to the US, but have been in place in Europe for over 30 years (Daughton 2008). Annual household pharmaceutical disposal days are often organized by municipalities or towns and are an effective way to both raise awareness on proper disposal methods and reduce the amounts of drugs entering the natural system. It is not known whether these programs have a significant reduction in the overall amount of pharmaceuticals entering the marine environment, as it is unknown what proportion of drugs enters the environment via improper disposal as opposed to excretion, as the relative contributions may differ between drugs (Daughton 2008). However, since controlling the amount of drugs that people consume at this time is not an option, proper disposal is the best area for municipalities to focus their efforts.

Nova Scotia has a formal province-wide program in place for the disposal of household pharmaceutical waste. Administrated by the Pharmacy Association of Nova Scotia (PANS), the Medication Disposal program allows consumers to return pharmaceuticals to provincial community pharmacies for safe disposal (PCPSA, 2012). New Brunswick, does not have a formal province-wide program for the disposal of household pharmaceutical waste. However, the majority of the province's regional Solid Waste Commissions offer Household Hazardous Waste programs allow the public to dispose of pharmaceuticals in a safe manner. The public can also return unused medications to local pharmacies, who bear the cost of collection and proper disposal. This method may not be sustainable, as both the disposal costs and the number of prescriptions dispensed to the public are rising (MacDonnell Pharmacies, 2009). A formal program would allow for increased public education opportunities and coordinated monitoring of volume of returned medications.

d) Treatment

Various levels of sewage treatment remove contaminants from wastewater before it is released into the Bay of Fundy. Although wastewater treatment plants are designed to remove solids, nutrients, and biodegradable organic matter plants will also remove many types of pharmaceuticals and other personal care products.

Studies are currently being conducted to better understand the removal efficiencies of different levels of wastewater treatment. Environment Canada is operating an ongoing Wastewater Monitoring program that measures levels of various pollutants, including some pharmaceuticals, entering wastewater treatment facilities and levels found in effluent. The purpose of this study is to better understand treatment systems, not to encourage municipalities to undergo upgrades such as biological or UV treatments. This study includes sites in Atlantic Canada and an internal report on data collected from 2010-2011 has been completed. This report will be available for circulation following Environment Canada's internal review (Smyth, S.A. Environment Canada, Burlington, Ontario, personal communication, May 16, 2012).

At present time, insufficient information exists to recommend the best treatment methods, however it is generally thought that tertiary treatment has higher removal efficiencies than secondary or primary treatment. However advanced treatment, such as biological or UV, may be required to completely remove active pharmaceutical compounds. Mercer and Kidd (2012) summarized removal efficiencies of select pharmaceuticals and personal care products for lagoons, primary, secondary and tertiary treatment. Published research indicates that the most common sequence of treatment – primary settling followed by biological treatment, secondary clarification and disinfection – can remove over 90% of endocrine disrupting compounds from wastewater through degradation and/or partitioning (WERF, 2005). New research is focusing on advanced treatment such as ozonation, activated carbon, and tight membrane filtration (Kleywgt 2007).

Although removal efficiencies for various treatment levels, and other best management practices are being studied, the knowledge does not exist to make recommendations on wastewater treatment upgrades at this time (Kleywgt 2007). Therefore it is advised that no extensive infrastructure investments are made until more knowledge exists.

Workshop Results

The workshops also presented information on the emerging issue of pharmaceuticals in the environment. During the Digby and Saint John workshops, a presentation was given by researcher, Dr. Jen Ings, which aimed to provide participants with an overview of the impacts of specific drugs that have been detected in the aquatic environment and options for treatment and mitigation that could be considered by municipalities around the Bay of Fundy.

Summary from presentation by Dr. Jen Ings (UNB-SJ)

- Pharmaceutical and personal care products (PPCPs) in municipal effluent is a new line of research
- Drugs in wastewater effluent come from the disposal unused to the toilet and through human excretion. Other groups of compounds (metabolites) are changed in the body and are often more active than the parent compound
- We don't know the effects of pharmaceuticals on the ecosystem. We also don't know what the combined effect of multiple drugs is.
- Many studies have been done on the effects of pharmaceuticals on fish. Lab studies involve higher concentrations than would otherwise be found in the environment. We don't know what the long term effects are under natural conditions, i.e. continual exposure to low concentrations
- Most research has been done on freshwater systems. Little research on impacts to marine environments
- Studies have shown exposure to estrogen, one of the most studied drugs, can effect fish reproductive systems and lead to less egg production in the female spawning population, or egg production in male testes (intersex). Exposure also alters hormone levels and can decrease secondary sex characteristics in males reducing the capacity of males to attract females. These effects may impact reproductive success in the wild which could potentially impact population levels over time.
- The problem is that we don't know how to remove pharmaceuticals from waste effluent. Many pharmaceuticals go through the treatment process without being removed while others change form depending on the process in the sewage treatment plant. Treatment only works for

certain chemicals, ie. Estrogens are broken down 60% by secondary sewer treatments, while other drugs are unchanged or may be converted into something different.

- Until more is known about removal of pharmaceuticals from municipal effluent the best we can do is encourage proper disposal (stop unused drugs going down the drain). Return unused pharmaceuticals to the pharmacy for proper disposal.
- Education, information and more research is needed.

Workshop discussion on pharmaceuticals:

The workshop participants were very engaged by the presentation on pharmaceuticals in the environment and for many, it was the first introduction to this issue. Several questions were asked to the presenter, Jen Ings, which focused primarily on the impacts of pharmaceuticals in the marine environment and current research on treatment methods. A key recommendation was brought forth by a workshop participant that there is a need for education on proper disposal of pharmaceuticals is needed. People need to be aware of the impacts of flushing unused medications down the drain.

Pharmaceuticals in the environment:

- *What proportion of drugs is disposed down the drain versus from the body?* A: Cannot say the relative proportion with certainty; however, we believe that the majority go through the body.
- *Is there a coordinated monitoring system along waterways in the East coast for pharmaceuticals?* A: No, not currently. Research involves individual research groups going out themselves. Monitoring is very expensive and you need a standard to measure each compound . If there is no standard, you can't measure the chemical. There is no formal monitoring program right now.
- *We know chemicals found in water bottles (BPA) mimicked estrogen. Can you tell if a fish is changing sex as the result of human estrogen, from a pharmaceutical or another chemical?* A: No you can't tell the source.
- *Is estrogen the most prominent pharmaceutical in the environment?* No, but it is the most studied. Researchers in the UK noticed intersex in fish (saw eggs in testes). Investigative work found that the effects were downstream of a sewage treatment plant. They started research by exposing fish to estrogen because a number of estrogens are found in effluents, including normal estrogens excreted by humans. Phenol A acts as an estrogen in fish and is a huge problem. Estrogen was and is so prevalent that it has become a focus of research.

Treatment:

- *What kinds of technologies are being suggested to remove estrogen from wastewaters?* A: Researchers are not sure how to remove estrogen. Current research suggests that a change in hydraulic retention time might help to remove estrogen. Nanowire technology to filter out pharmaceuticals is also being researched, but this is highly technical. Important to know that all chemicals behave differently, so a system that removes estrogen may increase the proportion of another drug.
- *What is the effect of secondary treatment removal?* A: The effect depends on the drug - some drugs don't get broken down. Estrogens however, are broken down by 60%. Other

drugs are broken down to something undetectable while others are converted to something different.

- *Is there any movement toward reducing the overall number and volume of pharmaceuticals being used?* This is a whole other issue. Source control is best. Reducing the pharmaceuticals you take is the best way to go.

Analysis

Humans use a wide-range of pharmaceuticals and personal care products. These drugs enter the environment via two pathways – excretion and direct disposal of unused medications. Research on the environmental impacts of pharmaceuticals and removal efficiencies of varying levels of treatment is still in the very early stages. Studies have linked pharmaceutical exposure to effects on reproduction, stress, bioenergetics and other endocrine system functions in fish as well as growth of invertebrates and algae. However, most studies to date have been conducted in a laboratory setting using freshwater species and tests often investigate the impacts of a single drug. Therefore, very little is is known about the cumulative impacts that pharmaceuticals are having on wildlife populations in the marine environment and the effectiveness of current and future treatment options.

Environment Canada has monitored the presence of drugs in wastewater influent and effluent to better understand presence, distribution and removal efficiencies of wastewater treatment processes across Canada. Data has been collected by Environment Canada's Pharmaceutical and Personal Care Product Surveillance Network (2008-2011) and under the Federal Wastewater Monitoring Program (ongoing) although no results have yet been made public. These studies will be very beneficial in enhancing our understanding of pharmaceuticals in the Bay of Fundy. The wide range of different drugs that are distributed to humans greatly complicate the issue of removal, as all drugs react differently to treatment. Many pharmaceuticals go through the treatment process without being removed while others change form and may result in a compound being released that is more active than the parent compound. Therefore it is too early to make strong recommendations on proper treatment methods at the present time.

The 'Stormwater and Wastewater Management' workshops helped to bring the emerging issue of pharmaceuticals in the environment to the attention of municipalities around the Bay of Fundy and present some mitigation and treatment options for municipalities to consider. There are some actions that municipalities can take to increase awareness on the connection between what enters our wastewater systems and the health of our streams, rivers and coastal waters. Many people are not aware that what goes down the drain eventually ends up in the natural environment – nor are they aware of the potential impacts of disposed pharmaceuticals on the environment. Public education initiatives on proper disposal methods of pharmaceuticals through posters at pharmacies and in municipal offices or through the organization of public 'take-back' days are measures that municipalities can take to help reduce the volume of drugs that enter our wastewater system.

Recommendations on pharmaceuticals

a) Recommendations for Municipalities:

It was apparent from discussions at the 'Stormwater and Wastewater Management' workshops (see Section II: Workshop Overview) that many people did not know how to properly dispose of unused drugs. This highlights the need for public education on these issues. An opportunity exists for municipalities to take a lead role in a campaign to raise public awareness of disposal pathways from the household to the environment, of disposal impacts, and of proper disposal methods. Education initiatives could include posters in municipal offices, at local pharmacies and in the local newspaper coupled with a well-advertised public disposal day.

Municipalities in New Brunswick could also encourage the New Brunswick Association of Pharmacies to adopt a formal program for the collection of unused medications. This would allow for better tracking of returned unused pharmaceuticals and if well-advertised, would present a key opportunity to educate the public on the impacts of pharmaceuticals in the environment.

Questions also arose from workshop participants on what pharmaceutical monitoring programs were in place in the Bay of Fundy. Environment Canada's wastewater monitoring program and Pharmaceutical and Personal Care Products Surveillance Network will provide some much needed baseline data on presence of chemicals in the Bay of Fundy and on removal efficiencies of current treatment facilities. The results of these studies should be communicated back to municipalities as soon as they are publically available. BoFEP would be an appropriate organization to disseminate this information to workshop participants.

b) Recommendations for BoFEP:

BoFEP can play an important role in information sharing and between researchers and municipalities on the emerging issue of pharmaceuticals in the environment. BoFEP should continue to follow literature published on this issue as it becomes available and disseminate relevant research on effective treatment methods and results of local monitoring studies (i.e., Environment Canada's Pharmaceutical and Personal Care Products Surveillance Network and Wastewater Monitoring Program). BoFEP could also aid in the development of educational materials, such as posters or handouts, which municipalities could distribute to the general public. A session on pharmaceuticals in the environment at the next BoFEP Workshop, or prepared as Fundy Tidings articles, would be a good way to share information with a wider audience.

Section II: Stormwater Management

Environment Canada models predict Atlantic Canada will see an increase in precipitation and an increase in rainfall intensity within the next 80 years (Zhang, X. et al. 2007.) The impacts of more severe and more frequent storm events are felt primarily in urban landscapes where the high area of impervious surface cover (roofs, roads, parking lots) prevents water from being retained in the ground. Stormwater runoff normally includes both particulate and soluble pollutants that can impact water quality. Common pollutants include phosphorus, nitrogen, chloride, trace metals, coliforms and organic matter (GEMTEC Limited 2008).The anticipated impacts of more frequent and severe extreme precipitation events include 1) possible increased incidents of storm sewers and sanitary systems unable to deal with more frequent, high-intensity rainfall and storms, 2) projected increased insurance costs associated with damage to vulnerable infrastructure and buildings; and 3) potential for increased incidents of aquatic pollution associated with runoff and flooding (HRM 2007). Effective stormwater management therefore, is essential to reduce these risks and their subsequent costs.

In areas serviced by combined systems, both stormwater and wastewater are treated in sewage treatment plants before being released into the environment. In times of heavy rain fall events, the high volumes of stormwater and wastewater can exceed capacity of wastewater treatment plants and result in the direct release of untreated sewage into the environment. These combined sewer overflow (CSO) events directly impact water quality and cause environmental and economic impacts.

CSOs often lead to the closure of shellfish harvesting areas, which is a common occurrence in the Annapolis Basin. In Nova Scotia, the number of shellfish closures doubled between 1985 and 2000, resulting in 939 km^2 of coastline being off limits to shellfish harvesters in 2000 (Environment Canada 2000). CSOs can also result in closure of recreational beaches due to elevated bacteria levels, which can impact tourism in coastal communities and pose a risk to human health.

Data on the exact number of CSOs that occur around the Bay of Fundy and the volume of untreated stormwater and wastewater that enters the marine environment due to these events is very difficult to track down. Municipalities and towns are required to submit incidence reports to the Department of Environment when CSOs occur, however this information is only accessible to the public via an application to the Freedom of Information and Protection of Privacy Act (Lonergan, J. District Manager, Nova Scotia Environment, Kentville, Nova Scotia, personal communication, May 22, 2012).

The EAC, in partnership with BoFEP, hosted two workshops around the Bay of Fundy in order to raise awareness on impacts associated with stormwater and innovative techniques to reduce quantity and improve quality of stormwater entering the natural environment.

'Stormwater and Wastewater Management' Workshop Overview

'Stormwater and Wastewater Management' workshops were held on February 22nd in Digby and February 23rd in Saint John. The workshops targeted municipal planners, engineers, provincial government representatives, consultants and environmental organizations. Workshop invitations were sent to BoFEP's list of municipal contacts, to the Union of Nova Scotia Municipalities and to several watershed groups and non-government organizations.

Twenty-two participants attended the Digby workshop from Annapolis Royal, Middleton, West Hants, Digby, Yarmouth. Representatives from local environmental organizations Tusket River Environmental Protection Association (TREPA) and Clean Annapolis River Association (CARP) were also in attendance. Forty-six participants attended the workshop in Saint John from Hampton, Quispamsis, Saint John, Saint Andrews, Sussex, Moncton, Dieppe, Woodstock, St Louis-de-Kent, and Fredericton. Environmental organizations represented include Fundy Baykeeper, Friends of Kouchibouguacis, Kennebecasis Watershed Restoration Committee, Petitcodiac Wastershed Alliance and Kings County Agri-Conservation Club (For full participants list see Appendix V and VI).

The morning portion of the workshop included presentations on issues associated with stormwater runoff and changing weather patterns, followed by presentations on innovative stormwater management including examples of local policies and projects. (See workshop agendas Appendix III and IV). Participants took part in an interactive stormwater scenario exercise designed to increase capacity of workshop participants to identify and implement stormwater Best Management Practices (BMPs). The afternoon session included a presentation on pharmaceuticals in municipal effluent and the impacts of these drugs on the marine environment. The final session of the workshop included a group discussion where participants recommended next steps and actions to improve stormwater and wastewater management around the Bay of Fundy. The following presentations were given at each workshop. All workshop presentations are available online at: http://www.ecologyaction.ca/content/stormwater-workshop-presentations-march-2012

Digby:

- Ashley Sprague, Restoration Coordinator – Ecology Action Centre - "Introduction to Stormwater Management"
- Amanda Dean, Manager, Government Relations – Insurance Bureau of Canada Atlantic - "The Costs and Impacts of Storm Events on Homeowners and Municipalities"
- Kevin McLean, Superintendent of Public Works – Town of Annapolis Royal – "Annapolis Royal Stormwater Management Initiatives"
- Joy Elliot, Landscape Architect - Joy Elliott Landscape Architectural – "Stormwater Best Management Practices"
- Jen Ings, Postdoctoral Fellow, University of New Brunswick – Saint John – "Pharmaceuticals in the Environment"

Saint John:

- Ashley Sprague, Restoration Coordinator – Ecology Action Centre - "Introduction to Stormwater Management"
- Steve Olmstead, Manager, Government Relations – Insurance Bureau of Canada Atlantic - "The Costs and Impacts of Storm Events on Homeowners and Municipalities"
- Darryl Bonhower, Project Engineer – City of Moncton – "Stormwater Management Initiatives: Preparing for the Inevitable"

- Hans Arizs, Associate Director - RV Anderson Associates Limited - "Stormwater Best Management Practices"
- Jen Ings, Postdoctoral Fellow, University of New Brunswick – Saint John – "Pharmaceuticals in the Environment"

Workshop participants also took part in a stormwater scenario exercise (Appendix VII). The purpose of this exercise was to allow participants to practice selecting appropriate BMPs to improve stormwater management on an individual property and neighbourhood scale. The participants were divided into four groups and assigned to work on one of two different scenarios. The participants were encouraged to identify opportunities to reduce the velocity, volume and pollutant load of runoff on their site by reducing impervious surface area, selecting tools to allow water to infiltrate into the ground and promoting water capture and reuse. Each group was given a large map of their site, smaller additional site photos, a write-up describing the site and various water issues being impacting the area, a table describing of stormwater BMPs (Appendix VIII) and tracing paper.

The groups each had 45 minutes to work through the exercise and select appropriate BMPs that could be implemented on their site. The groups drew their designs on the site map using tracing paper and then reported their design plans back to the larger group. A large group discussion was then held to compare results and explore alternative solutions. This presented an excellent opportunity for participants to learn from each other's experience as well as receive feedback on their design plans from regional stormwater experts.

The final workshop session focused on the impacts of pharmaceuticals in the marine environment. An excellent resource person, Jen Ings, attended both workshops and presented an overview of the most common pharmaceuticals present in municipal effluent, potential impacts of pharmaceuticals on marine ecosystem health and approaches for treatment and mitigation of pharmaceuticals discharged to the marine environment.

Workshop Results including Stormwater Scenario Exercise

The following is a summary of key points from the workshop presentations. All workshop presentations are available online at: http://www.ecologyaction.ca/content/stormwater-workshop-presentations-march-2012

Key Points on Issues Associated with Stormwater Management:
Summary from Amanda Dean and Steve Olmstead (Insurance Bureau of Canada) presentations:

- We are experiencing more intense and frequent precipitation events due to climate change Nova Scotia's coast and water resources (including residential, municipal, and industrial infrastructure) are increasingly vulnerable to extreme weather impacts.
- Development and land use patterns (increased impervious surface area coverage) are changing peak volume, speed and quality of runoff.
- Old infrastructure/past standards do not meet reality of today's weather
- Inadequate investment to upgrade infrastructure

- National municipal water supply, wastewater and stormwater system deficit stands at $31 billion for existing infrastructure, with new needs estimated at almost $57 billion ($88 billion total)
- Several different regulators are involved. Nova Scotia Environment regulates freshwater environments, Department of Fisheries and Oceans regulates marine environment
- Across Canada, extreme weather has replaced fire as the highest cost of insurance payouts. Water related damage (mostly basement flooding and sewage backups caused by increasingly intense and unpredictable precipitation) costs the insurance industry 1.2 billion dollars annually in insurance payouts.
- These costs are rising quickly. In Atlantic Canada, home insurance claims resulting from water damage, increased by 143% between 2005 and 2009**.**
- Consumer awareness is an issue. Do people know what their policy covers?
- Adaptation is local. Individuals can make a difference.

Local Stormwater Initiatives:
Summary from Kevin McLean (Town of Annapolis Royal) presentation

- Six years ago a developer proposed a new subdivision in Annapolis Royal.
- The current sewage treatment plant was already at capacity, so the Town knew a new system would be required.
- Extensive investigations were done to review personal properties and see if houses were directly connected to sanitary system. All problems were documented and an inventory identifying problem areas that will require future work was created.
- Homes were provided with storm drains to prevent stormwater entering sanitary system.
- The Town decided to separate storm and sewer systems, instead of building a new lagoon (treatment area).
- These efforts have reduced costs for the Town of Annapolis Royal (power bills, wear and tear of pumps)

Summary from Darryl Bonhower (*City of Moncton*) presentation

- Stormwater management initiatives can be quantitative (Flood Reduction Measures) or qualitative (Pollutant Reduction Measures)
- Important to understand the problem through local/regional climate change adaptation study
  - What is predicted increase in precipitation?
  - What is the predicted increase in sea level?
  - How will these changes impact stormwater and wastewater infrastructure?
- Identify and target vulnerabilities (i.e., inlet control devices can limit water entering storm sewer inlets, storm outlet flap gates/tide flex valves can help manage outfall submergence)
- City of Moncton stormwater initiatives include:
  - Homeowners Guide to Flood Protection: http://www.moncton.ca/Assets/Government+English/Publications+English/Flood+protection+manual.pdf
  - Main backwater valve by-law: *No person shall make any connections to the municipal sewage works without installing a backwater valve that is of a normally open design to the building drain*

- Backwater valve incentive and grant program - $500 rebate towards installation of approved backwater valve, residents who are refused sewer backup insurance may qualify for installation of backwater valve at no cost.
- Minimum Habitable Space Elevation Zoning By-law: *No development of any habitable space, occupied floor space or indoor parking area shall be permitted in any zone, unless the minimum geodetic elevation of any floor is at least 10.2 metres.*
- Zero Net Increase Policy: *Stormwater runoff rates for a land parcel under a developed condition, do not exceed existing condition runoff rates for the 2-year through the100-year design storms.*

Key Points on Innovative Stormwater Management Approaches:
Summary from Ashley Sprague (EAC), Joy Elliot (Joy Elliot Landscape Architectural) and Hans Arisz (RV Anderson) presentations
Key Concepts:

- Watersheds include land (forests, fields, urban/rural developed areas), not just streams, rivers and lakes. Any activity on land will impact how runoff through the environment and contaminants enter the water from many sources.
- Innovative stormwater management approaches aim to keep it simple. Look for opportunities for multiple gains and simple approaches rather than a giant solution. Favour passive, low energy solutions.
- stormwater management usually approached in an engineered way - but preference is to deal with it naturally
- Retrofit versus new development - stormwater management on-site is easier at the outset when the design of a new system is involved. The real challenge lies in a retrofit involving impermeable surfaces and the lack of space

Key Approaches:

- Stormwater management starts with good planning
- Reducing runoff volume commonly looks for opportunities to increase infiltration, increase storage and slow peak flows. (I.e., Slow it, spread it, sink it)
- Enhancing runoff quality commonly uses settling, filtration, vegetation measures, or a combination of practices where possible.
- Runoff can be viewed as either a resource (chronic events can be source of water to reuse)or hazard (catastrophic, intense rainfall events lead to flooding)
- Sites should be designed to have same pre and post peak flow and volume of runoff for the chronic storms
- Tree planting is a good stormwater management tool. Tree canopy intercepts rate of passage of water to the ground - lessens runoff
- 3 tiers of stormwater management - on-site, neighborhood level and watershed level
- On-site measures aim to:
    - Reduce directly connected impervious areas,
    - Divert runoff from impervious to pervious

        - Increase water storage and reuse.
- Neighbourhood measures aim to:
    - Reduce impervious surfaces, avoid curb & gutter street design
    - Compact stormwater treatment devices
    - Stormwater ponds and wetlands
    - Parking lots with pervious pavement
    - Source controls (street sweeping, reduce road salting, contaminants retention, restoration of contaminated areas)
- Watershed measures aim to:
    - Establish riparian buffer zones
    - Provide passive or active treatment for all stormwater
    - Designate and maintain temporal flood waters storage areas
    - Maintain natural stream channels
- Policy (non-structural) measures are an important component
- To sustain benefits, monitoring and maintenance are needed
- Education and incentives
- Importance of watershed planning – cumulative impacts

Considerations:

- Water Balance over different timescales
- New developments vs. retrofit developments: New developments have space for SW BMPs and costs can be covered by new homeowners. Retrofits have more space and financial constraints. Focus depends on rate of municipal growth. Managing stormwater in new developments is important in areas that are growing, retrofits important in areas that are shrinking.
- Residential features need to be dovetailed with education and consideration of practicality (climatic conditions, expense)
- Seasonal changes of rain events

Stormwater Scenario Exercise Summary

Scenario One: Cattail Lake

Site Description:

- Suburban lakeside development with many new homes, a school and a community centre recently constructed
- Untreated stormwater enters into the lake
- Algal blooms have been occurring over the past several years
- The large parking lot frequently floods
- A recently introduced 'Stormwater Surcharge' has motivated homeowners to reduce imperviousness and runoff in the neighbourhood

Options presented by groups to improve stormwater management on-site (Results are from both workshops):

To reduce runoff leaving homes/streets:

- Introduce a rain barrel program with over flow going to raingardens
- Encourage property owners to plant low height vegetation to serve as a buffer
- Construct a raingarden/vegetated island in the middle of the cul-de- sac
- lowering the sides of streets and deletion of curbing
- promote infiltration and filtration through re-landscaping and regarding
- Make streets one-way to reduce width

To reduce parking lot flooding:

- Use permeable pavement on large parking lot, or reduce size of parking lot
- Develop an underground retention pond
- capture of drainage in the parking lot
- reduce the outfall outlets and concentrate flows in the parking lot and promote infiltration

To improve water quality in lake:

- Engineered wetland between parking lot and lake
- Filtration of water through the drain and underground storage then discharge to a constructed wetland.
- Re-establishment of riparian vegetation along the lake

Non-structural BMPs:

- Municipality initiates public education program to focus on water quality in lakes involving the whole community
- Municipality enacts a municipal bylaw against pesticide use.
- Design a water quality monitoring program demonstrate improvements in water quality

Scenario Two: Muddy Creek Developments

Site Description:

- Muddy Creek Developments consists of rows of apartments and townhouses with ample parking, landscaped green space, paved bike trail and interest to plant a community garden
- Unfiltered stormwater enters the small pond and growing algal blooms are a concern for residence
- Water has been collecting between the rows of apartments and a few homes are experiencing basement flooding following heavy rain events

Options presented by groups to improve stormwater management on-site (Results are from both workshops):

To reduce flooding on site:

- Rain barrel for each downspout
- Bioswale between rows of houses Lot grading away from building and toward pond to reduce basement flooding
- Parking lots - separate the collection system and build another pond which can be used in winter as a hockey rink
- Reduce size of parking lots
- Treeline street scaping
- Add additional pond. Swale parking lots and direct runoff to first pond
- Put plants along the trail and a swale if plants don't do the job
- Ask residents if they want to get rid of pavement along the trail and build a skate park

To improve water quality of pond:

- Put a dye in the pond to kill the algae, or put in a solar aerator to get rid of the algae Plant vegetation along shore of pond (create riparian buffer) to increase nutrient uptake, improve habitat
- Add stormwater septor/ oil grit separator to treat runoff and ensure proper maintenance
- Plants around perimeter of pond

Other non-structural BMPs:

- Educate residence on reducing fertilizer use, composting policy

Moving Forward:

Each workshop ended with a group discussion to identify ways to move forward on stormwater and wastewater issues facing municipalities around the Bay of Fundy. Participants suggested regulatory changes, partnerships and increased collaboration, homeowner and developer education and research were priorities.

	Saint John	Digby
Government/ Regulatory	• Stormwater surcharge is one of best ways to get action. We pay for treated water and by how much is used. Funding generated could pay for low impact development. • Need for standard regulations. However regulations come with a cost - If there are no resources to enforce regulations, they are ineffective	• If you want to effect change, you must work with municipalities and the province to develop regulations. Best Practices won't be implemented by homeowners, developers without enforced regulations • There needs to be a provincial Statement of Interest around stormwater management
Partnerships	• There are many opportunities for partnerships among provincial and municipal agencies and NGOs	• Opportunities must be created to collaborate at all levels (municipalities, province, NGOs, universities and among political jurisdictions) within a landscape on watershed protection. • Adjacent municipalities need to be consistent in views/perspectives. The closer municipalities agree, the less potential for pushback exists.
Best Management Practices	• A mixture of best management practices and practical approaches are needed (i.e., Annapolis Royal case study)	• Programs must find ways to reward success (i.e., Financial incentives, rebates, free assessments/ risk evaluations) • There are concerns regarding the cost of change to senior citizens e.g. storm lines to everyone's property. People couldn't afford to do it themselves
Education/ Communication	• Education and buy-in of developers and residents is crucial. Developers don't want to do anything harmful but extra steps are equated to extra costs. The question is, who pays? • What is the cost of *not* implementing technology. Developers and the public	• Municipalities, homeowners, developers, engineers need to be more aware of the issues, and stewardship must be encouraged • Education should be personalized i.e., brought down to an individual property level (impacts and solutions for individual

	could benefit from understanding the cost of doing nothing • The average homeowner is unaware of resources/events available to them through municipalities (i.e., rebate incentives). Municipalities need do a better job at making resources known and available.	property owners). • Interpretive signage can help educate public on municipal initiatives to protect the environment (stormwater treatment lagoon system and wetlands in Annapolis Royal) • Celebrate successful initiatives. Very few people in attendance at the Digby workshop were aware of the work that Annapolis Royal had undertaken around separating the stormwater and wastewater systems. • More local case studies on EAC blog to highlight innovative • Rather than having one huge project, have a phased approach to projects. Will lead to greater potential for success. • Encourage communication with NS municipalities through their website (Sustainability Office)
Research	• Research needed on housing and development prices that prove to developers that it won't cost more to develop a low impact dwelling/building. We need the proof that there is no additional cost, instead the costs lies with doing nothing.	• Research needed on relative water uptake by plant species • An assessment tool must be developed to identify where/how systems are stressed. The tool could then assess municipal infrastructure capacity to withstand flooding /overflow with the proviso that insurance won't be offered unless this assessment has been done.

Workshop Analysis

The workshops provided an excellent opportunity to bring people from various backgrounds together to network, talk about issues, share information and knowledge and discuss what is needed to improve stormwater management in the Bay of Fundy. Information presented was relevant and needed by the planning community. The workshops provided an opportunity for participants to learn first-hand about

successful stormwater management policies and initiatives that have been developed locally. For many participants, the workshops were the first time they had heard about these local initiatives, which highlights the need for increased communication between municipalities.

The high number of participants was a clear indication that the topics covered at the workshops were of great interest to municipalities around the Bay of Fundy. Improved stormwater management is essential to help municipalities adapt to more frequent and intense precipitation events as a result of climate change. Participants were looking for information on innovative BMPs that work with nature, as opposed to expensive networks of infrastructure, to reduce stormwater runoff.

A key theme that arose from the workshops was the importance of controlling stormwater on-site, as opposed to the traditional 'end of pipe' approach to managing stormwater which relies heavily on extensive underground infrastructure. Several small actions by individual property owners can have a large impact of the amount of stormwater runoff that enters the natural environment. Workshop participants were introduced to many bioretention tools (e.g., rain gardens, bioswales) and various rainwater harvesting methods (e.g., rain barrels and cisterns) that could be used on individual properties. These tools aim to reduce the volume and improve the quality of stormwater runoff that enters municipal drainage systems. This Low Impact Development approach requires a shift in thinking for many public works officials, who are trained to approach stormwater management in a more engineered way that relies on traditional infrastructure. However, working with nature and attempting to manage stormwater at the source can save municipalities money by requiring fewer repairs to infrastructure, causing less strain on wastewater treatment plants and resulting in fewer CSO events.

Workshop participants suggested that regulatory change is an essential component of improving stormwater management around the Bay of Fundy. Municipalities, along with the Provinces of New Brunswick and Nova Scotia, must work together to develop consistent policies and guidelines. Best Management Practices (BMPs) should also be encouraged for developers and homeowners, but workshop participants felt that compliance is unlikely without enforceable regulations or financial incentives.

There are many examples of stormwater policies that have been implemented by towns and municipalities across North America. The general purpose of stormwater policies is to reduce stormwater runoff rates and volume in order to limit associated impacts such as flooding, infrastructure and property damage, erosion, sediment transport, decrease in groundwater recharge, degradation of aquatic habitats and combined storm sewer overflows. One policy that workshop participants agreed could be effective is the introduction of a stormwater credit policy. The City of Kitchener, Ontario, recently approved a stormwater credit policy that offers incentives to property owners who reduce quantity and improve quality of stormwater runoff leaving their properties. In 2011, the City of Kitchener altered the funding approach of its stormwater program, moving it from the tax base to a user-pay system. The rate is based on the amount of impervious area on each property and creates sustainable funding for the City's stormwater management program. Private property owners are encouraged to reduce total volume and pollutant load of stormwater runoff through already existing or proposed stormwater facilities or through best management practices. Property owners who pay the stormwater rate are eligible to apply for up to 45 per cent credit based on the volume of stormwater diverted from the municipal stormwater system from their property. More information can be found here: http://www.kitchener.ca/en/livinginkitchener/Stormwater_Credit_Policy.asp.

Many municipalities in Canada and the United States now spray paint 'No Dumping, Drains to Ocean' messages on storm drains. This is an effective visual reminder that all pollutants entering the storm drains eventually end up in the ocean. Elementary schools in Yarmouth, Nova Scotia, have partnered with Trout Unlimited Canada's Yellow Fish Road program and have begun painting yellow fish with the message 'Rainwater Only' on storm drains around the community. By partnering with local NGOs and schools, municipalities can build successful outreach campaigns to encourage stewardship and protection of waterways. A great video on the Yellow Fish Road project in Yarmouth can be found here: http://www.youtube.com/watch?feature=player_embedded&v=x8vrdPR9D8k.

Yellow Fish Road – Trout Unlimited Program (source: www.severnsound.ca)

Recommendations on Stormwater Management:

a) Recommendations for Municipalities

Improving stormwater management around the Bay of Fundy will require collaboration between municipalities, the provinces of New Brunswick and Nova Scotia and local NGOs and watershed organizations. It is recognized that both regulatory changes increased public awareness must be made to address this serious problem. Municipalities should consider implementing policies to regulate the volume and pollutant load of stormwater runoff that is entering the natural environment. One example could be a stormwater policy that prevents the direct discharge of untreated stormwater into the aquatic environment. There is a need for consistent regulations and standards between municipalities. As one workshop participant noted, "The closer municipalities agree, the less potential for pushback exists from developers and property owners". Municipalities could also jointly advocate for a Provincial Statement of Interest around stormwater management.

The immediate need for a concerted education effort that targets developers, homeowners and municipal engineers was acknowledged at the workshops. Homeowners should be encouraged to reduce the amount of imperviousness on their properties and implement low-cost, low impact techniques such as rain gardens, french drains and rain barrels. Developers should be required to

maintain pre-development hydrologic conditions on their sites. Low impact development BMPs such as bioswales, permeable pavement, cisterns and green roofs should be encouraged. Financial incentives offered by municipalities are an effective way to encourage homeowners and developers to make improvements on their properties. The City of Moncton's Backwater Valve Incentive and Grant Program is a good example of this. A $500 rebate towards installation of approved backwater valve is offered to all homeowners, and residents who are refused sewer backup insurance may qualify for installation of backwater valve at no cost. As many of these BMPs are new concepts to many people, resources such as fact-sheets and 'how-to' videos, should be made available on municipal websites.

Stormwater demonstration sites are an effective way for developers and homeowners to learn about various BMPs and see them being applied. The Ecology Action Centre has partnered with Halifax Regional Municipality, Halifax Water and the Insurance Bureau of Canada to create a stormwater demonstration site in Halifax by retrofitting an existing site with a range of BMPs. The demonstration site will be constructed in the summer of 2012 and will include several interpretive panels to explain the benefits of the various tools that have been implemented. Site tours will also be offered as another way to raise public awareness. The entire retrofit project will be documented using video and photos on the EAC's stormwater blog (www.stormwatercentral.ca). This type of demonstration project could be undertaken by municipalities around the Bay of Fundy to help build local capacity.

b) Recommendations for BoFEP

The 'Stormwater and Wastewater Management' workshops were of great interest to municipalities around the Bay of Fundy. These workshops presented a comprehensive overview of a range of stormwater best management practices that homeowners, developers and municipalities could consider implementing. A future workshop on this topic could focus more on building technical skills. For example, a 'how to build a rain garden' session could be included where participants take part in the actual construction of a bioretention feature.

BoFEP could also aid in the development of educational materials, such as brochures, that could be distributed to homeowners who are dealing drainage problems on their property. Interpretive panels could also be an effective outreach tool if placed on existing or newly constructed innovative stormwater management features. Future Fundy Tidings articles on issues associated with stormwater runoff and best practices to improve stormwater management are suggested.

A future research project for BoFEP could focus on combined sewage overflows in the Bay of Fundy, as little specific information is known on the volume and distribution of untreated stormwater and wastewater that enter the Bay due to these events. Gathering data for this research would require an application to the Freedom of Information and Protection of Privacy Act.

References

Brun, G., Bernier, M., Losier, R., Doe, K., Jackman, P. and Lee, H. 2006. Pharmaceutically active compounds in Atlantic Canadian sewage treatment plant effluents and receiving waters, and potential for environmental effects as measured by acute and chronic aquatic toxicity. Environ. Toxicol. Chem. 25(8):2163-2176.

Comeau, F., Surette, C., Brun, G. and Losier, R. 2008. The occurrence of acidic drugs and caffeine in sewage effluents and receiving waters from three coastal watersheds in Atlantic Canada. Sci. Tot. Environ. 396: 132-146.

Crouse, B.A., Ghoshdastidar, A.J., Tong, A.Z. 2012. The presence of acidic and neutral drugs in treated sewage effluents and receiving waters in the Cornwallis and Annapolis River watersheds and the Mill Cove Sewage Treatment Plant in Nova Scotia, Canada. Environmental Research. 112, pp. 92-99.

Daughton CG. 2008**.** Drug Usage and Disposal: Overview of Environmental Stewardship and Pollution Prevention. USEPA, Office of Research and Development, Environmental Services Division, Las Vegas, Nevada. Accessed online: Feb 2, 2012. http://environmentalhealthcollaborative.org/images/ChristianDaughtonAbstract.pdf

Environment Canada. 2000. Canada's National Programme of Action for the Protection of Marine Environment from Land-based Activities (NPA). Publication EN 21-204/2000E.

Environment Canada. 2011. Pharmaceutical and Personal Care Products Surveillance Network. Accessed online: Feb 10, 2012. http://www.ec.gc.ca/scitech/default.asp?lang=en&n=FDFE3DAA-1

Environmental Protection Agency 2010. Pharmaceuticals and Personal Care Products. Accessed online: January 24, 2012. http://www.epa.gov/ppcp/basic2.html

GEMTEC Limited. 2008. Best Practices Assessment Stormwater Management. Final Report. Submitted to New Brunswick Environment Industry Association (NBEIA). Accessed online: May 21, 2012. http://www.nbeia.nb.ca/pdf/Storm%20Water%20Management%20Best%20Practices%20Assessment.pdf

Halifax Regional Municipality (HRM). 2007. ClimateSMART Climate Change: Developer's Risk Management Guide. Accessed online: January 18, 2012. http://www.halifax.ca/climate/documents/DevelopersGuidetoRiskManagment.pdf

Hinch, P.R. 1990. Toxic Chemicals Management in a Small Municipality. MES Thesis. Dalhousie University, Halifax, Nova Scotia.

Kleywegt, S., Smyth, S-A., Parrott, J., Schaefer, K., Lagacé, E.,Payne, M., Topp, E., Beck, A., McLaughlin, A. and K. Ostapyk (eds). 2007. Pharmaceuticals and Personal Care Products in the Canadian Environment: Research and Policy Directions. NWRI Scientific Assessment Report Series No.8. 53 p.

Kolpin, D.W.; Furlong, E.T.; Meyer, M.T.; Thurman, E.M.; Zaugg, S.D.; Barber, L.B.; Buxton, H.T. **2002** Pharmaceuticals, hormones, and other organic wastewater contaminants in US streams, 1999–2000: A national reconnaissance. *Environ. Sci. Technol. 36*, 1202-1211.

MacDonnell Pharmacies Ltd. 2009. Review and Recommendations on effective disposal of unused medications and unused sharps. Submitted for consideration to the New Brunswick Pharmacists Association. Accessed online Feb 2, 2012. http://www.nbpharma.ca/images/Effective%20Disposal%20of%20Unused%20Medications%20and%20Sharps.pdf

Mercer, A. and K. Kidd. 2012. Chemicals of emerging concern in the Bay of Fundy watershed: What are the risks? *Draft Report*. University of New Brunswick, Saint John, New Brunswick.

Metcalfe, C.D.,Koenig, B.G., Bennie, D.T., Servos, M., Ternes, T.A., and Hirsch, R., 2003. Occurrence of neutral and acidic drugs in the effluents of Canadian sewage treatment plants. Environmental Toxicology and Chemistry. 22, pp. 2872–2880.

Parrott, J.L. and Blunt, B.R. 2005. Life-cycle exposure of fathead minnows *(Pimephales promelas)* to an ethinylestradiol concentration below 1 ng/L reduces egg fertilization success and demasculinizes males. Environmental Toxicology 20 (2), pp. 131-141.

Peters, R.E., Courtenay, S.C., Cagampan, S., Hewitt, M.L., MacLatchy, D.L. 2007. Effects on reproductive potential and endocrine status in the mummichog (*Fundulus heteroclitus*) after exposure to 17alpha-ethynylestradiol in a short-term reproductive bioassay. Aquatic Toxicology. 30, 85(2), 154-166.

PCPSA: Post Consumer Pharmaceutical Stewardship Association. 2012. Accessed online February 2, 2012. http://www.medicationsreturn.ca/nova_scotia_en.php

United States Geological Survey (USGS). 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: A national reconnaissance. In *Environmental Science & Technology* 36 (6), pp. 1202-1211.

Water Environment Research Foundation (WERF). 2005. Technical Brief: Endocrine Disrupting Compounds and Implications for Wastewater Treatment. Technical Brief 04-WEM-6, Co-published by WERF and IWA Publishing, Alexandria, Virginia, USA, 44pp.

Appendix I: Pharmaceutical Handout

Pharmaceuticals in the Marine Environment

Humans use a wide-range of pharmaceuticals to control disease and improve health conditions. After we take these drugs, they are used and then excreted by our bodies in either a modified form called a metabolite or in its original form, and enter the wastewater system. Drugs may also enter the wastewater system when unused medications are flushed down the toilet. Many pharmaceuticals and their metabolites have been detected in municipal wastewater, and most are only partially removed using current sewage treatment processes, leading to their presence in wastewater effluents entering rivers, lakes and coastal waters.

A nationwide study done in 1999 and 2000 by the United States Geological Survey (USGS 2002) found low levels of drugs such as antibiotics, hormones, anti-depressants and beta-blockers in 80% of the rivers and streams tested [(1)], and a number of studies conducted in Canada have also found a high prevalence of these compounds in the aquatic environment[(2,3)].

Environmental Concerns

Pharmaceuticals are designed to be biologically active, which means they have the potential to impact organisms living in the aquatic environment once they are released into freshwater and marine systems, even at very low concentrations. The impacts of pharmaceuticals on the health of the aquatic environment may be of particularly significance in urban and industrial areas where organisms are already stressed by degraded water quality.

Studies have linked pharmaceutical and wastewater exposure to effects on reproduction, stress, bioenergetics and other endocrine system functions in fish. Of particular concern is the synthetic estrogen, ethinylestradiol, used in oral contraceptive medications. Studies on small minnow species, including those found in the estuaries of the Bay of Fundy, have shown that exposure to this estrogen causes a significant decrease in egg production and changes in hormone levels [(4,5)]. Recent studies are starting to identify other drugs, such as anti-depressants and beta-blockers, which have the potential to reduce fertility or affect spawning in certain aquatic organisms, as well as affect other parameters that may impact long-term health and survival. Often the greatest environmental impacts are seen near wastewater treatment plants.

What Can Municipalities Do?

The most important thing you can do to reduce the amount of drugs in our waterways is to encourage proper disposal by not flushing unused medications down the drain. The best option is to return unused pharmaceuticals to a pharmacy for proper disposal. Nova Scotia has a formal province-wide program for the disposal of household pharmaceutical waste. Administrated by the Pharmacy Association of Nova Scotia (PANS), the Medication Disposal program allows consumers to return pharmaceuticals to provincial community pharmacies for safe disposal.

New Brunswick, does not have a formal province-wide program for the disposal of household pharmaceutical waste. However, the majority of the province's regional Solid Waste Commissions offer Household Hazardous Waste programs which allow the public to dispose of pharmaceuticals in a safe

manner. Upgrades to sewage treatment plants, such as biological or UV treatment, may be required to completely remove active pharmaceutical compounds. However, this may be an expensive option for municipalities and research is still underway to determine the best available treatment techniques. Therefore it is recommended that extensive infrastructure investments are not made until more knowledge exists.

References:

1. United States Geological Survey (USGS). 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: A national reconnaissance. In Environmental Science & Technology 36 (6), pp. 1202-1211.

2. Metcalfe, C.D.,Koenig, B.G., Bennie, D.T., Servos, M., Ternes, T.A., and Hirsch, R., 2003. Occurrence of neutral and acidic drugs in the effluents of Canadian sewage treatment plants. *Environmental Toxicology and Chemistry*. 22, pp. 2872–2880.

3. Crouse, B.A., Ghoshdastidar, A.J., Tong, A.Z. 2012. The presence of acidic and neutral drugs in treated sewage effluents and receiving waters in the Cornwallis and Annapolis River watersheds and the Mill CoveSewage Treatment Plant in Nova Scotia, Canada. *Environmental Research*. 112, pp. 92-99.

4. Parrott, J.L. and Blunt, B.R. 2005. Life-cycle exposure of fathead minnows (*Pimephales promelas*) to an ethinylestradiol concentration below 1 ng/L reduces egg fertilization success and demasculinizes males. *Environmental Toxicology* 20 (2), pp. 131-141.

5. Peters, R.E., Courtenay, S.C., Cagampan, S., Hewitt, M.L., MacLatchy, D.L. 2007. Effects on reproductive potential and endocrine status in the mummichog (*Fundulus heteroclitus*) after exposure to 17alpha-ethynylestradiol in a short-term reproductive bioassay. *Aquatic Toxicology*. 30, 85(2), 154-166.

Ecology Action Centre

BOLUM BAY OF FUNDY ECOSYSTEM PARTNERSHIP

Appendix II: Fundy Tidings Article

Pharmaceuticals in the Marine Environment

Humans use a wide-range of pharmaceuticals to control disease and improve health conditions. After we take these drugs, they are used and then excreted by our bodies and enter the wastewater system. Drugs also enter the wastewater system when unused medications are flushed down the toilet. Many pharmaceuticals, along with other personal care products such as shampoos and cosmetics, have been detected in municipal wastewater, and most are only partially removed using current sewage treatment processes, leading to their presence in wastewater effluents entering rivers, lakes and coastal waters. A nationwide study done in 1999 and 2000 by the United States Geological Survey (USGS 2002) found low levels of drugs such as antibiotics, hormones, anti-depressants and beta-blockers in 80% of the rivers and streams tested [(1)], and a number of studies conducted in Canada have also found a high prevalence of these compounds in the aquatic environment[(2,3)].

Environmental Concerns

Pharmaceuticals are designed to be biologically active, which means they have the potential to impact aquatic organisms once they are released into the environment, even at very low concentrations. Studies have linked pharmaceutical exposure to effects on reproduction, stress, bioenergetics and other endocrine system functions in fish as well as growth of invertebrates and algae. Of particular concern is the synthetic estrogen, ethinylestradiol, used in oral contraceptive medications. Studies on small minnow species, including those found in the estuaries of the Bay of Fundy, have shown that exposure to this chemical causes a significant decrease in egg production and changes in hormone levels [(4,5)]. Recent studies are starting to identify other drugs, such as anti-depressants and beta-blockers, which have the potential to reduce fertility or affect spawning in certain aquatic organisms, as well as affect other parameters that may impact long-term health and survival. Often the greatest environmental impacts are seen near wastewater treatment plants.

What Can Municipalities Do?

The most important thing municipalities can do to reduce the amount of drugs entering the environment is to encourage proper disposal by not flushing unused medications down the drain. The best option is to return unused pharmaceuticals to a pharmacy for proper disposal. Nova Scotia has a formal province-wide Medication Disposal program which allows consumers to return pharmaceuticals directly to pharmacies for safe disposal. New Brunswick does not have a formal disposal program, however, the majority of the province's regional Solid Waste Commissions offer Household Hazardous Waste programs which allow the public to dispose of pharmaceuticals in a safe manner. Some cities and towns in the United States hold annual pharmaceutical disposal days to encourage the safe disposal of household pharmaceuticals and raise awareness on the environmental impacts of these drugs.

Although sewage treatment plants (STP) are not designed to remove pharmaceuticals, in general, tertiary treatment will have higher removal efficiencies than secondary or primary treatment. Upgrades to STPs, such as biological or UV treatment, may be required to completely remove active pharmaceutical compounds. However, this may be an expensive option for municipalities and research is still underway to determine the best available treatment techniques. Therefore it is recommended that extensive infrastructure investments are not made until more knowledge exists.

A new report prepared by researchers at UNBSJ presents information on the occurrence of pharmaceuticals and other personal care products in influents, effluents and surface waters, removal

efficiencies in different types of sewage treatment and potential risks to aquatic organisms with respect to their toxicity and ability to disrupt the hormone system. Although limited data exists on pharmaceuticals in Atlantic Canada, this report includes regional studies when possible and will be available on the BoFEP website at:_____

References:

1. United States Geological Survey (USGS). 2002. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: A national reconnaissance. In Environmental Science & Technology 36 (6), pp. 1202-1211.
2. Metcalfe, C.D.,Koenig, B.G., Bennie, D.T., Servos, M., Ternes, T.A., and Hirsch, R., 2003. Occurrence of neutral and acidic drugs in the effluents of Canadian sewage treatment plants. *Environmental Toxicology and Chemistry*. 22, pp. 2872–2880.
3. Crouse, B.A., Ghoshdastidar, A.J., Tong, A.Z. 2012. The presence of acidic and neutral drugs in treated sewage effluents and receiving waters in the Cornwallis and Annapolis River watersheds and the Mill CoveSewage Treatment Plant in Nova Scotia, Canada. *Environmental Research*. 112, pp. 92-99.
4. Parrott, J.L. and Blunt, B.R. 2005. Life-cycle exposure of fathead minnows (*Pimephales promelas*) to an ethinylestradiol concentration below 1 ng/L reduces egg fertilization success and demasculinizes males. *Environmental Toxicology* 20 (2), pp. 131-141.
5. Peters, R.E., Courtenay, S.C., Cagampan, S., Hewitt, M.L., MacLatchy, D.L. 2007. Effects on reproductive potential and endocrine status in the mummichog (*Fundulus heteroclitus*) after exposure to 17alpha-ethynylestradiol in a short-term reproductive bioassay. *Aquatic Toxicology*. 30, 85(2), 154-166.

Appendix III: Digby Workshop Agenda

Isaiah W.Wilson Memorial Library February 22nd, 2012		
Time	Activity	Speaker
8:30	Doors open	
8:45	Overview of day/workshop objectives	Jen Graham, EAC
9:00	Introduction to stormwater management	Ashley Sprague, EAC
9:30	Climate change and storm events: Costs and impacts to homeowners and municipalities	Amanda Dean, Insurance Bureau of Canada
10:00	BREAK	
10:15	Stormwater initiatives: Town of Annapolis Royal	Kevin McLean, Annapolis Royal
10:45	Stormwater Best Management Practices	Joy Elliot, Landscape Architect
11:15	Summary of morning Discussion/Questions	
11:30	Stormwater scenario exercise	Ashley Sprague, EAC
12:00	LUNCH	
12:45	Stormwater scenario exercise: Group work	All participants
1:15	Stormwater scenario exercise: Facilitated discussion	Feedback from speakers
2:00	Emerging Water Issues: Pharmaceuticals in Municipal Effluent	Jen Ings, UNBSJ
2:30	Group discussion How to address stormwater and wastewater issues : Opportunities and limitations	Jen Graham, EAC
3:00	Wrap up, Evaluation	
3:30	End	

Appendix IV: Saint John Workshop Agenda

Market Square Public Library February 23rd, 2012		
Time	Activity	Speaker
10:00	Doors open	
10:10	Overview of day/Welcome	Jen Graham, EAC
10:30	Introduction to stormwater management	Ashley Sprague, EAC
10:50	Costs and impacts of storm events to homeowners and municipalities	Insurance Bureau of Canada
11:15	Stormwater initiatives: City of Moncton	Darryl Bonhower, City of Moncton
11:45	Stormwater Best Management Practices	Hans Arisz, RV Anderson
12:15	Lunch	
1:15	Stormwater scenario exercise: Explanation explain objectives, groups, scenario characteristics	Ashley Sprague, EAC
1:45	Stormwater scenario exercise: Group work	All participants
2:15	Stormwater scenario exercise: Facilitated discussion	Feedback from speakers
3:00	Break	
3:15	Emerging Water Issues: Pharmaceuticals in Municipal Effluent	Jen Ings, UNBSJ
3:45	Group discussion How to address stormwater and wastewater issues : Opportunities and limitations	Jen Graham, EAC
4:15	Wrap up, Evaluation	
4:30	End	

Appendix V: Digby Workshop Participants List

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Appendix VI: Saint John Workshop Participants List

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Appendix VII: Stormwater Scenario Exercise

Why a Stormwater Scenario Exercise*?*
The participants at this workshop represent many different types of expertise and experience about stormwater management. To maximize the opportunity to learn from each other, we will be spending some time today working in groups on stormwater scenario exercises.

We are using a scenario exercise format because it allows participants to apply the concepts presented in today's workshop, as well as their own expertise to hypothetical (yet realistic) urban stormwater management situations.

The purpose of this exercise is to practice selecting appropriate Best Management Practices (BMPs) to improve stormwater management on an individual property and neighbourhood scale. Try to identify opportunities to reduce the velocity, volume and pollutant load of runoff on your site by reducing impervious surface area, selecting tools to allow water to infiltrate into the ground and capturing and reusing rainwater.

How the activity works
Each group will work on one of two stormwater scenarios. Your scenario, along with a description of stormwater BMPs, are included in the workshop kit. The groups will work together to answer specific questions and prepare to report back to the larger group. Each group will find more photos of their site, flip chart paper and markers to help prepare to report back to the larger group. There will be a facilitated large group discussion after the small group session, to compare results and explore alternative solutions.

Getting started

- Introduce yourselves to each other. Find out about the background each member brings to the group.
- Read through your group's stormwater management scenario. Ask each other or the facilitators for clarification as needed.
- Lay the clear sheet provided on top of your site map and use a marker to draw changes to your site and selected BMPs.
- Assign a note taker to record highlights from the discussion for reporting back to the larger group.
- Figure out who will present your results to the larger group.

Answer these questions, keeping in mind the particular condition of your site, as well as the need to incorporate essential stormwater management concepts:

1. What are the opportunities and challenges for improving stormwater management on your site?

2. What are the on-site retrofit locations opportunities on your site? (rooftops, parking lots, underground, streets, parks, etc.)
3. What BMPs are the most appropriate to improve stormwater management on your site? Use a minimum of 3 different tools.
4. What additional benefits will your retrofit design plan create? (i.e., habitat, aesthetic value, water reuse, etc.)
5. What maintenance considerations apply to your design plan?

During the large group discussion you will have **5 minutes** to:

- Introduce your scenario
- Describe the on-site retrofit location opportunities on your site
- Present the various BMPs you have chosen to implement in your scenario
- Explain your reasoning behind the citing of various BMPs and how they will function to reduce velocity, volume and pollutant load of stormwater runoff.

Other tips

- It's your site! Feel free to add relevant information about existing land use, water use, habitat value, and human activities on the property. Also, you can make assumptions about your site if you feel the scenario is incomplete. For example: the size of stormwater outflows, drainage area, presence of bedrock.
- You can use additional BMPs that are not listed in the handout (i.e., tree planting, daylighting, education and awareness tools such as brochures for homeowners).
- If helpful, use sketches or additional drawings to explain your design plan when presenting back to the large group
- If time remains, feel free to discuss costs of your design plan based on your experience

Stormwater Scenario 1: Muddy Creek Apartment Development

Site Description:
Muddy Creek Developments is a spacious housing complex located only 20 km outside of the urban centre of Waterville, Nova Scotia. Land use has changed quickly in this area with several new housing developments, a school, community centre, and a shopping mall constructed in the past eight years. Only 10 years ago, the area was primarily forest with some land developed for agricultural purposes.

Muddy Creek Developments offers a range apartments, townhouses and condominiums at affordable prices. Ample parking space exists for residents and their guests. Rooftop rainwater is collected into downspouts which drain onto the site. The beautifully landscaped grounds consist of large grassed areas, a small water park and playground for kids, and a pond where you can relax and watch the

resident ducks swim. A paved bike trail runs adjacent to the Development. Several youth in the area have recently decided to plant a community garden.

Stormwater Runoff Concerns:
The developer has recently started receiving complaints from tenants who are concerned about the health of the pond. Over the past two summers, the usually clear water has become covered with algal blooms. Families are no longer able to enjoy this space and the beloved ducks did not return to the pond this Spring. Storm drains collect runoff from the roofs and parking lots of the site, which drain into the pond unfiltered via one stormwater outlet. Wet areas have started to develop in between the rows of apartments and a few homeowners are also experiencing basement flooding following heavy rain events.
Additional Site information:
Soil type: Well-draining loam (60% sand, 30% silt, 10% clay)
Depth of water table: 4 m

Scenario #2: Cattail Lake

Site Description:
Development is rapidly growing around this suburban lake. The lake is very popular for recreation purposes, with canoeing, kayaking, swimming, fishing and bird watching all taking place during the spring and summer months. A large parking lot and paved road was built to provide public access to the lake. Many new homes, a school and a community centre have been constructed in the past 15 years.

Many of the lakefront homes have removed a high percentage of the existing vegetation in order to have an unobstructed view of the lake. The use of cosmetic pesticides is common practice for many homeowners. Untreated stormwater from the developments drains into the lake unfiltered via 10 different stormwater outlets.

Stormwater Runoff Concerns:
In the past 12 years, users of the lake have reported algal blooms and eutrophication, and for the past 5 years the local beach has had to be closed on days following heavy rain events. A local residents committee was formed to raise awareness about the health of the lake. The committee began testing the lake's water quality and found high levels of phosphorous.

The site slopes toward a depression where the parking lot was constructed to provide public access to the lake. Several large pools of water form in this area following heavy rain events and accelerated shoreline erosion has been reported in this area.

The municipality has recently introduced a 'Stormwater Surcharge' and rates are based on the area of impervious surfaces in a neighbourhood. The rates can be greatly reduced if the neighbourhood can demonstrate a reduction in runoff volume through of on-site retention and reuse or a reduction of impervious surface area.

In order to address these growing concerns, a community meeting was held and several homeowners committed to making changes on their individual properties. Residents also agreed to look for opportunities to help reduce the amount and pollutant load of runoff entering the lake in shared, public areas of the neighbourhood.

Additional Site information:
Soil type: Well-draining loam (60% sand, 30% silt, 10% clay)
Depth of water table: 4m